Professional Health Systems

Quick Reference Evidence Based

MUSCLE MANUAL

A must have for all physical medicine providers!

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Professional Health

- ☑ Origins, Insertions, Actions
- ☑ Nerve & Blood Supply
- ☑ Synergists, Antagonists
- ☑ Anatomical Variation
- ☑ Kinesiology & Biomechanics
- ☑ Differential Diagnosis
- ☑ Palpation
- ☑ Muscle Testing
- ☑ Trigger Point Referral Patterns
- ☑ Strengthening Exercises
- ☑ Stretching Movements
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- ☑ 2000+ Images

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How to use this book, and legal disclaimer

This text is designed as a quick reference guide for students, therapists, doctors and instructors. It assumes the reader is receiving or has had thorough training in musculoskeletal anatomy and diagnostic procedures, and is meant as a supplemental source for information used in daily practice, and as a reminder of knowledge and information learned elsewhere. The information in this book is compiled from sources believed to be reliable, and exhaustive efforts have been put forth to make the book as accurate as possible. The contents are to be used as a guide only and health care professionals should use sound judgment and individualized therapy for each specific patient care situation. This book is not meant to be a replacement for training, experience or continuing education. This text is sold without warranties of any kind, expressed or implied, and the publisher, authors, consultants and editors disclaim any liability, loss, or damage caused by the contents.

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In virtute sunt multi ascensus - There are many degrees in excellence

Without your assistance and support this text would not have been possible, thank you.

This text is dedicated to all health care providers that can use the information it contains.

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Environmental Printing Awards

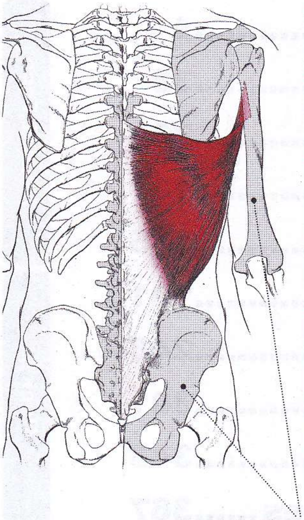
Contents

This text is the most up-to-date, functional and cost effective clinical book on muscles available. To assemble the information contained in this text from individual sources would cost hundreds, if not thousands of dollars. Countless hours of research & design were spent to develop the content & format. This text bridges the gap between basic anatomy information and clinical application & productivity. Information sources include: original journal articles with cutting-edge information, standard recognized text on anatomy, cadaver dissections & evidence based clinical experience.

Illustrations have been drawn and adapted from some of the greatest anatomy illustrators of all time (Dr. Paul Richer "Artistic Anatomy", and Dr. H.V. Carter "Gray's Anatomy"). Coil binding allows the book to lay flat & a numbered labeling system allows students to self quiz directly from the text (which is further supported by numerous web-based learning materials). The chapters are marked with soft tabs & the start of each chapter provides a detailed table of contents for that section. As well, the rapid find muscle index inside the back cover is an excellent alternate method to locate information.

In order to get the most clinical utility from this text, it must be available at all times, as such the books size allows for easy transport & storage. Do not be fooled, this text contains more useful information than most full-size textbooks.

As environmental costs & impact are becoming more of a reality in the production of goods, this text is not only financially less costly, but also environmentally more responsible, using about 70% less paper and requiring much less in shipping fuel consumption for delivery. To help ensure gender equity, 'his' & 'her' are used interchangeable throughout the text. The ☺ symbol signifies a section containing humor, laughter is optional ☺.



O **ORIGIN: more proximal or fixed point of attachment**
- *bold indicates primary attachment point(s)*

I **INSERTION: more distal or moveable point of attachment**
- *bold indicates primary attachment point(s)*

A **ACTION: main actions performed by muscle**
- *bold indicates primary or important action(s)*

N **NERVE: nerve that activates muscle tissue**
- *bold indicates primary innervation*

B **BLOOD SUPPLY: blood vessel supplying muscle**

S **SYNERGIST:** other muscles that assist the action of the primary muscle

P **PALPATION:** simple palpation includes instructions here

Bony attachments are shaded light grey

General origins (red) & insertions (dark grey) are shown in at the start of each chapter

Clinical Notes

- **Anatomical variation***:* people may have subtle differences in the attachment of their muscles. Some of us are taller, thinner or wider due to the shape & length of our bones, so too do our muscles vary. Because of anatomical variation certain people can run faster, jump higher or lift more; others may also be predisposed to injury and/or slower healing times
- Interesting information & facts about the muscle are also stated in this section
- **ADL:** Activities of Daily Living (ADL) that require activity of the specified muscle
- **Common injuries:** common injuries or sports & activities that may cause muscle damage
- **DDx:** Differential Diagnosis - a common error made by many practitioners is to have a bias toward single cause for a given patient issue - when in it is often more commonly a combination of a variety of factors & coexisting conditions (remember patients do NOT read the text books to know how to present in your office ☺)

Palpation

- Suggested palpation methods for the muscle tissue
- Excellent physical palpation skills demand relaxed hands, good understanding of the anatomy, muscle fiber direction & hours of practice with direct mental concentration (do not palpate casually)
- Use the least amount of pressure possible (touch receptors respond best to light touch)
- Use a broad or flat contact whenever possible
- Closing your eyes may increase your palpatory sense
- Develop a palpation routine that is standard for you & apply it to all patients
- Compare results bilaterally
- Numerous studies show excellent interexaminer reliability for the palpation of bony & soft tissue tenderness (palpation is one of the best tools a clinician can use)
- Stay in touch (pun intended) with your patient's comfort level - continually ask how they are doing
- *See page iv for further information on palpation technique ☺*

Muscle Test

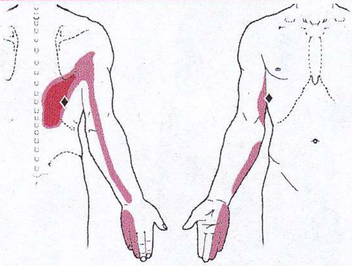
Patient position: Position prior to application of patient's resistance/force
Examiner's force: Direction & location of clinician's pressure
Stabilization: Used to avoid excessive or inappropriate movement

Muscle testing is graded on a scale of 0/5 to 5/5:
- 0/5 - No contraction
- 1/5 - Muscle flickers, no movement
- 2/5 - Movement possible, not against gravity
- 3/5 - Movement possible against gravity, but not against the examiner
- 4/5 - Movement possible against some resistance from examiner
- 5/5 - Normal strength

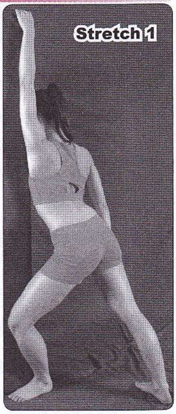
See page 27 for more specifics on technique

Trigger Point Referral

- Diamond '♦' shows common locations of myofascial trigger point (MFTP)
- Dark red region shows *primary area of pain referral*
- Light red shows *secondary or 'spill-over' area of pain referral*
- Other somatic observations are also noted in this section



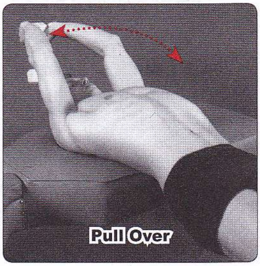
Stretch & Strengthen

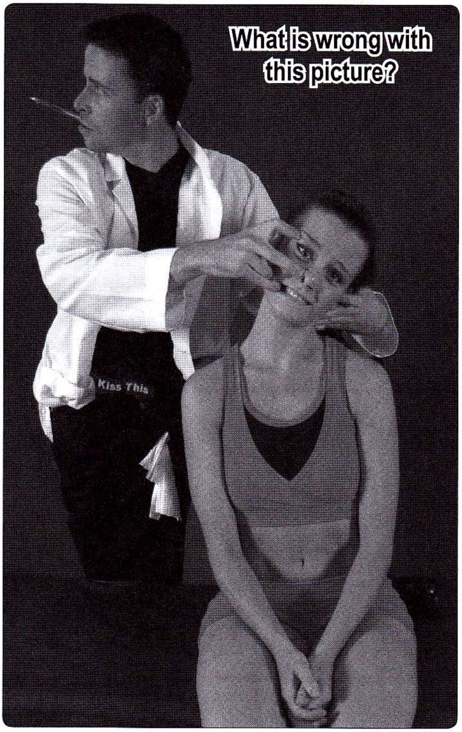


Self Stretch (see page 385 for more technique specifics)
- **Stretch:** deliberate lengthening of muscles, in order to increase muscle flexibility and/or joint range of motion (stretches develop passive tension)
- Sample stretches are given for each muscle or muscle group & should be performed ***bilaterally***. Realize there are also many variations & stretches that must be specifically designed to each patient's flexibility
- It is crucial to ask patients to demonstrate the stretches they are performing to ensure proper technique & injury avoidance
- Stretches should be held for 15-30 seconds & performed after a mild warm up

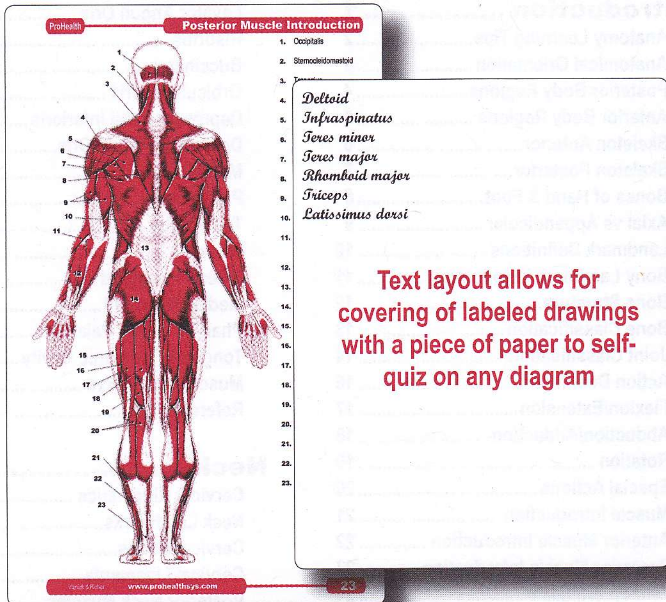
Strengthen (see page 386 for specific weight training régimes)
- **Exercise:** resisted concentric contraction of muscle
- Sample strengthening exercises (although there are many others)
- None of the exercises demonstrated require expensive equipment or gym memberships, they may be performed at home with weights, therapy bands, soup cans, pots or any other device that can provide muscle resistance

Tips for Patient Compliance
- **Keep it simple.** Exercises & stretches should be easy to do & easy to remember (e.g., show patients how to do it, have them demonstrate it & give handouts with pictures to use at home)
- **Keep it short.** Time is precious, so keep the home routine to under 15 minutes
- **Keep it pain-free**. The patient should not work in painful areas; the amount of stretch, weight & reps should be started at below what the practitioner believes the patient's ability is & progress slowly



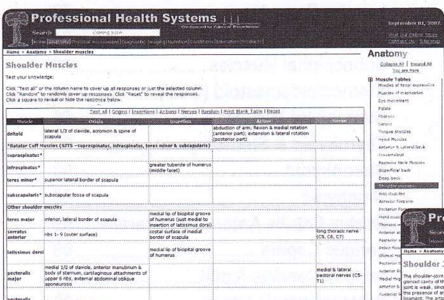


- ***Examiner is not paying attention*** to patient - can you even tell what is being palpated? Mental concentration & understanding of the regional anatomy are required for competent palpation (in this case the examiner is looking at an anatomy poster on the wall to try and figure out what he is doing - not good)
- ***Patient is in obvious discomfort*** but is not informing examiner of situation - rapport must be developed that allows the patient to feel safe in expressing how they are experiencing the situation - always attend to patient comfort - simply state "if at any time anything is uncomfortable please let me know," and repeatedly verbalize to monitor how they are doing.
- ***Palpating fingers in body orifices*** is usually NOT recommended - this examiner has a finger in the patient's eye, up their nose, in their ear and even hooked into the mouth! Unless you are performing very specific techniques, and the patient is fully aware of the situation, orifice palpation degrades the quality of the patient's experience
- ***Lack of professionalism*** by examiner on multiple levels
    - ***Examiners foot on table*** - this is non-hygenic considering patients will be lying on the table. This also places the patient between the examiner's legs; it is considered good practice technique to NEVER place a patient's body between your legs, or to place yourself between the patient's legs
    - ***Poor clothing choice*** - jacket is tucked into pants, wearing a non-collared T-shirt, underwear are visible with inappropriate slogan & there appears to be some tissue hanging from the zipper of the pants. Under garments, should NOT be visible during any part of a patient encounter
    - ***Pen in mouth*** during examination is extremely unprofessional
    - ***Dirty fingernails*** - good personal hygiene is fundamental for any health care provider, this includes physical cleanliness, but also potential breath & body odor issues. When washing your hands it is good practice to let the patient casually observe the process so they know it was done
- ***Poor Examiner & Patient Position*** - good biomechanics are required to help prevent the development of postural injuries, practice injuries & to set a good example to patients (practice what you preach)
- Of course the image above is a completely staged situation, but it does bring up a number of good points that are often over-looked as the casualness of classroom learning can spill over into the public clinical arena. Be professional, know your anatomy and you will have no issues



Text layout allows for covering of labeled drawings with a piece of paper to self-quiz on any diagram

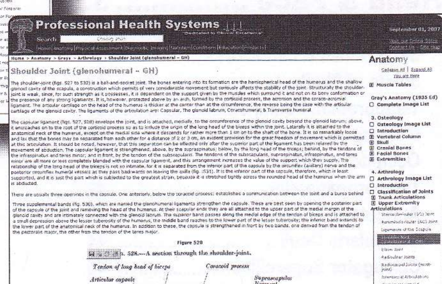
www.prohealthsys.com/anatomy/index.php



On-line resources include printable or computer based quizzes on muscle tables for all muscles of the body origins, insertions, actions & nerves. Excellent for rapid review!

There is also an edition of Gray's Anatomy that can provide further images & information detail to help improve understanding

On-line resources are continually being updated and include many valuable aids



Free on-line videos demonstrations of manual medicine techniques are available at **http://www.prohealthsys.com/education/index.php**

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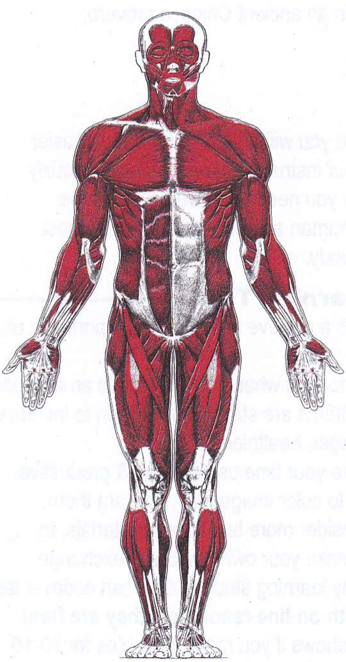
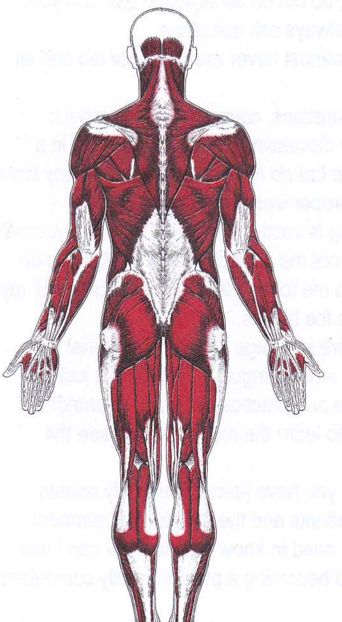




Anatomy Learning Tips

Among the wisest educational words ever spoken exist in an ancient Chinese proverb;

Tell me, I will forget,
Show me, I may remember,
Involve me, I will understand.

The more involved you become in your learning the more you will understand and the easier learning will be. To be truly involved you need to hear your instructors words, conscientiously observe images & models and perhaps most importantly you need to actively palpate the structures you are learning. Fortunately, when studying human anatomy you have the most amazing study guide you could ever ask for - your own body.

---------------------- Dr. Vizniak's Top 10 Learning Tips ----------------------

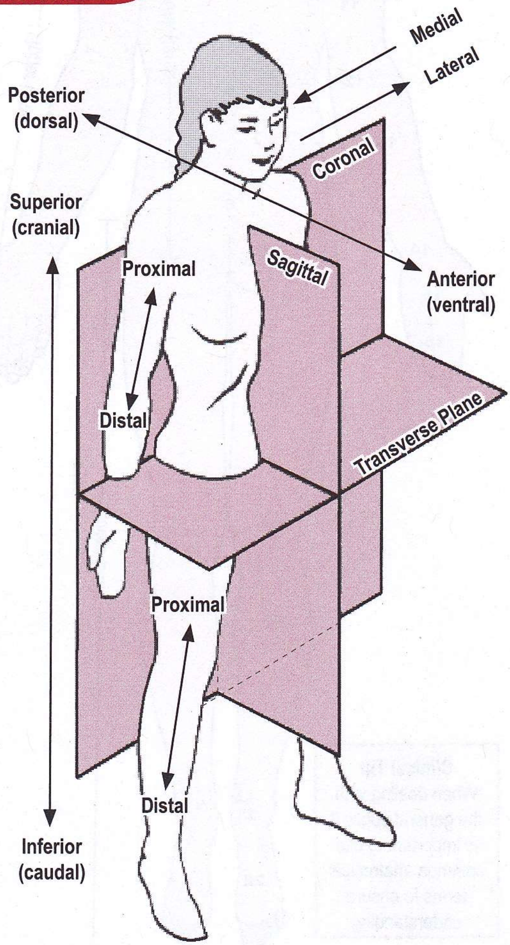
1. **Have fun.** Any task, including learning, is easier with a positive attitude - the importance of a positive mind-set can never be over stated.
2. **Good sleep & exercise habits.** Trying to learn information when you are tired is an exercise in futility. A regular exercise schedule and sleep patterns are statistically proven to increase learning capability, reduce stress and result in a longer, healthier life.
3. **Organization & alternate learning resources.** Make your time use efficient & productive. Depending upon your learning style you may want to color images as you learn them, or use web based resources, if you like to read consider more text based materials; try drawing things on a white board, use flash cards, make your own quizzes & exchange them with classmates, or for the ultimate in anatomy learning study in a human cadaver lab with actual anatomical variation. **Use the Pro Health on-line resources, they are free!**
4. **Re-read lecture/lab notes EVERY DAY**. Research shows if you read your notes for 10-15 minutes a day, you will perform better on your exams. Repetition works!
5. **Ask questions.** If you do not understand something, do not be ashamed to ask, it is your right to understand. Good students & practitioners always ask questions.
6. **Attend all classes.** Statistics show that 'A' students almost never miss class or lab and sit closer to the front of the room.
7. **Actively learn.** Don't just stare at diagrams and illustrations, cover the list and label it yourself. Test your comprehension and retention by discussing the material. Study in a group. Set up weekly meetings to go over the notes; but *do NOT allow anyone at any time to substitute words* like "thingy," or "dealie" for the proper words required.
8. **Fill in the blank NOT multiple choice.** Your learning is vastly improved if you quiz yourself with fill in the blank type questions where you write out the correct answers. Patients do not come to your office and say "What is wrong with me today? Is it 'A' my shoulder, 'B' my elbow, or 'C' my wrist?" You need to be able to fill in the blanks.
9. **Break the material into manageable sections.** There is a huge volume of material to learn in anatomy. Learning anatomy is like learning a new language, you do not just see or hear words once and become fluent, it takes time and practice. As much of anatomy nomenclature is based in Greek & Latin it is useful to learn the root meaning **(see the appendix for a list of common meanings)**.
10. **Real life application.** Consider how the information you have learned currently relates to you and how in the future it may relate to your patients and the creation of treatment plans. Once you make the transition from "why do I need to know this" to "how can I use this information" you have taken a giant step toward becoming a phenomenally competent healthcare provider.
11. **Have fun.** Try not to take yourself or the material you are leaning too seriously.

Anatomical Position: body standing erect, feet flat on supporting surface, and hands rotated so palms are facing forward, thumbs facing away from body, fingers extended.

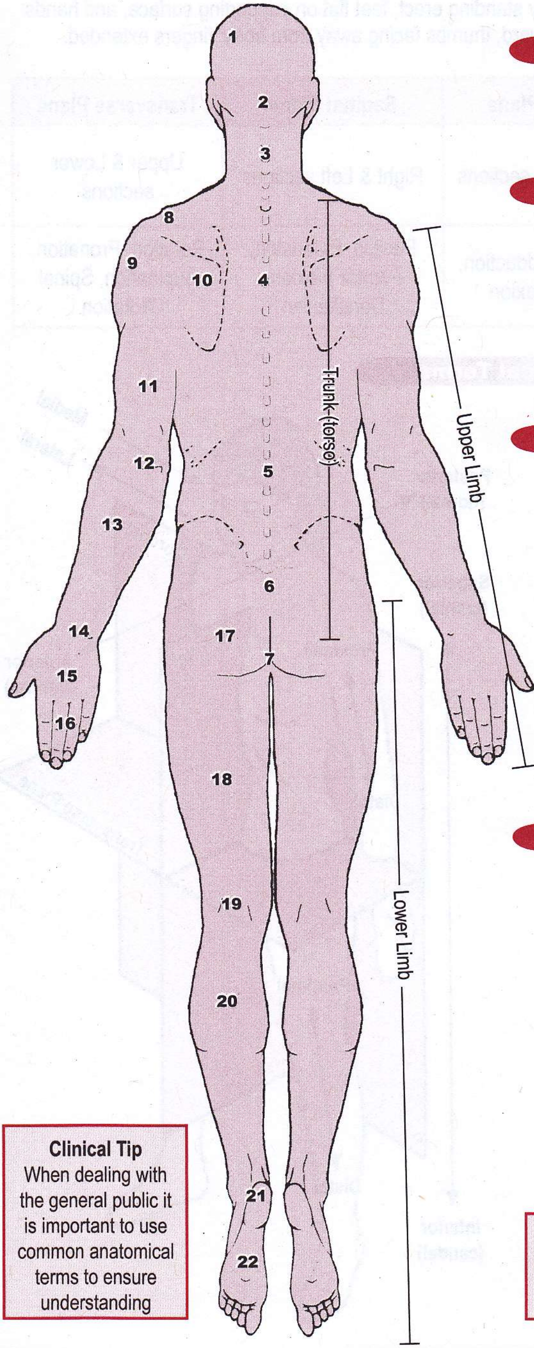
Body Planes	Coronal Plane	Sagittal Plane	Transverse Plane
Divides body into:	Front & Back sections	Right & Left sections	Upper & Lower sections
Movements plane:	Abduction, Adduction, Lateral Flexion	Flexion, Extension, Plantar Flexion, Dorsiflexion	Rotation, Pronation, Supination, Spinal Rotation

Anatomical Terms

Anterior: front of the body
Posterior: back of the body
Superior: toward head or upper part of a structure
Cephalad: towards the head
Inferior: away from head or lower part of a structure
Caudad: towards the tail
Medial: toward the midline
Lateral: away from midline
Proximal: closer to the point of origin
Distal: further away from the point of origin
Superficial: near the surface of the body
Deep: away from the surface of the body
External: located closer to the surface of the body
Internal: located away from the surface of the body
Ipsilateral: same side
Contralateral: opposite sides
Bilateral: both sides
Unilateral: one side
Supine: lying on spine or back
Prone: lying on belly or front



Posterior Body Regions



Head (cranial)

1. Upper lateral skull (parietal)
2. Base of skull (occipital)

Back

3. Neck (cervical)
4. Middle back (thoracic)
5. Loin (lumbar)
6. Tail bone (sacral)
7. Anal region (perineal)

Upper Limb

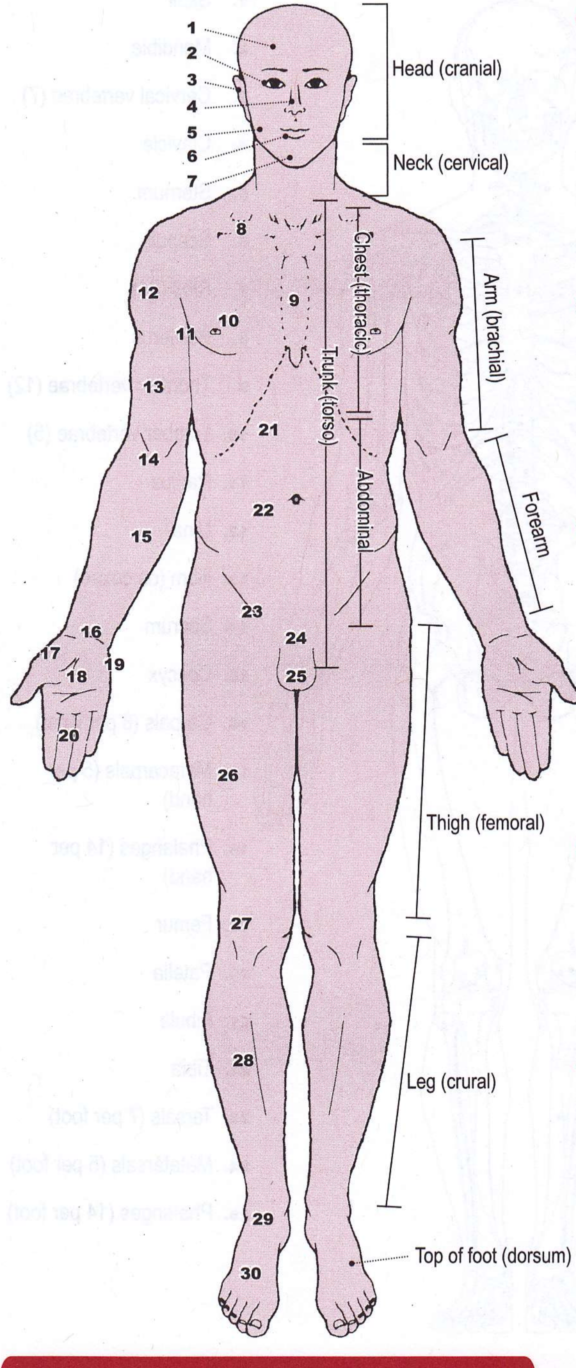
8. Shoulder (acromial)
9. Shoulder (deltoid)
10. Shoulder blade (scapular)
11. Arm (brachial)
12. Elbow (olecranon)**
13. Forearm (antebrachial)
14. Wrist (carpal)
15. Back of hand (dorsum)
16. Fingers (digits/phalanges)

Lower Limb

17. Buttock (gluteal)
18. Thigh (femoral)
19. Back of knee (popliteal)
20. Calf (sural)
21. Heel (calcaneal)
22. Sole of foot (plantar)

Clinical Tip
When dealing with the general public it is important to use common anatomical terms to ensure understanding

****The loose skin over the posterior elbow is known as the 'wenis' (funny but true ☺)**



Head (cranial)

1. Forehead (frontal)
2. Eye (orbital)
3. Ear (auricular)
4. Nose (nasal)
5. Cheek (buccal)
6. Mouth (oral)
7. Chin (mental)

Chest (thoracic)

8. Collar bone (clavicular)
9. Breast bone (sternal)
10. Breast (mammary)
11. Arm pit (axillary)
12. Shoulder (deltoid)

Upper Limb

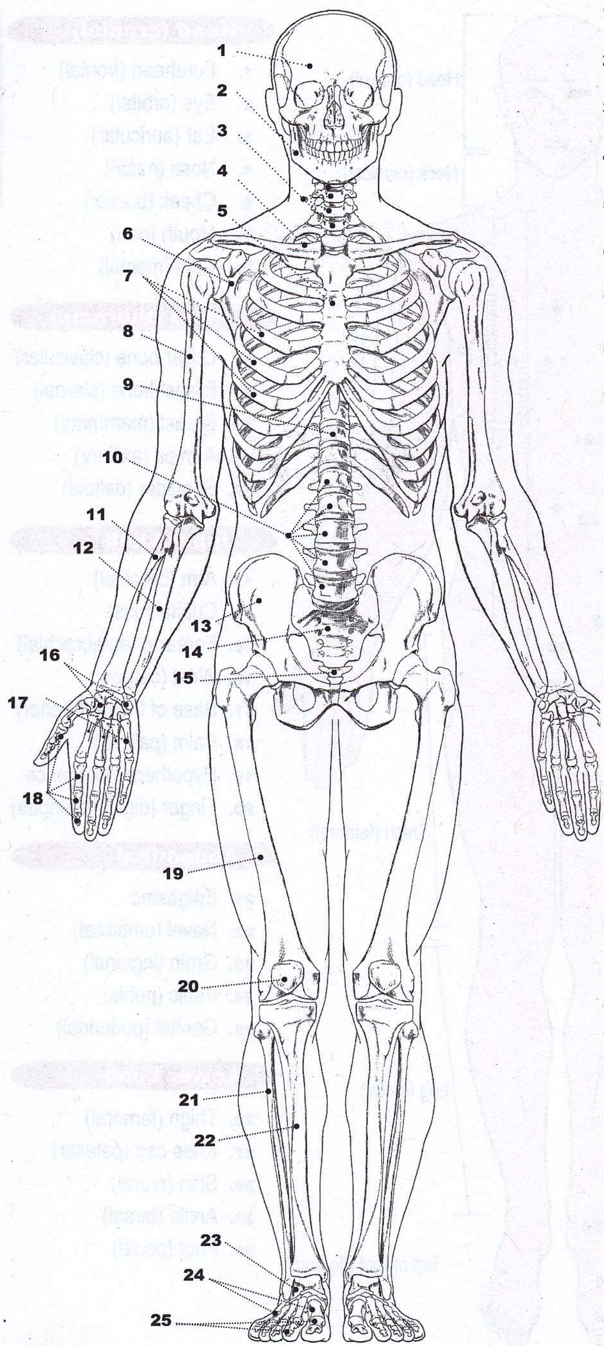
13. Arm (brachial)
14. Cubital fossa
15. Forearm (antebrachial)
16. Wrist (carpal)
17. Base of thumb (thenar)
18. Palm (palmar)
19. Hypothenar eminence
20. Finger (digit/phalanges)

Abdominal

21. Epigastric
22. Navel (umbilical)
23. Groin (inguinal)
24. Pubic (pubis)
25. Genital (pudendal)

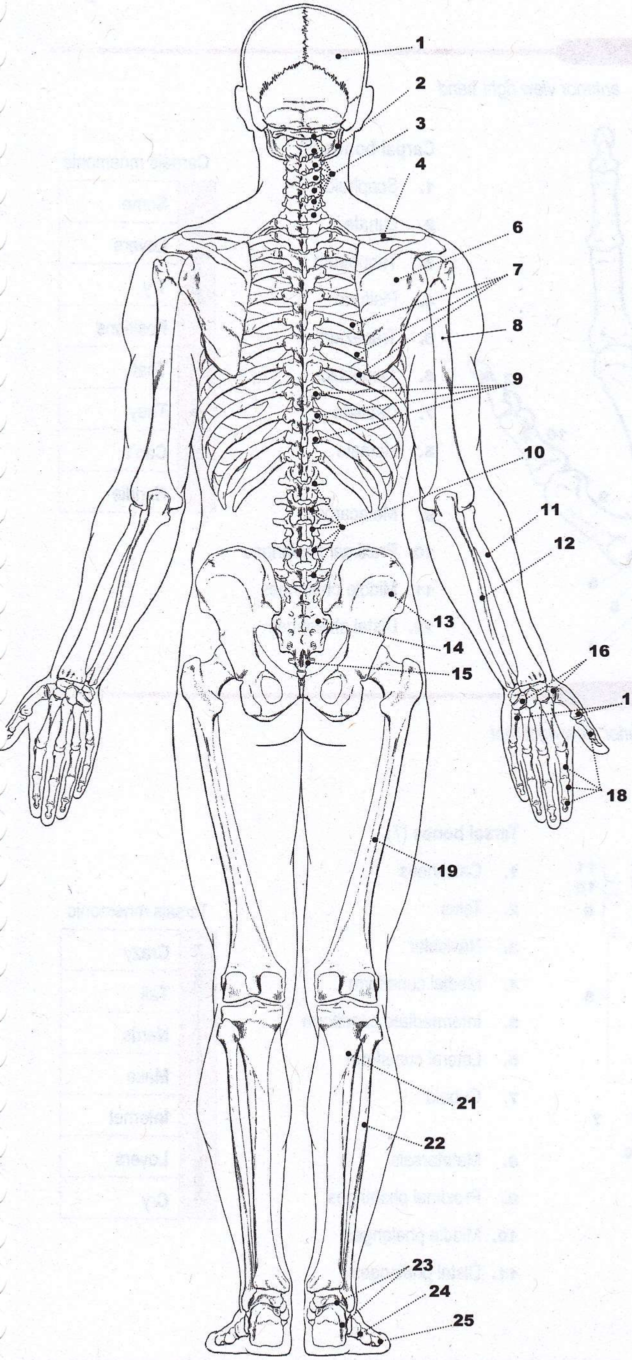
Lower Limb

26. Thigh (femoral)
27. Knee cap (patellar)
28. Shin (crural)
29. Ankle (tarsal)
30. Foot (pedal)



1. Skull
2. Mandible
3. Cervical vertebrae (7)
4. Clavicle
5. Sternum
6. Scapula
7. Ribs (24)
8. Humerus
9. Thoracic vertebrae (12)
10. Lumbar vertebrae (5)
11. Radius
12. Ulna
13. Ilium (os coxae)
14. Sacrum
15. Coccyx
16. Carpals (8 per wrist)
17. Metacarpals (5 per hand)
18. Phalanges (14 per hand)
19. Femur
20. Patella
21. Fibula
22. Tibia
23. Tarsals (7 per foot)
24. Metatarsals (5 per foot)
25. Phalanges (14 per foot)

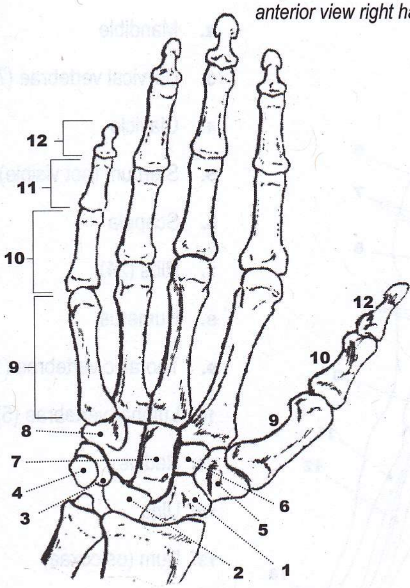
Skeleton Posterior



1. Skull
2. Mandible
3. Cervical vertebrae (7)
4. Clavicle
5. Sternum (not visible)
6. Scapula
7. Ribs (24)
8. Humerus
9. Thoracic vertebrae (12)
10. Lumbar vertebrae (5)
11. Radius
12. Ulna
13. Ilium (os coxae)
14. Sacrum
15. Coccyx
16. Carpals (8 per wrist)
17. Metacarpals (5 per hand)
18. Phalanges (14 per hand)
19. Femur
20. Patella
21. Tibia
22. Fibula
23. Tarsals (7 per foot)
24. Metatarsals (5 per foot)
25. Phalanges (14 per foot)

Bones of the Hand

anterior view right hand



Carpal bones (8)

1. Scaphoid
2. Lunate
3. Triquetrum
4. Pisiform
5. Trapezium
6. Trapezoid
7. Capitate
8. Hamate

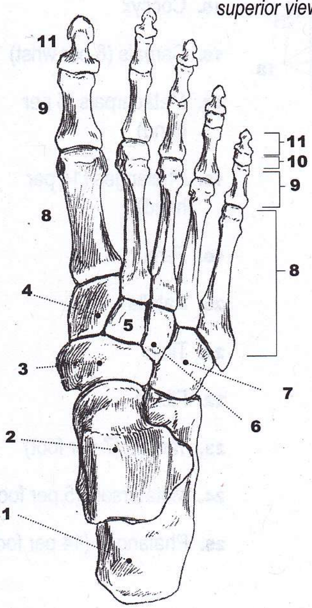
9. Metacarpals
10. Proximal phalanges
11. Middle phalanges
12. Distal phalanges

Carpals mnemonic

Proximal Row	**Some**
	Lovers
	Try
	Positions
Distal Row	**That**
	They
	Can't
	Handle

Bones of the Foot

superior view right foot



Tarsal bones (7)

1. Calcaneus
2. Talus
3. Navicular
4. Medial cuneiform
5. Intermediate cuneiform
6. Lateral cuneiform
7. Cuboid

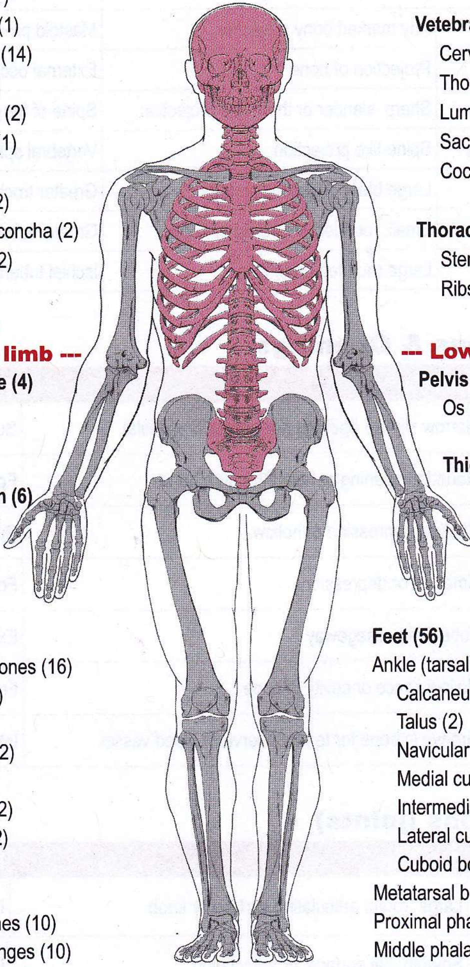
8. Metatarsals
9. Proximal phalanges
10. Middle phalanges
11. Distal phalanges

Tarsals mnemonic

anterior <------------ posterior	**Crazy**
	Tall
	Nerds
	Make
	Internet
	Lovers
	Cry

The axial skeleton consists of the bones in the head and trunk and it is composed of five parts: skull, ossicles of the middle ear, hyoid bone, vertebral column and the thoracic cage. The appendicular skeleton consists of the bones in the upper and lower extremities.

■ = Axial
■ = Appendicular



Axial Skeleton (80 bones)

Skull (22)
- Cranial Bones (8)
  - Parietal (2)
  - Temporal (2)
  - Frontal (1)
  - Occipital (1)
  - Ethmoid (1)
  - Sphenoid (1)
- Facial Bones (14)
  - Maxilla (2)
  - Zygomatic (2)
  - Mandible (1)
  - Nasal (2)
  - Palatine (2)
  - Inf. nasal concha (2)
  - Lacrimal (2)
  - Vomer (1)

Ear Ossicles (6)
- Malleus (2)
- Incus (2)
- Stapes (2)

Hyoid bone (1)

Vetebral Column (26)
- Cervical (7)
- Thoracic (12)
- Lumbar (5)
- Sacrum (1)
- Coccyx (1)

Thoracic cage (25)
- Sternum (1)
- Ribs (24)

Appendicular Skeleton (134 bones)

--- Upper limb ---

Shoulder girdle (4)
- Clavicle (2)
- Scapula (2)

Arm & Forearm (6)
- Humerus (2)
- Ulna (2)
- Radius (2)

Hands (58)
- Wrist (carpal) bones (16)
  - Scaphoid (2)
  - Lunate (2)
  - Triquetrum (2)
  - Pisiform (2)
  - Trapezium (2)
  - Trapezoid (2)
  - Capitate (2)
  - Hamate (2)
- Metacarpal bones (10)
- Proximal phalanges (10)
- Middle phalanges (8)
- Distal phalanges (10)
- Sesamoid bones (4)

--- Lower limb ---

Pelvis (2)
- Os coxae (ilium) (2)

Thigh & Leg (8)
- Femur (2)
- Patella (2)
- Tibia (2)
- Fibula (2)

Feet (56)
- Ankle (tarsal) bones (14)
  - Calcaneus (2)
  - Talus (2)
  - Navicular bone (2)
  - Medial cuneiform bone (2)
  - Intermediate cuneiform (2)
  - Lateral cuneiform (2)
  - Cuboid bone (2)
- Metatarsal bone (10)
- Proximal phalanges (10)
- Middle phalanges (8)
- Distal phalanges (10)
- Sesamoid bones (4)

Non-articulating prominences

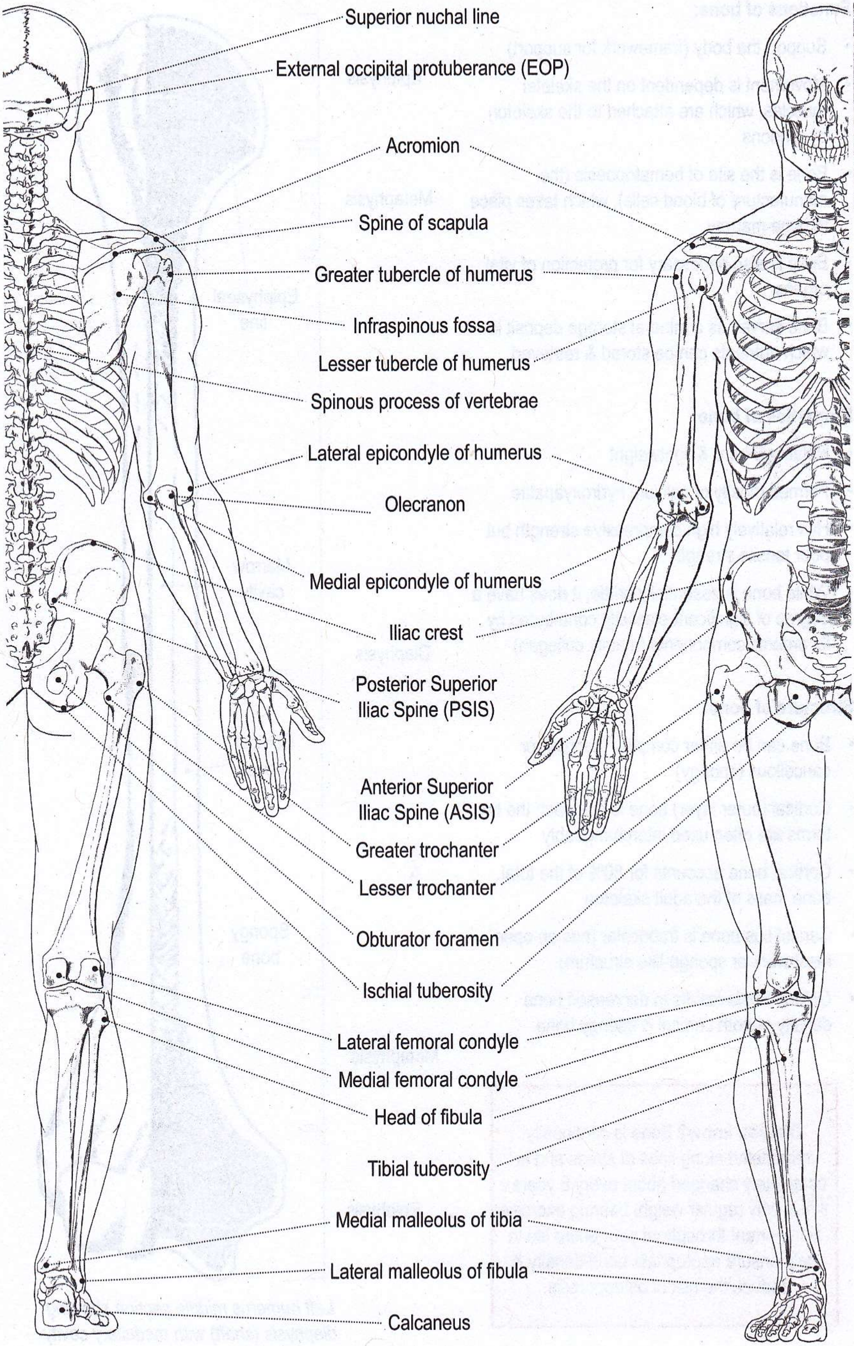
Name	Definition	Example
Crest	Narrow ridge-like prominence	Iliac crest
Epicondyle	Projection above a condyle	Medial femoral epicondyle
Line	Long linear elevation	Soleal line of tibia
Malleolus	Rounded process at the end of bone	Lateral malleolus
Notch	Indentation at the edge of bone	Mandibular notch
Process	Any marked bony projection	Mastoid process
Protuberance	Projection of bone	External occipital protuberance (EOP)
Spine	Sharp, slender or thorn-like projection	Spine of the scapula
Spinous process	Spine-like projection	Vertebral spinous process
Trochanter	Large blunt projection on femur	Greater trochanter of femur
Tubercle	Small, rounded projection or knob	Greater tubercle of humerus
Tuberosity	Large rounded projection	Ischial tuberosity

Depressions & Openings

Name	Definition	Example
Fissure	Narrow slit-like opening (for nerves & vessels)	Superior orbital fissure
Foramen	Rounded opening or hole through a bone	Foramen magnum
Fossa	Shallow depression or hollow	Supraspinatus fossa
Fovea	Small pit or depression	Fovea capitis of femur
Meatus	Tube-like passageway	External auditory meatus
Sinus	Hollow space or cavity in bone	Frontal sinus
Sulcus	Groove in bone for tendon, nerve or blood vessel	Intertubercular sulcus

Articulations (joints)

Name	Definition	Example
Condyle	Large, round articulating surface or knob	Lateral femoral condyle
Facet	Smooth, flat surface for articulation	Inferior articular facet
Head	Rounded articulation at the end of a bone	Femoral head


Superior nuchal line
External occipital protuberance (EOP)
Acromion
Spine of scapula
Greater tubercle of humerus
Infraspinous fossa
Lesser tubercle of humerus
Spinous process of vertebrae
Lateral epicondyle of humerus
Olecranon
Medial epicondyle of humerus
Iliac crest
Posterior Superior Iliac Spine (PSIS)
Anterior Superior Iliac Spine (ASIS)
Greater trochanter
Lesser trochanter
Obturator foramen
Ischial tuberosity
Lateral femoral condyle
Medial femoral condyle
Head of fibula
Tibial tuberosity
Medial malleolus of tibia
Lateral malleolus of fibula
Calcaneus

Functions of bone:

- Support the body (framework for support)
- Movement is dependent on the skeletal muscles, which are attached to the skeleton by tendons
- Bone is the site of hematopoesis (the manufacture of blood cells), which takes place in bone marrow
- Bone is also necessary for protection of vital organs
- Bone serves as a mineral storage deposit in which nutrients can be stored & retrieved

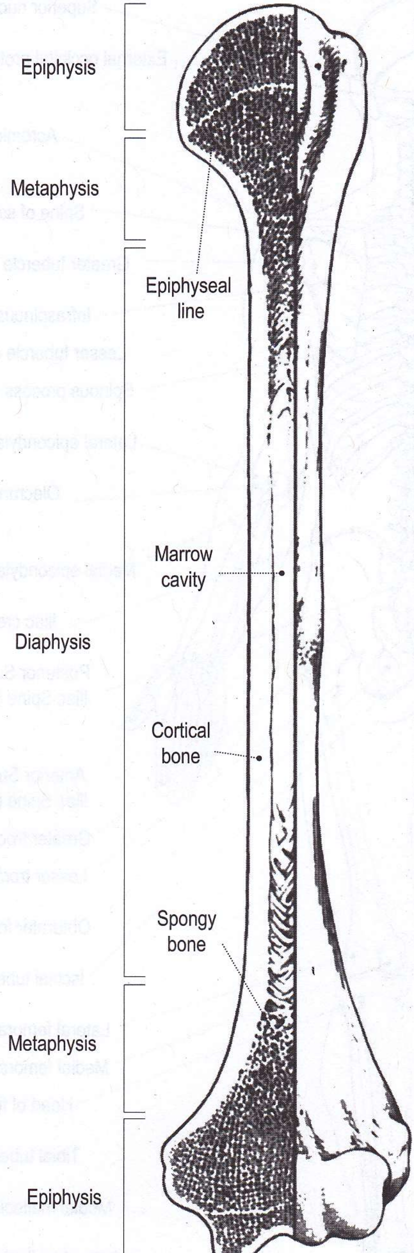
Properties of bone:

- Relatively hard & lightweight
- Formed mostly of calcium hydroxyapatite
- Has relatively high compressive strength but poor tensile strength
- While bone is essentially brittle, it does have a degree of significant elasticity contributed by its organic components (mainly collagen)

Structure of bone:

- Bone can be either compact (cortical) or cancellous (spongy)
- Cortical (outer layer) bone is compact; the two terms are often used interchangeably
- Cortical bone accounts for 80% of the total bone mass of the adult skeleton
- Cancellous bone is trabecular (has an open, meshwork or sponge-like structure).
- *Osteoporosis* results in decreased bone density of both cortical & spongy bone

Did you know? Bone is continually remodeled along lines of stress and is completely changed about every 8 years - this is why regular weight bearing exercise is important throughout your entire life to help ensure appropriate bone density & reduce the risk of osteoporosis.



Left humerus middle section showing diaphysis (shaft) with medullary cavity

Bone Classification

There are approximately 214 bones in the adult human skeleton; the skeleton of an infant contains 350 bones that fuse together as they grow. The number of bones in the adult skeleton can vary slightly from individual to individual. Anatomical variation may result in extra bones, most commonly noted in the skull (sutural bones), the vertebrae (extra lumbar vertebrae), ribs (cervical & lumbar ribs) and sesamoid bones.

The longest and heaviest bone in the body is the *femur* and the smallest is the *stapes* bone in the middle ear. In an adult, the skeleton comprises around 20% of the total body weight.

Types of Bones

Long Bones: found in extremities, and consist of a body or shaft. The body (diaphysis) is cylindrical, with a central cavity (medullary canal). Long bones are not straight, but curved, which provides greater strength to the bone. Long bones include: *the clavicle, humerus, radius, ulna, femur, tibia, fibula, metacarpals, metatarsals, and phalanges.*

Short Bones: found mainly in the wrist & ankle, are somewhat cube-shaped bones. Short bones include most of the *carpals & tarsals*

Flat Bones: expand into broad, flat plates, as in the skull and the scapula. These bones are composed of two thin layers of compact tissue enclosing between them a variable quantity of cancellous tissue. The flat bones are: *the occipital, parietal, frontal, nasal, lacrimal, vomer, scapula, ilium (os coxae), sternum, & ribs.*

Irregular Bones: have complex shapes & cannot fall into any of the other classifications of bone. The irregular bones are: *the vertebrae, sacrum, coccyx, temporal, sphenoid, ethmoid, zygomatic, maxilla, mandible, palatine, inferior nasal concha, hyoid & calcaneus.*

Sesamoid Bones: free floating bones that develop in certain tendons where there is increased friction around a joint. Sesamoid bones include: *the patella & the sesamoid bones of the foot & hand.*

Gender Differences

Structure	Male skeleton	Female skeleton
General	Slightly thicker and longer limbs & digit bones	Narrower rib cage Smaller teeth & less angular mandible Less pronounced cranial features such as the brow ridges
Pelvis*		
Overall	narrow and thick	wide and shallow
Pelvic inlet	heart-shaped	circular shaped
Pelvic outlet	relatively small	relatively large
Pubic arch	< 60 degrees	> 80 degrees
Obturator foramen	round	oval
Acetabulum	large	small
Wing of ilium	less flared	more flared

***see page 250 for images of male & female pelvis**

Without a joint cavity - Fibrous joints*

	Type	Definition (example)
Synarthrosis (immovable)	Suture**	Two bones grow together, with only a thin layer of fibrous periosteum between (sutures of the skull)
	Cartilagenous (synchondrosis)	Temporary joint with cartilage that is later converted to bone (between diaphysis & epiphysis of long bones)
	Gomphosis	Cone shaped peg fits firmly into a socket (root of the teeth into the mandible & maxilla)
Amphiarthrosis (slightly moveable)	Syndesmosis	Slight motion permitted by meager elasticity of ligaments between two bones (coracoclavicular joint, mid radioulnar joint, mid tibiofibular joint, inferior tibiofibular joint)
	Fibrocartilaginous (symphysis)	Bones are separated by a fibrocartilaginous disc, whose fibers join the bones. Motion is only allowed by deformation of the disc (between bodies of vertebrae, symphysis pubis)

*Joints without a cavity (fiberous joints) do not contain synovial fluid

** some classifications systems include both sutures and syndesmosis under the heading of fibrous joints. Sutures and some amphiarthroses tend to ossify completely later in life, in which case the union is known as a synostosis

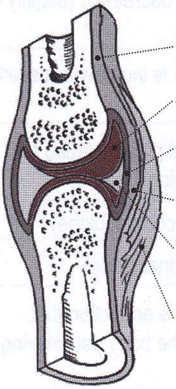
With a Joint Cavity - Synovial joints

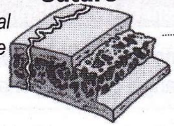
	Type (technical name)	Definition (examples)
Diarthrosis (moveable)	**Gliding** (plane joint)	**Uni-axial**. Allows gliding or twisting (intercarpal/intertarsal joints, vertebrae zygapophyseal joint)
	Hinge joint (ginglymus)	**Uni-axial.** a concave surface glides around a convex surface allowing flexion and extension (elbow joint - humeroulnar joint)
	Pivot joint (trochoid)	**Uni-axial.** Rotation around a vertical or long axis is allowed (atlantoaxial joint, proximal radioulnar joint)
	Condyloid (ellipsoid)	**Bi-axial.** Condyle or ovoid articular surface with an elliptical cavity to permit flexion, extension, adduction, abduction and circumduction, but no axial rotation (wrist, 2nd to 5th metacarpophalangeal joints)
	Saddle joint	**Bi-axial.** Both joints have saddle-shaped surfaces (reciprocally concave-convex) fitted into each other. Allows flexion, extension, abduction, adduction, circumduction (carpometacarpal joint of thumb)
	Ball & socket (spheroid)	**Poly-axial.** Spheroid ball and sockets allows flexion, extension, abduction, adduction, true circumduction, and rotation on long axis (shoulder and hip joints)

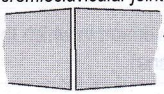
Capsular Pattern
When inflammation of a joint is present (known as synovitis or capsulitis), not only does passive stretching of the capsule cause pain, but limitation of motion is often found to be in a consistent, specific pattern for that joint (the 'capsular pattern').

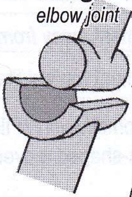
A joint is the location at which two bones make contact. Joints are constructed to allow movement and provide mechanical support.

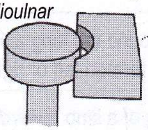
Generic Synovial Joint

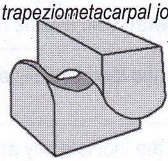


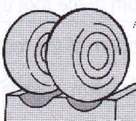


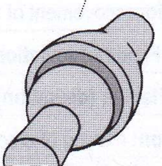


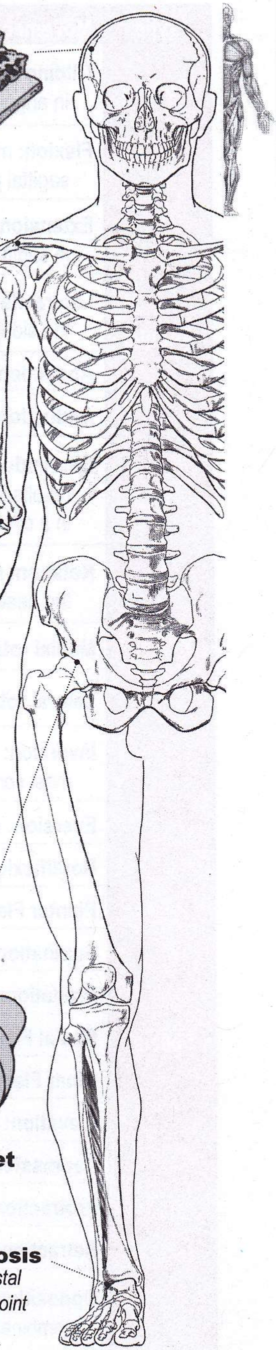












Synovial Fluid

Synovial fluid is a thick (egg-like consistency), stringy liquid found in the cavities of synovial joints.

Functions of synovial fluid:

1. Nutrient exchange for cartilage
2. Reduces friction (lubrication)
3. Shock absorption during movement

The synovial membrane secretes synovial fluid into the joint cavity.

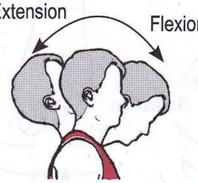
During normal movements, the synovial fluid held within the cartilage is squeezed out mechanically (weeping lubrication) to maintain a layer of fluid on the cartilage surface & circulate nutrients

Regular motion and activity are crucial to ensure optimal joint health

Type	Movement & definition (all movements are defined from anatomical position)
Gliding	**Gliding:** flat surface movements side to side, back & forth with little or no change in angel between bones (e.g. ulnar flexion)
Angular	**Flexion:** movement in which the angle between two bones is decreased (usually in sagittal plane)
	Extension: movement in which the angle between two bones is increased (usually in sagittal plane)
	Lateral flexion: movement of the spine or head in the coronal plane, named for the side of movement (also called side bending or side flexion)
	Abduction: movement *away from the midline* of the body (in coronal plane)
	Adduction: movement *toward the midline* of the body (in coronal plane)
	Circumduction: combination of flexion, abduction, extension & adduction that results in a cone-shaped movement with the distal end of the body part moving in a circle
Rotation	**Rotation:** movement around the long axis of a bone or the spine. Movements of the head & spine are termed left or right rotation.
	Medial rotation: turning of a limb *toward* midline (also called *internal rotation*)
	Lateral rotation: turning of a limb *away* from midline (also called *external rotation*)
Special	**Inversion:** movement of the sole of the foot medially at the ankle (how ankles are most commonly sprained)
	Eversion: movement of the sole of the foot laterally at the ankle joint
	Dorsiflexion: moving the dorsum of the foot upward
	Plantar Flexion: moving the bottom of the foot to the floor
	Supination: movement of the forearm in which the palm is turned upwards
	Pronation: movement of the forearm in which the palm is turned downward
	Radial Flexion (deviation): abduction of the wrist away from the midline
	Ulnar Flexion (deviation): adduction of the wrist toward the midline
	Elevation: moving of a body part superiorly
	Depression: moving a body part inferiorly
	Protraction: movement forward in a plane parallel to the ground
	Retraction: movement backward in a plane parallel to the ground
	Opposition: movement of thumb across hand to touch fingertips (opposition is a combination of flexion, adduction & internal rotation)

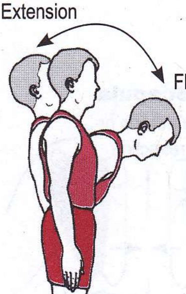
Trunk	Upper Limb	Lower Limb

Neck

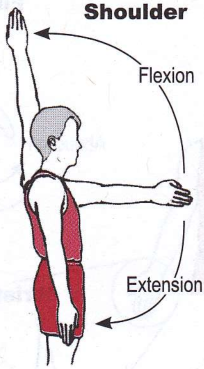


Hyperextension is greater than normal extension of the neck as may occur in whiplash

Trunk

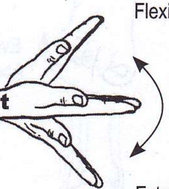


Shoulder

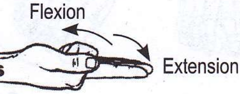


Elbow

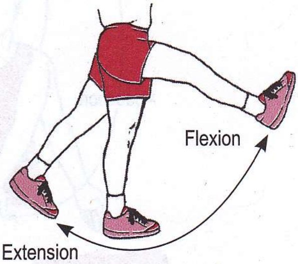
Wrist



Fingers

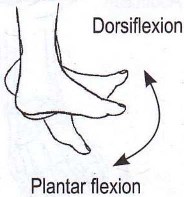


Hip

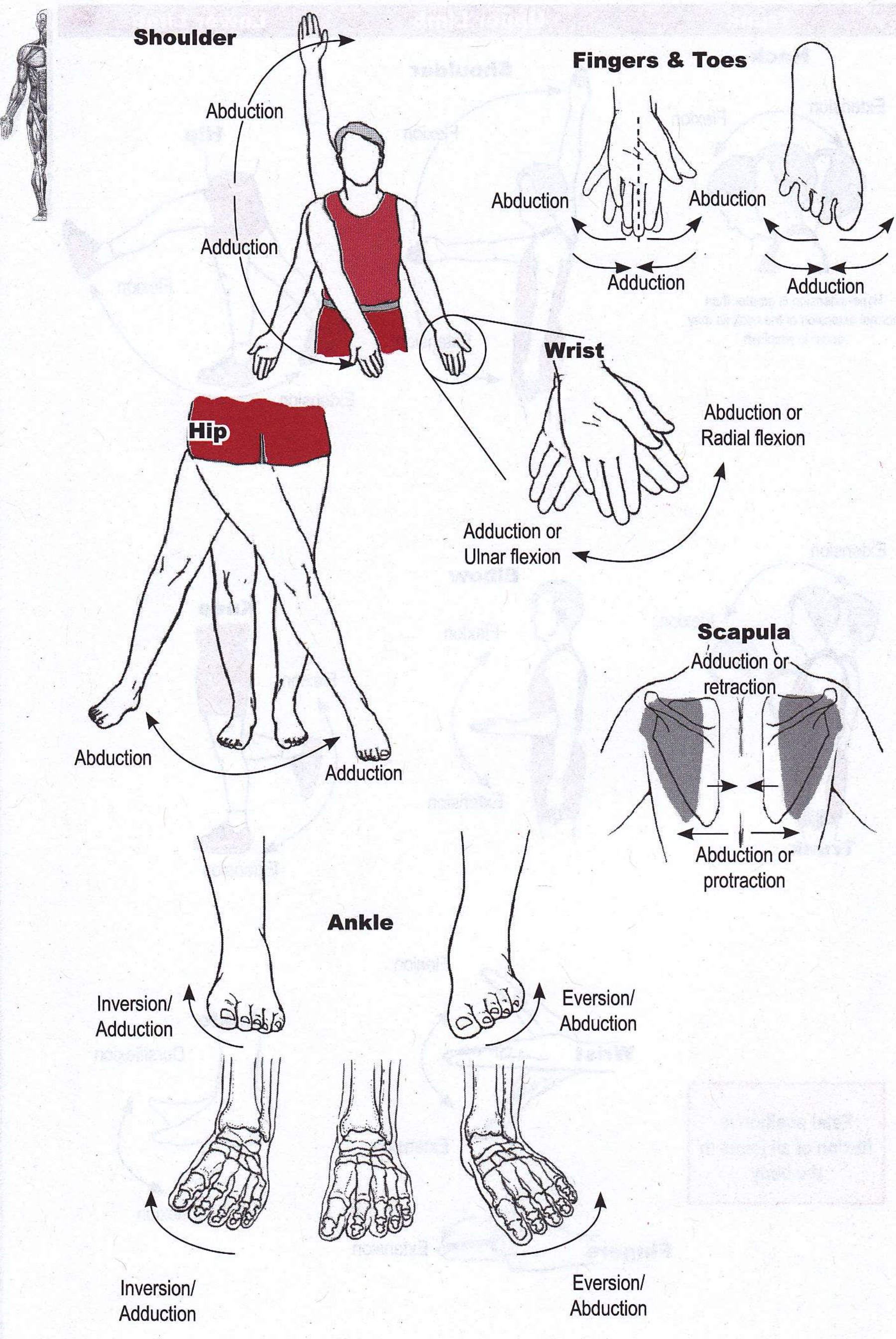


Knee

Ankle



Fetal position is flexion of all joints in the body


Shoulder
Abduction
Adduction
Fingers & Toes
Abduction
Abduction
Adduction
Adduction
Wrist
Abduction or
Radial flexion
Adduction or
Ulnar flexion
Hip
Abduction
Adduction
Scapula
Adduction or
retraction
Abduction or
protraction
Ankle
Inversion/
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Eversion/
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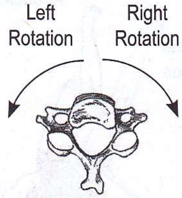
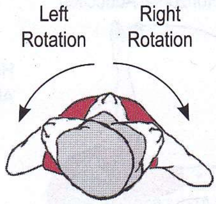
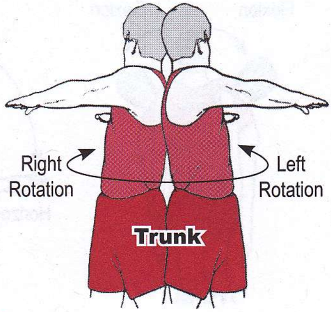
Adduction
Eversion/
Abduction



Vertebra

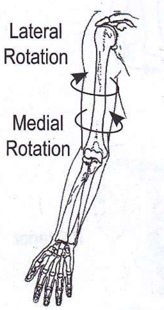


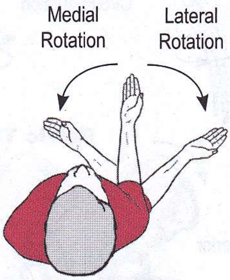
Neck



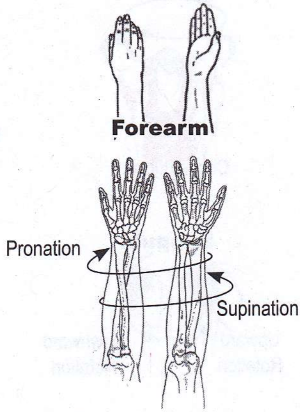
Lateral rotation = external rotation
Medial rotation = internal rotation

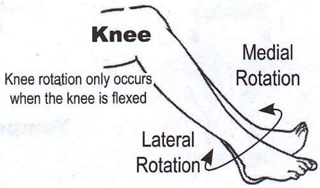
Shoulder



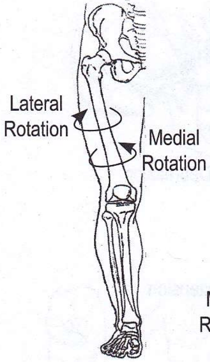


Shoulder

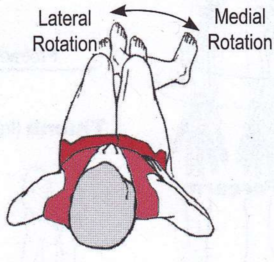




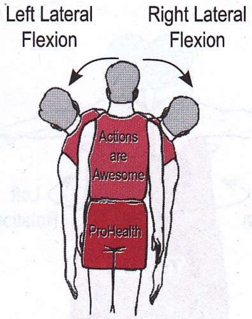
Hip



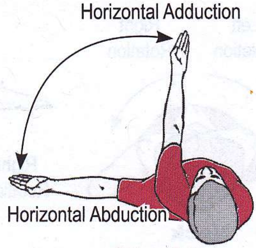
Hip



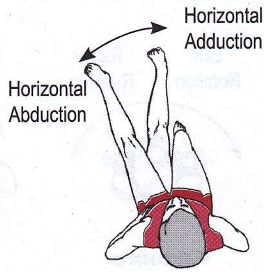
Horizontal adduction/abduction are sometimes named horizontal flexion/extension



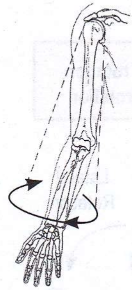
Trunk



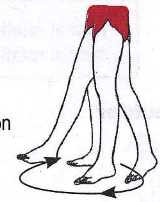
Shoulder



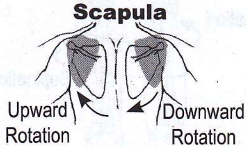
Hip



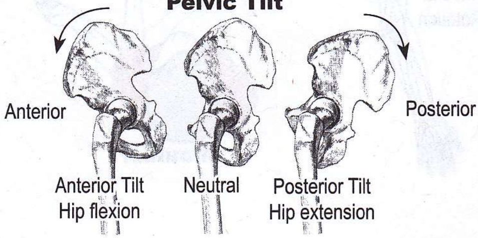
Circumduction

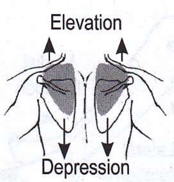


Scapula

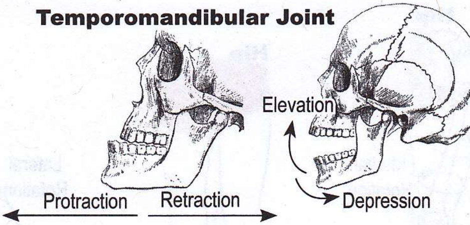


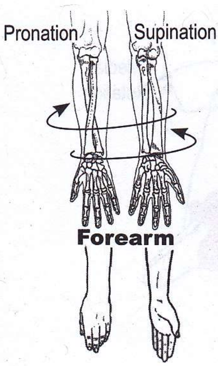
Pelvic Tilt





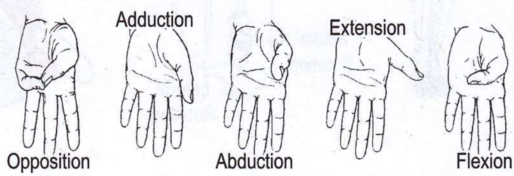
Temporomandibular Joint





Forearm

Thumb (trapeziometacarpal joint)

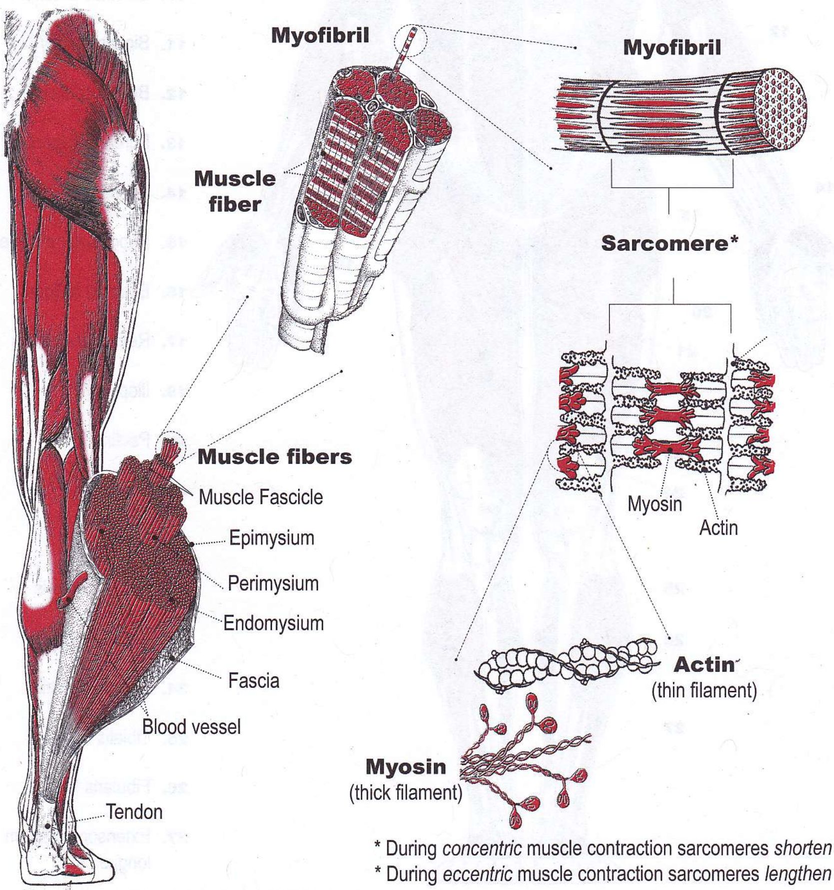


Definition: (Latin *musculus* "little mouse") muscle is contractile tissue of the body. Its function is to produce force and cause motion, either locomotion or movement within internal organs; three types of muscle:

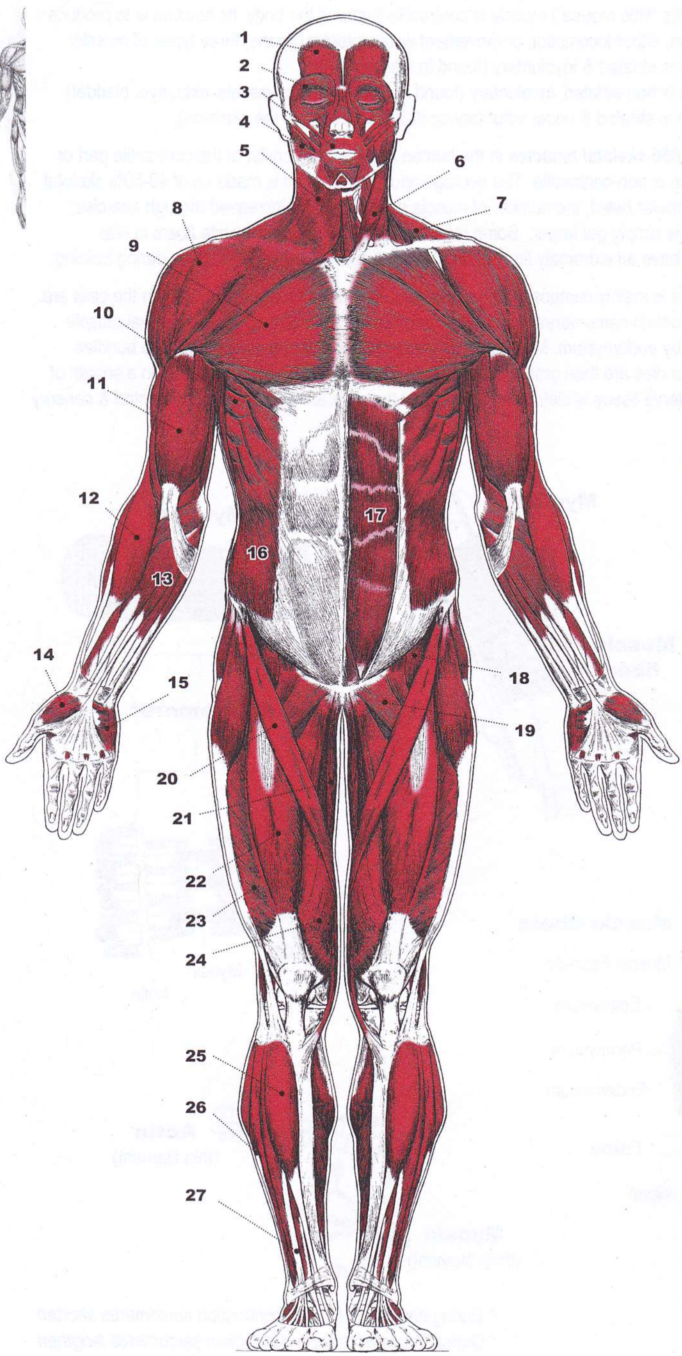
1. Cardiac muscle is striated & involuntary (found in the heart)
2. Smooth muscle is non-striated, involuntary (found in GI tract, blood vessels, skin, eye, bladder)
3. Skeletal muscle is striated & under voluntary control (found around the skeleton)

There are approximately ***650 skeletal muscles*** in the human body, which consist of the contractile part or 'belly' & a tendon which is non-contractile. The average adult body weight is made up of 40-50% skeletal muscle. Contrary to popular belief, the number of muscle cells cannot be increased through exercise; instead the muscle cells simply get larger. Some recent studies have shown muscle fibers in elite Olympic athletes may have an extremely limited capacity for growth through cell division during training.

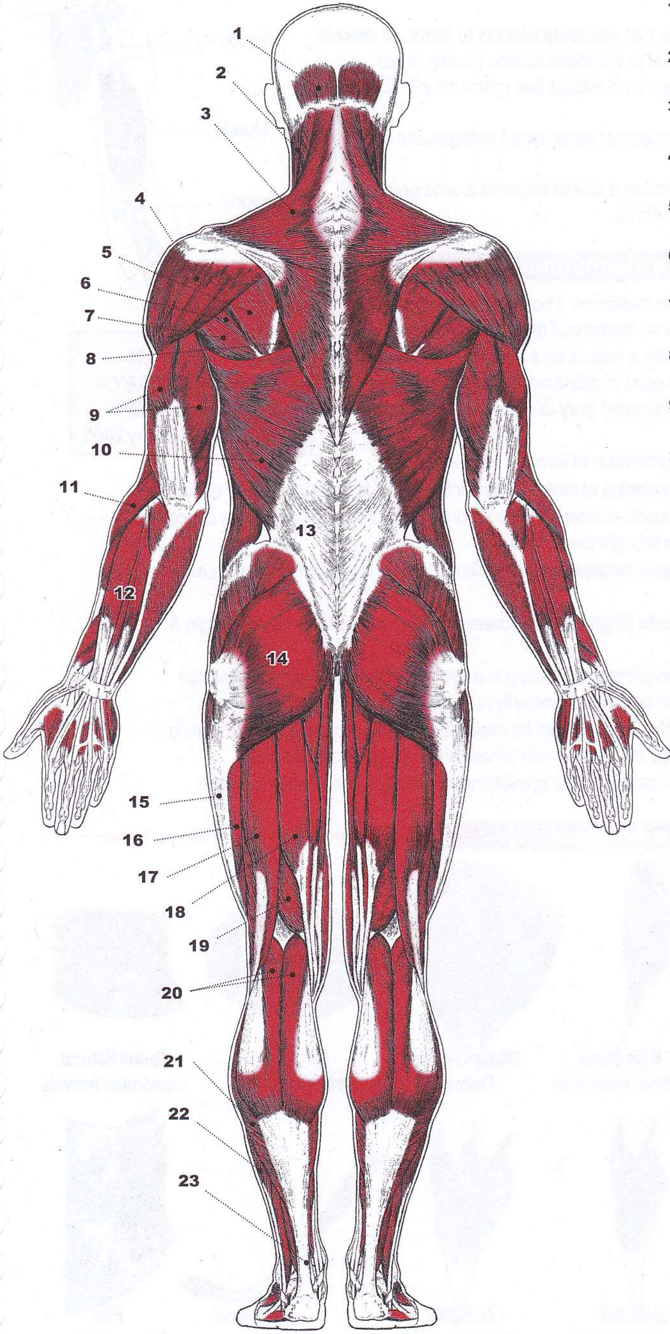
Anatomy: skeletal muscle is mainly composed of muscle cells, known as *muscle fibers*. Within the cells are *myofibrils*; myofibrils contain *sarcomeres*, which are composed of *actin* and *myosin*. Individual muscle fibers are surrounded by *endomysium*. Muscle fibers are bound together by *perimysium* into bundles called *fascicles*; the bundles are then grouped together to form muscle, which is enclosed in a sheath of *epimysium (Fascia)*. Nerve tissue is distributed throughout the muscles to provide motor control & sensory feedback.



* During *concentric* muscle contraction sarcomeres *shorten*
* During *eccentric* muscle contraction sarcomeres *lengthen*



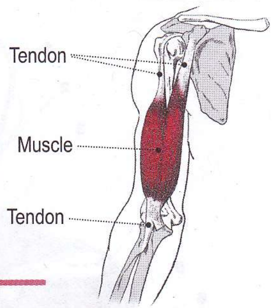
1. Frontalis
2. Orbicularis oculi
3. Orbicularis oris
4. Masseter
5. Platysma
6. Sternocleidomastoid
7. Trapezius
8. Deltoid
9. Pectoralis major
10. Serratus anterior
11. Biceps brachii
12. Brachioradialis
13. Forearm flexors
14. Thenar muscles
15. Hypothenar muscles
16. External oblique
17. Rectus abdominis
18. Iliopsoas
19. Pectineus
20. Sartorius
21. Gracilis
22. Rectus femoris
23. Vastus lateralis
24. Vastus medialis
25. Tibialis anterior
26. Fibularis longus
27. Extensor digitorum longus



1. Occipitalis
2. Sternocleidomastoid
3. Trapezius
4. Deltoid
5. Infraspinatus
6. Teres minor
7. Teres major
8. Rhomboids
9. Triceps brachii
10. Latissimus dorsi
11. Extensor carpi radialis longus
12. Forearm extensors
13. Thoracolumbar fascia
14. Gluteus maximus
15. Iliotibial band
16. Vastus lateralis
17. Biceps femoris
18. Semitendinosus
19. Semimembranosus
20. Gastrocnemius
21. Soleus
22. Fibularis longus
23. Calcaneal (Achilles) tendon

Tendon:

- Fibrous connective tissue that **connects muscle to bone, or muscle to muscle** and is designed to withstand tension (pulling force)
- Tendons are similar to ligaments except that ligaments join bone to bone
- Tendons are composed mainly of water, type-I collagen and specialized fibroblasts (tenocytes)
- Most of the strength of tendon is due to the vertical arrangement of densely-packed collagen fibrils.



Common Muscle Terminology

Origin: attachment point of a muscle on a bone; usually more proximal/medial, or more fixed attachment (denoted **red** on anatomical drawings & models)

Insertion: attachment point for a muscle on a bone; usually more distal/lateral, or movable point of attachment on which the force of the muscle is applied (denoted **grey** or **blue** on anatomical drawings & models)

> Origins are **RED,**
> Insertions are **GREY.**
> Anatomy is FUN,
> Because I use it every DAY!

Contraction: refers to the generation of force by muscle fibers

Contracture: permanent shortening of muscle, ligament or fascia from lack of use or stretching

Concentric contraction: muscle shortening contraction (muscle actions are given as concentric contractions). Insertion is brought closer to origin

Eccentric contraction: muscle lengthening contraction. Origin and insertion are taken away from each other

Isometric contraction: muscle length stays the same, when tension is developed. Origin & insertion do not move

Agonist: muscle that creates primary movement in a joint by contracting. Agonists are also known as '***prime movers***' as they are primarily responsible for generating movement

Synergist: aids the action of a 'prime mover' by assisting the same movement or preventing undesirable movements by stabilizing joints across which the prime mover acts

Antagonist: muscle acts in opposition the agonist and returns a limb to its initial position

Common Muscle Shapes

Unipennate
Palmar interossei

Bipennate
Dorsal interossei

Multipennate
Deltoid

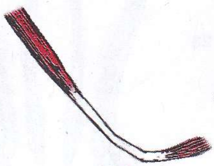
Circular
Orbicularis oris

Quadrilateral
Quadratus femoris

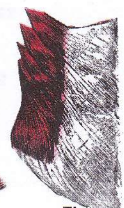
Fusiform
Extensor ulnaris

Bicipital
Biceps brachii

Tricipital
Triceps brachii

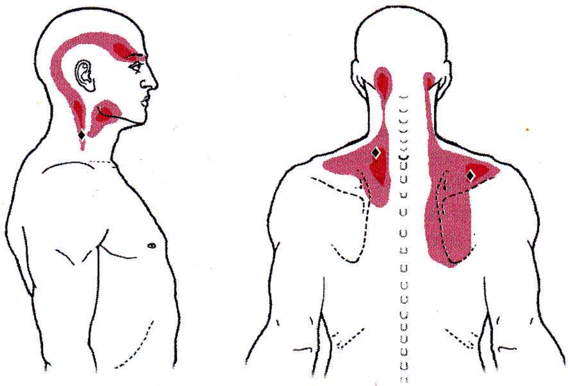


Digastric
Digastric muscle



Flat
External oblique

Definition: a myofascial trigger point (MFTP) or 'trigger point' is a discrete, focal, hyperirritable "knots" located in a tight band of skeletal muscle or fascia; the "knots" are painful on compression & can produce referred pain, referred tenderness, motor dysfunction & autonomic changes. A trigger point in the lower neck, for example, might cause a headache.



Upper trapezius MFTP referral
The MFTP location is denoted by a '♦'
Darker color signifies more intense pain referral.

MFTP Theories:

Initial trauma: muscular over activity causes a prolonged release of Ca^{+2} ions, resulting in myospasm or a small 'cramp' of the untrained or overloaded cells. This leads to a compression of capillaries and results in an increased local energy demand and local ischemia (loss of blood circulation) to the area; as local blood flow decreases there is a build up metabolic by-products causing pain. Since an involved muscle is weakened by this theorized sustained shortening, surrounding muscles themselves may develop trigger points in a compensatory manner.

Sympathetic spindle theory: short muscle fibers (muscle spindles), about 1 cm in length, called *intrafusal muscle fibers* are over-stimulated (*extrafusal fibers* are regular contractile muscle cells). Only the intrafusal muscle fibers inside the spindle are activated by adrenalin via the sympathetic nervous system. When spindles are over-activated by adrenalin they become painful. This theory may support the idea that increased stress and decrease of moderate physical activity in modern lives have increased the occurrence of myofascial pain and trigger points.

Diagnostic criteria: presence of a taut band, spot tenderness, referred pain distant from the stimulation point, reproduction of the patient's symptoms & possible local twitch response

Classification: active or latent (depending on their clinical characteristics)

Active trigger point: painful at rest, tender upon palpation with a referred pain pattern that is similar to the patient's pain complaint; the pain is often described as 'radiating' (referred pain is an important characteristic of a trigger point - it differentiates a *trigger point* from a *tender point*, which is associated with pain at the site of palpation only)

Latent trigger point: does not cause spontaneous pain; may restrict movement or cause muscle weakness; the patient presents with muscle restrictions or weakness & may become aware of a latent trigger point only when pressure is applied directly over the point

Etiology: acute trauma or repetitive microtrauma can cause the development of a trigger point. Other causes include: lack of exercise, prolonged poor posture, vitamin deficiencies, sleep disturbances, joint problems, repetitive stress disorders, poor biomechanics, surgical scars & tissues under tension frequently found after spinal surgery & hip replacement

Clinical presentation: patients often report regional, persistent pain that usually results in a decreased range of motion of the muscle in question. The pain is reproducible & does not follow a dermatomal or nerve root distribution. Patients report few systemic symptoms such as joint swelling; neurologic deficits are generally absent on physical examination.

Muscle Strength

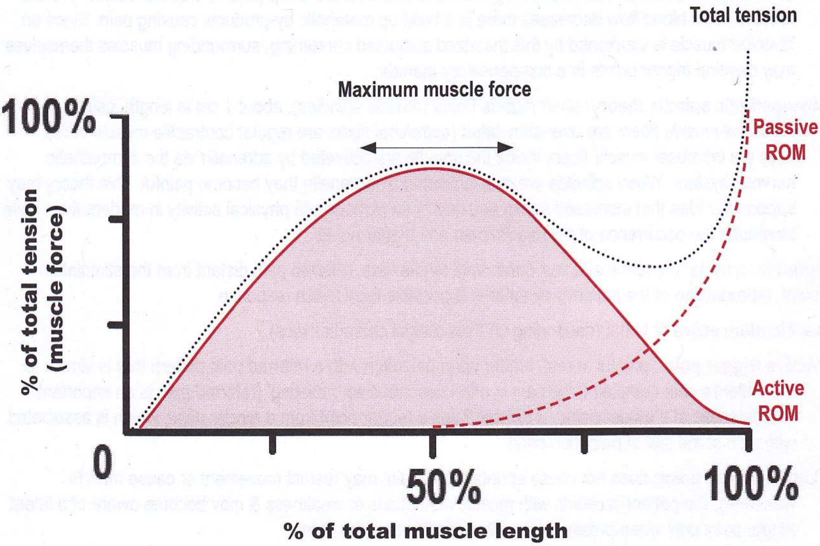
Strength of muscle contraction is determined by 3 factors

1. **Physiological strength** (muscle size, cross sectional area, available cross-bridging, training)
2. **Neurological strength** (how strong or weak is the signal telling the muscle to contract)
3. **Mechanical strength** (muscle's force angle on the lever, movement arm length, joint capabilities)

Because these three factors exist simultaneously, and muscles never work individually, it is unrealistic to believe that one could accurately compare strength in individual muscles, and crown one "strongest". Some muscles that are classically considered the strongest in the body include:

- **Masseter** - according to Guinness Book of Records (2008) - however, masseter has the advantage of working against a short lever arm & two masseters work with synergists temporalis, medial pterygoid attaching to one bone (the mandible) to develop force
- **Gluteus maximus or quadriceps** - largest cross-sectional area at their bellies
- **Latissimus dorsi** - able to lift the weight of the entire body
- **Uterus** - may be the strongest muscle by weight in the human body; during childbirth, the uterus exerts 100 to 400 N (25 to 100 lbf) of downward force with each contraction
- **Tongue** - possibly the 'strongest' muscle at birth but otherwise totally untrue
- **Heart** - performs the largest quantity of physical work in the course of a lifetime and does "outwork" other muscles, giving you about 2.5 billion beats in a life time

Muscle Strength vs Length



Muscle Strength Facts

- Muscles have their maximum strength in the mid-range of their active ROM
- As tissues begin to passively lengthen tension increases, this is felt as a muscle stretch
- Movements beyond normal anatomical limits result in fiber tears at the weakest point (a muscle strain, a ligament sprain or a bone avulsion fracture)

An accurate & objective measurement of muscle strength is useful for many reasons:

- **Neurologic screen** - assessment of muscle strength also assesses motor nerve function
- **Diagnostic aid** - helps clinician identify specific muscles that are weak or damaged
- **Therapeutic aid** - creates an objective measure of progress through a treatment plan & allows the patient to witness the effect & necessity of treatment

Manual Muscle Testing

Static Manual Muscle Tests (MMT) or 'Break Tests' are isometric contraction tests for specific muscles; they are easier to quantify & much more efficient to perform than functional muscle testing (see below)

- Patient is positioned in optimum posture (attempt to eliminate action of other synergistic muscles)
- **Clinician states "*Don't let me move you from this position*" & demonstrates motion to be resisted**
- Ask patient to hold position & relax when test is done ("hold, hold, hold, & relax")
  - Typically patient holds position for 3-5 seconds
  - If there is a high index of suspicion of muscle damage or neurologic compromise
    - Hold for 5-10 seconds or,
    - Repeat for up to 10 repetitions (e.g. chart as 3/5 at 8x) or,
    - Test at multiple angles through ROM, and through eccentric, concentric, isometric contractions
- Joint should only be moved ~5° or through ~5% of range of motion at most - little or no motion is better
  - Common error is to move joint too much, thereby testing many different muscles & joint capsule
  - Consider testing in positions or actions that cause patient mild discomfort to help get a true sense of specific limitations & actual muscle damage
  - Compare results bilaterally & keep in mind dominant vs. non-dominant extremity
- Examiner must remember to use good ergonomics & biomechanics

Muscle Testing Scale

Grade		%	Definition
5	Normal	100%	Patient can maintain position against gravity & against *full* examiner-applied resistance
4	Good*	75%	Patient can maintain position against gravity & against *minimal* examiner-applied resistance
3	Fair*	50%	Movement against gravity but not against examiner's resistance
2	Poor*	25%	Movement possible, not against gravity
1	Trace	~5%	Evidence of slight contractility; *little* or *no joint motion*
0	Zero	0%	No palpable or perceivable evidence of contractility (*flaccid*)

% = % normal strength, ROM = range of motion, *Pain, muscle spasm or contracture may limit strength or ROM
Chart as a rating out of 5; e.g.; 5/5, 4/5, 3/5, 2/5, 1/5, 0/5

Functional Muscle Testing

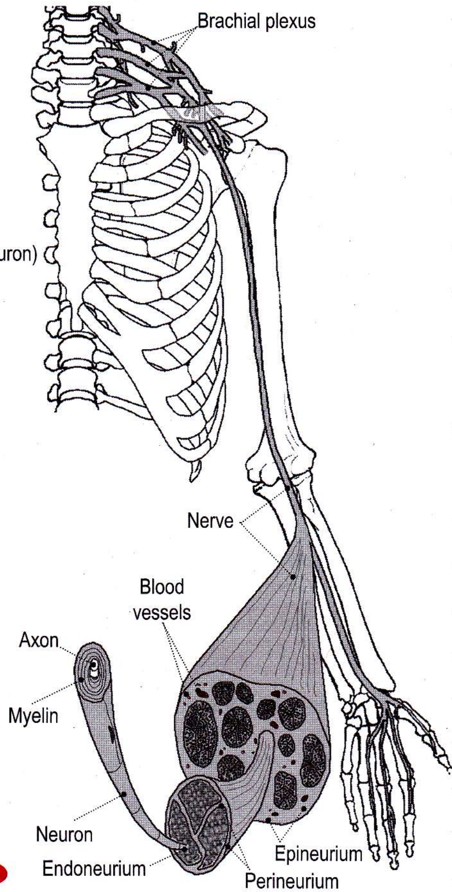
- Dynamic Functional Muscle Testing (FMT) - provides a more functional ROM assessment, but does not test specific muscles as well, & is more difficult to quantify, perform & interpret
- Clinician asks patient to perform an action (AROM), as patient performs action clinician resist action; not enough to stop patient
- Clinician should request verbal feedback from the patient & observe non-verbal cues regarding the muscle/action that is being strength-tested

Common Muscle Testing Findings

- Strong painless resistance indicates normal tissue integrity
- Weak & painless resistance indicates a loss of motor nerve supply or complete rupture of musculotendinous structure
- Painful resistance indicates partial tear or rupture of musculoskeletal structure

Nerve: an enclosed, cable-like bundle of *axons* outside CNS & includes connective tissue coverings and blood vessels

- Most nerves and major branches of nerves have descriptive names. In the CNS bundles of axons are termed *tracts* rather than nerves
- Nerves may include both afferent (sensory) and efferent (motor) fibers



Terminology

Axon: long, slender projection of a single nerve cell (neuron)

Myelin: fatty sheath coating covering neuron axons that allows for the efficient conduction of nerve impulses. Myelin is produced by oligodendrocytes in the CNS and by Schwann cells in the PNS

Synapse: where one neuron meets another neuron there is a small space between the cells (*synapse)*, when a neuron meets a muscle it is called a *neuromuscular junction*. One neuron may synapse with hundreds of other neurons!

Ganglion: mass of cell bodies outside the CNS

Plexus: network of nerves

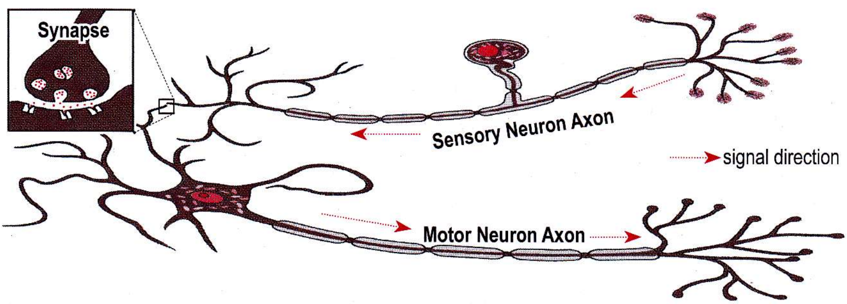
Center: group of neuron cell bodies in the CNS sharing common function

Tract: bundle of axons within the CNS sharing common origin, destination and function

Column: a group of tracts found within a specific region of the spinal cord

Connective Tissue coverings
Epineurium: covers many fascicles or entire nerve
Perineurium: covers a bundle (fascicle) of axons
Endoneurium: covers single axon

Sensory & Motor Neurons



Sensory (afferent) neurons: nerves that carry information *from* the environment back into the brain (the senses - touch, sight, smell, hearing & taste). Skin & body sensation consists of the various sensory receptors that trigger the experiences labelled as touch or pressure, temperature (warm or cold), pain (including itch and tickle), and the sensations of muscle movement and joint position including posture, movement, and facial expression (collectively called ***proprioception** or position sense*)

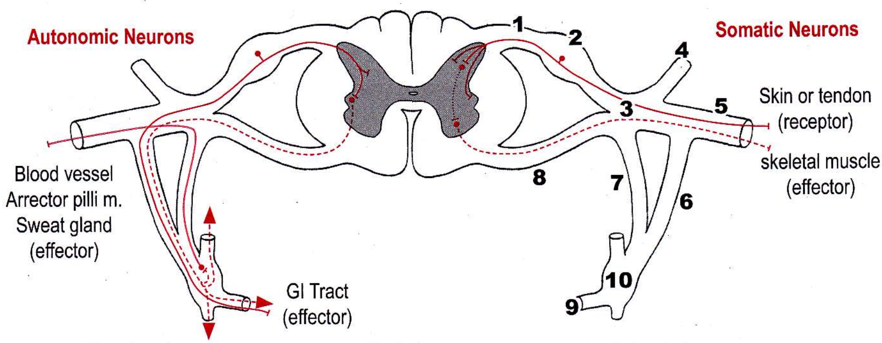
Motor (efferent) neurons: nerves that *innervate* or activate muscles or glands to perform work

Anatomical Divisions of Nervous System

- **Central nervous system (CNS)** - brain, brainstem & spinal cord
- **Peripheral nervous system (PNS)** - all nerves *outside* of the brain & spinal cord
  - **Spinal nerves: *31 pairs*** (8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal) which are given letter-number combinations according to the vertebrae through which they connect to the spinal column (e.g. L3 for the 3rd lumbar nerve)
  - **Cranial nerves: *12 pairs*** that connect directly to the brain; cranial nerves are assigned numbers, usually expressed as Roman numerals from I to XII (see neurovascular chapter)

Functional Divisions of Nervous System

- **Somatic nervous system** (voluntary muscle control) - contraction of skeletal muscle & skin sensations
- **Autonomic nervous system (ANS)** (involuntary control) which is divided into
  - **Sympathetic** division (**'fight or flight'**)
    - Actions: ↑ heart & respiration rate, ↓ digestion, dilate pupils
    - Exits the CNS form T1-L2 spinal levels
  - **Parasympathetic** division (**'rest & digest'**)
    - Actions: ↑ digestion, ↓ heart & respiration rate, constrict pupils
    - Exits the CNS through **cranial nerves III, VII, IX, X and sacral levels S2-4**



1. Dorsal root
2. Dorsal root ganglion (DRG)
3. Spinal nerve
4. Dorsal ramus
5. Ventral ramus
6. White ramus
7. Gray ramus
8. Ventral root
9. Splanchnic nerve
10. Sympathetic chain ganglion

Clinical Significance

Damage to nerves can be caused by swelling (e.g. carpal tunnel syndrome), direct compression (e.g. disc herniation), autoimmune diseases (e.g. Guillain-Barré syndrome), infection (neuritis), diabetes, or failure of the blood vessels surrounding the nerve

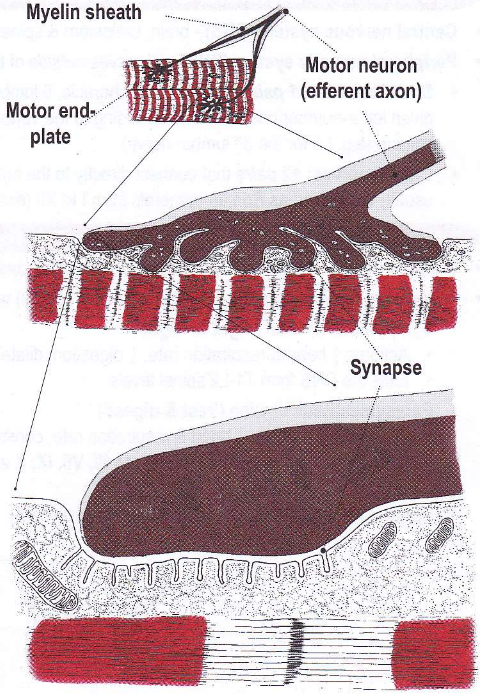
'Pinched' nerves occur when pressure is placed on a nerve, usually from swelling due to an injury or pregnancy. Nerve damage or pinched nerves are usually accompanied by ***shooting or electrical type pain, numbness, tingling, weakness, or paralysis***. Patients may feel these symptoms in areas far from the actual site of damage, a phenomenon called *referred pain*. Referred pain occurs because a nerve is damaged, resulting in a defective signal from all parts of the area which the nerve receives input, not just the site of the damage. A common example occurs during a heart attack, the damage is in the heart but pain may be felt down the left arm, across the chest & even up into the jaw.

Tests used to diagnose nerve disorders include a detailed history and physical exam, including; testing of reflexes, muscle strength testing, active range of motion (AROM), proprioception, and the sense of touch

Neuromuscular Junction

A *neuromuscular junction* (NMJ) is the synapse or junction of the axon terminal of a motor neuron with the *motor end plate*, the highly-excitable region of muscle fiber plasma membrane responsible for initiation of action potentials across the muscle's surface, causing the muscle to contract. The signal passes through the neuromuscular junction via the neurotransmitter *acetylcholine*.

As a motor neuron (which originates in the spinal cord), enters a muscle, it loses its *myelin sheath* and splits into many terminal branches. These terminal fibers run along the muscle cells to end at the neuromuscular junction. Each motor neuron can innervate from one to over 2000 muscle fibers, but each muscle fiber receives inputs from only one motor neuron.



When a motor neuron depolarizes, an electrical current is passed down the nerve fiber and the impulse causes acetylcholine to be released into the synapse to the muscle cell. Acetylcholine then binds with receptors on the muscle membrane to create the contraction.

Over time, the brain autonomically learns the chosen motion and induces its own form of memory. This process is called *neuromuscular facilitation* or 'muscle memory.'

Once muscle memory is created and retained, there is no longer need to actively think about the movement and this frees up brain capacity for other activities.

Muscle Memory

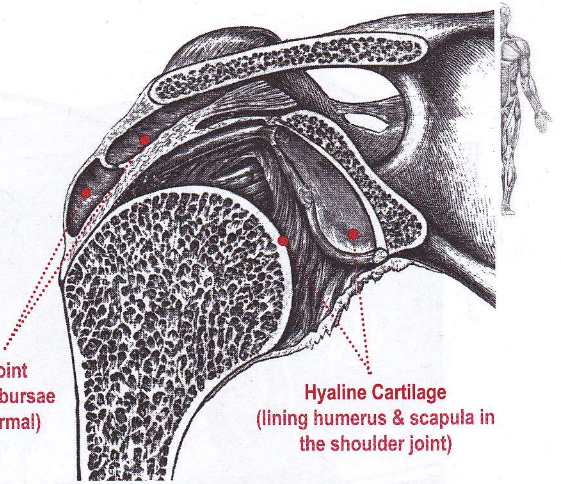
Even though the process is really brain memory, the nickname 'muscle memory' is commonly used. Muscle memory is accomplished through repetition of a given motor skill and the ability through brain activity to remember it. Activities such as brushing the teeth, combing the hair, or even driving a vehicle are not as easy as they look to the beginner. As we reinforce movements day after day, the nervous system learns those fine and gross motor skills to the degree that you no longer need to think about them, but merely to react and to perform (they become part of your autonomic function, almost like breathing).

If you want to see muscle memory at work, try and learn a new skill or just watch a child learning to walk. The learning process can take months, even years, to perfect, depending on the individual's dedication to practice, and their unique biochemical neuromuscular learning system to retain that practice

Muscle Spindle Reflex & Stretching
Bouncing when you stretch is not recommended as it activates the muscle spindle reflex & may be counter-productive. Muscle stretching should be done slowly and in a relaxed manner after physical activity for optimal benefit.

Bursa: (bursae, plural) small fluid-filled sac located at the point where muscles, tendons or ligaments slide across bone

- Bursae reduce friction between two moving surfaces
- There are hundreds of them throughout the body
- Bursae are filled with synovial fluid
- Bursae are also found between bone & skin (eg. subcutaneous olecranon bursa)
- Bursa is Latin for purse, which is what a bursa resembles when inflamed (bursitis)



Right shoulder (glenohumeral) joint showing subacromial & subdeltoid bursae (note joint space is larger than normal)

Hyaline Cartilage (lining humerus & scapula in the shoulder joint)

Cartilage: type of dense connective tissue composed of collagen fibers and/or elastin fibers, and cells called chondrocytes, all of which are embedded in a firm gel-like ground substance called the *matrix*

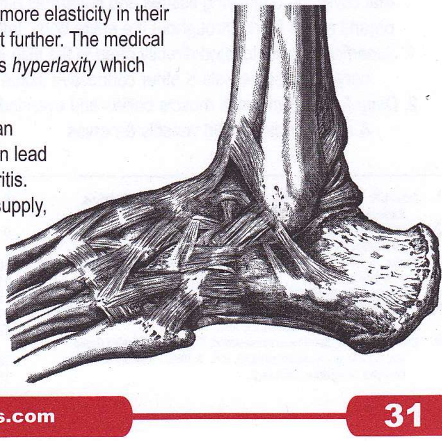
- Three main types of cartilage:
  1. **Hyaline** (articular cartilage) - most common cartilage, found lining the articular surfaces of bones in synovial joints
  2. **Elastic** (yellow cartilage) - found in the ear, larynx, nose, trachea
  3. **Fibrocartilage** (white cartilage) found in areas of high stress like the vertebral discs, meniscus of the knee & TMJ disc
- Because cartilage is mostly avascular, it has very limited repair capabilities; damaged cartilage is usually replaced by fibrocartilage scar tissue. Osteoarthritis develops as the cartilage eventually is worn away & bone rubs on bone

Ligament: short band of dense regular connective tissue composed mainly of long, stringy collagen fibers. Ligaments ***connect bones to other bones*** to form a joint (tendons connect *muscles to bones*). Some ligaments limit the mobility of articulations, or prevent certain movements altogether.

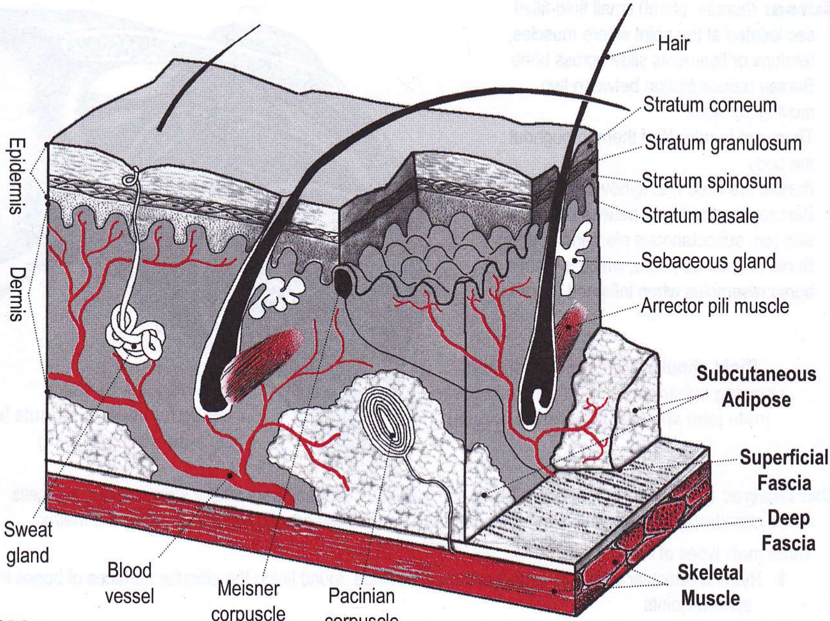
Ligaments are slightly elastic & under tension they gradually lengthen; if ligaments lengthen too much, the joint will be weakened, becoming prone to future injury or dislocations. Athletes, gymnasts, dancers, & martial artists perform stretching exercises to lengthen their ligaments, making their joints more supple.

The term 'double-jointed' refers to people who have more elasticity in their ligaments, allowing their joints to stretch & contort further. The medical term for describing such double-jointed persons is *hyperlaxity* which results in *hypermobility* (excess movement).

An excessively stretched or torn ligament (sprain) can result in *instability* of the joint; which over time can lead to wear of the cartilage & eventually to osteoarthritis. Because ligaments have a relatively poor blood supply, they can take a very long time to heal.



Left Lateral Ankle showing lateral ankle ligaments often injured in an inversion ankle sprain



Skin:

- The body's outer covering, protects us against heat, light, injury, and infection
- Helps regulate body temperature and stores water, fat, and vitamin D
- Skin is the body's largest organ and makes up almost 10% of your body weight
- Skin thickness & texture varies through different regions of the body and skin is connected to the superficial fascia below

Did you know? In a person of normal weight, about 50% of body fat is stored in the skin. This also holds true for other animals - one reason why removing the skin from your chicken prior to cooking makes it a lower fat choice.

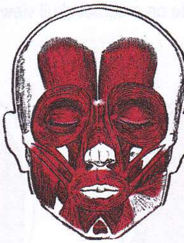
Adipose (fat):

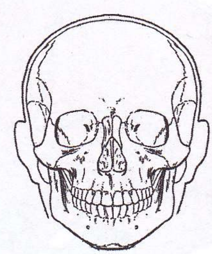
- A type of connective tissue stores fat that serves as a source of energy
- Adipose tissue also cushions and insulates & supports vital organs
- The cells found in adipose tissue are called adipocytes

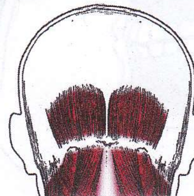
Fascia: (Latin for 'band' or 'bandage') flat bands of dense irregular connective tissue below the skin that cover the underlying tissues and separates different layers of tissue. Fascia encloses muscles & organs and is found throughout the entire body. Inflammation of the fascia is referred to as *fascitis*.

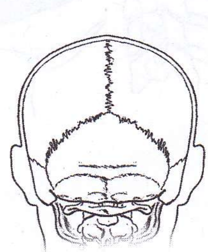
1. *Superficial fascia:* located directly deep to the skin & surrounds the entire body. It is filled with fat, nerves, blood vessels & other connective tissue
2. *Deep fascia:* surrounds muscle bellies and even individual muscle cells. It fills space between muscles & also contains blood vessels & nerves

1. Acland, R, 2008., Video Atlas of Human Anatomy, Williams & Wilkins, Baltimore
2. Beck M 1994 Milady's Theory and Practice of Therapeutic Massage, Milady Pub, Albany, NY
3. Cailliet, R, 1977, Soft Tissue Pain and Disability, F.A. Davis Company, Philadelphia
4. Calais-Germain, B, 1993, Anatomy of Movement, Eastland Press, Seattle
5. Cantu, RL,& Grodin, A. 1992: Myofascial manipulation - Theory and Clinical Application, Aspen Publishers Inc. 1992.
6. Chaitow, L, 1980, Soft Tissue Manipulation, Thorsons Publishing Group, Wellingborough, Northamptonshire, U.K. & 1996, Palpatory Skills, Churchill Livingstone, Edinburgh
7. Gray et al, 1995, Gray's Anatomy, 38th Edition, Churchill Livingstone, New York
8. Leonard, CT, 1998, The Neuroscience of Human Movement, Mosby, St. Louis, MO
9. Martin JH: Neuroanatomy text and atlas, ed 2, Stamford, Conn, 1996, Appleton & Lange.
10. Mathers LH, et al: Clinical anatomy principles, St Louis, 1996, Mosby.
11. Netter, F, 1989, Atlas of Human Anatomy, 2nd ed. , Novartis, New Jersey
12. Radinsky, LB, 1987, The Evolution of Vertebrate Design, University of Chicago Press, Chicago
13. Reid, D.C.: Sports Injury Assessment and Rehabilitation. New York, Churchill Livingstone, 1992.
14. Vander, A et al, 1990, Human Physiology, Fifth Edition, McGraw-Hill, New York
15. Vizniak, NA. Gross Anatomy: Human Cadaver Dissections. 1999-2008









Skull Bones

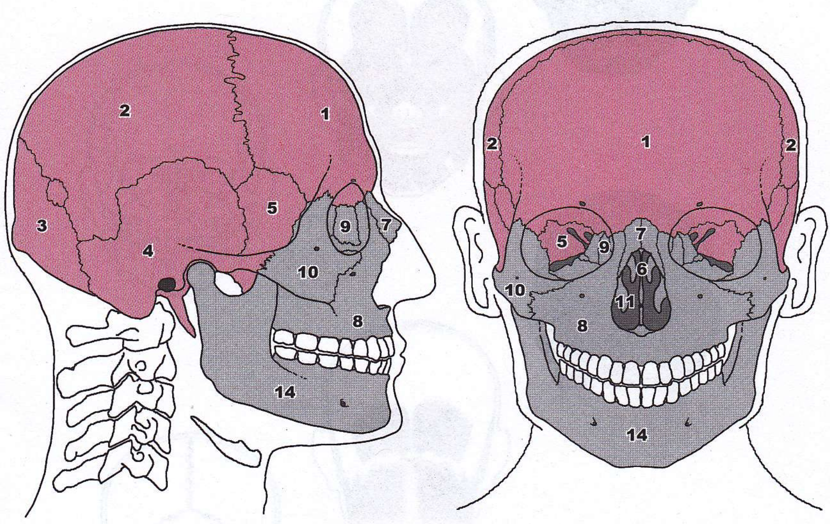
The skull has two parts

1. **Cranium**, which houses and protects the brain (8 bones)
2. **Face**, which makes up the anterior portion of the skull (14 bones)

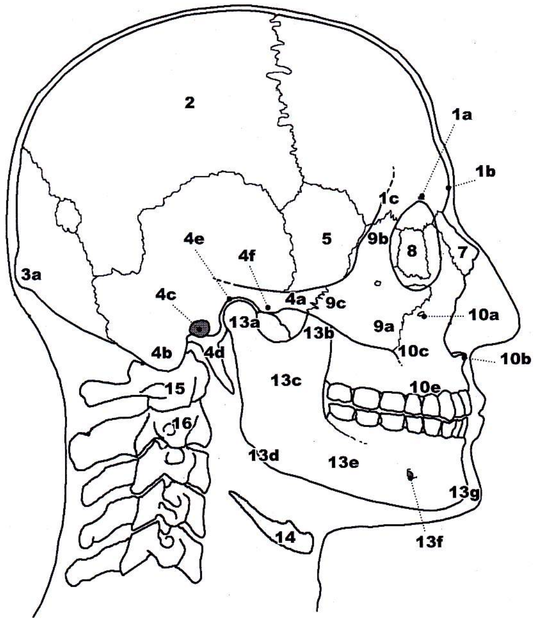
Skull (22 bones)

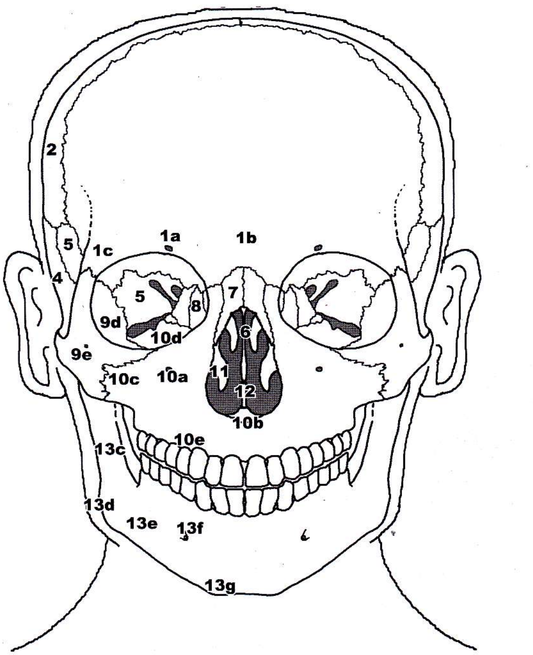
- ***Cranium*** (8 bones)
  1. **Frontal**
  2. **Parietal** (2 bones)
  3. **Occipital**
  4. **Temporal** (2 bones)
  5. **Sphenoid**
  6. **Ethmoid**
- ***Face*** (14 bones)
  7. **Nasal** (2 bones)
  8. **Maxilla** (2 bones that may fuse)
  9. **Lacrimal** (2 bones)
  10. **Zygomatic** (2 bones)
  11. **Inferior Nasal Conchae** (2)
  12. **Palatines** (2)
  13. **Vomer**
  14. **Mandible**

* Note *palatine* & *vomer* are not easily visible on external skull views shown



= Cranium
= Face





Detailed views of skull bones are available at:
http://www.prohealthsys.com/anatomy/grays/osteology/skull_introduction.php

1. **Frontal bone**
   a. Supraorbital foramen
   b. Glabella
   c. Zygomatic process

2. **Parietal bone**

3. **Occipital bone**
   a. External occipital protuberance (EOP)

4. **Temporal bone**
   a. Zygomatic process
   b. Mastoid process
   c. External auditory meatus
   d. Styloid process
   e. Mandibular fossa
   f. Articular tubercle

5. **Sphenoid bone**
6. **Ethmoid bone**
7. **Nasal bone**
8. **Lacrimal bone**

9. **Zygomatic bone**
   a. Maxillary process
   b. Frontal process
   c. Temporal process
   d. Orbital surface
   e. Zygomaticofascial foramen

10. **Maxilla**
    a. Infraorbital foramen
    b. Anterior nasal spine
    c. Zygomatic process
    d. Orbital plate
    e. Alveolar process

11. **Inferior Nasal Conchae**

12. **Vomer**

13. **Mandible**
    a. Condylar process
    b. Coronoid process
    c. Ramus
    d. Angle
    e. Body
    f. Mental foramen
    g. Mental tubercle
14. **Hyoid bone**
15. **C1 (Atlas)**
16. **C2 (Axis)**

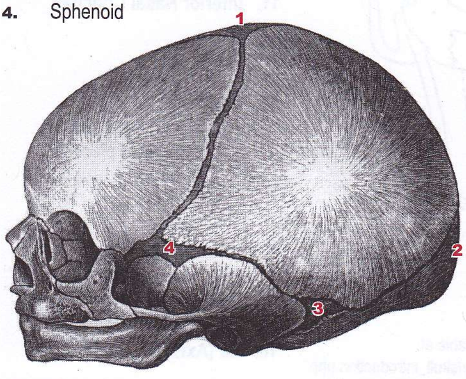
1. **Coronal suture**
2. **Sagittal suture**
3. **Lambdoidal suture**
4. **Squamosal suture**
5. **Occipitomastoid suture**
6. **Bregma** - junction of coronal & sagittal sutures
7. **Lambda** - junction of sagittal & lamdoidal sutures
8. **Pterion** - junction of temporal, parietal, frontal & sphenoid bones
9. **Nasion** - junction of nasal suture & frontal bone
10. **Asterion** - junction of occipital, parietal & temporal bones
11. **Inion** - external occipital protuberance (EOP)

There are many other smaller sutures of the skull that are simply named after the bones on either side of the suture.

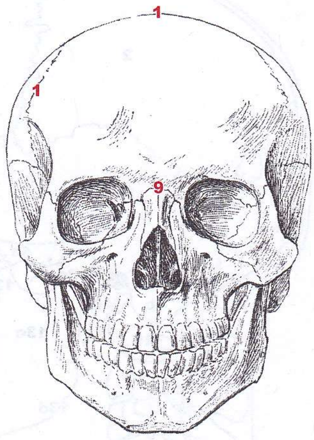
Skull at birth (below) showing fontanelles, which allow the head to pass through the birth canal and the brain to grow until skeletal maturity. The anterior fontanelle is known as the "soft spot" on a baby.

Fontanelles

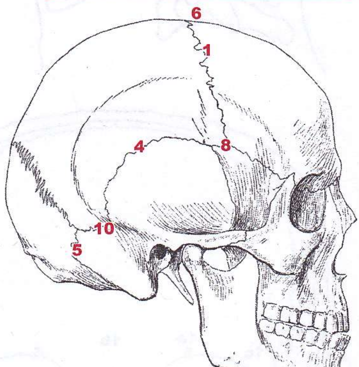
1. Anterior
2. Posterior
3. Mastoid
4. Sphenoid



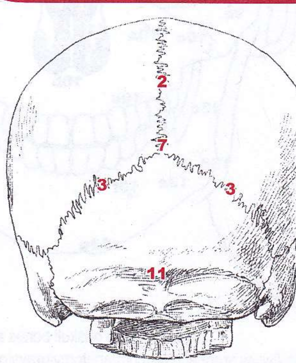
Anterior View



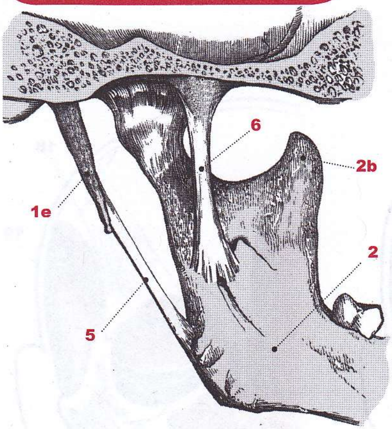
Lateral View



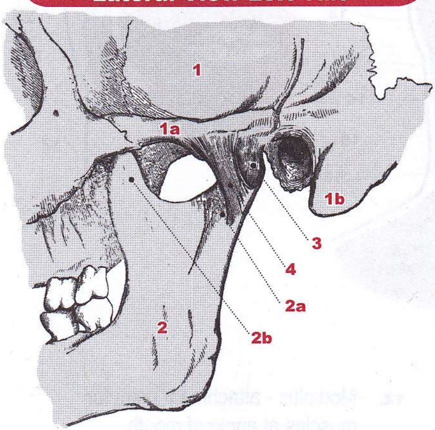
Posterior View



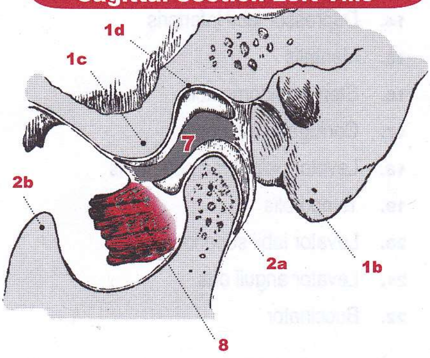
Medial View Left TMJ



Lateral View Left TMJ

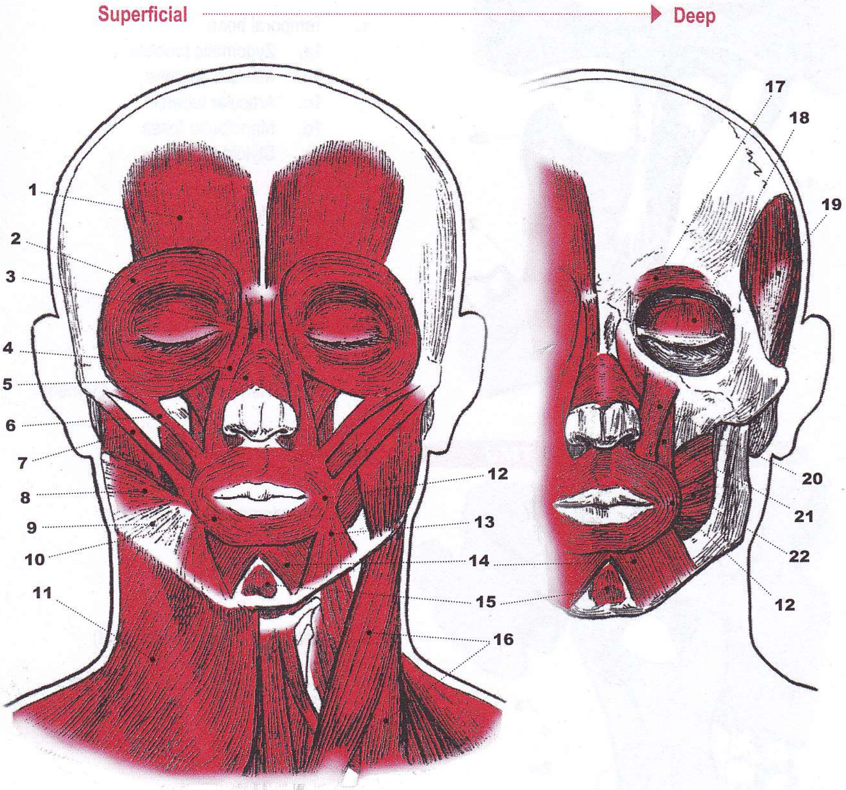


Sagittal Section Left TMJ

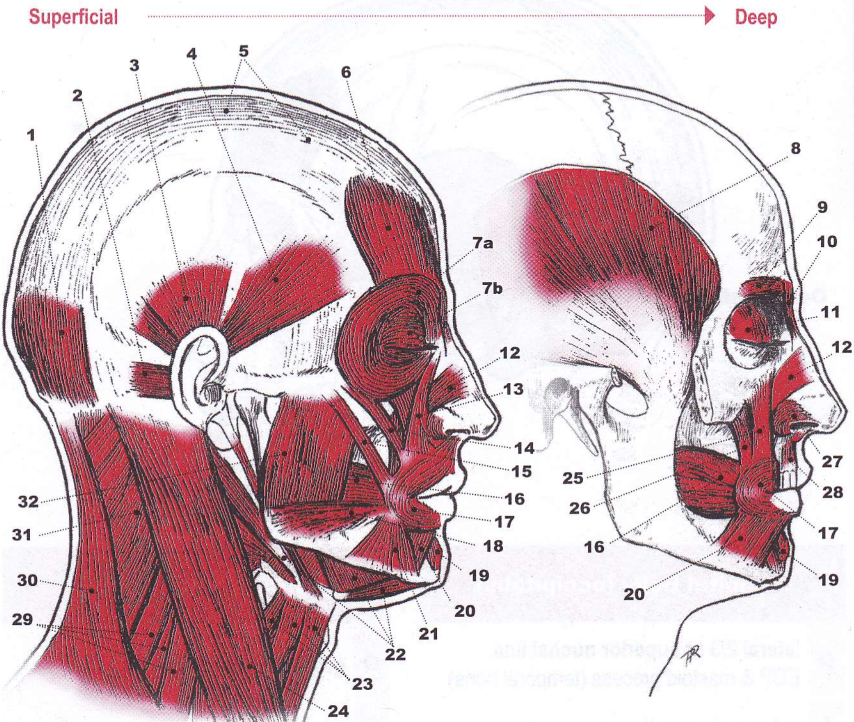


1. Temporal bone
   - **1a.** Zygomatic process
   - **1b.** Mastoid process
   - **1c.** Articular tubercle
   - **1d.** Mandibular fossa
   - **1e.** Styloid process
2. Mandible
   - **2a.** Condylar process
   - **2b.** Coronoid process
3. Joint Capsule
4. Lateral temporomandibular ligament
5. Stylomandibular ligament
6. Sphenomandibular ligament
7. Articular disc
8. *Lateral pterygoid* muscle (cut)

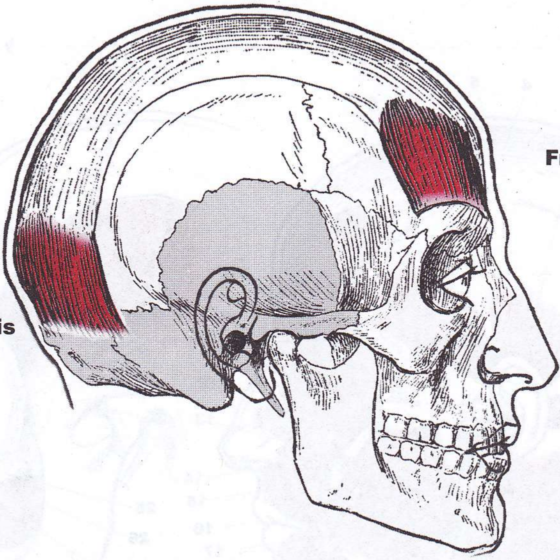
Note that the TMJ is actually two joints (one above & one below the articular disc); also the *Lateral pterygoid* muscle attaches to the joint capsule & disc of the TMJ, and may be a potential contributor to the development of a TMJ syndrome



1. Frontalis (epicranius)
2. Orbicularis oculi
3. Procerus
4. Levator labii superioris alaeque nasi
5. Nasalis
6. Zygomaticus minor
7. Zygomaticus major
8. Risorius
9. Parotid fascia
10. Orbicularis oris
11. Platysma
12. Modiolus - attachment point for muscles at angle of mouth
13. Depressor anguli oris
14. Depressor labii inferioris
15. Mentalis
16. Sternocleidomastoid
17. Corrugator supercilii
18. Levator palpebrae superioris
19. Temporalis
20. Levator labii superioris
21. Levator anguli oris
22. Buccinator



1. Occipitalis (epicranius)
2. Auricularis posterior
3. Auricularis superior
4. Temporoparietalis
5. Galea aponeurotica
6. Frontalis (epicranius)
7. Orbicularis oculi
   a. Orbital part
   b. Palpebral part
8. Temporalis
9. Corrugator supercilii
10. Procerus
11. Levator palpebrae superioris
12. Nasalis
13. Levator labii superioris alaeque nasi
14. Zygomaticus minor
15. Zygomaticus major
16. Buccinator
17. Orbicularis oris
18. Risorius
19. Mentalis
20. Depressor labii inferioris
21. Depressor anguli oris
22. Suprahyoid muscles
23. Infrahyoid muscles
24. Sternocleidomastoid
25. Levator labii superioris
26. Levator anguli oris
27. Nasalis (dilator naris)
28. Depressor septi nasi
29. Scalenes
30. Trapezius
31. Splenius capitis
32. Masseter



	Occipital Belly (occipitalis)
O	**lateral 2/3 of superior nuchal line**, EOP & mastoid process (temporal bone)
I	**galea aponeurotica**
A	**pulls back scalp to raise eyebrows** & wrinkles brow (surprise)
N	**facial nerve** (CN VII), posterior auricular branch
B	occipital & posterior auricular arteries

	Frontal Belly (frontalis)
O	**galea aponeurotica**
I	**skin & fascia above nose & eyes**
A	**pulls scalp posteriorly to raise eyebrows** & wrinkle brow (surprise)
N	**facial nerve** (CN VII), temporal branch
B	ophthalmic artery

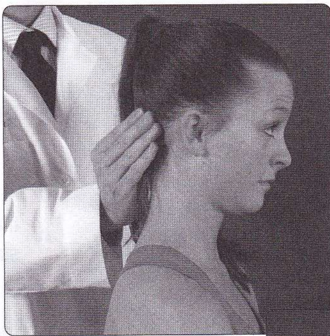
Clinical Notes

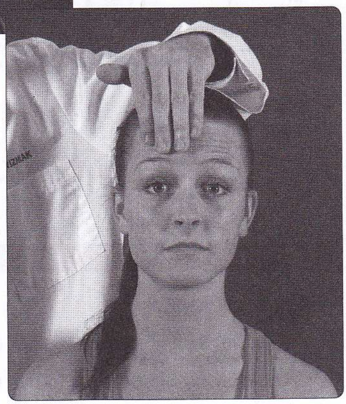
- *Occipitofrontalis* or *epicranius* is sometimes referred to as two separate muscles known as the *occipitalis* and *frontalis*
- Contraction of *occipitofrontalis* is associated with expressions of surprise, shock & horror
- The main action of occipitalis is stabilization of the galea aponeurotica to provide a stable base of contraction for the *frontalis* muscle
- Often over-looked, the *occipitofrontalis* may be involved in muscle tension headaches
- Botox injections partially paralyze the *frontalis* muscle, eliminating "worry lines"
- *Frontalis* & *corrugator supercilii* may compress branches of the supraorbital nerve & potentially contribute to migraine headaches
- To muscle test *occipitofrontalis* have the patient raise their eyebrows

Palpation

1. Patient seated, prone or supine
2. *Occipitalis*: place palpating hand over occipital bone & have patient elevate eyebrows

OccipitoFrontalis is superficial and very easy to palpate



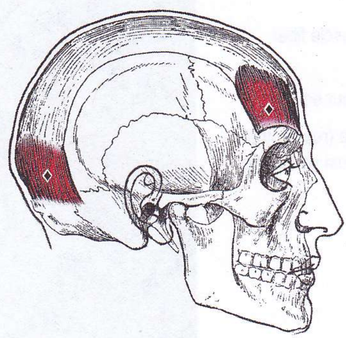


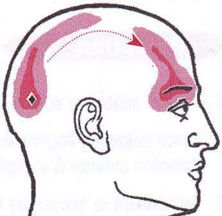
1. Patient seated or supine
2. *Frontalis:* place palpating hand over frontal bone & have patient elevate eyebrows

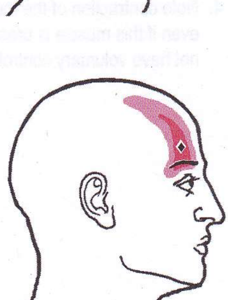
Occipitofrontalis is superficial and very easy to palpate

Trigger Point Referral

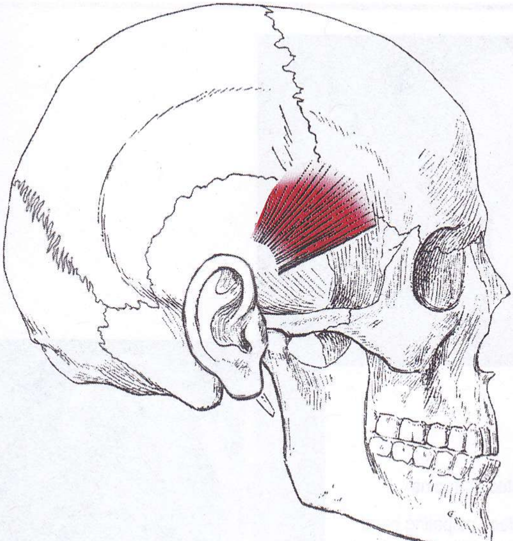
- MFTPs are commonly located in the muscle bellies & pain referral is usally the posterior head & above or 'in' the eye







Temporoparietalis



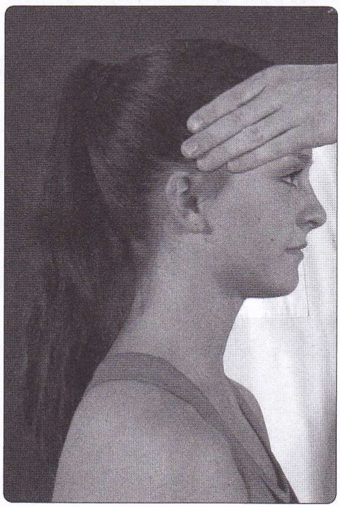
O	**temporal fascia above ear**
I	**lateral border of galea aponeurotica**
A	**elevation of ear,** stabilizes galea aponeurotica
N	**facial nerve** (CN VII), temporal branch
B	superficial temporal & posterior auricular arteries

Clinical Notes

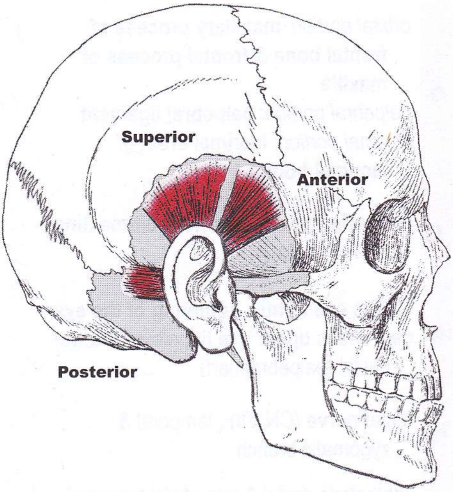
- ***Anatomical variation:***
  - *Temporoparietalis* is absent in ~50% of the population
  - Occasionally, *Temporoparietalis* may extend to attach to the belly of the *Frontalis* muscle
- The posterior fibers of *temporoparietalis* are known as the *auricularis superior* and the anterior fibers may be continuous with *auricularis anterior*

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction anterior & superior to ear
3. Ask patient to "please try to move your ear up."
4. Note contraction of the muscle tissue (realize that even if this muscle is present that most people do not have voluntary control of it)



Auricularis



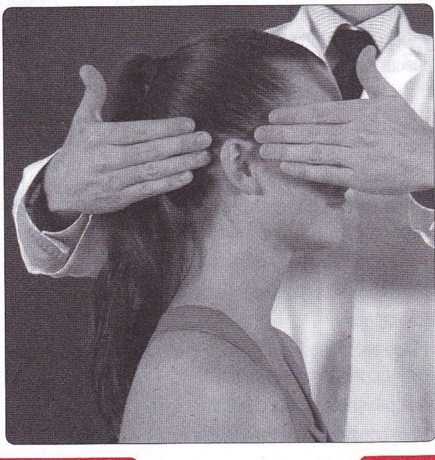
O	*anterior:* **galea aponeurotica** *superior:* **galea aponeurotica** *posterior:* **temporal bone** (mastoid area)
I	*anterior:* **anterior ear** *superior:* **superior ear** *posterior:* **posterior ear**
A	*anterior:* **pulls ear anterior** (protraction) *superior:* **elevation of ear** *posterior:* **pulls ear posterior** (retraction)
N	**facial nerve** (CN VII)
B	superficial temporal & posterior auricular arteries

Clinical Notes

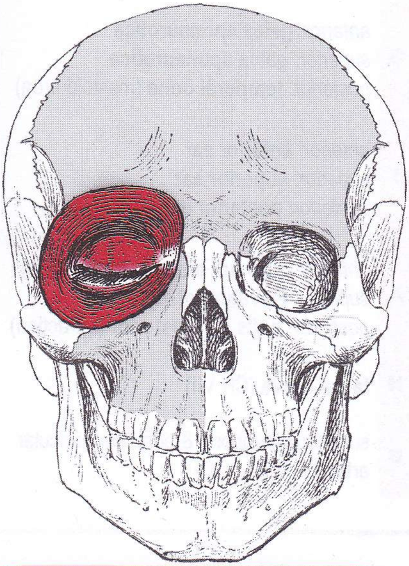
- ***Anatomical variation:***
  - There is huge variation in both size and motor control of these muscles
  - *Auricularis superior* & *anterior* may be continuous with the fibers of the *Temporoparietalis*
  - *Auricularis anterior* & *superior* may also have attachment point onto the temporal fascia
  - *Auricularis posterior* may have 2 muscle bellies
- The *auricularis* muscles can be involved in muscle tension headaches
- Most people do not have voluntary control over these muscles, however in cats, dogs, horses and many other animals these muscle are extremely well developed (as is evident when you watch a house cat or dog locating a sound)

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction of the *auricularis* muscle you are attempting to palpate
3. Ask patient to "please try to move your ear forward, up, or back."
4. Note contraction of the muscle tissue (realize that most people do not have voluntary control of these muscles)



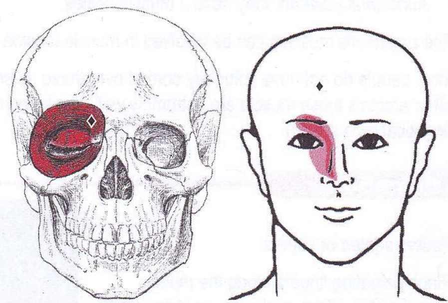
Orbicularis Oculi



O	*orbital portion:* **maxillary process of frontal bone & frontal process of maxilla** *palpebral portion:* **palpebral ligament** *lacrimal portion:* **lacrimal crest of lacrimal bone**
I	**circumferentially around orbit meeting at the origin**
A	**closes eye tightly, squinting of the eye** **depresses upper eye lid**, elevates lower eyelid (palpebral part)
N	**facial nerve** (CN VII) , temporal & zygomatic branch
B	ophthalmic, facial & superficial temporal arteries

Clinical Notes

- ***Anatomical variation:*** fibers of the *orbicularis oculi* also blend into the *frontalis, corrugator supercilli, zygomaticus minor, levator labii superioris & levator labii superioris alaque nasi*
- The orbital part is mainly involved with firm closure of the eye
- ***ADL:*** winking and closing the eyes tightly during bright light exposure, sand storms or physical attack
- The palpebral part is under both voluntary & involuntary control (during blinking reflex)
- The lacrimal part is also known as Horner's muscle & assists in tear transport & drainage (crying)
- "Crow's feet" are radial folds & creases in the skin produced by this muscle
- MFTPs are usually found in the upper medial quadrant & refer pain over the medial eye & down the nose; there may be visual disturbances



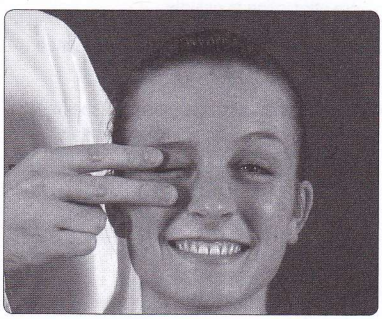
Palpation

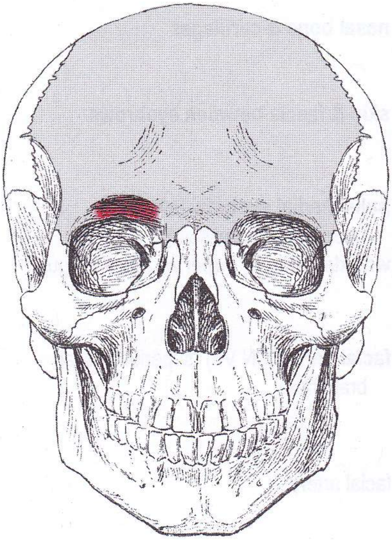
Orbital part

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction over orbit
3. Ask patient to *tightly* close their eyes
4. Note contraction of the muscle tissue

Palpebral part

1. Place palpating fingers along the muscle fiber direction over upper & lower eyelids
2. Ask patient to *gently* close their eyes
3. Note contraction of the muscle tissue





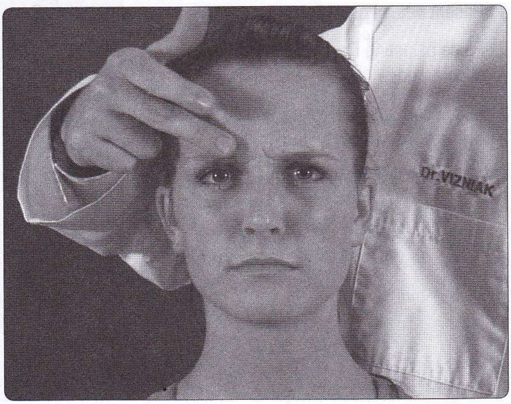
O	**frontal bone just above medial eye** (lateral to glabella)
I	**skin of middle portion of eyebrows**
A	**pulls eyebrows downward & medially** ("thinker's brow")
N	**facial nerve** (CN VII, zygomatic branch)
B	ophthalmic/supraorbital artery

Clinical Notes

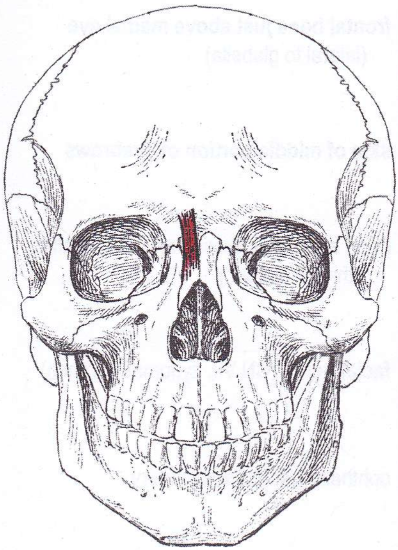
- ***Anatomical variation:*** Fibers of *corrugator supercilli* blend into the *frontalis* & *orbicularis oculi*
- Contraction of *corrugator supercilli* results in vertical furrows in the skin superior & medial to the eye ("thinker's brow")
- **ADL:** *corrugator supercilli* along with *procerus* & *orbicularis oculi* may contract to offer some protection from bright sunlight (squinting); *corrugator supercilli* can be involved in looks of menace, disgust, frowning & deep thought

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction over medial eyebrow
3. Ask patient to frown or pull eyebrows together
4. Note contraction of the muscle tissue



Procerus



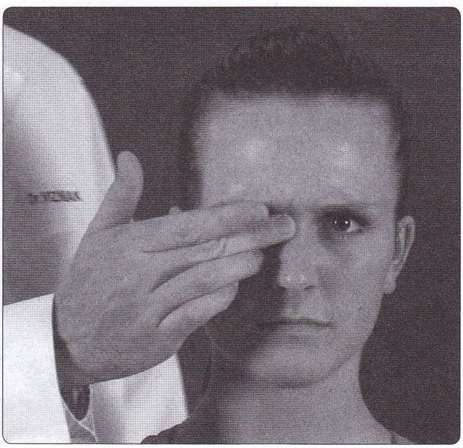
O	**nasal bone & cartilages**
I	**skin & fascia between eyebrows**
A	**pulls medial eyebrow inferiorly** (menacing expression) **wrinkles skin of superior nose** (disgust)
N	**facial nerve** (CN VII) (superior buccal branches)
B	facial artery

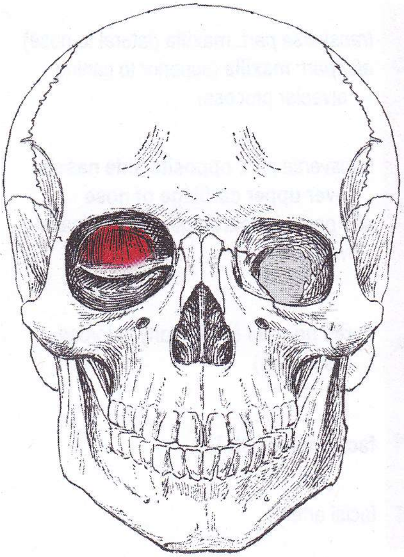
Clinical Notes

- ***Anatomical variation:*** fibers of *procerus* blend with *frontalis* & *nasalis*
- *Procerus* along with *orbicularis oculi* & *corrugator supercilli* help shield the eyes from bright sunlight (squinting)
- **ADL:** pulling the eyebrow down & wrinkling the skin of the nose can be involved in looks of menace, disgust & frowning

Palpation

1. Patient seated or supine
2. Place palpating fingers over the medial superior nose
3. Ask patient to make a look of disgust or pull eyebrows down
4. Note contraction of the muscle tissue



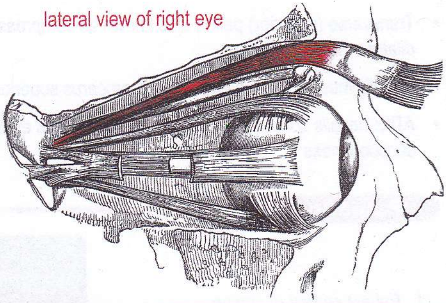


O	**lesser wing of sphenoid bone** (anterior surface)
I	**upper eyelid** (fascia & skin)
A	**elevation of upper eyelid**
N	**oculomotor nerve** (CN III)
B	ophthalmic artery

Clinical Notes

- *Levator palpebrae superioris* is innervated by the oculomotor nerve along with other muscles of eye movement
- Fibers of the palpebral portion of *orbicularis occuli* may blend with fibers of *levator palpebrae superioris*
- Damage to the oculomotor nerve can result in ptosis (drooping of the eyelid)

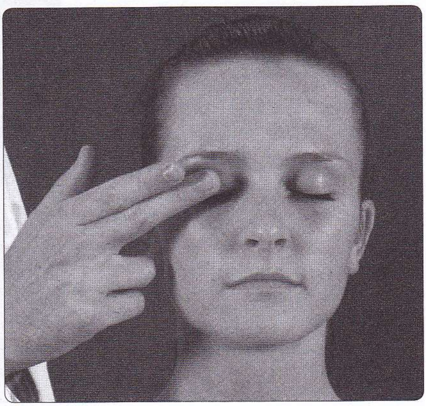
lateral view of right eye

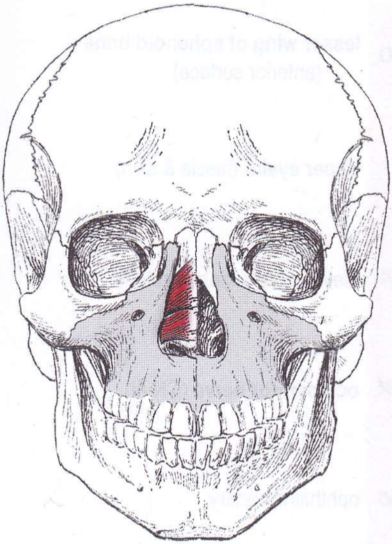


Palpation

1. Patient seated or supine
2. Delicately place palpating fingers along the muscle fiber direction over the upper eyelid
3. Ask patient to slowly open their eye
4. Note contraction of the muscle tissue

   Be careful not to have your finger contact the eyeball directly





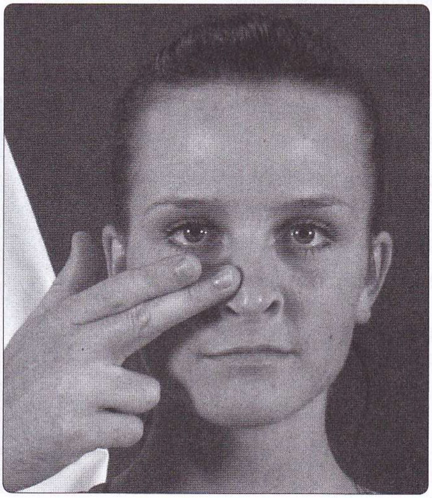
O	*transverse part:* **maxilla** (lateral to nose) *alar part:* **maxilla** (superior to canine alveolar process)
I	*transverse part:* **opposite side nasalis over upper cartilage of nose** *alar part:* **alar cartilage of nose** (nasal wing)
A	**flares nostrils** (particularly in forced respiration)
N	**facial nerve** (CN VII)
B	facial artery

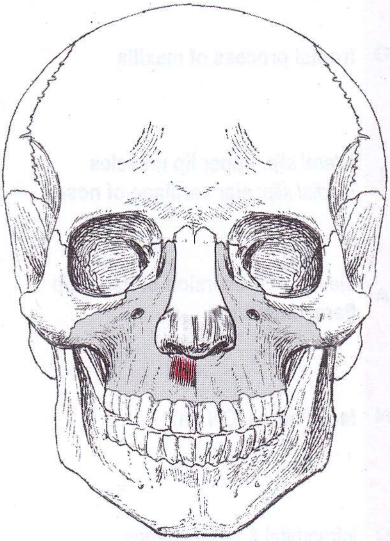
Clinical Notes

- Transverse (superior) part is also known as *compressor nares*, alar (inferior) part is also known as *dilatator nares*
- *Nasalis* muscle fibers blend with the *procerus* superiorly & the *depressor septi* inferiorly
- **ADL:** *nasalis* contraction may be associated with expressions of happiness, astonishment & sensuousness

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction over the lateral sides of the nose
3. Ask patient to flare their nostrils or take a deep breath
4. Note contraction of the muscle tissue





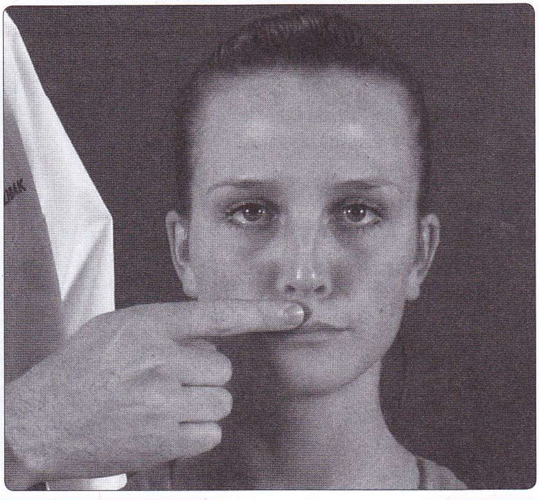
O	**incisive fossa of maxilla**
I	**septum & alar cartilage of nose**
A	**constriction of notrils**
N	**facial** (CN VII)
B	facial artery

Clinical Notes

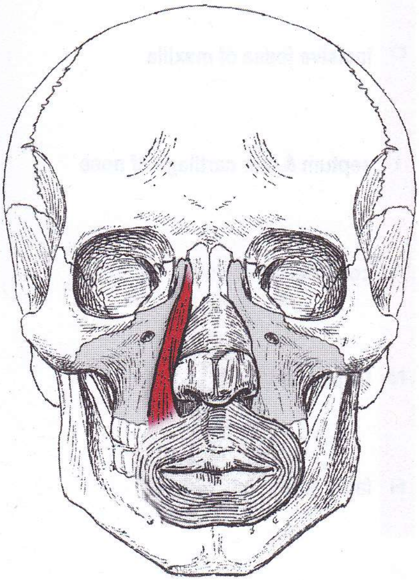
- *Depressor septi nasi* is also known as the *depressor septi* or *depressor portion of the nasalis*
- *Depressor septi nasi* is involved with many of the same facial expression as *nasalis*
- **ADL:** *depressor septi nasi* contraction may be associated with expressions of happiness, astonishment & sensuousness

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction inferior to the nose
3. Ask patient to try and constrict nostrils or pull nose downward (look of disgust)
4. Note contraction of the muscle tissue



Levator Labii Superioris Alaeque Nasi



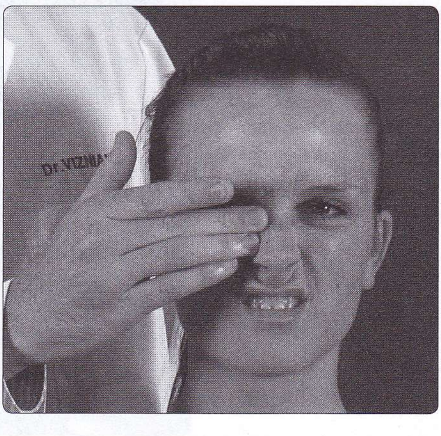
O	**frontal process of maxilla**
I	*lateral slip:* **upper lip muscles** *medial slip:* **alar cartilage of nose**
A	**elevation & eversion of upper lip** **flares nostrils**
N	**facial nerve** (CN VII)
B	infraorbital & facial arteries

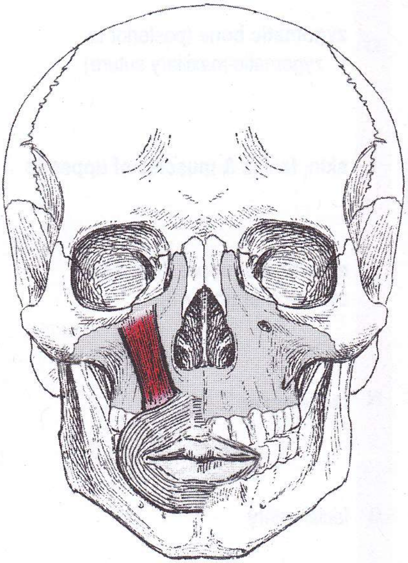
Clinical Notes

- Fibers of *levator labii superioris alaeque nasi* blend with *levator labii superioris & orbicularis oris*
- *Levator labii superioris alaeque nasi* may also be considered to be an *angular head of the levator labii superioris*
- **ADL:** contraction of this muscle is associated with expressions of distrust, disgust or anger

Palpation

1. Patient seated or supine
2. Place palpating fingers over the muscle fiber direction just lateral to nose
3. Ask patient to make a look of disgust or flare their nostrils
4. Note contraction of the muscle tissue





O **medial inferior orbital margin of maxilla**

I **upper lip muscles**

A **elevation & eversion of upper lip**

N **facial** (CN VII)

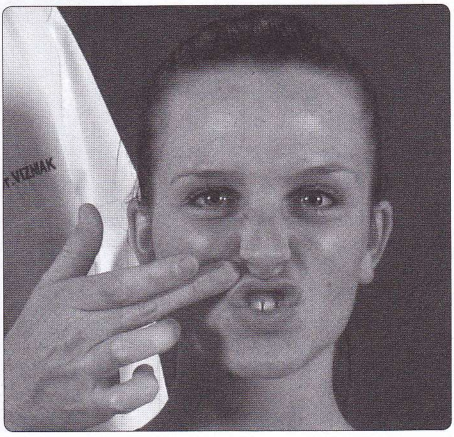
B facial artery

Clinical Notes

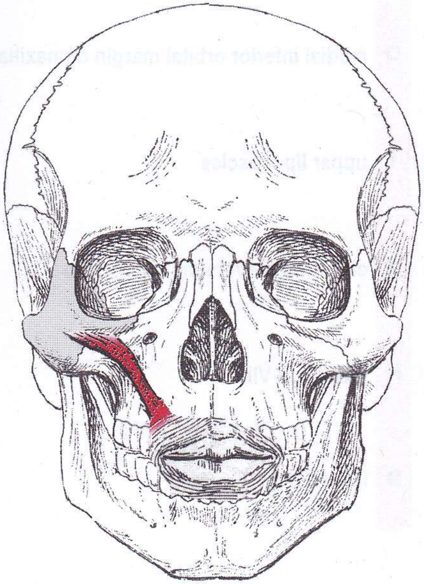
- *Levator labii superioris alaeque nasi* may also be considered to be an *angular head of the levator labii superioris*
- Fibers of the *levator labii superioris* blend with the *orbicularis oris & levator labii superioris alaeque nasi*
- *Levator labii superioris* is also known as the "Elvis" or "Rocky" muscle due to the action of elevating & everting the upper lip
- **ADL:** contraction of this muscle is associated with expressions of distrust, disgust or anger

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction ~1 cm lateral to nose
3. Ask patient to lift their upper lip like Elvis (show teeth & gums)
4. Note contraction of the muscle tissue



Zygomaticus Minor



O	**zygomatic bone** (posterior to zygomatic-maxillary suture)
I	**skin, fascia & muscles of upper lip**
A	**elevation of upper lip** (smile) **eversion of upper lip**
N	**facial nerve** (CN VII)
B	facial artery

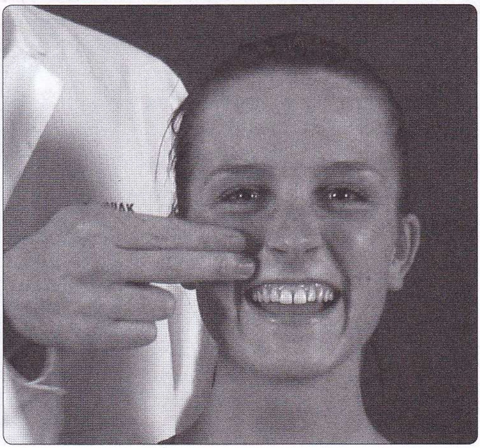
Clinical Notes

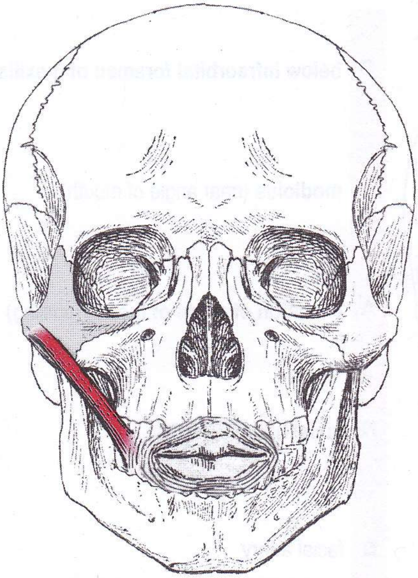
- **Anatomical variation:** *zygomaticus minor* fibers blend with *levator labii superioris & orbicularis oris*
- **ADL:** *Zygomaticus minor* contraction is associated with expressions of happiness, contempt & disgust
- MFTP referal pattern is the same a zygomaticus major

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction ~2 cm lateral to nose
3. Ask patient to lift their upper lip (show teeth & gums)
4. Note contraction of the muscle tissue

May be difficult to distinguish from levator labii superioris (fibers may blend together)

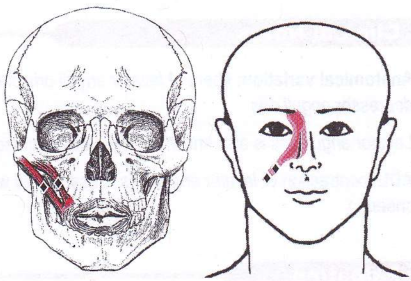




O	**zygomatic bone** (anterior to zygomatic-temporal suture)
I	**modiolus** (near angle of mouth)
A	**elevation of angle of mouth** (smiling) **pulls angle of mouth laterally**
N	**facial nerve** (CN VII)
B	facial artery

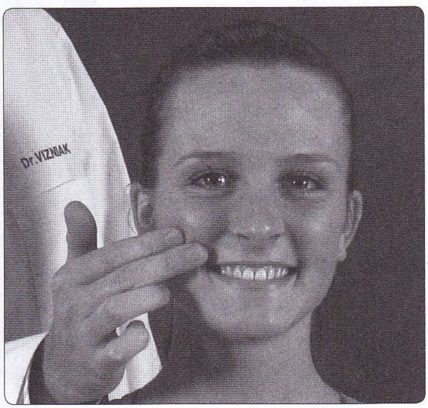
Clinical Notes

- *Zygomaticus major* fibers blend with levator anguli superioris & orbicularis oculi
- **ADL:** *Zygomaticus major* contraction is associated with expressions of happiness & laughter (smiling)
- MFTPs are usually located mid belly & refer pain over the nose & medial forehead

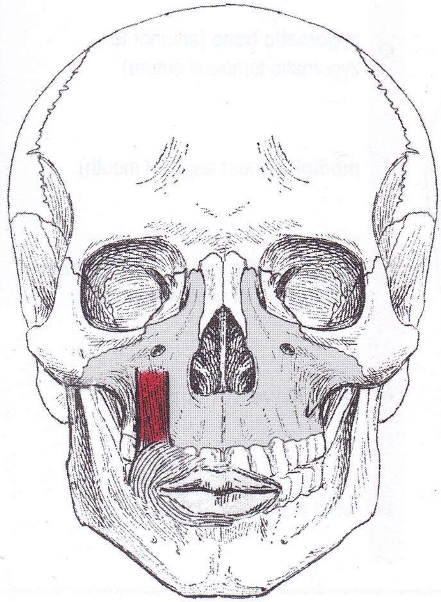


Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction above the angle of the mouth
3. Ask patient to smile
4. Note contraction of the muscle tissue



Levator Anguli Oris



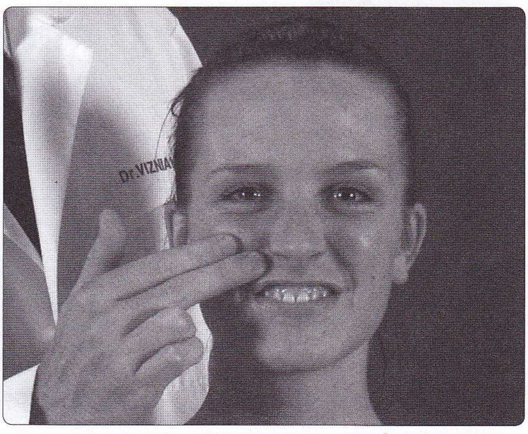
O	**below infraorbital foramen of maxilla**
I	**modiolus** (near angle of mouth)
A	**elevation of angle of mouth** (smiling)
N	**facial nerve** (CN VII)
B	facial artery

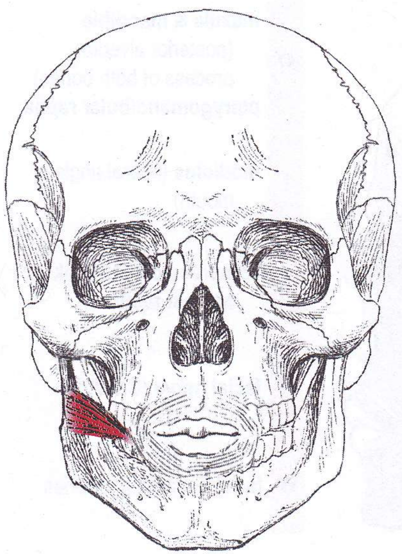
Clinical Notes

- **Anatomical variation:** fibers of *levator anguli oris* blend with *orbicularis oris, zygomaticus major & depressor anguli oris*
- *Levator anguli oris* is also known as the *caninus muscle* (contraction everts lip to expose canine teeth)
- **ADL:** contraction of *levator anguli oris* is associated with expressions of smiling, self confidence & sneering

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction above the angle of the mouth
3. Ask patient to smile or pull angle of mouth straight up to expose canine tooth
4. Note contraction of the muscle tissue





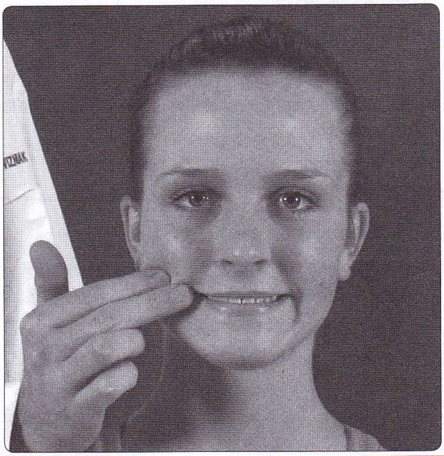
O	**parotid fascia** (superficial to masseter)
I	**modiolus** (near angle of mouth)
A	**pulls angle of mouth laterally** (false smile)
N	**facial nerve** (CN VII)
B	**facial artery**

Clinical Notes

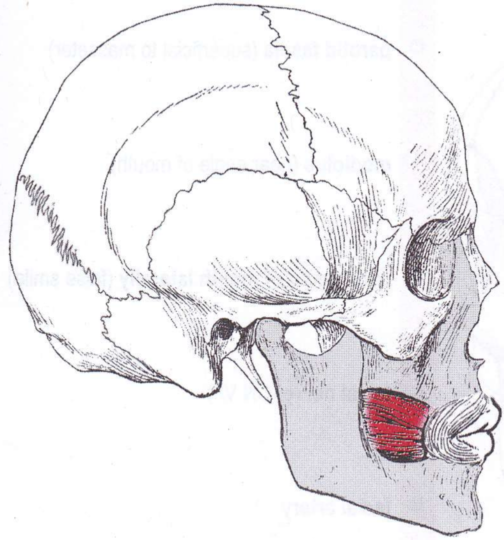
- There is significant anatomical variation in both the exact origin & insertion of *risorius*, but clinically the net action always remains the same
- *Risorius* is superficial to the *buccinator* muscle
- **ADL:** contraction of *risorius* results in expression associated with smiling & laughter (false smile)

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction lateral to angle of the mouth
3. Ask patient to pull angle of mouth back (false smile)
4. Note contraction of the muscle tissue

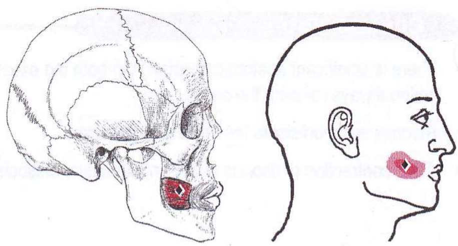


Buccinator



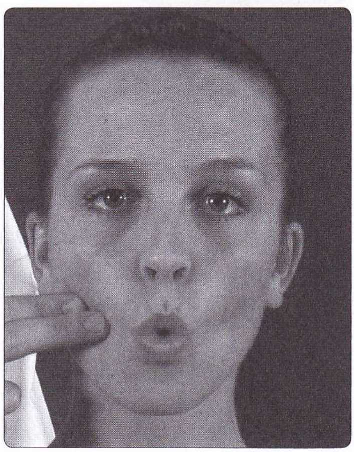
O	**maxilla & mandible** (posterior alveolar process of both bones) **pterygomandibular raphe**
I	**modiolus** (lateral angle of mouth)
A	**compression of cheek against teeth**
N	**facial nerve** (CN VII)
B	facial & maxillary arteries

Clinical Notes

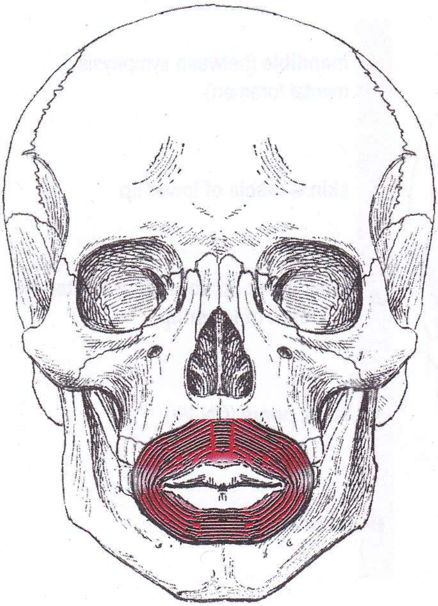


- *Buccinator* makes up the lateral wall of the oral cavity & is deep to *risorius*
- **ADL:** although not technically classified as a muscle of mastication, the *buccinator* does play an important role in eating by keeping food between the teeth; Contraction of the *buccinator* muscle bilaterally is required for forceful blowing of air from the mouth (whistling, blowing up a balloon); contraction of the *buccinator* may be associated with expressions of laughing, crying & satisfaction
- The parotid duct passes through the muscle belly of the buccinator
- MFTPs may be found mid belly & usually refer over the local area; sudden onset *Buccinator* pain has appeared following dental/orthotic work

Palpation



1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction, anterior to ramus of mandible & lateral to angle of the mouth
3. Ask patient to pull cheeks against teeth (not to suck in cheeks)
4. Note contraction of the muscle tissue



O	**modiolus** (just lateral to angle of mouth)
I	**circumferentially around mouth blends with other muscles**
A	**closes mouth** **protrusion of lips** (puckering of lips)
N	**facial nerve** (CN VII)
B	facial artery

Clinical Notes

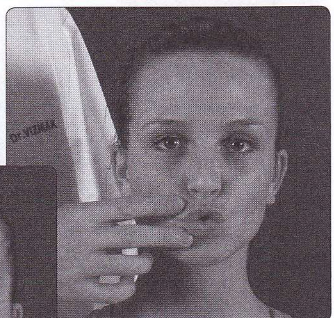
- *Orbicularis oris* can be divided into 4 regions corresponding to each quadrant to the mouth, left superior, left inferior, right superior & right inferior
- **ADL:** the primary function of *orbicularis oris* is observed during eating, drinking & talking (particularly when imitating monkeys "ooh, ooh, ooh, ooh" ☺)
- Fibers of *orbicularis oris* blend into *levator labii superioris, levator labii superioris alaeque nasi, depressor labii inferioris, depressor anguli oris, zygomaticus major & buccinator*

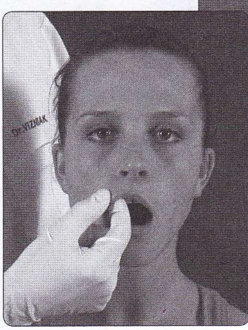
Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction around mouth
3. Ask patient to move & pucker lips
4. Note contraction of the muscle tissue

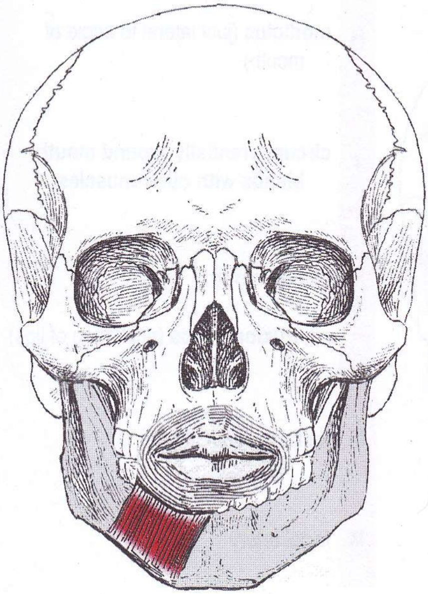
Inside mouth:

1. Wear latex gloves (flavored preferably)
2. Gently pinch skin just inside lip & outside lip
3. Ask patient to move & pucker lips
4. Note contraction of the muscle tissue





Depressor Labii Inferioris



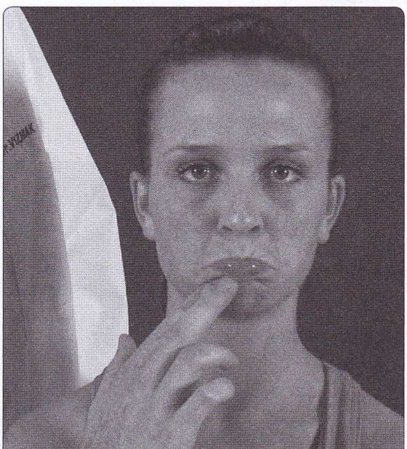
O	**mandible** (between symphysis & mental foramen)
I	**skin & fascia of lower lip**
A	**pulls lower lip downward & laterally eversion of lower lip**
N	**facial nerve** (CN VII)
B	facial artery

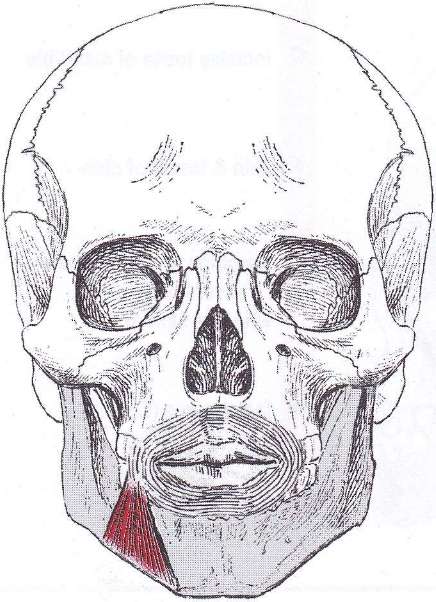
Clinical Notes

- Fibers of *depressor labii inferioris* blend with *orbicularis oris*
- **ADL:** contraction of *depressor labii inferioris* is associated expression of pouting, sorrow & doubt ("I don't know")

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction, inferior to lower lip
3. Ask patient to make a pouting face
4. Note contraction of the muscle tissue





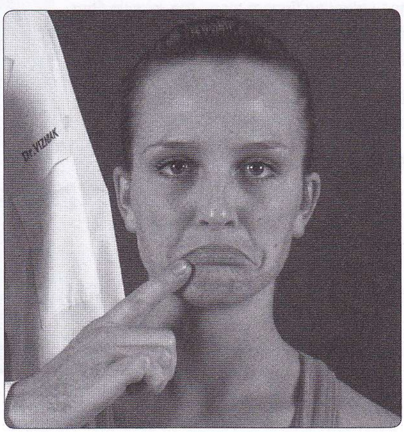
O	**oblique line of mandible** (lateral aspect of mental tubercle of mandible)
I	**modiolus** (near angle of mouth)
A	**depression of angle of mouth** (frown)
N	**facial nerve** (CN VII)
B	facial artery

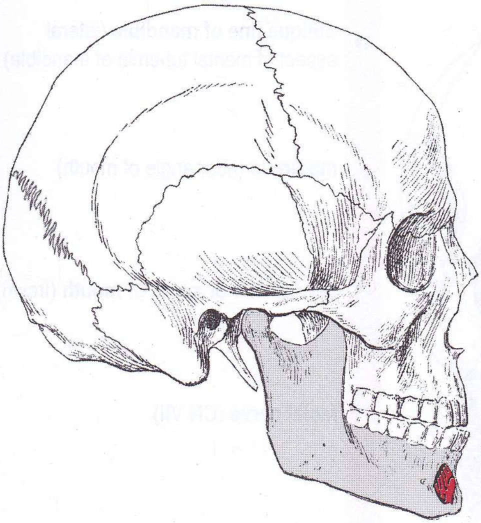
Clinical Notes

- **Anatomical variation:** fibers of *depressor anguli oris* blend into *levator anguli oris & platysma*
- **ADL:** contraction of *depressor anguli oris* is associated with expressions of sadness, pouting & doubt ("I don't know")

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction, inferior to angle of the mouth
3. Ask patient to make a sad clown face
4. Note contraction of the muscle tissue





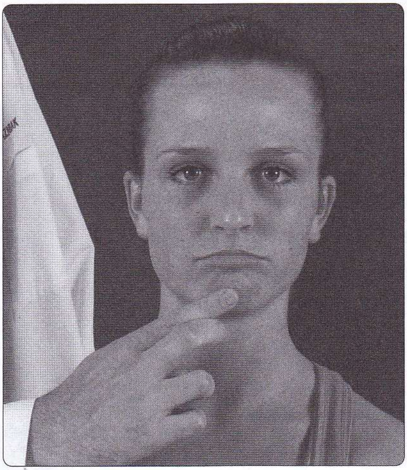
O	**incisive fossa of mandible**
I	**skin & fascia of chin**
A	**elevation & eversion of lower lip** **wrinkles skin of chin**
N	**facial nerve** (CN VII)
B	facial artery

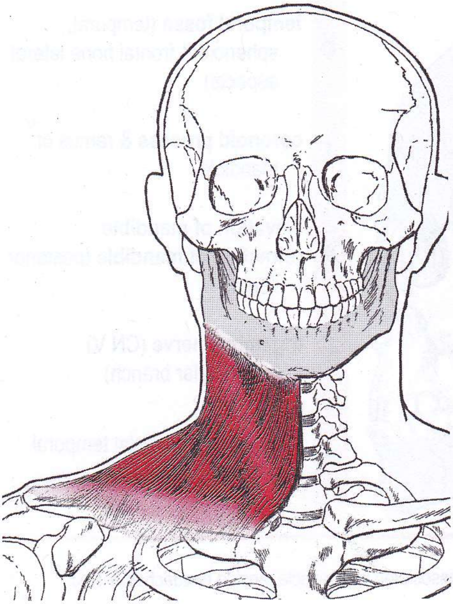
Clinical Notes

- **ADL:** Contraction of *mentalis* is associated with expressions of pouting, doubt, indecision & smug confidence

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction, inferior & just lateral to the midline of the mandible
3. Ask patient to make a pouting face & stick out lower lip
4. Note contraction of the muscle tissue





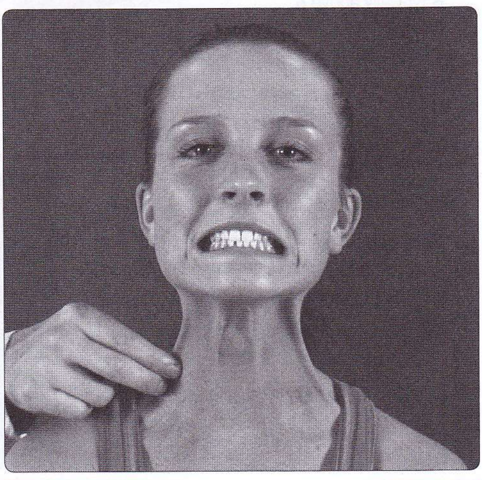
O	**subcutaneous fascia** (deltopectoral region)
I	**mandible & subcutaneous fascia of lower face**
A	**tenses skin over lower neck** (creates ridge in skin) depression of mandible & lower lip
N	**facial nerve** (CN VII)
B	facial artery

Clinical Notes

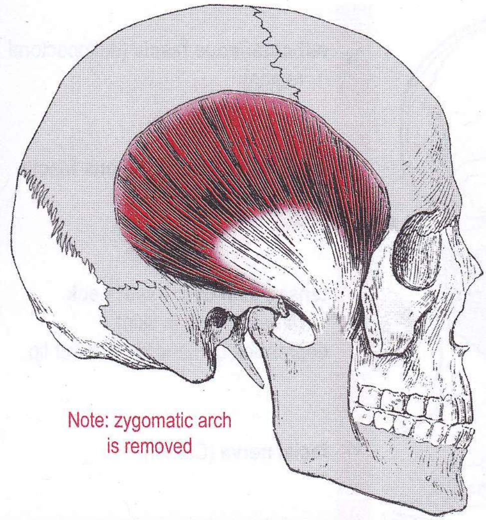
- Although technically correct, the action of *platysma* to depress jaw is extremely weak
- Fibers of the *platysma* may blend with the *risorius, depressor anguli oris & depressor labii inferioris*
- **ADL:** contraction of *platysma* is associated with extreme emotion & physical exertion

Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction over anterior neck
3. Ask patient to tense the skin of the neck by clenching their jaw & pulling the lower lip laterally
4. Note contraction of the muscle tissue (often visible as tight flaps of skin)



Temporalis

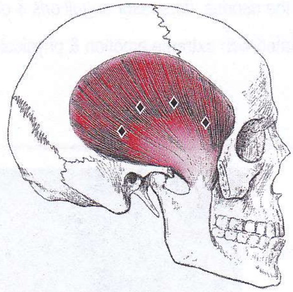


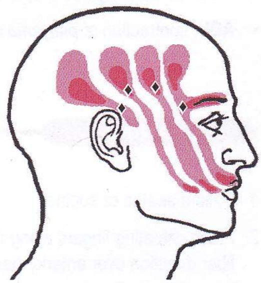
Note: zygomatic arch is removed

O	**temporal fossa** (temporal, sphenoid & frontal bone lateral aspects)
I	**coronoid process** & ramus of mandible
A	**elevation of mandible** **retraction of mandible** (posterior fibers)
N	**trigeminal nerve** (CN V) (mandibular branch)
B	maxillary & superficial temporal arteries

Clinical Notes

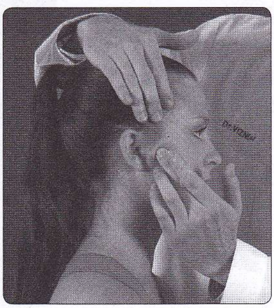
- Tightness & myospasm of *Temporalis* may be associated with muscle tension headaches & TMJ syndromes
- *Temporalis* is covered by a thick fibrous layer (temporal fascia); the more superficial fibers of *Temporalis* actually blend with the temporal fascia
- A pulse may be palpated over the *Temporalis* muscle by palpating the superficial temporal artery
- Test muscle strength by having patient bite down on tongue depressor
- MFTP pain referral is typically above & below & may also refer to upper teeth

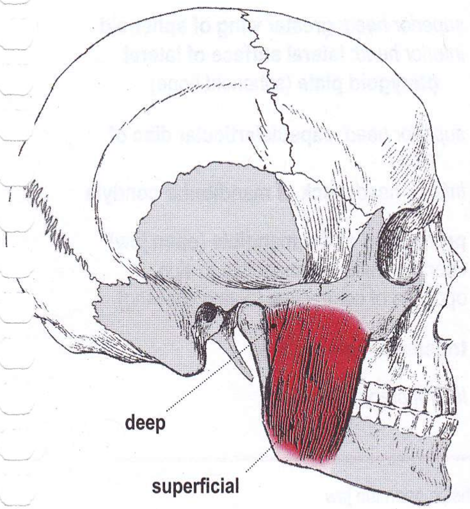




Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction, over temporal fossa and/or coronoid process of mandible
3. Ask patient to repeatedly clench & unclench teeth
4. Note contraction of the muscle tissue

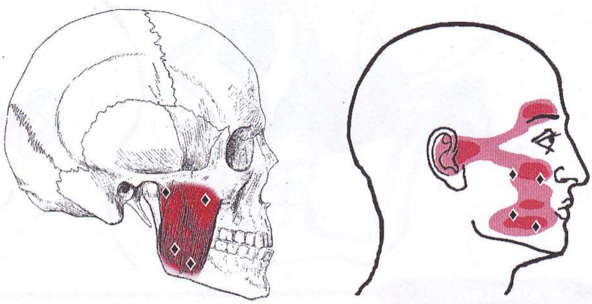




O	*superficial part:* **zygomatic process** (maxilla) **inferior border of zygomatic arch** *deep part:* **posterior aspect of inferior border of zygomatic arch**
I	*superficial part:* **angle & ramus of mandible** *deep part:* **superior ramus & coronoid process of mandible**
A	**elevation of mandible** (clenches teeth) protraction of mandible (anterior fibers) retraction of mandible (posterior fibers)
N	**trigeminal nerve** (CN V)
B	maxillary artery

Clinical Notes

- *Masseter* is the prime mover in elevation of the mandible (closing the mouth) and because of the leverage it develops on the mandible, many consider it among the strongest muscles in the body
- Tightness & myospasm of *Masseter* may be associated with muscle tension headaches & TMJ syndromes
- Test muscle strength by having patient bite down on tongue depressor
- MFTP are usually located near the origin or insertion & refer pain over the ear, cheek & jaw as well as above the eye & molars

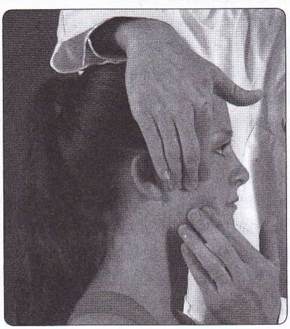


Palpation

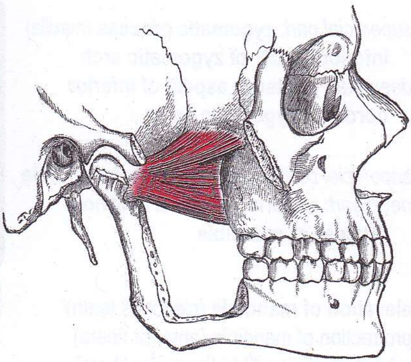
1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction, inferior to zygomatic arch
3. Ask patient to repeatedly clench & unclench teeth
4. Note contraction of the muscle tissue

Inside mouth:

1. Wear latex gloves (flavored preferably)
2. Pinch cheek just anterior to mandibular ramus
3. Ask patient to repeatedly open & close mouth
4. Note contraction of the anterior muscle fibers



Lateral Pterygoid

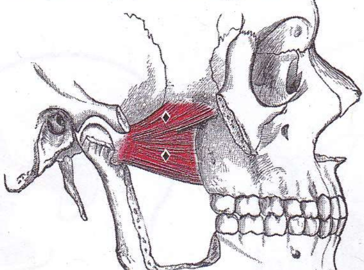


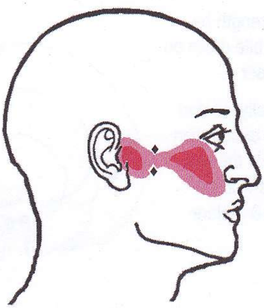
Note: zygomatic arch is removed

O	*superior head:* **greater wing of sphenoid** *inferior head:* **lateral surface of lateral pterygoid plate** (sphenoid bone)
I	*superior head:* **capsule/articular disc of TMJ** *inferior head:* **neck of mandibular condyle**
A	**protraction of the mandible (open jaw)** lateral deviation of mandible to side opposite of contraction (during chewing)
N	**trigeminal nerve** (CN V)
B	*lateral pterygoid* artery

Clinical Notes

- *Lateral pterygoid* is the only muscle of mastication that helps open the jaw
- Movements of lateral deviation are important during the mastication of food
- Because the *Lateral pterygoid* directly attaches to the TMJ it is often associated with TMJ syndromes & should be assessed in such cases
- Test muscle strength by resisting protraction of mandible
- MFTP refer pain over the TMJ & zygomatic arch



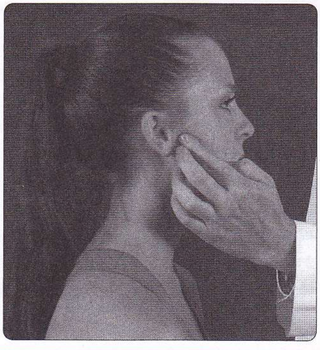


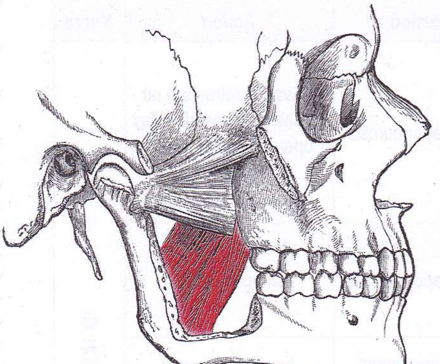
Palpation

1. Patient seated or supine
2. Place palpating fingers along the muscle fiber direction, inferior to zygomatic arch
3. Ask patient to repeatedly protract & retract their jaw
4. Note contraction of the muscle tissue (may be difficult to distinguish from masseter)

Inside mouth:

1. Wear latex gloves (flavored preferably)
2. Palpate upper back molars, then press posterior & finger slides into pocket area
3. Ask patient to repeatedly protract & retract mandible
4. Note contraction of the muscle fibers



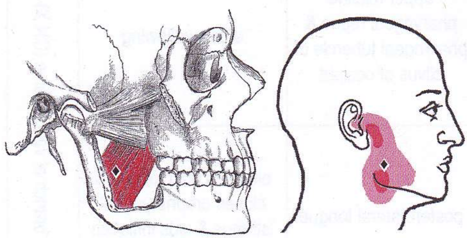


Note: zygomatic arch is removed

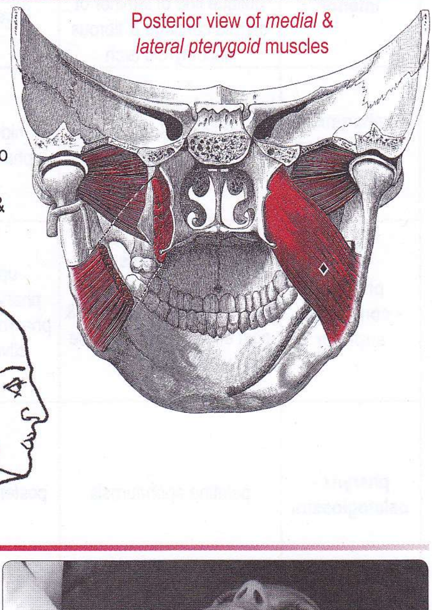
O	**medial surface of lateral pterygoid plate** (sphenoid bone) palatine bone & pterygoid fossa
I	**inner surface of mandibular ramus & angle of mandible**
A	**elevation of mandible** (clenches teeth) **lateral deviation of mandible** protraction of mandible
N	**trigeminal nerve** (CN V)
B	*medial pterygoid* artery

Clinical Notes

- *Medial pterygoid* is the muscle most responsible for lateral deviation of the mandible (important movement during mastication)
- Hypertonicity of the *Medial pterygoid* may be associated with TMJ dysfunction
- Test muscle strength by having patient bite down o tongue depressor
- MFTP are commonly located in the muscle belly & pain referral is usally over the TMJ & angle of the mandible both on the internal & external aspects

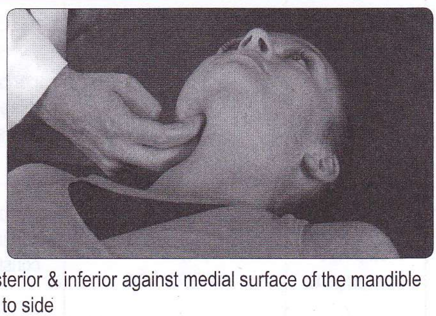


Posterior view of *medial & lateral pterygoid* muscles



Palpation

1. Patient seated or supine
2. Gently hook palpating fingers along the muscle fiber direction under angle of mandible
3. Ask patient to repeatedly clench & unclench their jaw
4. Note contraction of the muscle tissue (may be difficult to distinguish from masseter)

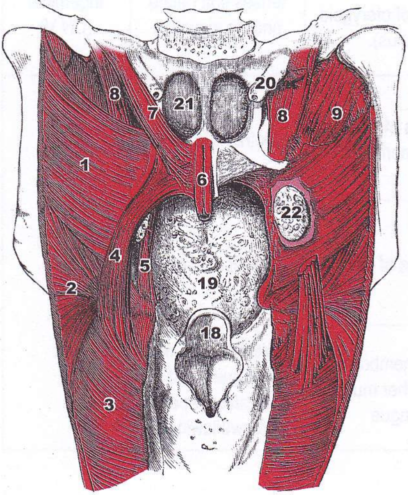


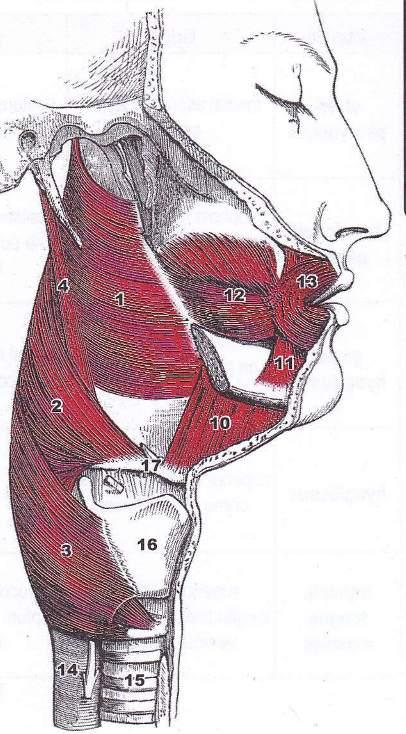
Inside mouth:

1. Wear latex gloves (flavored preferably)
2. Palpate lower back molars, then gentely press posterior & inferior against medial surface of the mandible
3. Ask patient to alternately move their jaw form side to side
4. Note contraction of the muscle fibers

Muscle	Origin	Insertion	Action	Nerve
levator veli palatini	apex of inf surface of petrous temporal bone & medial rim of auditory tube	palatine aponeurosis	elevates, retracts & lat deviates soft palate. May open auditory tube on swallowing	pharyngeal branch of vagus nerve (CN X) with motor fibres from spinal accessory nerve (CN XI)
m. uvulae	posterior border of hard palate	palatine aponeurosis	shapes uvula	
pharynx - constrictor inferior	*Cricopharyngeus:* lateral aspect of arch of cricoid cartilage. *Thyropharyngeus:* oblique line of laminar of thyroid cartilage & fibrous cricothyroid arch	*Cricopharyngeus:* continuous with muscle of opposite side *Thyropharyngeus:* lower pharyngeal raphe	aids swallowing; *Cricopharyngeus* acts as upper esophageal sphincter	
pharynx - constrictor middle	lower third of stylohyoid lig, lesser cornu & sup border of greater cornu of hyoid bone	middle portion of pharyngeal raphe	aids swallowing	
pharynx - constrictor superior	lower two thirds of med pterygoid plate, pterygomandibular raphe & post end of mylohyoid line on mandible	upper midline pharyngeal raphe & pharyngeal tubercle of clivus of occiput	aids swallowing	
pharynx - palatoglossus	palatine aponeurosis	posterolateral tongue	elevates post tongue & closes oropharyngeal isthmus & aids initiation of swallowing	
pharynx - palato-pharyngeus	palatine aponeurosis & post margin of hard palate	upper border of thyroid cartilage & blends with constrictor fibers	elevates pharynx & larynx; *Passavant's* muscle closes nasopharyngeal isthmus in swallowing	
pharynx - salpingo-pharyngeus	inferior cartilage & mucosa of pharyngeal orifice of auditory tube	upper border of thyroid cartilage & inferior constrictor muscle fibers	elevates pharynx & larynx & aids swallowing; opens auditory canal during swallowing	

Posterior view with pharynx reflected





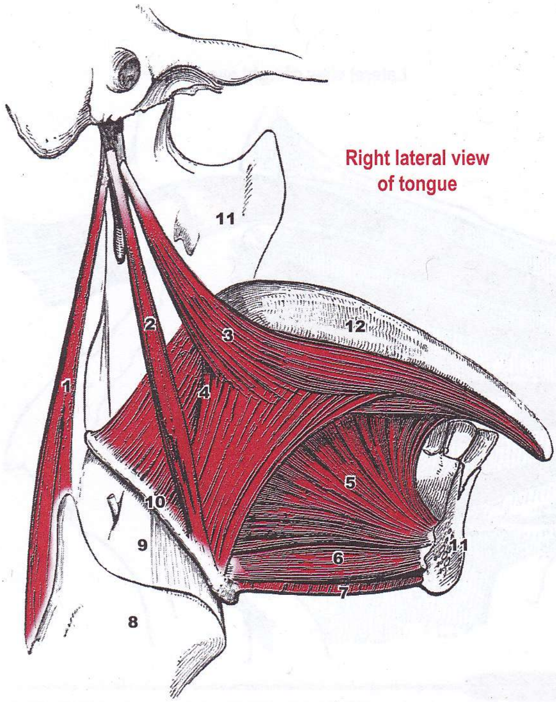
1. superior pharyngeal constrictor
2. middle pharyngeal constrictor
3. inferior pharyngeal constrictor
4. palato-pharyngeus
5. palato-glossus
6. musculus uvulae
7. levator veli palatini
8. tensor tympany
9. lateral pterygoid
10. mylohyoid
11. depressor anguli inferioris
12. buccinator
13. orbicularis oris
14. esophagus
15. trachea
16. thyroid cartilage
17. hyoid bone
18. epiglottis
19. tongue (posterior)
20. eustatchian tube
21. posterior naris (nasal avity)
22. tonsil

Tongue

Muscle	Origin	Insertion	Action	Nerve
stylo-pharyngeus	medial aspect of styloid process	posterolateral border of thyroid cartilage	elevates larynx & pharynx aids swallowing	glosso-pharyngeal nerve (CN IX)
tensor veli palatini	scaphoid fossa & medial aspect of spine of sphenoid bone	palatine aponeurosis (via pulley of pterygoid hamulus).	tenses soft palate prior to elevation	trigeminal (CN V)
genio-hyoglossus	superior mental spine on posterior surface of symphysis menti	central mass of tongue & mucous membrane	protracts tongue	hypoglossal nerve (CN XII)
hyoglossus	superior border of greater cornu of hyoid bone	lateral sides of tongue	depresses tongue	
intrinsic tongue muscles	superior & inferior longitudinal, transverse & vertical elements	mucous membrane, septum & other muscles of tongue	alters shape of tongue & aid mastication, speech & swallowing	

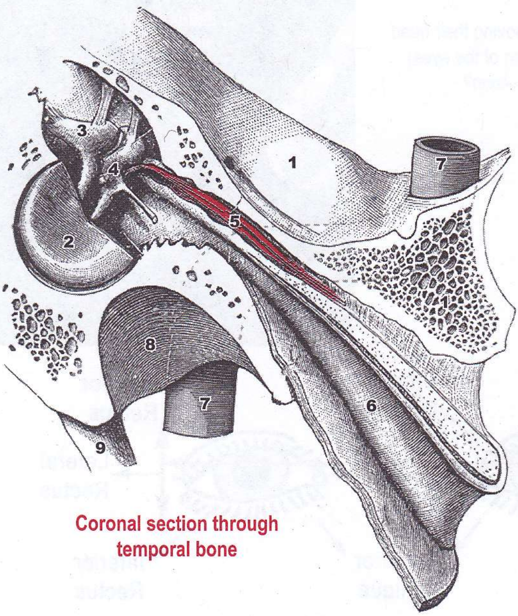
Tympanic Cavity

Muscle	Origin	Insertion	Action	Nerve
stapedius	posterior wall of middle ear	neck of stapes	protects & damps ossicular chain	facial nerve (CN VII)
tensor tympani	cartilaginous & bony margins of auditory tube	handle of malleus (via processus trochleariformis)	protects & damps ossicular chain	trigeminal nerve (CN V)



Right lateral view of tongue

1. stylopharyngeus
2. stylohyoid
3. styloglossus
4. hyoglossus
5. geniohyoglossus
6. geniohyoid
7. mylohyoid
8. thyroid cartilage
9. thyrohyoid membrane
10. hyoid bone
11. mandible



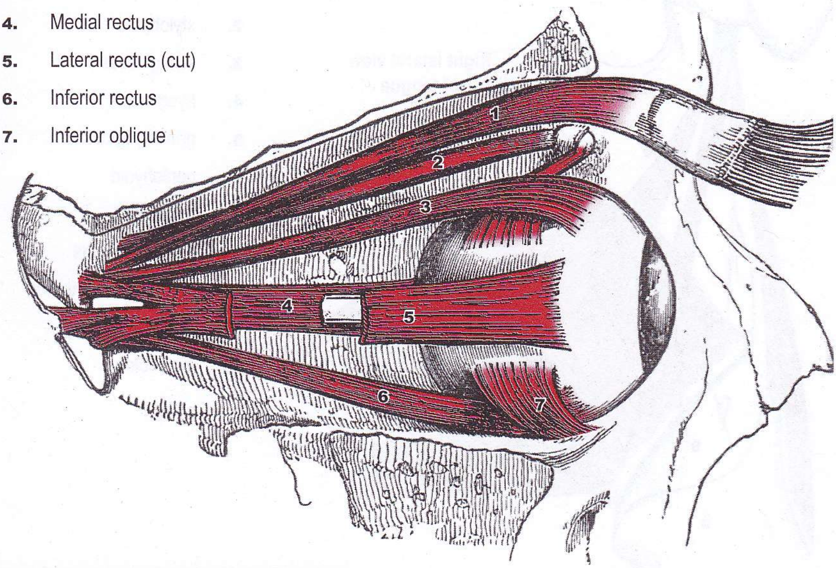
Coronal section through temporal bone

1. temporal bone
2. tympanic membrane
3. incus
4. malleus
5. tensor tympani
6. eustachian tube (open)
7. carotid artery
8. mandibular fossa
9. styloid process

Muscles of the Eye

1. Levator palpebrae
2. Superior oblique
3. Superior rectus
4. Medial rectus
5. Lateral rectus (cut)
6. Inferior rectus
7. Inferior oblique

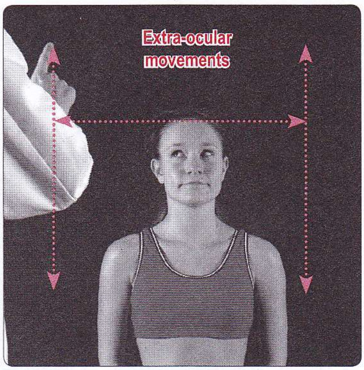
Lateral view of right eye

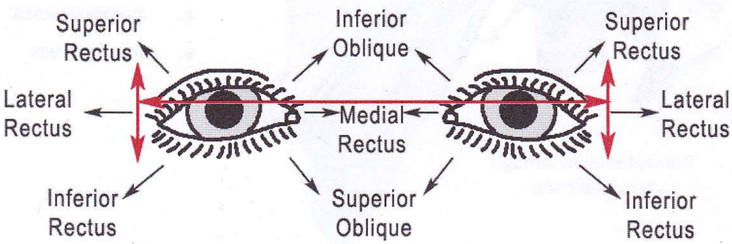


Muscle Nerve Test

Extra-ocular movements (H-pattern)

- Ask patient to follow finger with out moving their head
- Note presence of *nystagmus* (fluttering of the eyes)
- Ask patient: did you note any *double vision*?

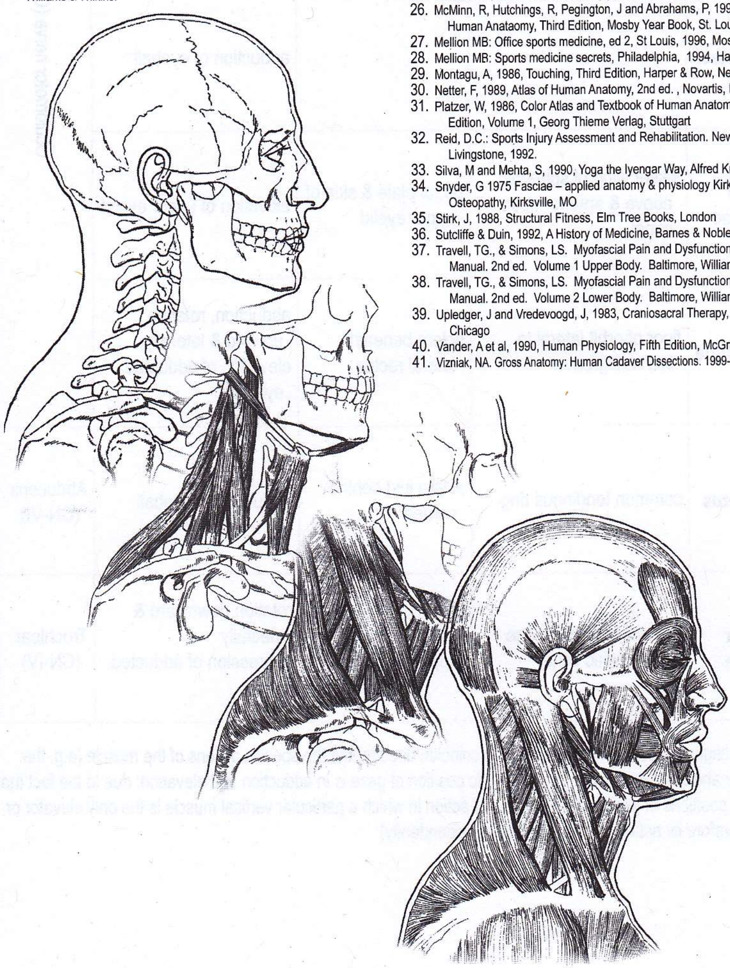


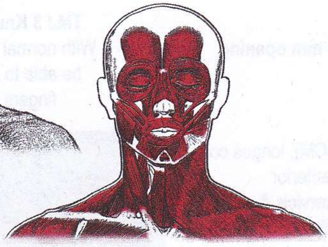


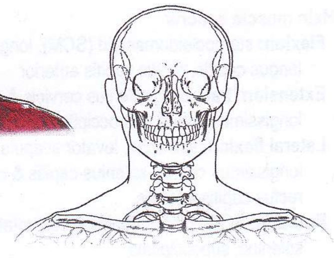
<table>
<tr><th>Muscle</th><th>Origin</th><th>Insertion</th><th>Action</th><th>Nerve</th></tr>
<tr><td>Superior rectus</td><td rowspan="3">common tendinous ring</td><td rowspan="3">sclera just behind cornea</td><td>elevation & adduction of eyeball</td><td rowspan="5">Oculomotor nerve (CN-III)</td></tr>
<tr><td>Inferior rectus</td><td>depression & adduction of eyeball</td></tr>
<tr><td>Medial rectus</td><td>adduction of eyeball</td></tr>
<tr><td>Levator palpebrae</td><td>lesser wing of sphenoid above & anterior optic canal</td><td>tarsal plate & skin of upper eyelid</td><td>elevation of upper eyelid</td></tr>
<tr><td>Inferior oblique</td><td>floor of orbit lateral to lacrimal groove</td><td>sclera beneath lateral rectus</td><td>abduction, rotation upward & laterally;
elevation of adducted eye</td></tr>
<tr><td>Lateral rectus</td><td>common tendinous ring</td><td>sclera just behind cornea</td><td>abduction of eyeball</td><td>Abducens (CN-VI)</td></tr>
<tr><td>Superior oblique</td><td>body of sphenoid bone above optic canal</td><td>sclera beneath superior rectus</td><td>rotation downward & medially
depression of adducted eye</td><td>Trochlear (CN-IV)</td></tr>
</table>

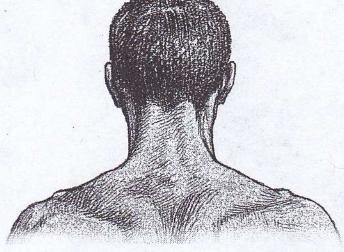
Note that the diagnostic positions of gaze do not coincide directly with the specific actions of the muscle (e.g. the inferior oblique abducts the eye, but the diagnostic position of gaze is in adduction and elevation; due to the fact that the diagnostic positions of gaze isolate the field of action in which a particular vertical muscle is the only elevator or depressor, therefore its action can be assessed independently)

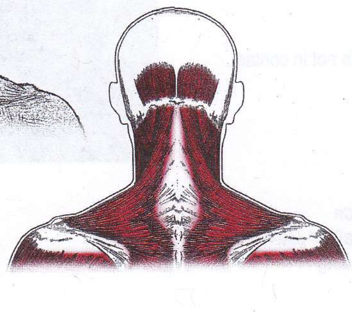
1. Acland, R, 2008., Video Atlas of Human Anatomy, Williams & Wilkins, Baltimore
2. Beck M 1994 Milady's Theory and Practice of Therapeutic Massage, Milady Pub, Albany, NY
3. Cailliet, R, 1977, Soft Tissue Pain and Disability, F.A. Davis Company, Philadelphia
4. Calais-Germain, B, 1993, Anatomy of Movement, Eastland Press, Seattle
5. Cameron, J et al, 1992, Physics of the Body, Medical Physics Publishing, Madison, WI
6. Canale ST: Campbell's operative orthopaedics, vol 1-4, ed 9, St Louis, 1998, Mosby.
7. Cantu, RL,& Grodin, A. 1992: Myofascial manipulation - Theory and Clinical Application, Aspen Publishers Inc. 1992.
8. Chaitow, L, 1980, Soft Tissue Manipulation, Thorsons Publishing Group, Wellingborough, Northamptonshire, U.K. & 1996, Palpatory Skills, Churchill Livingstone, Edinburgh
9. Clemente, C, 1987, Anatomy, A Regional Atlas of the Human Body, Third Edition, Lea & Febiger, Philadelphia
10. Cottingham, J, 1985, Healing Through Touch, Rolf Institute, Boulder, CO
11. Cyriax, JH. & Cyriax, PJ. Cyriax's Illustrated Manual of Orthopedic Medicine, 3rd ed., Butterworth-Heinemann, 1996.
12. Dambro MR, Griffith JA: Griffith's 5 minute clinical consult, Baltimore, 2008, Williams & Wilkins.
13. Dandy DJ: Essential orthopaedics and trauma, Edinburgh, 1989, Churchill Livingstone.
14. Fritz, S 1999 Mosby's Fundamentals of Therapeutic Massage, 2nd ed, Mosby, NY
15. Gartland, I.I.: Fundamentals of Orthopaedics. Philadelphia, W.B. Saunders Co., 1979.
16. Gray et al, 1995, Gray's Anatomy, 38th Edition, Churchill Livingstone, New York
17. Greenman, PE. Principles of Manual Medicine, 2nd ed., Williams & Willkins, 1995.
18. Hoppenfeld, S.: Physical Examination of the Spine and Extremities. New York, Appleton-Century-Crofts, 1976.
19. Kapandji, I, 1982, The Physiology of Joints, Fifth Edition, Volumes 1,2, and 3, Churchill Livingstone, Edinburgh
20. Kapandji, I.A.: The Physiology of Joints, vol. 1: Upper Limb. New York, Churchill Livingstone, 1970.
21. Kendall HO, Kendall FP, Wadsworth GE: Muscles testing and function, ed 4, Baltimore, 2003, Williams & Wilkins.
22. Kisner C, Colby LA: Therapeutic exercise; foundations and techniques, ed 2, Philadelphia, 1990, FA Davis.
23. Leonard, CT, 1998, The Neuroscience of Human Movement, Mosby, St. Louis, MO
24. Martin JH: Neuroanatomy text and atlas, ed 2, Stamford, Conn, 1996, Appleton & Lange.
25. Mathers LH, et al: Clinical anatomy principles, St Louis, 1996, Mosby.
26. McMinn, R, Hutchings, R, Pegington, J and Abrahams, P, 1993, Color Atlas of Human Anataomy, Third Edition, Mosby Year Book, St. Louis, MO
27. Mellion MB: Office sports medicine, ed 2, St Louis, 1996, Mosby.
28. Mellion MB: Sports medicine secrets, Philadelphia, 1994, Hanley & Belfus.
29. Montagu, A, 1986, Touching, Third Edition, Harper & Row, New York
30. Netter, F, 1989, Atlas of Human Anatomy, 2nd ed. , Novartis, New Jersey
31. Platzer, W, 1986, Color Atlas and Textbook of Human Anatomy, Third Revised Edition, Volume 1, Georg Thieme Verlag, Stuttgart
32. Reid, D.C.: Sports Injury Assessment and Rehabilitation. New York, Churchill Livingstone, 1992.
33. Silva, M and Mehta, S, 1990, Yoga the Iyengar Way, Alfred Knopf, New York
34. Snyder, G 1975 Fasciae – applied anatomy & physiology Kirksville College of Osteopathy, Kirksville, MO
35. Stirk, J, 1988, Structural Fitness, Elm Tree Books, London
36. Sutcliffe & Duin, 1992, A History of Medicine, Barnes & Noble, NY
37. Travell, TG., & Simons, LS. Myofascial Pain and Dysfunction: The Trigger Point Manual. 2nd ed. Volume 1 Upper Body. Baltimore, Williams & Wilkins, 1993.
38. Travell, TG., & Simons, LS. Myofascial Pain and Dysfunction: The Trigger Point Manual. 2nd ed. Volume 2 Lower Body. Baltimore, Williams & Wilkins, 1993.
39. Upledger, J and Vredevoogd, J, 1983, Craniosacral Therapy, Eastland Press, Chicago
40. Vander, A et al, 1990, Human Physiology, Fifth Edition, McGraw-Hill, New York
41. Vizniak, NA. Gross Anatomy: Human Cadaver Dissections. 1999-2008

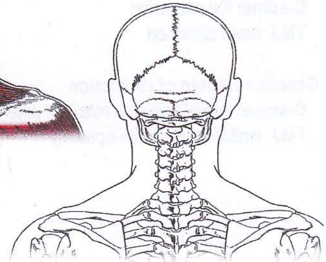












Cervical Kinematics

Joint types:
- Gliding (zygapophyseal joints)
- Pivot (atlantoaxial joint)
- Fibrocartilaginous (intervertebral joints)
- Hinge & gliding (TMJ)

Articular surfaces
- **Atlanto-occipital joint:** *convex* (occipital condyles of occiput) on *concave* (superior articular facets of atlas)
- **Atlantoaxial:** *concave* (articular facet for dens on atlas) *on convex* (anterior facet of dens on axis)
- **Zygapophyseal:** facets are oriented 45°
- **Intervertebral discs:** horizontal plane
- **TMJ:** *convex* (mandibular condyle & disc) *on concave* (mandibular fossa of temporal bone)

Active range of motion
- **Flexion** .... **60°**
- **Extension** .... **60°**
- **Lateral Flexion** .... **45°**
- **Rotation** .... **80°**
- **TMJ** .... **35-50 mm opening** (3 knuckle test)

Main muscle actions
- **Flexion:** sternocleidomastoid (SCM), longus coli, longus capitis, rectus capitis anterior
- **Extension:** trapezius, splenius cervicis & capitis, longissimus capitis, suboccipitals
- **Lateral flexion:** scalenes, levator scapula, longissimus capitis, splenius capitis & cervicis, rectus capitis lateralis
- **Rotation:** SCM, longus capitis & coli, rotatores, splenius, suboccipitals

Resting position
- **C-spine:** slight extension
- **TMJ:** mouth closed with teeth not in contact

Close packed position
- **C-spine:** full extension
- **TMJ:** teeth clenched

Capsular pattern of restriction
- **C-spine:** lateral flexion = rotation, extension
- **TMJ:** limitation of mouth opening

Normal end feel
- **Flexion:** tissue stretch
- **Extension:** tissue stretch
- **Lateral flexion:** tissue stretch
- **Rotation:** tissue stretch

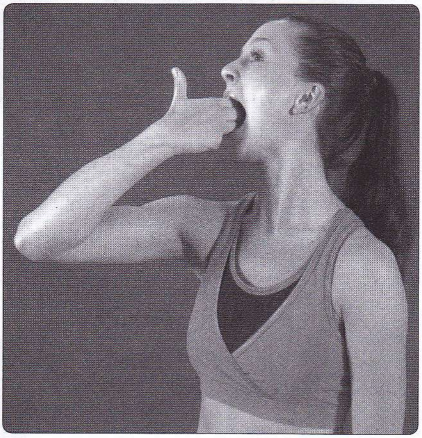
Abnormal end feel
- **Early myospasm** → muscle/ligament tear
- **Late myospasm** → instability
- **Empty** → ligament rupture
- **Hard** → bone approximation (osteophyte)

Coupled motions

Pure rotation and pure lateral flexion do not occur at any region in the spine

C2-T5 vertebral segments
- Ipsilateral flexion & lateral flexion
- Left lateral flexion coupled with leftt rotation
- Right lateral flexion coupled with rightt rotation

TMJ 3 Knuckle or 3-Finger Test:
With normal TMJ ROM patient should be able to place three knuckles or fingers between open teeth



Neck

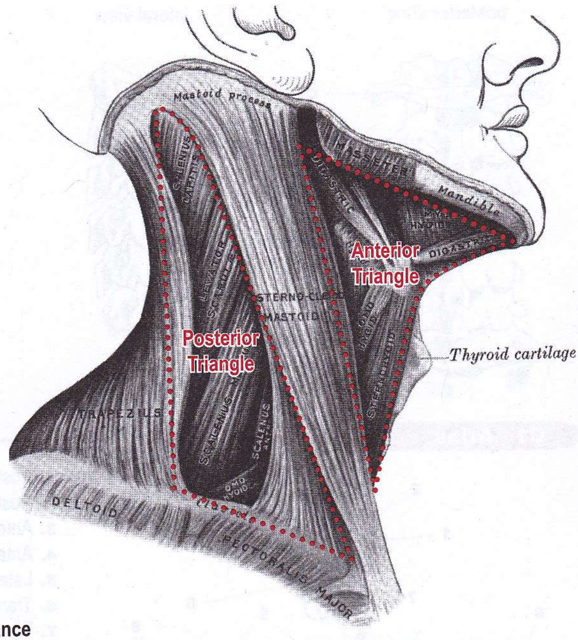
Posterior Triangle

Borders:

- *Sternocleidomastoid* (anterior), trapezius (posterior), middle third of the clavicle (base), occipital bone (apex)
- Platysma & deep cervical fascia (roof), *scalenes, splenius* & *levator scapulae* (floor)

Occipital & subclavian triangles

- The space is crossed, about 2 cm above the clavicle, by the inferior belly of the *omohyoid*, which divides it into two triangles; an upper or occipital triangle & a lower or subclavian triangle



Contents & Clinical Significance

- It contains the spinal accessory nerve, external jugular vein, roots & trunks of the brachial plexus.
- It is particularly vulnerable to damage at lymph node biopsy, where damage results in an inability to shrug the shoulders or raise the arm above the head (e.g., ADL for brushing hair)

Anterior Triangle

Borders

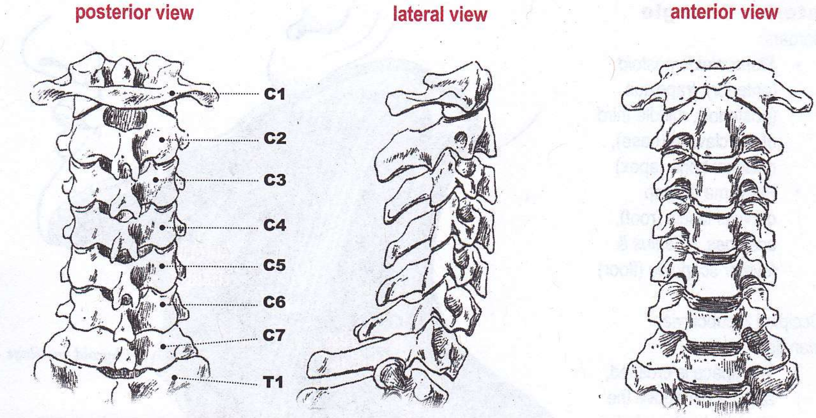
- Middle line of the neck (anterior)
- Anterior margin of the *Sternocleidomastoid* (posterior)
- Inferior border of the body of the mandible (base),

This space is subdivided into four smaller triangles by the *digastric* muscle above, & the superior belly of the *omohyoid* below; the smaller triangles are named:

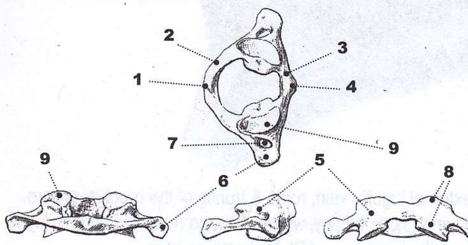
- *Muscular (inferior carotid) triangle* (between superior belly of omohyoid, lower anterior margin of SCM & mid-line of the neck}
- *Carotid triangle* (between posterior belly of the digastric, superior belly of omohyoid & deep SCM)
- *Digastric (submaxillary) triangle* (between posterior & anterior bellies of digastric & inferior border of mandible; its floor is formed by the mylohyoid, hyoglossus & middle constrictor muscles
- *Submental triangle* (between anterior belly of digastric, superior to hyoid bone & mid-line of neck)

Contents & Clinical Significance

- It contains the common carotid artery, internal jugular vein, vagus nerve, lymph nodes
- It is particularly vulnerable to damage during aggressive palpation & treatment, in which patients may experience pain, discomfort & even a loss of consciousness in sever cases. Great care should be taken in examining & treating this area

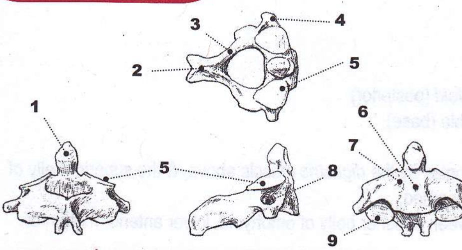


C1 - Atlas



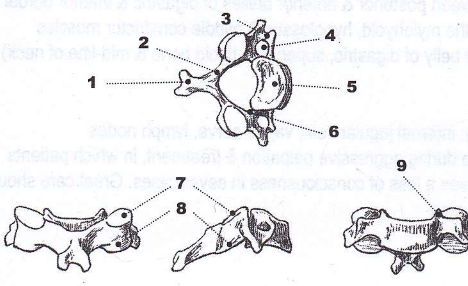
1. Posterior tubercle (no spinous process)
2. Posterior arch
3. Anterior arch
4. Anterior tubercle
5. Lateral mass (no body)
6. Transverse process
7. Transverse foramen
8. Articular process (superior & inferior)
9. Superior articular facet

C2 - Axis



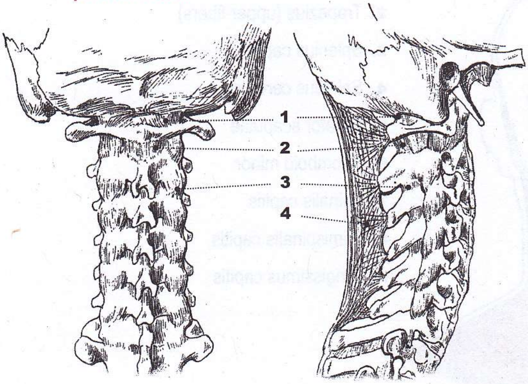
1. Dens (odontoid process)
2. Spinous process (bifid)
3. Lamina
4. Transverse process
5. Superior articular facet
6. Body
7. Pedicle
8. Transverse foramen
9. Inferior articular facet

Typical Cervical Vertebra

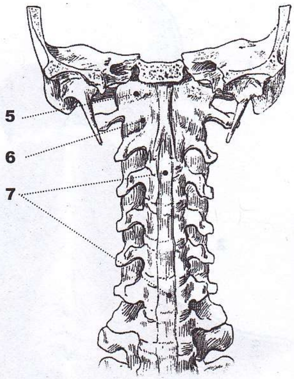


1. Spinous process (bifid)
2. Lamina
3. Transverse process
4. Transverse foramen
5. Body
6. Pedicle
7. Superior articular facet
8. Inferior articular process
9. Uncinate process (uncus)

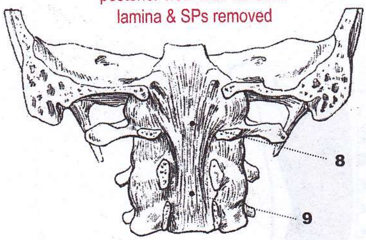
posterior view | lateral view

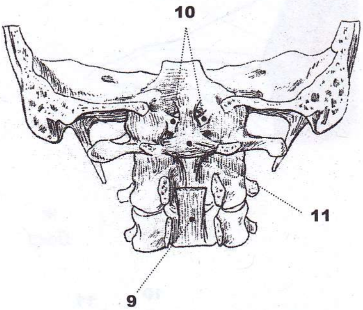


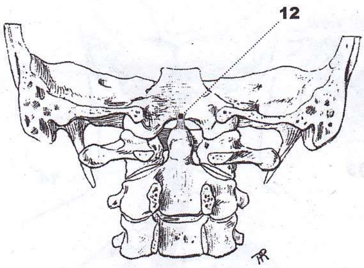
anterior view



posterior view with vertebral lamina & SPs removed



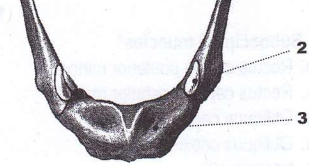


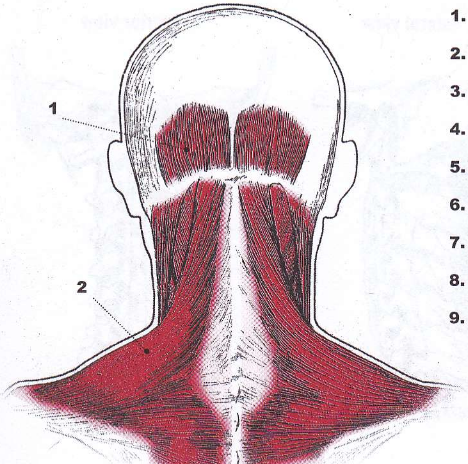


1. Posterior atlanto-occipital membrane
2. Posterior atlantoaxial membrane
3. Capsular ligaments (zygapophyseal)
4. Nuchal ligament
5. Anterior atlanto-occipital membrane
6. Anterior atlantoaxial membrane
7. Anterior longitudinal ligament
8. Tectorial membrane
9. Posterior longitudinal ligament
10. Alar ligaments
11. Cruciform / cruciate ligament
12. Apical ligament

Hyoid Bone
(anterior superior view)

1. Greater cornu
2. Lesser cornu
3. Body

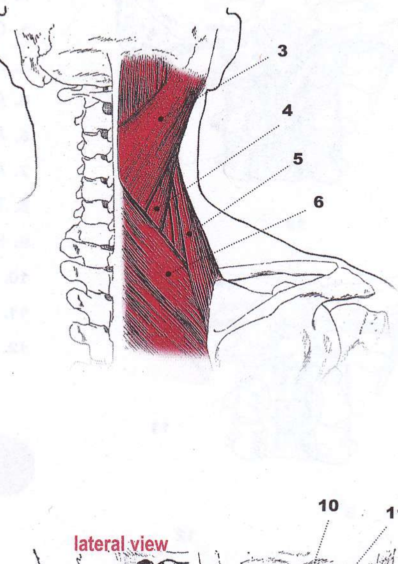


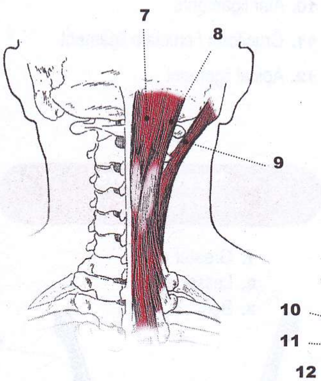


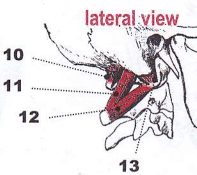
Superficial

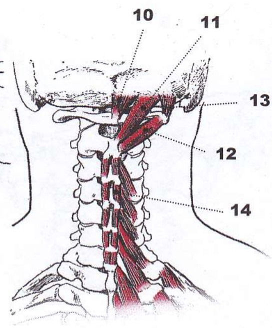
1. Occipitalis
2. Trapezius (upper fibers)
3. Splenius capitis
4. Splenius cervicis
5. Levator scapulae
6. Rhomboid minor
7. Spinalis capitis
8. Semispinalis capitis
9. Longissimus capitis

Deep





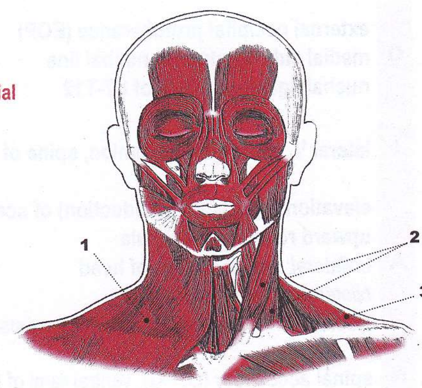


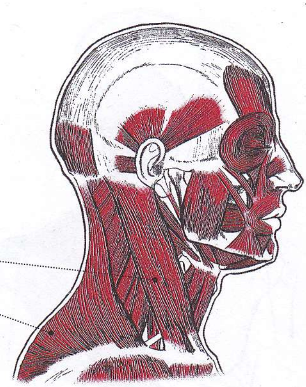


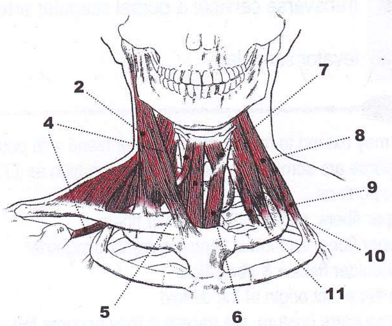
Suboccipital muscles*

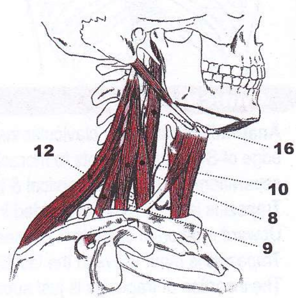
10. Rectus capitis posterior minor*
11. Rectus capitis posterior major*
12. Obliquus capitis inferior*
13. Obliquus capitis superior*
14. Interspinalis

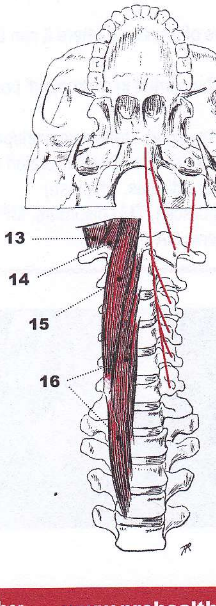
Superficial







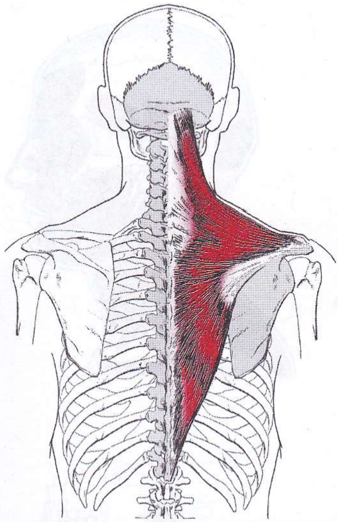




Deep

1. Platysma
2. Sternocleidomastoid
3. Trapezius
4. Omohyoid
5. Sternohyoid
6. Sternothyroid
7. Thyrohyoid
8. Middle scalene
9. Posterior scalene
10. Anterior scalene
11. Scalenus minimus
12. Levator scapulae
13. Rectus capitis lateralis
14. Rectus capitis anterior
15. Longus capitis
16. Longus cervicis

Lines indicate muscle attachments to the base of the skull



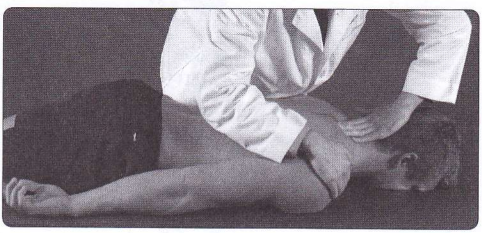
O	**external occipital protuberance (EOP)** **medial side of superior nuchal line** **nuchal ligament & SPs of C7-T12**
I	**lateral $^1/_3$ of clavicle, acromion, spine of scapula**
A	**elevation & retraction (adduction) of scapula** **upward rotation of scapula** *unilateral:* **lateral flexion of head** *bilateral:* **extension of head** stabilization of scapula for arm movements
N	**spinal accessory** (CN XI), ventral rami of C2-C4
B	transverse cervical & dorsal scapular arteries
S	levator scapulae

Clinical Notes

- **Anatomical variation:** clavicular insertion may extend to middle of clavicle, or blend with posterior edge of SCM; attachments to thoracic vertebrae are sometimes reduced (up to as high as T7); often separations between the cervical & thoracic portions
- Trapezius is often clinically divided into: upper fibers, middle fibers & lower fibers
- Upward rotation of scapula is caused by upper fibers and lower fibers contracting together
- *Trapezius* is most active in the last 60º of shoulder flexion & abduction
- The insertion of trapezius is just superior to the exact origin of the deltoid
- With an anterior head carriage & rounded shoulders posture, the trapezius may become fatigued which may contribute to postural fatigue syndrome
- The greater occipital nerve passes through the upper fibers of *trapezius* where it can be compressed, potentially contributing to muscle tension headaches
- Paralysis of trapezius will cause the ipsilateral shoulder to be carried in a 'dropped' position & weakness in the final 60º of shoulder abduction
- **Common injuries:** Postural Fatigue Syndrome (trapezius myalgia) - repetitive work/posture sitting at a computer, desk or working with a mouse (other contributing factors: anterior rotated shoulders, large breasts, cradling a phone on one shoulder, one-sided sports activities, whiplash)
- **DDx:** trapezius myalgia, articular dysfunction (cervical or thoracic), TMJ disorders, MFTPs in other muscles, tension headache, occipital neuralgia & cervicogenic HA

Palpation

1. Patient prone
2. Place palpating hand over upper trapezius
3. Ask patient to elevate their arm/shoulder (resistance may be applied with non-palpating hand)
4. Upper trapezius can be further exposed by asking patient to perform slight extension of the head & neck



During shoulder abduction, upward rotation of the scapula occurs (requires both upper & lower fibers to activate)

Muscle Test

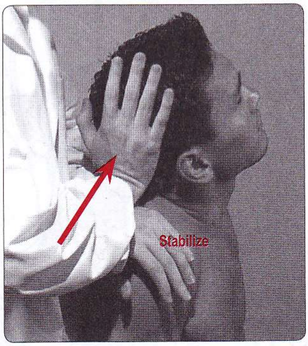
Patient position
- Seated, head laterally flexed toward, *rotated away* & slightly extended from side being tested

Examiner's force
- 75% toward opposite lateral flexion, 25% down on shoulder

Stabilization
- Ipsilateral shoulder

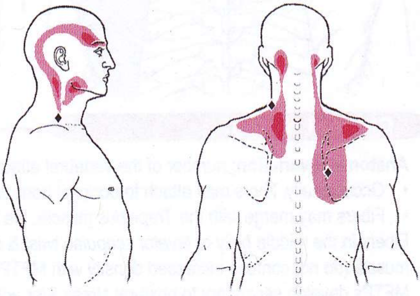
Note: Upper trapezius may also be tested bilaterally by resisting shoulder elevation (also tests levator scapulae)

Middle/lower trapezius muscle testing are discussed in trunk chapter



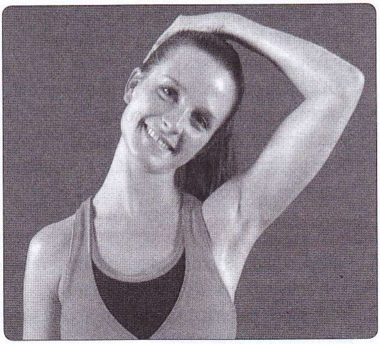
Trigger Point Referral

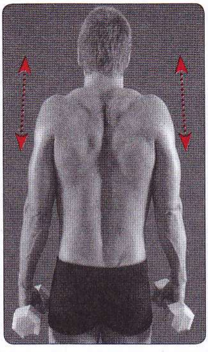
- Primary locations for MFTP are just above the superior border of the scapula & just inferior to the inferior angle of the scapula
- Refer pain over posterolateral neck & mastoid process
- May cause "tension neck ache"
- Intense pain may reach temples, back of eye, and angle of the jaw
- Pain can extend to occiput and rarely lower molar teeth can be accompanied by dizziness

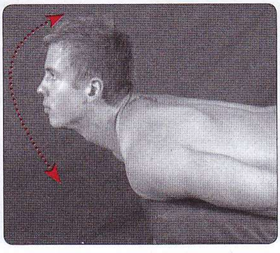


Stretch & Strengthen

Self Stretch:
- Laterally flex head to one side & apply mild tension with opposite hand
- To increase stretch consider gripping side of chair with ipsilateral hand (if you are stretching the right trapezius grab the chair with you right hand)
- Stretching of middle and lower fibers are discussed in the trunk & back chapter

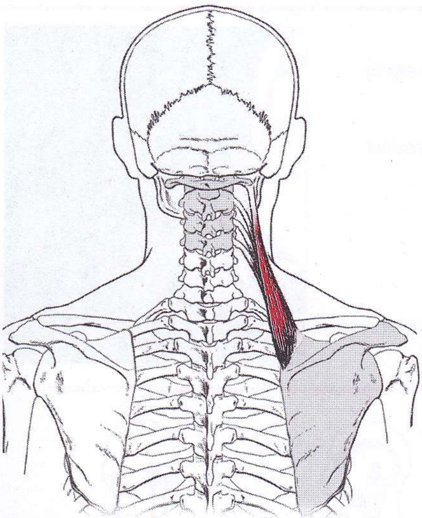






Strengthen
- Resisted shoulder elevation
- Shrug
- Prone neck extension

Levator Scapulae



O	**TPs of C1-C4**
I	**medial border of scapula** (superior part)
A	**elevation of scapula** **extension & lateral flexion of neck**
N	**dorsal scapular nerve** (C3, C4, C5)
B	dorsal scapular artery
S	trapezius (upper fibers)

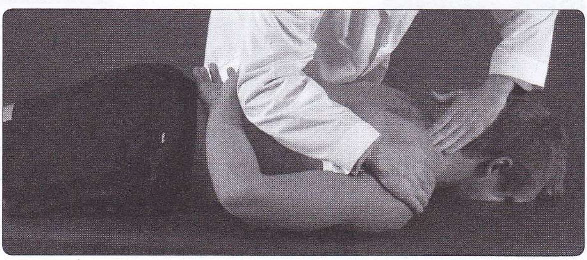
Clinical Notes

- **Anatomical variation:** number of the vertebral attachments may vary (C1-C3)
  - Occasionally, fibers may attach to occipital bone or mastoid process or 1st or 2nd rib
  - Fibers may merge with the *Trapezius* muscle, the Serratus Anterior muscle or a *Scalene* muscle
- Fibers in the middle belly of *levator scapulae* twist & result in increased tissue density in that region of the muscle (do not confuse increased density with MFTP)
- MFTPs develop secondary to postural stress &/or activity overload stresses
- In most brachial plexus lesions the *levator scapulae* in not affected because of its C3-C4 nerve supply
- Due to close relation of levator scapulae with cervical vertebrae, spastic contracture of this muscle sometimes leads to sensory disturbances (numbness or paresthesia) in dermatomes of this plexus (mainly posterior neck region)
- **ADL:** lifting objects, cradling a phone on one shoulder, one-sided sports activities, saying "I don't know"
- **Common injuries:** patient complains of "stiff neck", common area for many people to "hold" stress, possible neck & shoulder postural asymmetries (shoulder hiking), anterior rotated shoulders, whiplash
- **DDx:** trapezius myalgia, articular dysfunction (cervical or thoracic), MFTPs in other muscles, tension headache, torticollis

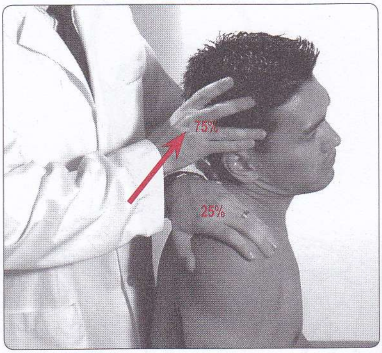
Palpation

1. Patient seated or prone with their forearm over their lumbar spine (position relaxes trapezius to help differentiate fibers of levator scapulae)
2. Place place palpating fingers just above superior angle of the scapula
3. Ask patient to alternately elevate and depress their scapula on the side you are palpating
4. Continue palpating the Levator Scapulae fibers superiorly as they extend to the lateral side of the neck

Most of the Levator Scapulae runs deep to the Trapezius



Muscle Test

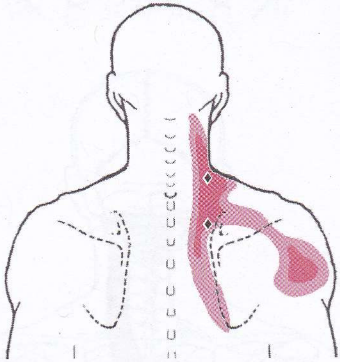


Patient position
- Seated, head laterally flexed, rotated & slightly extended toward same side

Examiner's force
- 75% toward opposite lateral flexion & 25% pressure down on scapula

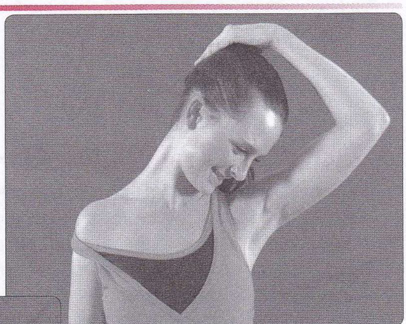
Stabilization
- Ipsilateral shoulder

Trigger Point Referral

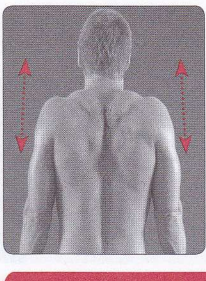


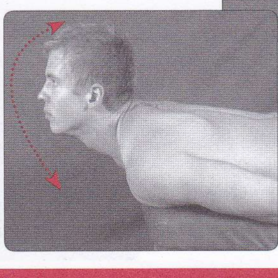
- Primary location for trigger points is at the angle of the neck (where the muscle emerges from deep to the trapezius muscle)
- Secondary location for trigger points is just superior to the scapular attachment of the muscle
- Both primary and the secondary location trigger points refer pain to the angle of the neck, with a spillover zone along the medial border of the scapula and also out to the posterior shoulder

Stretch & Strengthen



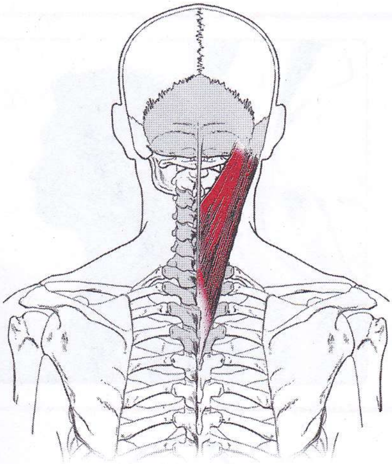
Self Stretch:
- Contralaterally flex, contralaterally rotate & flex head & apply mild tension with opposite hand (smell opposite armpit ☺)
- To increase stretch consider gripping side of chair with ipsilateral hand to anchor shoulder (if you are stretching the right trapezius grab the chair with you right hand)





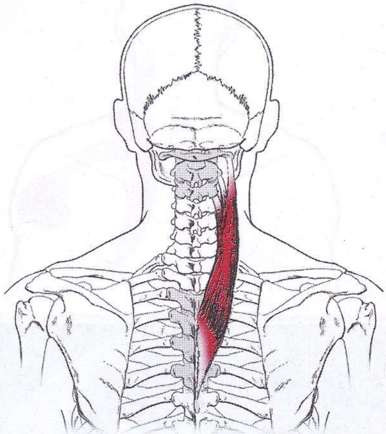
Strengthen
- Resisted shoulder elevation
- Shrug
- Prone neck extension

Neck



Splenius Capitis

O	**SPs of C3-T4 & nuchal ligament** (lower portion)
I	**mastoid process of temporal bone, occipital bone** (superior nuchal line)
A	*unilateral:* **ipsilateral rotation & lateral flexion of head & neck** *bilateral:* **extension of head & neck**
N	**cervical spinal nerves** (dorsal rami)
B	occipital artery
S	upper trapezius, semispinalis, longus capitis



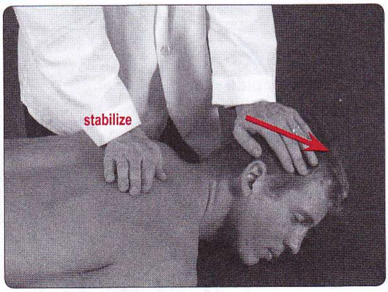
Splenius cervicis

O	**SPs of T3-T6**
I	**TPs of C1-C3** (posterior tubercles)
A	*unilateral:* **ipsilateral rotation & lateral flexion of neck** *bilateral:* **extension of neck**
N	**cervical spinal nerves** (dorsal rami)
B	occipital artery
S	upper trapezius, semispinalis, longus cervicis

Clinical Notes

- **Anatomical variation:** *splenius capitis* may only attach to T3 and above, *splenius cervicis* insertion point may only be on C1 & C2 vertebrae in some people
- *Splenius capitis* forms a "V" shape on the back of the neck
- *Splenius capitis* runs obliquely whereas *semispinalis* runs more vertically & is deeper
- **ADL:** shoulder check, looking up
- **Common injuries:** repetitive trauma from work/posture sitting at a computer, desk or working with a mouse; strain from cradling a phone on one shoulder, one-sided sports activities, excess stress causing upper back tension, whiplash
- **DDx:** trapezius myalgia, articular dysfunctions (cervical or thoracic), MFTPs in other muscles, tension headache, cervicogenic headache, costothoracic syndrome
- **Palpation:** Patient prone, place palpating fingers along fiber direction & have patient extend neck (realize that splenius muscles are deep to trapezius)

Muscle Test



Patient position

- Prone, head laterally flexed, rotated & slightly extended toward same side

Examiner's force

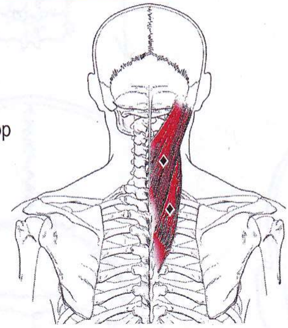
- 75% toward flexion & 25% pressure toward opposite side lateral flexion (in fiber direction of muscle)

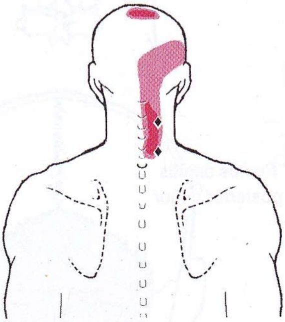
Stabilization

- Upper thoracic spine

Trigger Point Referral

- MFTPs are generally located in the muscle belly & refer pain over the posterior neck, above the ear, at the top of the head & on rare occasions even to the supraorbital region

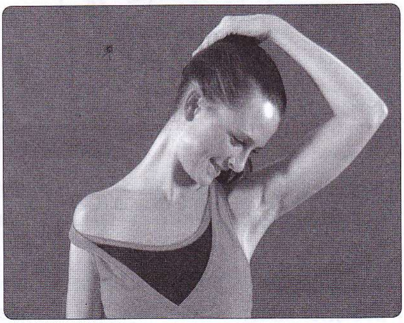


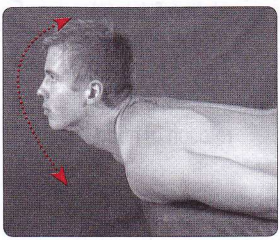


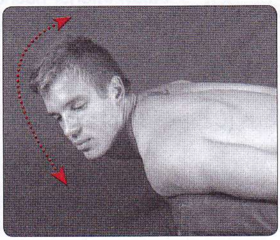
Stretch & Strengthen

Self Stretch:

- Flex, contralaterally flex & contralaterally rotate head to one side & apply mild tension with opposite hand
- Keep the shoulder loose & Do NOT anchor the shoulder being stretched (anchoring will result in more stretch of levator scapulae)

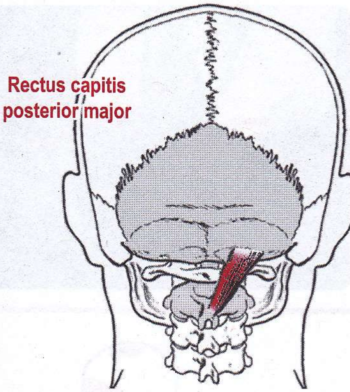


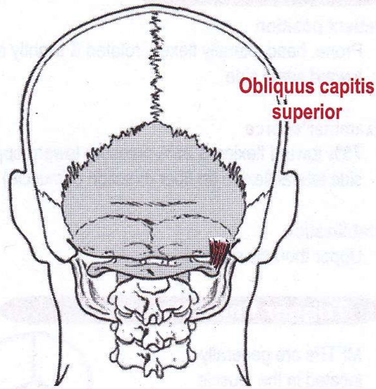


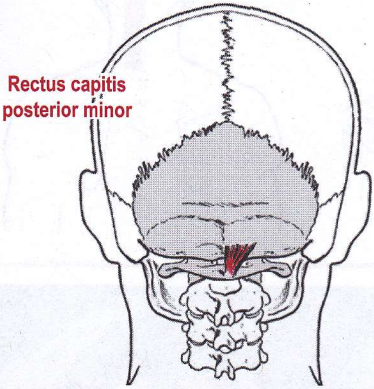


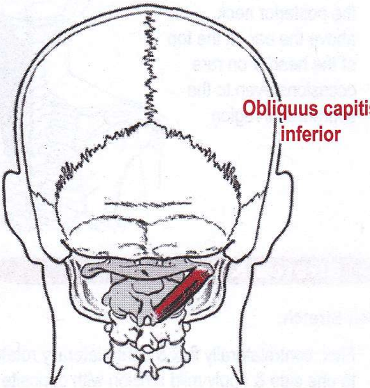
Strengthen

- Prone neck extension
- Neck extension with head ipsilaterally rotated









Muscle	Origin	Insertion	Action	Nerve
Rectus capitis posterior major	spine of axis (C2)	lateral portion of inferior nuchal line	extension, ipsilateral rotation & lateral flexion of head	**Subocciptal nerve (dorsal rami of C1)**
Rectus capitis posterior minor	posterior tubercle of atlas (C1)	medial portion of inferior nuchal line	extension & ipsilateral lateral flexion of head	
Obliquus capitis superior	TP of atlas (C1)	below inferior nuchal line (occipital bone)	extension, ipsilateral rotation & lateral flexion of head	
Obliquus capitis inferior	spine of axis (C2)	TP of atlas (C1)	extension & ipsilateral rotation of head	

Note: The main function of the suboccipital muscles is postural stabilization of the head, not powerful contractions

Clinical Notes

- **Anatomical variation:**
  - Occasionally *rectus capitus posterior minor* may be absent
  - *Rectus capitus posterior major* may split into two muscle bellies
  - Fibers of the *rectus capitis posterior minor* may also attach to the dura mater surounding the spinal cord & may help pull it out of the way during anterior translation of the occipital bone on the atlas
- *Obliquus capitis inferior* is the only suboccipital muscle that does not attach to the head or cross the atlanto-occipital joint (the term 'capitis' is misleading)
- Myospasm of the suboccipitals may be associated with muscle tension headaches
- Studies have shown that there is a very high spindle density in the suboccipital muscles; which is linked to the ability to facilitate fine motor movement, indicating that their primary function is as "sensors of joint position [proprioception] and movements of craneovertebral joints" (Kulkarni et al. 2001)
- **Common injuries:** cervical hyperflexion & hyperextension (whiplash), very commonly chronic poor posture or stress can cause contracture of the muscle tissue, resulting in myospasm

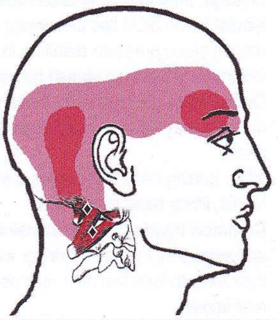
Palpation

1. Patient supine
2. Cradle the patient's skull in both hands
3. Locate superior nuchal line & spinous process of C2; cradle skull with palms & palpate with two flat finger tips
4. Palpate gently through the layers of trapezius, splenius capitis, and semispinalis capitis
5. Ask patient to slightly extend head & note muscle contraction

It may be difficult to distinguish individual muscle bellies

Trigger Point Referral

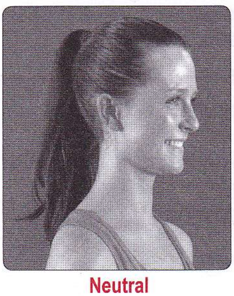
- MFTPs refer head pain that may be difficult to localize; pain is often described as being from the occiput to the eye and forehead area
- MFTPs typically occur when a person is maintaining flexion or extension of the associated joint for extended periods of time
- Note that MFTPs in the suboccipital muscles are often accompanied by MFTPs in the trapezius, sternocleidomastoid, and the splenius muscles



Stretch

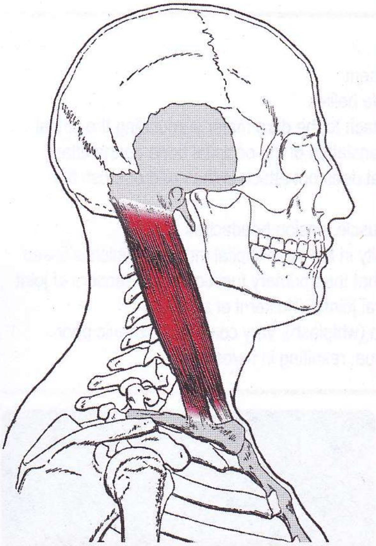
Self Stretch:

- Capital flexion - chin retraction or "tuck your chin in"
- Consider placing fingers on chin to push head posteriorly
- Capital flexion is an action between the upper cervical spine & occipital bone; it must be distinguished from cervical flexion in order to effectively stretch the suboccipital muscles



Neutral

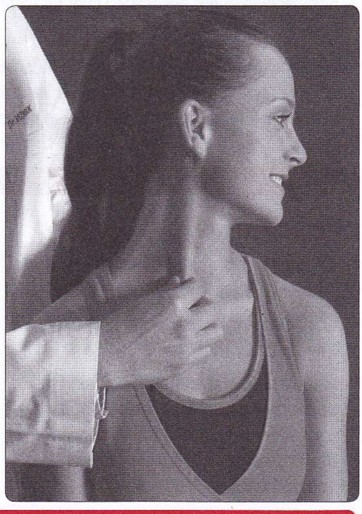
Stretch



O	*sternal head:* **manubrium of sternum** *clavicular head:* **medial portion of clavicle**
I	**mastoid process of temporal bone**
A	**rotation of head to contralateral side** **lateral flexion to ipsilateral side** *bilateral action:* neck flexion & capital extension
N	*motor:* **spinal accessory** (CN XI) *sensory:* ventral rami of C2, C3
B	occipital & superior thyroid arteries
S	longus capitis, longus cervicis

Clinical Notes

- **Anatomical variation:** upper medial fibers may blend with posterior lateral edge of *trapezius*
- The specific action of SCM is flexion of the cervical spine & head, and extension of the upper cervical spine (C1-C3) & at the atlanto-occipital joint (C0-C1) (cervical flexion with capital extension)
- Because SCM attaches to the medial clavicle & sternum it may also theoretically help elevate the anterior rib cage, therefore SCM is considered an "accessory muscle of respiration"
- Medial to the SCM lies the carotid sinus & carotid arteries; pressure over the carotid sinus may cause a drop in blood pressure resulting in feeling light-headed or even unconsciousness, therefore palpation & treatment in the area should be performed with caution
- During whiplash, where the head may be thrown into hyperextension, the SCM & other anterior neck muscles may be torn. In addition, the posterior neck muscles may be damaged during the hyperflexion phase
- **ADL:** turning head while doing a shoulder check, watching tennis, lifting head from pillow
- **Common injuries:** hyperextension (whiplash): frequent and severe injury; usually driver will contralaterally rotate their neck to look into their rear view mirror just prior to rear impact
  - Torticollis - contracture or spasm of SCM
- **DDx:** articular dysfunction (cervical or thoracic), MFTPs in suboccipitals, tension headache, torticollis

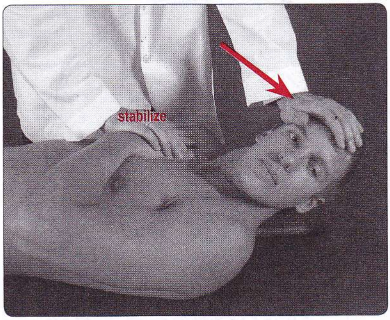


Palpation

1. Patient supine, seated or standing with head rotated to one side
2. Place palpating fingers along the muscle fiber direction & ask patient to flex or rotate their neck
3. Note contraction of the muscle tissue

Realize that platysma is superficial to SCM

Muscle Test



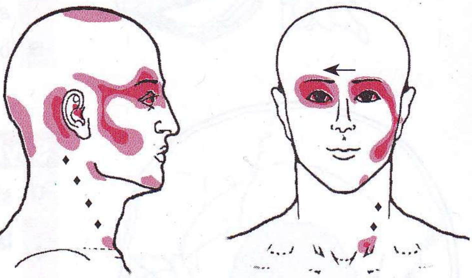
Patient position
- Patient seated or supine with neck flexed & rotated to contralateral side

Examiner's force
- With hand on lateral frontal bone, force is posterior and slightly lateral, in a curve following anatomical arc of muscle action

Stabilization
- Sternum (have patient cover chest with free hand)

Trigger Point Referral

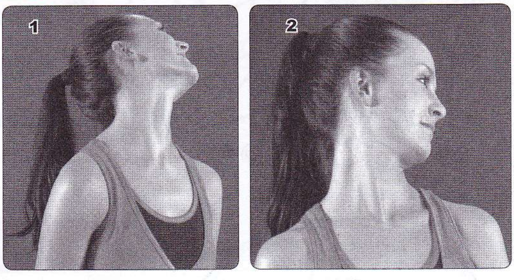
- Trigger points can be located throughout the entire muscle belly
- Primary referral zones are over the mastoid process & supraorbital regions of the face
- Referred pain from these trigger points can be misdiagnosed as tension headache, cervicocephalalgia and myofascial pain-dysfunction syndrome
- Referral pain from the upper part of the SCM can cause disequillibrium (balance problems)

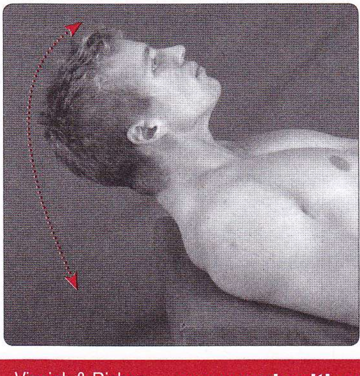


Stretch & Strengthen

Self Stretch 1:
- Extend, contralaterally flex & rotate neck to contralateral side

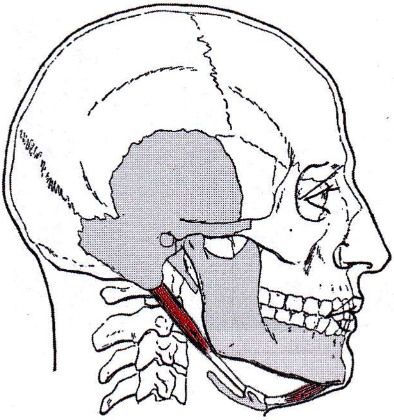
Self Stretch 2:
- Extend lower neck & flex upper neck, extend & rotate neck to contralateral side





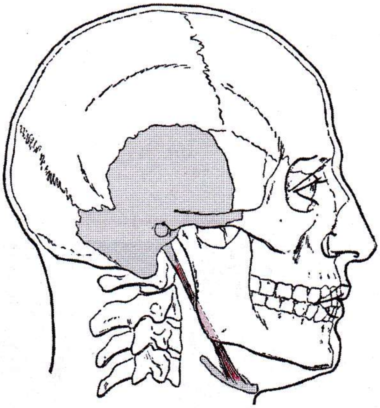
Strengthen
- Supine neck curls with chin out

Neck



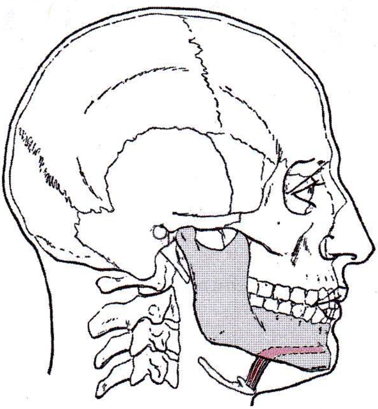
Digastric

O	*posterior belly:* **mastoid notch of temporal bone** *anterior belly:* **digastric fossa of internal mandible**
I	**body of hyoid** (both bellies meet & attach by a pulley tendon)
A	**elevation of hyoid bone** depression of mandible (open mouth) stabilize hyoid bone for infrahyoid action
N	*posterior belly:* **facial nerve** (CN VII) *anterior belly:* **trigeminal nerve** (CN V)
B	branches of external carotid



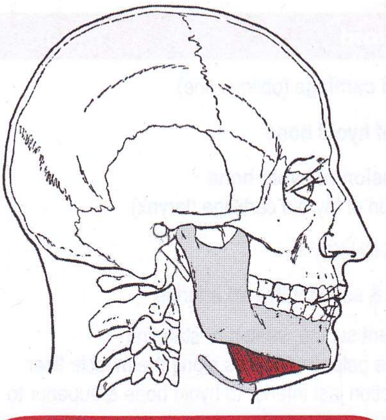
Stylohyoid

O	**styloid process of temporal bone**
I	**lateral margin of hyoid body** (base of greater horn)
A	**elevation of hyoid** (during swallowing) stabilizes hyoid bone for infrahyoid action
N	**facial nerve** (CN VII)
B	facial & occipital artery



Geniohyoid

O	**inner surface of mandible** (mental spines)
I	**body of hyoid** (paired muscles separated by septum)
A	**elevation of hyoid bone** depression of mandible (works with mylohyoid)
N	**hypoglossal nerve** (CN XII)
B	lingual artery



Mylohyoid

O	**inner surface of mandible** (mylohyoid line)
I	**body of hyoid** (anterior surface) along midline at mylohyoid raphe
A	**elevation of hyoid bone** (raises floor of mouth for swallowing) depression of mandible when hyoid is fixed
N	**trigeminal nerve** (CN V - mandibular division, V3)
B	inferior alveolar & lingual arteries

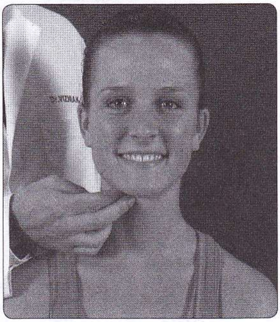
Clinical Notes

- **Anatomical variation:** fibers of the right & left *geniohyoid* may blend together
- *Geniohyoid* may also draw the hyoid bone anteriorly & thus help protrude the tongue
- *Digastric* is the prime mover for depression of the mandible
- When the mouth is closed the suprahyoid & infrahyoid muscles can weakly assist with neck flexion
- *Stylohyoid* shares its point of origin with *styloglossus* & *stylopharyngeus*
- There are 4 supra hyoid muscle (*digastric, mylohyoid, stylohyoid & geniohyoid*)
- **ADL:** the main function of all hyoid muscles is to assist with the action of swallowing & speech

Palpation

All suprahyoid muscles are palpated in a similar way, but may be difficult to distinguish from other suprahyoid muscles; remember the attachment points & actions to help differentiate individual muscles

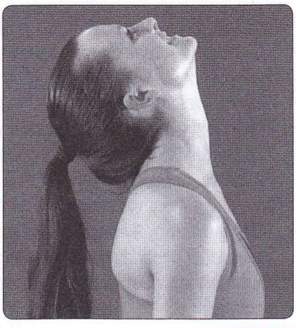
1. Patient supine, seated or standing
2. Place palpating fingers along the muscle fiber direction under chin & superior to hyoid bone
3. Ask patient to swallow or push tongue against roof of mouth or perform primary action of the individual muscle
4. Note contraction of the muscle tissue



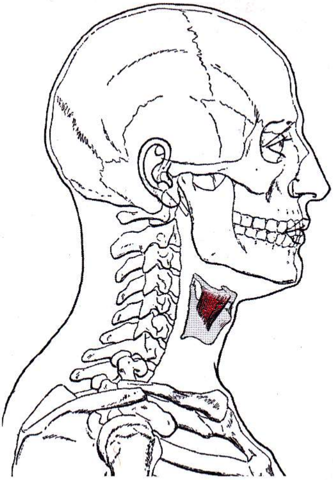
Stretch

Self Stretch:

- Keep jaw closed, extend head & neck

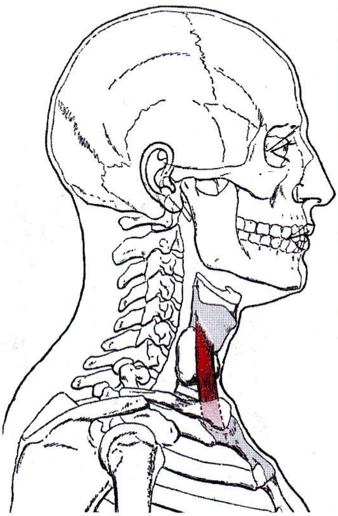


Neck



Thyrohyoid

O	**thyroid cartilage** (oblique line)
I	**body of hyoid bone**
A	**depression of hyoid bone** elevation of thyroid cartilage (larynx)
N	**C1** (via CN XII)
B	inferior & superior thyroid arteries
P	1. Patient supine, seated or standing 2. Place palpating fingers along the muscle fiber direction just inferior to hyoid bone & superior to thyroid cartilage; then ask patient to swallow May be difficult to distinguish from other infrahyoid muscles

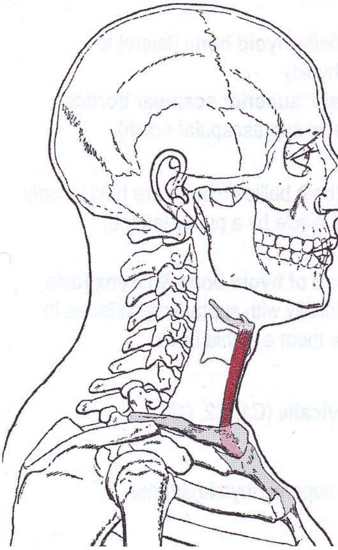


Sternothyroid

O	**manubrium of sternum** (posterior aspect)
I	**thyroid cartilage** (oblique line)
A	**depression of thyroid cartilage** acts eccentrically with suprahyoid muscles to provide them a stable base
N	**ansa cervicalis** (C1, C2, C3)
B	inferior & superior thyroid arteries
P	1. Patient supine, seated or standing 2. Place palpating fingers along the muscle fiber direction just inferior to thyroid cartilage & superior to sternum; then ask patient to swallow May be difficult to distinguish from other infrahyoid muscles

Clinical Notes

- The action of *sternothyroid* is transmitted by the thyrohyoid membrane & muscle to result in depression of the hyoid bone & larynx
- *Sternothyroid* is the only "hyoid" muscle that does not directly attach to the hyoid bone
- The infrahyoid muscles also assist very weakly with neck flexion
- The *thyrohyoid* is innervated by fibers from C1 which have piggybacked onto the hypoglossal nerve (CN XII) and subsequently jump off that nerve twice: once to supply this muscle, and a second time in the floor of the mouth to supply the geniohyoid
- **ADL:** the infrahyoid muscles (*sternohyoid, sternothyroid, thyrohyoid & omohyoid*) are important for the actions that occur during swallowing, chewing & speech
- **Common injuries:** infra & suprahyoid muscles may be damaged with prolonged vocal straining (yelling or cheering)



O	**manubrium & sternoclavicular joint** (posterior aspect of both)
I	**body of hyoid**
A	**depression of hyoid & larynx** acts eccentrically with suprahyoid muscles to provide them a stable base
N	**ansa cervicalis** (C1, C2, C3)
B	inferior & superior thyroid arteries
S	omohyoid, thyrohyoid, sternothyroid

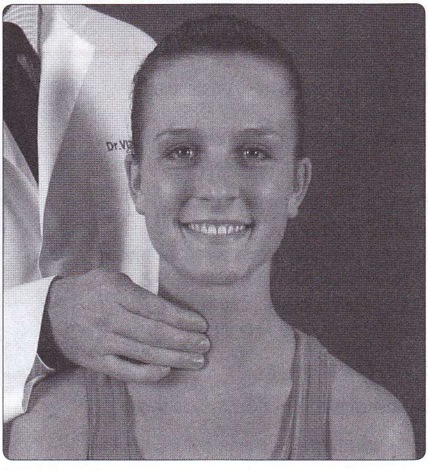
Clinical Notes

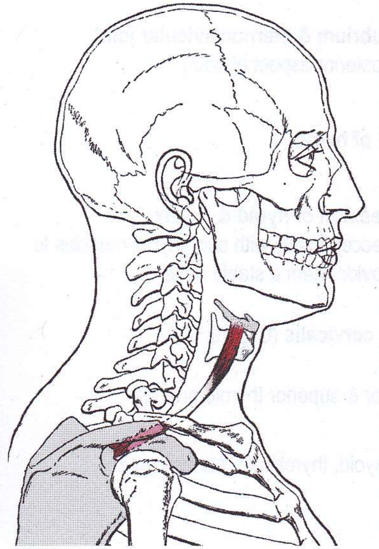
- **Anatomical variation:** occasionally the *sternohyoid* may originate from the posterior aspect of the medial clavicle
- The carotid sinus (which helps control blood pressure) is located just lateral to the sternohyoid, as such physical medicine procedures performed in this area should be done with caution (especially with elderly patients)
- **ADL:** The infrahyoid muscles (*sternohyoid, sternothyroid, thyrohyoid & omohyoid*) are important for the actions that occur during swallowing, chewing & speech
- The infrahyoid muscles also assist very weakly with neck flexion
- To stretch muscle use same action as suprahyoid muscles (neck extension with jaw closed - see page 91)

Palpation

All infrahyoid muscles are palpated in a similar way, but may be difficult to distinguish from other infrahyoid muscles; remember the attachment points & actions to help differentiate individual muscles

1. Patient supine, seated or standing
2. Place palpating fingers along the muscle fiber direction just inferior to hyoid bone & superior to the sternum
3. Ask patient to swallow
4. Note contraction of the muscle tissue





O	*superior belly:* **hyoid bone** (lateral to sternohyoid) *inferior belly:* **superior scapular border** (medial to suprascapular notch)
I	**clavicle** (both bellies meet & are held loosely to the clavicle by a pulley tendon)
A	**depression of hyoid bone & larynx** (acts eccentrically with suprahyoid muscles to provide them a stable base)
N	**ansa cervicalis** (C1, C2, C3)
B	inferior & superior thyroid arteries

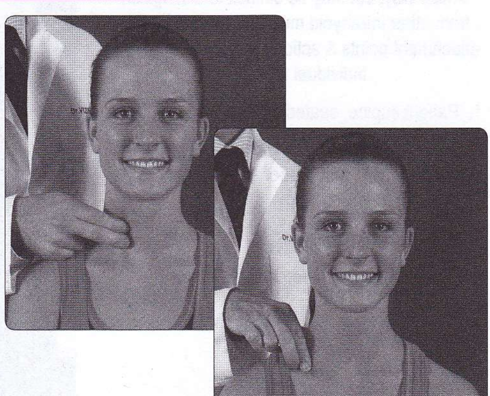
Clinical Notes

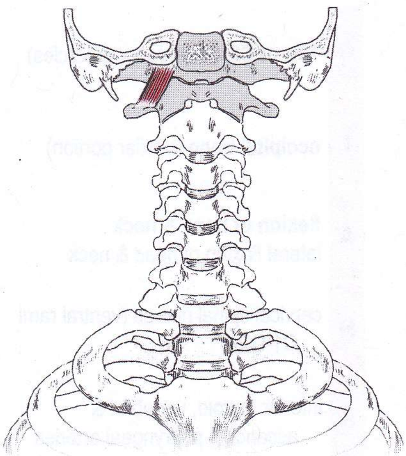
- **ADL:** the infrahyoid muscles (*sternohyoid, sternothyroid, thyrohyoid & omohyoid*) are important for the actions that occur during swallowing, chewing & speech
- The pulley of attachment of the omohyoid at the clavicle allows the muscle so slide back & forth
- The carotid sinus (which helps control blood pressure) is located just lateral to the superior belly of the *omohyoid,* as such physical medicine procedures in this area should be performed with caution (especially with elderly patients)
- *Omohyoid* also lies over the middle cervical fascia, superficial to the jugular vein, as such it can help to hold open the internal jugular vein & may help increase the return of blood flow from the head to the inferior vena cava
- There are also documented cases of a omohyoideus myofascial pain syndrome that may cause pain in the shoulder, neck, arm, and hand, and in the scapular, supraclavicular, mandibular, and temporal regions

Palpation

1. Patient supine, seated or standing
   Superior belly
2. Place palpating fingers along the muscle fiber direction just inferior to hyoid bone
3. Ask patient to swallow
   Inferior Belly
4. Place palpating fingers along the muscle fiber direction just lateral to SCM & superior to clavicle (note scalene fiber direction is more vertical)
5. Ask patient to swallow
6. Note contraction of the muscle tissue

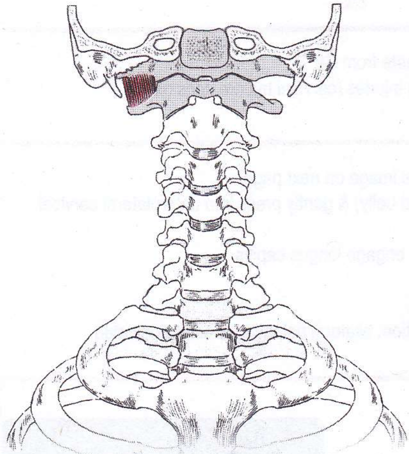
May be difficult to distinguish from other infrahyoid muscles





Rectus Capitis Anterior

O	**atlas (C1)** (anterior base of TP)
I	**occipital bone** (basilar part anterior to foramen magnum)
A	**flexion of head**
N	cervical spinal nerves (ventral rami C1-C2)
B	vertebral artery
P	Rectus capitis anterior muscle is too deep to be palpated

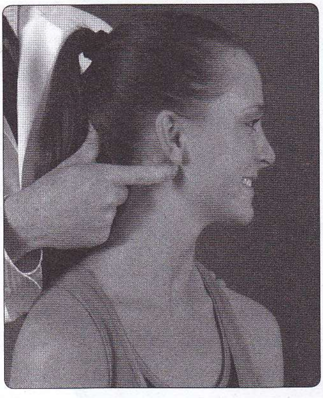


Rectus Capitis Lateralis

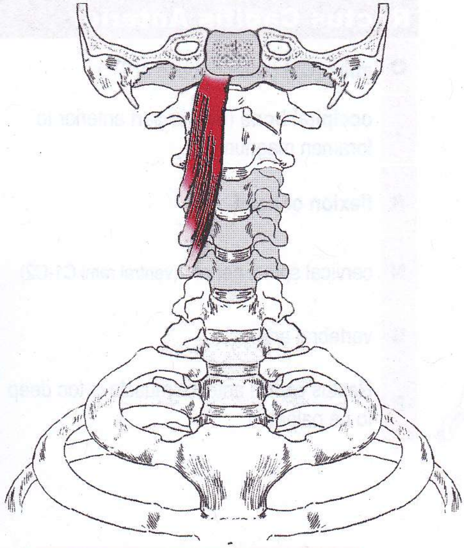
O	**atlas (C1)** (superior surface of TP)
I	**occipital bone** (jugular process)
A	**lateral flexion of head**
N	cervical spinal nerves (ventral rami C1-C2)
B	vertebral & occipital arteries

Palpation

1. Patient seated or supine
2. Palpate the transverse process of C1 (posterior to ramus of mandible & anterior to mastoid process)
3. Gently move your palpating finger superior and deep (just above transverse process of C1)
4. Ask patient to laterally flex head to the same side
5. Note contraction of the muscle tissue



Longus Capitis



O	**TPs of C3-C5** (anterior tubercles)
I	**occipital bone** (basilar portion)
A	**flexion of head & neck** lateral flexion of head & neck
N	cervical spinal nerves (ventral rami C1-C3)
B	inferior thyroid, vertebral & ascending pharyngeal arteries
S	SCM, rectus capitis anterior

Clinical Notes

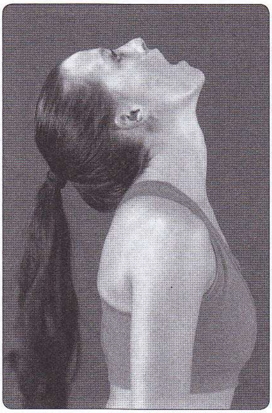
- **Anatomical variation:** *longus capitis* may also originate from C6
- *Longus capitis* may be injured or strained in whiplash injuries (cervical hyperextension)

Palpation

- Patient supine (same position as longus cervicis - see image on next page)
- Place palpating fingers just medial to SCM (upper mid belly) & gently press into anterolateral cervical spine
- Ask patient to patient to flex the neck as you resist to engage longus capitis
- Note contraction of the muscle tissue

CAUTION: The carotid artery runs near the site of palpation, bilateral palpation is contraindicated

Stretch

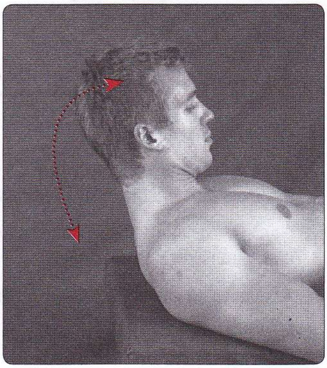


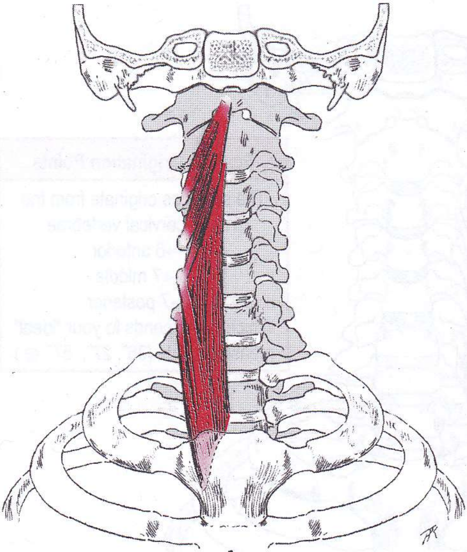
Self Stretch:

- Open jaw open, extend head & neck
- By opening jaw stretch on supra & infrahyoid muscles is reduced

Strengthen

- Supine neck curls with chin tucked in





O	**lower anterior vertebral bodies & TPs of C3-T3**
I	**anterior vertebral bodies & TPs C1-C6**
A	**flexion & lateral flexion of neck** rotation of neck (weak action)
N	cervical spinal nerves (ventral rami C2-C6)
B	inferior thyroid, vertebral & ascending pharyngeal arteries
S	SCM, longus capitis

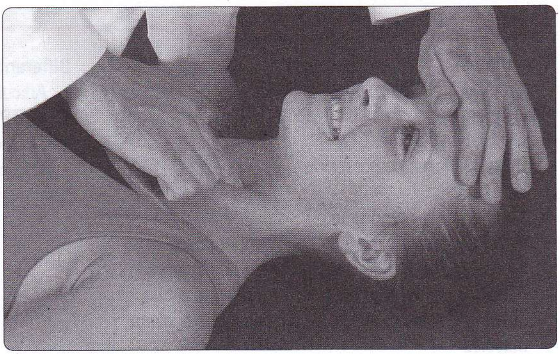
Clinical Notes

- Some clinicians divide *longus cervicis* into 3 anatomical parts; superior oblique fibers, inferior oblique fibers & medial fibers
- **ADL:** *longus cervicis*, also known as *longus colli*, is a strong flexor of the neck & also stabilization of the neck during coughing, sneezing, swallowing & talking
- **Common injuries:** *Longus cervicis* may be damaged during whiplash (cervical hyperextension injury), damage to this muscle may present very similar to a sore throat
- Prevertebral muscle include *longus colli, longus capitis, rectus capitis anterior & rectus capitis lateralis*
- ***Stretch & strengthen*** are the same as *longus capitis* (see page 96)

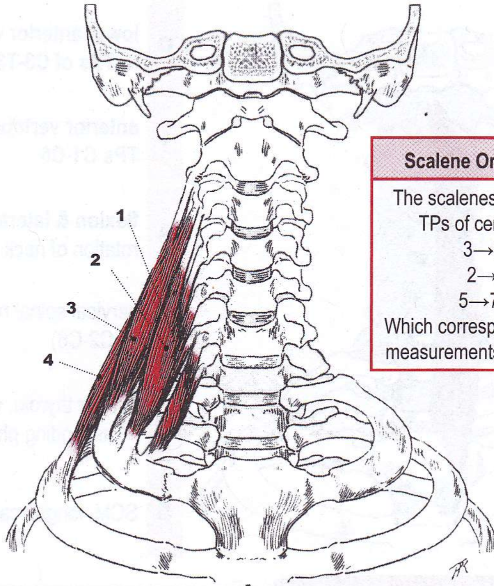
Palpation

1. Patient supine
2. Place palpating fingers just medial to SCM (mid belly) & gently press into anterolateral cervical spine
3. Ask patient to patient to flex the neck as you resist to engage longus colli
4. Note contraction of the muscle tissue

CAUTION: The carotid artery runs near the site of palpation, bilateral palpation is contraindicated



1. Scalenus minimus
2. Anterior scalene
3. Middle scalene
4. Posterior Scalene



Scalene Origination Points
The scalenes originate from the TPs of cervical vertebrae 3→6 anterior 2→7 middle 5→7 posterior Which corresponds to your "ideal" measurements (36", 27", 57" ☺)

Neck

Muscle Test

Patient position

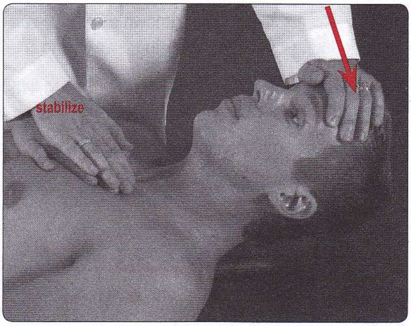
- Supine with arms at their side, neck flexed without tucking of the chin

Examiner's force

- Finger, thumb & palm pushing down on forehead (moving patient into extension)

Stabilization

- Over superior sternum or shoulder



Consider resisted lateral flexion to test scalene muscles as well (all tests also recruit synergist muscles)

Common Injuries/DDx

Common Injuries Causes

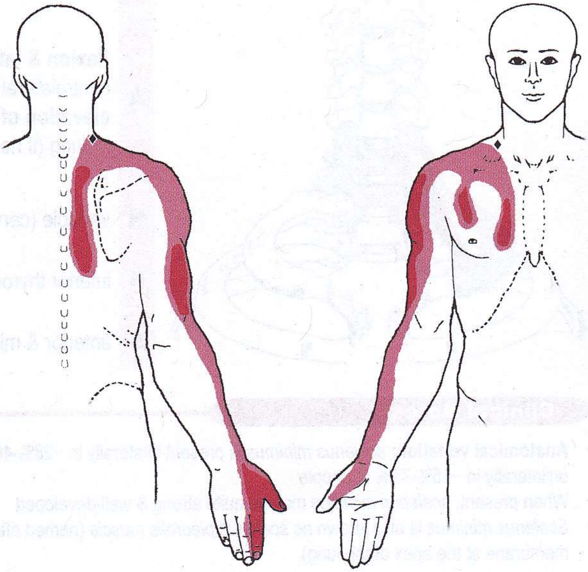
- Cradling a phone on one shoulder
- Poor ergonomics at work station
- Overuse syndrome, COPD
- Brachial plexus compression
- Whiplash
- Thoracic outlet syndrome
- Prolonged anxiety tends to cause upper chest breathing, instead of using abdomen and diaphragm; often associated with head forward posture & hunched shoulders; leading to chronic tension in the scalene muscles

Differential Diagnosis

- Articular dysfunctions (cervical or thoracic)
- MFTPs in other cervical muscles
- Thoracic outlet syndrome
- Carpal tunnel syndrome

Trigger Point Referral

- MFTPs cause referral patterns that travel anteriorly, laterally and posteriorly
- Anterior referral pattern consists of pain in the pectoral region (pattern often spreads out in two inferior projections); common for middle & posterior scalene
- Lateral referral pattern radiates down radial side of the forearm to the 1st & 2nd phalanges; common for anterior & middle scalene
- Posterior referral pattern extends down back towards the medial border of scapula and the interscapular region
- When scalene minimus is present, referral pain can occur around the deltoid tuberosity of the humerus

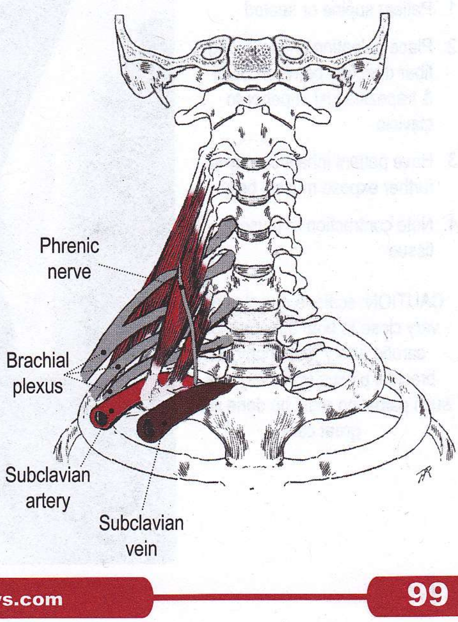


Scalenes & Brachial Plexus

The brachial plexus is a network of nerves that supplies the upper extremity. Usually the brachial plexus passes between the anterior & middle scalenes; however there are many anatomical variations that can occur:

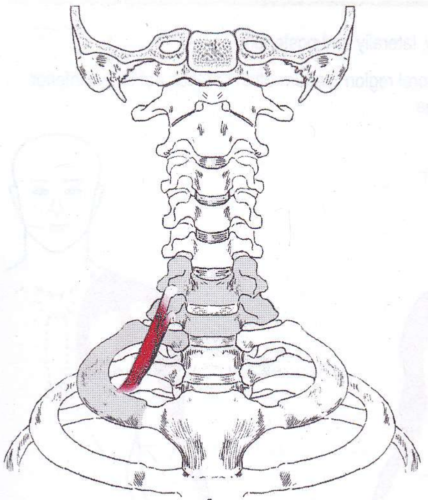
- ~66% of population plexus passes between anterior & middle scalene
- ~33% of population have brachial plexus roots that penetrate the anterior scalene
- ~1% of the population may have a subclavian artery that passes behind or pierces through the anterior scalene
- Scalenus minimus, when present, may also play a role in the development of clinical symptoms

Tightness or contracture of the scalenes may cause compression of the brachial plexus resulting in symptoms of numbness, tingling & muscle weakness in the upper extremity & may also be associated with thoracic outlet syndrome



Neck

Scalenus Minimus



O	**TPs C6-C7** (anterior tubercles)
I	**1st rib** and/or supraplural membrane of lung
A	**flexion & lateral flexion of neck** contralateral rotation of neck (weak action) **elevation of 1st rib** & superior pleura of lung (if neck is stabilized)
N	variable (cervical & brachial plexus)
B	inferior thyroid artery
S	anterior & middle scalene

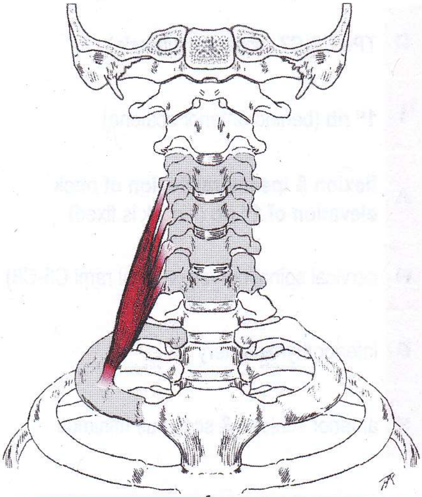
Clinical Notes

- **Anatomical variation:** *scalenus minimus* is present bilaterally in ~28%-46% of the population & unilaterally in ~45%-75% of people
- When present, *scalenus minimus* may be quite strong & well developed
- *Scalenus minimus* is also known as *scalenus pleuralis muscle* (named after its insertion on the pleural membrane at the apex of the lung)

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction between SCM & trapezius just superior to clavicle
3. Have patient inhale deeply to further expose muscle belly
4. Note contraction of muscle tissue

CAUTION: scalene muscles are very close to both the common carotid artery (superiorly) & brachial plexus (mid belly), as such palpation must be done with great care

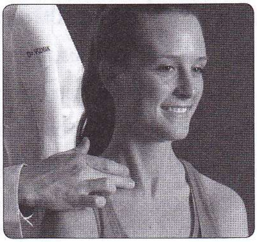


O	**TPs of C3-C6** (anterior tubercles)
I	**1st rib** (scalene tubercle)
A	**flexion & ipsilateral flexion of neck** **elevation of 1st rib** (if neck is stabilized) contralateral rotation of neck (weak action)
N	cervical spinal nerves (ventral rami C3-C6)
B	inferior thyroid artery (branch of thyrocervical trunk)
S	middle scalene & scalenus minimus

Clinical Notes

- *Anterior scalene* is considered an accessory muscle of respiration
- The brachial plexus & subclavian artery usually pass between the *middle* and *anterior scalenes*; however in ~30% of cases branches of the brachial plexus may pass directly through the *anterior scalene*; rarely, (~1%) the subclavian artery will also pass through the *anterior scalene*
- Compression on the brachial plexus by the scalenes often contributes to thoracic outlet syndrome (TOS)
- **Common injuries:** whiplash (hyperextension & hyperflexion injury of the neck)

Palpation



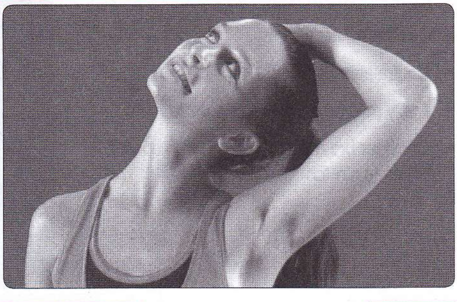
1. Patient supine or seated
2. Rotate the patient's head slightly to contralateral side being palpated (moves SCM out of the way)
3. Place palpating finger just lateral to SCM & superior to clavicle
4. Ask patient to inhale deeply to further expose the muscle belly
5. Anterior scalene can also be palpated inferiorly behind the clavicle
6. Just lateral to anterior scalene is middle scalene

CAUTION: scalene muscles are very close to both the common carotid artery (superiorly) & brachial plexus (mid belly), palpation must be done with great care

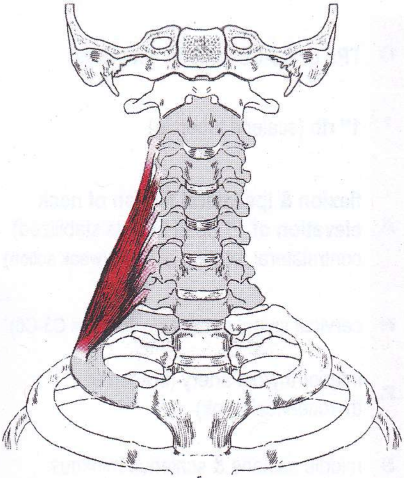
Stretch

Self Stretch:

- Contralaterally flex & ipsilaterally rotate neck
- Apply mild pressure with opposite hand
- Consider breathing out to depress chest & increase stretch



Middle Scalene



O	**TPs C2-C7** (posterior tubercle)
I	**1st rib** (behind anterior scalene)
A	**flexion & ipsilateral flexion of neck** **elevation of 1st rib** (if neck is fixed)
N	cervical spinal nerves (ventral rami C3-C8)
B	inferior thyroid artery
S	anterior scalene & scalenus minimus

Clinical Notes

- *Middle scalene* is considered an accessory muscle of respiration
- The brachial plexus & subclavian artery usually pass between the *middle* and *anterior scalene*
- Compression on the brachial plexus by the scalenes often contributes to thoracic outlet syndrome (TOS)
- **Common injuries:** whiplash (hyperextension & hyperflexion injury of the neck)

Palpation

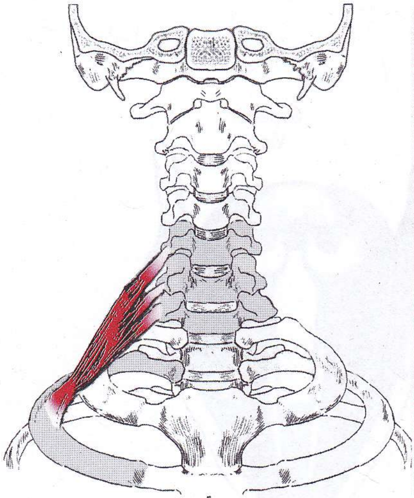
1. Patient supine or seated
2. Contralaterally rotate the patients head slightly to opposite side being palpated (moves SCM out of the way)
3. Place palpating finger just lateral to SCM & superior to clavicle
4. Ask patient to inhale deeply to further expose the muscle belly
5. Middle scalene can also be palpated inferiorly, behind the clavicle
6. Just medial to middle scalene is anterior scalene

CAUTION: scalene muscles are very close to both the common carotid artery (superiorly) & brachial plexus (mid belly), palpation must be done with great care

Stretch

Self Stretch:

- Contralaterally flex neck
- Apply mild pressure with opposite hand
- Consider breathing out to depress chest & increase stretch



O	**TPs of C5-C7** (posterior tubercles)
I	**2^{nd} rib**
A	**ipsilateral lateral flexion of neck** **elevation of 2^{nd} rib** (if neck is fixed)
N	cervical spinal nerves (ventral rami C6-C8)
B	inferior thyroid artery (branch of thyrocervical trunk)
S	anterior & middle scalene

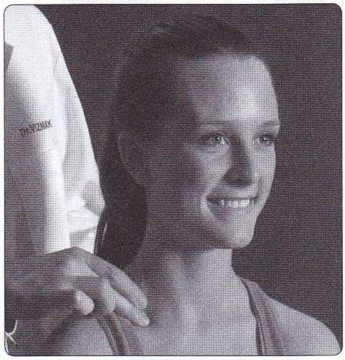
Clinical Notes

- **Anatomical variation:** occasionally the posterior scalene may attach to the lateral border of the 3^{rd} rib
- Posterior scalene is considered an accessory muscle of respiration
- **Common injuries:** whiplash (hyperextension & hyperflexion injury of the neck)

Palpation

1. Patient supine or seated
2. Locate *middle scalene & levator scapulae*, place palpating finger pad between to muscles
3. Have patient inhale deeply to further expose muscle belly
4. Posterior scalene may be differentiated from levator scapulae/trapezius by asking the patient to alternately elevate & depress the scapula

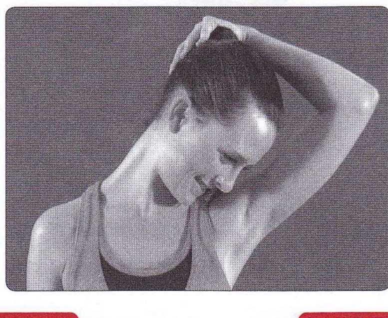
CAUTION: scalene muscles are very close to both the common carotid artery (superiorly) & brachial plexus (mid belly), as such palpation must be done with great care



Stretch

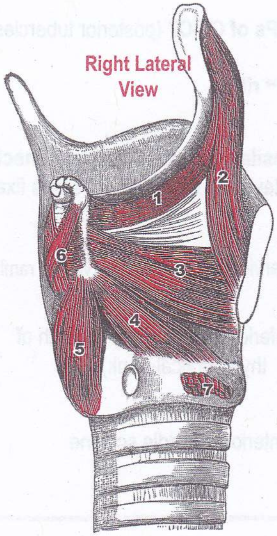
Self Stretch:

- Laterally flex & contralaterally rotate neck
- Apply mild pressure with opposite hand
- Consider breathing out to depress chest & increase stretch

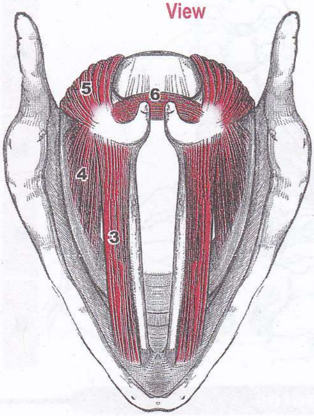


Neck

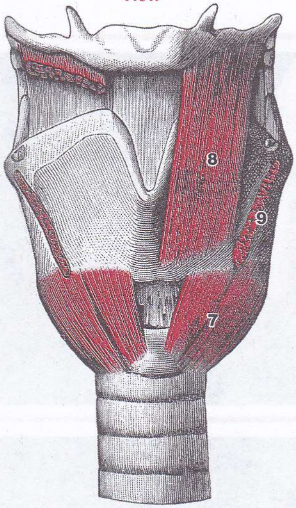
Right Lateral View



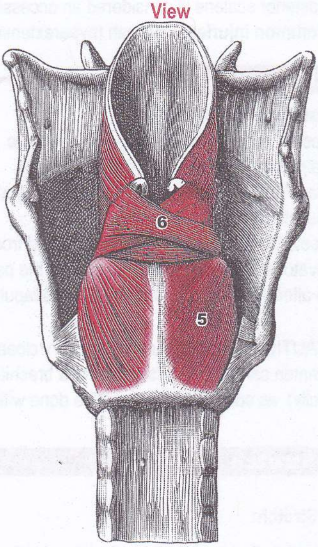
Superior View



Anterior View



Posterior View

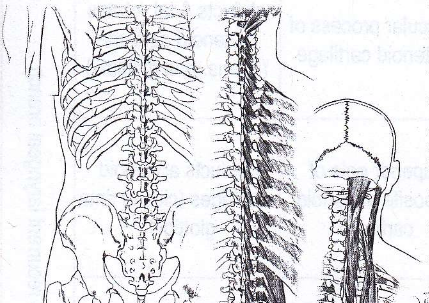


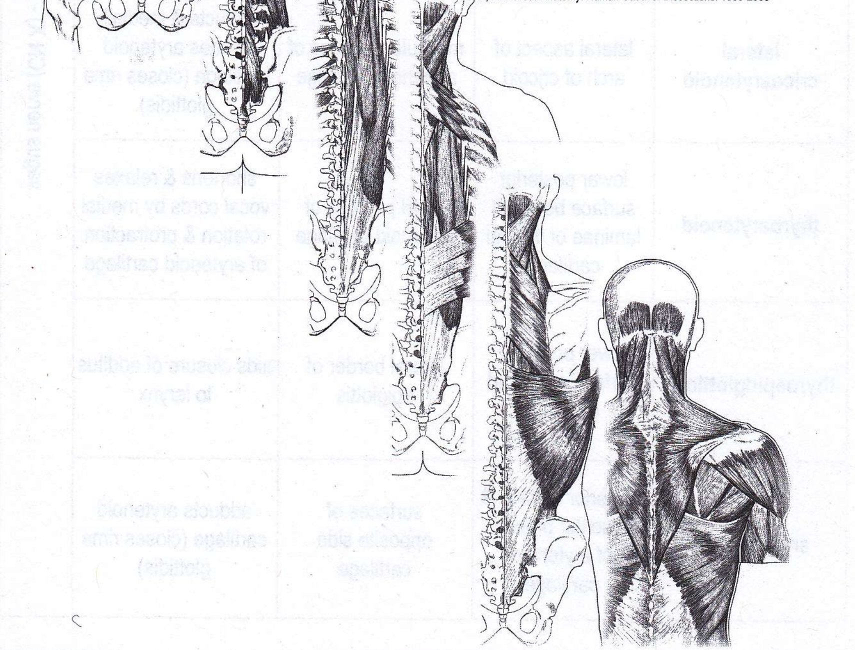
1. Aryepiglotticus
2. Thyroepidglotticus
3. Thyroarytenoid
4. Lateral cricoarytenoid
5. Posterior cricoarytenoid
6. Arytenoideus
7. Cricrothyroid
8. Thyrohyoid
9. Sternothyroid

Muscle	Origin	Insertion	Action	Nerve
aryepiglotticus	apex of arytenoid cartilage	lateral border of epiglottis	aids closure of additus of larynx	vagus nerve (CN X) - recurrent laryngeal branch
cricrothyroid	anterolateral aspect of cricoid cartilage	Inferior cornu & lower laminar of thyroid cartilage	lengthens & tenses vocal cords by tilting thyroid cartilage forwards	
posterior cricoarytenoid	posterior aspect of cricoid cartilage	muscular process of arytenoid cartilage	abducts & lat rotates arytenoid cartilage (opens rima glottidis)	
larynx - oblique arytenoideus	muscular process of arytenoid cartilage	superior pole of opposite arytenoid cartilage	adducts arytenoid cartilages (closes rima glottidis)	
lateral cricoarytenoid	lateral aspect of arch of cricoid	muscular process of arytenoid cartilage	adducts & medially rotates arytenoid cartilage (closes rima glottidis)	
thyroarytenoid	lower posterior surface between laminae of thyroid cartilage	vocal process of arytenoid cartilage	shortens & relaxes vocal cords by medial rotation & protraction of arytenoid cartilage	
thyroepidglotticus	lower posterior surface of thyroid cartilage	lateral border of epiglottis	aids closure of additus to larynx	
arytenoideus	posterior surface & muscular process of arytenoid cartilage	surfaces of opposite side cartilage	adducts arytenoid cartilage (closes rima glottidis)	

References

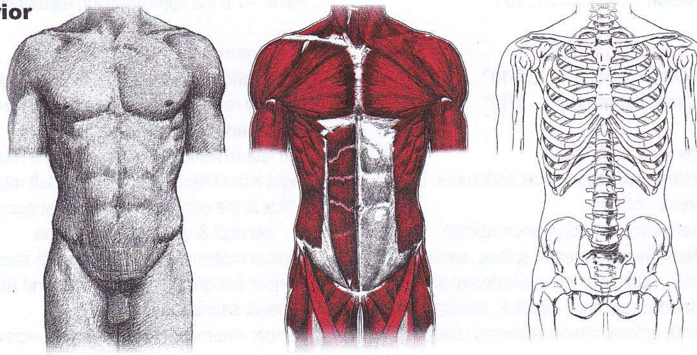
1 Buford JA, Yoder SM, Heiss DG, Chidley JV. "Actions of the scalene muscles for rotation of the cervical spine in macaque and human." J Orthop Sports Phys Ther. 2003 Mar; 33(3): 144-6; author reply 146-8.
2 Harry, Walter G.; Bennett, John D. C.; Guha, Somes C. "Scalene muscles and the brachial plexus: Anatomical variations and their clinical significance." Clin. Anat. 10:250-252, 1997.
3 Wayman, J; Miller, S; and Shanahan, D. Anatomical variation of the insertion of scalenus anterior in adult human subjects: implications for clinical practice. J Anat. 1993 August; 183(Pt 1): 165–167.
4 Davis, Clair (DC). "Self-Treatment Of Trigger Points In The Scalenes & Sternocleidomastoids." 2002, American Massage Therapy Association
5 Fernandez-de-las-Penas C, Alonso-Blanco C, Cuadrado ML, Gerwin RD, Pareja JA. "Trigger points in the Suboccipital muscles and Forward Head Posture in Tension-type Headache". Headache: The Journal of Head and Face Pain. 2000; 46 (3): 456-460.
6 Kulkarni V, Chandy MJ, Babu KS. "Quantitative Study of Muscle Spindles in Suboccipital Muscles of Human Fetuses. Neurol India. 2001; 49: 355-9.
7 Seaman, D. and Troyanovich, S. "The Forward Head Posture". Dynamic Chiropractic: 2000; Apr.3, 18, issue 08.
8 Tagil SM, Ozcakar L, Bozkurt MC. "Insight into Understanding the Anatomical and Clinical Aspects of Supernumerary Rectus Capitis Posterior Muscles". Clinical Anatomy: 2005 Jul; 18(5): 373-5.
9 D. Falla, D. Farina, M. Kanstrup Dahl, and T. Graven-Nielsen. "Muscle pain induces task-dependent changes in cervical agonist/antagonist activity" J Appl Physiol 102: 601-609, 2007.
10 Anderson, RWG. "Whiplash associated disorders: a comprehensive review." Centre for Automotive Safety Research, The University of Adelaide, Australia, 2006 http://casr.adelaide.edu.au/reports/CASR016.pdf
11 Cantu, RL,& Grodin, A. 1992: Myofascial manipulation - Theory and Clinical Application, Aspen Publishers Inc. 1992.
12 Cash, M. Pocket Atlas of the Moving Body : For All Students of Human Biology, Medicine, Sports and Physical Therapy, Ebury House, 2000.
13 Chaitow, L. Palpation Skills Assessment and Diagnosis Through Touch, Churchill-Livingston, 1996.
14 Cyriax J. Textbook of orthopaedic medicine. Vol. 1. Diagnosis of soft tissue lesions.
15 Cyriax, JH. & Cyriax, PJ. Cyriax's Illustrated Manual of Orthopedic Medicine, 3rd ed., Butterworth-Heinemann, 1996.
16 Dambro MR, Griffith JA: Griffith's 5 minute clinical consult, Baltimore, 2008, Williams & Wilkins.
17 Dandy DJ: Essential orthopaedics and trauma, Edinburgh, 1989, Churchill Livingstone.
18 Gartland, I.I.: Fundamentals of Orthopaedics. Philadelphia, W.B. Saunders Co., 1979.
19 Greenman, PE. Principles of Manual Medicine, 2nd ed., Williams & Willkins, 1995.
20 Hoppenfeld, S.: Physical Examination of the Spine and Extremities. New York, Appleton-Century-Crofts, 1976.
21 Kapandji, I.A.: The Physiology of Joints, vol. 1: Upper Limb. New York, Churchill Livingstone, 1970.
22 Kendall HO, Kendall FP, Wadsworth GE: Muscles testing and function, ed 4, Baltimore, 2003, Williams & Wilkins.
23 Kisner C, Colby LA: Therapeutic exercise; foundations and techniques, ed 2, Philadelphia, 1990, FA Davis.
24 Malone TR, MePoil TG, Nitz AJ: Orthopedic and sports physical therapy, ed 3, St Louis, 1997, Mosby.
25 Martin JH: Neuroanatomy text and atlas, ed 2, Stamford, Conn, 1996, Appleton & Lange.
26 Mathers LH, et al: Clinical anatomy principles, St Louis, 1996, Mosby.
27 Mellion MB: Sports medicine secrets, Philadelphia, 1994, Hanley & Belfus.
28 O'Donoghue, D.H.: Treatment of Injuries to Athletes, 4th ed. Philadelphia. W.B. Saunders Co., 1984.
29 Reid, D.C.: Sports Injury Assessment and Rehabilitation. New York, Churchill Livingstone, 1992.
30 Travell, TG., & Simons, LS. Myofascial Pain and Dysfunction: The Trigger Point Manual. 2nd ed. Volume 1 Upper Body. Baltimore, Williams & Wilkins, 1993.
31 Travell, TG., & Simons, LS. Myofascial Pain and Dysfunction: The Trigger Point Manual. 2nd ed. Volume 2 Lower Body. Baltimore, Williams & Wilkins, 1993.
32 Vizniak, NA. Gross Anatomy: Human Cadaver Dissections. 1999-2008



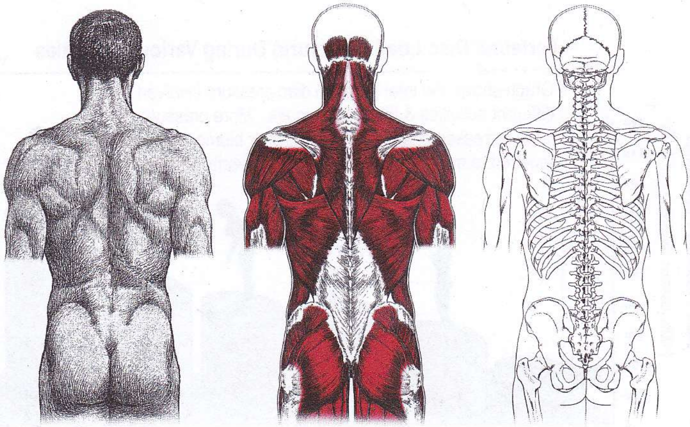


Torso & Back Contents

Anterior



Posterior



Joint types:
- Gliding (zygapophyseal/facet joints)
- Gliding (costal & transverse costal)
- Fibrocartilaginous (intervertebral joints)

Articular surfaces
- **Thoracic:** facets are oriented in coronal plane
- **Lumbar:** facet oriented in sagittal plane
- **Sacroiliac:** facets oriented ~45°

Active range of motion (thoracic)
Flexion...............60° *(Adam's sign for scoliosis)*
Extension..........25°
Lateral flexion...35°
Rotation............50°

Active range of motion (lumbar)
Flexion ....90°
Extension ....30°
Lateral Flexion ....30°
Rotation ....30°

Active range of motion (SI)
Flexion/Extension........0-10°
Int./external rotation ...0-10°

Main muscle actions
- **Flexion:** iliopsoas, rectus abdominis, internal/external oblique
- **Extension:** multifidi, erector spinae
- **Lateral flexion:** erector spinae, semispinalis, rectus abdominis, internal/external oblique
- **Rotation:** rotatores, multifidi, semispinalis, erector spinae, internal/external oblique

Resting position
- **T-spine:** mid way between flexion & extension
- **L-spine:** mid way between flexion & extension

Close packed position
- **T-spine:** full extension
- **L-spine:** full extension

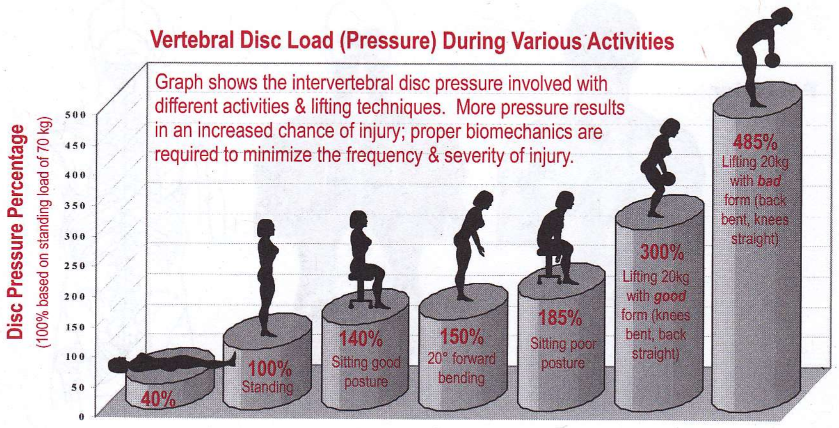
Capsular pattern of restriction
- **T-spine:** lateral flexion = rotation, then extension
- **L-spine:** lateral flexion = rotation, then extension

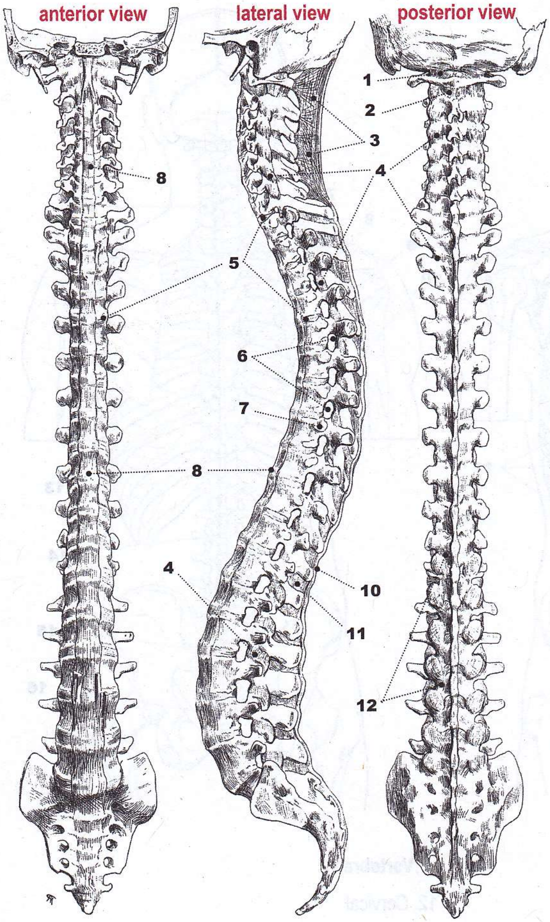
Normal end feel
- **Flexion:** tissue stretch
- **Extension:** tissue stretch
- **Lateral flexion:** tissue stretch
- **Rotation:** tissue stretch

Abnormal end feel
- **Early myospasm** → muscle/ligament tear
- **Late myospasm** → instability
- **Empty** → ligament rupture
- **Hard** → bone approximation (osteophyte)

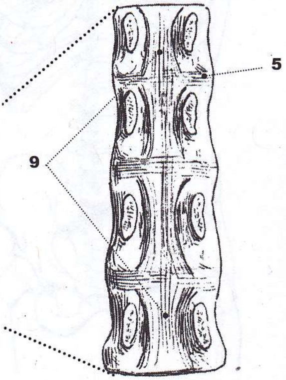
Coupled motions
Pure rotation and pure lateral flexion do not occur at any region in the spine below C1-C2
- **T6-L5 vertebral segments***
- Left lateral flexion coupled with right rotation
- Right lateral flexion coupled with left rotation
  *this is the opposite coupling that occurs in the cervical & upper thoracic spine
- Lumbar motion is also coupled with sacral motion
- Lumbar flexion is coupled with sacral ***nutation*** (anterior sacral tilting or "nod")
- Lumbar extension is coupled with sacral ***counter-nutation*** (posterior sacral tilting or extension)

Vertebral Disc Load (Pressure) During Various Activities



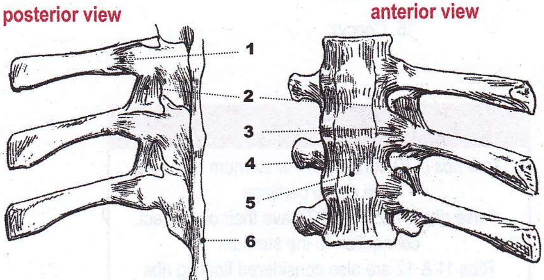


1. Posterior atlanto-occipital membrane
2. Posterior atlanto-axial membrane
3. Nuchal ligament
4. Zygapophyseal joint
5. Intervertebral joint (disc)
6. Intervertebral foramen
7. Costal facet (for rib head)
8. Anterior longitudinal ligament
9. Posterior longitudinal ligament
10. Supraspinous ligament
11. Interspinous ligament
12. Ligamentum flavum

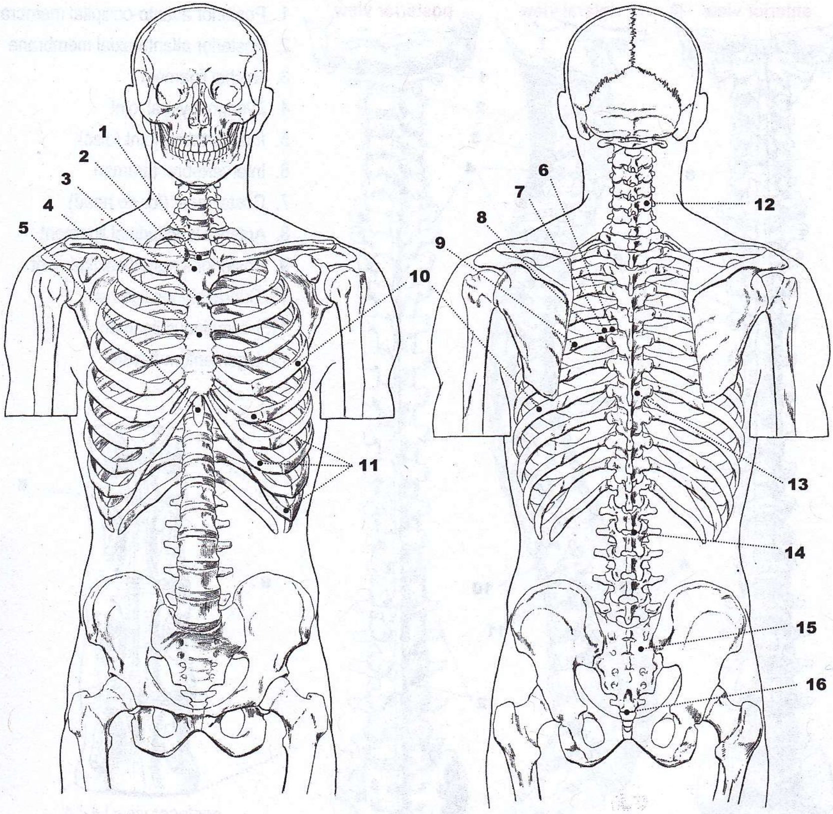


posterior view L1-L4
(pedicles have been cut to show posterior aspect of the lumbar vertebral bodies)

Rib Articulations Detailed



1. Costotransverse ligament
2. Superior costotransverse lig.
3. Radiate ligament
4. Inferior costotransverse ligament
5. Anterior longitudinal ligament
6. Supraspinous ligament



Sternum

1. Suprasternal / jugular notch
2. Manubrium
3. Sternal angle
4. Body / corpus
5. Xiphoid process

Ribs

6. Head
7. Neck
8. Tubercle
9. Angle
10. Body
11. Costal cartilages

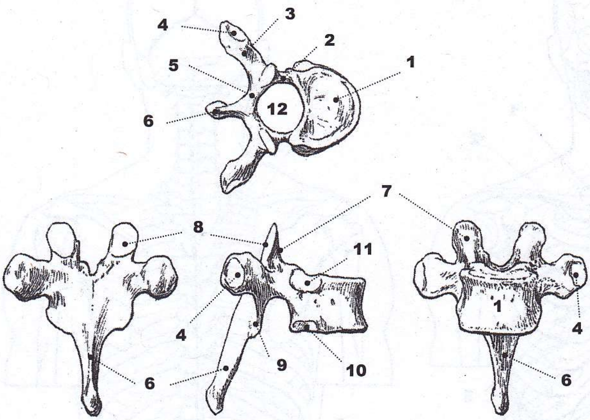
Vertebrae

12. Cervical
13. Thoracic
14. Lumbar
15. Sacrum
16. Coccyx

Ribs

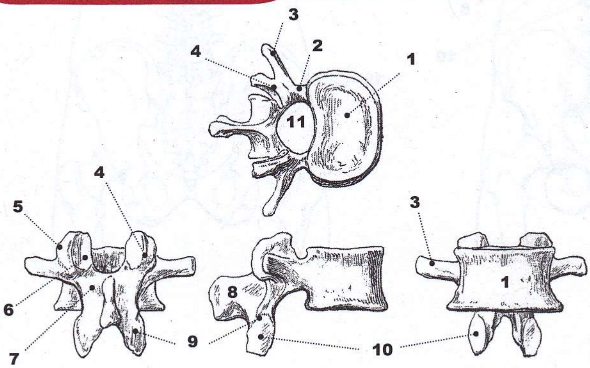
True ribs (1-8) connect to the sternum with their own costal cartilage
False ribs (9-12) do NOT have their own direct connection to the sternum
Ribs 11 & 12 are also considered floating ribs

Thoracic Vertebra



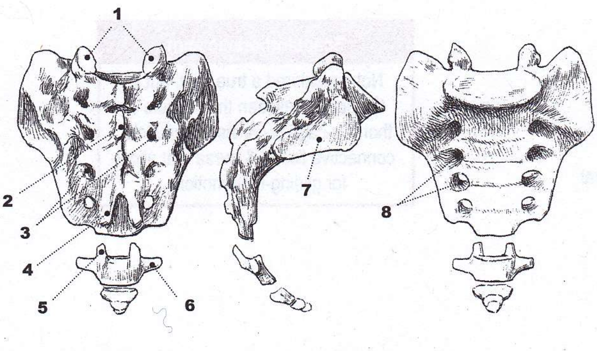
1. Body
2. Pedicle
3. Transverse process
4. Transverse costal facet
5. Lamina
6. Spinous process
7. Superior articular process
8. Superior articular facet
9. Inferior articular process
10. Inferior costal facet
11. Superior costal facet
12. Vertebral canal

Lumbar Vertebra

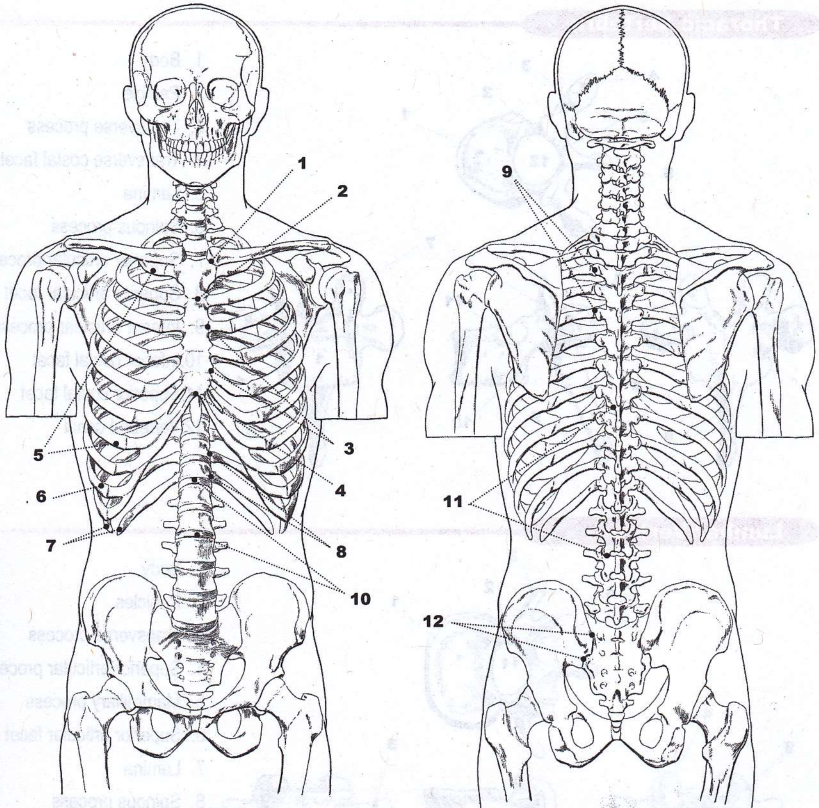


1. Body
2. Pedicles
3. Transverse process
4. Superior articular process
5. Mammillary process
6. Superior articular facet
7. Lamina
8. Spinous process
9. Inferior articular process
10. Inferior articular facet
11. Vertebral canal

Sacrum & Coccyx



1. Superior articular facet
2. S2 tubercle
3. Posterior sacral foramen
4. Cornu of sacrum
5. Cornu of coccyx
6. Transverse process
7. Articular surface for ilium
8. Anterior sacral foramen



1. Sternoclavicular joint
2. Sternomanubrial joint
3. Sternocostal joint
4. Xiphisternal joint

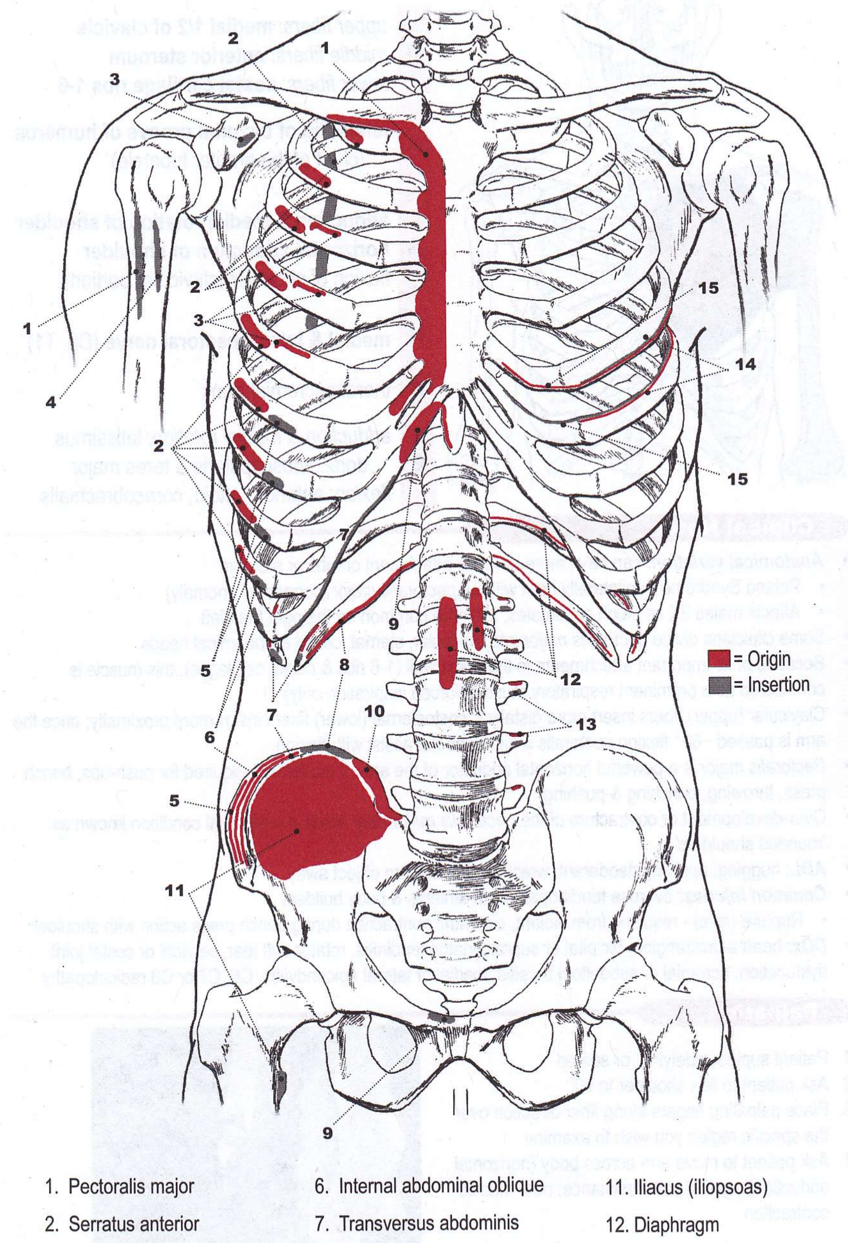
Ribs

5. True ribs (1-7)
6. False ribs (8-12)
7. Floating ribs (11-12)
8. Costovertebral joint
9. Transverse costovertebral

10. Intervertebral joint
11. Zygapophyseal joint
12. Sacroiliac (SI) joint

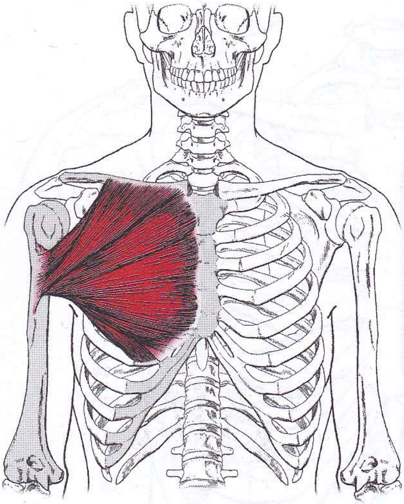
Scapulothoracic joint

Not considered a true joint, but is the space between the scapula & thoracic cage & consists of muscle, connective tissue & bursa that allow for gliding-type motions



1. Pectoralis major
2. Serratus anterior
3. Pectoralis minor
4. Latissimus dorsi
5. External abdominal oblique
6. Internal abdominal oblique
7. Transversus abdominis
8. Quadratus lumborum
9. Rectus abdominis
10. Erector spinae
11. Iliacus (iliopsoas)
12. Diaphragm
13. Intertransversarius
14. External intercostal
15. Internal intercostal

Pectoralis Major



O	*upper fibers:* **medial 1/2 of clavicle** *middle fibers:* **anterior sternum** *lower fibers:* **costal cartilage ribs 1-6**
I	**lateral lip of bicipital groove of humerus** (crest of the greater tubercle)
A	**adduction & medial rotation of shoulder** **horizontal adduction of shoulder** flexion of shoulder (clavicular portion)
N	**medial & lateral pectoral nerve** (C8, T1)
B	thoracoacromial trunk
S	*adduction & medial rotation:* latissimus dorsi, subscapularis & teres major *flexion:* anterior deltoid, coracobrachialis

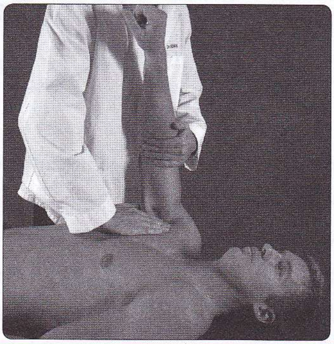
Clinical Notes

- ***Anatomical variation:*** can have more or fewer attachment on ribs or sternum
  - Poland Syndrome - unilaterally born without *pectoralis major* (congenital anomaly)
  - Affects males 3X as much as females, 2X more common on the right than left
- Some clinicians divide *pectoralis major* into clavicular, sternal, costal & abdominal heads
- Because of its important attachments to the chest wall (1-6 ribs & costal cartilages), this muscle is considered as a prominent respiratory muscle (forced inspiration only)
- Clavicular (upper) fibers insert more distally & costosternal (lower) fibers insert more proximally; once the arm is passed ~60° flexion pectoralis major does not assist with flexion
- *Pectoralis major* is a powerful horizontal adductor of the arm, a movement required for push-ups, bench press, throwing, punching & pushing
- Over-development or contracture of the *pectoralis major* may result in a postural condition known as 'rounded shoulders'
- ***ADL:*** hugging, applying deoderant, wrestling, pushing an object away
- ***Common injuries:*** overuse tendinopathies in athletes & body builders
  - Rupture (rare) - resulting from violent, eccentric contraction during bench press action with shoulder
- ***DDx:*** heart attack/angina, bicipital or supraspinatus tendinitis, rotator cuff tear, cervical or costal joint dysfunction, acromial or subdeltoid bursitis, medial or lateral epicondylitis, C6, C7 or C8 radiculopathy

Palpation

1. Patient supine, sidelying, or seated
2. Ask patient to flex shoulder to 90°
3. Place palpating fingers along fiber direction over the specific region you wish to examine
4. Ask patient to move arm across body (horizontal adduction) against your resistance; note muscle contraction

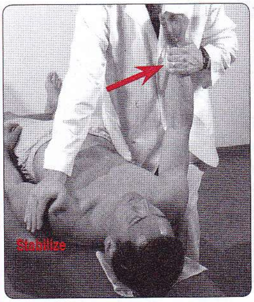
Pectoralis major may also be palpated by 'pinching' the anterior axillary fold



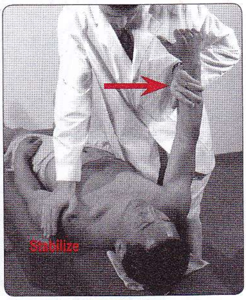
Muscle Test

	Sternal head	Clavicular head
PP	Supine, shoulder flexed 90°, fully internally rotated arm	Supine, shoulder flexed 90°, arm internally rotated 45°
EF	Diagonal toward abduction & slight *flexion*	Diagonal toward abduction & slight *extension*
S	Opposite shoulder	

PP = patient position, EF = examiner force, S = stabilization

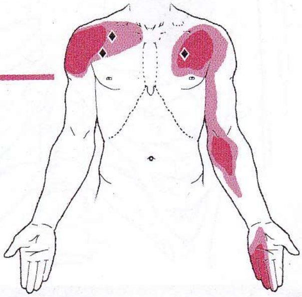


Clavicular Head



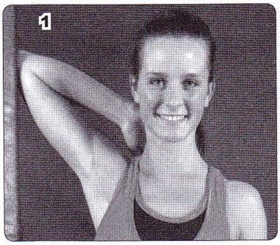
Sternal Head

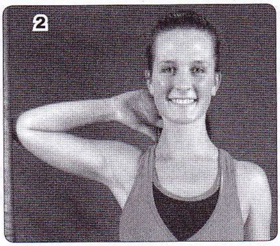
Trigger Point Referral

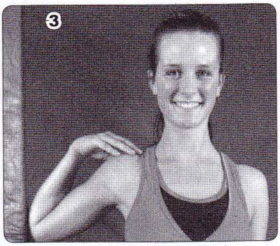


- Pain may extend up over subclavicular area & may cover the entire ipsilateral pectoral & anterior deltoid region
- Pain may radiate down the ulnar side, elbow, forearm & hypothenar side of hand (last 3 digits)
- **Note:** Pain from pectoralis major can mimic pain of a heart attack (a differential that must be ruled out)

Stretch & Strengthen



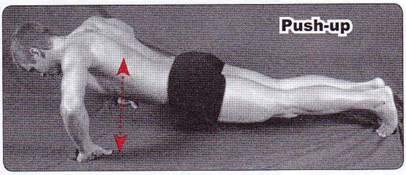


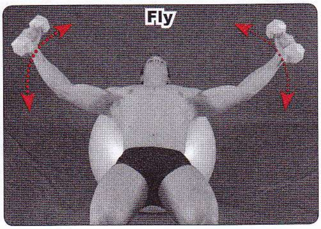


1. **Lower fibers:** elbow flexed, shoulder abduct 150° & extended against door or wall
2. **Middle fibers:** elbow flexed, shoulder abduct 100° & extended against door or wall
3. **Upper fibers:** elbow flexed, shoulder abduct 60° & extended against door or wall

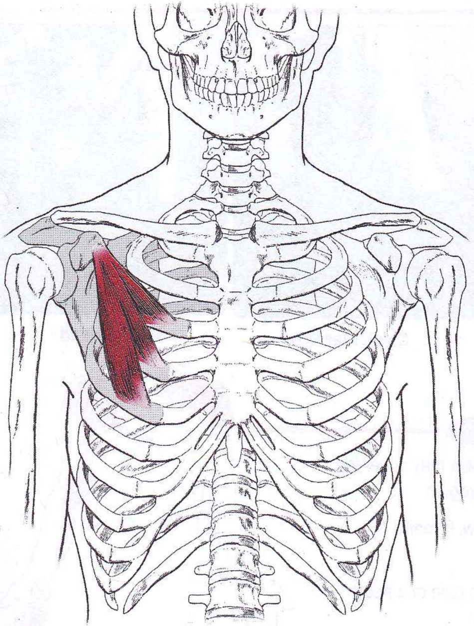
By flexing the elbow the stretches are more specific to pectoralis major; may also be done with the arm straight but will also stretch anterior arm muscles. Stretches may be done bilaterally through a door.

Strengthen
- Push ups
- Flys
- Pull over
- Chest dips
- Bench press -
  - incline for upper fibers
  - decline for lower fibers





Torso & Back



O	**ribs 3-5** (anterior lateral portion)
I	**coracoid process of scapula** (medial aspect)
A	**stabilizes scapula for arm movements** **depresses & downwardly rotates scapula** assists in scapular protraction from retracted position elevates ribs 3-5
N	**medial pectoral nerve** (C8, T1)
B	thoracoacromial trunk
S	serratus anterior

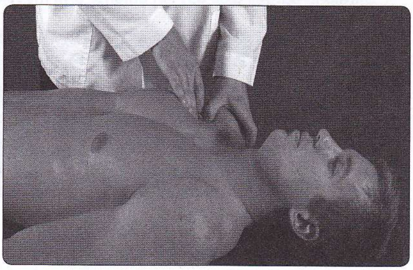
Clinical Notes

- ***Anatomical variation:*** rarely *pectoralis minor* may attach to the 2nd rib or even the 6th rib
- Myospasm or contracture of *pectoralis minor* may cause compression of the brachial plexus & subclavian artery & vein which run between *pectoralis minor* & the anterior rib cage; this compression can cause thoracic outlet syndrome (specifically, pectoralis minor syndrome)
- Contracture or tightness of *pectoralis minor* may contribute to a postural condition known as 'rounded shoulders'
- *Pectoralis minor* is considered an accessory muscle of respiration
- EMG studies show increased activity during forced inspiration (but not quiet breathing), in which the trapezius & levator scapulae help fix the scapula in position so the pectoralis minor can be used to elevate the ribs
- ***Common injuries:*** specific injuries to the *pectoralis minor* are rare
- ***DDx:*** heart attack/angina, bicipital or supraspinatus tendinitis, cervical articular joint dysfunction, bursitis, medial or lateral epicondylitis, C5, C6, C7 radiculopathy

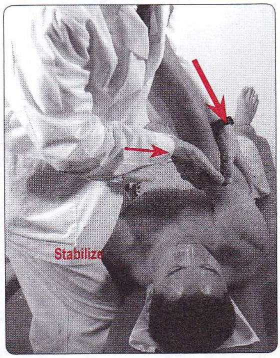
Palpation

1. Patient supine, sidelying, seated
2. Place palpating fingers along fiber direction just inferior to the coracoid process
3. Ask patient to take a deep breath
4. Note muscle contraction

Pectoralis minor may also be palpated by 'pinching" the medial portion of the anterior axillary fold



Muscle Test



Patient position

- Supine, shoulder adducted across body & lifted off examination table (note the patient's hand grips the examiner's upper arm)

Examiner's force

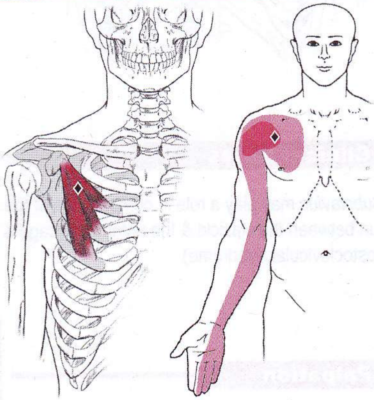
- Diagonal toward retraction of the scapula (force is not directed through the examiner's hand but through the upper arm)

Stabilization

- Patient may grip table with opposite arm

Trigger Point Referral

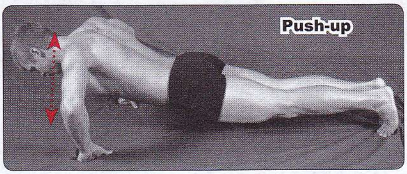
- Pain is usually most prominent over the anterior deltoid, but may extend up over subclavicular area & may cover the entire ipsilateral pectoral & anterior deltoid region
- Pain may radiate down the ulnar side, elbow, forearm & hypothenar side of hand (last 3 digits)
- **Note:** Pain from pectoralis minor can mimic pain of a heart attack (a differential that must be ruled out)

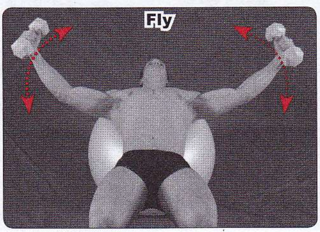


Stretch & Strengthen

Strengthen

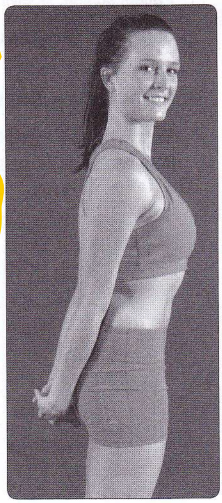
- Pectoralis minor is recruited during most shoulder movements & pectoralis major exercises





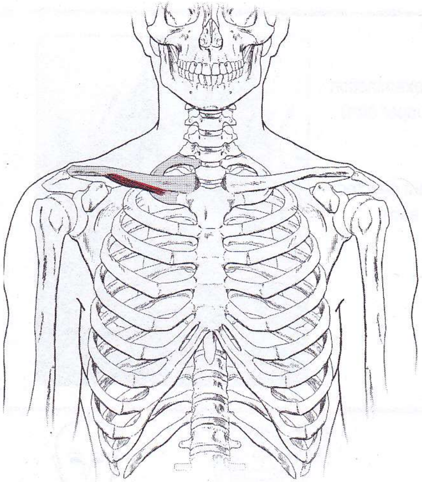
Self Stretch:

- Shoulders extended with scapulas fully retracted, stick out chest
- Taking a deep breath may further expand the chest & enhance the stretch
- Note: this action may also stretch pectoralis major



Torso & Back

Subclavius



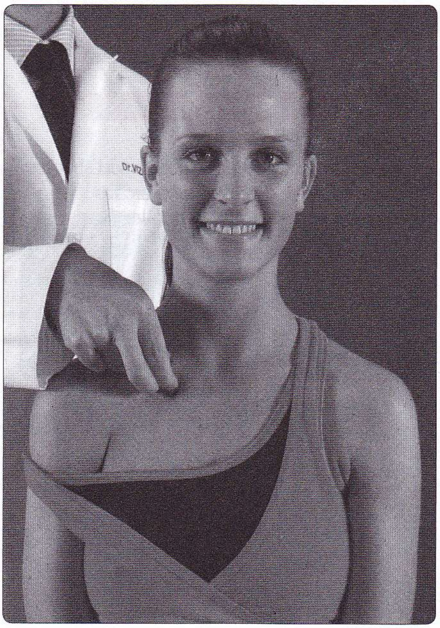
O	**1st rib** (junction of costocartilage)
I	**middle 1/3 of clavicle** (inferior surface)
A	**assists in stabilization of clavicle** **depression of clavicle** elevation of 1st rib
N	**nerve to subclavius** (C5, C6)
B	clavicular branch of thoracoacromial artery

Clinical Notes

- *Subclavius* may play a role in compression of the brachial plexus & subclavian artery & vein, which run between the clavicle & the anterior rib cage & can cause thoracic outlet syndrome (specifically costoclavicular syndrome)

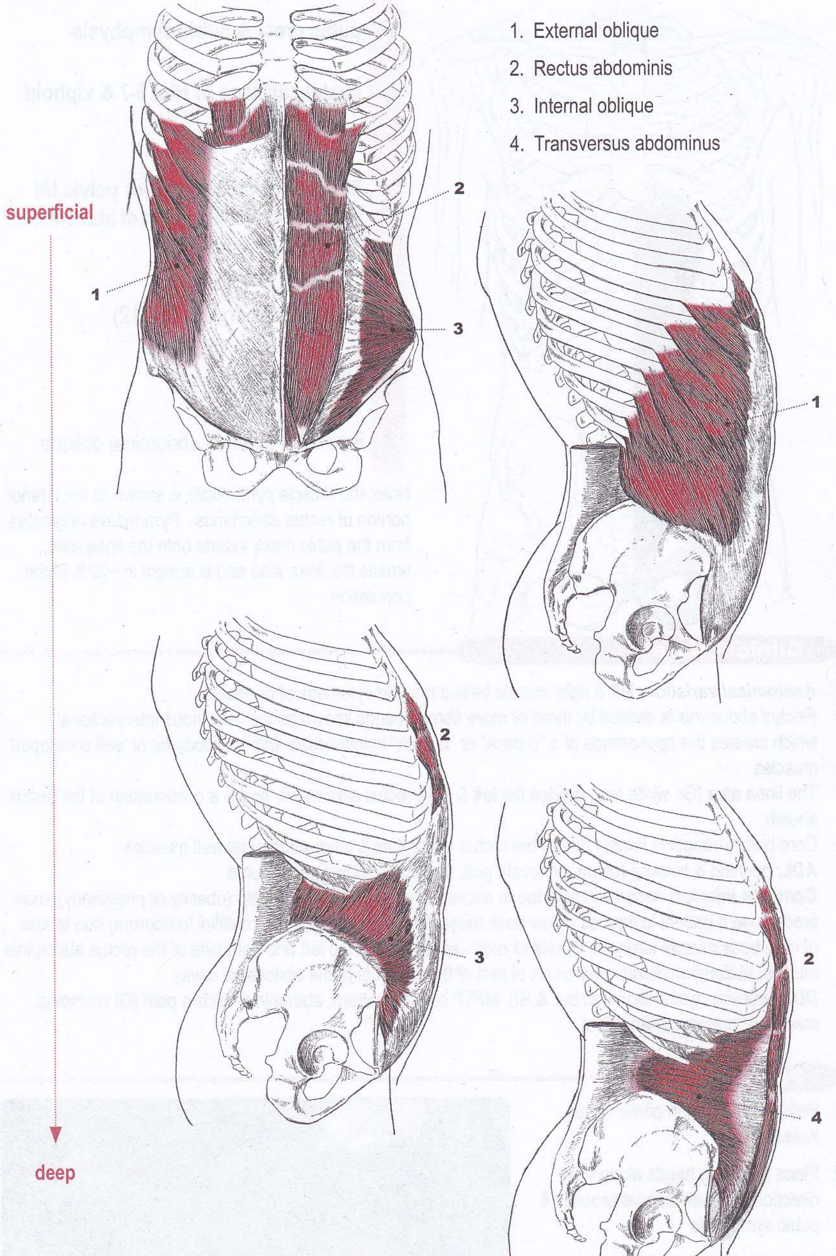
Palpation

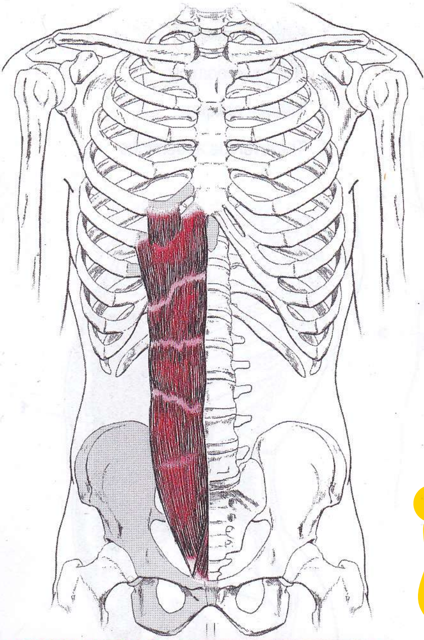
1. Patient supine, sidelying, seated
2. Curl palpating fingers under middle 1/3 of clavicle
3. Ask patient to elevate shoulder
4. Muscle may be difficult to distinguish from pectoralis major's clavicular fibers



Torso & Back

1. External oblique
2. Rectus abdominis
3. Internal oblique
4. Transversus abdominus





O	**pubic crest & pubic symphysis**
I	**costal cartilage of ribs 5-7 & xiphoid process**
A	**flexion of trunk, posterior pelvic tilt** compression/stabilization of abdomen (core body strength)
N	**intercostal nerves** (T5-T12)
B	epigastric arteries
S	internal & external abdominal oblique

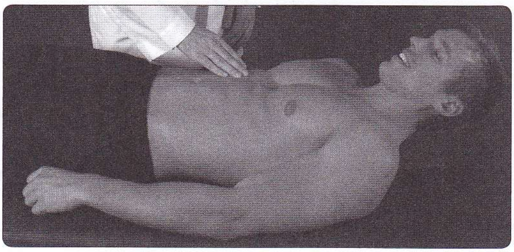
Note: the muscle *pyramidalis* is shown at the inferior portion of rectus abdominus. Pyramidalis originates from the pubic crest, inserts onto the linea alba, tenses the linea alba and is absent in ~20% of the population

Clinical Notes

- ***Anatomical variation:*** left & right muscle bellies may be symmetrical or offset
- *Rectus abdominis* is divided by three or more fibrous bands known as the 'tendinous intersections', which creates the appearance of a "6-pack" or "8-pack" in individuals with low body fat or well developed muscles
- The linea alba (Gr. white line) divides the left & right *rectus abdominis*, and is a continuation of the rectus sheath
- Core body strength is largely due to the rectus abdominis & other abdominal wall muscles
- ***ADL:*** pushing & twisting (using a shovel), golf, base ball, cricket, intercourse
- ***Common injuries:*** deconditioning due to excessive abdominal weight gain (obesity or pregnancy), may predispose a patient to injuries of low back musculature (erector spinae, multifidi lumborum) due to loss of core body muscle strength; Diastasis recti - separation of the left and right side of the rectus abdominis muscle; abdominal hernia: protrusion of part of the contents of the abdominal cavity
- ***DDx:*** articular dysfunction (lumbar & SI), MFTP referral pattern, abdominal viscera pain (GI cramping, menstrual cramps, apendicitis)

Palpation

1. Patient supine, with pillow under knees
2. Place palpating hands along fiber direction between xiphoid process & pubic symphysis
3. Ask patient to do a 'sit up' or 'crunch'
4. Note contraction of muscle tissue



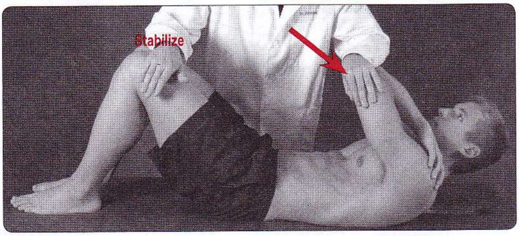
Torso & Back

Muscle Test

Patient position
- Supine, with knees flexed to 90°
- Ask patient to perform a sit-up or crunch

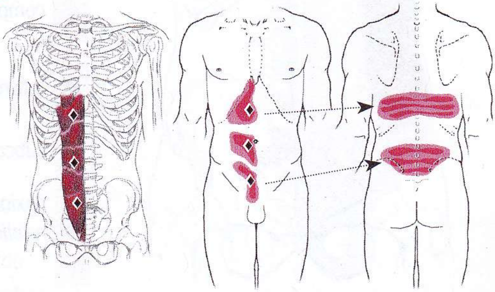
Examiner's force
- Observation without force may suffice, examiner may choose to apply resistance over patient's upper chest through arms into extension

Stabilization
- Examiner may stabilize patient's ankles or thighs if required



Trigger Point Referral

- MFTP location can be divided into upper third, periumbilical & lower third
- Upper & lower region refer bilaterally horizontally across the back; pain may be described as heartburn, indigestion or nausea
- Periumbilical MFTPs refer pain to the abdomen & are often described as cramping or colic



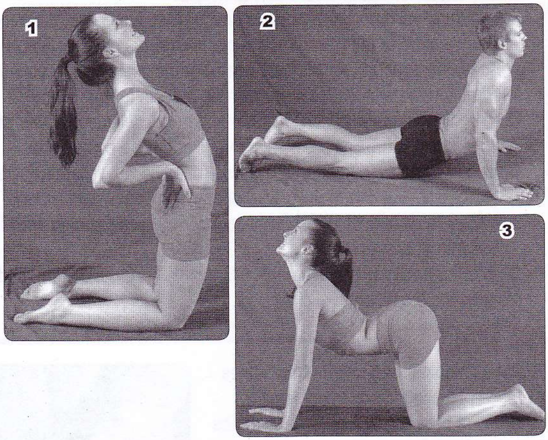
Stretch & Strengthen

Self Stretch 1:
- Standing or kneeling extend back

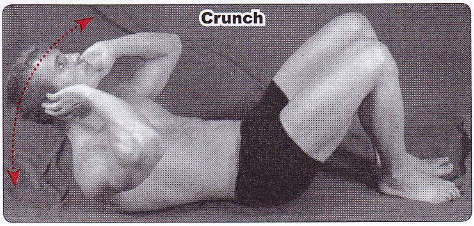
Self Stretch 2:
- Lying flat on stomach slowly extend spine

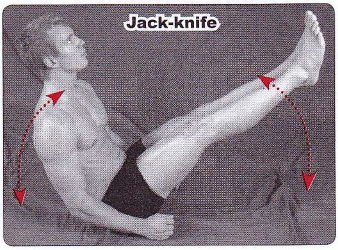
Self Stretch 3:
- On all fours, extend lumbar spine

- Stretches may also be performed supine over a gym ball

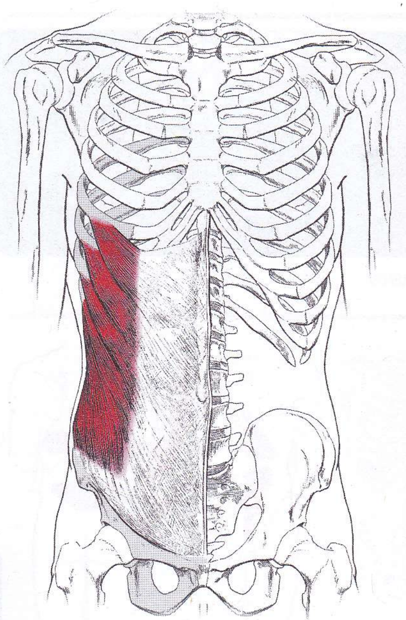


Strengthen
- Sit up (knee bent)
- Crunch
- Hanging leg raise
- Jack knife sit up (legs bent or straight)





External Abdominal Oblique



O	**anterior 1/2 of iliac crest, inguinal ligament, pubic tubercle/crest & rectus sheath**
I	**inferior border of ribs 6-12**
A	**flexion, lateral flexion & contralateral rotation of trunk** **posterior pelvic tilt** compression/stabilization of abdomen
N	**intercostal nerves** (T7-T12)
B	subcostal & intercostal arteries
S	*flexion:* rectus abdominis *rotation:* contralateral internal abdominal oblique

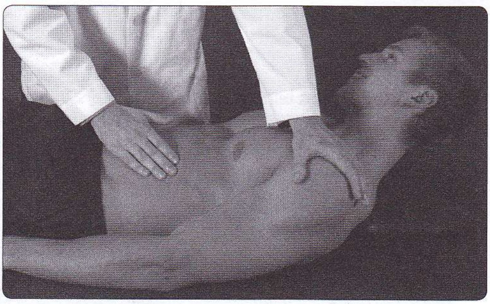
Clinical Notes

- ***Anatomical variation:*** the *external oblique* may also have attachments to ribs 4 & 5
- To help remember the fiber direction of the *external oblique*, simply place your hands in your front pockets; the direction your fingers point is the muscle fiber direction
- *Internal & external obliques* are the prime movers for trunk rotation
- Core body strength is largely due to the *external obliques* & other abdominal wall muscles
- ***ADL:*** pushing & twisting (using a shovel), golf, base ball, cricket
- ***Common injuries:*** strains with overuse (bending & twisting activities)
  - Deconditioning due to excessive abdominal weight gain (obesity or pregnancy), may predispose a patient to injuries of low back musculature (erector spinae, multifidi lumborum) due to loss of core body muscle strength
- ***DDx:*** articular dysfunction (lumbar & SI), MFTP referral pattern, abdominal viscera pain (GI cramping, menstrual cramps, appendicitis)

Palpation

1. Patient supine, with pillow under knees
2. Place palpating hands along fiber direction between iliac crest & lower ribs
3. Ask patient to rotate their torso contralaterally
4. Note contraction of muscle tissue (contraction can be felt on the right side if the patient moves to the left, and vice versa for the opposite side)

It may be difficult to distinguish the contraction of the external oblique from the internal oblique

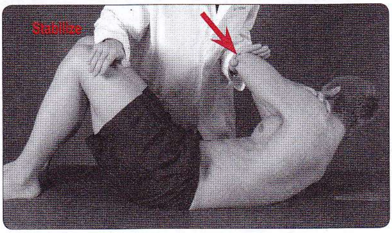


Muscle Test

Patient position: supine, with knees flexed to 90°
- Ask patient to perform a sit-up or crunch with contralateral rotation

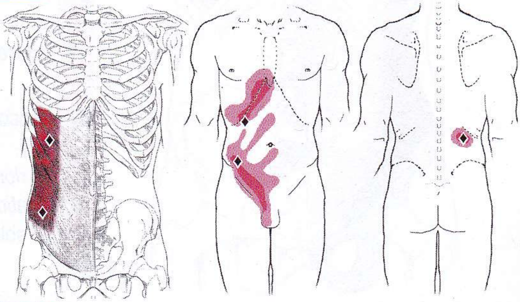
Examiner's force
- Observation without force may suffice, examiner may choose to apply mild resistive force over patient's upper chest into extension & ipsilateral rotation

Stabilization
- Examiner may stabilize patient's thighs if required



Trigger Point Referral

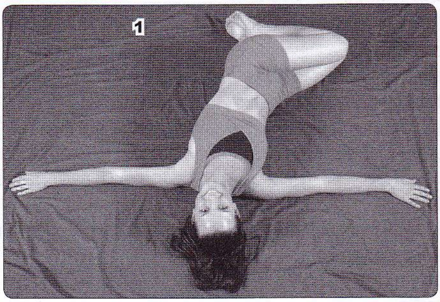
- MFTP location can be divided into upper & lower regions
- Upper may refer upper chest or diagonally across abdomen
- Lower typically refers over the local area or down to the groin, possibly into the testicles
- Belch button (rare) - just below 12th rib, when compressed, belching occurs

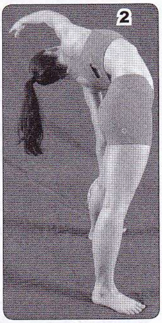


Stretch & Strengthen

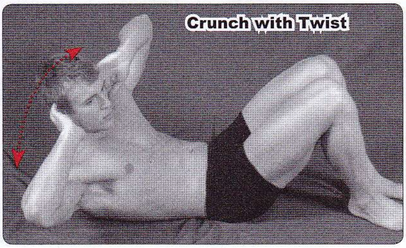
Self Stretch 1:
- Lying supine, bend knees & rotate legs to contralateral side (may be done with legs straight)

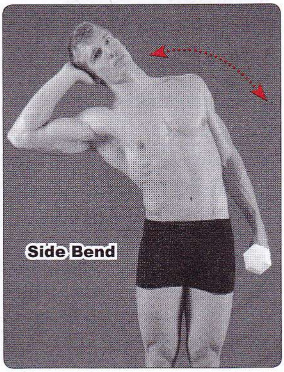
Self Stretch 2:
- Standing, contralaterally laterally flex & extend trunk



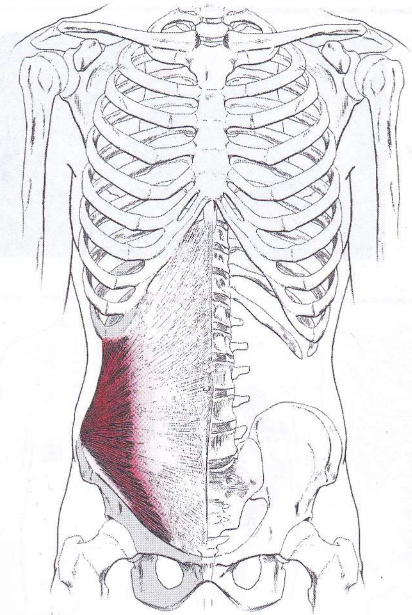


Strengthen
- Sit-up or crunch with rotation
- Side bending
- Lying leg twist





Internal Abdominal Oblique



O	**iliac crest, inguinal ligament, thoraco-lumbar fascia**
I	**ribs 10-12 & rectus sheath**
A	**flexion, lateral flexion & ipsilateral rotation of trunk** **posterior tilt of pelvis** compression/stabilization of abdomen
N	**intercostal nerves** (T7-L1)
B	subcostal & intercostal arteries
S	*flexion:* rectus abdominis *rotation:* contralateral external abdominal oblique

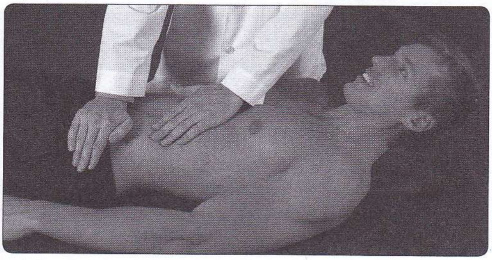
Clinical Notes

- Fiber direction of *internal oblique* muscle is generally perpendicular to the *external oblique*
- *Internal & external obliques* are the prime movers for trunk rotation
- Core body strength is largely due to the *internal obliques* & other abdominal wall muscles
- ***ADL:*** pushing & twisting (using a shovel), golf, baseball, cricket
- ***Common injuries:*** strains with overuse (bending & twisting activities)
  - Deconditioning due to excessive abdominal weight gain (obesity or pregnancy), may predispose a patient to injuries of low back musculature (erector spinae, multifidi lumborum) due to loss of core body muscle strength
- ***DDx:*** articular dysfunction (lumbar & SI), MFTP referral pattern, abdominal viscera pain (GI cramping, menstrual cramps, appendicitis)

Palpation

1. Patient supine, with pillow under knees
2. Place palpating hands along fiber direction over abdomen between iliac crest & lower ribs
3. Place opposite hand over ASIS & ask patient to flex & rotate their pelvis against your resistance
4. Note contraction of muscle tissue (contraction can be felt on the right side if the patient moves to the right, and vice versa for the opposite side)

It may be difficult to distinguish the contraction of the external oblique from the internal oblique



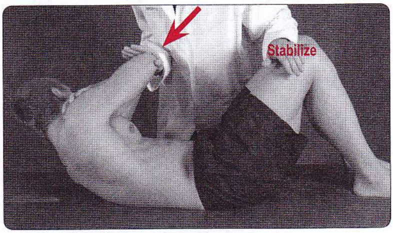
Torso & Back

Muscle Test

Patient position
- Supine, with knees flexed to 90°
- Ask patient to perform a sit-up or crunch with rotation

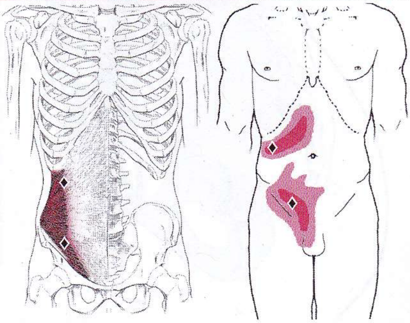
Examiner's force
- Observation without force may suffice, examiner may choose to apply mild resistive force over patient's upper chest into extension & contralateral rotation

Stabilization
- Examiner may stabilize patient's thighs if required



Trigger Point Referral

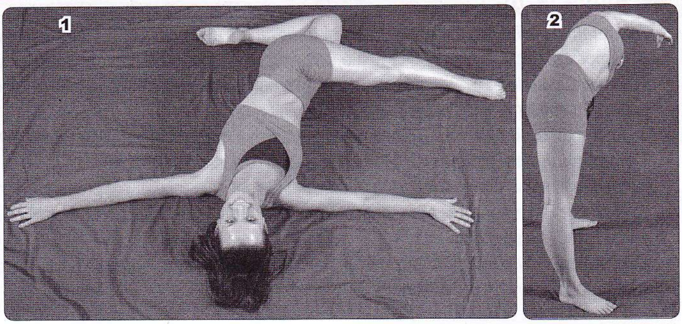
- MFTP location can be divided into upper & lower regions
- Upper may refer to lower chest or diagonally across abdomen
- Lower typically refer over the local area, or down the groin, possibly into the genital region
- It may be difficult to distinguish MFTPs in the internal oblique from the external oblique



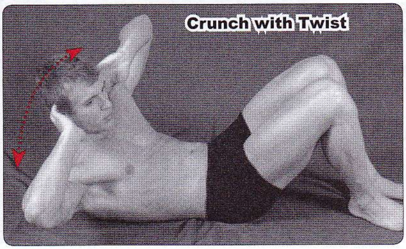
Stretch & Strengthen

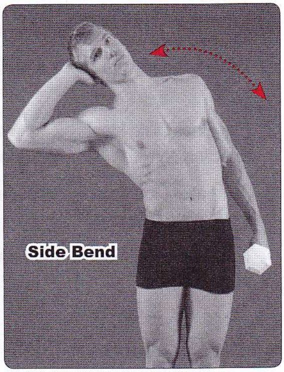
Self Stretch 1:
- Lying supine, bend knees & rotate legs to side (may be done with legs straight)

Self Stretch 2:
- Standing, laterally flex & rotate trunk to opposite side

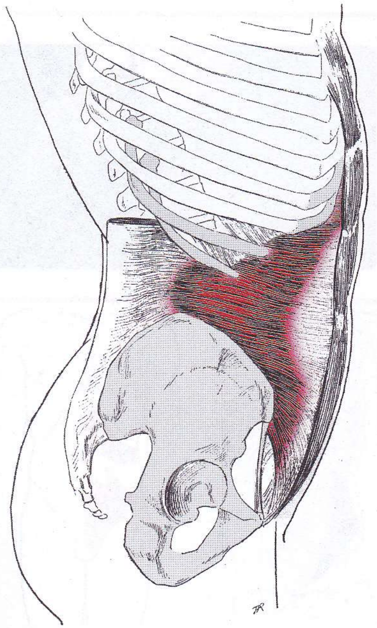


Strengthen
- Sit-up or crunch with rotation
- Side bending
- Lying leg twist





Transversus Abdominis



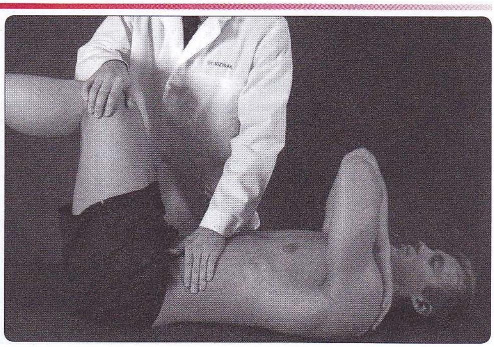
O	**iliac crest, inguinal ligament, thoraco-lumbar fascia & lower ribs & costal cartilage**
I	**abdominal aponeurosis** (rectus sheath)
A	**compression/stabilization of abdomen**
N	**intercostal nerves** (T7-L1)
B	subcostal & intercostal arteries
S	rectus abdominis, internal & external abdominal oblique

Clinical Notes

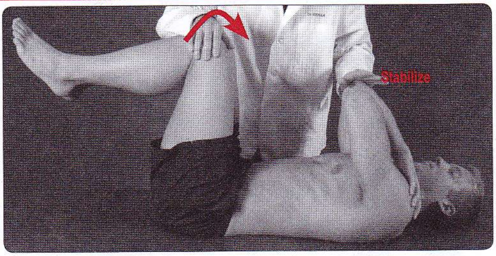
- ***Anatomical variation:*** the upper fibers of *transversus abdominis* may blend with the *diaphragm*
- Core body strength is largely due to the *transversus abdominis* & other abdominal wall muscles
- *Transversus abdominis* play a key role in movements that involve abdominal compression (coughing, sneezing, vomiting, defecation & valsalva maneuvers)
- ***ADL:*** forced expiration, sneezing, coughing, Valsalva maneuver, vomiting (hopefully not an ADL ☺)
- ***Common injuries:*** strains with overuse (bending & twisting activities)
  - Deconditioning due to excessive abdominal weight gain (obesity or pregnancy), may predispose a patient to injuries of low back musculature (erector spinae, multifidi lumborum) due to loss of core body muscle strength
- ***DDx:*** articular dysfunction (lumbar & SI), MFTP referral pattern, abdominal viscera pain (GI cramping, menstrual cramps, appendicitis)

Palpation

1. Patient supine with knees & hips flexed to 90°
2. Place palpating hands along fiber direction between iliac crest & lower ribs
3. Ask patient to forcefully exhale or rotate trunk without flexing
4. It may be difficult but note contraction of muscle tissue



Muscle Test



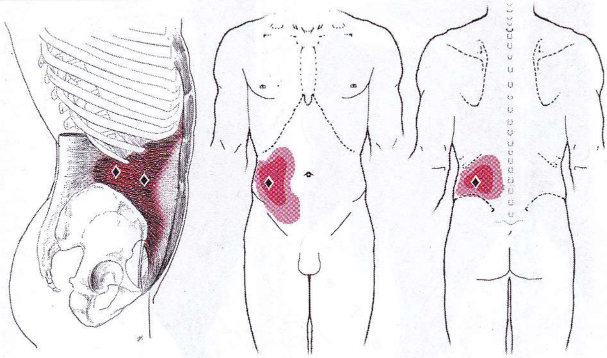
Patient position
- Supine, with knees & hips flexed to 90°, arms crossed in front of body
- Ask patient to maintain position

Examiner's force
- Examiner applies mild pulling force over patient's knees into rotation

Stabilization
- Patient's upper body (elbows)

Trigger Point Referral

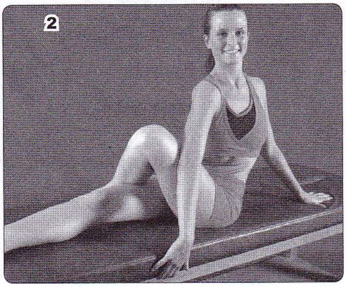
- MFTPs typically refer over the local area
- Referral to the abdomen is often described as cramping or colic



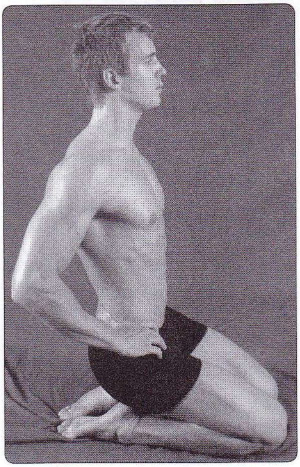
Stretch & Strengthen

Self Stretch 1:
- Seated with legs stabilized off end of chair rotate to side (perform bilaterally)

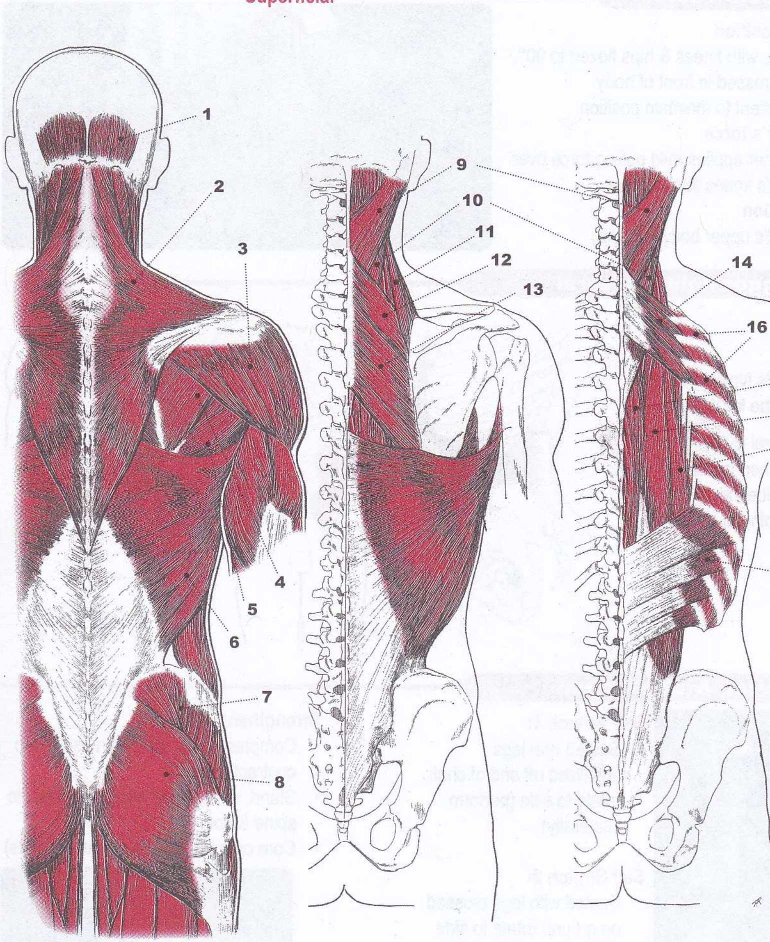
Self Stretch 2:
- Seated with legs crossed on ground rotate to side
- Over pressure may be applied with upper arm



Strengthen
- Compression of abdomen (isometric contraction)
- Stand, sit, kneel or lying; pull navel to spine & hold
- Core oriented type exercises (Pilates)



Superficial

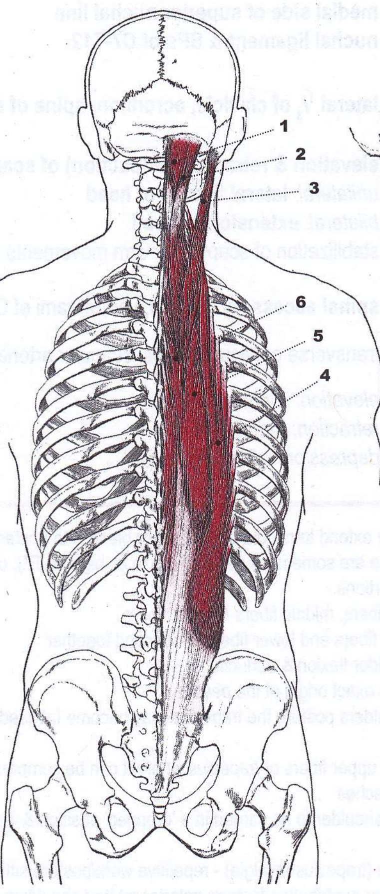


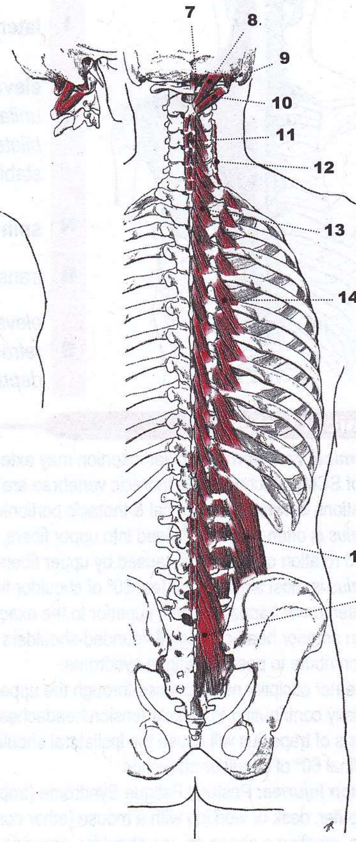
1. Occipitalis
2. Trapezius
3. Deltoid
4. Infraspinatus
5. Teres minor & major
6. Latissimus dorsi
7. Gluteus medius
8. Gluteus maximus
9. Splenius capitis
10. Splenius cervicis
11. Levator scapulae
12. Rhomboid minor
13. Rhomboid major
14. Serratus posterior superior
15. Serratus posterior inferior
16. Intercostal muscles

Erector spinae (deep layer)

17. Spinalis
18. Longissimus
19. Iliocostalis

Deep



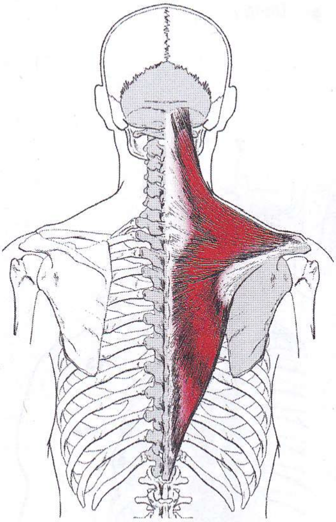


1. Spinalis capitis
2. Semispinalis capitis
3. Longissimus capitis

Erector spinae muscle group

4. Iliocostalis
5. Longissimus
6. Spinalis
7. Rectus capitis posterior minor
8. Rectus capitis posterior major
9. Obliquus capitis superior
10. Obliquus capitis inferior
11. Interspinalis
12. Intertransversarius
13. Multifidi
14. Levator costarum
15. Quadratus lumborum
16. Multifidi lumborum

Trapezius (middle & lower fibers)



O	**external occipital protuberance (EOP)** **medial side of superior nuchal line** **nuchal ligament & SPs of C7-T12**
I	**lateral $^1/_3$ of clavicle, acromion, spine of scapula**
A	**elevation & retraction (adduction) of scapula** *unilateral:* **lateral flexion of head** *bilateral:* **extension of head** stabilization of scapula for arm movements
N	**spinal accessory** (CN XI), ventral rami of C2-C4
B	transverse cervical & dorsal scapular arteries
S	*elevation:* levator scapulae *retraction:* rhomboids *depression:* latissimus dorsi

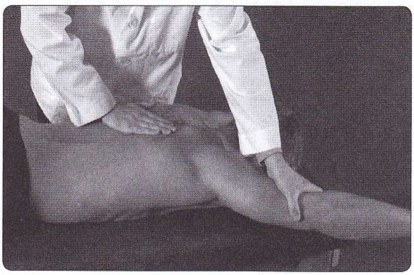
Clinical Notes

- ***Anatomical variation:*** clavicular insertion may extend to middle of clavicle, or blend with posterior edge of SCM; attachments to thoracic vertebrae are sometimes reduced (up to as high as T7); often separations between the cervical & thoracic portions
- *Trapezius* is often clinically divided into upper fibers, middle fibers & lower fibers
- Upward rotation of scapula is caused by upper fibers and lower fibers contracting together
- *Trapezius* is most active in the last 60° of shoulder flexion & abduction
- The insertion of *trapezius* is just superior to the exact origin of the *deltoid*
- With an anterior head carriage & rounded-shoulders posture the trapezius may become fatigued which may contribute to postural fatigue syndrome
- The greater occipital nerve passes through the upper fibers of *trapezius* where it can be compressed, potentially contributing to muscle tension headaches
- Paralysis of trapezius will cause the ipsilateral shoulder to be carried in a 'dropped' position & weakness in the final 60° of shoulder abduction
- ***Common injuries:*** Postural Fatigue Syndrome (trapezius myalgia) - repetitive work/posture sitting at a computer, desk or working with a mouse (other contributing factors: anterior rotated shoulders, large breasts, cradling a phone on one shoulder, one-sided sports activities, whiplash)
- ***DDx:*** trapezius myalgia, articular dysfunction (cervical or thoracic), TMJ disorders, MFTPs in other muscles, tension headache, occipital neuralgia & cervicogenic headache

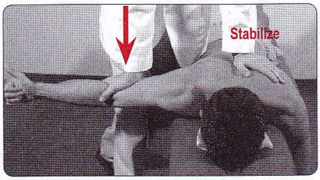
Palpation

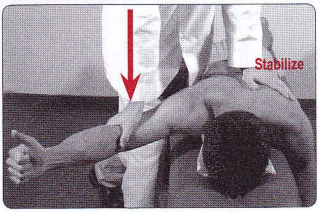
1. Patient prone
2. Place palpating hand over lower trapezius
3. Ask patient to abduct their shoulder to 120°
4. Mild resistance may be applied to abducted arm
5. Repeat steps #1-3 to with shoulder 90° abducted to palpate middle trapezius

During shoulder abduction, upward rotation of the scapula occurs (this requires both upper & lower fibers)



Muscle Test





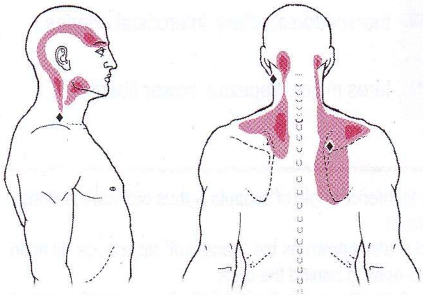
Patient position
- Prone
- *Middle trapezius:* shoulder abducted 90° & externally rotated
- *Lower trapezius:* shoulder abducted 120° & externally rotated

Examiner's force
- Toward floor (horizontal adduction)

Stabilization
- Contralateral scapula

Upper trapezius muscle testing is discussed in the neck chapter *(see page 81)*

Trigger Point Referral



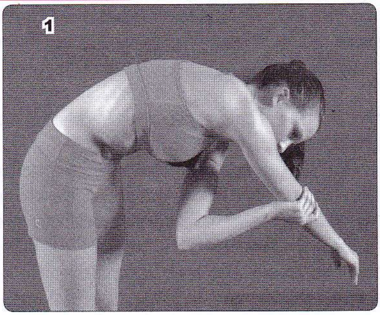
- Primary locations for MFTP are just above the superior border of the scapula & just inferior to the inferior angle of the scapula
- Pain may be referred to posterolateral neck & mastoid process
- May cause "tension neck ache"
- Intense pain may reach temples, back of eye, and angle of the jaw
- Pain can extend to occiput (rarely lower molar teeth) & can be accompanied by dizziness

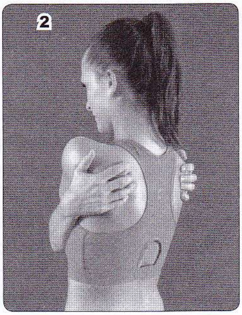
Torso & Back

Stretch & Strengthen

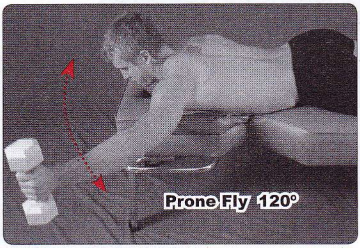
Self Stretch 1 (lower):
- Flex thoracic spine & abduct arm to 120°, protract scapula & apply gentle traction on arm (also consider grabbing door jam or table)

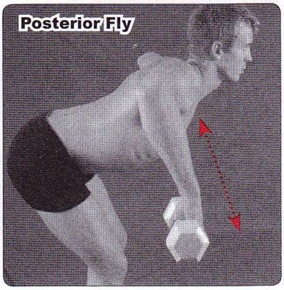
Self Stretch 2 (middle):
- Cross arms, grab scapulas & pull laterally (may be difficult with decreased flexibility)



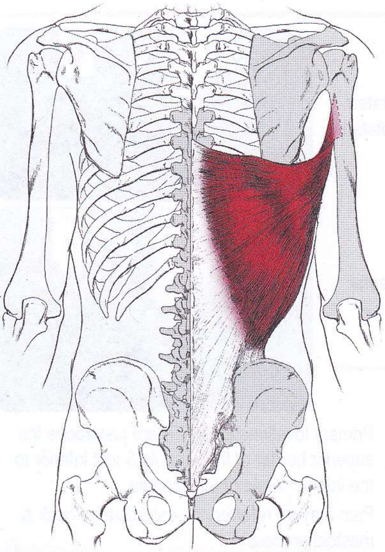


Strengthen
- Standing or prone posterior fly with shoulder at 90° (middle fibers)
- Prone posterior fly with shoulder at 120° (inferior fibers)





Latissimus Dorsi



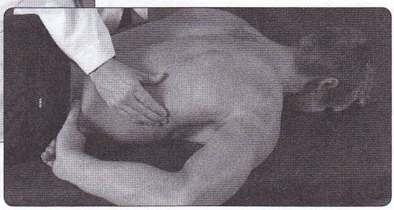
O	**SPs T7-L5; thoracolumbar fascia; iliac crest; posterior sacrum, ribs 9-12**; inferior angle of scapula (occasionally)
I	**bicipital groove of humerus** (medial lip)
A	**adduction, medial rotation & extension of shoulder** anterior pelvic tilt, elevation of pelvis depression of scapula; downward rotation of scapula
N	**thoracodorsal nerve** (C6, C7, C8)
B	thoracodorsal artery, intercostal arteries
S	teres major, trapezius (lower fibers)

Clinical Notes

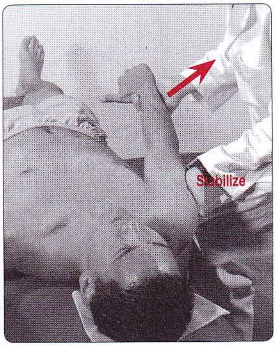
- ***Anatomical variation:*** *Latissimus dorsi* may attach to inferior angle of scapula & thus can have actions on scapula (depression, retraction & downward rotation)
- *Latissimus dorsi* is the main extensor of the arm and is also known as the "hand-cuff" muscle, as its main actions are similar to the position when handcuffs are applied behind the back
- The distal fibers of *latissimus dorsi* twist so that the inferior fibers attach proximally & superior fiber attach distally on humerus; *latissimus* & *teres major* make up most of the posterior axillary fold
- Because of the innervation from the upper, middle & lower trunks of the brachial plexus, *latissimus dorsi* is usually only slightly weakened by upper or lower brachial plexus trunk lesions
- The reverse function of *latissimus dorsi* is to elevate the lower trunk (ie. when the arms are fixed and kept stationary)
- This muscle is very important for disabled people, especially in transferring from wheelchair, car, bed and other activities that require the body weight to be lifted by the arms
- ***ADL:*** massage, osseous manipulation, push-ups, most upper extremity movements
- ***Common injuries:*** overuse syndromes (body builders, swimmers), glenohumeral dislocation, shoulder imbalances in throwing athletes (baseball pitcher, javelin) may predispose to latissimus strains
- ***DDx:*** rotator cuff tear, subacromial &/or sub-deltoid bursitis, articular dysfunction (cervical, thoracic, GH), MFTP referral pattern from other muscles, supraspinatus or bicipital tendinitis, C6 or C7 radiculopathy, brachial plexus injuries, thoracic outlet syndrome

Palpation

1. Patient seated or prone
2. Place palpating hand over posterior axillary region
3. Ask patient to push down arm on your shoulder
4. Note contraction of the muscle tissue



Muscle Test



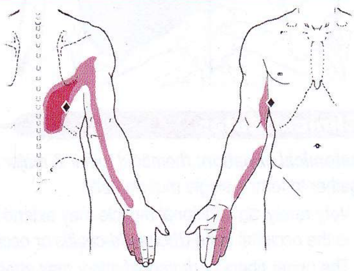
Patient position
- Supine, arm internally rotated

Examiner's force
- Diagonal toward abduction & flexion of the shoulder

Stabilization
- Over the patient's shoulder or upper arm

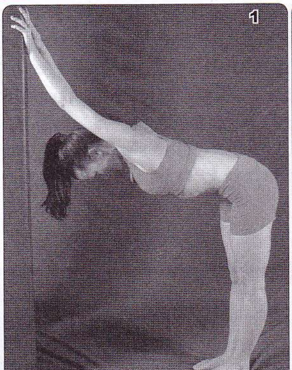
Alternate Method:
- Patient prone with head toward side being tested, arms at sides (palms up), with shoulder on the test side elevated
- Examiner at side being tested with both hands grasping the elbow; examiner attempts to push arm superiorly & instructs patient to resist action ("don't let me move you")

Trigger Point Referral



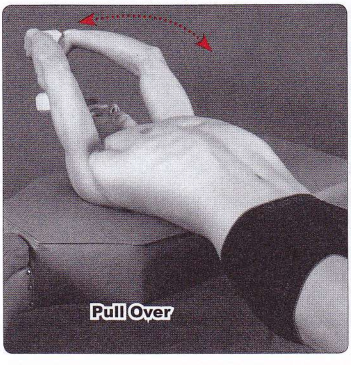
- Primary MFTP location is in the axillary region along the posterior axillary fold, inferior angle of scapula & the lower to mid thoracic spine
- Occasionally, pain may extend down the back of the shoulder, and/or down the medial side of the arm & hand into the 4th & 5th digits

Stretch & Strengthen



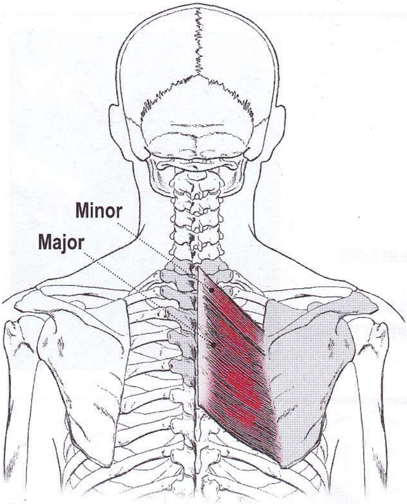
Self Stretch 1:
- Abduct & externally rotate shoulders above head against wall or door, pull body inferiorly

Self Stretch 2:
- Abduct & externally rotate shoulder above head against wall or door, pull body inferiorly



Strengthen
- Chin up
- Pull over
- Seated rows
- Swimming breast stroke

Rhomboid Major & Minor



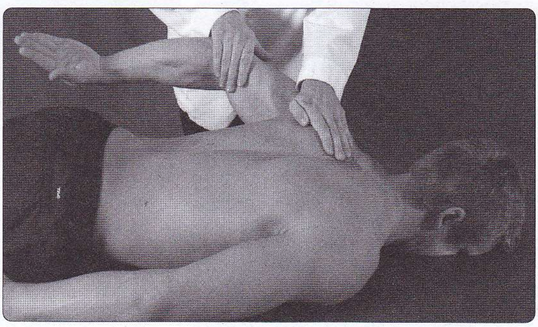
O	*minor:* **SPs C7 & T1**, supraspinous ligament *major:* **SPs T2-T5**, supraspinous ligament
I	*minor:* **medial border of scapula** (medial angle/root of spine) *major:* **medial border of scapula** (scapular spine to inferior angle)
A	**retraction (adduction) of scapula** elevation & downward rotation of scapula
N	**dorsal scapular nerve** (C4-C5)
B	deep branch of transverse cervical artery or dorsal scapular artery
S	trapezius (middle fibers)

Clinical Notes

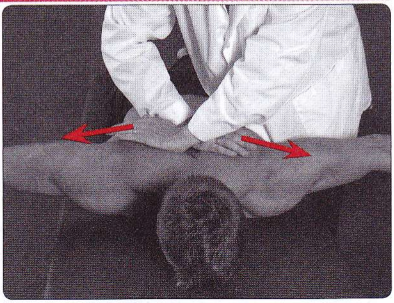
- ***Anatomical variation:*** *rhomboid minor & major* are usually separate muscles, however they often blend together to form a single muscle belly
  - Very rarely, an additional muscle may extend from the upper border of *rhomboid minor* on the scapula to the occipital bone (*rhomboid-capitis* or *occipitoscapularis*)
  - The upper fibers of *rhomboid minor* may attach to the nuchal ligament
- The *rhomboid* muscles play an important role in stabilization of the scapula during upper extremity movements
- Poor posture & over development of the anterior shoulder muscles (*pectoralis major* in particular) may result in rounded shoulders where the *rhomboid* muscles may be stretched & weakened
- ***ADL:*** pulling or lifting objects toward body (opening door), rowing, archery
- ***Common injuries:*** muscle strain from repetitive activity (rowing, excessive pulling with arms), poor posture with slouching & anterior rotated shoulders may cause muscle lengthening & weakness
- ***DDx:*** articular dysfunction (thoracic, lumbar & SI), trapezius or levator scapulae strain, postural fatigue syndrome

Palpation

1. Patient seated or prone with hand placed over lumbar spine
2. Place palpating fingers along the muscle fiber direction between the medial border of scapula & upper thoracic spinous processes
3. Ask patient to lift hand posteriorly away from back
4. Note contraction of the muscle tissue



Muscle Test



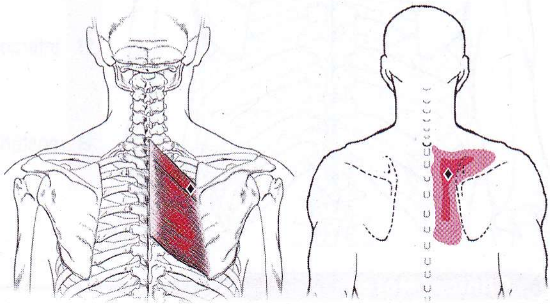
Patient position
- Prone, with shoulders abducted to 90°, scapulas fully retracted
- Ask patient to maintain position

Examiner's force
- Examiner applies mild resistive force over patient's medial scapulas, pushing into protraction

Stabilization: oppisite scapula

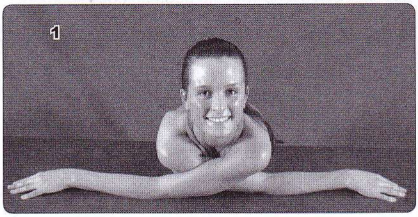
Trigger Point Referral

- MFTP referral pattern begins along the vertebral border of the spine between the scapula and the paraspinal muscles
- Usually extends to over the supraspinous portion of the scapula
- Snapping or crunching in the scapulocostal joint may be due to the trigger points of rhomboids being activated

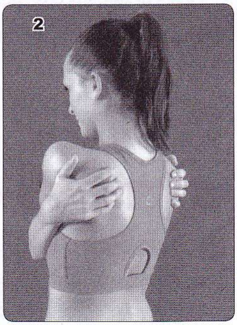


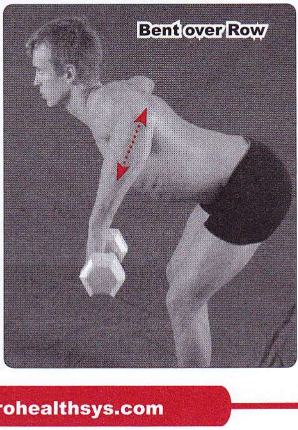
Stretch & Strengthen

Self Stretch 1:
- Cross arms in front of body & 'walk' hands out laterally



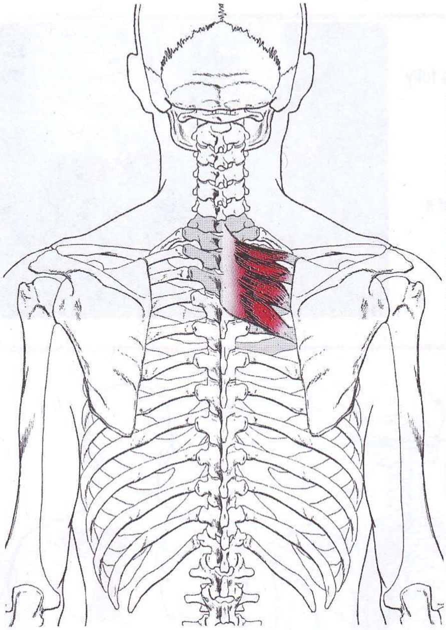
Self Stretch 2:
- Cross arms, grab scapulas & pull laterally (may be difficult with decreased flexibility)





Strengthen
- Resisted shoulder extension retraction (pull shoulder blades together & hold)
- Seated row
- Bent over row

Serratus Posterior Superior



O	**SPs of C7-T3**
I	**ribs 2-5** (superior external border)
A	**elevation of ribs**
N	intercostal & sub costal nerves
B	posterior intercostal arteries

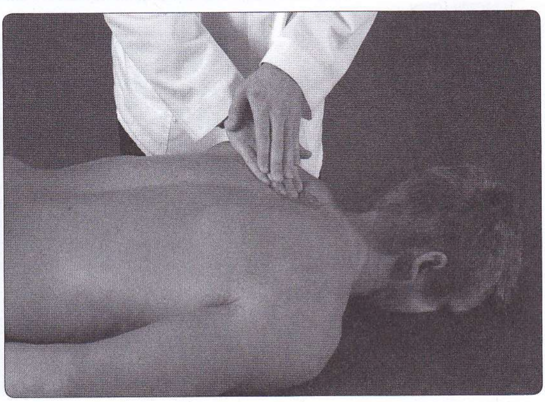
Clinical Notes

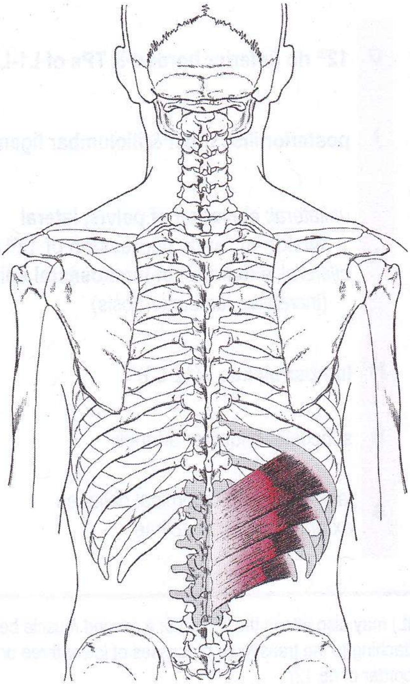
- ***Anatomical variation:*** *serratus posterior superior* & *inferior* may vary slightly in spinal & rib attachments
- Fibers of *serratus posterior superior* also blend with the supraspinous ligament
- This muscle also assists in forced expiration & inspiration and may be considered an accessory muscle of respiration

Palpation

1. Patient prone or seated
2. Place palpating hand along the fiber direction, medial to scapula
3. Ask patient to take deep breath
4. Note contraction of muscle tissue

Serratus posterior superior may be difficult to distinguish from rhomboids as the fiber direction is the same





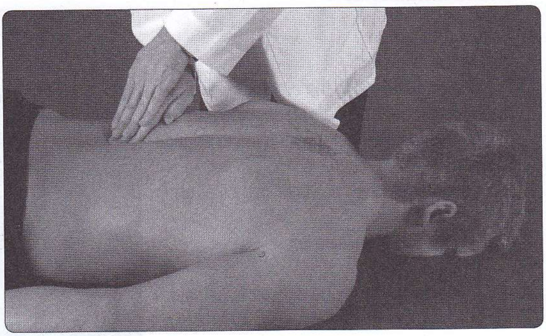
O	**SPs of T11-L3**
I	**ribs 9-12** (inferior external border)
A	**depression of ribs 9-12**
N	intercostal & sub costal nerves
B	posterior intercostal arteries

Clinical Notes

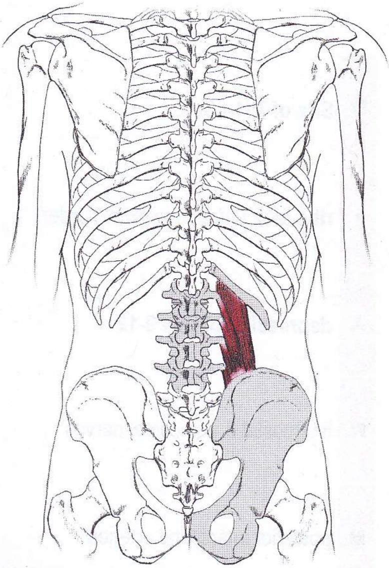
- ***Anatomical variation:*** *serratus posterior superior & inferior* may vary in spinal & rib attachments
- *Serratus posterior inferior* also helps to stabilize the thoracic wall for contractions of the diaphragm
- Fibers of *serratus posterior inferior* also blend with the supraspinous ligament
- This muscle also assists in forced expiration & inspiration and may be considered an accessory muscle of respiration

Palpation

1. Patient prone or seated
2. Place palpating hand along the fiber direction, over upper lumbar & lower rib area
3. Ask patient to take deep breath
4. Note contraction of muscle tissue



Quadratus Lumborum



O	**12th rib (inferior border) & TPs of L1-L4**
I	**posterior iliac crest & iliolumbar ligament**
A	*unilateral:* **elevation of pelvis, lateral flexion of trunk, depression of 12th rib** *bilateral:* **extension of lumbosacral spine** (increases lumbar lordosis)
N	**lumbar plexus** (T12-L3)
B	subcostal & lumbar arteries
S	*lateral flexion:* abdominal obliques *extension:* erector spinae

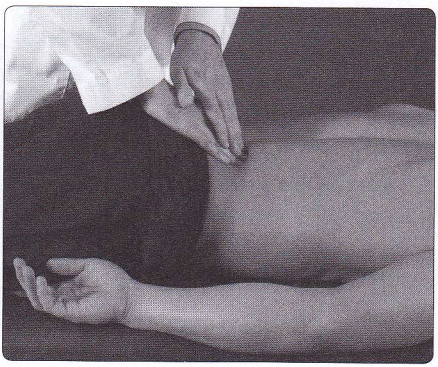
Clinical Notes

- ***Anatomical variation:*** *quadratus lumborum* (QL) may also attach the TP of L5; a second muscle belly is sometimes found in front of the main portion (attaching to the transverse processes of lower three or four lumbar vertebrae and inserting on to the lower border of rib 12)
- A main action of QL is to stabilize the 12th rib, preventing its elevation, when the diaphragm contracts during inspiration
- Quadratus lumborum is one of the 'core' body muscles, along with other muscles that help to stabilize the abdomen & lower back
- ***ADL:*** bending to the side, rolling over in bed, tennis serve, hip-hop & belly dancing ☺
- ***Common injuries:*** low back strain with overuse (bending & twisting activities), may be associated with injuries to other low back musculature (erector spinae, multifidi lumborum), leg length inequality may result in muscle endurance weakness (Knutson et.al. 2005)
- ***DDx:*** articular dysfunction (lumbar & SI), MFTP referral pattern of another muscle', abdominal viscera pain referral (GI cramping, possible passing of a kidney stone)

Palpation

1. Patient prone
2. Locate the iliac crest
3. Position hand lateral to the erector spinae (to distinguish the edge of erector spinae muscles, ask patient to lift their head off table to engage the erector spinae)
4. Ask patient to lift their pelvis or "hip hike" on the palpating side
5. Note contration of muscle tissue

Note: QL is deep and may be difficult to palpate



Muscle Test

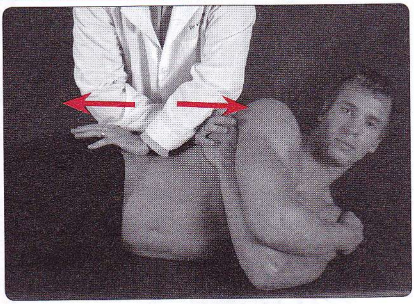
Patient position

- Side-lying, with upper body laterally flexed & ipsilateral hip elevated
- Ask patient to maintain position

Examiner's force

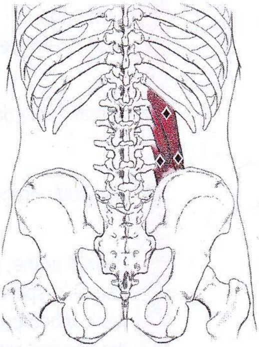
- Examiner applies resistive force over patient's iliac crest & lower lateral rib cage

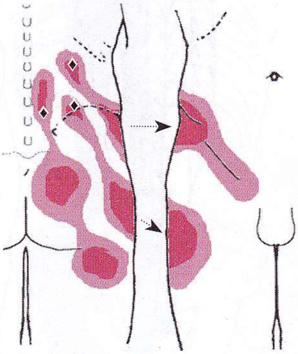
Alternate method: patient prone, hikes hip, examiner attempts to pull ipsilateral leg inferiorly



Trigger Point Referral

- Three regions may cause the development of MFTPs
  1. Deep in the angle where the crest of ilium & paraspinal muscle mass meet
  2. Inner crest of ilium where iliocostalis lumborum fibers attach
  3. Angle where paraspinal muscles & 12th rib meet
- MFTP pain referral is felt in the hips, buttocks, around SI joint or at the base of the spine





Stretch & Strengthen

Self Stretch 1:

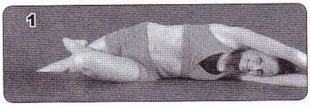
- Grip table, let posterior leg hang off & laterally flex trunk

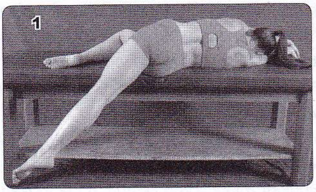
Self Stretch 2:

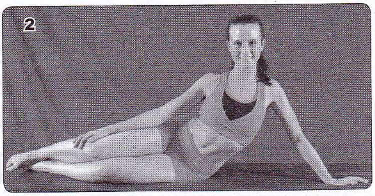
- Lift upper body, support with arm, allow trunk to laterally flex

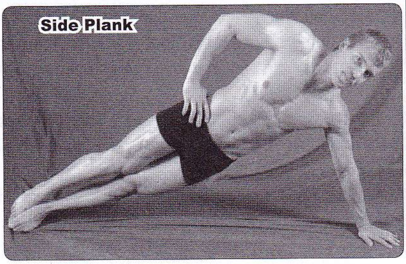
Strengthen

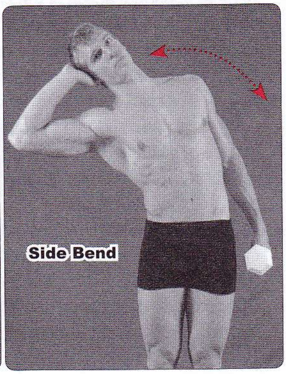
- Side plank (can be done with knees bent)
- Side bending
- Resisted trunk lateral flexion

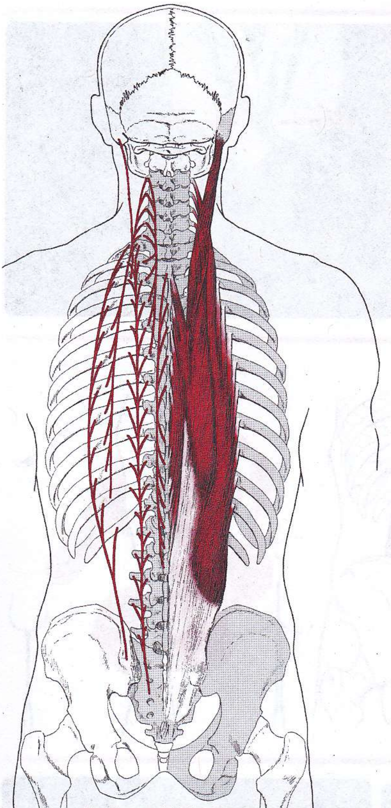












Red lines on left show attachments of subdivisions

Erector Spinae

O **broad tendon from the iliac crest & posterior surface of the sacrum, lumbar spines**

I **angle of ribs, cervical transverse processes, mastoid process**

A *bilateral:* **extension (erection) of vertebral column & head**
eccentric stabilization during trunk flexion
unilateral: **lateral flexion of spine**

N spinal nerve dorsal rami

B muscular branches of aorta

P patient prone, place palpating hands just lateral to spine, ask patient to extend their back; when palpating the erector spinae in the cervical region have the patient supine

Clinical Notes

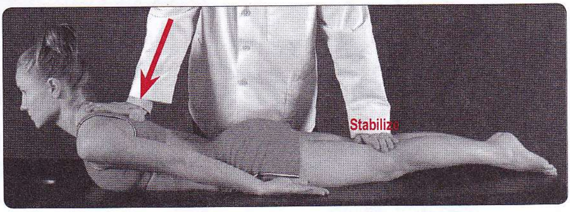
- The *erector spinae* are divided into 3 subdivisions: ***iliocostalis, longissimus & spinalis***
- The main action of the muscles is the maintenance of posture; mnemonic for *erector spinae* muscle group (from lateral to medial) Iliocostalis, Longissimus, Spinalis = I Like Standing (the action they perform)
- Another important action of the *erector spinae* is stabilization of vertebral column during flexion, acting in contrast to abdominal muscles & force of gravity
- Conditions which affect these muscles unilaterally (e.g. scoliosis) may cause deformity of the vertebral column by unilateral muscle tension of the unaffected muscles
- The *erector spinae* are active in final 30° of shoulder abduction & flexion. If the movement is performed unilaterally, the muscle of the opposite side contracts & causes ipsilateral flexion of the vertebral column. In case of bilateral movement, muscles of both sides contract & result in hyperlordosis of lumbar vertebrae. Thus, bilateral flexion or abduction of the shoulder joint in those people suffering from low back pain is not recommended
- ***ADL:*** bending forward (eccentric), standing/sitting, all sports (especially wrestling, gymnastics)
- ***Common injuries:*** repetitive trauma strain (rowers & manual labor), poor lifting technique strain, weak core body strength will predispose to injury
- ***DDx:*** articular dysfunction (thoracic, lumbar, SI), heart attack/angina, herpes zoster, MFTPs in other muscles, fibromyalgia, lumbar radiculopathy, lipoma (subcutaneous fat lobules)

Muscle Test

Patient position
- Prone, with back extended

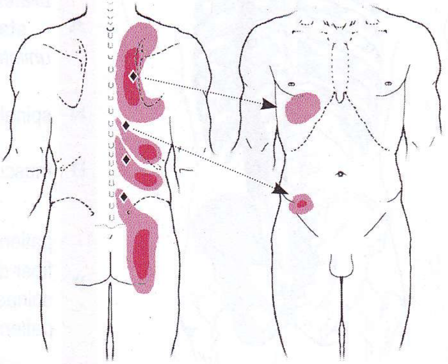
Examiner's force
- Towards flexion of the spine

Stabilization
- Posterior thigh



Trigger Point Referral

- MFTP pain from the erector spinae generally radiates directly outward from their location
- Thoracic MFTPs may project laterally across the back of the chest & may spill over in to the anterior abdomen or up towards the back of the shoulder
- Lumbar trigger points refer pain to the buttock & sacroiliac region

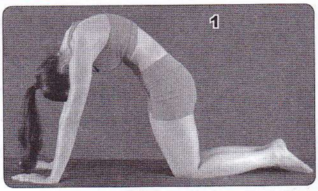


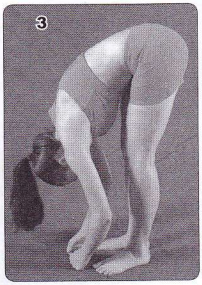
Stretch & Strengthen

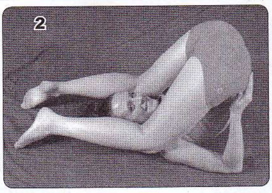
Self Stretch 1:
- "Cat stretch" on all fours arch back

Self Stretch 2:
- Lying supine, flex back bringing knees toward head

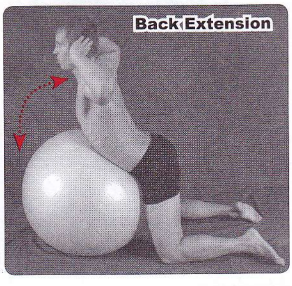
Self Stretch 3:
- Attempt to touch toes (may also induce stretch of hamstring muscles)

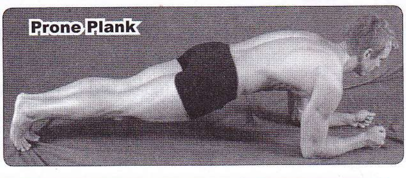


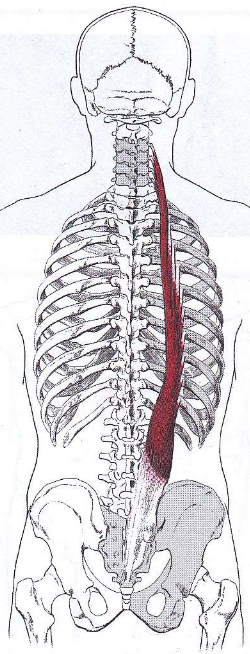




Strengthen
- Prone plank
- Back extensions
- Bent knee good morning
- Dead lift

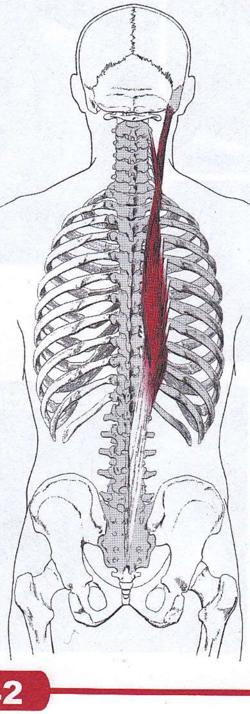






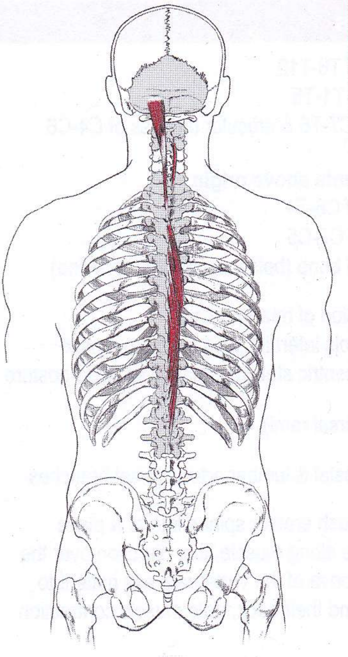
Iliocostalis

O	*lumborum:* sacrum & iliac crest *thoracis:* angle of ribs 8-12 *cervicis:* angle of ribs 3-7
I	*lumborum:* angle of ribs 8-12 *thoracis:* angle of ribs 1-7 *cervicis:* TPs of C3-C6
A	*bilateral:* **extension spine & head, eccentric stabilization during trunk flexion** *unilateral:* **lateral flexion of spine**
N	spinal nerve (dorsal rami)
B	muscular branches of aorta
P	patient prone, place palpating fingers along fiber direction over most lateral region of erector spinae (just medial to the angles of the ribs), ask patient to extend back, note muscle contraction



Longissimus

O	*thoracis:* sacrum & TPs of L1-L5 *cervicis:* TPs of T1-T5 *capitis:* TPs of C6-T3
I	*thoracis:* TPs of T1-12 & angle of ribs 1-12 *cervicis:* TPs of C2-C6 *capitis:* mastoid process
A	*bilateral:* **extension spine & head, eccentric stabilization during trunk flexion** *unilateral:* **lateral flexion of spine**
N	spinal nerve (dorsal rami)
B	muscular branches of aorta
P	patient prone, place palpating fingers along fiber direction over middle region of erector spinae, ask patient to extend back, note muscle contraction



Spinalis

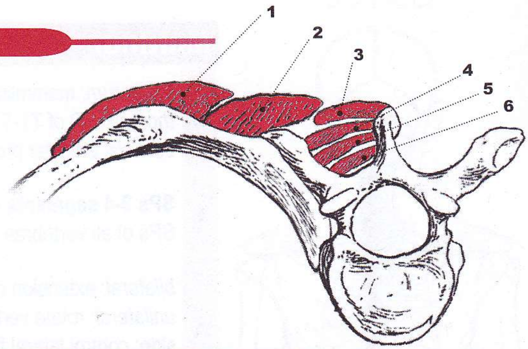
O	*thoracis:* SPs of T10-L2 *cervicis:* SPs of C6-7 *capitis:* SPs of C7-T2 (medial part of semispinalis capitis)
I	*thoracis:* SPs of T3-T9 *cervicis:* SPs of C2-C3 *capitis:* occipital bone (below superior nuchal line)
A	*bilateral:* **extension of spine & head, eccentric stabilization during trunk flexion** *unilateral:* **lateral flexion of spine**
N	spinal nerve (dorsal rami)
B	muscular branches of aorta
P	patient prone, place palpating fingers along fiber direction over medial region of erector spinae, ask patient to extend back, note muscle contraction

Deep Back Layers

Erector spinae
1. Iliocostalis
2. Longissimus
3. Spinalis

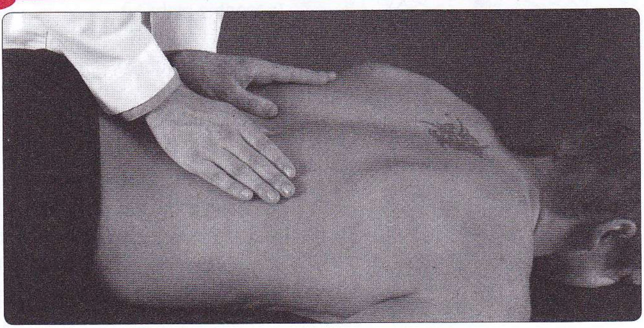
Transversospinalis

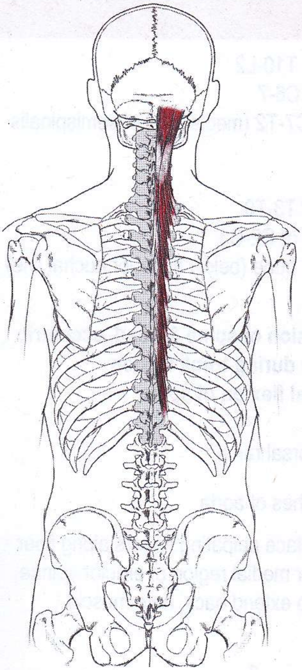
4. Semispinalis
5. Multifidi
6. Rotatores



Palpation

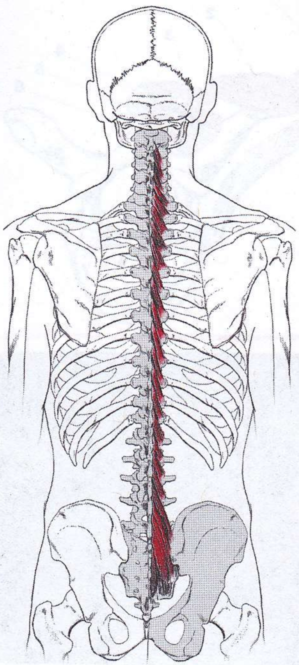
1. Patient prone
2. See specifics for each muscle subdivision





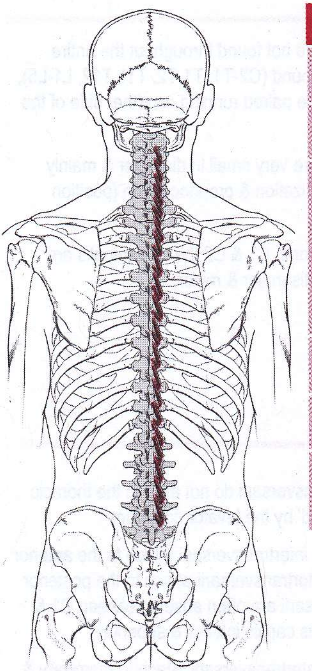
Semispinalis

O	*thoracis:* TPs of T6-T12 *cervicis:* TPs of T1-T5 *capitis:* TPs of C7-T6 & articular process of C4-C6
I	**SPs 5-6 segments above origin** *thoracis:* SPs of C6-T4 *cervicis:* SPs of C2-C5 *capitis:* occipital bone (below superior nuchal line)
A	*bilateral:* extension of head & neck *unilateral:* controls lateral flexion to side opposite contraction (eccentric stability); maintains head posture
N	spinal nerve (dorsal rami)
B	posterior intercostal & lumbar artery dorsal branches
P	patient prone, push erector spinae lateral & place palpating fingers along muscle fiber direction over the spinolaminar groove of the vertebrae; ask patient to very subtly extend their back, note muscle contraction



Multifidi

O	*lumborum:* mammillary processes of L1-L5 *thoracis:* TP of T1-T12 *cervicis:* articular processes of C4-C7
I	**SPs 3-4 segments above origin** SPs of all vertebrae extending from L5 - C2
A	*bilateral:* extension of vertebral column (trunk & neck) *unilateral:* rotate vertebral bodies (column) to opposite side; control lateral flexion to side opposite contraction (eccentric stability)
N	spinal nerve (dorsal rami)
B	posterior intercostal & lumbar artery dorsal branches
P	patient prone, push erector spinae lateral & place palpating fingers along muscle fiber direction over the spinolaminar groove of the vertebrae; ask patient to very subtly extend their back, note muscle contraction **Multifidi lumborum are very large & easy to palpate



Rotatores

O	**TPs of C4-L5** (most developed in thoracic spine)
I	**SPs (base) & lamina 1-2 segments above origin**
A	*unilateral:* rotation to opposite side *bilateral:* extension; stabilize vertebrae & are involved as organs of proprioception (position sense of the spine due to the large number of sensory nerve fibers in these tiny muscles)
N	spinal nerve (dorsal rami)
B	posterior intercostal & lumbar artery dorsal branches
P	palpation of these very tiny, deep muscles is extremely difficult & often even impossible

Because the transversospinalis originate on TPs & insert on SPs, they produce contralateral rotation upon contraction

Clinical Notes

Tranversospinalis consists of three muscle groups:

1. **Semispinalis (running 5-6 segments)**
2. **Multifidi (running 3-4 segments)**
3. **Rotatores (running 1-2 segments)**

SEMISPINALIS

- ***Anatomical variation:*** medial fibers of *semispinalis capitis* may blend with the *spinalis capitis* of the erector spinae muscle group
- The greater occipital nerve passes through the muscle belly of *semispinalis capitis* and upper *trapezius*; compression of this nerve by either muscle is a potential cause for the development of tension headaches or greater occipital neuralgia

MULTIFIDI

- *Multifidi lumborum* is the largest region of the multifidi muscle group; in the lumbar region there is very little erector spinae muscle, however the multifidi are still somewhat covered by the tendinous fibers of the erector spinae & thoracolumbar fascia
- *Multifidi lumborum* also attach to the lower portion of dorsal sacrum, PSIS, deep surface of tendinous origin of erector spinae and thus also assist in anterior pelvic tilt
- In individuals with poor posture, excessive abdominal weight and/or corresponding hyperlordosis of the lumbar spine, the multifidi may become extremely tight/hypertonic

ROTATORES

- ***Anatomical variation:*** *rotatores thoracis* is the most developed region; *rotatores cervicis & lumborum* are often irregular or absent
- *Rotatores brevis* inserts 1 vertebrae above; *rotatores longus* inserts 2 vertebrae above
- Rotatores may be subdivided into cervicis, thoracis & lumborum

Other Deep Back Muscles

Interspinalis

O SP of vertebra below

I SP of vertebra above

A extension of neck & trunk

N dorsal rami of spinal nerves

B branches off aorta

- Interspinalis muscles are not found throughout the entire spine; where they are found (C2-T1, T1-T2, T11-T12, L1-L5), interspinalis muscles are paired running on either side of the interspinous ligament
- Fibers of interspinalis are very small in diameter & mainly function for spinal stabilization & proprioception (position sense)
- Between the occipital bone, C1 & C2 the interspinalis are replaced by rectus capitis major & minor

Intertransversarius

O TP of vertebra below

I TP of vertebra above

A lateral of neck & trunk

N dorsal rami of spinal nerves

B branches off aorta

- Thoracic spine: intertransversarii do not exist in the thoracic spine; they are 'replaced' by the levator costarum
- Cervical spine: anterior intertransversarii attach to the anterior tubercles & posterior intertransversarii attach to the posterior tubercles (intertransversarii are often absent between C1 & C2, replaced by obliquus capitis inferior & superior)
- Lumbar spine: medial intertransversarii attach to mamillary & accessory tubercles, lateral intertransversarii attach directly to the TPs
- Spinal nerves (dorsal & ventral rami) run between the intertransversarii muscles
- The main function of intertransversii are proprioception (position sense) & stabilization of spinal segments

Levator Costarum

O TPs C7-T11 (posterior lateral tip)

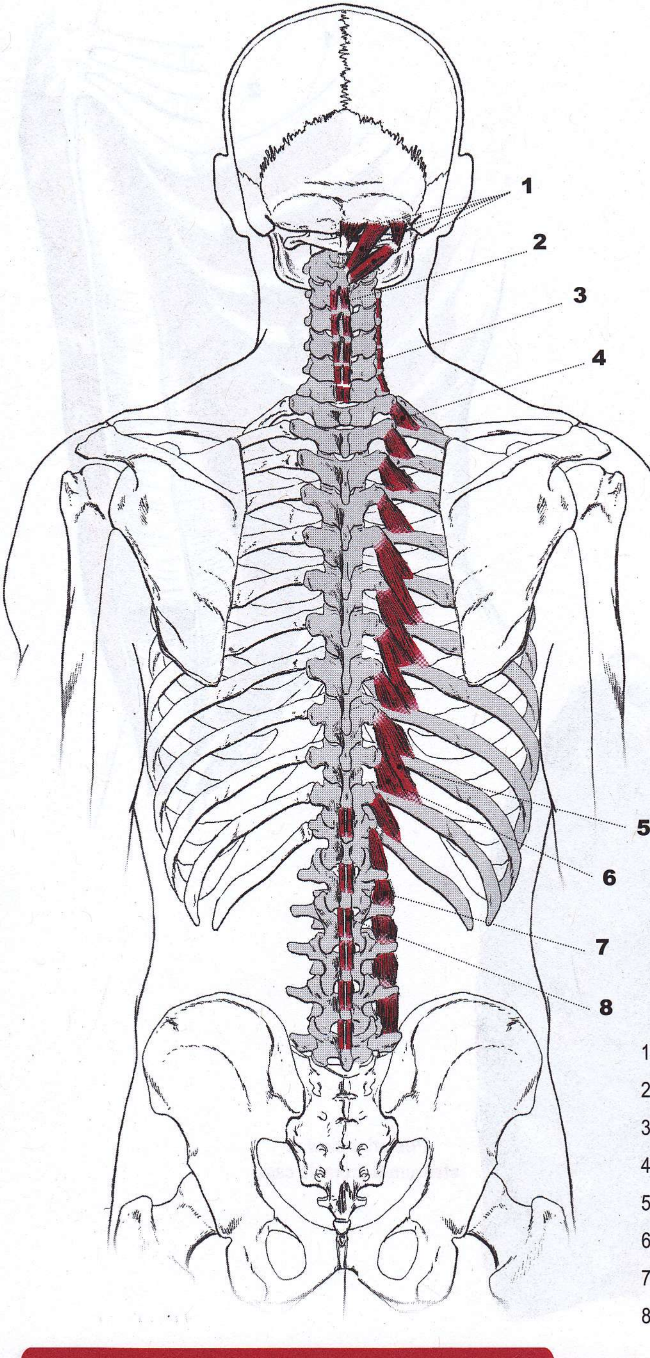
I ribs 1-12 (below the TP)

A elevation of ribs (inspiration)

N dorsal rami of spinal nerves

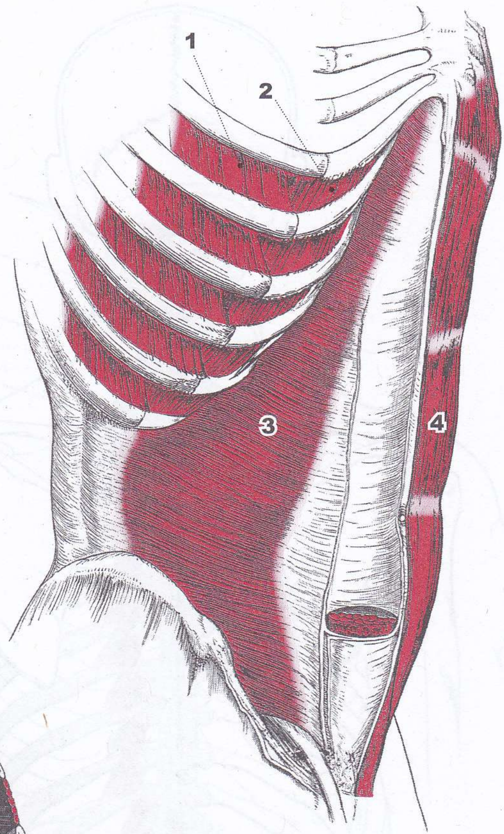
B posterior intercostal arteries

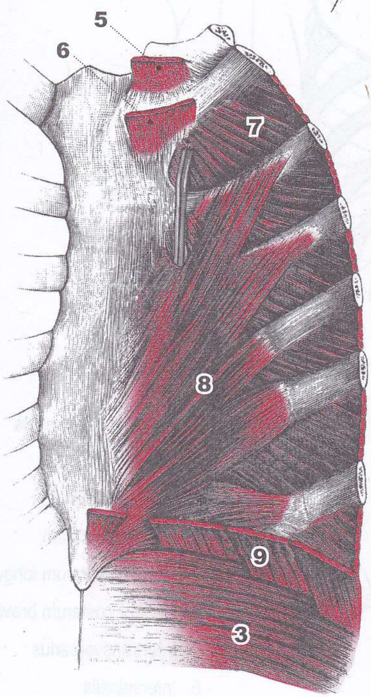
- All thoracic levels have a *levator costarum brevis* (1 rib below); *levator costarum longus* occurs from the TPs of T5-T10 & run to ribs 7-12 (2 ribs below)
- Levator costarum take the place of the intertransversarii in the thoracic spine
- Levator costarum may also weakly assist with lateral flexion of the thoracic spine
- Levator costarum is considered an accessory muscle of respiration



1. Suboccipital muscles
2. Interspinalis
3. Intertransversarius
4. Levator costarum
5. Levátor costarum longus
6. Levator costarum brevis
7. Intertransversarius
8. Interspinalis

1. External intercostal
2. Internal intercostal
3. Transversus abdominis
4. Rectus abdominis
5. Sternohyoid
6. Sternothyroid
7. Innermost intercostals
8. Transversus thoracis
9. Diaphragm



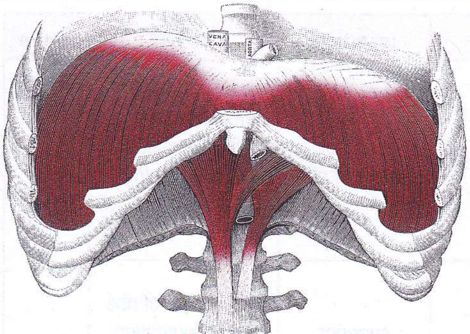


Posterior view of
sternum & thoracic cage

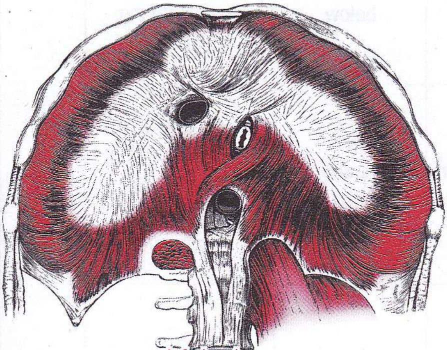
Muscle	Origin	Insertion	Action	Nerve
external intercostal	inferior border of ribs	superior border of ribs	elevation of ribs; fix intercostal spaces during respiration	intercostal nerves
internal intercostal	inferior border of ribs	superior border of ribs below	depression of ribs during expiration; fix intercostal spaces during expiration	
innermost intercostal	interior inferior border of ribs above	interior superior border of ribs below	depression of ribs during expiration; fix intercostal spaces during expiration	
subcostalis	internal surface ribs 10-12	internal surface of ribs 8-10	depression ribs of 10-12	
transversus thoracis (sternocostalis)	inferior 1/3 of inner aspect of sternum, xiphoid process & costosternal junctions of ribs 4-7	costal cartilage of ribs 2-6	depresses upper ribs	

Clinical Notes

- If you order ribs at a restaurant you are eating intercostal muscles ☺
- ***Palpation:*** locate adjacent ribs, palpate between ribs & have patient take a deep breath
    - Note contraction of muscle tissue



Anterior view



Inferior view

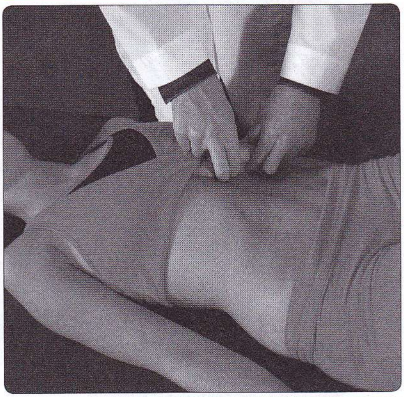
O	*vertebral:* crura from bodies of L1, 2 on the left, L1-3 on the right (may vary) *costal part:* medial & lateral arcuate ligaments, inner aspect of lower 6 ribs *sternal:* two slips from posterior aspect of xiphoid
I	**central tendon of diaphragm** (dome of diaphragm)
A	**inspiration** (increase thoracic cavity volume) assists in raising intra-abdominal pressure (Valsalva maneuver)
N	**phrenic nerve** (C3, **C4**, C5)
B	phrenic & internal thoracic arteries
S	abdominal wall muscles (abdominal obliques, quadratus lumborum)

Clinical Notes

- ***Anatomical variation:*** conditions which change the shape of the thoracic cavity (scoliosis, hyperkyphosis, pectus excavatum & carnitum) can change the shape & attachment points
  - Given the complexity of the *diaphragm*, attachment points may show subtle variation
- The *diaphragm* is the primary muscle of inspiration and the second most important muscle of the body next to the heart; although it is skeletal muscle the *diaphragm* is under voluntary & involuntary control
- The central tendon of the *diaphragm* is an aponeurosis & the muscle itself has three large openings (hiatus) to allow the esophagus, aorta & inferior vena cava to pass through it
- Part of the stomach can herniate above the *diaphragm* into the thoracic cavity resulting in a hiatal hernia
- "C3, 4, & 5 keep the diaphragm alive" (mnemonic for spinal levels of phrenic nerve), although some people have an accessory phrenic nerve which makes it possible for the *diaphragm* to continue to function even when the phrenic nerve is completely severed
- In order for the diaphragm to function efficiently the abdominal wall has to be stable, in cases of spinal cord injuries the muscle of the abdominal wall may become paralyzed resulting in decreased breathing efficiency & possible shortness of breath with exertion - by wearing a girdle many paraplegics & quadriplegics are able to improve their breathing by artificially stabilizing the abdominal wall
- ***ADL:*** breathing, Valsalva maneuver (cough, sneeze, strain)
- ***Common injuries:***
  - A weak diaphragm can contribute to gastroesophageal reflux disease (GERD) due to inefficient or weak contraction of the muscle fibers around the esophagus
  - A '*side stitch*' (cramp) can be due to the diaphragm is not receiving enough oxygen to work effectively causing it to spasm
  - Blunt force trauma following car accidents (lateral impact): distortion of the thoracic wall that can result in unilateral diaphragmatic shearing and tears

Torso & Back

Palpation



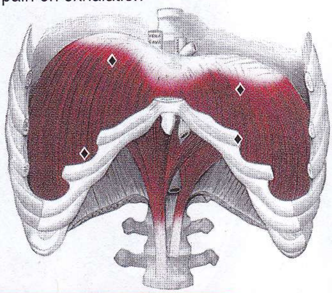
1. Perform gently, slowly & with caution
2. Patient supine; place large pillow under knees
3. Place fingers of one or both hands flat on the anterior inferior margin of the rib cage
4. Ask patient to *"take a deep breath and slowly exhale"*
5. As patient exhales, curl fingertips under the rib cage, gently slide fingers along the interior surface of the ribs & costal cartilage
6. Note that palpation of the diaphragm is very difficult to perform even in the most flexible patient & only the anterior margin under the costal cartilage may be noted; it may be impossible to palpate in more muscular or obese patients

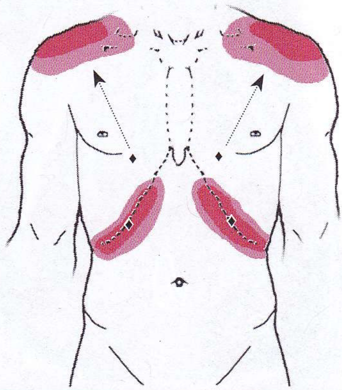
Muscle Test

- The strength of the diaphragm is often measured indirectly along with other respiratory muscles as a functional capacity through forced vital capacity, maximal inspiratory and expiratory pressures
- "Balloon" test - have patient fill a balloon while in a supine position & observe equal expansion in the abdomen and thoracic cage with inspiration; if abdomen drops - diaphragm is being 'sucked' up into the lungs which may indicate weak or deteriorating diaphragm muscle
- More directly diaphragm strength is determined by measuring transdiaphragmatic pressure during maximal *inspiratory* effort through the use of a balloon catheter for recording esophageal pressure (pleural pressure) and gastric pressure (abdominal pressure); transdiaphragmatic pressure is the difference between pleural and abdominal pressure *(American Thoracic Society/European Respiratory Society Statement on Respiratory Muscle Testing, 2008)*

Trigger Point Referral

- MFTPs near the central dome of the diaphragm can refer to upper border of the ipsilateral shoulder
- Peripheral part refers to adjacent costal margin
- Avoid confusion of rectus abdominis & diaphragm MFTPs:
  - *Rectus abdominis:* pain on full inhalation
  - *Diaphragm:* pain on exhalation





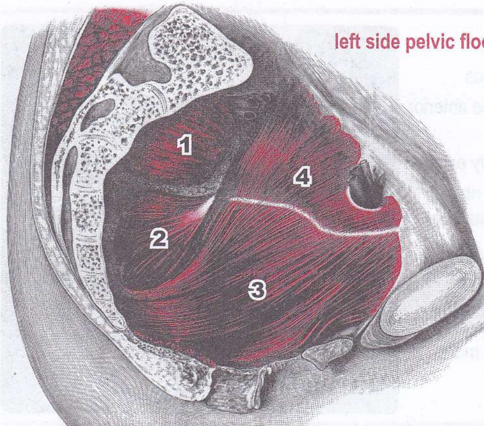
Common Injuries/DDx

Common Injuries

- Injuries are rare but may occur with trauma to the thoracic cage, or over use in cases of asthma & respiratory distress syndromes
- The diaphragm should be assessed in any patient with thoracic, lumbar & abdominal dysfunction

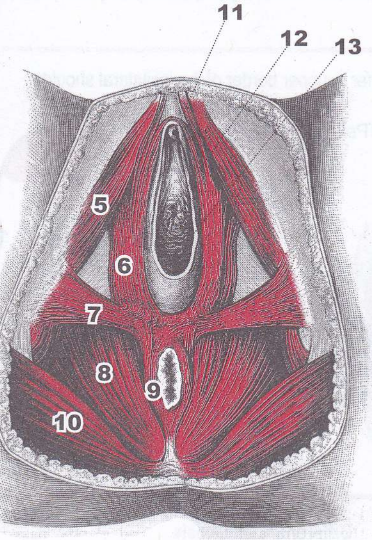
Differential Diagnosis

- Articular dysfunction (thoracic, lumbar & SI)
- MFTP referral pattern
- Heart burn (GERD)
- Abdominal viscera pain (GI cramping, menstrual cramps, appendicitis)

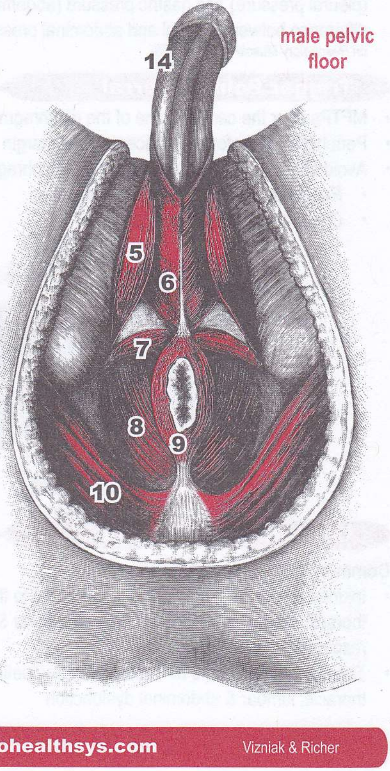


left side pelvic floor

1. Piriformis
2. Coccygeus
3. Levator ani
4. Obturator internus
5. Ischiocavernosus
6. Bulbospongiosus
7. Transversus pernei
8. Levator ani
9. External anal sphincter
10. Gluteus maximus
11. Clitoris
12. Urethra
13. Vagina
14. Penis



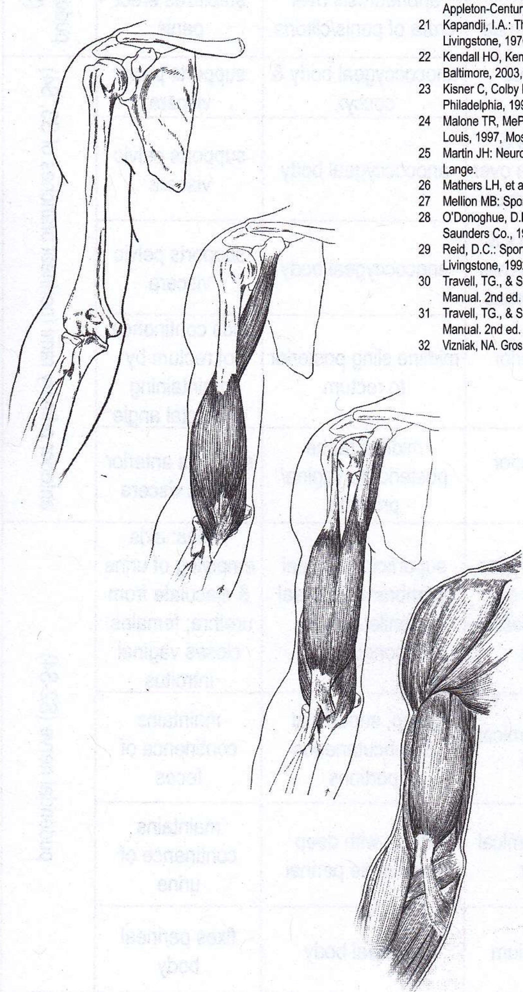
female pelvic floor



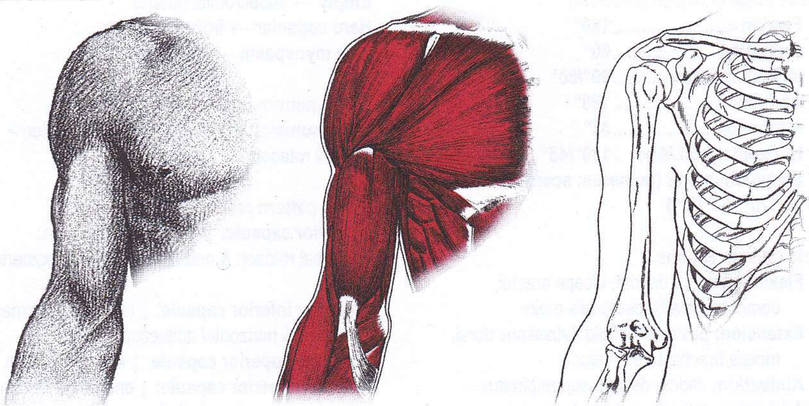
male pelvic floor

Muscle	Origin	Insertion	Action	Nerve
cremaster	internal abdominal oblique & transversus abdominis	loops around spermatic cord & tunica vaginalis	retraction or elevation of testis	genitofemoral nerve (L1, 2)
dartos	subcutaneous tissue of scrotum	skin & midline fibrous septum of scrotum	corrugates scrotal skin	
deep transverse perinei	ischiopubic ramus & body of ischium	midline raphe & perineal body	supports pelvic viscera	pudendal nerve (S2-S4)
ischiocavernosus	ischium & ischiopubic ramus	aponeurosis over crura of penis/clitoris	stabilizes erect penis	
levator ani coccygeus	sacrospinous ligament	anococcygeal body & coccyx	supports pelvic viscera	anterior primary rami (perineal branches of S3, S4)
levator ani iliococcygeus	ischial spine & posterior fascia over obturator internus	anococcygeal body	supports pelvic viscera	
levator ani - pubococcygeus	posterior pubis & anterior fascia over obturator internus	anococcygeal body	supports pelvic viscera	
levator ani - puborectalis	pubis (posterior surface)	midline sling posterior to rectum	aids continence of rectum by maintaining anorectal angle	
levator ani - pubovaginalis	pubis (posterior surface)	midline raphe posterior to vagina/ prostate	supports anterior pelvic viscera	
bulbospongiosus	perineal body (also midline raphe over corpus spongiosum in males)	superficial perineal membrane & dorsal penile/clitoral aponeurosis	males: aids emptying of urine & ejaculate from urethra; females: closes vaginal introitus	pudendal nerve (S2-S4)
sphincter ani	circular anatomical sphincter	deep, superficial & subcutaneous portions	maintains continence of feces	
sphincter urethra	circular anatomical sphincter	fuses with deep transverse perinei	maintains continence of urine	
superficial transverse perinei	body of ischium	perineal body	fixes perineal body	

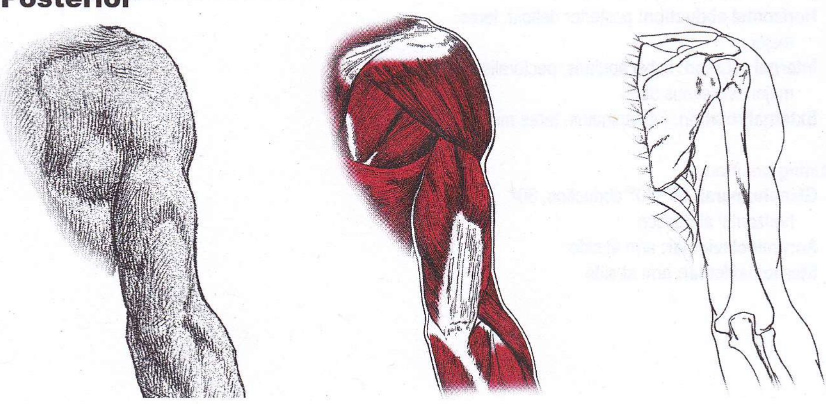
1 American Thoracic Society/ European Respiratory Society Statement on Respiratory Muscle Testing. American Journal of Respiratory and Critical Care Medecine. 166: 518-624, 2002.
2 Bradley, Dinah & Tania Clifton-Smith. Breathing Works for Asthma. Kyle Cathie Limited: London, England, 2003.
3 Gardevia, SC, Gorman RB, McKenzie DK, Southon FC. Dynamic changes in human diaphragm length: maximal inspiratory and expulsive efforts studied with sequential radiography. Journal of Physiology. 457: 167-176, 1992
4 Moore, Keith L. Clinically Oriented Anatomy, 3rd ed. Williams & Wilkins: Baltimore, MD, 1992.
5 Tolop, K.; Higgins, N; Muza, S.; Criner, G; Kelsen, SG. Comparison of diaphragm strength between healthy adult elderly and young men. American Journal of Respiratory and Critical Care Medicine. 152-2: 677-682, 1995.
6 Weller, Stella. The Breath Book. Thorsons: Hammersmith, London, 1999.
7 Kocher MS, Dupre MM, Feagin JA Jr. Shoulder injuries from alpine skiing and snowboarding. Aetiology, treatment and prevention. Sports Med. Mar;25(3):201-11, 1998
8 Teboul F, Bizot P, Kakkar R, Sedel L, Surgical management of trapezius palsy. J Bone Joint Surg Am. Sep;87 Suppl 1(Pt 2):285-91, 2005
9 Pouliart N, Gagey O. Significance of the latissimus dorsi for shoulder instability. I. Variations in its anatomy around the humerus and scapula. Clinical Anatomy. Oct;18(7):493-9, 2005.
10 Knutson GA, Owens E. Erector spinae and quadratus lumborum muscle endurance tests and supine leg length alignment asymmetry: an observational study. Oct; 28(8):575-81, 2005
11 Cantu, RL,& Grodin, A. 1992: Myofascial manipulation - Theory and Clinical Application, Aspen Publishers Inc. 1992.
12 Cash, M. Pocket Atlas of the Moving Body : For All Students of Human Biology, Medicine, Sports and Physical Therapy, Ebury House, 2000.
13 Chaitow, L. Palpation Skills Assessment and Diagnosis Through Touch, Churchill-Livingston, 1996.
14 Cyriax J. Textbook of orthopaedic medicine. Vol. 1. Diagnosis of soft tissue lesions.
15 Cyriax, JH. & Cyriax, PJ. Cyriax's Illustrated Manual of Orthopedic Medicine, 3rd ed., Butterworth-Heinemann, 1996.
16 Dambro MR, Griffith JA: Griffith's 5 minute clinical consult, Baltimore, 2008, Williams & Wilkins.
17 Dandy DJ: Essential orthopaedics and trauma, Edinburgh, 1989, Churchill Livingstone.
18 Gartland, I.I.: Fundamentals of Orthopaedics. Philadelphia, W.B. Saunders Co., 1979.
19 Greenman, PE. Principles of Manual Medicine, 2nd ed., Williams & Willkins, 1995.
20 Hoppenfeld, S.: Physical Examination of the Spine and Extremities. New York, Appleton-Century-Crofts, 1976.
21 Kapandji, I.A.: The Physiology of Joints, vol. 1: Upper Limb. New York, Churchill Livingstone, 1970.
22 Kendall HO, Kendall FP, Wadsworth GE: Muscles testing and function, ed 4, Baltimore, 2003, Williams & Wilkins.
23 Kisner C, Colby LA: Therapeutic exercise; foundations and techniques, ed 2, Philadelphia, 1990, FA Davis.
24 Malone TR, MePoil TG, Nitz AJ: Orthopedic and sports physical therapy, ed 3, St Louis, 1997, Mosby.
25 Martin JH: Neuroanatomy text and atlas, ed 2, Stamford, Conn, 1996, Appleton & Lange.
26 Mathers LH, et al: Clinical anatomy principles, St Louis, 1996, Mosby.
27 Mellion MB: Sports medicine secrets, Philadelphia, 1994, Hanley & Belfus.
28 O'Donoghue, D.H.: Treatment of Injuries to Athletes, 4th ed. Philadelphia. W.B. Saunders Co., 1984.
29 Reid, D.C.: Sports Injury Assessment and Rehabilitation. New York, Churchill Livingstone, 1992.
30 Travell, TG., & Simons, LS. Myofascial Pain and Dysfunction: The Trigger Point Manual. 2nd ed. Volume 1 Upper Body. Baltimore, Williams & Wilkins, 1993.
31 Travell, TG., & Simons, LS. Myofascial Pain and Dysfunction: The Trigger Point Manual. 2nd ed. Volume 2 Lower Body. Baltimore, Williams & Wilkins, 1993.
32 Vizniak, NA. Gross Anatomy: Human Cadaver Dissections. 1999-2008



Anterior



Posterior



Joint type: synovial

Glenohumeral (ball & socket)
Acromioclavicular joint (gliding)
Scapulothoracic - not considered a true joint, but is the space between the scapula & thoracic cage & consists of muscle, connective tissue & bursa that allow for gliding-type motions

Articular surfaces

Glenohumeral: *convex* (head of humerus) on *concave* (glenoid fossa)
Acromioclavicular: *convex* (acromion) *on convex* (lateral clavicle)
Scapulothoracic: *concave* (subscapular fossa) *on convex* (posterior ribs)

Active range of motion (shoulder)

Flexion .... **180°**
Extension .... **60°**
Int./ext. rotation .... **90°/80°**
Abduction .... **180°**
Adduction .... **35°**
Horizontal Add./Abd. .. **130°/45°**
Scapulohumeral (humerus: scapula) 120°:60° (2:1)

Main muscle actions

Flexion: anterior deltoid, biceps brachii, coracobrachialis, pectoralis major
Extension: posterior deltoid, latissimus dorsi, triceps brachii, teres major
Abduction: middle deltoid, supraspinatus
Adduction: latissimus dorsi, teres major, pectoralis major
Horizontal adduction: pectoralis major, coracobrachialis, anterior deltoid
Horizontal abduction: posterior deltoid, teres major
Internal rotation: subscapularis, pectoralis major, latissimus dorsi
External rotation: infraspinatus, teres minor

Resting position

Glenohumeral: 55°-70° abduction, 30° horizontal abduction
Acromioclavicular: arm at side
Sternoclavicular: arm at side

Close packed position

Glenohumeral: maximal abduction & lateral rotation
Acromioclavicular: 90° abduction
Sternoclavicular: full elevation

Normal end feel

Flexion: elastic, firm-bony contact
Abduction: elastic
Extension: firm
IR / ER: elastic / firm
Horizontal adduction: soft tissue
Horizontal abduction: firm/elastic

Abnormal end feel

Empty → subacromial bursitis
Hard capsular → frozen shoulder
Late myospasm → instability

Capsular pattern of restriction

Glenohumeral: external rotation > abduction > internal rotation

Capsular pattern restrictions (detailed)

Posterior capsule: ↓ horizontal adduction, internal rotation & end range flexion, ↓ posterior glide
Posterior inferior capsule: ↓ elevation, internal rotation & horizontal adduction
Posterior superior capsule: ↓ internal rotation
Anterior superior capsule: ↓ end range flexion & extension, ↓ external rotation & horizontal abduction
Anterior capsule: ↓ abduction, extension, external rotation & horizontal adduction

Joint type: synovial
Hinge (humeroulnar & humeroradial)
Pivot (proximal radioulnar)

Articular surfaces
Humeroulnar: *concave* (trochlear notch of ulna) *on convex* (trochlea of humerus)
Humeroradial: *concave* (radial head) *on convex* (capitulum of humerus)
Proximal radioulnar: *convex* (radial head) *on concave* (radial notch of ulna)

Active range of motion (elbow)
Flexion .... **150°**
Extension .... **0° to -5°**
Pronation .... **80°-90°**
Supination .... **90°**

Main muscle actions
Flexion: brachialis, biceps brachii, brachioradialis
Extension: triceps brachii, anconeus
Pronation: pronator teres, pronator quadratus
Supination: biceps brachii, supinator

Resting position
Humeroulnar: 70° flexion
Humeroradial: full extension & supination
Proximal radioulnar: 70° flexion, 35° supination

Close packed position
Humeroulnar: full extension
Humeroradial: 90° flexion, 5° supination
Proximal radioulnar: 5° supination, 90° flexion

Capsular pattern of restriction
Humeroulnar: flexion > extension
Humeroradial: flexion > extension
Proximal radioulnar: supination = pronation limited

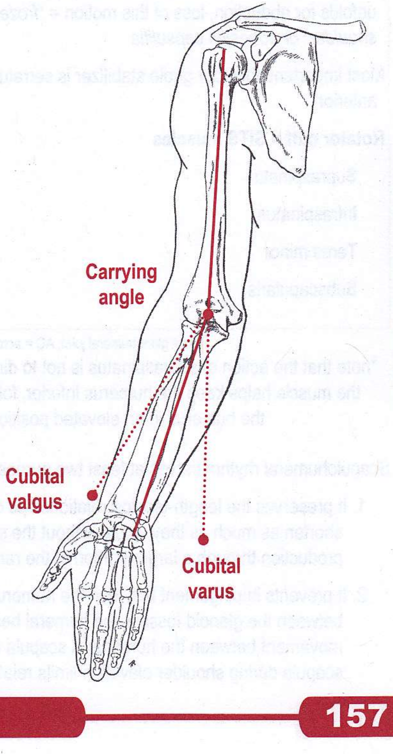
Normal end feel
Flexion: soft tissue or bony approximation
Extension: bony approximation
Pronation: bony approx. or ligamentous
Supination: ligamentous

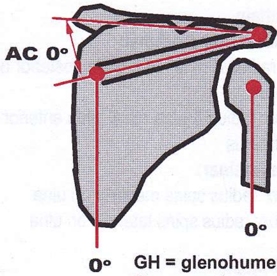
Abnormal end feel
Boggy → joint effusion
Early myospasm → acute injury
Late myospasm → instability
Springy block → loose body (osteochondritis dissecans)

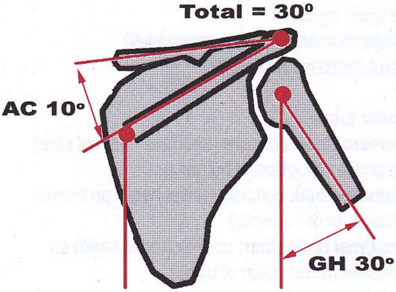
Open kinetic chain
Humeroulnar & humeroradial:
Flexion: radius & ulna roll & glide posterior on humerus
Extension: radius & ulna roll & glide anterior on humerus
Proximal radioulnar:
Pronation: radius spins medially on ulna
Supination: radius spins laterally on ulna

Closed kinetic chain
Humeroulnar & humeroradial:
Flexion: humerus roll & glide anterior on radius & ulna
Extension: humerus roll & glide posterior on radius & ulna
Proximal radioulnar:
Pronation: ulna spins laterally on radius
Supination: ulna spins medially on radius

Carrying angle of the elbow
Normal = 5°-15° - angle permits the forearms to clear the hips in swinging movements during walking & is important when carrying objects
Cubital valgus - angle greater than 15°
Cubital varus - angle less than 5°







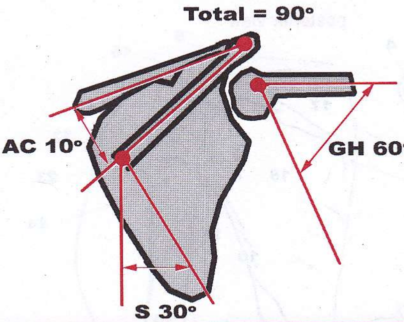
Resting phase (neutral)	Phase 1 (0°-30°)
Shoulder ROM is measured from standard anatomical position Shoulder hiking (elevation) in phase 1 may indicate shoulder pathology **GH:** 120° **Shoulder Girdle** (Scap./SC/AC): 60° **Total Motion** = 180°, 2:1 (GH:S) Clavicle follows the humerus The inferior capsule folds like an accordion, & unfolds for abduction, loss of this motion = *"frozen shoulder" or adhesive capsulitis* Most important shoulder girdle stabilizer is serratus anterior **Rotator cuff = SITS muscles** **S**upraspinatus **I**nfraspinatus **T**eres minor **S**ubscapularis	Important abductors Deltoid (60%-70%) Supraspinatus (30%-40%) When arm is externally rotated, long head of biceps will help in abduction (coracobrachialis & biceps short head help with GH flexion when the arm externally rotated) **Rotator cuff as a group** Depresses humerus*, cancels superior translation by deltoid **GH:** 15°-20°, superior roll with inferior slide **Scapula:** 10°-15°, external rotation Serratus anterior is the major stabilizer, at this point, of the shoulder girdle. Upper & lower trapezius are minor stabilizers at this point **SC:** Distal end elevates 10°-15° Superior roll with inferior glide (same as GH) Upper trapezius is not very active

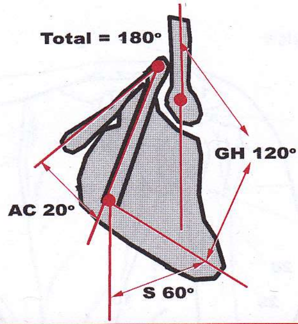
GH = glenohumeral joint, AC = acromioclavicular joint, SC = sternoclavicular joint

*note that the action of supraspinatus is not to directly depress the humerus, rather the space occupied by the muscle helps keep the humerus inferior, following a full supraspinatus rupture it is possible to observe the humerus in an elevated position relative to the glenoid fossa on MRI or X-ray

Scapulohumeral rhythm serves at least two purposes:

1. It preserves the length-tension relationships of the glenohumeral muscles; the muscles do not shorten as much as they would without the scapula's upward rotation, so they can sustain their force production through a larger portion of the range of motion
2. It prevents impingement between the humerus & the acromion. Because of the difference in size between the glenoid fossa & the humeral head, subacromial impingement can occur unless relative movement between the humerus & scapula is limited. Simultaneous movement of the humerus & scapula during shoulder elevation limits relative (arthrokinematic) movement between the two bones



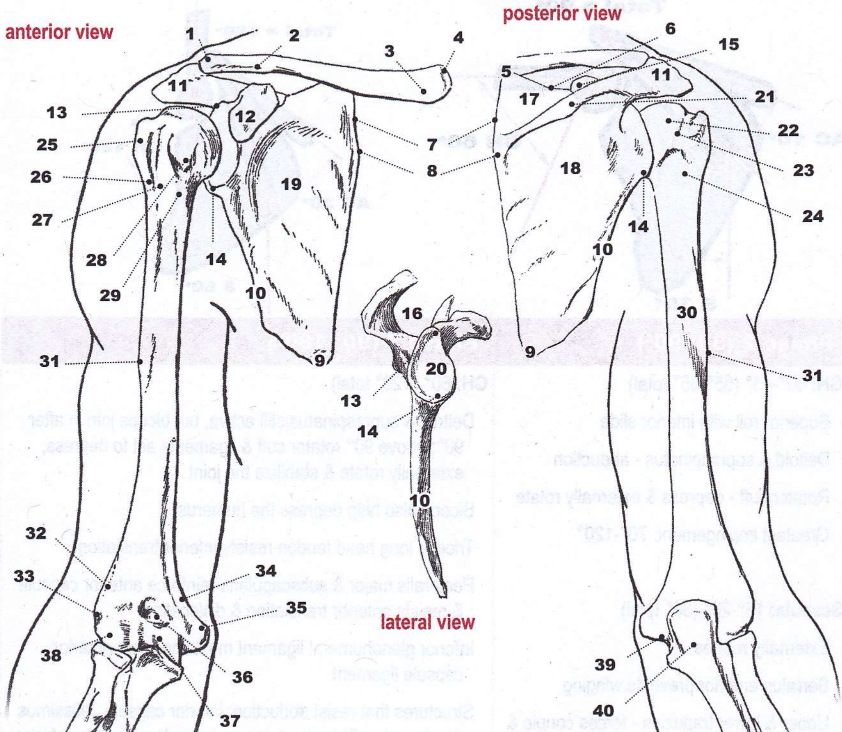


Phase 2 (30°-90°)	Phase 3 (90°-180°)
GH: 40°-45° (55°-65° total) Superior roll with inferior slide Deltoid & supraspinatus - abduction Rotator cuff - depress & externally rotate Greatest impingement: 70°-120° **Scapula:** 15°-20° (30° total) Externally rotates Serratus anterior prevents winging Upper & lower trapezius - forces couple & cancel each other out **SC:** 15°-20° (30° total) Elevation of distal clavicle due to superior roll & inferior glide At end of 1st 30° the coracoclavicular ligaments (conoid & trapezoid) become taut & stop the superior roll & inferior slide that make up the hinge action, this will cause rotation in the 3rd phase **AC:** twisting/rotation: 0°-5° (10°-15° total) AC: 5°-10° scapula rotation	**GH:** 60° (120° total) Deltoid & supraspinatus still active, but biceps join in after 90°; above 90° rotator cuff & ligaments act to depress, externally rotate & stabilize the joint Biceps also help depress the humerus Triceps long head tendon resists inferior translation Pectoralis major & subscapularis reinforce anterior capsule & resists anterior translation & dislocation Inferior glenohumeral ligament most important anterior capsule ligament Structures that resist abduction: inferior capsule, latissimus dorsi, pectoralis major, teres major, subscapularis, inferior GH ligament, long head of triceps (resist inferior translation) **Scapula:** 30° (60° total) upper more than lower trapezius, serratus anterior externally rotates scapula Structures that limit external rotation; rhomboids (esp. if tight), lower trapezius, upper trapezius **SC:** rotates externally & points upwards Crank-shaped clavicle allows elevation at distal end, while proximal rotates, this causes a 30° elevation at the distal clavicle due to taut coracoclavicular ligaments, which stop the hinge & cause rotation, this is resisted by costoclavicular ligaments from the 1st rib & eccentric contraction of the subclavius **AC:** 10° (20° total) final 10° rotation during phase 1-2 the AC rotation is due to scapular rotation; the AC is the weak link in abduction

Shoulder Stability

Muscles provide a full 50% of the GH joint stability (bone shape, glenoid labrum & ligaments provide the other 50%)

GH = glenohumeral joint, AC = acromioclavicular joint, SC = sternoclavicular joint



Clavicle

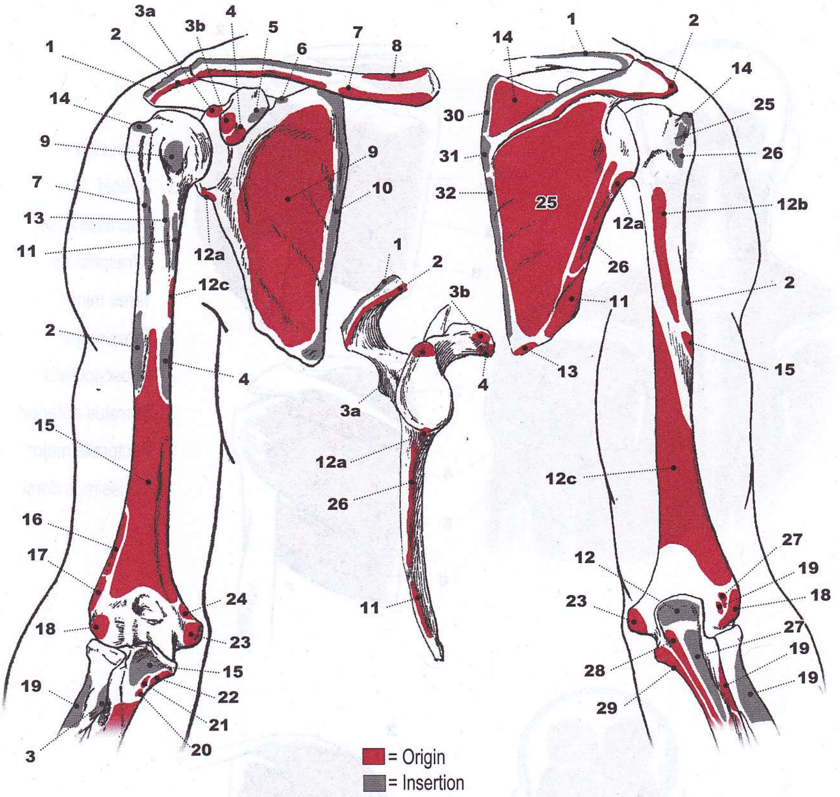
1. Acromial end
2. Conoid tubercle
3. Costal tubercle
4. Sternal end

Scapula

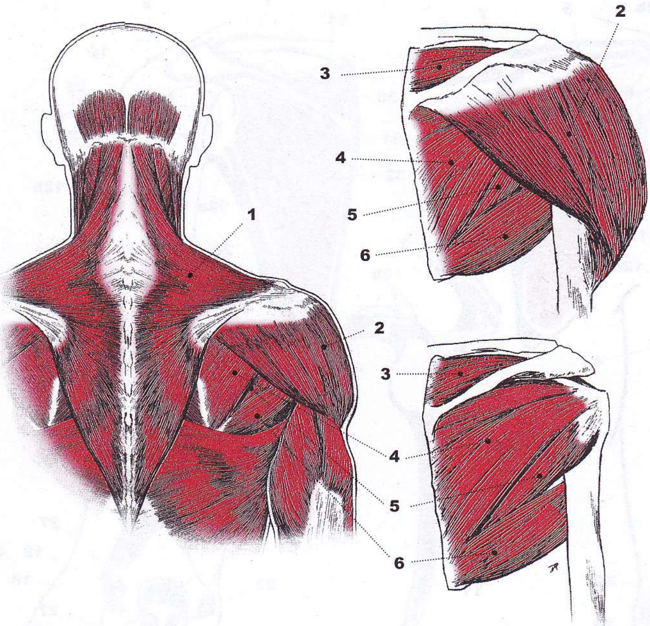
5. Superior angle
6. Superior border
7. Medial (vertebral) border
8. Medial angle
9. Inferior angle
10. Lateral (axillary) border
11. Acromion
12. Coracoid process
13. Supraglenoid tubercle
14. Infraglenoid tubercle
15. Suprascapular notch
16. Spinoglenoid notch
17. Supraspinous fossa
18. Infraspinous fossa
19. Subscapular fossa
20. Glenoid fossa
21. Spine of the scapula

Humerus

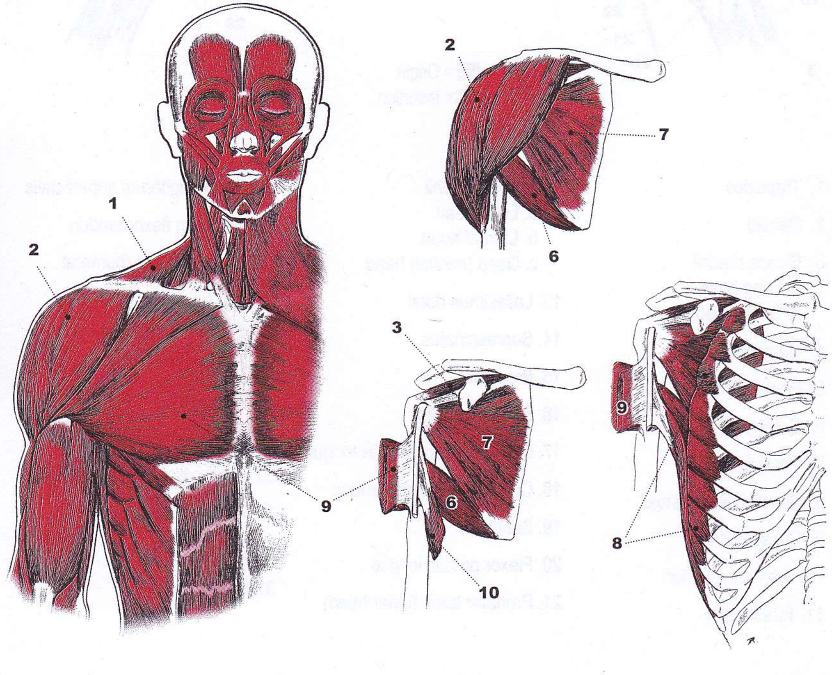
22. Head
23. Anatomical neck
24. Surgical neck
25. Greater tubercle
26. Crest of greater tubercle
27. Intertubercular sulcus (bicipital groove)
28. Lesser tubercle
29. Crest of lesser tubercle
30. Radial/spiral groove
31. Deltoid tuberosity
32. Lateral supracondylar ridge
33. Lateral epicondyle
34. Medial supracondylar ridge
35. Medial epicondyle
36. Coronoid fossa
37. Trochlea
38. Capitulum
39. Notch for the ulnar nerve
40. Olecranon

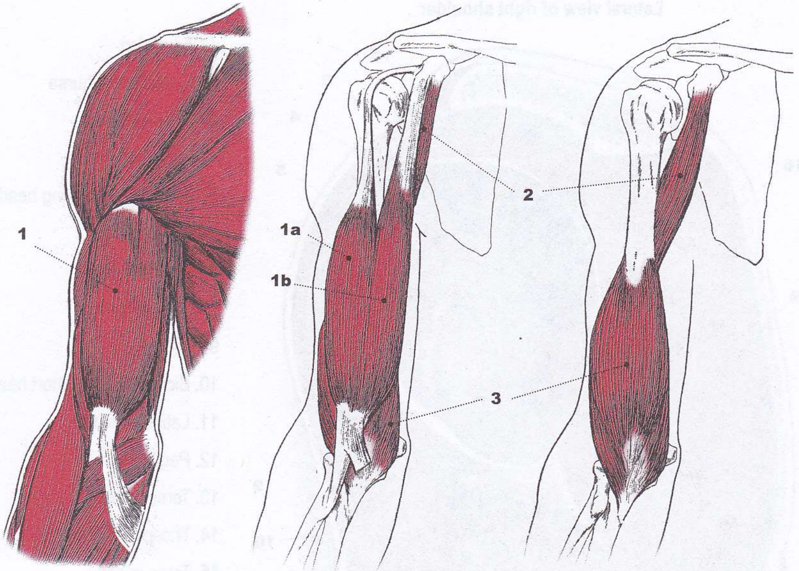


1. Trapezius
2. Deltoid
3. Biceps brachii
   a. Long head
   b. Short head
4. Coracobrachialis
5. Pectoralis minor
6. Omohyoid
7. Pectoralis major
8. Sternocleidomastoid
9. Subscapularis
10. Serratus anterior
11. Teres major
12. Triceps brachii
    a. Long head
    b. Lateral head
    c. Deep (medial) head
13. Latissimus dorsi
14. Supraspinatus
15. Brachialis
16. Brachioradialis
17. Extensor carpi radialis longus
18. Common extensor tendon
19. Supinator
20. Flexor pollicis longus
21. Pronator teres (ulnar head)
22. Flexor digitorum superficialis
23. Common flexor tendon
24. Pronator teres (humeral head)
25. Infraspinatus
26. Teres minor
27. Anconeus
28. Flexor carpi ulnaris
29. Flexor digitorum profundus
30. Levator scapulae
31. Rhomboid minor
32. Rhomboid major

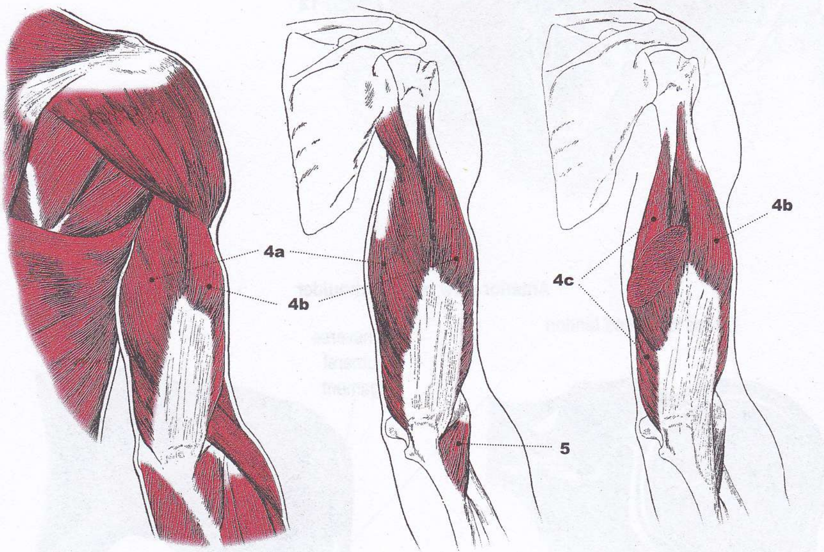


1. Trapezius
2. Deltoid
3. Supraspinatus
4. Infraspinatus
5. Teres minor
6. Teres major
7. Subscapularis
8. Serratus anterior
9. Pectoralis major
10. Latissimus dorsi



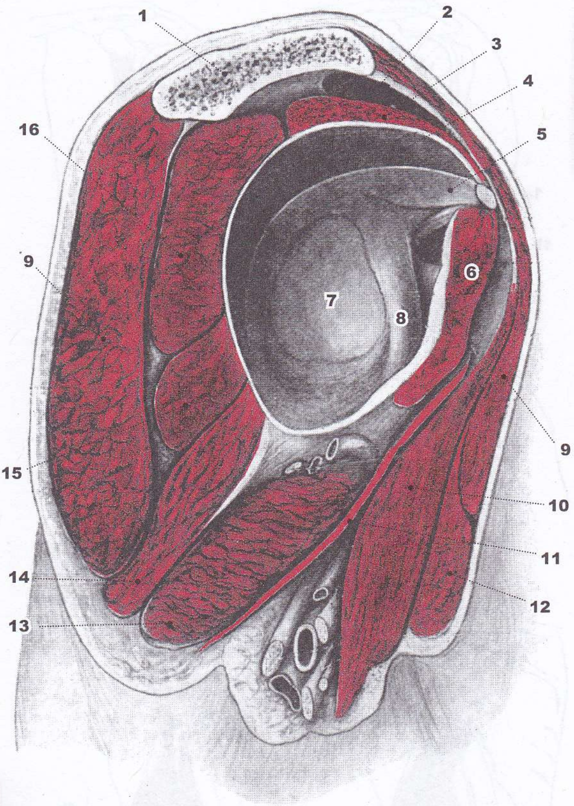


Superficial → Deep



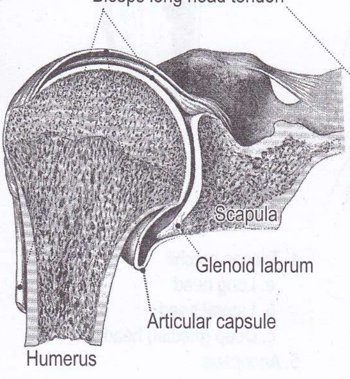
1. Biceps brachii
   a. Long head
   b. Short Head
2. Coracobrachialis
3. Brachialis
4. Triceps brachii
   a. Long head
   b. Lateral head
   c. Deep (medial) head
5. Anconeus

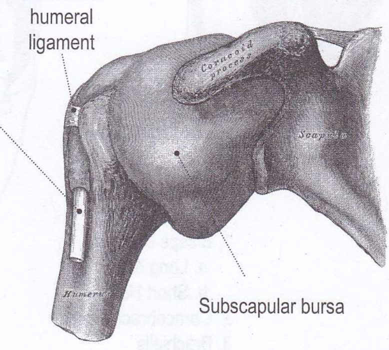
Lateral view of right shoulder

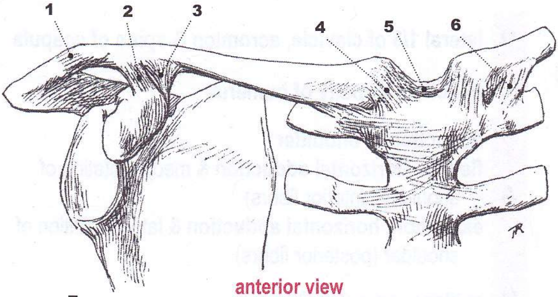


1. Acromion
2. Subacromial bursa
3. Supraspinatus
4. Articular capsule
5. Biceps brachii (long head)
6. Subscapularis
7. Glenoid fossa
8. Glenoid labrum
9. Deltoid
10. Biceps brachii (short head)
11. Latissimus dorsi
12. Pectoralis major
13. Teres major
14. Triceps (long head)
15. Teres minor
16. Infraspinatus

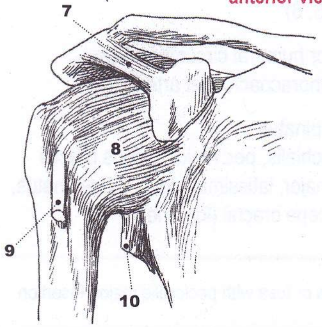
Anterior view of right shoulder

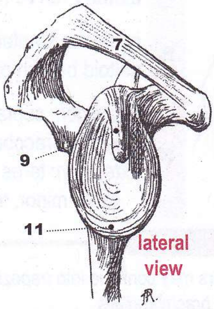






anterior view





lateral view

1. **Acromioclavicular (AC) joint**
2. Trapezoid ligament
3. Conoid ligament

Sternoclavicular (SC) joint

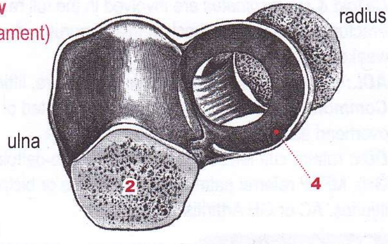
4. Anterior SC ligament
5. Interclavicular ligament
6. Costoclavicular ligament

Glenohumeral (GH) joint

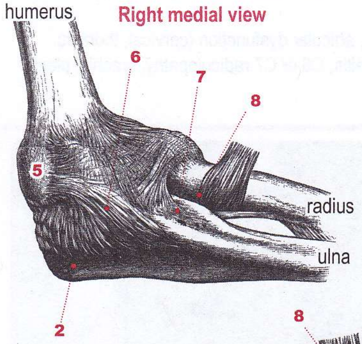
7. Coracoacromial ligament
8. Joint capsule
9. Biceps brachii long head tendon
10. Triceps brachii long head tendon
11. Glenoid labrum

Scapulothoracic joint
Not considered a true joint, it is the space between the scapula & thoracic cage & consists of muscle, connective tissue & bursa that allow for gliding type motions

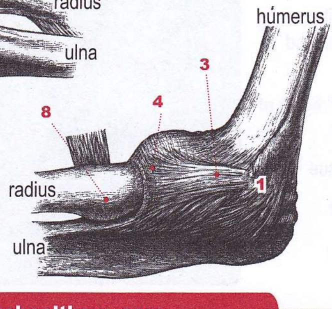
Posterior view right elbow
(radius removed from annular ligament)



Right medial view



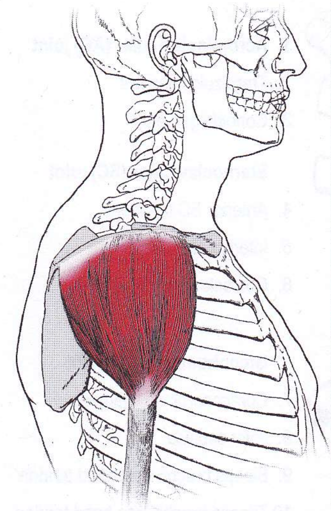
Right lateral view



Elbow joint

1. Lateral epicondyle
2. Olecranon
3. Radial collateral ligament
4. Annular ligament
5. Medial epicondyle
6. Ulnar collateral ligament
7. Ulnar tuberosity
8. Radial tuberosity

Deltoid



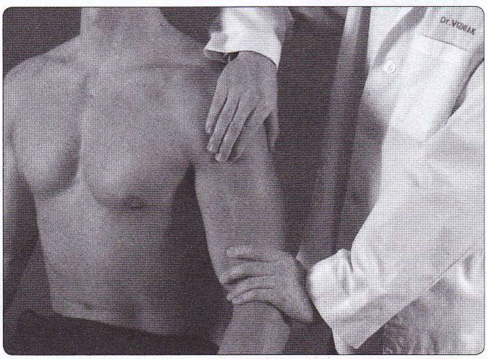
O	**lateral 1/3 of clavicle, acromion & spine of scapula**
I	**deltoid tuberosity of humerus**
A	**abduction of shoulder** **flexion, horizontal adduction** & medial rotation of shoulder (anterior fibers) **extension, horizontal abduction** & lateral rotation of shoulder (posterior fibers)
N	**axillary nerve** (C5, 6)
B	posterior & anterior humeral circumflex artery deltoid branch of thoracoacromial artery
S	*abduction:* supraspinatus *flexion:* coracobrachialis, pec major, biceps brachii *extension:* teres major, latissimus dorsi, infraspinatus, teres minor, triceps brachii (long head)

Clinical Notes

- ***Anatomical variation:*** rarely, fibers may continue into *trapezius* or fuse with pectoralis major; insertion fibers may blend with the origin of *brachioradialis*
- *Deltoid* is divided into 3 functional regions (anterior, middle & posterior)
- Anterior *deltoid* is a strong flexor of the shoulder & is considered a prime mover in this action; the middle fibers are the prime mover for abduction. The anterior and posterior fibers act as stabilizers for the middle fibers during abduction of the shoulder; posterior deltoid is a strong extensor of the shoulder
- *Deltoid* abduction action is strongest between 30º-120º
- *Deltoid & supraspinatus* are involved in the full range of arm abduction
- Fracture of the surgical neck of the humerus with shoulder dislocations may damage the axillary nerve & weaken the *deltoid* muscle
- ***ADL:*** reaching above head, waving good-bye, lifting above head
- ***Common injuries:*** muscle strain with repeated or forceful shoulder abduction and/or flexion & other overhead activities, direct blunt force trauma
- ***DDx:*** rotator cuff tear, subacromial &/or sub-deltoid bursitis, articular dysfunction (cervical, thoracic, GH), MFTP referral pattern, supraspinatus or bicipital tendinitis, C6 or C7 radiculopathy, brachial plexus injuries, AC or GH Arthritis

Palpation

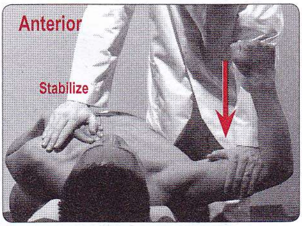
1. Patient seated or standing
2. Place palpating fingers along fiber direction over region to be assessed (anterior, middle or posterior)
3. Have patient perform action of region of deltoid (flex, abduct or extend)
4. Note contraction of muscle tissue
5. Palpate from origin to insertion

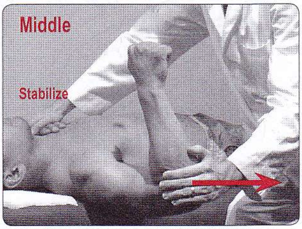


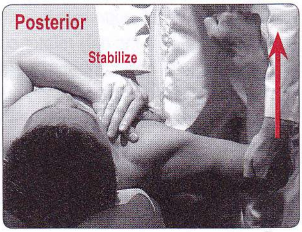
Muscle Test

	Anterior Fibers	Middle Fibers	Posterior Fibers
PP	Supine Shoulder abducted 90º, elbow flexed 90º		
EF	Toward floor (horizontal abduction)	Adduction (pull arm inferiorly)	Toward ceiling (horizontal adduction)
S	Contralateral shoulder		Ipsilateral shoulder

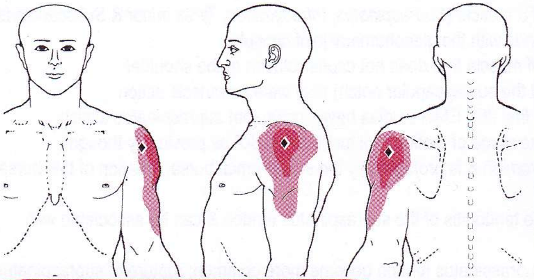
PP = patient position, EF = examiner force, S = stabilization



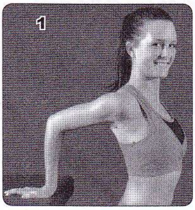


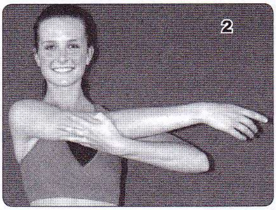


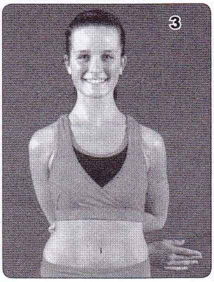
Trigger Point Referral



Stretch & Strengthen

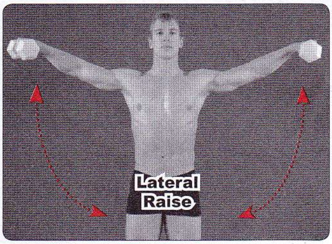


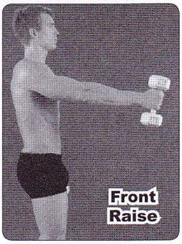




Self Stretch 1: Extend shoulder to stretch anterior deltoid fibers
Self Stretch 2: Pull shoulder anteriorly across body to stretch posterior fibers
Self Stretch 3: Pull & adduct shoulder inferiorly behind back to stretch middle fibers

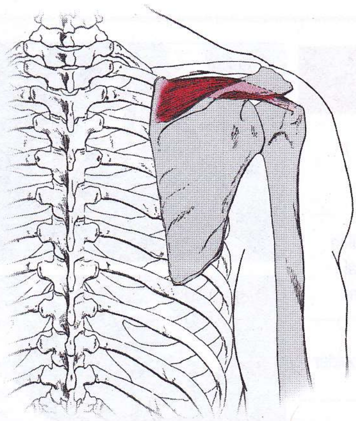
Strengthen
- Resisted shoulder abduction, flexion or extension
- Lateral raises (standing or lying)
- Front raises
- Rear lateral raises
- Military press
- Arnold press





Shoulder & Arm

Supraspinatus



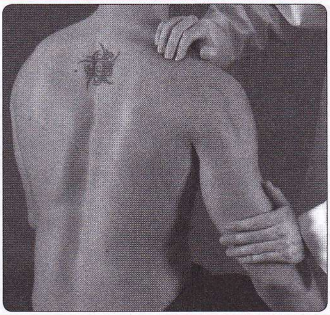
O	**supraspinous fossa of scapula**
I	**greater tubercle of humerus** (superior facet)
A	**abduction of shoulder** stabilizes glenohumeral joint
N	**suprascapular nerve** (C5, C6)
B	suprascapular artery
S	deltoid (middle fibers)

Clinical Notes

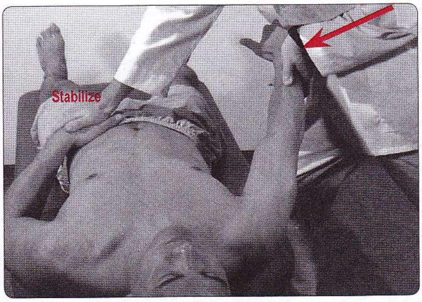
- ***Anatomical variation:*** very rare, *subscapularis* is known as the "singularly invariable muscle"
- *Supraspinatus* is a rotator cuff or SITS muscle (*Supraspinatus, Infraspinatus, Teres minor & Subscapularis*)
- The tendon of the *supraspinatus* blends with the glenohumeral joint capsule
- *Supraspinatus* is the only rotator cuff muscle that does not cause rotation at the shoulder
- Suprascapular nerve entrapment (at the suprascapular notch) may weaken muscle action
- Although it is most active during the first 30°, EMG studies have shown that *supraspinatus* assists shoulder abduction through the entire range of motion (not just the first 30° as previously thought)
- *Supraspinatus* passes under the acromion & is protected by the subacromial bursa; irritation of this bursa can result in subacromial bursitis
- Excessive strain & trauma can cause tendonitis of the supraspinatus tendon & can be associated with calcific tendonitis
- After the age of 40 ruptures of the supraspinatus tendon become more common; rupture of supraspinatus tendon results in superior displacement of the humerus (visible on radiograph & MRI); rupture of the tendon may also be seen following calcification of the tendon & is considered as one of the most important factors for a clinical condition known as "frozen shoulder"
- ***ADL:*** reaching above head, waving good-bye, lifting above head
- ***Common injuries:*** supraspinatus tendonitis, strain with repetitive or forceful abduction of shoulder (baseball, golf, racket ball), injured in shoulder instability or dislocation, possible muscle rupture in older patients, impingement syndrome (compression of tendon between acromion & greater tubercle)
- ***DDx:*** Rotator cuff tear, bursitis, articular dysfunction (cervical, thoracic, GH), MFTP referral pattern, adhesive capsulitis (frozen shoulder), C6 or C7 radiculopathy, brachial plexus injuries, suprascapular nerve entrapment, AC or GH Arthritis

Palpation

1. Patient prone or seated
2. Place palpating fingers along fiber direction just superior to the spine of the scapula & medial to acromion
3. Palpate through trapezius muscle to the fibers of the supraspinatus
4. Ask patient to abduct shoulder & resist action
5. Note contraction of the muscle tissue



Muscle Test

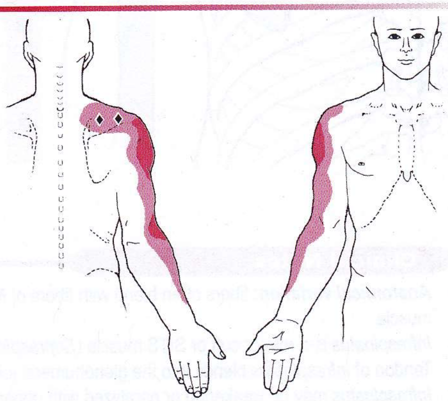


Patient position
- Supine, arm internally rotated, shoulder abducted & flexed 10° (in scaption plane)

Examiner's force
- Diagonal toward adduction & slight extension of shoulder

Stabilization
- Opposite ASIS (covered with patient's hand)

Trigger Point Referral

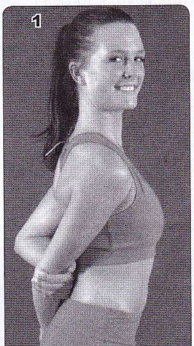


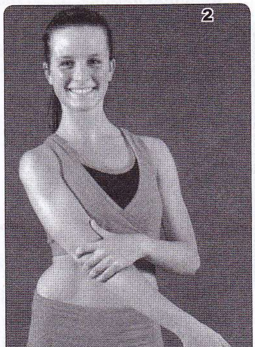
- Primary referral - felt as a deep ache in the mid-deltoid region of the shoulder; pain often extends down lateral arm & upper forearm; pain can concentrate at lateral epicondyle; rarely pain may extend to wrist
- Activation of MFTPs may occur if heavy objects are carried with arm hanging down, or when lifted above shoulder height
- Associated MFTPs are commonly found in infraspinatus & upper trapezius, anterior/ middle deltoid & latissimus dorsi

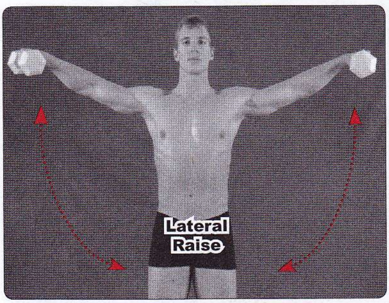
Stretch & Strengthen

Self Stretch 1:
- Adduct shoulder & pull arm inferiorly behind back

Self Stretch 2:
- Adduct shoulder & pull arm inferiorly in front of body



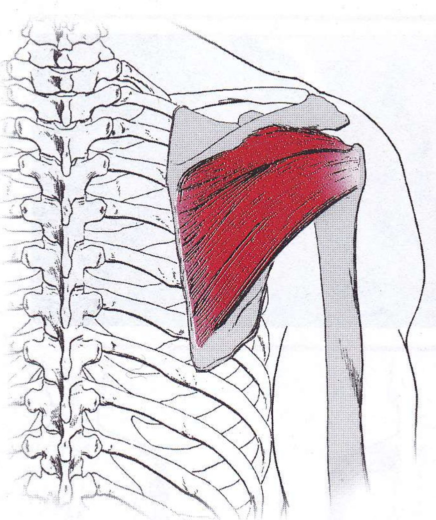




Strengthen
- Resisted shoulder abduction
- Lateral raises

Shoulder & Arm

Infraspinatus



O	**infraspinous fossa** **inferior portion of spine of scapula**
I	**greater tubercle of humerus** (middle facet)
A	**lateral rotation of shoulder** stabilizes glenohumeral joint
N	**suprascapular nerve** (C5, 6)
B	suprascapular artery scapular circumflex artery
S	teres minor, deltoid (posterior fibers)

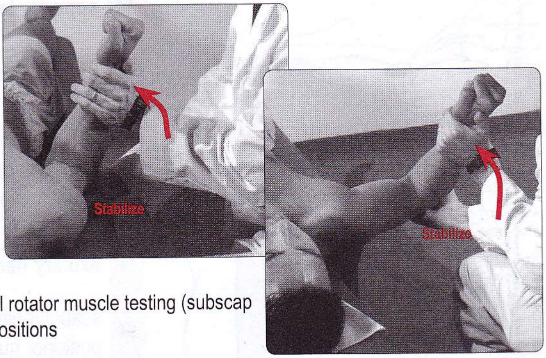
Clinical Notes

- ***Anatomical variation:*** fibers often blend with fibers of *teres minor*, such that they may appear as one muscle
- *Infraspinatus* is a rotator cuff or SITS muscle (*Supraspinatus, Infraspinatus, Teres minor & Subscapularis*)
- Tendon of *infraspinatus* blends into the glenohumeral joint capsule
- *Infraspinatus* may be weakened or paralyzed with upper trunk injuries to the brachial plexus
- ***ADL:*** brushing hair back, back-hand in racket sports, cocking phase before throwing
- ***Common injuries:*** strain with repetitive or forceful external rotation of arm, may be injured in shoulder instability or dislocation
- ***DDx:*** rotator cuff tear, bursitis, articular dysfunction (cervical, thoracic, GH), MFTP referral pattern, adhesive capsulitis (frozen shoulder), C6 or C7 radiculopathy, brachial plexus injuries, suprascapular nerve entrapment, arthritis

Palpation

1. Patient prone, seated or standing
2. Place palpating fingers along fiber direction just inferior to spine of scapula & over lateral border of scapula
3. Ask patient to externally rotate their shoulder & mildly resist action with non-palpating hand
4. Note contraction of the muscle tissue
5. Palpate from origin to insertion

Muscle Test



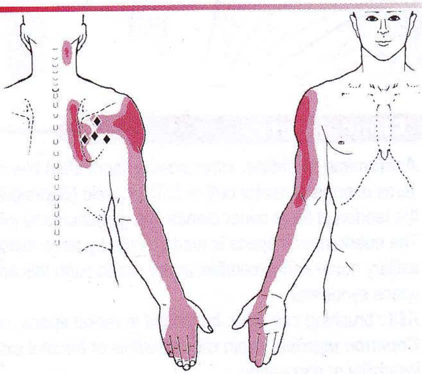
Patient position
- Supine, shoulder slightly externally rotated, elbow flexed 90º

Examiner's force
- Toward internal rotation

Stabilization: Elbow
- Should be tested in two positions (shoulder at 0º & 90º)

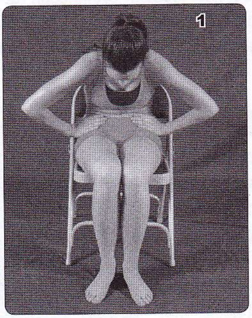
Internal rotators should follow external rotator muscle testing (subscap & pec major) also in the same two positions

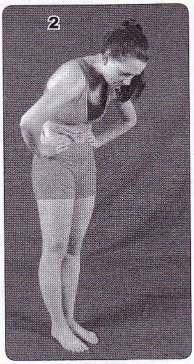
Trigger Point Referral



- MFTPs occur mainly in muscle belly
- Primary referral is to the anterior deltoid region & in shoulder joint
- Pain may extend down front & lateral aspect of arm & forearm, & sometimes include the radial half of hand
- Less commonly, pain may refer to suboccipital & posterior cervical areas
- Rarely may refer pain over ipsilateral rhomboid muscles
- MFTP activation: usually results from overload while reaching backward and up

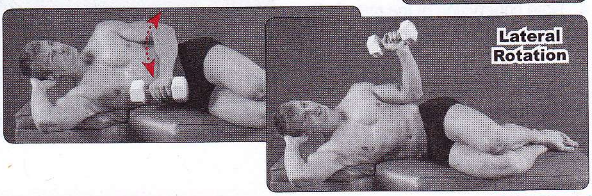
Stretch & Strengthen





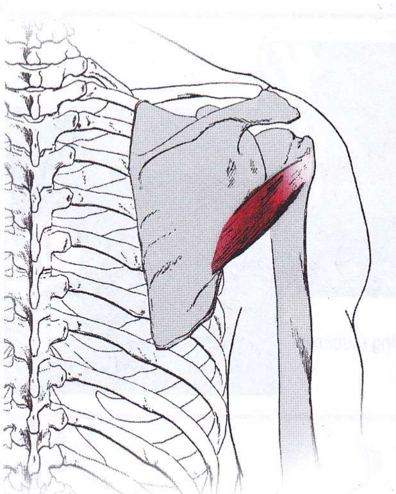
Self Stretch 1:
- While seated, place both hands on waist with thumbs forward, bend foward & let elbows fall toward floor

Self Stretch 2:
- Place both hands on waist with thumbs forward, bend forward & let elbows fall toward floor



Strengthen
- Lying lateral rotation

Teres Minor



O	**superior lateral border of scapula**
I	**greater tubercle of humerus** (inferior facet)
A	**lateral rotation of shoulder** stabilizes glenohumeral joint adduction of shoulder (weak action)
N	**axillary nerve** (C5, C6)
B	scapular circumflex artery posterior humeral circumflex artery
S	infraspinatus, deltoid (posterior fibers)

Clinical Notes

- ***Anatomical variation:*** *infraspinatus* fibers often blend with *teres minor* forming one muscle
- *Teres minor* is a rotator cuff or SITS muscle (*Supraspinatus, Infraspinatus, Teres minor & Subscapularis*); the tendon of teres minor blends into glenohumeral joint capsule
- The quadrangular space is made by the by *teres minor, teres major, triceps muscles* & humerus; the axillary nerve and circumflex artery run through this space & may be entrapped resulting in 'quadrangular space syndrome'
- ***ADL:*** brushing hair back, backhand in racket sports, cocking phase before throwing
- ***Common injuries:*** strain with repetitive or forceful external rotation of arm, may be injured in shoulder instability or dislocation
- ***DDx:*** rotator cuff tear, bursitis, articular dysfunction (cervical, thoracic, GH), MFTP referral pattern, adhesive capsulitis (frozen shoulder), C6 or C7 radiculopathy, brachial plexus injuries, arthritis, quadrangular space syndrome (axillary nerve and/or circumflex artery entrapment

Palpation

1. Patient prone, seated or standing
2. Place palpating fingers along fiber direction between lateral border of scapula & greater tubercle of humerus
3. Ask patient to externally rotate their shoulder & mildly resist action with non-palpating hand
4. Note contraction of the muscle tissue
5. Palpate from origin to insertion

To differentiate teres minor from major, have patient internally rotate shoulder - teres minor will relax & teres major will contract

Muscle Test

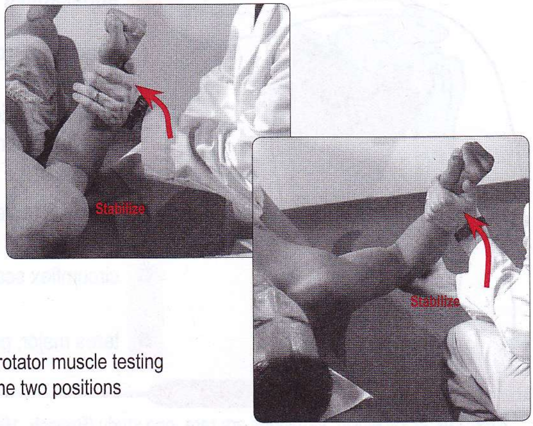
Patient position
- Supine, shoulder slightly externally rotated, elbow flexed 90º

Examiner's force
- Toward internal rotation

Stabilization
- Elbow

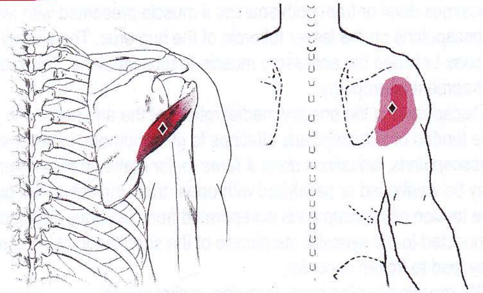
Note: should be tested in two positions (shoulder at 0º & 90º)

Internal rotators should follow external rotator muscle testing (subscap & pec major) also in the same two positions



Trigger Point Referral

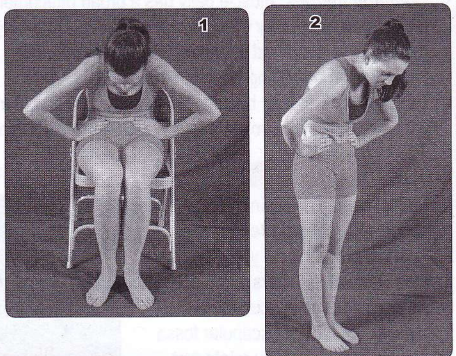
- Primary referral is over a very small, specific area of back & shoulder, near the lateral border of the scapula; the back of arm, deep in the posterior deltoid
- Rarely to 4th and 5th fingers as numbness and tingling (not pain)



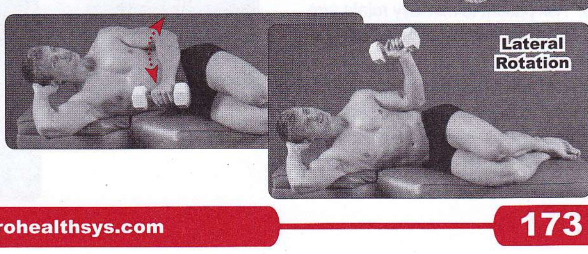
Stretch & Strengthen

Self Stretch 1:
- While seated, place both hands on waist with thumbs forward, bend forward & let elbows fall toward floor

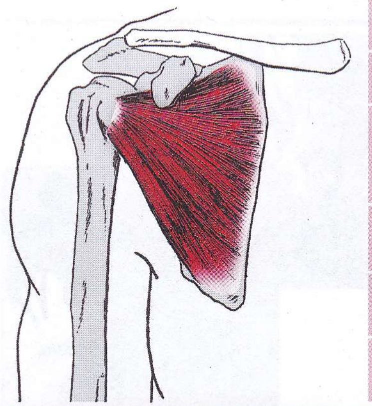
Self Stretch 2:
- Place both hands on waist with thumbs forward, bend forward & let elbows fall toward floor



Strengthen
- Resisted lateral rotation
- Lying lateral rotation



Subscapularis



O	**subscapular fossa of scapula**
I	**lesser tubercle of humerus**
A	**medial rotation of shoulder** stabilizes glenohumeral joint
N	**upper & lower subscapular nerves** (C5, C6)
B	circumflex scapular artery, dorsalscapular artery
S	teres major, pectoralis major, latissimus dorsi

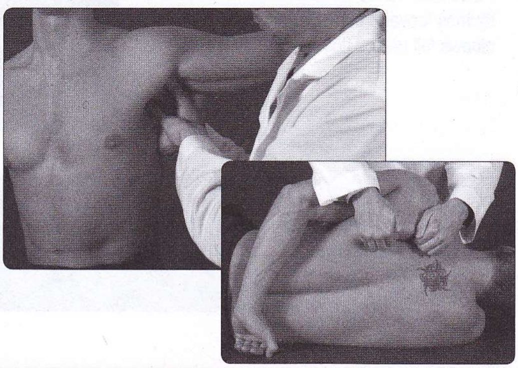
Clinical Notes

- ***Anatomical variation:*** variations are rare, one study (Breisch, 1986) showed an accessory muscle: arises near the lateral margin of scapula, either from surface of subscapular muscle or from border of latissimus dorsi or from both sources if muscle presented with two heads. It runs upwards to fuse with subscapularis on the lesser tubercle of the humerus. The axillary & the lower subscapular nerves tend to pass between the accessory muscle & subscapularis. This relationship is notable in terms of potential entrapment neuropathy
- *Subscapularis* is the primary medial rotator of the arm and is the largest rotator cuff or SITS muscle
- The tendon of *subscapularis* attaches to glenohumeral joint capsule
- *Subscapularis, latissimus dorsi & teres major* make up the posterior axillary wall
- May be weakened or paralyzed with upper trunk injuries to the brachial plexus
- The tendon of *subscapularis* is separated from shoulder joint capsule by a bursa; since this bursa is often connected to the synovial membrane of the shoulder joint, its chronic inflammation (subscapular bursitis) may lead to frozen shoulder
- ***ADL:*** reaching behind back, throwing, racket sports
- ***Common injuries:*** muscle belly has a broad attachment in the subscapular fossa and is rarely injured; the ***tendon is usually the structure involved in an injury;*** tendonitis from repetitive forceful internal rotation (e.g. overhead stroke of the crawl in swimming, or pitching a baseball) & jobs with repeated forceful overhead lifting while in strong adduction
- ***DDx:*** rotator cuff tear, bursitis, articular dysfunction (cervical, thoracic, GH), MFTP referral pattern, adhesive capsulitis (frozen shoulder), C6 or C7 radiculopathy, brachial plexus injuries, arthritis

Palpation

1. Patient seated or supine with shoulder abducted & pulled anteriorly
2. Rest patient's arm on your shoulder
3. Place palpating fingers along posterior axillary fold & gently curl them inwards, into the subscapular fossa
4. Ask patient to medially rotate arm
5. Note contraction of muscle tissue

Medial fibers may be palpated by having patient side-lying with hand behind small of back; gently curling palpating fingers under the medial border of the scapula & palpating through trapezius & rhomboids



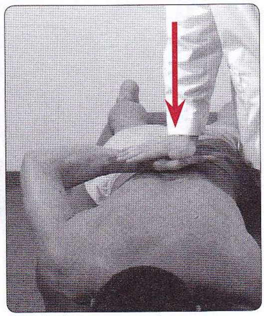
Muscle Test

Patient position
- Prone, arm behind lower lumbar spine

Examiner's force
- Straight posterior to anterior (make sure patient lifts arm away from body, not extension of elbow)

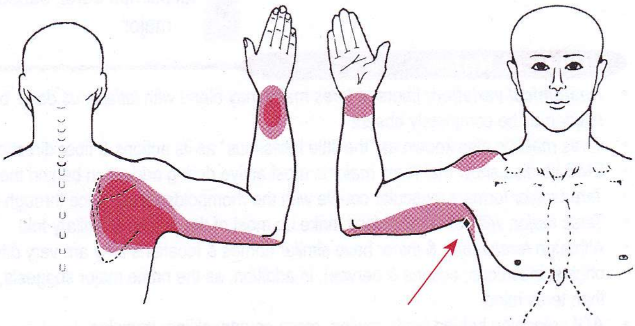
Stabilization
- None required

Note: subscapularis may also be tested with pectoralis major by testing the arm into internal rotation (tested in two positions; shoulder at 0º & 90º)



Trigger Point Referral

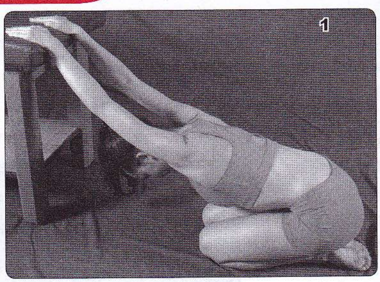
- Pain referral is generally over the posterior axillary fold & medial arm
- Sometimes pain referral extends down to wrist & over mid deltoid

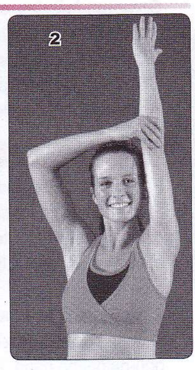


Stretch & Strengthen

Self Stretch 1:
- Abduct & externally rotate shoulders above head against chair or bench, pull body inferiorly

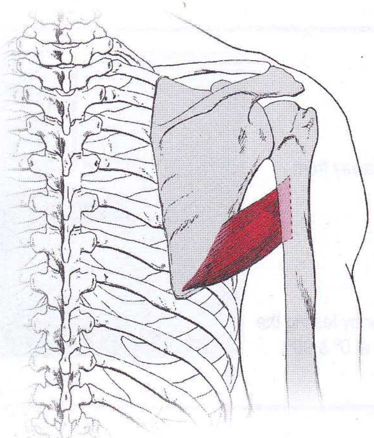
Self Stretch 2:
- Abduct & externally rotate shoulder, pull arm superiorly over head or hang from bar





Strengthen
- Resisted shoulder medial rotation
- Lying medial rotation
- Standing medial rotation

Teres Major



O	**inferior, lateral border of scapula**
I	**medial lip of bicipital groove of humerus** (just medial to insertion of latissimus dorsi)
A	**medial rotation & adduction of shoulder** extension of shoulder from a flexed position upward scapular rotation (closed chain action)
N	**lower subscapular nerve** (C5, C6, C7)
B	scapular circumflex artery, thoracodorsal artery
S	latissimus dorsi, subscapularis, pectoralis major

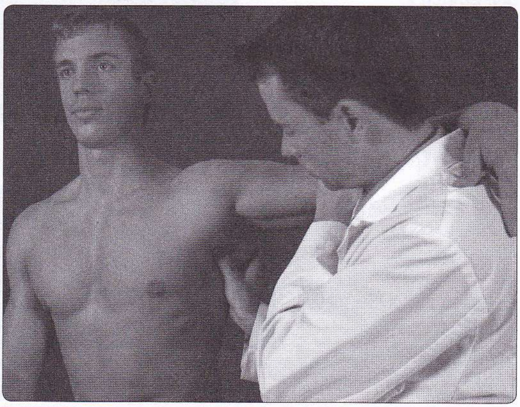
Clinical Notes

- ***Anatomical variation:*** fibers of *teres major* may blend with *latissimus dorsi*, on rare occasion the *teres major* may be completely absent
- *Teres major* is also known as "the little latissimus" as its actions & fiber direction are very similar
- EMG studies show that *teres major* is most active during adduction behind the back
- *Teres major* forms a muscular couple with the rhomboids (apply force through humerus)
- *Teres major*, with *latissimus dorsi* make up most of the posterior axillary fold
- Although *teres major & minor* have similar names & locations they are very different muscles (different origins, insertions, actions & nerves), in addition, as the name major suggests, *teres major* is much larger than teres minor
- ***ADL:*** reaching behind back, rowing, cross-country skiing, throwing
- ***Common injuries:*** strain with repetitive or forceful internal rotation of arm, may be injured in shoulder instability or dislocation
- ***DDx:*** rotator cuff tear, subacromial &/or sub-deltoid bursitis, articular dysfunction (cervical, thoracic, GH), MFTP referral pattern, supraspinatus or bicipital tendinitis, C6 or C7 radiculopathy, brachial plexus injuries, thoracic outlet syndrome

Palpation

1. Patient prone, seated or standing
2. Place palpating fingers along fiber direction between lateral border of scapula & medial lip of bicipital groove of humerus
3. Ask patient to internally rotate their shoulder & mildly resist action with non-palpating hand
4. Note contraction of the muscle tissue
5. Palpate from origin to insertion

To differentiate teres major from minor, have patient internally rotate shoulder - teres minor will relax & teres major will contract



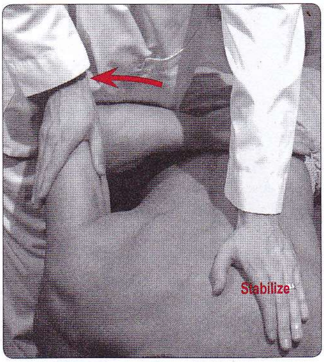
Muscle Test

Patient position: prone, arm externally rotated bent behind back, hand over lumbar spine

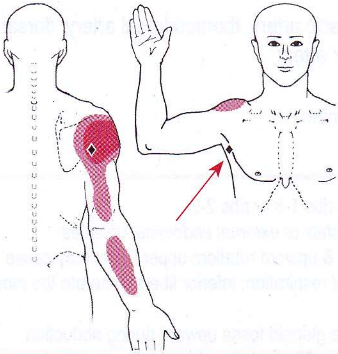
Examiner's force: toward abduction of shoulder

Stabilization: opposite scapular region

Note: teres major may also be tested with pectoralis major and/or latissimus dorsi muscle tests into abduction of the shoulder



Trigger Point Referral

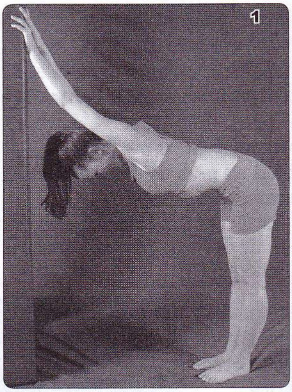


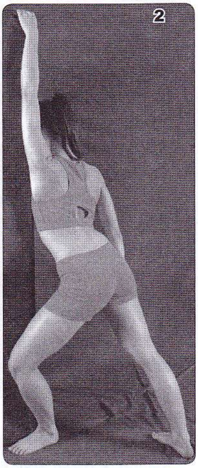
- Primary referral: feeling of sharp pain in posterior shoulder & arm
- Patients often describe feeling pain in deltoid muscle

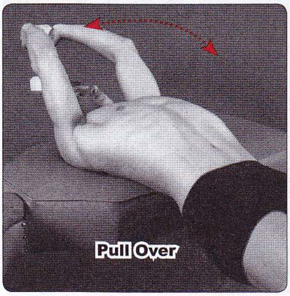
Stretch & Strengthen

Self Stretch 1:
- Abduct & externally rotate shoulders above head against wall or door, pull body inferiorly

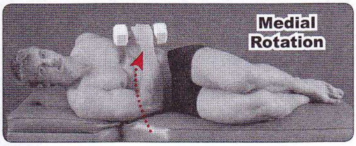
Self Stretch 2:
- Abduct & externally rotate shoulder above head against wall or door, pull body inferiorly





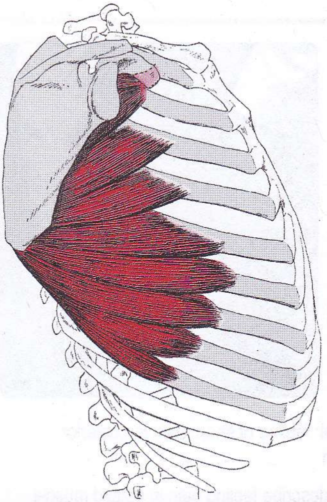


Strengthen
- Medial rotation of shoulder
- Pull over
- Chin up
- Swimming breast-stroke



Shoulder & Arm

Serratus Anterior



O	**ribs 1- 9** (lateral surface)
I	**costal surface of medial border of scapula**
A	**protraction** (abduction) **& upward rotation of scapula** stabilizes scapula for upper extremity movements
N	**long thoracic nerve** (C5, C6, C7)
B	lateral thoracic artery, thoracodorsal artery, dorsal scapular artery
S	pectoralis minor

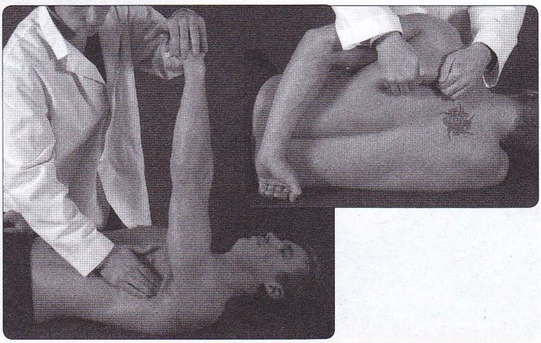
Clinical Notes

- ***Anatomical variation:*** *serratus anterior* may only attach to ribs 1-8 or ribs 2-9
  - Serratus fibers may blend with *levator scapulae, intercostals or external abdominal obliques*
- *Serratus anterior* is the prime mover in scapular protraction & upward rotation; upper fibers may cause downward rotation; also considered an accessory muscle of respiration; inferior fibers generate the most force & are the strongest
- *Serratus anterior & trapezius* are responsible for rotating the glenoid fossa upward during abduction (*serratus anterior & trapezius* rotate the scapula ~1° for every 2° of rotation done by the *supraspinatus & deltoid*)
- ***Winging of the scapula*** may occur with damage to the long thoracic nerve or weakness of the muscle (scapula lifts from back with wall push-up)
- Serratus anterior stabilizes the scapula to the chest wall & provides a stable base for the movements of the shoulder joint; paralysis or weakness of this muscle has negative influences on all shoulder movements
- ***ADL:*** pushing an object away, push-up, punching
- ***Common injuries:*** injuries are relatively uncommon, strain with repetitive or forceful punching or pushing -type motions, long thoracic nerve damage
- ***DDx:*** heart attack/angina, C7 or C8 radiculopathy, herpes zoster, intercostal nerve entrapment, costochondritis

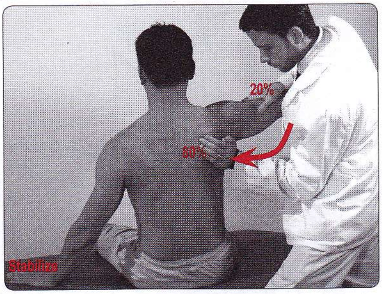
Palpation

1. Patient supine, shoulder flexed 90°
2. Place palpation hand along fiber direction in axilla region, between the latissimus dorsi and the pectoralis major
3. Ask patient to do a 'punching motion' & resist patient's movement
4. Note contraction of muscle tissue

Medial fibers can be located in the same manner as medial subscapularis



Muscle Test



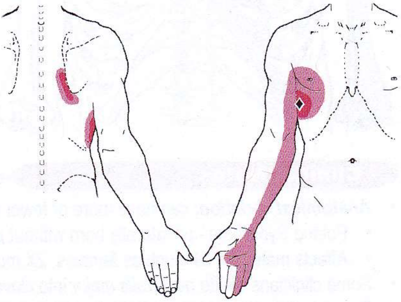
Patient position
- Seated, shoulder in scaption plane (parallel to the blade of the scapula) abducted 110°, arm externally rotated

Examiner's force
- Toward downward rotation of the scapula

Note: although the examiner's hand is on the humerus, most of the force (80%) is directed through the lateral scapula

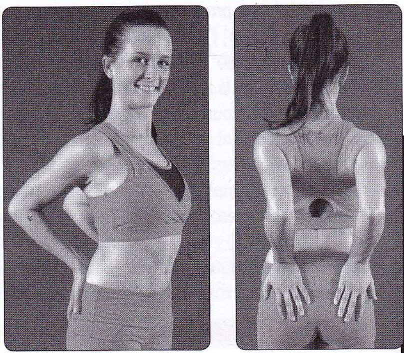
Stabilization: Patient's hand on table

Trigger Point Referral



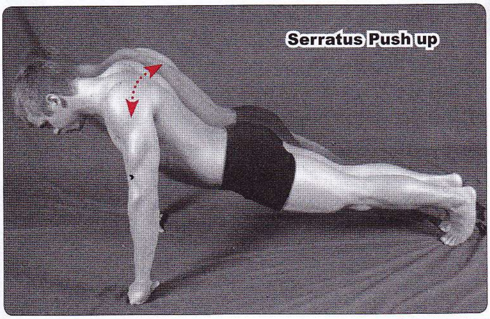
- MFTP pain referral is usually over the lateral inferior portion of the scapula
- When trigger points are present patient may experience pain in exhaling
- Pain of serratus anterior trigger points can be misinterpreted as symptoms of lung disease and heart attacks (differentials that must be rule out)

Stretch & Strengthen



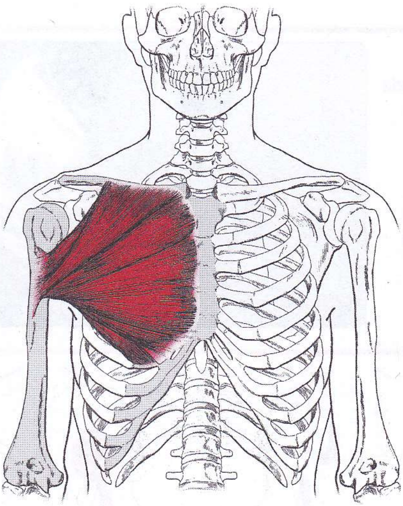
Self Stretch:

- Shoulders extended with scapulas fully retracted, stick out chest
- Taking a deep breath may further expand chest & further enhance stretch



Strengthen
- Resisted shoulder protraction
- Serratus push up (keep arms straight, protract & retract scapulas)
- Incline shoulder raises
- Supine shoulder raises
- Push ups
- Boxing/punching

Pectoralis Major



O	*upper fibers:* **medial 1/2 of clavicle** *middle fibers:* **anterior sternum** *lower fibers:* **costal cartilage ribs 1-6**
I	**lateral lip of bicipital groove of humerus** (crest of the greater tubercle)
A	**adduction & medial rotation of shoulder** **horizontal adduction of shoulder** flexion of shoulder (clavicular portion)
N	**medial & lateral pectoral nerve** (C8, T1)
B	thoracoacromial trunk
S	latissimus dorsi, subscapularis & teres major

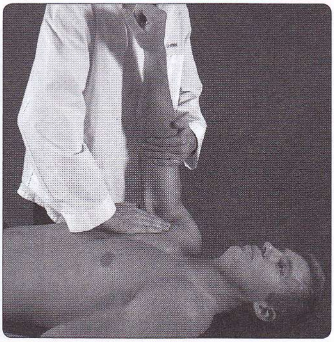
Clinical Notes

- ***Anatomical variation:*** can have more or fewer attachment on ribs or sternum
  - Poland Syndrome - unilaterally born without *pectoralis major* (congenital anomaly)
  - Affects males 3X as much as females, 2X more common on the right than left
- Some clinicians divide *pectoralis major* into clavicular, sternal, costal & abdominal heads
- Because of its important attachments to the chest wall (1-6 ribs & costal cartilages), this muscle is considered as a prominent respiratory muscle (forced inspiration only)
- Clavicular (upper) fibers insert more distally & costosternal (lower) fibers insert more proximally; once the arm is passed ~60° flexion pectoralis major does not assist with flexion
- *Pectoralis major* is a powerful horizontal adductor of the arm, a movement required for push-ups, bench press, throwing, punching & pushing
- Over-development or contracture of the *pectoralis major* may result in a postural condition known as 'rounded shoulders'
- ***ADL:*** hugging, applying deodorant, wrestling, pushing an object away
- ***Common injuries:*** overuse tendinopathies in athletes,
  - Rupture (rare) - resulting from violent, eccentric contraction during bench press action with shoulder
- ***DDx:*** heart attack/angina, bicipital or supraspinatus tendinitis, rotator cuff tear, cervical or costal joint dysfunction, acromial or subdeltoid bursitis, medial or lateral epicondylitis, C6, C7 or C8 radiculopathy

Palpation

1. Patient supine, sidelying, or seated
2. Ask patient to flex shoulder to 90°
3. Place palpating fingers along fiber direction over the specific region you wish to examine
4. Ask patient to move arm across body (horizontal adduction) against your resistance; note muscle contraction

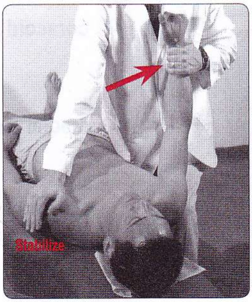
Pectoralis major may also be palpated by 'pinching' the anterior axillary fold



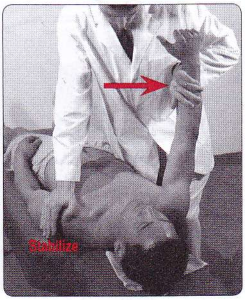
Muscle Test

	Sternal head	Clavicular head
PP	Supine, shoulder flexed 90°, fully internally rotated arm	Supine, shoulder flexed 90°, arm internally rotated 45°
EF	Diagonal toward abduction & slight *flexion*	Diagonal toward abduction & slight *extension*
S	Opposite shoulder	

PP = patient position, EF = examiner force, S = stabilization

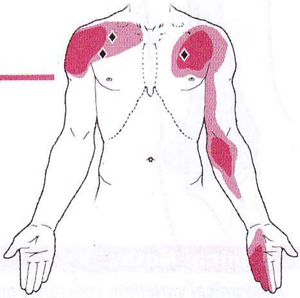


Clavicular Head



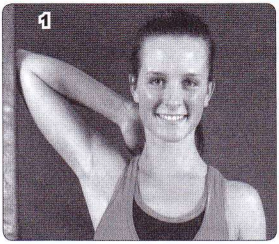
Sternal Head

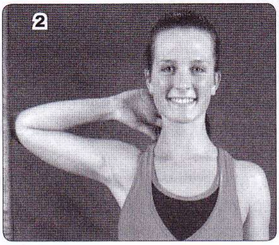
Trigger Point Referral

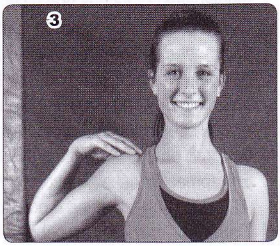


- Pain may extend up over subclavicular area & may cover the entire ipsilateral pectoral & anterior deltoid region
- Pain may radiate down the ulnar side, elbow, forearm & hypothenar side of hand (last 3 digits)
- **Note:** Pain from pectoralis major can mimic pain of a heart attack (a differential that must be ruled out)

Stretch & Strengthen



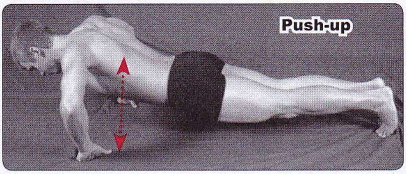


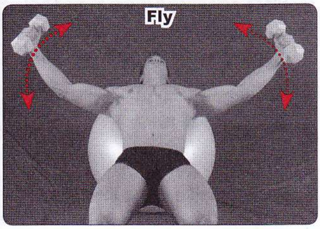


1. **Lower fibers:** elbow flexed, shoulder abduct 150° & extended against door or wall
2. **Middle fibers:** elbow flexed, shoulder abduct 100° & extended against door or wall
3. **Upper fibers:** elbow flexed, shoulder abduct 60° & extended against door or wall

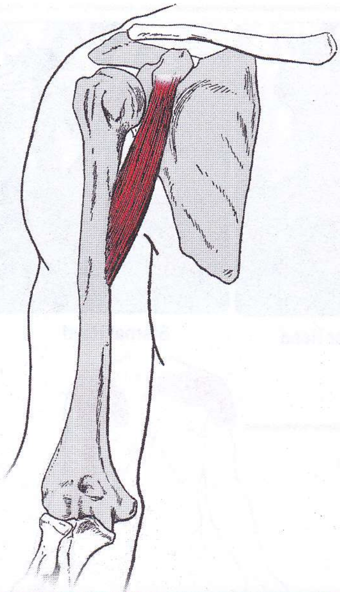
By flexing the elbow the stretches are more specific to pectoralis major; may also be done with the arm straight but will also stretch anterior arm muscles. Stretches may be done bilaterally through a door.

Strengthen
- Push ups
- Flys
- Pull over
- Chest dips
- Bench press -
  - incline for upper fibers
  - decline for lower fibers





Shoulder & Arm



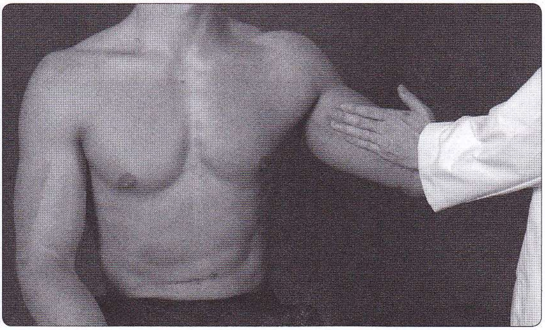
O	**coracoid process of scapula**
I	**medial shaft of humerus** (middle 1/3)
A	**flexion & adduction of shoulder** **horizontal adduction of shoulder**
N	**musculocutaneous nerve** (C5, C6, C7)
B	muscular branches of brachial artery & anterior humeral circumflex artery
S	pectoralis major, biceps brachii, anterior deltoid

Clinical Notes

- ***Anatomical variation:*** very rarely muscle may have two bellies, which form just distal to the coracoid process, one belly inserts into middle anteromedial surface of the humerus & other belly inserts into medial head of triceps brachii or medial epicondyle
- *Coracobrachialis* is a strong horizontal adductor, but is the smallest anterior arm muscle
- *Coracobrachialis* is one of 3 muscles that attaches to the coracoid process (*biceps brachii short head, pectoralis minor & coracobrachialis*)
- The musculocutaneous nerve usually runs directly through the muscle belly (possible site of musculocutaneous entrapment); entrapment can result in weakness in supination, elbow flexion, shoulder flexion & paresthesia of the lateral forearm
- Entrapment is usually secondary to hypertrophy (more common in bodybuilders & high-level athletes)
- ***ADL:*** hugging, covering mouth to cough, bringing food to mouth
- ***Common injuries:*** coracobrachialis weakness may contribute to shoulder dislocation
- ***DDx:*** musculocutaneous nerve entrapment, C5 or C6 radiculopathy, carpal tunnel syndrome, AC joint dysfunction, subacromial &/or subdeltoid bursitis

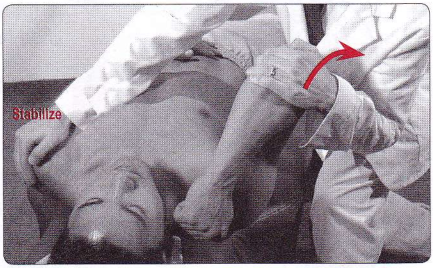
Palpation

1. Patient supine or seated; shoulder laterally rotated & abducted to ~45°
2. Place palpating fingers along fiber direction over mid medial side of arm & move finger pads into axilla
3. Ask patient to horizontally adduct against resistance
4. Note contraction of muscle tissue
5. Palpate from origin to insertion



Shoulder & Arm

Muscle Test



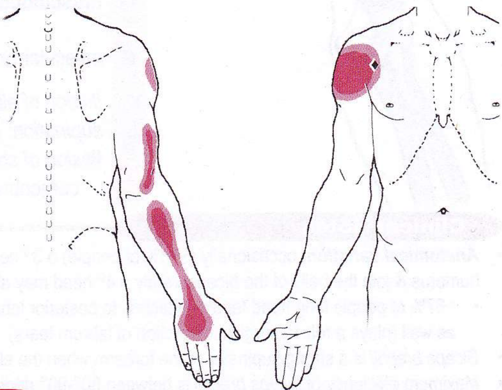
Patient position
- Supine, shoulder flexed 45º, abducted 30º & elbow flexed 150º

Examiner's force
- Diagonal toward extension & slight abduction of the shoulder

Stabilization
- Opposite shoulder

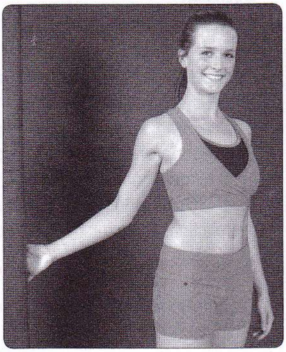
Trigger Point Referral

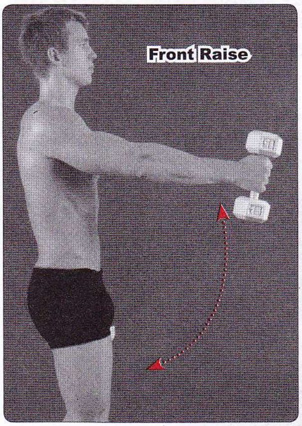
- MFTP pain is usually referred over anterior deltoid & down posterior arm to the dorsum of hand
- May extend to tip of middle finger
- Referral may skip elbow and wrist

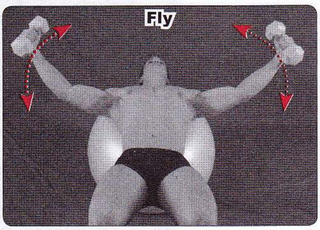


Stretch & Strengthen

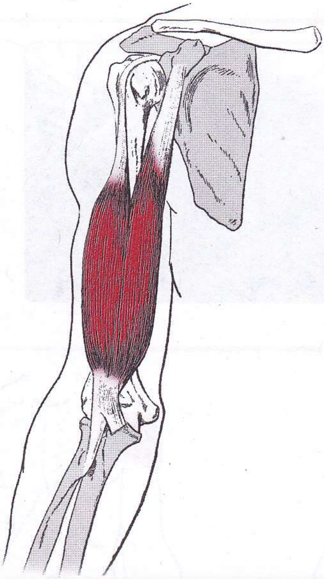
Self Stretch:
- Standing against wall or door way with shoulder extended, slightly abducted & externally rotated (keep the elbow flexed to limit stretch of biceps brachii)
- Image shows excellent definition of coracobrachialis fibers in tension







Strengthen
- Front raises
- Fly
- Bench press



O	*long head:* **supraglenoid tubercle & glenohumeral labrum** *short head:* **coracoid process of scapula**
I	**radial tuberosity & bicipital aponeurosis**
A	**flexion & supination of elbow** **flexion of shoulder** stabilization of anterior aspect of shoulder abduction of shoulder (long head), adduction of shoulder (short head)
N	**musculocutaneous nerve** (C5, C6)
B	muscular branches of brachial artery
S	*flexion of elbow:* brachialis, brachioradialis *supination:* supinator *flexion of shoulder:* deltoid (anterior), pec major, coracobrachialis

Clinical Notes

- ***Anatomical variation:*** occasionally (~10% of people) a 3rd head of the *biceps brachii* may arise from the humerus & join the belly of the biceps, rarely a 4th head may also exist
    - ~67% of people long head tendon attaches to posterior labrum; ~33% also attaches to anterior labrum as well (plays a role in surgical correction of labrum tears)
- *Biceps brachii* is a strong supinator of the forearm when the elbow is flexed
- Maximum efficiency of *biceps brachii* is between 80°-90° degrees of elbow flexion & when the forearm is supinated
- *Biceps brachii* runs through bicipital groove (intertubercular sulcus) & with repetitive stress activities may become irritated causing bicipital tendonitis
- Proximal fibers of *biceps brachii short head* may blend with fibers of *coracobrachialis* at coracoid process
- Deep tendon reflex of the biceps brachii tests mainly the C5 spinal level
- ***ADL:*** elbow flexion, eating, drinking, hugging
- ***Common injuries:*** strain with repetitive overhead and lifting activities, biceps tendonitis, ruptures of long head tendon, subluxation of biceps long head tendon out of bicipital groove
- ***DDx:*** bicipital tendonitis, musculocutaneous nerve entrapment, C5 or C6 radiculopathy, AC joint dysfunction, subacromial &/or subdeltoid bursitis

Palpation

1. Patient supine or seated; forearm supinated
2. Place palpating fingers along fiber direction over anterior arm
3. Ask patient to flex elbow against resistance
4. Note contraction of muscle tissue

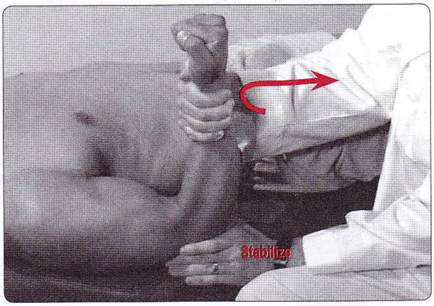
Biceps brachii is also easy to palpate without muscle contraction

Muscle Test

Patient position
- Supine, elbow flexed 90º & forearm supinated

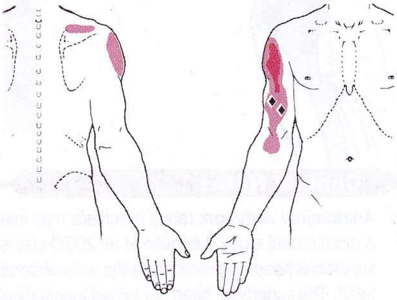
Examiner's force
- Toward extension of the elbow & slight pronation of the forearm

Stabilization
- Patient's elbow



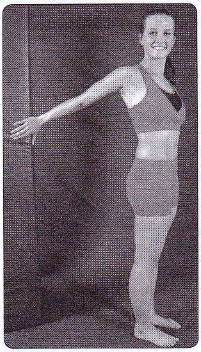
Trigger Point Referral

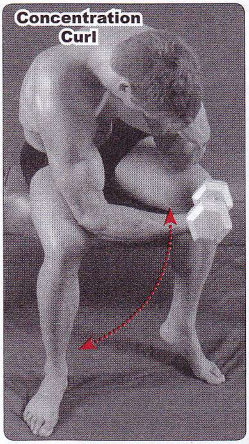
- MFTPs usually found in distal part of muscle
- Pain is generally referred upward over muscle & over anterior deltoid region
- May have a spillover pain pattern in suprascapular region

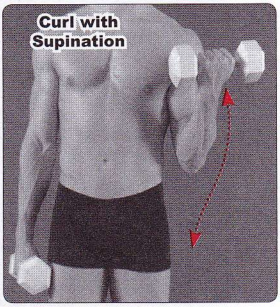


Stretch & Strengthen

Self Stretch:
- Stand at doorway or wall with shoulders extended, elbow straight, forearm pronated slowly flex knees & extend shoulder
- Other muscle stretched: anterior deltoid, pectoralis major & pectoralis minor



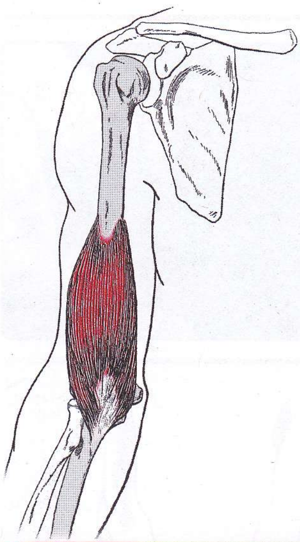




Strengthen
- Resisted elbow flexion with forearm supination
- Curls with supination
- Concentration curl with supination
- Preacher curl

Shoulder & Arm

Brachialis



O	**anterior distal 1/2 of humerus**
I	**ulnar tuberosity & coronoid process of ulna**
A	**flexion of elbow** (prime mover)
N	**musculocutaneous** & radial nerve (C5, C6, C7)
B	muscular branches of brachial artery & radial recurrent artery
S	biceps brachii, brachioradialis

Clinical Notes

- ***Anatomical variation:*** rarely *brachialis* may insert onto the oblique cord or radius
- A more recent study (Leonello et al. 2007) states the "brachialis muscle has two heads. The larger, superficial head originated from the anterolateral aspect of the humerus, proximal to the smaller, deep head. The superficial head contained longitudinal fibers, which inserted by means of a thick round tendon onto the ulnar tuberosity. The deep head fibers were fan-shaped and converged to insert by means of an aponeurosis onto the coronoid process. In all specimens, a branch of the radial nerve supplied the inferolateral fibers of the deep head"
- *Brachialis* is the main flexor of the elbow; maximum efficiency for brachialis is achieved at 90° of elbow flexion
- Although most people focus on the biceps when flexing their arms, the brachialis makes up much of the mass that makes the biceps prominent
- ***ADL:*** elbow flexion, eating, drinking, hugging
- ***Common injuries:*** specific injuries are rare, repetitive overhead and lifting activities, tendonitis
- ***DDx:*** bicipital tendonitis, musculocutaneous nerve entrapment, C5 or C6 radiculopathy, AC joint dysfunction, subacromial &/or subdeltoid bursitis

Palpation

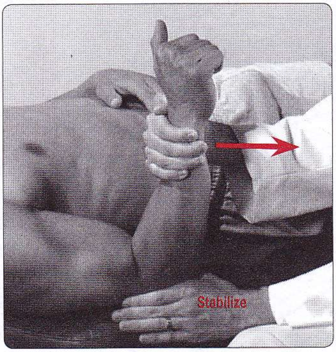
1. Patient supine or seated; elbow flexed 90° (shake hand with patient)
2. Place palpating fingers along fiber direction just lateral to biceps brachii
3. Ask patient to flex elbow against resistance
4. Note contraction of muscle tissue
5. Palpate from origin to insertion

Muscle Test

Patient position
- Supine, elbow flexed 90° & forearm pronated

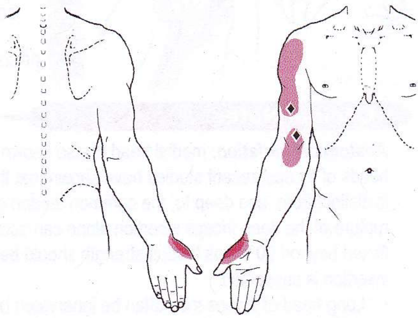
Examiner's force
- Toward extension of the elbow

Stabilization
- Patient's elbow



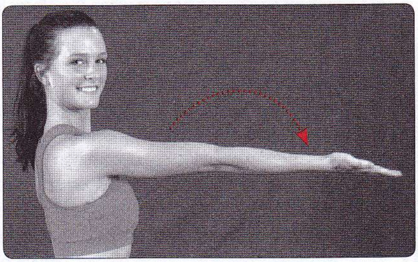
Trigger Point Referral

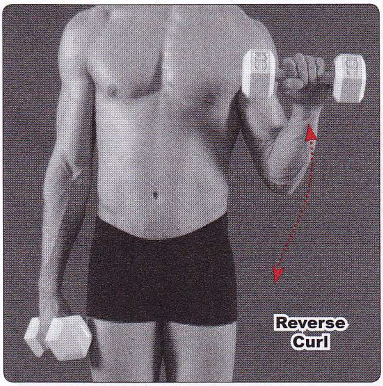
- MFTPs most commonly occur a ~2 cm (1 inch) above antecubital space
- Pain referral is mainly down to the base of 1st digit & thenar region
- Upper belly MFTPs may refer to the anterior deltoid region



Stretch & Strengthen

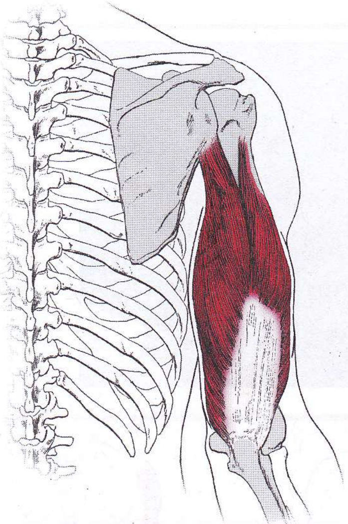
Self Stretch
- Have patient extend elbow (if the shoulder is extended like some sources suggest, biceps brachii fibers will be targeted not brachialis)
- In the absence of tissue contracture or pathology brachialis is a difficult muscle to stretch





Strengthen
- Resisted elbow flexion with forearm pronated (pronation limits biceps activity)
- Reverse curl
- Reverse preacher curl
- Reverse concentration curl

Triceps Brachii



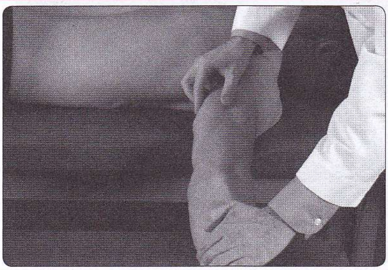
O	*long head:* **infraglenoid tubercle & neck of scapula** *lateral head:* **upper half of posterior surface of shaft of humerus** (above radial groove) *deep (medial) head:* **posterior shaft of humerus** (below radial groove)
I	**olecranon process of ulna**
A	**extension of elbow** (prime mover) adduction & extension of shoulder (long head only)
N	**radial nerve** (C6, **C7**, C8) axillary nerve (long head)
B	muscular branches of brachial artery, superior ulnar collateral artery, profunda brachii artery
S	anconeus

Clinical Notes

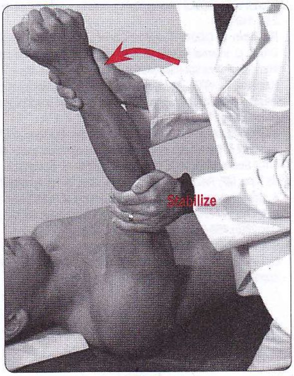
- ***Anatomical variation:*** medial head is also known as the *deep head* as it lies deep to the other two heads of triceps; recent studies have shown that the medial (deep) head of the triceps has a tendon that is distinct from, and deep to, the common tendon of the long and lateral heads - *Clinical implications:* rupture of the deep triceps insertion alone can occur & cause weakness of elbow extension with the elbow flexed beyond 90°; thus triceps strength should be tested with elbow fully flexed when injury to the tendon insertion is suspected
  - Long head of triceps may often be innervated by the axillary nerve (de Seze et. al. 2004)
- *Triceps brachii* is the main extensor of the elbow & account for ~60% of the arms mass
- Maximum efficiency of *triceps* is when the elbow joint is between 20°– 30° of flexion
- Radial nerve runs between the lateral & medial heads of the *triceps*, where it may become damaged or compressed; fracture of the surgical neck of the humerus may result in radial nerve damage which can cause paralysis of the triceps brachii
- The deep tendon reflex (DTR) of the triceps brachii tests mainly the C7 spinal level
- ***ADL:*** push-ups, extension of elbow during racket sports
- ***Common injuries:*** injuries are uncommon, but may result from indirect or direct trauma generally associated with an eccentric contraction; very rarely avulsion fracture of olecranon (usually due to a fall on an out stretched elbow, with sudden contraction of the triceps muscle) - exam will reveal pain, swelling, and a palpable depression just proximal to the olecranon
- ***DDx:*** lateral epicondylitis (tennis elbow), olecranon bursitis, TOS, C7 radiculopathy, radial nerve compression, AC joint dysfunction, subacromial &/or subdeltoid bursitis, upper thoracic joint dysfunction

Palpation

1. Patient prone, shoulder abducted to 90° and the forearm hanging off table (forearm flexed at 90°)
2. Place palpating hand over posterior arm just proximal to the olecranon process
3. Ask patient extend elbow & mildly resist action
4. Note contraction of muscle tissue, palpate medial, lateral and deep heads
5. Palpate from insertion to origin



Muscle Test

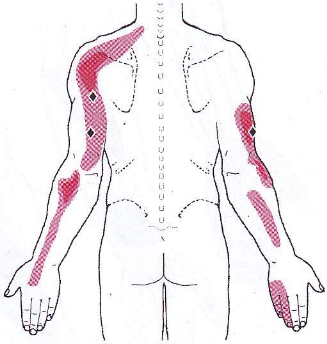


Patient position
- Supine, shoulder flexed 90°, elbow slightly flexed

Examiner's force
- Toward flexion of elbow (not flexion of shoulder)

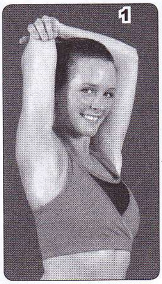
Stabilization
- Patient's elbow

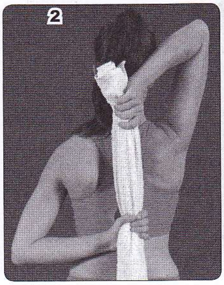
Trigger Point Referral



- MFTP or commonly located in the long head & lateral head
- Pain referral is usually to the posterior shoulder extending as far up as the angle of the neck, down the back & front of the arm & forearm
- Lateral head may also send referral down as far as the posterior medial 2 digits (ring & little finger)

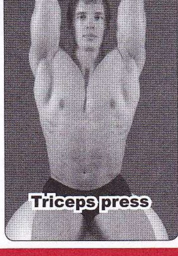
Stretch & Strengthen





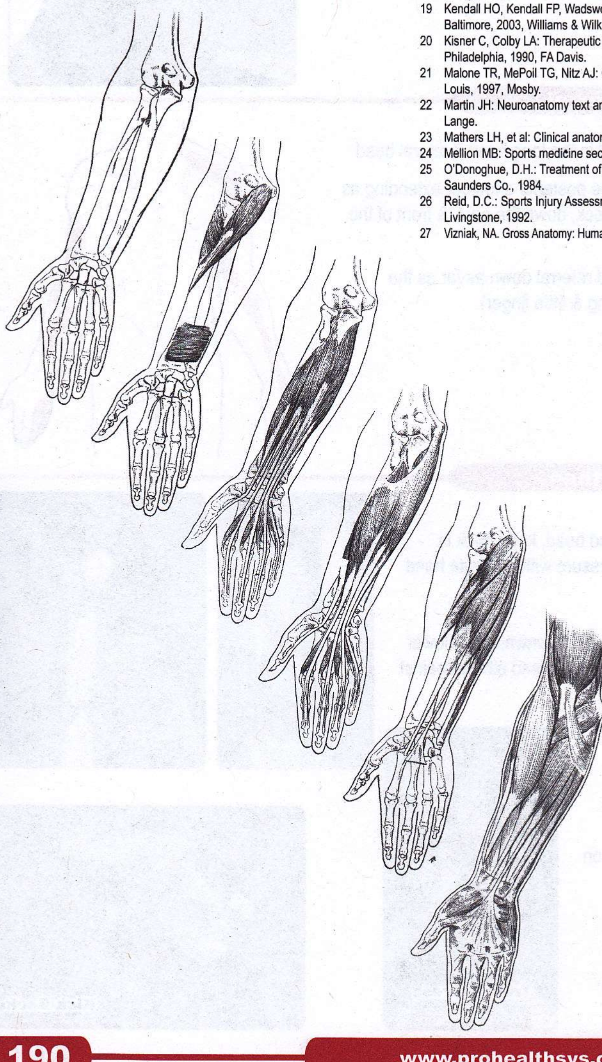
Self Stretch 1
- Flex elbow and place behind head, keep neck in neutral position & apply pressure with opposite hand

Self Stretch 2
- Place towel behind back & pull downward with lower hand; for more stretch place the raised elbow against the wall

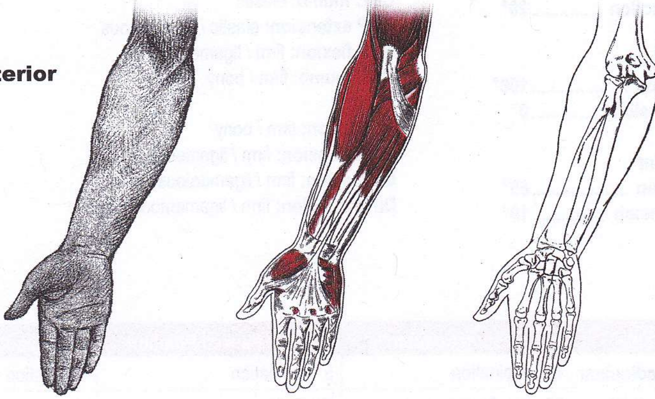


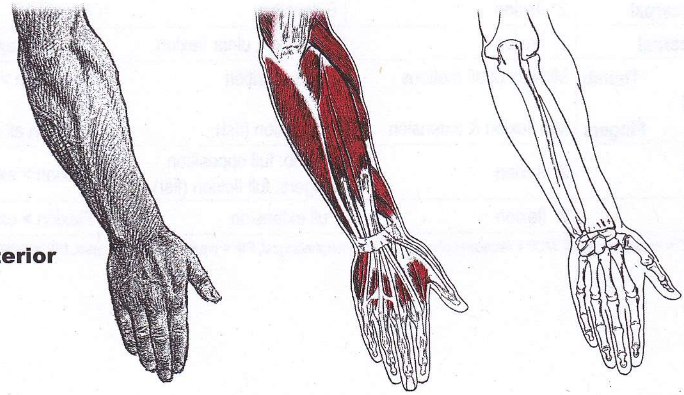
Strengthen
- Resisted elbow extension
- Triceps press
- Triceps kick backs
- Skull crusher
- Dips
- Close grip bench press

1 American Academy of Orthopaedic Surgeons, (AAOS). (2004). Frozen shoulder Accessed on November 26, 2006 from http://orthoinfo.aaos.org
2 Breisch, E. (1986). A rare human variation: the relationship of the axillary and inferior subscapular nerves to an accessory subscapularis muscle. Anat Rec. 216, 440-2.
3 Benjamin, B. (2004). The Most Common Shoulder Injury. Massage Today, Vol.4.
4 Drozd, C. Internal Rotator Cable Pull. Sportfit. Accessed on November 26, 2006 from http://www.sportfit.com/tips/rotatorcuff/Zstrch.html
5 Kameda, Y. (1976). An anomalous muscle (accessory subscapularis-teres-latissimus muscle) in the axilla penetrating the brachial plexus in man. Acta Anat (Basel). 96, 513-33.
6 Madsen M, Marx RG, Millett PJ, Rodeo SA, Sperling JW, Warren RF. Surgical anatomy of the triceps brachii tendon: anatomical study and clinical correlation. Am J Sports Med. 2006 Nov; 34(11):1839-43. Epub 2006
7 de Seze MP, Rezzouk J, de Seze M, Uzel M, Lavignolle B, Midy D, Durandeau A. Does the motor branch of the long head of the triceps brachii arise from the radial nerve? An anatomic and electromyographic study. Surg Radiol Anat. 2004 Dec;26(6):459-61;
8 Rezzouk J, Durandeau A, Vital JM, Fabre T. Long head of the triceps brachii in axillary nerve injury: anatomy and clinical aspects. Rev Chir Orthop Reparatrice Appar Mot. 2002 Oct;88(6):561-4
9 Cuadros CL, Driscoll CL, Rothkopf DM. The anatomy of the lower serratus anterior muscle: a fresh cadaver study. Plast Reconstr Surg. 1995 Jan;95(1):93-7; discussion 98-9.
10 Segonds JM, Alnot JY, Asfazadourian H. Isolated traumatic serratus anterior muscle palsy. Rev Chir Orthop Reparatrice Appar Mot. 2002 Dec;88(8):751-9.
11 Leonello D.T., Galley, I.J., .Bain, G.I., Carter, C.D.. Brachialis Muscle Anatomy, A Study in Cadavers. *The Journal of Bone and Joint Surgery (American)*. 2007;89:1293-1297.
12 Cash, M. Pocket Atlas of the Moving Body : For All Students of Human Biology, Medicine, Sports and Physical Therapy, Ebury House, 2000.
13 Through Touch, Churchill-Livingston, 1996.
14 Dambro MR, Griffith JA: Griffith's 5 minute clinical consult, Baltimore, 2008, Williams & Wilkins.
15 Dandy DJ: Essential orthopaedics and trauma, Edinburgh, 1989, Churchill Livingstone.
16 Gartland, I.I.: Fundamentals of Orthopaedics. Philadelphia, W.B. Saunders Co., 1979.
17 Greenman, PE. Principles of Manual Medicine, 2nd ed., Williams & Willkins, 1995.
18 Kapandji, I.A.: The Physiology of Joints, vol. 1: Upper Limb. New York, Churchill Livingstone, 1970.
19 Kendall HO, Kendall FP, Wadsworth GE: Muscles testing and function, ed 4, Baltimore, 2003, Williams & Wilkins.
20 Kisner C, Colby LA: Therapeutic exercise; foundations and techniques, ed 2, Philadelphia, 1990, FA Davis.
21 Malone TR, MePoil TG, Nitz AJ: Orthopedic and sports physical therapy, ed 3, St Louis, 1997, Mosby.
22 Martin JH: Neuroanatomy text and atlas, ed 2, Stamford, Conn, 1996, Appleton & Lange.
23 Mathers LH, et al: Clinical anatomy principles, St Louis, 1996, Mosby.
24 Mellion MB: Sports medicine secrets, Philadelphia, 1994, Hanley & Belfus.
25 O'Donoghue, D.H.: Treatment of Injuries to Athletes, 4th ed. Philadelphia. W.B. Saunders Co., 1984.
26 Reid, D.C.: Sports Injury Assessment and Rehabilitation. New York, Churchill Livingstone, 1992.
27 Vizniak, NA. Gross Anatomy: Human Cadaver Dissections. 1999-2008



Anterior





Posterior

Wrist & Hand Kinematics

Joint type: synovial
- Gliding (intercarpal)
- Ellipsoid (radiocarpal & ulnocarpal)
- Pivot (distal radioulnar)
- Saddle (trapeziometacarpal)

AROM

Distal radioulnar
- **Supination .... 85°-90°**
- **Pronation .... 85°-90°**

Wrist
- **Flexion .... 80°**
- **Extension .... 70°**
- **Ulnar Flexion .... 30°**
- **Radial Flexion .... 20°**

Fingers
- **Flexion (2-5 MCP) .. 90°**
- **Extension (MP) .... 40°**
- **Abduction .... 20°**
- **Adduction .... 20°**

PIP joint
- **Flexion .... 100°**
- **Extension .... 0°**

DIP joint
- **Flexion .... 80°**
- **Extension .... 10°**

Main muscle actions
- **Wrist flexion:** flexor carpi radialis & flexor carpi ulnaris, palmaris longus
- **Wrist extension:** extensor carpi radialis longus & brevis, extensor carpi ulnaris, extensor digitorum
- **Radial flexion:** extensor carpi radialis longus/brevis, flexor carpi radialis
- **Ulnar flexion:** flexor & extensor carpi ulnaris

- **Finger flexion:** flexor digitorum profundus, superficialis, lumbricals
- **Thumb flexion:** flexor pollicis longus & brevis
- **Finger extension:** extensor digitorum
- **Thumb extension:** extensor pollicis longus & brevis
- **Abduction:** dorsal interossei
- **Adduction:** palmar interossei

Normal joint end feels
- **Radiocarpal flex/ext:** firm ligamentous
- **Radiocarpal add/abd:** bony

- **CMC thumb:** elastic
- **MCP extension:** elastic / ligamentous
- **MCP flexion:** firm / ligamentous
- **MCP thumb:** firm / bony

- **PIP flexion:** firm / bony
- **PIP extension:** firm / ligamentous
- **DIP flexion:** firm / ligamentous / elastic
- **DIP extension:** firm / ligamentous / elastic

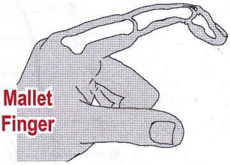
Joint	Resting Position	Tight Packed Position	Capsular Pattern
Distal radioulnar	10° supination	5° supination	Supination = pronation
Radiocarpal	2° ulnar flexion	Extension	Flexion > extension
Intercarpal	2° flexion	Extension	None
Midcarpal	2° flexion	Extension, ulnar flexion	Flexion > extension
CMC Thumb	Midway of all motions	Full opposition	Abduction > exten.
CMC Fingers	Mid flexion & extension	Full flexion (fist)	Limits in all directions
MCP	2° flexion	Thumb: full opposition Fingers: full flexion (fist)	Flexion > extension
IP	2° flexion	Full extension	Flexion > extension

CMC = carpometacarpal, MCP = metacarpophalangeal, IP = interphalangeal, PIP = proximal interphalangeal, DIP = distal interphalangeal

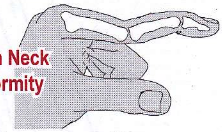
Bouchard's nodes: osteocartilaginous enlargement at the PIP; may be associated with both RA & osteoarthritis (usually RA)

Boutonniere deformity : 'button hole' deformity, rupture of the central band of the extensor tendon at the middle phalanx leading to hyperextension of MCP & DIP & hyper-flexion of PIP joint
May be seen in RA & following severe sprains/fractures of the finger (not a tendon injury in these cases)

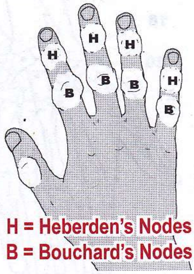
Boxer's knuckle: a shortened 2nd or 3rd metacarpal associated with a boxer's fracture of the metacarpals; when making a fist the involved knuckle is shorter than normal; also suspect lunate or capitate dislocation. Note: **Brawler's knuckle** – a shortened 4th or 5th metacarpal subsequent to fracture



Dupuytren's contracture: hypertrophic nodular fibroplasia of the palmar aponeurosis resulting in flexion contraction deformity of fingers most often involving ring & little fingers; familial trend; more common in males

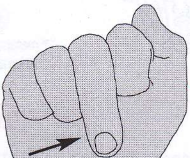


Heberden's nodes: small hard nodules at distal interphalangeal joints due to calcific spurring, usually associated with osteoarthritis



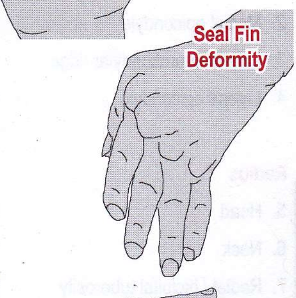
Jersey finger ('sweater sign'): rupture of a flexor digitorum profundus tendon; patient unable to bend the proximal finger & distal phalanges of injured finger when making a fist

Mallet finger (baseball finger, drop finger): rupture/avulsion of extensor tendon from its insertion on distal phalanx (unable to extend distal phalanx). Patient unable to actively extend the fingertip of injured finger, usually secondary to axial compressive trauma of finger tip



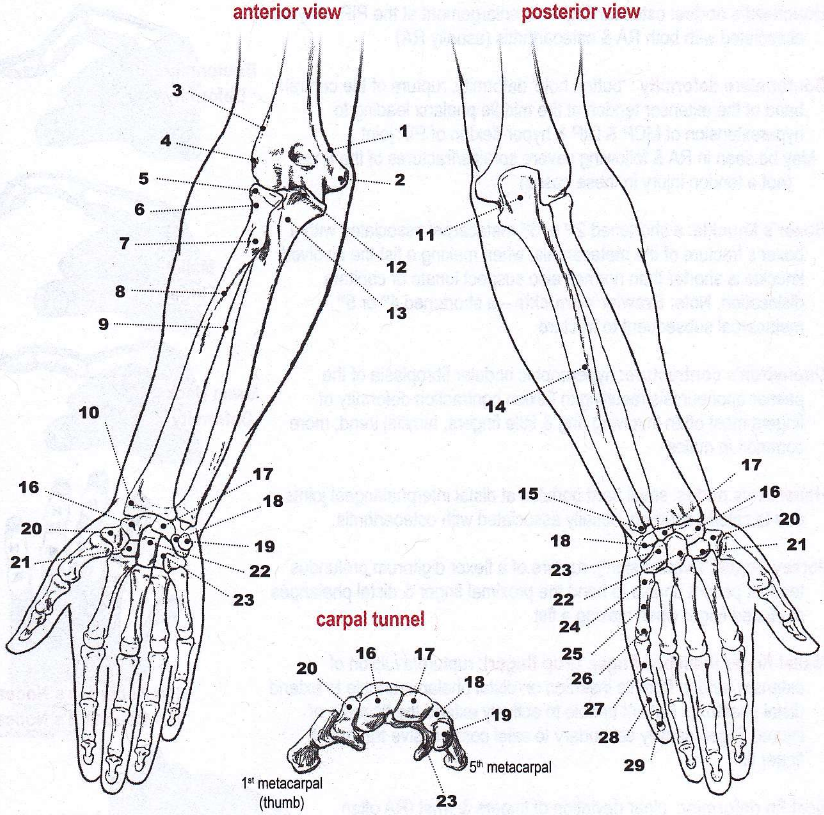
Seal fin deformity: ulnar deviation of fingers & wrist (RA often seen in combination with other deformities); Bouchard's nodes also may be present

Skew fingers/hand – associated with metacarpal fracture → rotational displacement of the distal fragment → the involved finger is deviated/skewed compared to its original position & the neighboring fingers; this abnormal relationship may be amplified if the patient is able to make a fist



Swan neck deformity - finger deformity where PIP joint is hyperextended & DIP joint is flexed, due to intrinsic hand muscles & tearing of volar plate; may be seen in several fingers in RA

Trigger finger/thumb - fusiform swelling in the flexor digitorum superficialis (or flexor pollicis longus) tendon just proximal to its bifurcation & at proximal end of the tendon sheath; initially snapping occurs during flexion-extension as the nodule passes in & out of the sheath; later the nodule is unable to enter the sheath & the finger becomes locked in a flexed position; often secondary to DJD, RA or direct tendon trauma



Humerus

1. Medial supracondylar ridge
2. Medial epicondyle
3. Lateral supracondylar ridge
4. Lateral epicondyle

Radius

5. Head
6. Neck
7. Radial / bicipital tuberosity
8. Oblique line
9. Interosseous border
10. Styloid process

Ulna

11. Olecranon
12. Coronoid process
13. Ulnar tuberosity
14. Posterior border
15. Styloid process

Carpals

16. Scaphoid
17. Lunate
18. Triquetrum
19. Pisiform
20. Trapezium
21. Trapezoid
22. Capitate
23. Hamate

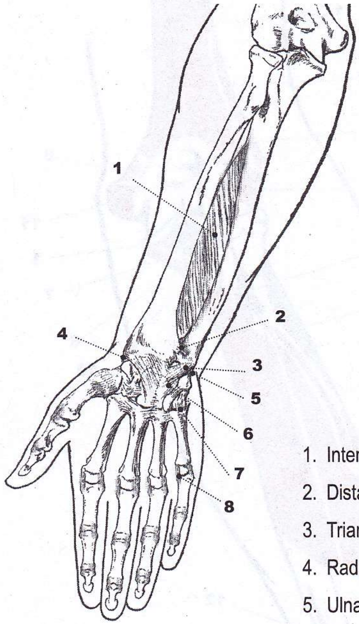
Metacarpals

24. Base
25. Body
26. Head

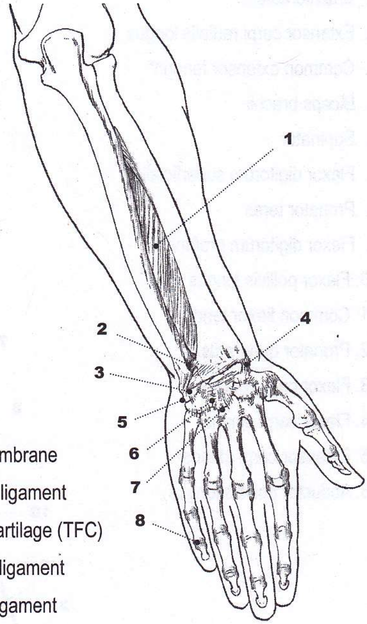
Phalanges

27. Proximal
28. Middle
29. Distal

anterior view



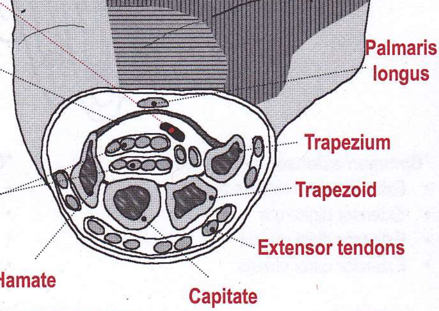
posterior view



1. Interosseous membrane
2. Distal radioulnar ligament
3. Triangular fibrocartilage (TFC)
4. Radial collateral ligament
5. Ulnar collateral ligament
6. Intercarpal ligaments
7. Carpometacarpal ligaments
8. Phalangeal collateral ligaments

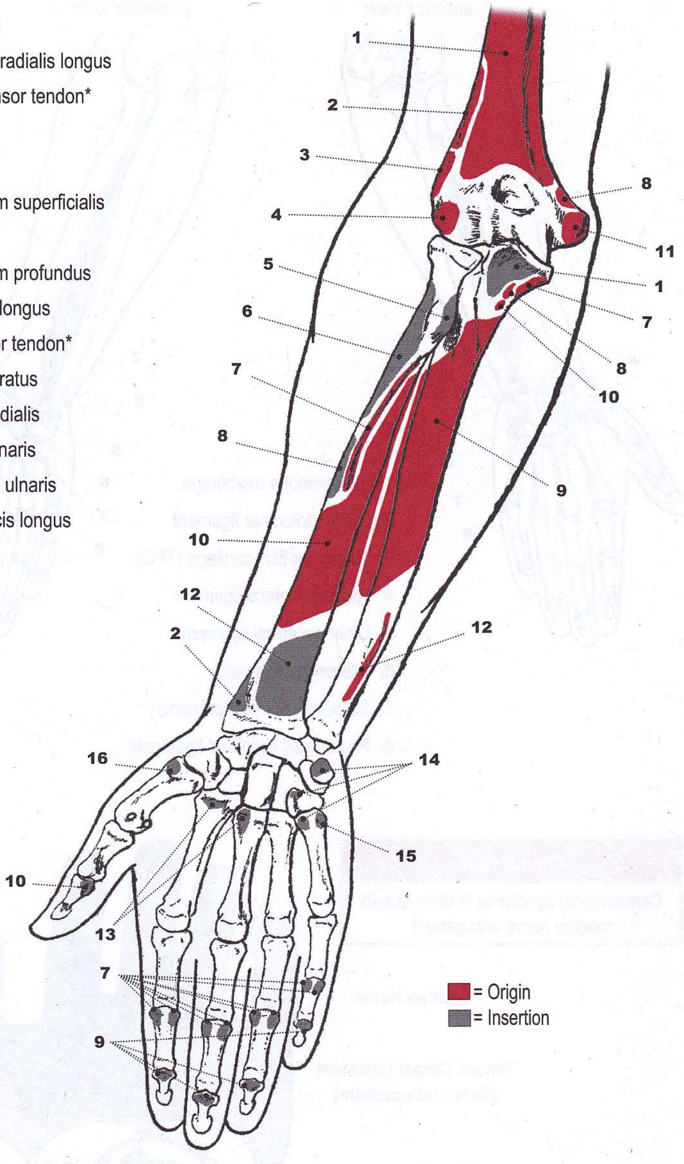
Clinical Note

Carpal tunnel syndrome is often due to median nerve entrapment



Forearm & Hand

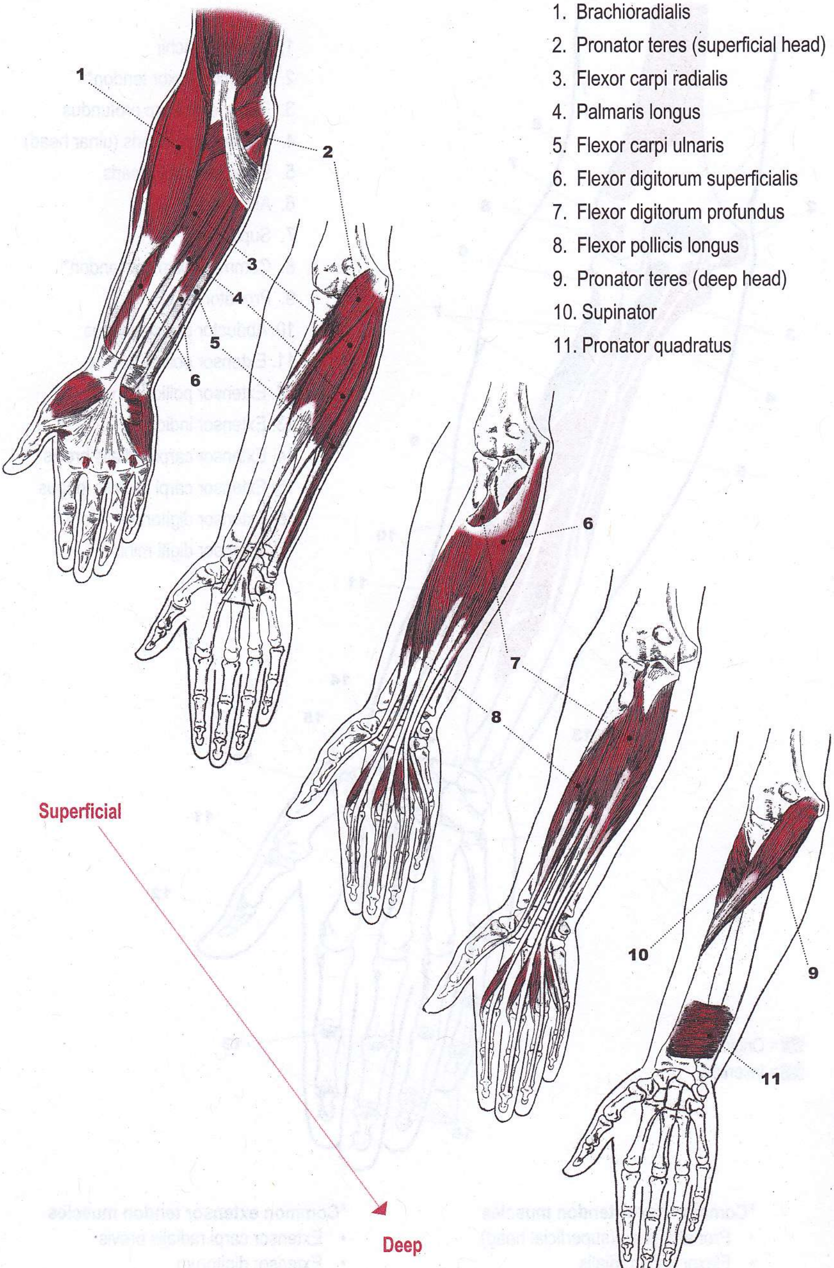
1. Brachialis
2. Brachioradialis
3. Extensor carpi radialis longus
4. Common extensor tendon*
5. Biceps brachii
6. Supinator
7. Flexor digitorum superficialis
8. Pronator teres
9. Flexor digitorum profundus
10. Flexor pollicis longus
11. Common flexor tendon*
12. Pronator quadratus
13. Flexor carpi radialis
14. Flexor carpi ulnaris
15. Extensor carpi ulnaris
16. Abductor pollicis longus



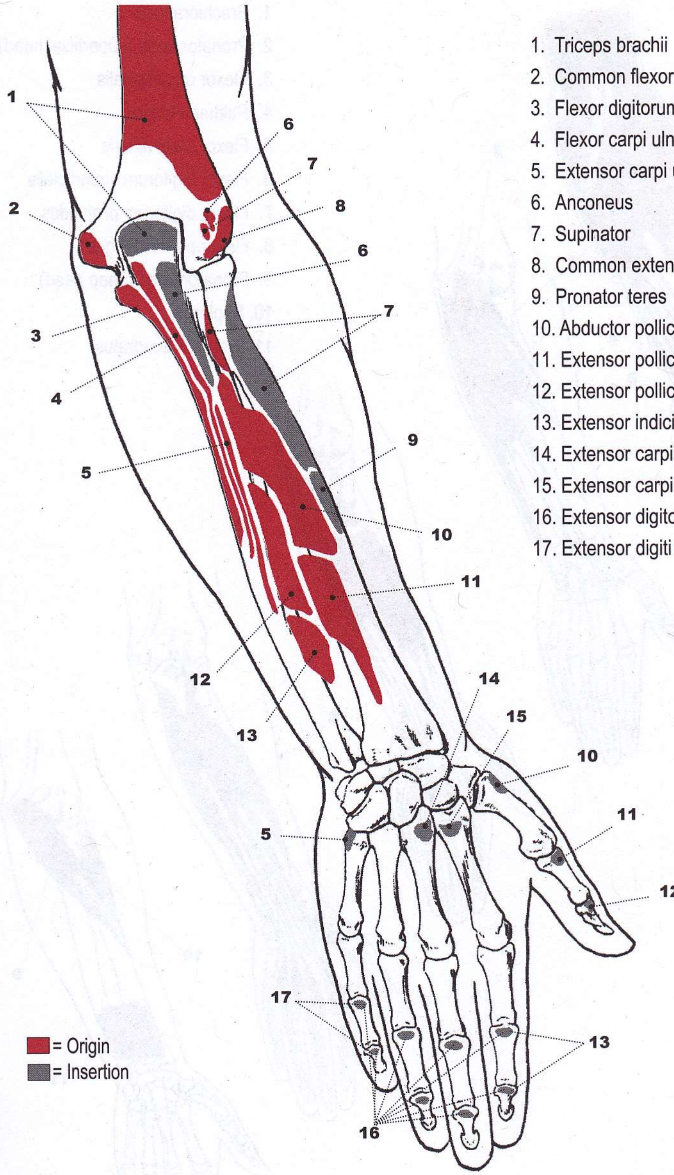
***Common extensor tendon muscles**
- Extensor carpi radialis brevis
- Extensor digitorum
- Extensor digiti minimi
- Extensor carpi ulnaris

***Common flexor tendon muscles**
- Pronator teres (superficial head)
- Flexor carpi radialis
- Palmaris longus
- Flexor carpi ulnaris
- Flexor digitorum superficialis

1. Brachioradialis
2. Pronator teres (superficial head)
3. Flexor carpi radialis
4. Palmaris longus
5. Flexor carpi ulnaris
6. Flexor digitorum superficialis
7. Flexor digitorum profundus
8. Flexor pollicis longus
9. Pronator teres (deep head)
10. Supinator
11. Pronator quadratus



Posterior Forearm Muscles

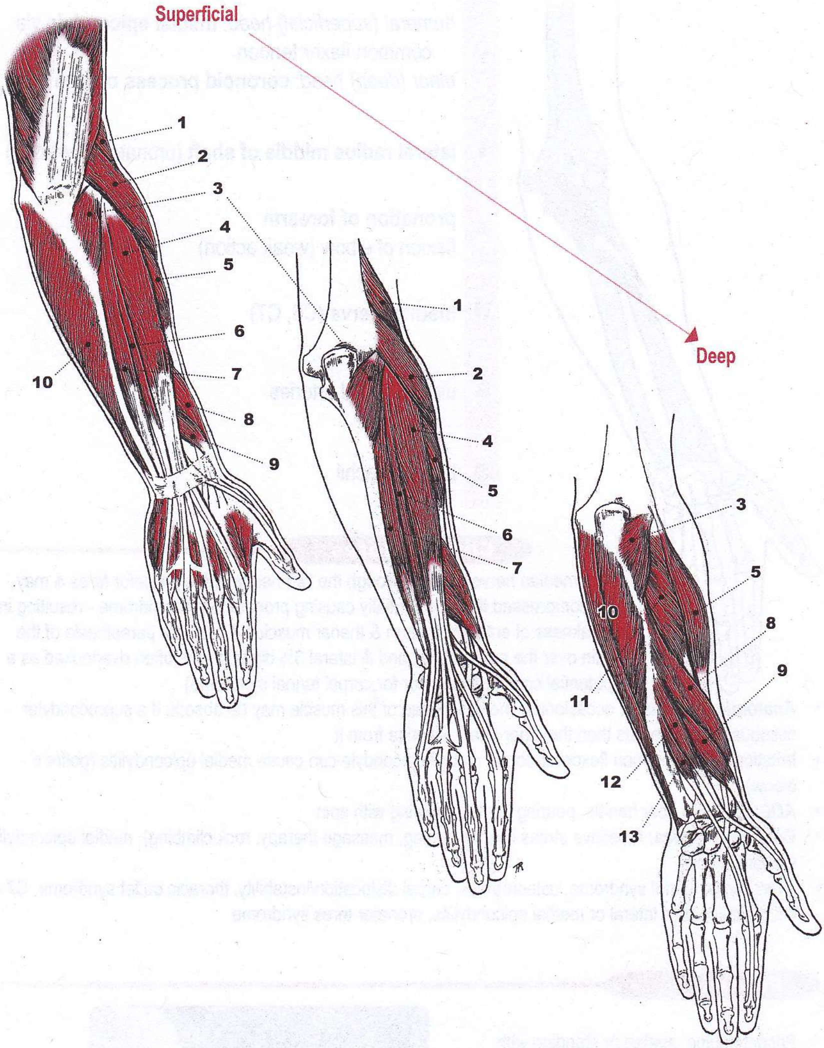


1. Triceps brachii
2. Common flexor tendon*
3. Flexor digitorum profundus
4. Flexor carpi ulnaris (ulnar head)
5. Extensor carpi ulnaris
6. Anconeus
7. Supinator
8. Common extensor tendon*
9. Pronator teres
10. Abductor pollicis longus
11. Extensor pollicis brevis
12. Extensor pollicis longus
13. Extensor indicis
14. Extensor carpi radialis brevis
15. Extensor carpi radialis longus
16. Extensor digitorum
17. Extensor digiti minimi

= Origin
= Insertion

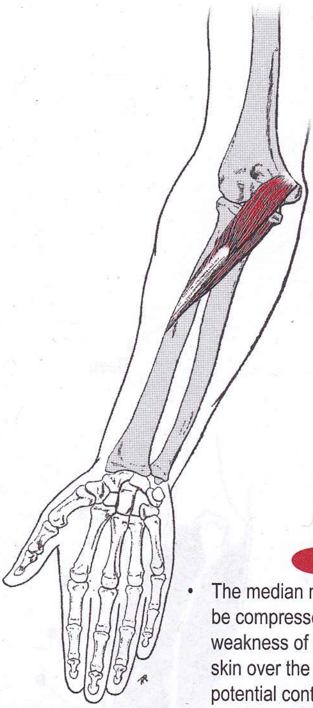
***Common flexor tendon muscles**
- Pronator teres (superficial head)
- Flexor carpi radialis
- Palmaris longus
- Flexor carpi ulnaris
- Flexor digitorum superficialis

***Common extensor tendon muscles**
- Extensor carpi radialis brevis
- Extensor digitorum
- Extensor digiti minimi
- Extensor carpi ulnaris



1. Brachioradialis
2. Extensor carpi radialis longus
3. Anconeus
4. Extensor digitorum
5. Extensor carpi radialis brevis
6. Extensor digiti minimi
7. Extensor carpi ulnaris
8. Abductor pollicis longus
9. Extensor pollicis brevis
10. Flexor carpi ulnaris
11. Supinator
12. Extensor pollicis longus
13. Extensor indicis

Pronator Teres



O	*humeral (superficial) head:* **medial epicondyle** via common flexor tendon *ulnar (deep) head:* **coronoid process of ulna**
I	**lateral radius middle of shaft** (pronator tuberosity)
A	**pronation of forearm** flexion of elbow (weak action)
N	**median nerve** (C6, C7)
B	ulnar & radial arteries
S	biceps brachii

Clinical Notes

- The median nerve passes through the two heads of the *pronator teres* & may be compressed there, potentially causing pronator teres syndrome - resulting in weakness of anterior forearm & thenar muscles & possible paresthesia of the skin over the palm of the hand & lateral 3½ digits (this is often overlooked as a potential contributing factor for carpal tunnel syndrome)
- ***Anatomical variation:*** occasionally the ulnar head of this muscle may be absent; if a supracondylar osseous process exists then the ulnar head will arise from it
- Irritation of the common flexor tendon or medial epicondyle can cause medial epicondylitis (golfer's elbow)
- ***ADL:*** turning a door handle, pouring drinks, throwing with spin
- ***Common injuries:*** repetitive stress injuries (typing, massage therapy, rock climbing), medial epicondylitis (golfer's elbow)
- ***DDx:*** carpal tunnel syndrome, osteoarthritis, carpal dislocation/instability, thoracic outlet syndrome, C7 or C8 radiculopathy, lateral or medial epicondylitis, pronator teres syndrome

Palpation

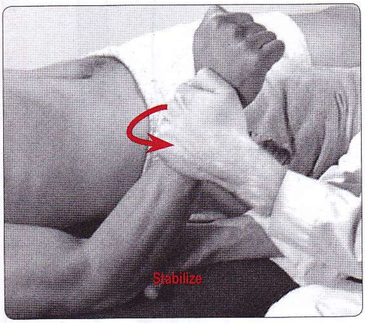
1. Patient supine, seated or standing with elbow slightly flexed & thumb pointing up
2. Place palpating fingers along fiber direction over anterior proximal forearm
3. Ask patient to pronate forearm & apply mild resistance
4. Note contraction of muscle tissue (may be difficult to feel the ulnar/deep head)
5. Palpate from origin to insertion

Muscle Test

Patient position
- Supine, elbow flexed 60º, forearm fully pronated

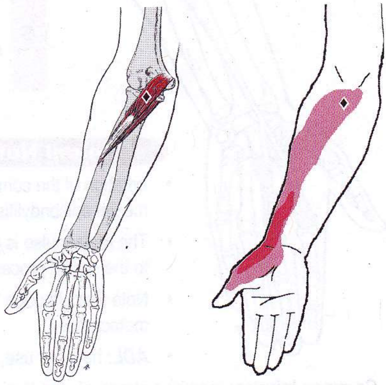
Examiner's force
- Towards supination

Stabilization
- Patient's elbow



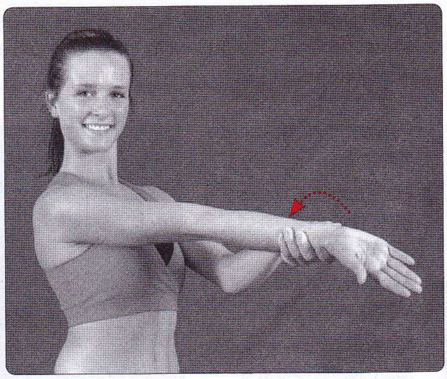
Trigger Point Referral

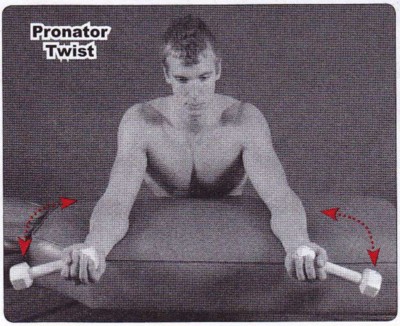
- Pronator teres often develops MFTPs in the mid muscle belly
- Main referral pattern is pain deep in the anterior radial region of the wrist also of the forearm & down to the base of the thumb



Stretch & Strengthen

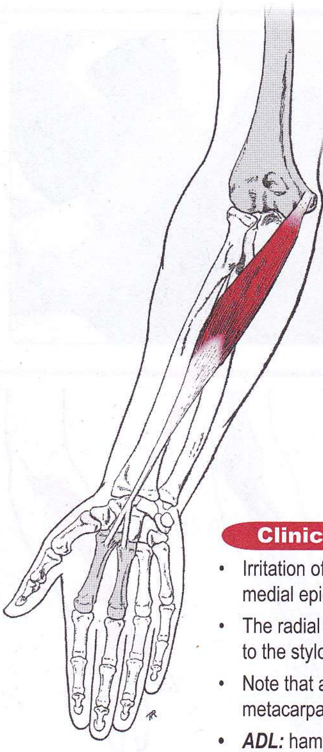
Self Stretch:
- With elbow straight, use opposite hand to supinate forearm





Strengthen
- Resisted forearm pronation
- Dumbell pronation ('Pronator twist')

Flexor Carpi Radialis



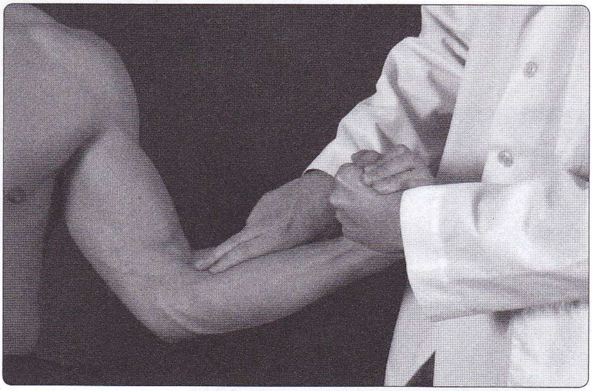
O	**medial epicondyle** (via common flexor tendon)
I	**base of 2nd & 3rd metacarpals** (anterior side)
A	**flexion of wrist** **radial flexion (abduction) of wrist** flexion & pronation of forearm (weak action)
N	**median nerve** (C6, C7)
B	ulnar & radial arteries
S	*flexion:* flexor carpi ulnaris, flexor digitorum profundus & superficialis, palmaris longus *radial flexion:* extensor carpi radialis longus & brevis

Clinical Notes

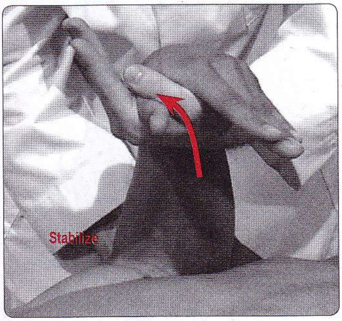
- Irritation of the common flexor tendon or medial epicondyle can cause medial epicondylitis (golfer's elbow)
- The radial pulse is palpated lateral to the distal tendon of the FCR (proximal to the styloid process of the radius)
- Note that although 'carpi' is part of the muscle name, it inserts onto a metacarpal
- ***ADL:*** hammer use, typing, racket sports, throwing
- **Common Injuries:** repetitive stress injuries (typing, massage therapy, rock climbing), medial epicondylitis (golfer's elbow)
- **DDx:** carpal tunnel syndrome, osteoarthritis of the wrist, carpal dislocation/instability, thoracic outlet syndrome, C7 or C8 radiculopathy, lateral or medial epicondylitis, pronator teres syndrome

Palpation

1. Patient supine, seated or standing
2. Place palpating fingers along fiber direction over anterior forearm
3. Ask patient to flex & radially deviate wrist
4. Note contraction of muscle tissue (distal tendon is located over lateral wrist)
5. Palpate from origin to insertion



Muscle Test



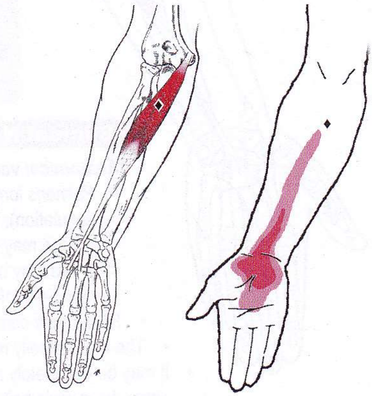
Patient position
- Supine, elbow flexed 90°, wrist flexed 90°, forearm fully pronated

Examiner's force
- Diagonal toward extension & adduction of the wrist

Stabilization
- Distal forearm

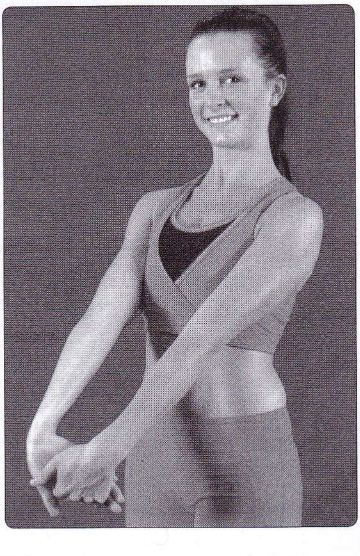
Trigger Point Referral

- Flexor carpi radialis often develops MFTPs in the mid muscle belly
- Main referral pattern is pain and tenderness that center in the radial aspect of the anterior wrist with some spillover into the adjacent forearm and palm

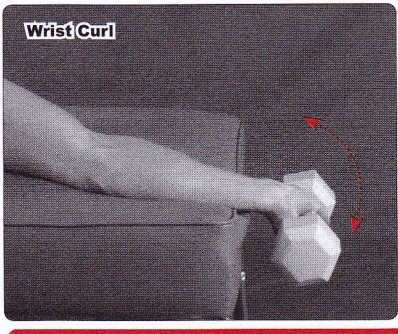


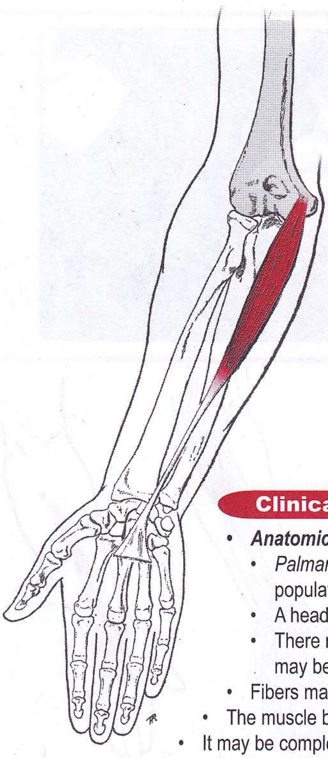
Stretch & Strengthen

Self Stretch:
- With elbow straight, extend wrist & use opposite hand to ulnar deviate wrist



Strengthen
- Resisted wrist flexion
- Wrist curls





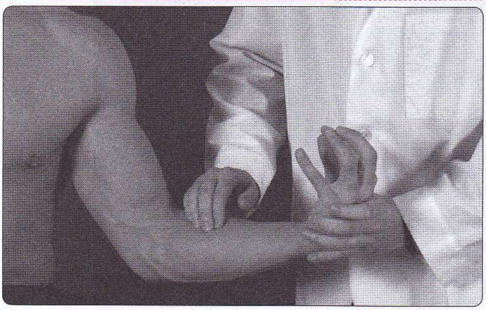
O	**medial epicondyle** (via common flexor tendon)
I	**palmar aponeurosis & flexor retinaculum**
A	**flexion of wrist**
N	**median nerve** (C7,C8)
B	ulnar artery
S	flexor carpi radialis & ulnaris, flexor digitorum profundus & superficialis

Clinical Notes

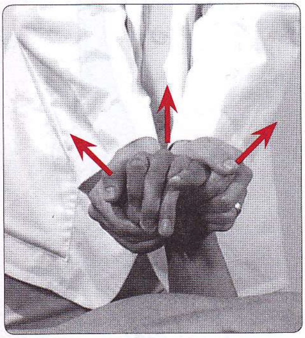
- ***Anatomical variation:*** one of the most variable muscles
  - *Palmaris longus* may be absent in some people (12-20% of the population); if the muscle is absent, ***no*** functional change is noted
  - A head may arise from the intermuscular septum of the humerus
  - There may be a coronoid head that is often absent or rudimentary, but may be reinforced by fibres from the ulna
  - Fibers may connect it with the *flexor carpi radialis or FDS*
  - The muscle belly may be central, distal or digastric in position
  - It may be completely muscular from origin to insertion or only a fibrous strand; either the muscle belly or tendon may be bifid, or both.
  - Accessory slips may insert into *abductor digiti minimi, flexor digiti minimi* or antebrachial fascia & may arise from the FDS, ulnar tuberosity and coronoid process or the radial tuberosity and the oblique line of the radius
- *Palmaris longus* is the only anterior forearm muscle that lies superficial to the flexor retinaculum
- Irritation of the common flexor tendon/medial epicondyle can cause medial epicondylitis (golfer's elbow)
- ***Common injuries:*** repetitive stress injuries (typing, massage therapy, rock climbing, throwing), medial epicondylitis (golfer's elbow)
- ***DDx:*** carpal tunnel syndrome, osteoarthritis, carpal dislocation/instability, thoracic outlet syndrome, C7 or C8 radiculopathy, lateral or medial epicondylitis, pronator teres syndrome

Palpation

1. Patient supine, seated or standing
2. Place palpating fingers along fiber direction over anterior forearm
3. Ask patient to oppose thumb & little finger & slightly flex the wrist
4. Note contraction of muscle tissue (remember muscle may be absent)
5. Palpate from origin to insertion



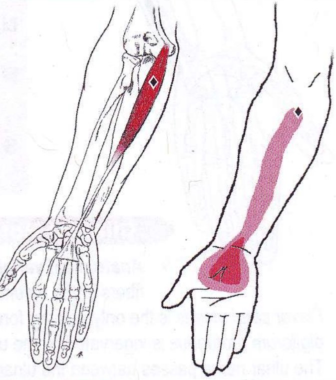
Muscle Test



Patient position
- Supine, elbow flexed 90º, wrist fully flexed
- Thenar & hypothenar eminences opposed
- Patient makes a beak with their hand

Examiner's force
- Toward extension of wrist & spreading of thenar/hypothenar eminences

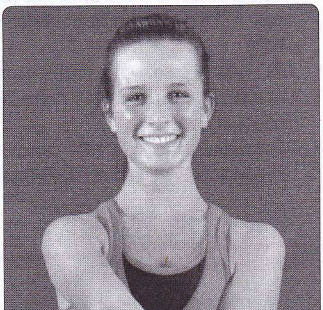
Trigger Point Referral



- Flexor carpi radialis often develops MFTPs in the mid & proximal muscle belly
- Main referral pattern is superficial needle-like prickling pain over the palm extending to the base of the thumb and the distal palm, but not into the digits

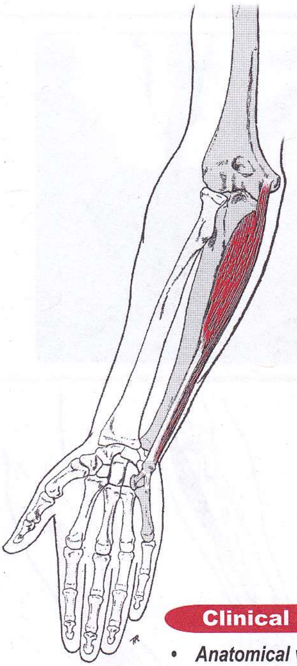
Stretch & Strengthen

Self Stretch:
- With elbow straight, extend wrist & use opposite hand to spread palm
- Image shows excellent striation from stretch in palm of hand



Strengthen
- Resisted wrist flexion
- Wrist curls

Flexor Carpi Ulnaris



O
humeral head: **medial epicondyle** (common flexor tendon)
ulnar head: **medial aspect of olecranon & proximal 2/3 of medial ulna**

I
pisiform & hamate bones (via pisohamate ligament)
base of 5th metacarpal (via pisometacarpal ligament)

A
flexion of wrist
ulnar flexion (adduction) of wrist
elbow flexion (weak action)
stabilizes wrist to permit powerful thumb motions

N
ulnar nerve (C7, C8)

B
ulnar artery

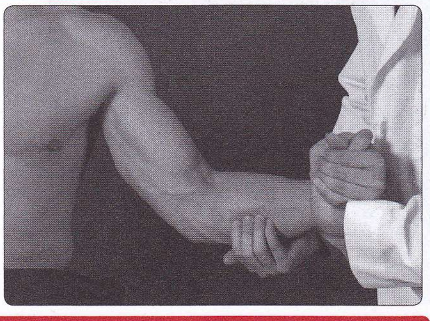
S
flexion: flexor carpi radialis
ulnar flexion: extensor carpi ulnaris

Clinical Notes

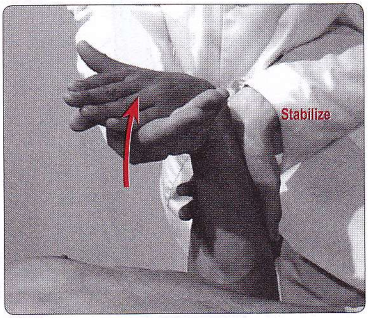
- ***Anatomical variation:*** fibers of the *flexor carpi ulnaris (FCU)* may blend with fibers of the *extensor carpi ulnaris & flexor digitorum profundus* along the ulna
- *Flexor carpi ulnaris* is the only anterior forearm muscle solely innervated by the ulnar nerve (*flexor digitorum profundus* is innervated by the ulnar & median nerves)
- The ulnar nerve passes between the ulnar & humeral head where it can sometimes become compressed resulting in cubital tunnel syndrome (SSx: tingling & numbness along ulnar border of hand)
- Irritation of the common flexor tendon or medial epicondyle can cause medial epicondylitis (golfer's elbow)
- ***ADL:*** hammer use, typing, racket sports, throwing
- ***Common injuries:*** repetitive stress injuries (typing, massage therapy, rock climbing), medial epicondylitis (golfer's elbow)
- ***DDx:*** carpal tunnel syndrome, osteoarthritis, carpal dislocation/instability, thoracic outlet syndrome, C7 or C8 radiculopathy, lateral or medial epicondylitis, pronator teres syndrome

Palpation

1. Patient supine, seated or standing
2. Place palpating fingers along fiber direction over anterior forearm
3. Ask patient to flex & ulnar deviate wrist
4. Note contraction of muscle tissue (distal tendon is located over medial wrist)
5. Palpate from origin to insertion



Muscle Test



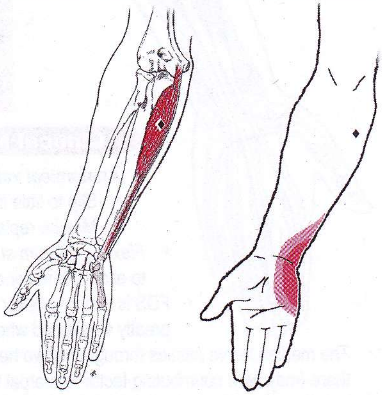
Patient position
- Supine, elbow flexed 90°, wrist fully flexed, forearm fully supinated

Examiner's force
- Diagonal toward extension & abduction of wrist

Stabilization
- Patient's distal forearm

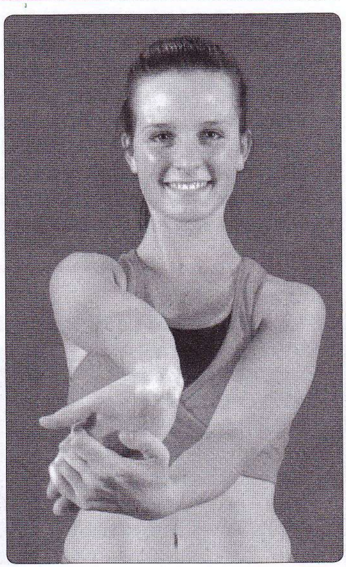
Trigger Point Referral

- Flexor carpi ulnaris often develops MFTPs in the mid & proximal muscle belly
- Main referral pattern is pain and tenderness to the ulnar side of the anterior aspect of the wrist with some similar spillover in the same general area

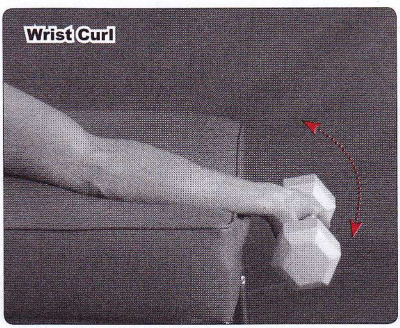


Stretch & Strengthen

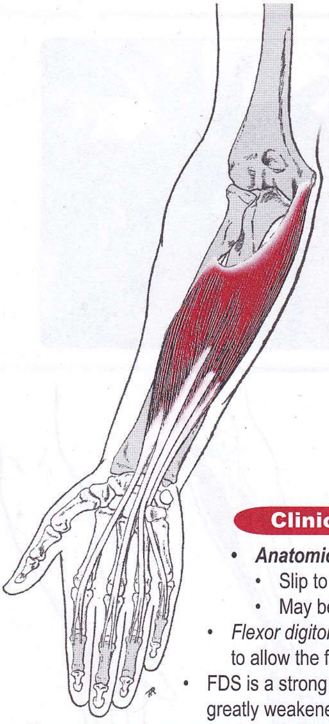
Self Stretch:
- With elbow straight, extend wrist & use opposite hand to radially deviate wrist



Strengthen
- Resisted wrist flexion
- Wrist curls



Flexor Digitorum Superficialis



O *humeral-ulnar head:* **medial epicondyle** via common flexor tendon & coronoid process of ulna, medial (ulnar) collateral ligament
radial head: **oblique line of radius** along its upper anterior border

I **base of middle phalanges of fingers 2-5** (tendons split at insertion)

A **flexion of fingers 2-5** (PIP, MCP), wrist & hand. flexion of elbow (weak action)

N **median nerve** (C7, C8, T1)

B ulnar & radial arteries

S flexor digitorum profundus

Clinical Notes

- ***Anatomical variation:*** radial head is sometimes absent
  - Slip to little finger is sometimes absent
  - May be replaced by another slip from FCU or from hand muscles
- *Flexor digitorum superficialis* (FDS) tendons split into two slips at their insertion to allow the flexor digitorum profundus tendons to pass through them
- FDS is a strong flexor of the wrist & fingers, but its strength of contraction is greatly weakened when the wrist is fully flexed
- The median nerve passes through the two heads of *flexor digitorum superficialis* & may be compressed there (may be a contributing factor for carpal tunnel syndrome)
- Irritation of FDS &/or FDP tendon sheaths as they pass through the carpal tunnel at the wrist may cause swelling & inflammation which can compress the median nerve, potentially contributing to the development of carpal tunnel syndrome
- An older name for *flexor digitorum superficialis* is *flexor digitorum sublimis*
- Fibers of *flexor digitorum superficialis* may blend with the ulnar collateral ligament of the elbow joint
- Simple puncture wounds to the digits can result in infections of the sheaths surrounding this muscle; untreated these infections may interrupt local blood supply
- ***ADL:*** all hand gripping movements, holding a racket, carrying a book, typing, playing piano
- ***Common injuries:*** repetitive stress injuries (typing, massage therapy, rock climbing)
- ***DDx:*** carpal tunnel syndrome, carpal instability, lateral or medial epicondylitis, pronator teres syndrome

Palpation

1. Patient seated or supine
2. Place palpating fingers along fiber direction over anterior medial proximal forearm
3. Ask patient to flex fingers keeping the DIP joints in extension ('sound of one hand clapping' - ☺) or apply resitance to middle phalanges
4. Note contraction of muscle tissue
5. Palpate from origin to insertion

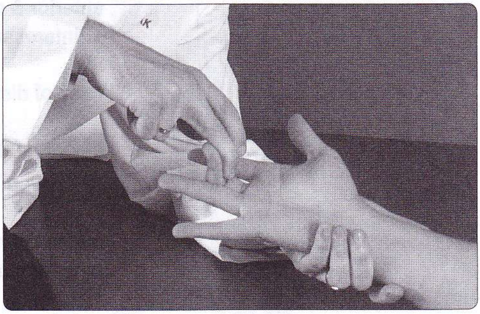
Muscle Test

Patient position
- Supine or seated, elbow flexed 90º, forearm supinated, fingers flexed

Examiner's force
- Towards extension of fingers at proximal interphalangeal joint

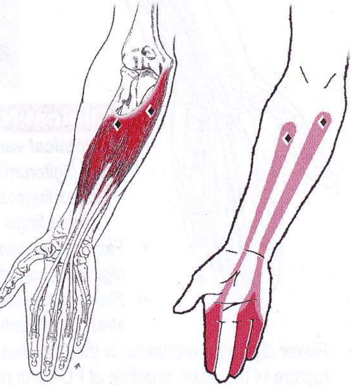
Stabilization: patient's wrist

Fingers may be tested individually or as a group



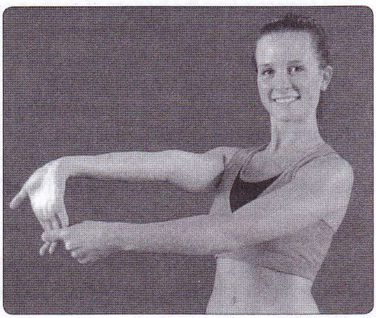
Trigger Point Referral

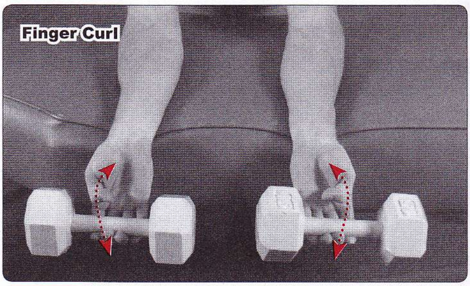
- Flexor digitorum superficialis often develops MFTPs in the mid & proximal muscle belly
- Main referral pattern is shooting pain and tenderness over the anterior forearm & fingers that correspond to the area of the muscle belly



Stretch & Strengthen

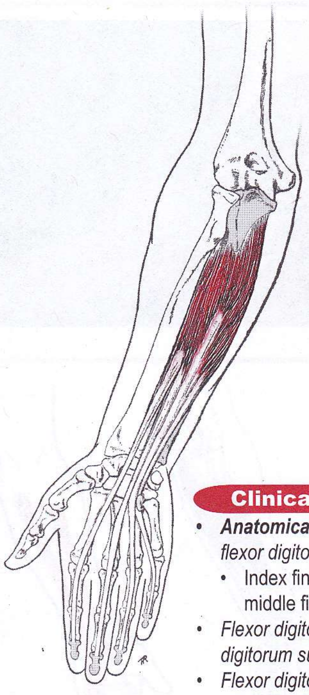
Self Stretch:
- Elbow straight wrist extended, use opposite hand to pull middle phalanges posteriorly





Strengthen
- Resisted finger flexion
- Wrist curls with finger extension
- Finger curls
- Grip strength exercises

Flexor Digitorum Profundus



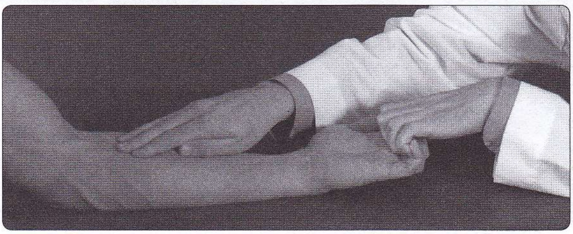
O	**anterior & medial surface of ulna** (proximal 1/2) & **interosseous membrane**
I	**base of distal phalange of fingers 2-5**
A	**flexion of fingers** (at DIP, PIP & MCP joints) flexion of wrist
N	**median nerve** (C8, T1) (radial 1/2 of muscle) **ulnar nerve** (C8, T1) (ulnar 1/2 of muscle)
B	ulnar & radial arteries
S	flexor digitorum superficialis

Clinical Notes

- ***Anatomical variation:*** may have accessory slips from flexor *pollicis longus or flexor digitorum superficialis*
  - Index finger usually distinct throughout, but tendon may be connected to middle finger (1 in 10) and/or flexor pollicis longus (1 in 200).
- *Flexor digitorum profundus* tendons pass between the two slips of *flexor digitorum superficialis*
- *Flexor digitorum profundus* is a strong flexor of the wrist & fingers but its strength of contraction is greatly weakened when the wrist is fully flexed
- *Flexor digitorum profundus* is the only muscle with the ability to flex the distal interphalangeal (DIP) joints, rupture of the distal insertion of FDP can result in a condition known as 'Jersey finger'
- The *lumbrical* muscles of the hand originate from the radial side of its tendons (one of the few muscles that originates from the tendons of another muscle)
- Irritation of FDS &/or FDP tendon sheaths, as they pass through the carpal tunnel at the wrist, may cause swelling & inflammation which can compress the median nerve, potentially contributing to the development of carpal tunnel syndrome
- ***ADL:*** all hand gripping movements, holding a racket, carrying a book, typing, playing piano
- ***Common injuries:*** repetitive stress injuries (typing, massage therapy, rock climbing)
- ***DDx:*** carpal tunnel syndrome, osteoarthritis, carpal dislocation/instability, thoracic outlet syndrome, C7 or C8 radiculopathy, lateral or medial epicondylitis, pronator teres syndrome

Palpation

1. Patient seated or supine with wrist in extension
2. Place palpating fingers along fiber direction over anterior medial proximal forearm
3. Ask patient to flex fingers at DIP joints or apply resistance over distal phalanges
4. Note contraction of muscle tissue
5. Palpate from origin to insertion



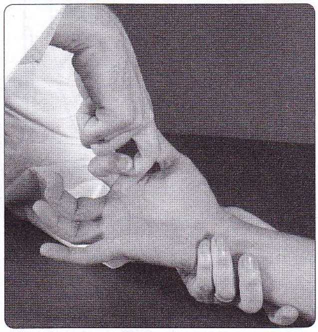
Muscle Test

Patient position
- Supine or seated, elbow flexed 90º, forearm supinated, fingers flexed with MCP joint in extension

Examiner's force
- Towards extension of distal interphalangeal joint

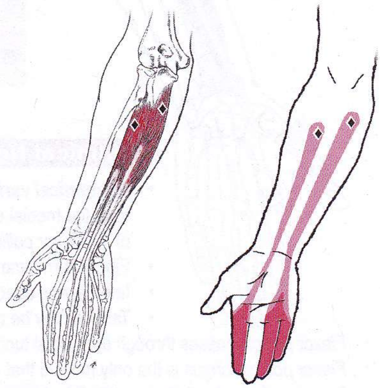
Stabilization: patient's wrist

Fingers may be tested individually or as a group



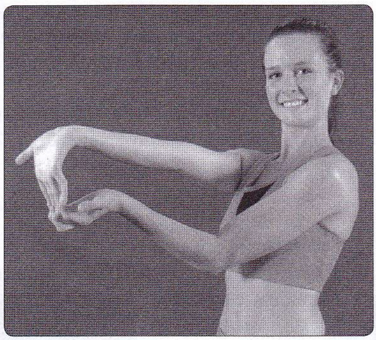
Trigger Point Referral

- Flexor digitorum profundus often develops MFTPs in the proximal muscle belly
- Main referral pattern is shooting pain and tenderness to the anterior forearm & fingers that correspond to the area of the muscle belly

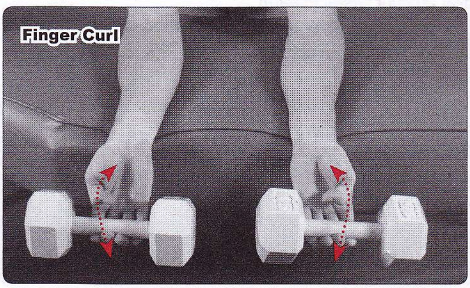


Stretch & Strengthen

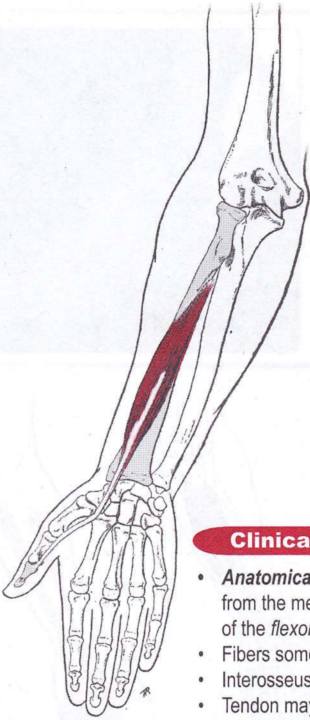
Self Stretch:
- Elbow straight, wrist extended, use opposite hand to pull distal phalanges posteriorly



Strengthen
- Resisted finger flexion
- Wrist curls with finger extension
- Finger curls
- Grip strength exercises (squeezing a tennis ball)



Flexor Pollicis Longus



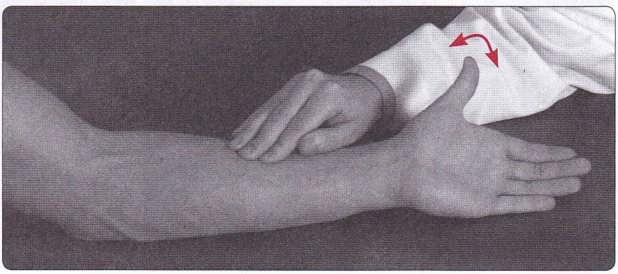
O	**radius** (middle anterior surface) & **interosseous membrane**
I	**base of distal phalanx of thumb** (anterior aspect)
A	**flexion of thumb** (CMC, MCP, IP joints) flexion of wrist
N	**median nerve** (C7, C8)
B	radial & anterior interosseous arteries
S	flexor pollicis brevis

Clinical Notes

- ***Anatomical variation:*** in ~40% of people the *flexor pollicis longus* originates from the medial epicondyle & coronoid process of ulna; in these cases fibers of the *flexor pollicis longus* blend with fibers of *flexor digitorum superficialis*
- Fibers sometimes connected to *FDP, FDS or pronator teres*
- Interosseus attachment - and **even the whole muscle** may be missing
- Tendon may be connected to FDP index (1 in 200) or even FDP medius (rare)
- *Flexor pollicis* passes through the carpal tunnel lateral to the median nerve
- *Flexor pollicis longus* is the only muscle that flexes the distal phalanx of the thumb (interphalangeal joint)
- This muscle is also known as the "blackberry or nintendo muscle" as prolonged video game controller use requires good dexterity, stamina and strength
- ***ADL:*** any gripping movement, playing video games
- ***Common injuries:*** repetitive stress injuries (typing, massage therapy, excessive video game play or cell phone keypad use)
- ***DDx:*** carpal tunnel syndrome, Skier's or Gamekeeper's thumb, osteoarthritis, carpal dislocation/ instability, thoracic outlet syndrome, C7 or C8 radiculopathy, lateral or medial epicondylitis, pronator teres syndrome

Palpation

1. Patient seated or supine
2. Place palpating fingers along fiber direction over anterior lateral forearm
3. Ask patient to repeatedly flex the IP joint of the thumb (just move the distal phalynx)
4. Note contraction of muscle tissue
5. Palpate from origin to insertion



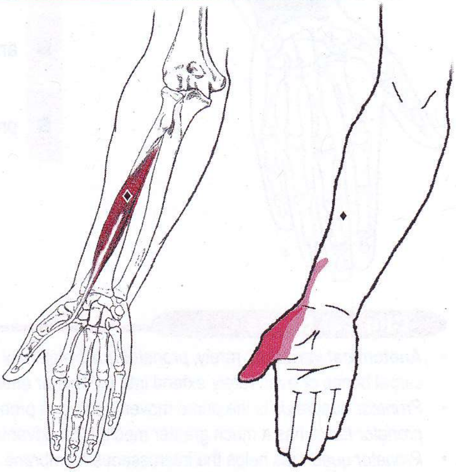
Muscle Test

Patient position
- Supine or seated, elbow flexed 90º, forearm supinated, thumb interphalangeal joint flexed

Examiner's force
- Towards extension of thumb interphalangeal joint

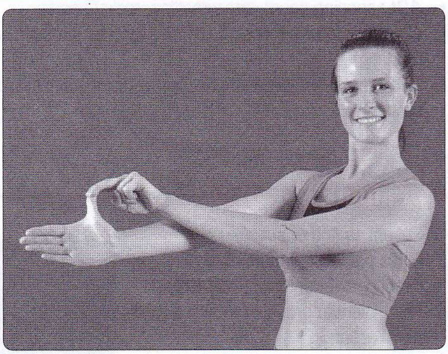
Stabilization
- Patient's forearm

Trigger Point Referral

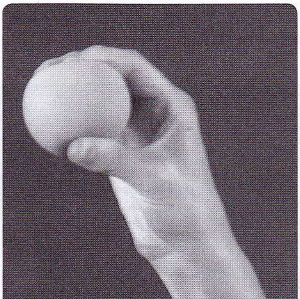


- Flexor pollicis longus may develop MFTPs in the middle & proximal muscle belly
- Main referral pattern is shooting pain and tenderness over the anterior thumb & thenar region

Stretch & Strengthen

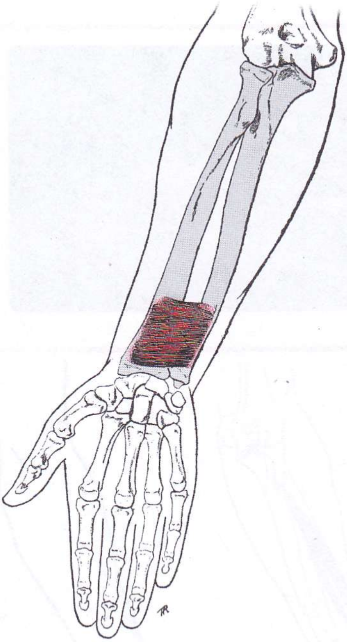


Self Stretch:
- Elbow straight, wrist extended, use opposite hand to pull distal phalanx of thumb into extension



Strengthen
- Resisted thumb flexion
- Stress ball
- Grip strength exercises

Pronator Quadratus



O	**anterior distal ulna** (distal 1/4)
I	**anterior distal radius** (distal 1/4)
A	**pronation of forearm**
N	**median nerve** (C7, C8)
B	anterior interosseous & radial arteries
S	pronator teres

Clinical Notes

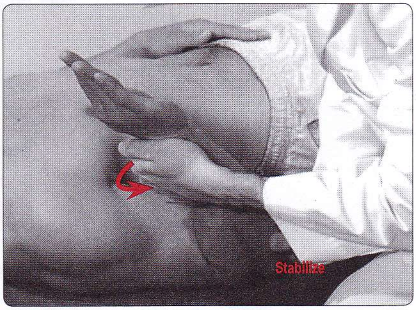
- ***Anatomical variation***: rarely, *pronator quadratus* may be absent; *pronator quadratus* may attach to carpal bones or even rarely extend into the thenar eminence
- *Pronator quadratus* is the prime mover in forearm pronation (*pronator quadratus*, although smaller than *pronator teres*, has a much greater mechanical advantage)
- *Pronator quadratus* helps the interosseous membrane hold the wrist (radius & ulna) together during thrusting motion transferred through the wrist (massage, osseous manipulation, punching)
- ***ADL:*** opening doors, arm wrestling, racket sports
- ***Common injuries:*** specific injuries are rare - repetitive stress injuries (typing, massage therapy, rock climbing)
- ***DDx:*** carpal tunnel syndrome, carpal dislocation/instability, lateral or medial epicondylitis, pronator teres syndrome

Palpation

1. Patient seated or supine
2. Place palpating fingers along fiber direction over anterior distal forearm
3. Ask patient to pronate forearm & mildly resist action
4. Note contraction of muscle tissue
5. Palpate from origin to insertion

Palpation may be difficult due to overlying structures (flexor tendons, nerves & arteries)

Muscle Test



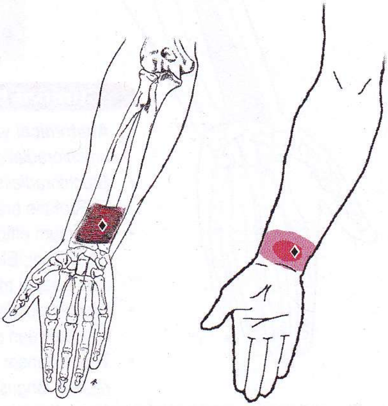
Patient position
- Supine, elbow flexed 125°, forearm fully pronated

Examiner's force
- Toward supination

Stabilization
- Patient's elbow

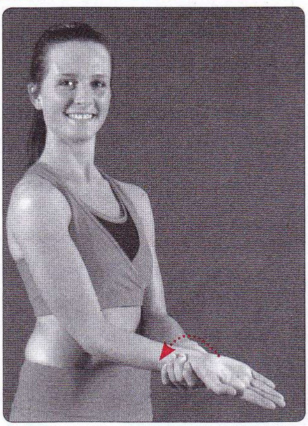
Trigger Point Referral

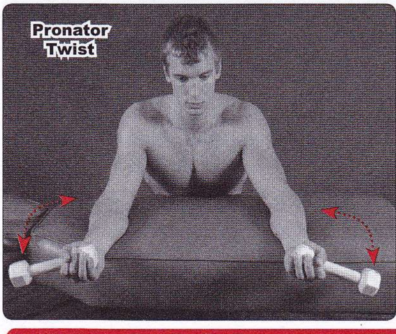
- Pronator quadratus may develop MFTPs in the middle & ulnar side of the muscle belly
- Main referral pattern is local deep aching pain and tenderness over the anterior wrist in the local area



Stretch & Strengthen

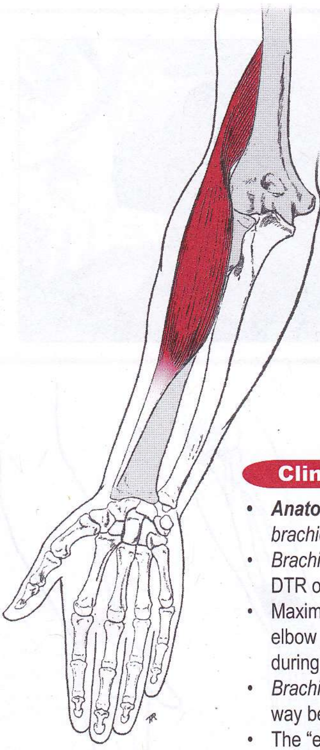
Self Stretch:
- With elbow bent, use opposite hand to supinate forearm





Strengthen
- Resisted forearm pronation
- Dumbell pronation ('Pronator twist')

Brachioradialis



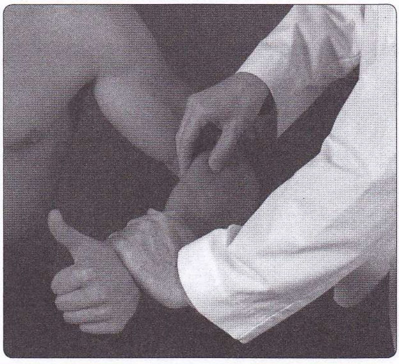
O	**lateral supracondylar ridge** of humerus
I	**styloid process of radius** (lateral side)
A	**flexion of elbow** pronation of forearm when supinated supination of forearm when pronated
N	**radial nerve** (C5, C6)
B	brachial & radial recurrent arteries
S	brachialis, biceps brachii

Clinical Notes

- ***Anatomical variation:*** proximal fibers may blend with *brachialis,* rarely *brachioradialis* may also insert onto the 3rd metacarpal
- *Brachioradialis* is the only elbow flexor innervated by the radial nerve; DTR of the brachioradialis tests mainly the C6 spinal level
- Maximum efficiency of this muscle is gained in 100°–110° of flexion of elbow joint; EMG studies show that *brachioradialis* is particularly active during rapid movements
- *Brachioradialis* is a powerful flexor of the elbow when the forearm is half way between supination & pronation (neutral position)
- The "extensor wad of 3" consists of the *brachioradialis, extensor carpi radialis longus & extensor carpi radialis brevis*
- The radial pulse may be palpated near the insertion point of *brachioradialis* & the distal tendon of *flexor carpi radialis*
- *Brachioradialis* is also known as the "beer drinker's muscle" as its main action is similar to bringing a drink to the mouth; early nomenclature called this "*supinator longus*" on the assumption that supination was its main action
- ***Common injuries:*** repetitive stress injuries (typing, massage therapy, rock climbing)
- ***DDx:*** carpal tunnel syndrome, osteoarthritis, carpal dislocation/instability, thoracic outlet syndrome, C7 or C8 radiculopathy, lateral or medial epicondylitis, pronator teres syndrome

Palpation

1. Patient seated or standing with elbow flexed 90° with thumb pointing up
2. Place palpating fingers along fiber direction of muscle over proximal radius
3. Ask patient to resist as examiner attempts to extend elbow
4. Note contraction of muscle tissue
5. Palpate from origin to insertion



Muscle Test

Patient position

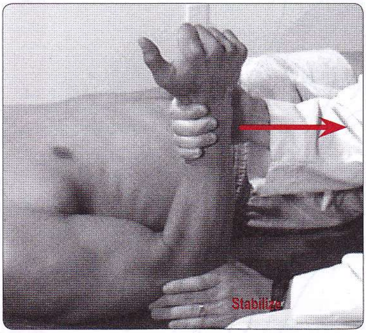
- Supine, elbow flexed 90º, forearm in neutral (thumb up)

Examiner's force

- Toward extension of elbow (note: some clinician's suggest a rapid short burst muscle test)

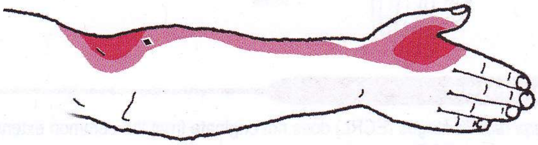
Stabilization

- Patient's elbow



Trigger Point Referral

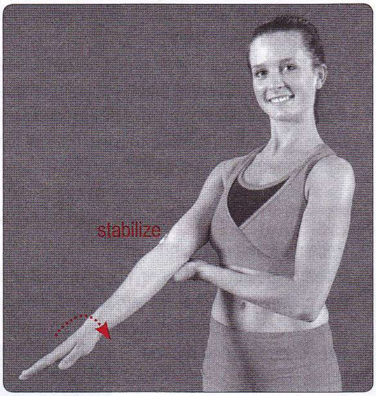
- Brachioradialis often develops MFTPs in association with the radial hand extensors (extensor carpi radialis longus & brevis)
- Main referral pattern is over the wrist & base of the thumb, and in the web space between the thumb and index finger

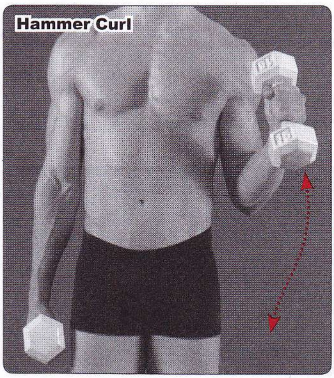


Stretch & Strengthen

Self Stretch:

- Start with elbow straight & supinated, use opposite hand to stabilize origin of brachioradialis; then fully pronate forearm

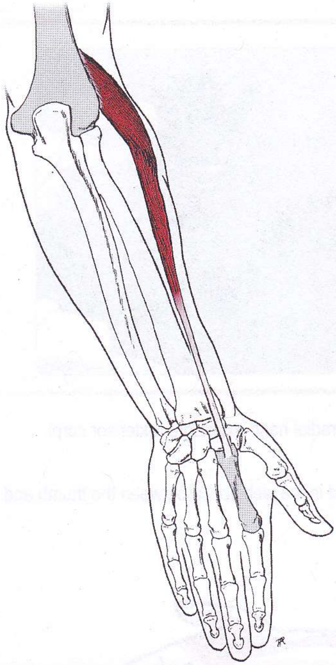




Strengthen

- Resisted elbow flexion with wrist in neutral
- Hammer curls
- Reverse curls
- Concentration hammer curls

Extensor Carpi Radialis Longus



O	**lower lateral supracondylar ridge** (below brachioradialis)
I	**base of 2nd metacarpal**
A	**extension of wrist** **radial flexion (abduction) of wrist** flexion & supination of elbow (weak action)
N	**radial nerve** (C5, C6)
B	radial recurrent & brachial arteries
S	*extension:* extensor carpi radialis brevis, extensor carpi ulnaris *radial flexion:* flexor carpi radialis

Clinical Notes

- *Extensor carpi radialis longus* (ECRL) does not originate from the common extensor tendon as most other wrist extensors (*ECRL & brachioradialis* originate from the lateral supracondylar ridge)
- During strong gripping movements or making a fist, the wrist extensors must contract to help stabilize the hand and balance out the force of the *flexor digitorum superficialis & profundus*
- In radial nerve lesions at the elbow, ECRL will not be affected as its nerve supply from the radial nerve arises above the elbow
- Note that although 'carpi' is part of the muscle name, it inserts onto a metacarpal
- ***ADL:*** tennis backhand, strong gripping actions, hammer use, typing
- ***Common injuries:*** repetitive stress injuries (tennis backhand swing, hammer use)
- ***DDx:*** lateral epicondylitis, osteoarthritis of the wrist, carpal dislocation/instability, C6, C7 or C8 radiculopathy, DeQuervain's syndrome

Palpation

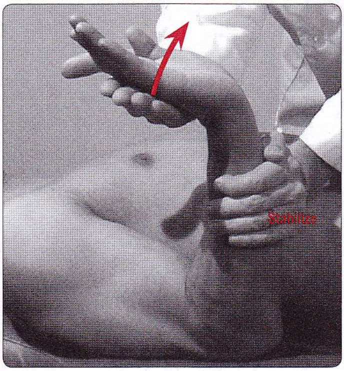
1. Patient seated or supine
2. Place palpating hand along fiber direction just posterior to the brachioradialis
3. Ask patient to make a fist with wrist slightly extended, examiner may apply mild flexion force to wrist (May also be done by shaking the patient's hand)
4. Note contraction of muscle tissue
5. Palpate from origin to insertion

Muscle Test

Patient position
- Supine or seated, elbow flexed 90°, wrist fully extended, forearm 10° pronated

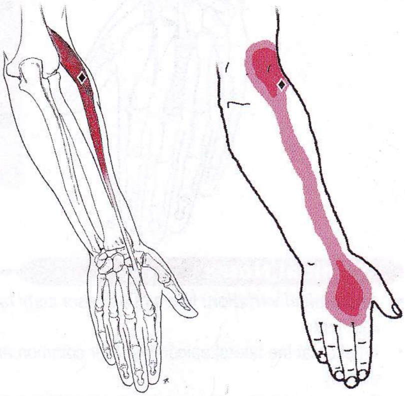
Examiner's force
- Toward flexion & adduction of wrist

Stabilization
- Patient's distal forearm



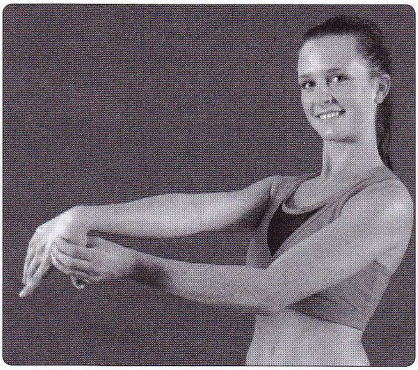
Trigger Point Referral

- Extensor carpi radialis longus may develop MFTPs in the proximal & middle muscle belly
- Main referral pattern is initially pain over the lateral epicondyle, and followed by pain radiating down toward the forearm, wrist, and posterior hand

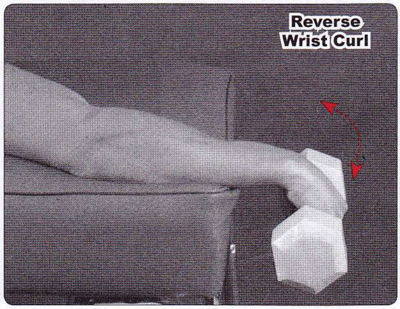


Stretch & Strengthen

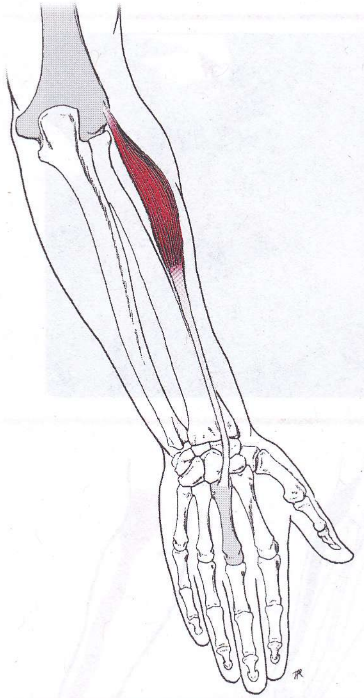
Self Stretch:
- Elbow straight, wrist flexed & pronated, use opposite hand to apply flexion pressure over the shaft of the 2nd metacarpal



Strengthen
- Resisted wrist extension
- Wrist roller
- Reverse wrist curl



Extensor Carpi Radialis Brevis



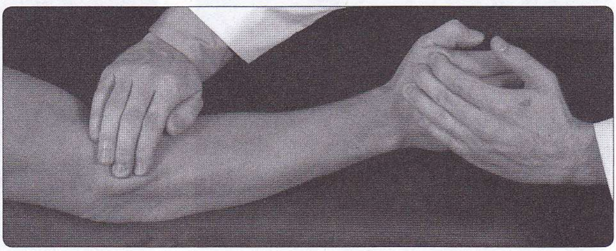
O	**lateral epicondyle** (common extensor tendon)
I	**base of 3rd metacarpal**
A	**extension of wrist** **radial flexion (abduction) of wrist** flexion of elbow joint (weak action)
N	**radial nerve** (C7, C8)
B	radial recurrent artery
S	*extension:* extensor carpi radialis longus, extensor carpi ulnaris *radial flexion:* flexor carpi radialis

Clinical Notes

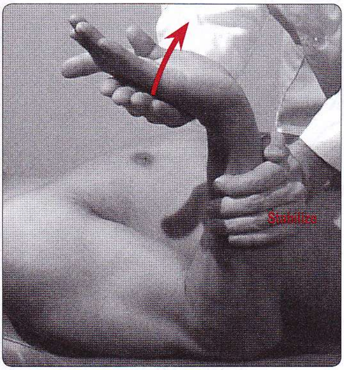
- ***Anatomical variation:*** fibers of *extensor carpi radialis brevis* (ECRB) may blend with radial collateral ligament
- Irritation at the lateral epicondyle &/or common extensor tendon may cause lateral epicondylitis ('tennis elbow')
- During strong gripping movements or making a fist, the wrist extensors must contract to help stabilize the hand and balance out the force of the *flexor digitorum superficialis & profundus*
- Note that although 'carpi' is part of the muscle name, it inserts onto a metacarpal
- ***ADL:*** tennis backhand, strong gripping actions, hammer use, typing
- ***Common injuries:*** repetitive stress injuries (tennis backhand swing, hammer use)
- ***DDx:*** lateral epicondylitis, osteoarthritis of the wrist, carpal dislocation/instability, C6, C7 or C8 radiculopathy, DeQuervain's syndrome

Palpation

1. Patient seated or supine
2. Place palpating fingers along fiber direction over radius
3. Ask patient to radially deviate wrist & mildly resist action
4. Note contraction of muscle tissue
5. Palpate from origin to insertion



Muscle Test



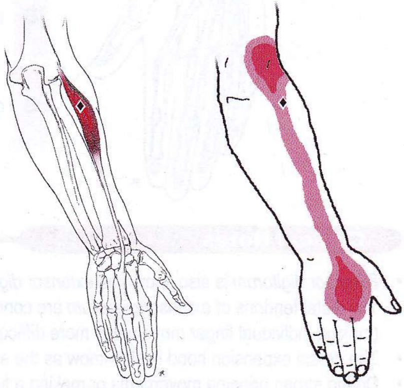
Patient position
- Supine, elbow flexed 90º, wrist fully extended, forearm 10º pronated

Examiner's force
- Toward flexion & adduction of wrist

Stabilization
- Patient's distal forearm

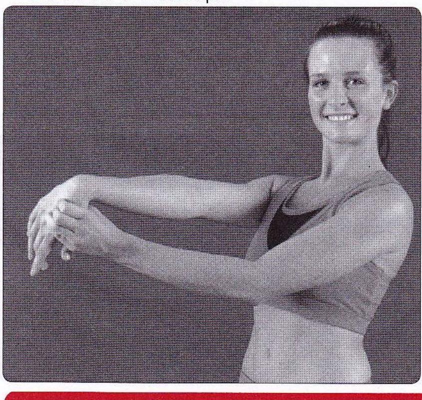
Trigger Point Referral

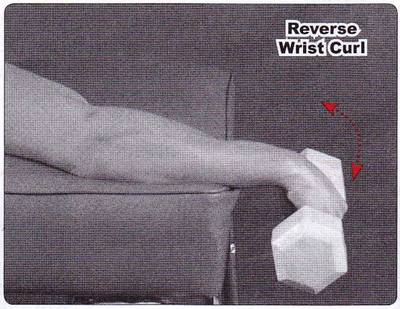
- Extensor carpi radialis brevis may develop MFTPs in the proximal & middle muscle belly
- Main referral pattern is pain over the posterior forearm, wrist, and posterior hand that may eventually involve the lateral epicondyle as well



Stretch & Strengthen

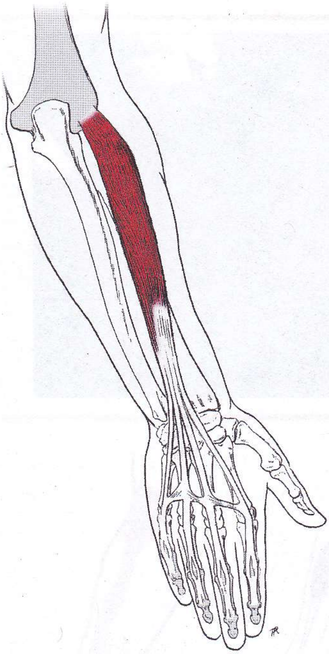
Self Stretch:
- Elbow straight, wrist flexed & pronated, use opposite hand to apply flexion pressure over the shaft of the 3rd metacarpal





Strengthen
- Resisted wrist extension
- Wrist roller
- Reverse wrist curl

Extensor Digitorum



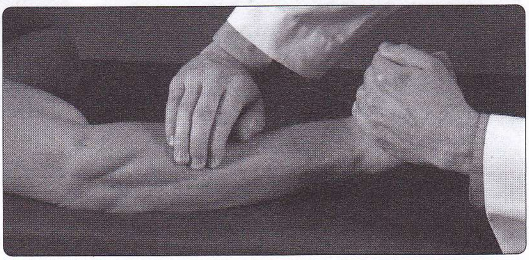
O	**lateral epicondyle of humerus** (via common extensor tendon)
I	**phalanges 2-5** (dorsal expansion hood)
A	**extension of fingers 2-5** (MCP, PIP & DIP joints) **extension of wrist** extension of elbow (weak action)
N	**radial nerve** (C7, C8)
B	ulnar artery
S	extensor indicis, extensor digiti minimi

Clinical Notes

- *Extensor digitorum* is also known as *extensor digitorum communis*
- The distal tendons of *extensor digitorum* are connected by intertendinous slips of connective tissue (making individual finger movements more difficult into extension)
- The dorsal expansion hood is also know as the extensor expansion
- During strong gripping movements or making a fist the wrist extensors must contract to help stabilize the hand and balance out the force of the *flexor digitorum superficialis & profundus*
- Irritation at the lateral epicondyle &/or common extensor tendon may cause lateral epicondylitis ('tennis elbow')
- ***ADL:*** letting go of a held object, wrist extension movements
- ***Common injuries:*** repetitive stress injuries (tennis backhand swing, hammer use)
- ***DDx:*** lateral epicondylitis, osteoarthritis of the wrist, carpal dislocation/instability, C6, C7 or C8 radiculopathy, DeQuervain's syndrome

Palpation

1. Patient seated or supine
2. Place palpating fingers along fiber direction over posterior forearm
3. Ask patient to extend fingers & mildly resist action
4. Note contraction of muscle tissue
5. Palpate from origin to insertion



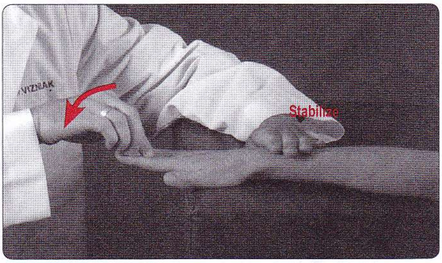
Muscle Test

Patient position
- Supine or seated, elbow flexed 90º, forearm fully pronated, fingers extended

Examiner's force
- Towards flexion of fingers

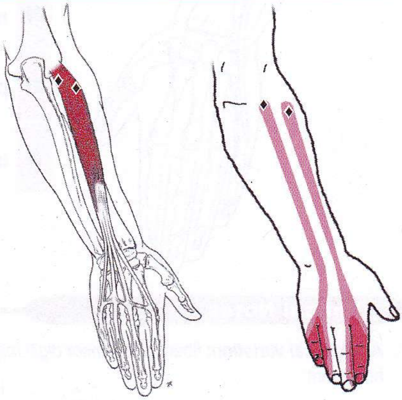
Stabilization
- Patient's elbow, examiner may choose to lay forearm flat on table

Fingers may be tested individually or as a group



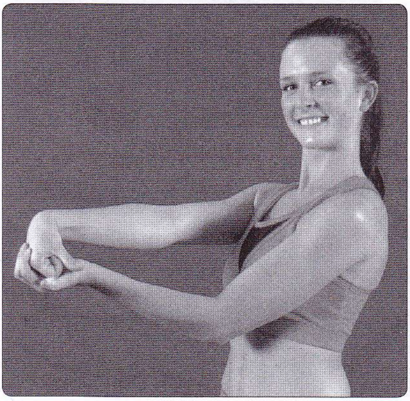
Trigger Point Referral

- Extensor digitorum may develop MFTPs in the proximal & middle muscle belly
- Main referral pattern is over the distal posterior forearm and to the digits that correspond to that area of the muscle

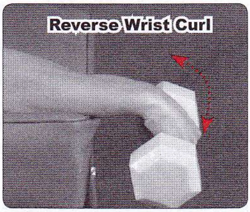


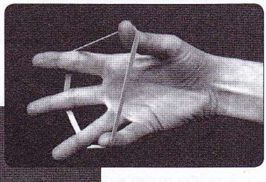
Stretch & Strengthen

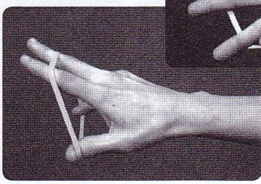
Self Stretch:
- Elbow straight, wrist flexed & hand in a fist, use opposite hand to apply flexion pressure
- Pronate & supinate the forearm to further stretch more specific fibers



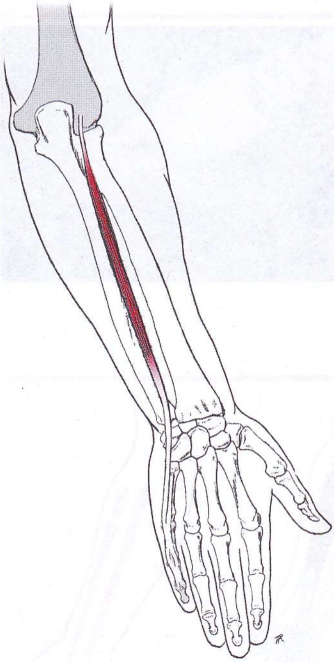
Strengthen
- Resisted wrist extension
- Wrist roller
- Reverse wrist curl
- Elastic band exercise







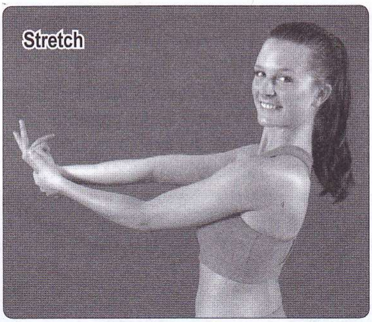
Extensor Digiti Minimi



O	**lateral epicondyle of humerus** (via common extensor tendon)
I	**middle & distal phalanges of 5th digit** (extensor expansion)
A	**extension of little finger** (5th digit) extension of wrist extension of elbow (weak action)
N	**radial nerve** (C6, C7, C8)
B	posterior interosseous artery
S	extensor digitorum

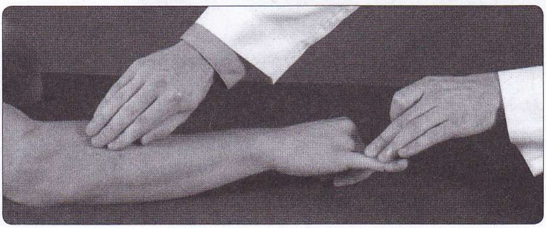
Clinical Notes

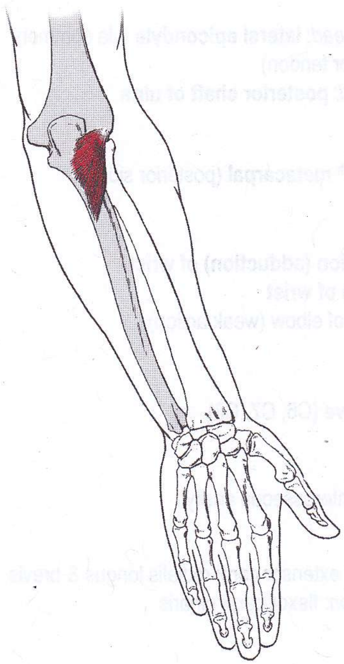
- ***Anatomical variation:*** fibers of *extensor digiti minimi* (EDM) may blend with extensor digitorum, or rarely be absent
- The action of *extensor digiti minimi* is easy to remember as it is the same action done by Dr. Evil in the popular Austin Powers movie series (don't for get the character 'Mini-Me' as well ☺)
- ***ADL:*** letting go of held object, picking nose ☺
- ***Muscle test:*** resist extension of the little finger
- ***Stretch:*** elbow straight, wrist & little finger flexed, use opposite hand to apply flexion pressure over 5th metacarpal (see image)



Palpation

1. Patient seated or supine
2. Place palpating fingers along fiber direction over posterior forearm
3. Ask patient to extend little fingers & mildly resist action
4. Note contraction of muscle tissue
5. Palpate from origin to insertion





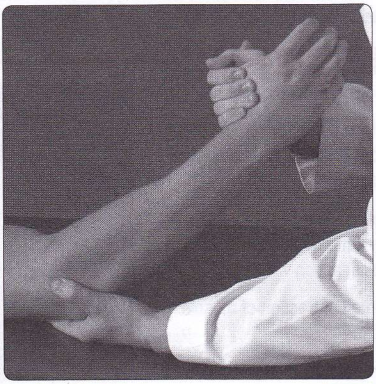
O	**lateral epicondyle of humerus**
I	**lateral posterior olecranon process** (proximal 1/4 of ulna)
A	**extension of elbow** stabilizes the lateral elbow joint
N	radial nerve (C6, C7, C8)
B	deep brachial artery
S	triceps brachii

Clinical Notes

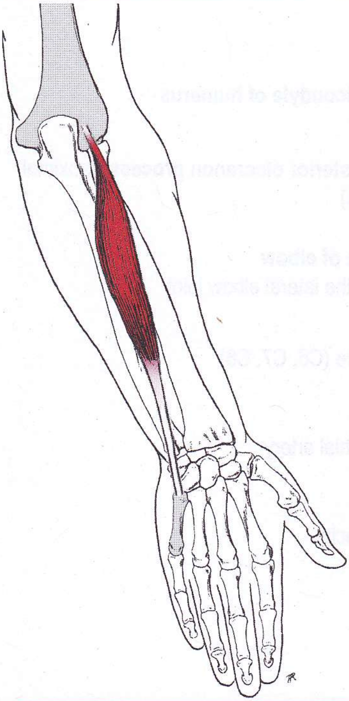
- ***Anatomical variation:*** fibers of *anconeus* may blend with triceps
- Some embyologists consider the anconeus to be the fourth head of the *triceps brachii* muscle as it assists the triceps in extension and it is part of the posterior compartment of the arm
- MFTP are usually found in the muscle belly & refer pain just superior to the lateral epicondyle
- Anconeus may be involved in cases of lateral epicondylitis (tennis elbow)

Palpation

1. Patient seated or standing with elbow extended
2. Place palpating thumb over fiber direction of muscle over lateral aspect of olecranon
3. Ask patient to resist as examiner attempts to flex elbow
4. Note contraction of muscle tissue



Extensor Carpi Ulnaris



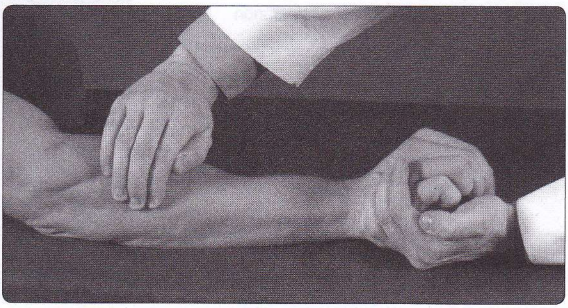
O	*humeral head:* **lateral epicondyle** (via common extensor tendon) *ulnar head:* **posterior shaft of ulna**
I	**base of 5th metacarpal** (posterior side)
A	**ulnar flexion (adduction) of wrist** **extension of wrist** extension of elbow (weak action)
N	**radial nerve** (C6, C7, C8)
B	posterior interosseous artery
S	*extension:* extensor carpi radialis longus & brevis *ulnar flexion:* flexor carpi ulnaris

Clinical Notes

- *Extensor carpi ulnaris* (ECU) is a misnamed muscle; while it does assist with wrist extension, its main action is ulnar deviation (which is easily understood based on its fiber direction & insertion in relation to the axis of rotation at the wrist)
- During strong gripping movements or making a fist, the wrist extensors must contract to help stabilize the hand and balance out the force of the *flexor digitorum superficialis & profundus*
- Irritation at the lateral epicondyle &/or common extensor tendon may cause lateral epicondylitis (tennis elbow)
- Note that although 'carpi' is part of its name this muscle inserts onto a metacarpal
- ***Common injuries:*** repetitive stress injuries (tennis backhand swing, hammer use)
- ***DDx:*** lateral epicondylitis, osteoarthritis of the wrist, carpal dislocation/instability, C6, C7 or C8 radiculopathy

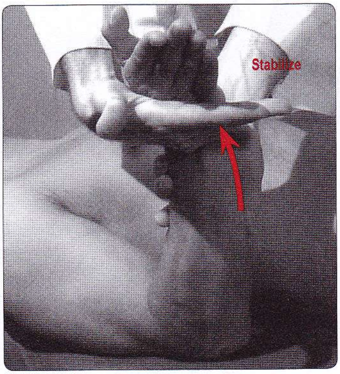
Palpation

1. Patient seated or supine
2. Place palpating fingers along fiber direction over posterior forearm
3. Ask patient to perform ulnar deviation of the wrist & mildly resist action
4. Note contraction of muscle tissue
5. Palpate from origin to insertion



Extensor Carpi Ulnaris

Muscle Test

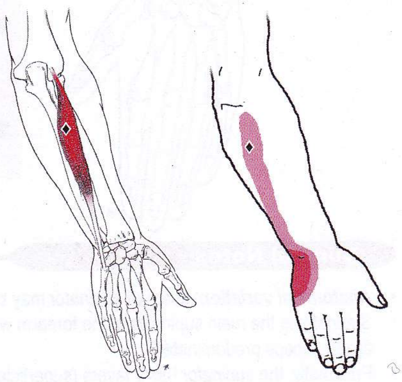


Patient position
- Supine, elbow flexed 90°, wrist fully extended, forearm in neutral position

Examiner's force
- Toward flexion & abduction of wrist

Stabilization
- Patient's distal forearm

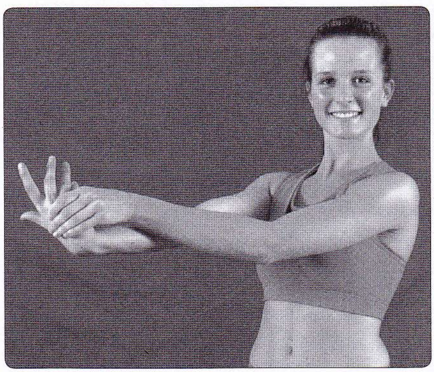
Trigger Point Referral

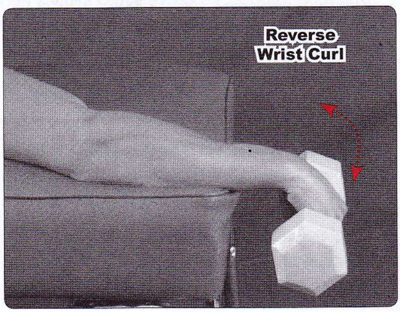


- Extensor carpi ulnaris usually develops MFTPs in the proximal & middle muscle belly
- Main referral pattern is pain over the posterior shaft of the ulna, down to the ulnar side of the wrist & posterior hand

Stretch & Strengthen

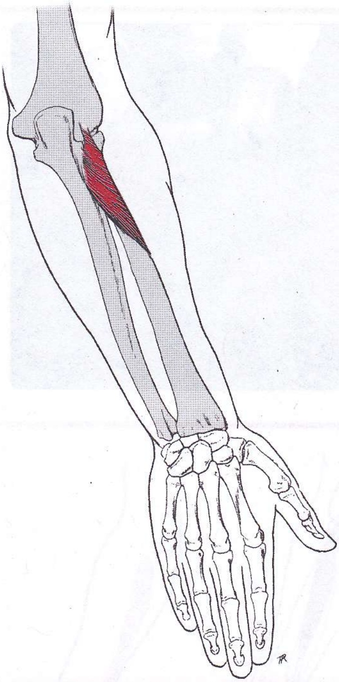
Self Stretch:
- Elbow straight, wrist flexed & supinated, use opposite hand to apply flexion pressure over the shaft of the 5th metacarpal





Strengthen
- Resisted wrist extension
- Wrist roller
- Reverse wrist curl
- Reverse wrist hammer curl

Supinator



O	**lateral epicondyle of humerus & supinator crest of ulna**
I	**proximal 1/3 of radius**
A	**supination of forearm** (proximal radioulnar joint)
N	**radial nerve** (C6, C7)
B	radial recurrent artery
S	biceps brachii, brachioradialis

Clinical Notes

- ***Anatomical variation:*** fibers of *supinator* may blend with the radial collateral ligament & annular ligament
- *Supinator* is the main supinator of the forearm when the upper extremity is straight (when the elbow is flexed, biceps predominates)
- Proximally, the *supinator* has 2 layers (superficial & deep); the posterior interosseous nerve runs between these two layers where it can become entrapped
- ***ADL:*** turning a door handle, using a screw driver
- ***Common injuries:*** repetitive stress injuries (tennis backhand swing, hammer use)
- ***DDx:*** lateral epicondylitis, osteoarthritis of the wrist, C5 or C6 radiculopathy, DeQuervain's syndrome, other MFTPs in extensor carpi ulnaris & radialis brevis

Palpation

1. Patient seated or supine with elbow flexed 90°
2. Place palpating thumb over muscle & shake patient's hand with non-palpating hand
3. Ask patient to supinate their forearm & mildly resist action
4. Note contraction of muscle tissue
5. Palpate from origin to insertion

Muscle Test

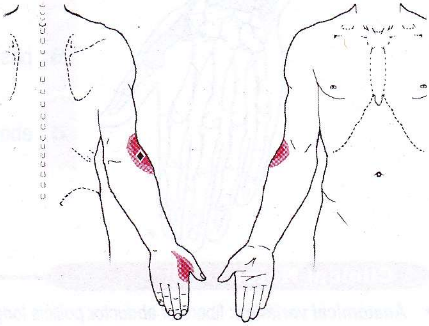
Patient position
- Supine, shoulder flexed 90º, elbow flexed 150º, forearm fully supinated

Examiner's force
- Toward pronation

Stabilization
- Patient's elbow

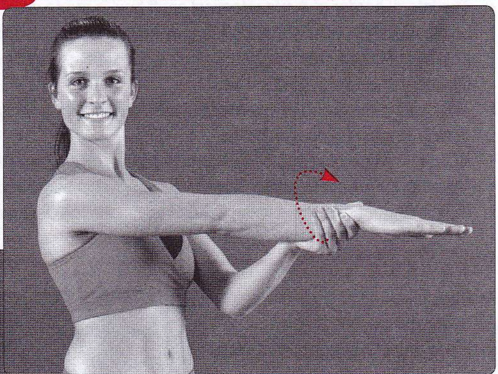
Trigger Point Referral

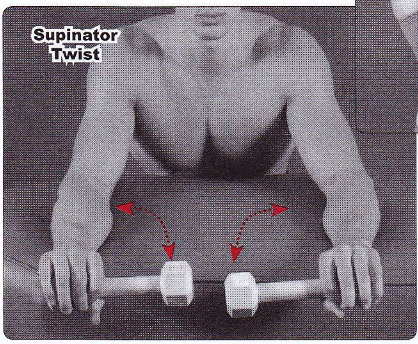
- Supinator often develops MFTPs in the proximal muscle belly
- Main referral pattern is pain over the lateral epicondyle and posterior web of the thumb & index finger



Stretch & Strengthen

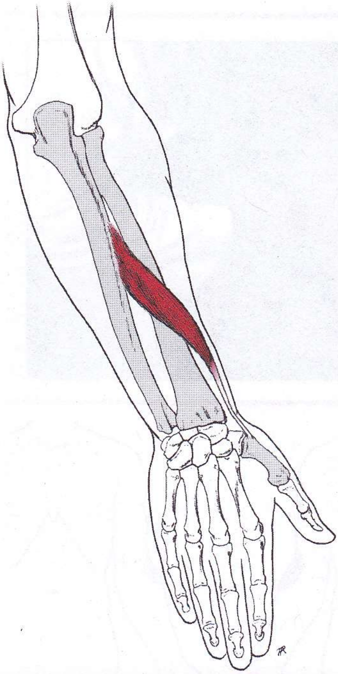
Self Stretch:
- Elbow straight, use opposite hand to apply pronation force over the distal forearm





Strengthen
- Resisted wrist supination
- Wrist supination

Abductor Pollicis Longus



O	**posterior surfaces of ulna, radius & interosseous membrane** (middle 1/3 of forearm)
I	**base of 1st metacarpal** (lateral side)
A	**abduction of thumb** (carpometacarpal joint) radial deviation (abduction) of wrist assists with extension & rotation of thumb assists with flexion & supination of hand at wrist
N	**radial nerve** (C7, C8)
B	posterior interosseous artery
S	abductor pollicis brevis

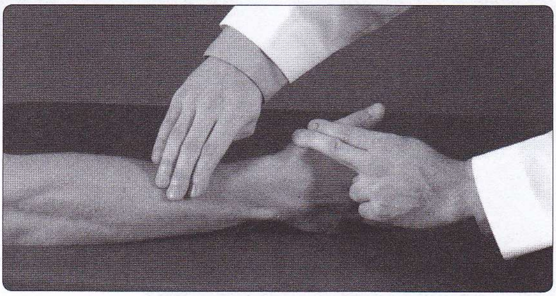
Clinical Notes

- ***Anatomical variation:*** fibers of *abductor pollicis longus* may attach to the trapezium bone
- *Abductor pollicis longus* is part of the 'deep distal four group'
- The lateral border of the 'anatomical snuff box' is made up of *abductor pollicis longus & extensor pollicis brevis* muscles (*extensor pollicis longus* makes up the medial border)
- Irritation of the *abductor pollicis longus &/or extensor pollicis brevis* can cause a condition known as DeQuervain's tenosynovitis
- The distal deep group of 4 is made up of the *abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus & extensor indicis*
- ***ADL:*** extension of thumb, video games, typing, giving "two thumbs up," letting go of objects held in hand
- ***Common injuries:*** repetitive stress injuries (tennis backhand swing, hammer use)
- ***DDx:*** osteoarthritis of the wrist, C6-C8 radiculopathy, DeQuervain's syndrome

Palpation

1. Patient seated or supine with forearm in neutral position
2. Place palpating fingers along fiber direction over lateral wrist
3. Ask patient to abduct & extend thumb
4. Note contraction of muscle tissue
5. Palpate from origin to insertion

Abductor pollicis longus is more lateral than extensor pollicis brevis



Muscle Test

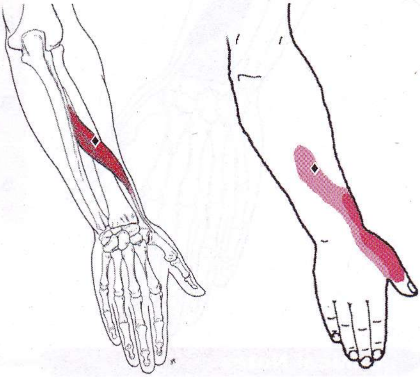
Patient position
- Supine or seated, elbow flexed 90°, forearm in neutral position, thumb abducted

Examiner's force
- Toward adduction of 1st CMC joint applied over shaft of 1st metacarpal

Stabilization
- Patient's posterior forearm

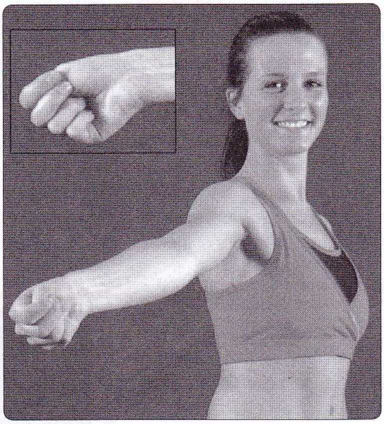
Trigger Point Referral

- Abductor pollicis longus may develop MFTPs in the middle & proximal muscle belly
- Main referral pattern is pain and tenderness over the distal posterior forearm, wrist & thumb

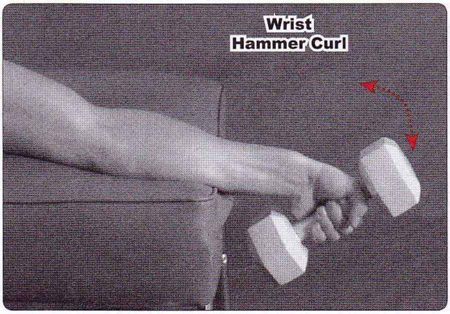


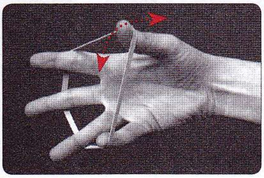
Stretch & Strengthen

Self Stretch:
- Curl thumb into fist & adduct (ulnar deviate) wrist
- This stretch is the same as Finklestein's test for DeQuervain's syndrome



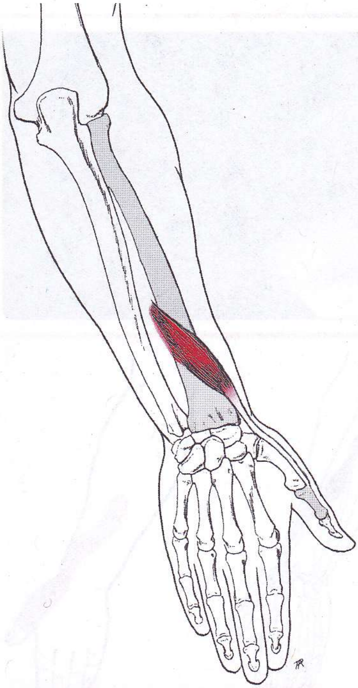
Strengthen
- Resisted wrist abduction
- Wrist hammer curl
- Elastic band exercises





Forearm & Hand

Extensor Pollicis Brevis



O	**posterior distal 1/3 surfaces of radius & interosseous membrane**
I	**base of proximal phalanx of thumb**
A	**extension of proximal phalanx** & 1st metacarpal of thumb radial flexion (abduction) of wrist
N	**radial nerve** (C7, C8)
B	posterior interosseous artery
S	extensor pollicis longus

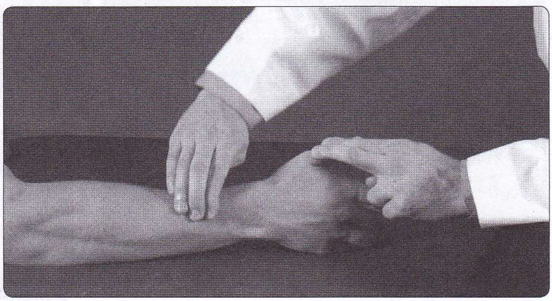
Clinical Notes

- ***Anatomical variation:*** often a slip inserts into *extensor pollicis longus tendon*, muscle may be absent or fused completely with *abductor pollicis longus*
- The lateral border of the 'anatomical snuff box' is made up of *abductor pollicis longus & extensor pollicis brevis* muscles (*extensor pollicis longus* makes up the medial border of the snuff box)
- Irritation of the *abductor pollicis longus &/or extensor pollicis brevis* can cause a condition known as DeQuervain's tenosynovitis
- The 'distal deep group of 4' is made up of the *abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus & extensor indicis*
- ***ADL:*** extension of thumb, video games, typing, giving "two thumbs up," letting go of objects held in hand
- ***Common injuries:*** repetitive wrist or thumb extension stress injuries (tennis backhand, hammer use)
- ***DDx:*** osteoarthritis of the wrist, C6-C8 radiculopathy, DeQuervain's syndrome

Palpation

1. Patient seated or supine with forearm in neutral position
2. Place palpating fingers along fiber direction over lateral wrist
3. Ask patient to extend & abduct thumb
4. Note contraction of muscle tissue
5. Palpate from origin to insertion

Abductor pollicis longus is more lateral than extensor pollicis brevis



Muscle Test

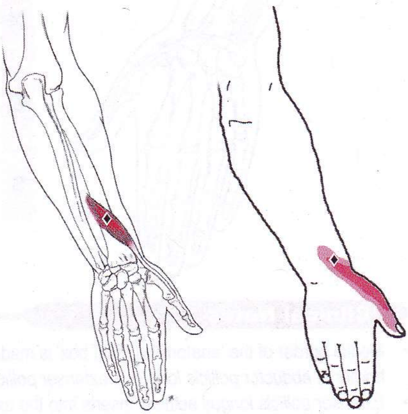
Patient position
- Supine or seated, elbow flexed 90°, forearm in neutral position, thumb extended

Examiner's force
- Towards flexion of 1st MCP joint, with pressure applied over the shaft of the proximal phalanx, without pressing into muscle belly

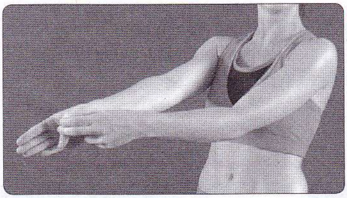
Stabilization
- Patient's posterior forearm

Trigger Point Referral

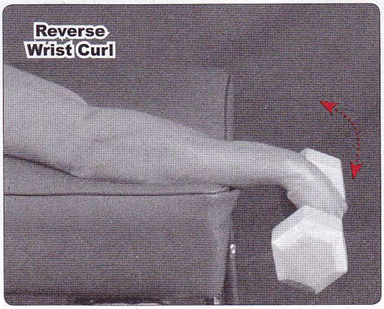
- Extensor pollicis brevis may develop MFTPs in the middle & proximal muscle belly
- Main referral pattern is shooting pain and tenderness over the posterior wrist & thumb



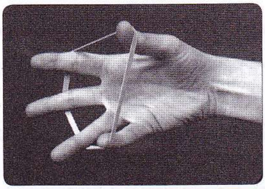
Stretch & Strengthen

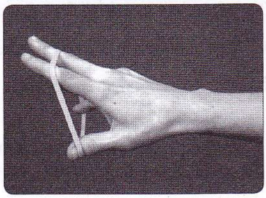


Self Stretch:
- Adduct (ulnar deviate) wrist & use opposite hand to flex thumb
- Pressure should be applied over the shaft of the proximal phalanx

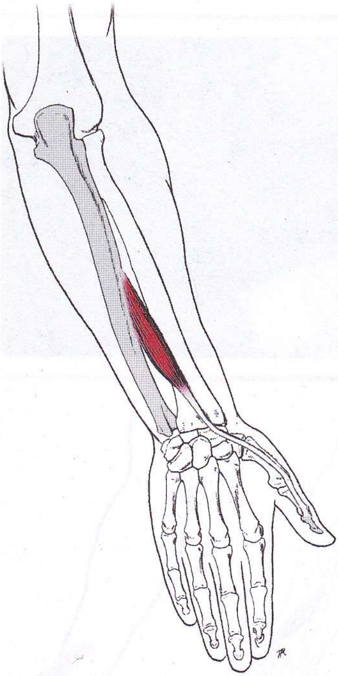


Strengthen
- Resisted wrist extension
- Wrist roller
- Reverse wrist curl
- Elastic band exercises





Extensor Pollicis Longus



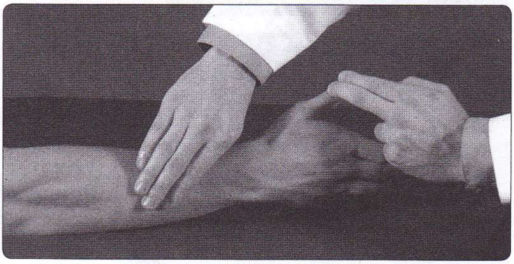
O	**posterior middle 1/3 of ulna & interosseous membrane**
I	**distal phalanx of thumb**
A	**extension of thumb** (CMC, MCP, IP joints) assists in extension & radial flexion (abduction) of wrist
N	**radial nerve** (C7, C8)
B	posterior interosseous artery
S	extensor pollicis brevis

Clinical Notes

- Medial border of the 'anatomical snuff box' is made by the tendon of *extensor pollicis longus* (lateral border is *abductor pollicis longus & extensor pollicis brevis*)
- *Extensor pollicis longus* actually inserts into the extensor expansion of the thumb
- The 'distal deep group of 4' is made up of the *abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus & extensor indicis*
- ***ADL:*** extension of thumb, video games, typing, giving "two thumbs up," letting go of objects held in hand
- ***Common injuries:*** repetitive wrist or thumb extension stress injuries (tennis backhand, hammer use)
- ***DDx:*** osteoarthritis of the wrist, C6-C8 radiculopathy, DeQuervain's syndrome

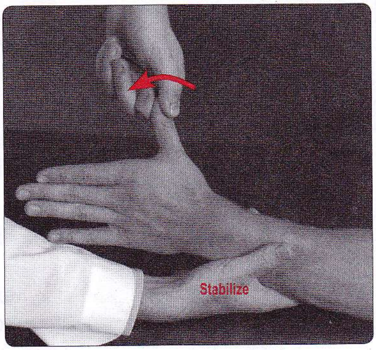
Palpation

1. Patient seated or supine with forearm in neutral position
2. Place palpating fingers along fiber direction over lateral wrist
3. Ask patient to extend & abduct thumb
4. Note contraction of muscle tissue
5. Palpate from origin to insertion



Extensor pollicis longus is the medial (ulnar) border of the anatomical snuff box

Muscle Test



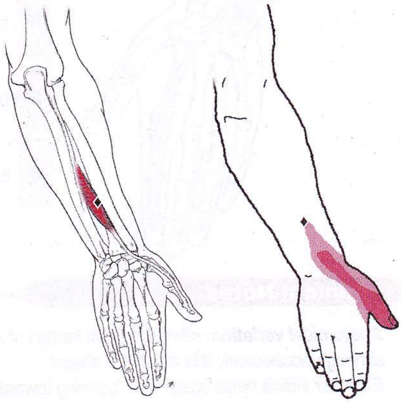
Patient position
- Supine or seated, elbow flexed 90º, forearm in neutral position, thumb extended

Examiner's force
- Towards flexion of 1st IP joint

Stabilization
- Patient's posterior forearm

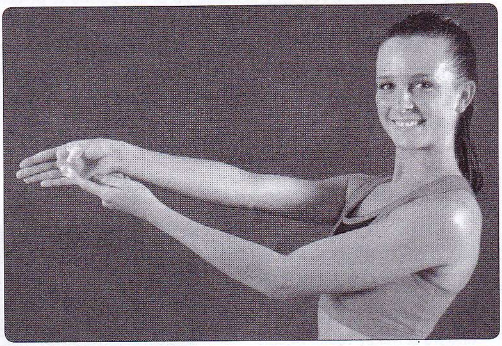
Trigger Point Referral

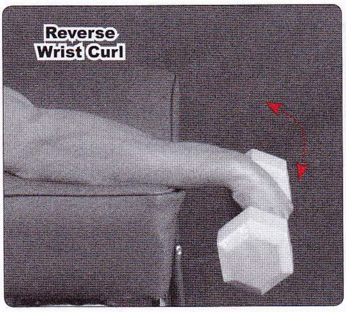
- Extensor pollicis longus may develop MFTPs in the middle & proximal muscle belly
- Main referral pattern is pain and tenderness over the posterior wrist & thumb



Stretch & Strengthen

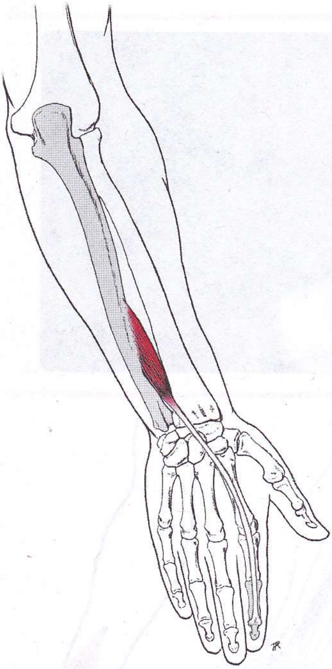
Self Stretch:
- Adduct (Ulnar deviate) wrist & use opposite hand to flex thumb
- Pressure should be applied over the distal phalanx





Strengthen
- Resisted wrist extension
- Wrist roller
- Reverse wrist curl

Extensor Indicis



O	**posterior distal 1/3 of ulna & interosseous membrane**
I	**base of middle & distal phalanx of index finger** (via extensor expansion & extensor digitorum muscle tendon)
A	**extension of index finger** (MCP, PIP & DIP joints) extension of hand at wrist adduction of index finger (weak)
N	**radial nerve** (C7, C8)
B	posterior interosseous artery
S	extensor digitorum

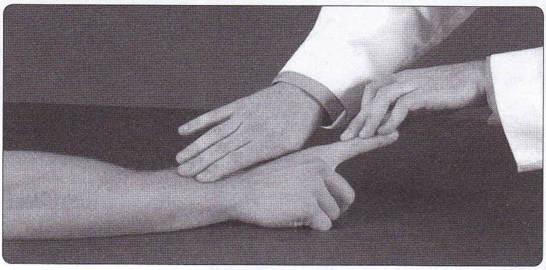
Clinical Notes

- ***Anatomical variation:*** often the distal tendon of *extensor indicis* may be made up of 2 or 3 tendons, although occasionally this muscle is absent
- *Extensor indicis* helps assist with "pointing toward" or "indicating" items, makes it possible to point index finger when the rest of the hand is in a fist
- The 'distal deep group of 4' is made up of the *abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus & extensor indicis*
- ***ADL:*** pointing to an object, letting go of an object held in hand
- ***Common injuries:*** repetitive index finger extension stress injuries (tennis backhand, hammer use)
- ***DDx:*** osteoarthritis of the wrist, C6-C8 radiculopathy, DeQuervain's syndrome

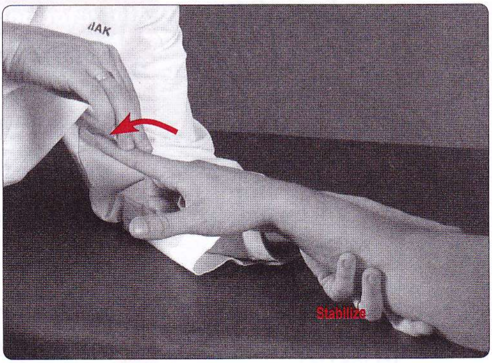
Palpation

1. Patient seated or supine with forearm pronated
2. Place palpating fingers along fiber direction over posterior forearm
3. Ask patient to extend index fingers & mildly resist action
4. Note contraction of muscle tissue
5. Palpate from origin to insertion

May be difficult to distinguish from tendon of extensor digitorum



Muscle Test



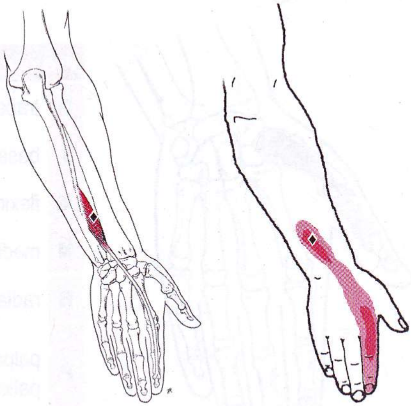
Patient position
- Supine or seated, elbow flexed 90º, forearm pronated, index finger extended

Examiner's force
- Towards flexion of index finger

Stabilization
- Patient's posterior forearm

Trigger Point Referral

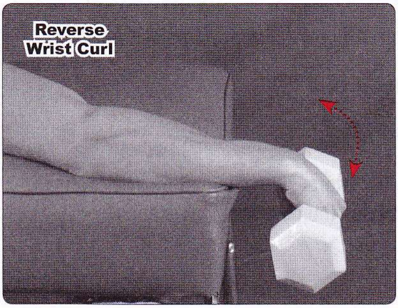
- Extensor indicis may develop MFTPs in the middle & proximal muscle belly
- Main referral pattern is pain and tenderness over the posterior forearm, wrist & index finger

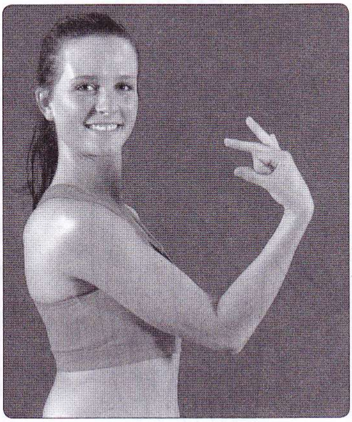


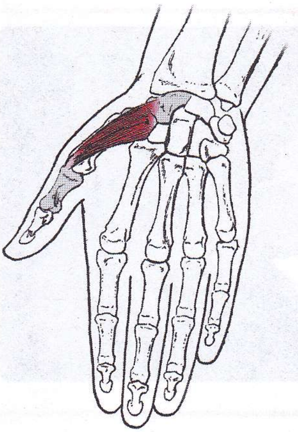
Stretch & Strengthen

Strengthen
- Resisted wrist extension
- Wrist roller
- Reverse wrist curl

Self Stretch:
- Wrist flexed, with index finger curled into fist
- Consider applying over pressure with opposite hand to increase stretch

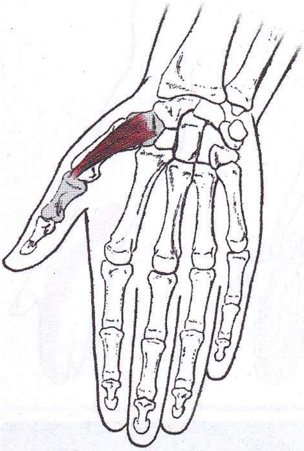






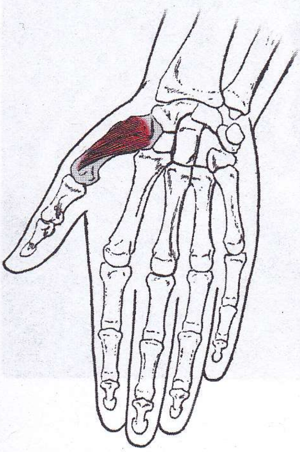
Abductor pollicis brevis

O	tubercles of scaphoid & trapezium (also flexor retinaculum)
I	base of proximal phalanx of thumb (lateral side)
A	abduction of thumb (at trapeziometacarpal joint)
N	median nerve (C8, T1)
B	radial artery
P	palpate over lateral side of thenar eminence, have patient abduct thumb against resistance



Flexor pollicis brevis

O	trapezium & flexor retinaculum
I	base of proximal phalanx of thumb (lateral side)
A	flexion of thumb (at trapeziometacarpal joint)
N	median nerve (C8, T1)
B	radial artery
P	palpate over medial side of thenar eminence, have patient flex thumb against resistance



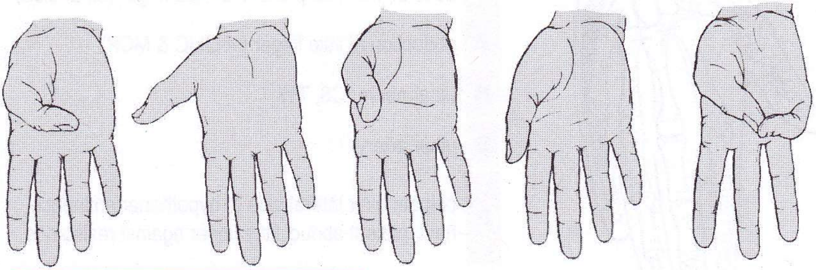
Opponens pollicis

O	trapezium & flexor retinaculum
I	metacarpal of thumb (anterolateral side)
A	opposition of thumb (at trapeziometacarpal joint)
N	median nerve (C8, T1)
B	radial artery
P	palpate over lateral side of thenar eminence, have patient oppose thumb against resistance

Muscle Test

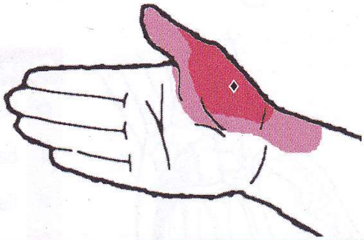
- To test any muscles attaching to the thumb, simply resist that specific action of the thumb

Flexion | **Extension** | **Abduction** | **Adduction** | **Opposition**



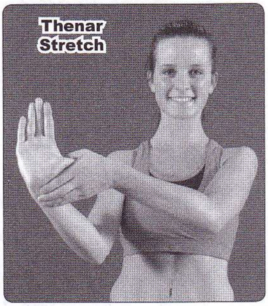
Trigger Point Referral

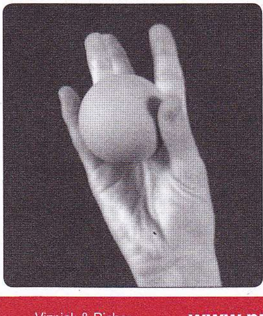
- Thenar muscles may develop MFTPs in the middle & proximal muscle bellies
- Main referral pattern is often described as achy pain and tenderness over the radial aspect of the hand & wrist

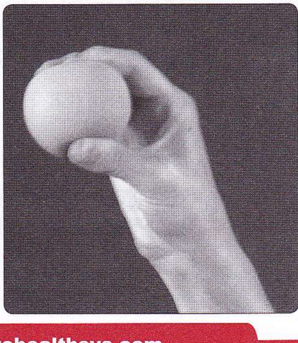


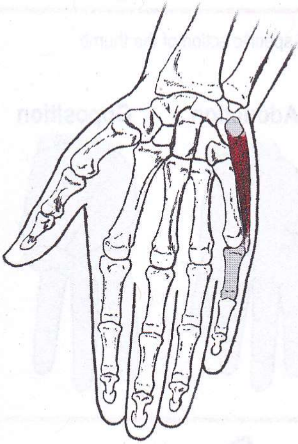
Clinical Notes

- Three muscles make up the thenar eminence; *abductor pollicis, flexor pollicis brevis & opponens pollicis*
- ***Anatomical variation:*** fibers of all three thenar muscles can blend with each other and may also blend with the flexor retinaculum and other ligamentous structures around the carpals
- Palpation of the thenar muscle group is easy, however locating the exact border of each individual muscle may be difficult or even impossible
- In the distal tendon of *flexor pollicis brevis* there is a sesamoid bone
- Opposition of the thumb is really a combination of flexion, medial rotation & adduction
- ***ADL:*** any gripping actions, picking up a spoon, opening a door
- ***Self stretch:*** extend wrist & thumb, use opposite hand to apply extension force over proximal phalynx of thumb (see image)
- ***Strengthen:*** resisted grip strength exercises, squeezing a racket ball or tennis ball



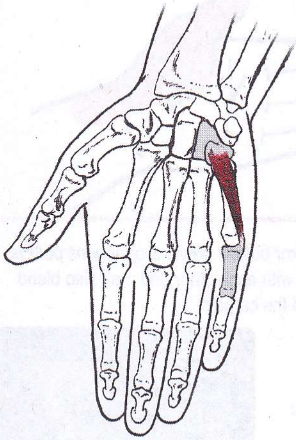






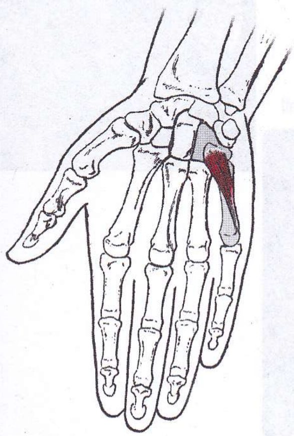
Abductor digiti minimi

O	pisiform & tendon of flexor carpi ulnaris
I	base of proximal phalanx of little finger (ulnar side)
A	abduction of little finger (at CMC & MCP)
N	ulnar nerve (C8, T1)
B	ulnar artery
P	palpate over lateral side of hypothenar eminence, have patient abduct little finger against resistance



Flexor digiti minimi

O	flexor retinaculum & hook of hamate
I	base of proximal phalanx of little finger (ulnar side)
A	flexion of little finger (at MCP joint)
N	ulnar nerve (C8, T1)
B	ulnar artery
P	palpate over lateral side of hypothenar eminence, have patient flex little finger against resistance

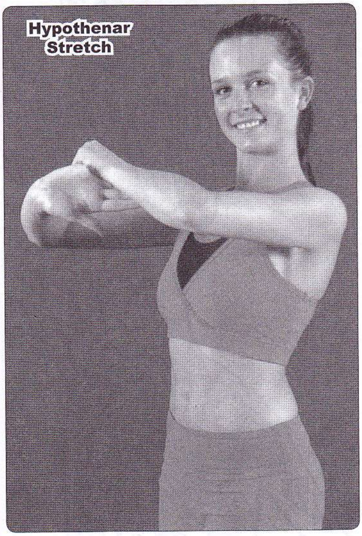


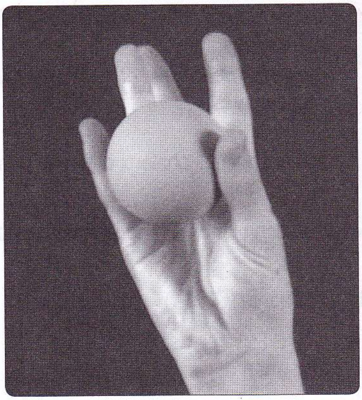
Opponens digiti minimi

O	flexor retinaculum & hook of hamate
I	5^{th} metacarpal (anterior & medial surface)
A	opposition of little finger
N	ulnar nerve (C8, T1)
B	ulnar artery
P	palpate over lateral side of hypothenar eminence, have patient oppose little finger against resistance

Clinical Notes

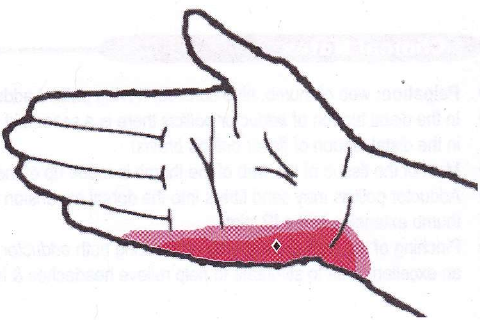
- Three muscles make up the hypothenar muscle group; *abductor digiti minimi, flexor digiti minimi & opponens digiti minimi*
- ***Anatomical variation:*** fibers of all three hypothenar muscles can blend with each other
  - Proximal fibers of *abductor digiti minimi* may blend with the *flexor carpi ulnaris* tendon
  - *Flexor digiti minimi* is often absent
- *Flexor digiti minimi* is also known as *flexor digiti minimi brevis & flexor digiti minimi manus*
- *Abductor digiti minimi* may assist in extension of the little finger at IP joint due to tendinous slips it extends out to the extensor expansion & extensor digitorum
- During contraction of *abductor digiti minimi*, the *flexor carpi ulnaris* must contract to help stabilize the pisiform
- The largest hypothenar muscle is the *opponens digiti minimi*
- Opposition of the little finger is really a combination of flexion, medial rotation & adduction
- ***Self stretch:*** extend little finger, use opposite hand to apply extension force over 5th metacarpal & proximal phalynx of little finger (see image)
- ***Strengthen:*** resisted grip strength exercises, squeezing a tennis/racket ball

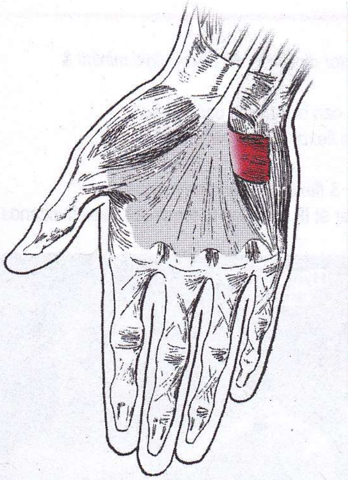




Trigger Point Referral

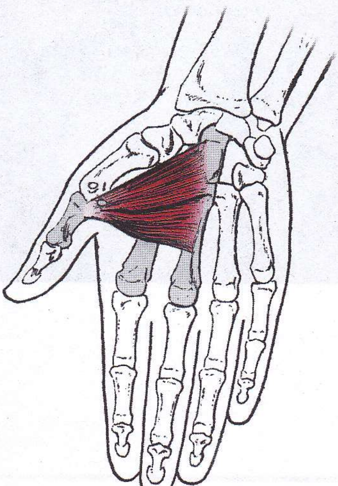
- Hypothenar muscles may develop MFTPs in the middle muscle bellies
- Main referral pattern is often described as achy pain and tenderness over the ulnar aspect of the hand & wrist





Palmaris brevis

O	palmar aponeurosis (medial side)
I	skin on medial side of hand
A	tenses skin on medial side (used in a grip action)
N	ulnar nerve (C8, T1)
B	ulnar artery
C	palmaris brevis is often absent, but when present is considered part of the hypothenar muscle group

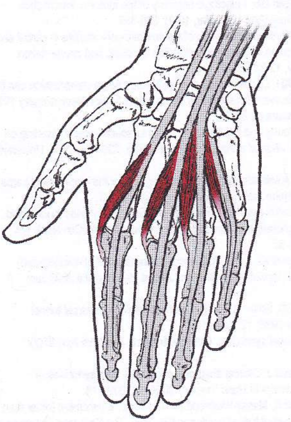


Adductor pollicis

O	*Oblique head:* capitate & bases of 2nd & 3rd metacarpals *Transverse head:* palmar surface of third metacarpal
I	base of proximal phalanx of thumb (medial side)
A	adduction of thumb (trapeziometacarpal joint)
N	ulnar nerve (C8, T1)
B	radial artery

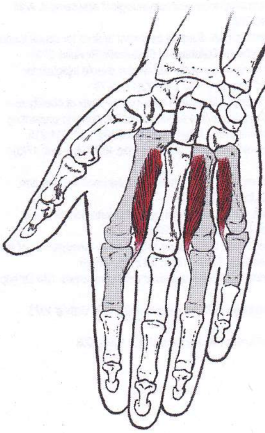
Clinical Notes

- **Palpation:** web of thumb, also consider having patient adduct thumb to feel muscle
- In the distal tendon of *adductor pollicis* there is a sesamoid bone (another sesamoid bone in the hand is in the distal tendon of *flexor pollicis brevis*)
- Most of the tissue of the web of the thumb is made up of the adductor pollicis
- Adductor pollicis may send fibers into the dorsal expansion of the thumb & thus may weakly contribute to thumb extension at the IP joint
- Pinching of the web of the thumb (squeezing both *adductor pollicis & the 1st dorsal interosseus* muscle) is an excellent area to stimulate to help relieve headaches & lower stress levels



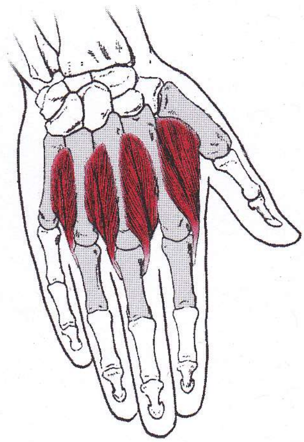
Lumbricals

O	tendons of flexor digitorum profundus (lateral side)
I	extensor expansion (lateral side)
A	flexion MCP joints & extension of IP joints
N	median (lateral 2), ulnar (medial 2)
B	ulnar & radial arteries
C	*Anatomical variation:* variation in ~45% of people • Any muscles may be unipennate or bipennate • May be absent or doubled Lumbricals are important during strong gripping actions Lumbricals alter the balance between flexors & extensors and are important proprioceptors; the 1st lumbrical has approximately 50 neuromuscular spindles for a weight of about 3 grams (this is a very high spindle density)



Palmar interossei

O	metacarpals 2, 4 & 5
I	base of proximal phalanx of digit 2, 4, 5 & extensor hood of same digit(s)
A	adduction of fingers (hint: PAD) flexion of fingers (MCP while IP joints are extended)
N	ulnar nerve (C8, T1)
B	radial & ulnar arteries
P	palpate between metacarpals & have patient adduct their fingers

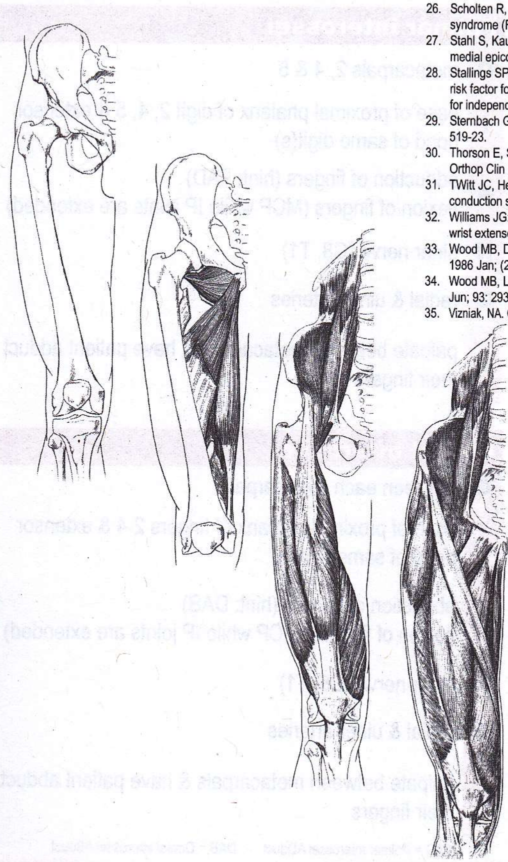


Dorsal interossei

O	between each metacarpal
I	base of proximal phalanx of fingers 2-4 & extensor hood of same digit(s)
A	abduction of fingers (hint: DAB) flexion of fingers (MCP while IP joints are extended)
N	ulnar nerve (C8, T1)
B	radial & ulnar arteries
P	palpate between metacarpals & have patient abduct their fingers

PAD = Palmar interossei ADduct - DAB = Dorsal interossei ABduct

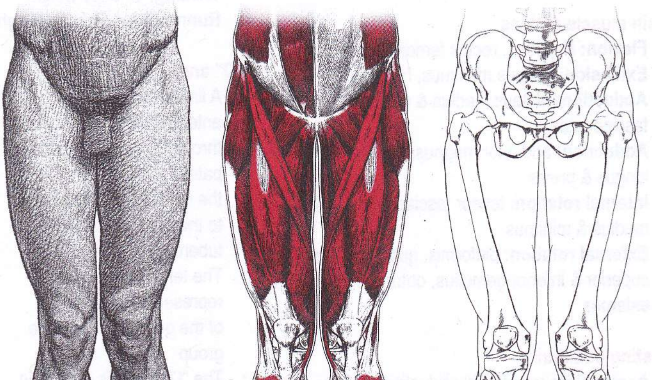
1. Anto C, Aradhya P: Clinical diagnosis of peripheral nerve compression in the upper extremity. Orthop Clin North Am 1996 Apr; 27(2): 227-36.
2. Atroshi I, Gummesson C, Johnsson R, et al: Prevalence of carpal tunnel syndrome in a general population. JAMA 1999 Jul 14; 282(2): 153-8.
3. Atroshi I, Gummesson C, Johnsson R, et al: Severe carpal tunnel syndrome potentially needing surgical treatment in a general population (1). J Hand Surg [Am] 2003 Jul; 28(4): 639-44.
4. Bindra RR, Evanoff BA, Chough LY, et al: The use of routine wrist radiography in the evaluation of patients with carpal tunnel syndrome. J Hand Surg [Am] 1997; 22: 115-119.
5. Borkholder CD, Hill VA, Fess EE: The efficacy of splinting for lateral epicondylitis: a systematic review. J Hand Ther 2004 Apr-Jun; 17(2): 181-99.
6. Bowen RE, Dorey FJ, Shapiro MS: Efficacy of nonoperative treatment for lateral epicondylitis. Am J Orthop 2001 Aug; 30(8): 642-6.
7. Brahme SK, Hodler J, Braun RM: Dynamic MR imaging of carpal tunnel syndrome. Skeletal Radiol 1997 Aug; 26(8): 482-7.
8. Ciccotti MG, Charlton WP: Epicondylitis in the athlete. Clin Sports Med 2001 Jan; 20(1): 77-93.
9. Cyriax JH: The pathology and treatment of tennis elbow. J Bone Joint Surg 1936; 18: 921-40.
10. de Araujo MP: Electrodiagnosis in compression neuropathies of the upper extremities. Orthop Clin North Am 1996 Apr; 27(2): 237-44.
11. G. Sella, Elbow Muscular Relationships: An SEMG View of Muscular Agonism & Antagonism, American Academy of Neurological and Orthopaedic Sugeons (website: www.aanos.org/articles/elbow.pdf) accessed on Jan. 4, 2008.
12. Gerritsen AA, de Vet HC, Scholten RJ: Splinting vs surgery in the treatment of carpal tunnel syndrome: a randomized controlled trial. JAMA 2002 Sep 11; 288(10): 1245-51.
13. Gerritsen AA, Korthals-de Bos IB, Laboyrie PM: Splinting for carpal tunnel syndrome: prognostic indicators of success. J Neurol Neurosurg Psychiatry 2003 Sep; 74(9): 1342-4.



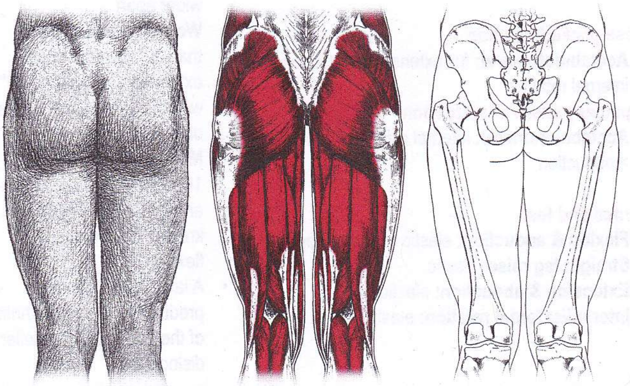
14. Grundberg AB, Reagan DS: Pathologic anatomy of the forearm: intersection syndrome. J Hand Surg [Am] 1985 Mar; 10(2): 299-302.
15. Hilburn JW: General principles and use of electrodiagnostic studies in carpal and cubital tunnel syndromes. With special, attention to pitfalls and interpretation. Hand Clin 1996 May; 12(2): 205-21.
16. Horch RE, Allmann KH, Laubenberger J, et al: Median nerve compression can be detected by magnetic resonance imaging of the carpal tunnel. Neurosurgery 1997 Jul; 41(1): 76-82; discussion 82-3.
17. J.R. Sanudo, R.C. Young and P. Abrahams, Brachioradialis muscle inserting on the third metacarpal, Journal of Anantomy, (Vol 188) p. 733-734, 1996, University of Cambridge, UK.
18. Katz JN, Stirrat CR: A self-administered hand diagram for the diagnosis of carpal tunnel syndrome. J Hand Surg [Am] 1990 Mar; 15(2): 360-3.
19. Kaufman MA: Differential diagnosis and pitfalls in electrodiagnostic studies and special tests for diagnosing compressive neuropathies. Orthop Clin North Am 1996 Apr; 27(2): 245-52.
20. Keles I, Karagulle Kendi AT, Aydin G: Diagnostic precision of ultrasonography in patients with carpal tunnel syndrome. Am J Phys Med Rehabil 2005 Jun; 84(6): 443-50.
21. Kerwin G, Williams CS, Seiler JG III: The pathophysiology of carpal tunnel syndrome. Hand Clin 1996; 12: 243-251.
22. Kulick RG: Carpal tunnel syndrome. Orthop Clin North Am 1996 Apr; 27(2): 345-54.
23. MacDermid JC, Wessel J: Clinical diagnosis of carpal tunnel syndrome: a systematic review. Journal of Hand Therapy 2004; 17: 309-319.
24. O'Connor D, Marshall S, Massy-Westropp N: Non-surgical treatment (other than steroid injection) for carpal tunnel syndrome (Review). The Cochrane Database of Systematic Reviews 2003;.
25. Padua L, Lo Monaco M, Aulisa L, et al: Surgical prognosis in carpal tunnel syndrome: Usefulness of a preoperative neurophysiological assessment. Acta Neurol Scand 1996; 94: 343-346.
26. Scholten R, Bouter LM, Gerritsen AA: Surgical treatment options for carpal tunnel syndrome (Review). The Cochrane Database of Systematic Reviews 2004;.
27. Stahl S, Kaufman T: Ulnar nerve injury at the elbow after steroid injection for medial epicondylitis. J Hand Surg [Br] 1997 Feb; 22(1): 69-70.
28. Stallings SP, Kasdan ML, Soergal TM, et al: A case-control study of obesity as a risk factor for carpal tunnel syndrome in a population of 600 patients presenting for independent medical examination. J Hand Surg [Am] 1997; 22: 211-215.
29. Sternbach G: The carpal tunnel syndrome. J Emerg Med 1999 May-Jun; 17(3): 519-23.
30. Thorson E, Szabo RM: Common tendinitis problems in the hand and forearm. Orthop Clin North Am 1992 Jan; 23(1): 65-74.
31. TWitt JC, Hentz JG, Stevens JC: Carpal tunnel syndrome with normal nerve conduction studies. Muscle Nerve 2004 Apr; 29(4): 515-22.
32. Williams JG: Surgical management of traumatic non-infective tenosynovitis of the wrist extensors. J Bone Joint Surg Br 1977 Nov; 59-B(4): 408-10.
33. Wood MB, Dobyns JH: Sports-related extraarticular wrist syndromes. Clin Orthop 1986 Jan; (202): 93-102.
34. Wood MB, Linscheid RL: Abductor pollicis longus bursitis. Clin Orthop 1973 Jun; 93: 293-6.
35. Vizniak, NA. Gross Anatomy: Human Cadaver Dissections. 1999-2008

Hip & Thigh

Anterior



Posterior



Joint type: synovial
- Gliding (sacroiliac)
- Symphysis (pubic symphysis)
- Ball & socket (acetabulofemoral)

Articular surfaces
- **Sacroiliac:** *concave* (sacrum) *on convex* (ilium)
- **Acetabulofemoral:** *convex* (head of femur) on *concave* (acetabulum)

Hip range of motion
SI Flex/Ext .... ~8°
Flexion (straight leg) **90°**
Flexion (bent leg)..... **120°**
Extension .... **30°**
Internal rotation ..... **40°**
External rotation .... **50°**
Abduction .... **50°**
Adduction .... **30°**
nutation = SI flexion
counter-nutation = SI extension

Main muscle actions
- **Flexion:** iliopsoas, rectus femoris, sartorius
- **Extension:** gluteus maximus, hamstrings
- **Abduction:** gluteus medius & minimus, tensor fasciae latae
- **Adduction:** adductor magnus, gracilis, adductor longus & brevis
- **Internal rotation:** tensor fasciae latae, gluteus medius & minimus
- **External rotation:** piriformis, quadratus femoris, superior & inferior gemellus, obturator internus & externus

Resting position
- **Acetabulofemoral:** 30° abduction, 30° flexion & slight external rotation

Close packed position
- **Acetabulofemoral:** full extension, abduction & internal rotation

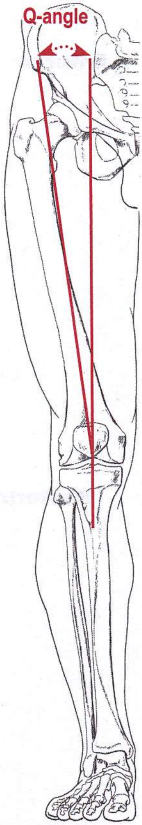
Capsular pattern of restriction
- **Acetabulofemoral:** internal rotation > extension > abduction

Normal end feel
- **Flexion & adduction:** elastic or tissue approx.
- **Straight leg raise:** elastic
- **Extension & abduction:** elastic / firm
- **Internal/external rotation:** elastic / firm

Abnormal end feel
- **Bony** = osteoarthritis
- **Late myospasm** = instability

Hip arthrokinematics
- **Flexion:** femur rolls superior & glides inferior on acetabulum
- **Extension:** femur rolls inferior & glides superior on acetabulum
- **Abduction:** femur rolls lateral/superior & glides inferior on acetabulum
- **Adduction:** femur rolls medial/inferior & glides superior on acetabulum
- **Internal rotation:** femur rolls medial & glides lateral on acetabulum
- **External rotation:** femur rolls lateral & glides medial on acetabulum

Hip joint forces
- **Standing:** 0.3x body weight
- **Standing one leg:** 2.5x body weight
- **Walking:** 3x body weight
- **Running:** > 4.5x body weight



"Q" angle
- A line drawn from the anterosuperior iliac spine through the center of the patella & a line drawn from the center of the patella to the center of the tibial tuberosity
- The term 'Q' is used to represent the main pulll of the quadriceps muscle group
- The "Q" angle is greater in women as the hips are set wider apart
- **Women:** should be less than 22° with the knee extended and less than 9° with the knee in 90 degrees of flexion
- **Men:** should be less than 18° with the knee extended and less than 8° with the knee in 90 degrees of flexion
- A large "Q" angle may predispose to osteoarthritis of the knee and/or patellar dislocation

Joint type: synovial
- Modified hinge (tibiofemoral) - largest & most complex joint in body
- Gliding (patellofemoral)

Articular surfaces
- **Tibiofemoral:** *concave* (tibial plateau) *on convex* (femoral condyles)

Active range of motion
Flexion .... **150°**
Extension .... **0° to -5°**
Internal rotation ...... **5°**
External rotation ..... **5°**

Main muscle actions
- **Flexion:** semitendinosus, semimembranosus, biceps femoris (hamstrings)
- **Extension:** vastus medialis, vastus lateralis, vastus intermedius, rectus femoris (quadriceps)
- **Internal rotation** (tibia)**:** popliteus with pes anserine muscles (knee flexed)
- **External rotation** (tibia)**:** biceps femoris

Resting position
- **Tibiofemoral:** 25° flexion
- **Patellofemoral:** full extension (straight leg)

Close packed position
- **Tibiofemoral:** full extension & external tibial rotation
- **Patellofemoral:** full flexion

Capsular pattern of restriction
- **Tibiofemoral:** flexion > extension

Normal end feel
- **Flexion:** soft tissue or bony approximation
- **Extension:** elastic/firm
- **SLR:** elastic

Abnormal end feel
- **Boggy** = joint effusion; ligamentous pathology
- **Springy block** = loose body (displaced meniscus)

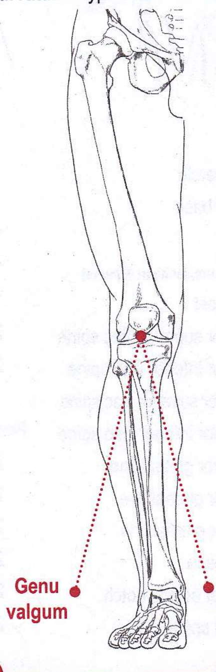
Open kinetic chain
- **Tibiofemoral:**
  Flexion: tibia rolls & glides posterior on femur
  Extension: tibia rolls & glides anterior on femur
- **Patellarfemoral:**
  Flexion: inferior patellar glide on femur
  Extension: superior patellar glide on femur

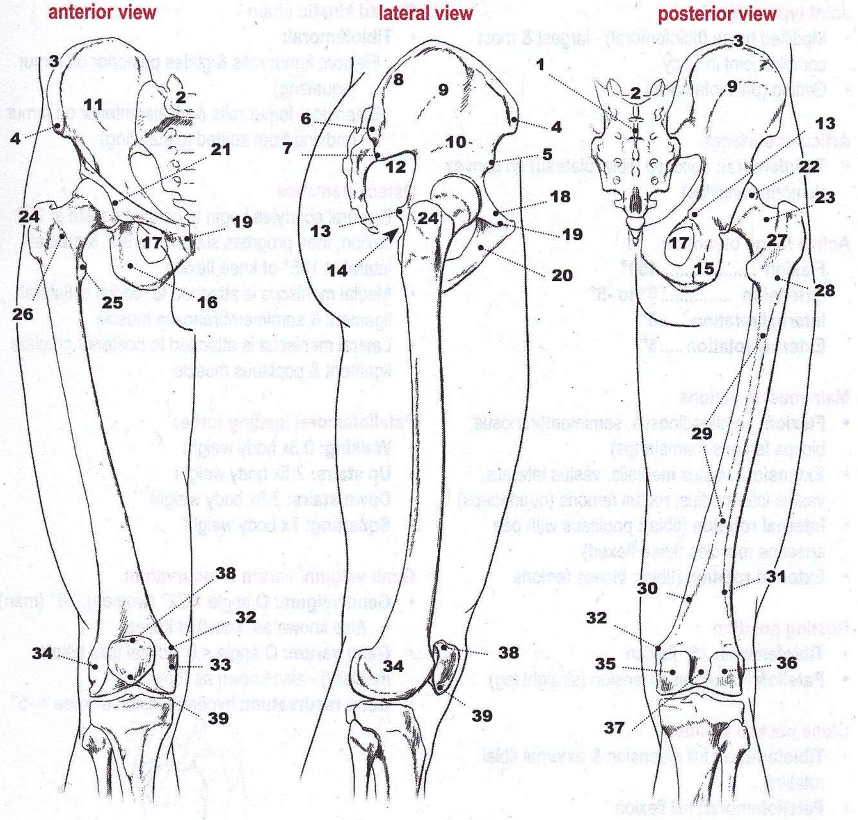
Closed kinetic chain
- **Tibiofemoral:**
  Flexion: femur rolls & glides posterior on femur (squatting)
  Extension: femur rolls & glides anterior on femur (moving from seated to standing)

Osteokinematics
- Femoral condyles begin to contact patella at 20° flexion; then progress superior to 90° & medial/lateral at 135° of knee flexion
- Medial meniscus is attached to medial collateral ligament & semimembranosus muscle
- Lateral meniscus is attached to posterior cruciate ligament & popliteus muscle

Patellofemoral loading forces
- **Walking:** 0.3x body weight
- **Up stairs:** 2.5x body weight
- **Down stairs:** 3.5x body weight
- **Squatting:** 7x body weight

Genu valgum, varum & recurvatum
- **Genu valgum:** Q angle > 22° (women), 18° (men)
  - Also known as “knocked knees”
- **Genu varum:** Q angle < 0° (distal tibia points medially) - also known as “bow legs”
- **Genu recurvatum:** hyperextension of knee > -5°





Sacrum

1. S2 tubercle
2. Sacral base

Os Coxae (ilium, ischium & pubis)

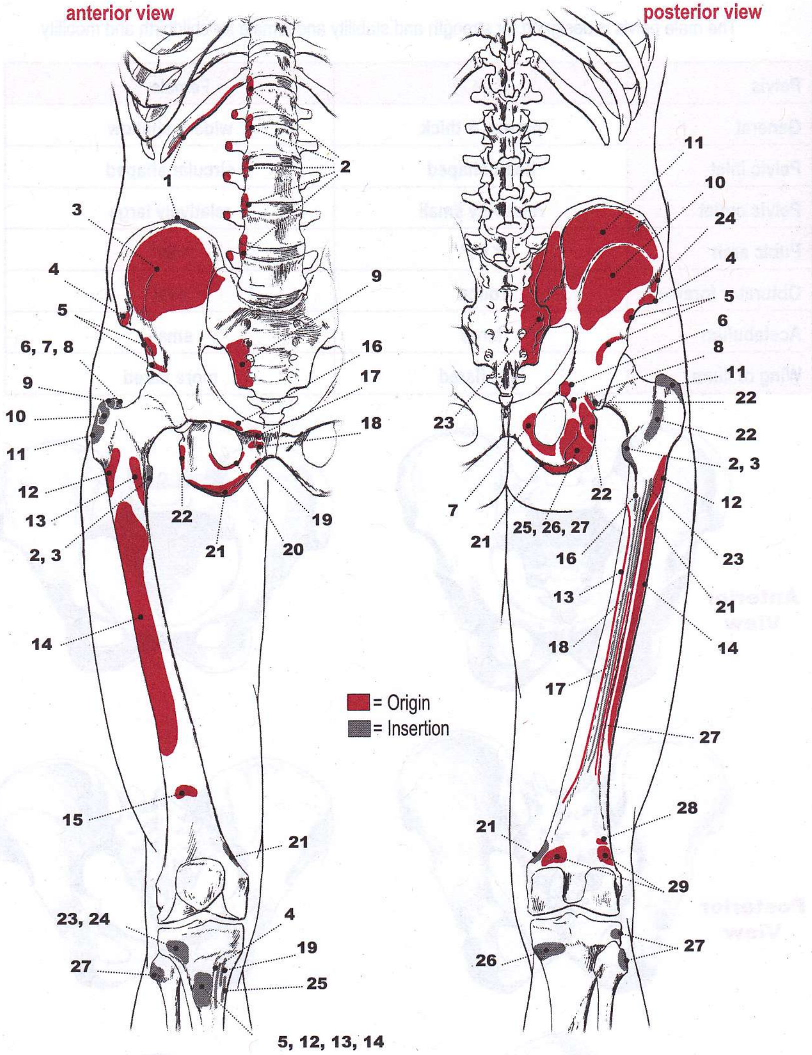
3. Iliac crest
4. Anterior superior iliac spine
5. Anterior inferior iliac spine
6. Posterior superior iliac spine
7. Posterior inferior iliac spine
8. Posterior gluteal line
9. Anterior gluteal line
10. Inferior gluteal line
11. Iliac fossa
12. Greater sciatic notch
13. Ischial spine
14. Lesser sciatic notch
15. Ischial tuberosity
16. Ramus of ischium
17. Obturator foramen
18. Superior pubic ramus
19. Pubic tubercle
20. Inferior pubic ramus
21. Acetabulum

Femur

22. Head
23. Neck
24. Greater trochanter
25. Lesser trochanter
26. Intertrochanteric line
27. Intertrochanteric crest
28. Gluteal tuberosity
29. Linea aspera
30. Medial supracondylar ridge
31. Lateral supracondylar ridge
32. Adductor tubercle
33. Medial epicondyle
34. Lateral epicondyle
35. Medial condyle
36. Lateral condyle
37. Intercondylar fossa

Patella

38. Base
39. Apex



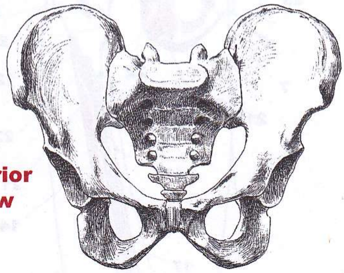
1. Quadratus lumborum
2. Psoas major
3. Iliacus
4. Sartorius
5. Rectus femoris
6. Superior gemellus
7. Obturator internus
8. Inferior gemellus
9. Piriformis
10. Gluteus minimus
11. Gluteus medius
12. Vastus lateralis
13. Vastus medialis
14. Vastus intermedius
15. Articularis genu
16. Pectineus
17. Adductor longus
18. Adductor brevis
19. Gracilis
20. Obturator externus
21. Adductor magnus
22. Quadratus femoris
23. Gluteus maximus
24. Tensor fasciae latae
25. Semitendinosus
26. Semimembranosus
27. Biceps femoris
28. Plantaris
29. Gastrocnemius

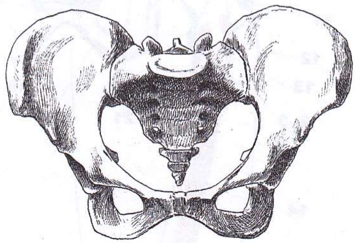
Male vs. Female Pelvis

The male pelvis is designed for strength and stability and female for childbirth and mobility

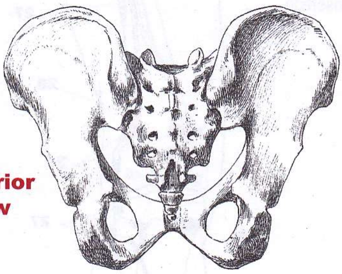
Pelvis	Male ♂	Female ♀
General	narrow & thick	wide & shallow
Pelvic inlet	heart shaped	circular shaped
Pelvic outlet	relatively small	relatively large
Pubic arch	< 60°	> 80°
Obturator foramen	round	oval
Acetabulum	large	small
Wing of ilium	less flared	more flared

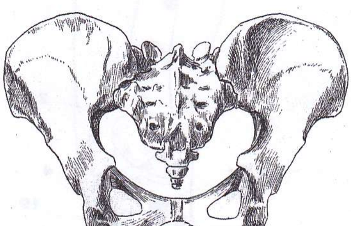
Anterior View



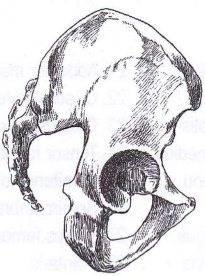


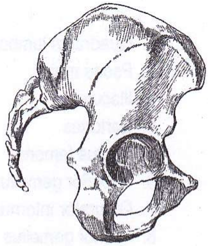
Posterior View

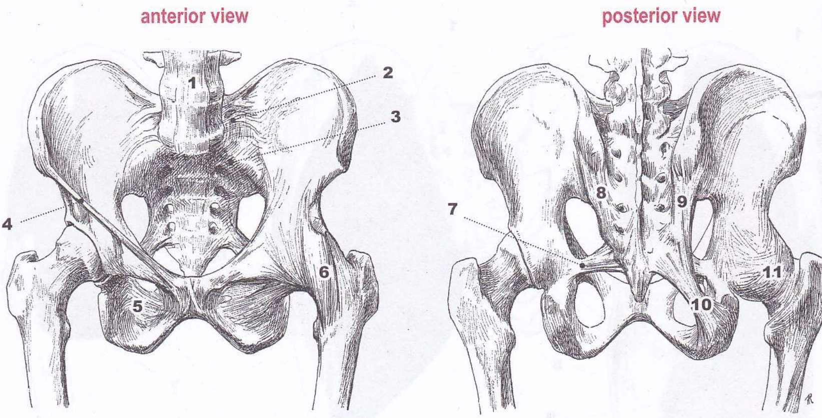




Lateral View





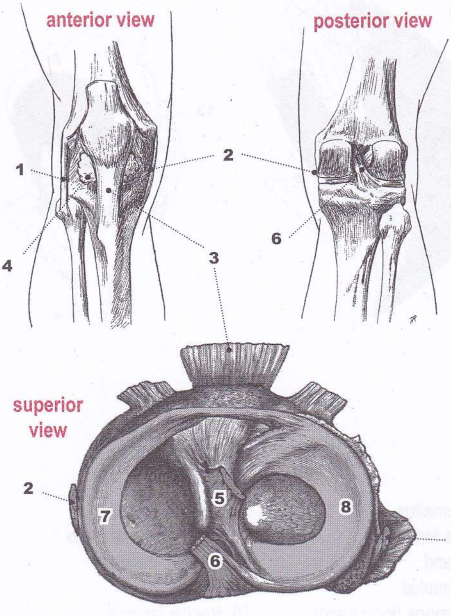


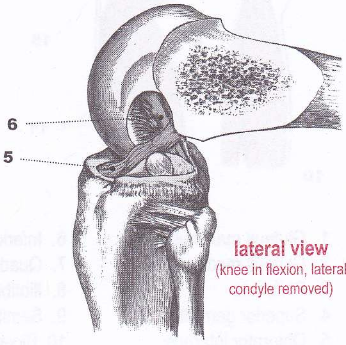
Pelvis & Hip

1. Anterior longitudinal ligament
2. Iliolumbar ligaments
3. Anterior sacroiliac ligaments
4. Inguinal ligament
5. Obturator membrane
6. Iliofemoral ligament
7. Sacrospinous ligament
8. Posterior sacroiliac ligament
9. Long posterior sacroiliac ligament
10. Sacrotuberus ligament
11. Acetabulofemoral joint capsule

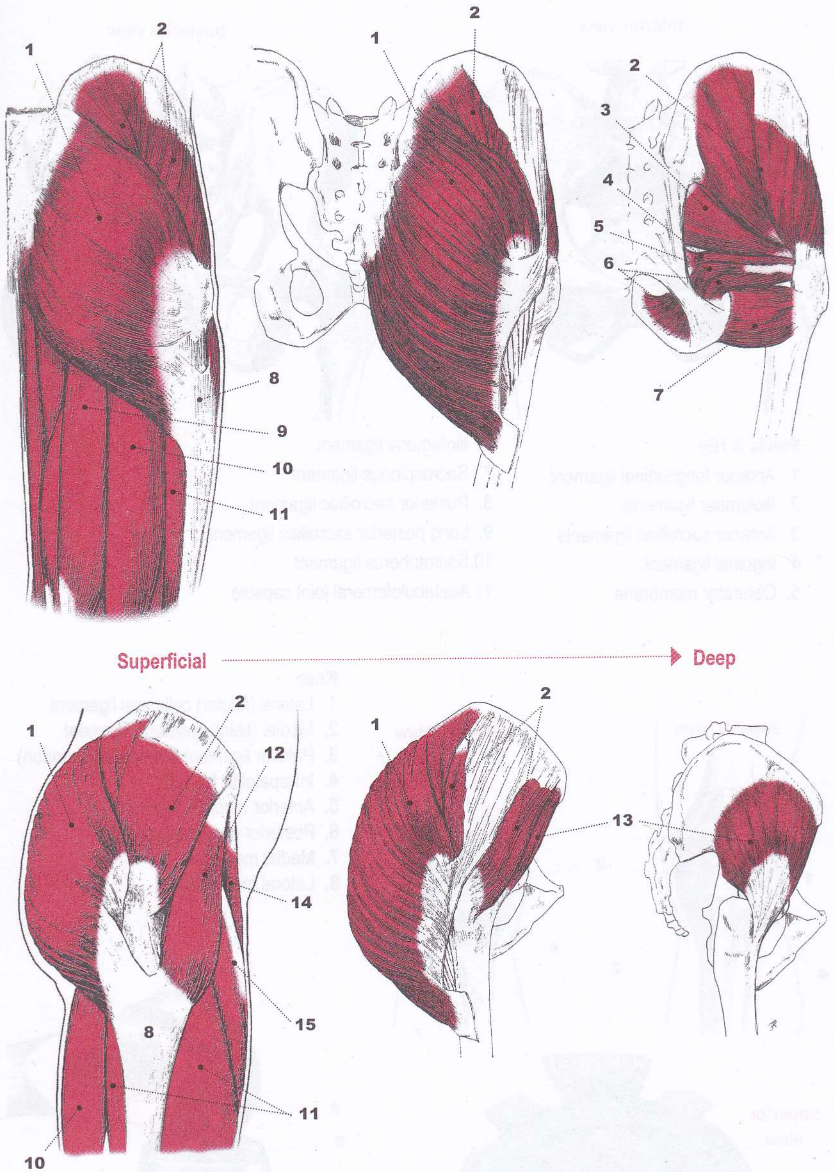
Knee

1. Lateral (fibular) collateral ligament
2. Medial (tibial) collateral ligament
3. Patellar ligament (infrapatellar tendon)
4. Infrapatellar fat pad
5. Anterior cruciate ligament
6. Posterior cruciate ligament
7. Medial meniscus
8. Lateral meniscus

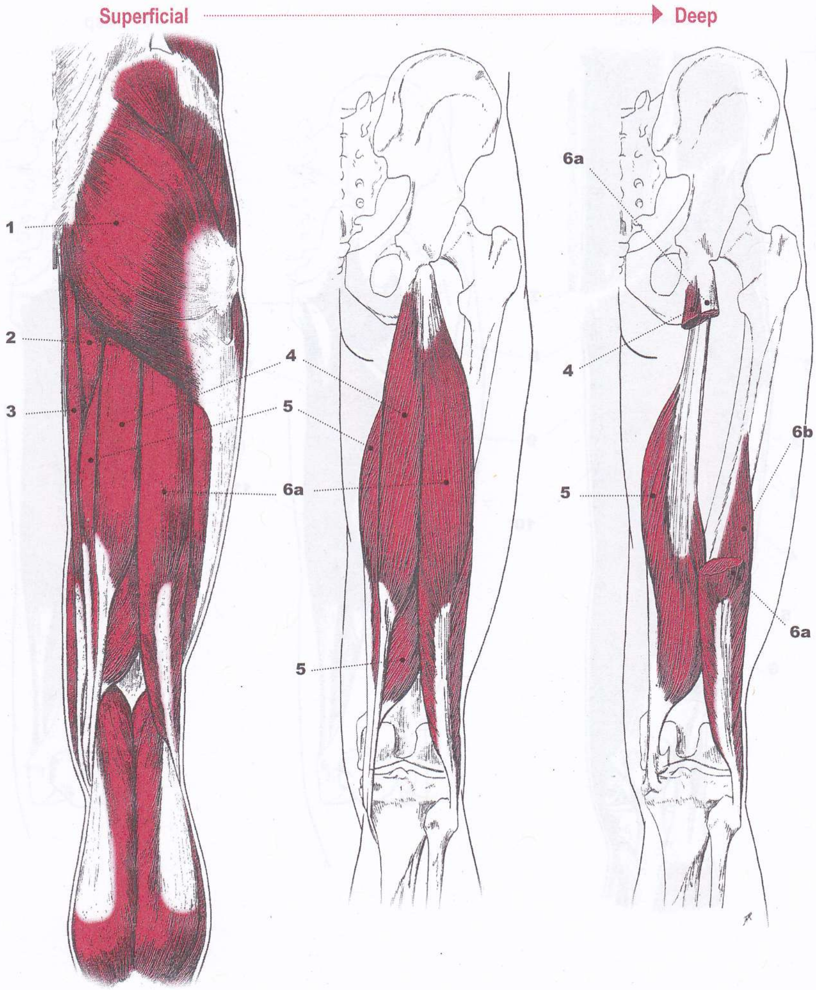




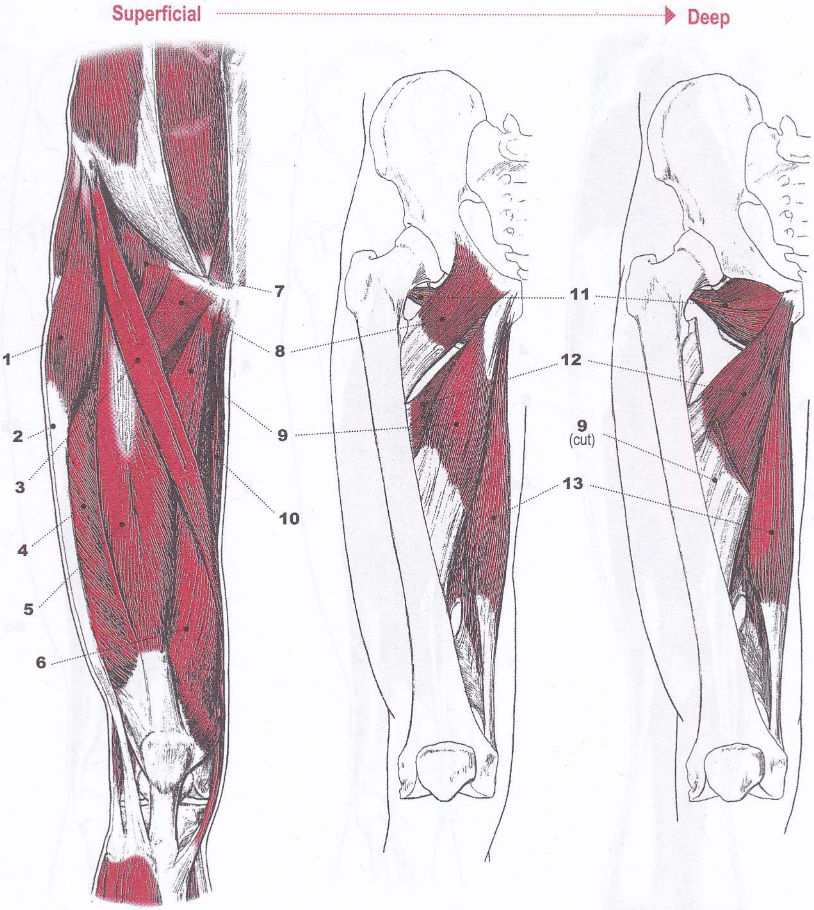
lateral view
(knee in flexion, lateral condyle removed)



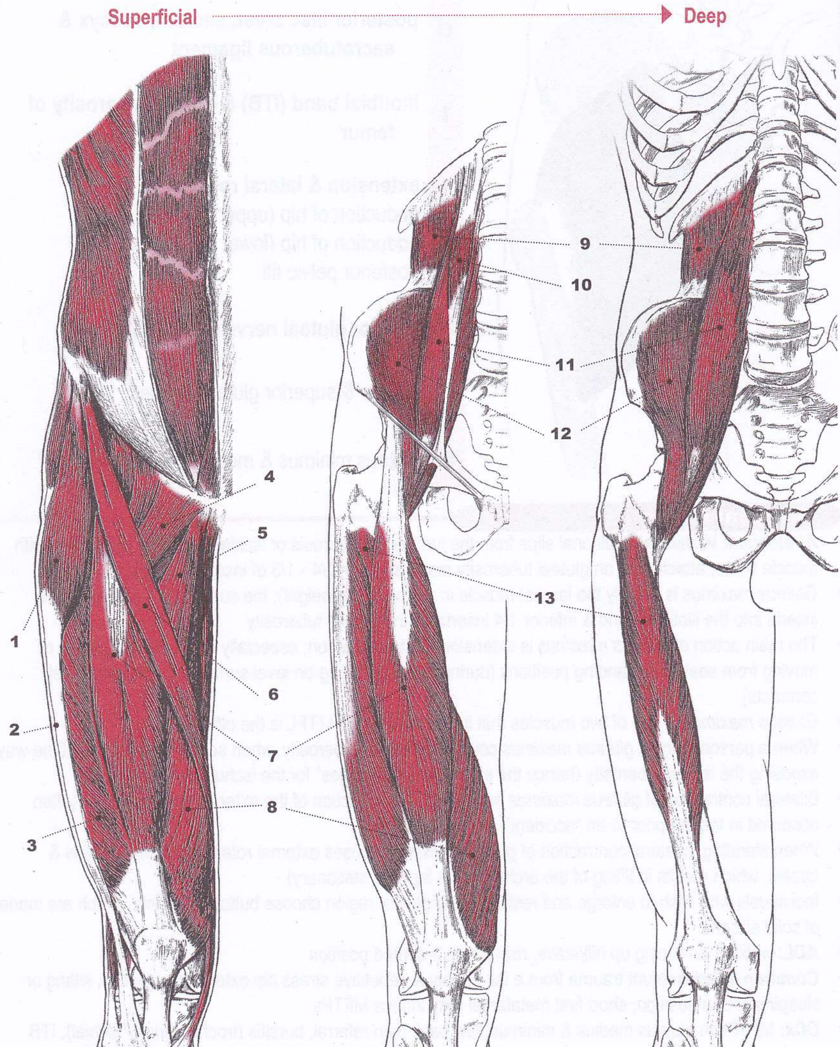
1. Gluteus maximus
2. Gluteus medius
3. Piriformis
4. Superior gemellus
5. Obturator internus
6. Inferior gemellus
7. Quadratus femoris
8. Iliotibial band
9. Semitendinosus
10. Biceps femoris (long head)
11. Vastus lateralis
12. Tensor fasciae latae
13. Gluteus minimus
14. Sartorius
15. Rectus femoris



1. Gluteus maximus
2. Adductor magnus
3. Gracillis
4. Semitendinosus
5. Semimembranosus
6. Biceps femoris
   a. Long head
   b. Short head



1. Tensor fasciae latae
2. Iliotibial band
3. Sartorius
4. Vastus lateralis
5. Rectus femoris
6. Vastus medialis
7. Iliopsoas
8. Pectineus
9. Adductor longus
10. Gracilis
11. Obturator externus
12. Adductor brevis
13. Adductor magnus

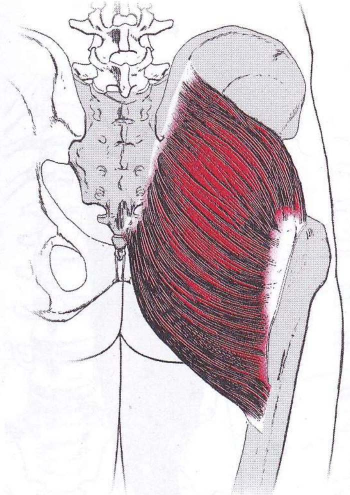


* Quadriceps muscle group

** Iliacus & psoas major together are known as iliopsoas

1. Tensor fasciae latae
2. Iliotibial band
3. Vastus lateralis*
4. Pectineus
5. Adductor longus
6. Sartorius
7. Rectus femoris*
8. Vastus medialis*
9. Quadratus lumborum
10. Psoas minor
11. Psoas major**
12. Iliacus**
13. Vastus intermedius*

Gluteus Maximus



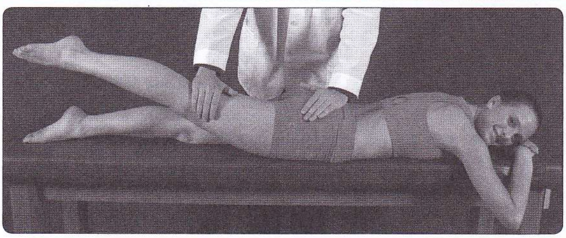
O	**posterior iliac crest, sacrum, coccyx & sacrotuberous ligament**
I	**iliotibial band (ITB) & gluteal tuberosity of femur**
A	**extension & lateral rotation of hip** abduction of hip (upper 1/3) adduction of hip (lower 2/3) posterior pelvic tilt
N	**inferior gluteal nerve** (L5, S1, S2)
B	inferior & superior gluteal arteries
S	gluteus minimus & medius, hamstrings

Clinical Notes

- ***Anatomical Variation:*** additional slips from the lumbar aponeurosis or ischial tuberosity may blend with muscle fibers, attachment on gluteal tuberosity may vary from 1/4 - 1/3 of insertion length
- *Gluteus maximus* is usually the largest muscle in the body (by weight); the superior 3/4 of the muscle inserts into the iliotibial band & inferior 1/4 inserts on the gluteal tuberosity
- The main action of *gluteus maximus* is extension & lateral rotation; especially when climbing stairs or moving from seated to standing positions (during normal walking on level surfaces the muscle barely contracts)
- *Gluteus maximus* is one of two muscles that insert onto the ITB (TFL is the other)
- When a person stands, *gluteus maximus* covers the ischial tuberosity, when seated it slides out of the way exposing the ischial tuberosity (hence the slang term "sits bones" for the ischial tuberosity)
- Bilateral contraction of *gluteus maximus* may assist in contraction of the external anal sphincter (often observed in toddler prior to an "accident" ☺)
- When standing, bilateral contraction of *gluteus maximus* causes external rotation of femurs, tibias & tarsals, which results in lifting of the arches (if the feet are stationary)
- Individuals who wish to enlarge and reshape their gluteal region choose buttock implants, which are made of solid silicone
- ***ADL:*** walking & running up hill/stairs, rising from a seated position
- ***Common injuries:*** blunt trauma from a fall or spank, repetitive stress hip extension activities, sitting or sleeping in one position, short first metatarsal may induce MFTPs
- ***DDx:*** MFTPs in gluteus medius & minimus, low back pain referral, bursitis (trochanteric or ischial), ITB syndrome may involve gluteus maximus, pain referred by the lumbar zygapophyseal (facet) joints (facet syndrome), lumbar, sacroiliac or hip joint dysfunction

Palpation

1. Patient prone
2. Place palpating fingers along fiber direction between lateral sacrum & gluteal tuberosity
3. Ask patient to extend hip
4. Note muscle tissue contraction
5. Palpate from origin to insertion

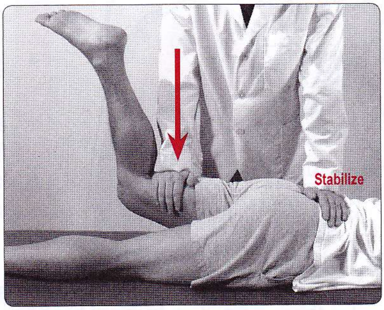


Muscle Test

Patient position
- Prone, knee flexed 90°, hip fully extended

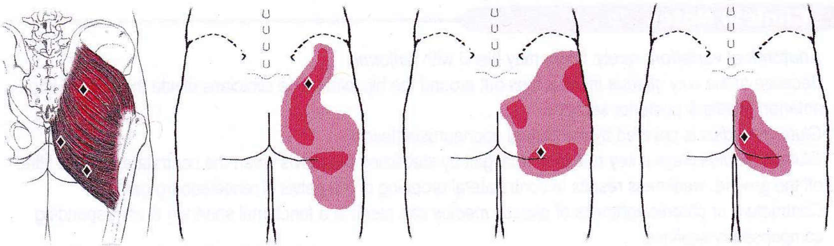
Examiner's force
- Towards hip flexion (down into the table)

Stabilization
- PSIS on opposite side

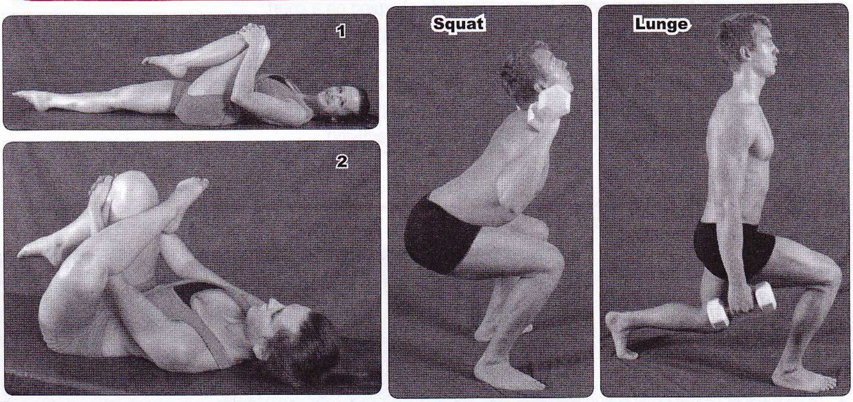


Trigger Point Referral

- MFTPs are usually located in 3 common regions
  - *Adjacent to sacrum*: refers pain to gluteal cleft, gluteal fold & sacroiliac joint
  - *Superior to ischial tuberosity*: refers pain to entire buttock
  - *Medial inferior fibers*: refer pain to coccyx & gluteal cleft



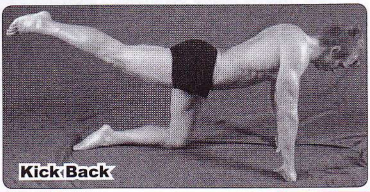
Stretch & Strengthen



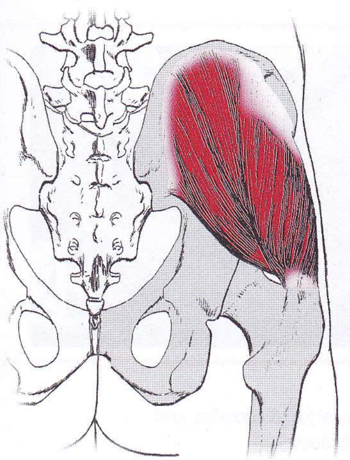
Self Stretch 1:
- Pull knee to chest

Self Stretch 2:
- Cross ankle of other leg over thigh & pull knee to chest (may be done seated, supine or standing)

Strengthen
- Squat
- Kick back
- Lunge
- Step up



Gluteus Medius



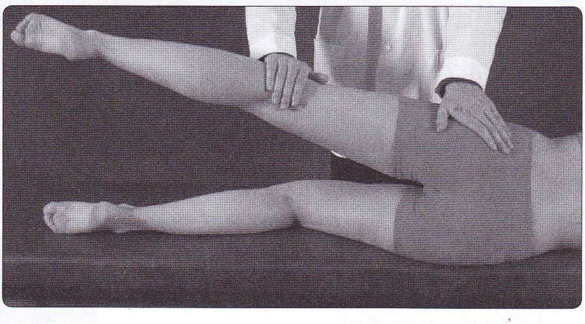
O	**outer ilium** (between anterior & posterior gluteal lines)
I	**greater trochanter** (superior & lateral surface)
A	**abduction of hip** flexion & medial rotation of hip (anterior fibers) lateral rotation & extension of hip (posterior fibers) stabilizes pelvis & prevents free limb from sagging during gait
N	**superior gluteal nerve** (L4, L5, S1)
B	superior gluteal artery
S	gluteus minimus & maximus, TFL

Clinical Notes

- ***Anatomical variation:*** rarely, fibers may blend with *piriformis*
- Because of the way *gluteus medius* fans out around the hip joint some clinicians divide the muscle into anterior, middle & posterior sections
- *Gluteus medius* is covered by the gluteal aponeurosis (fascia)
- *Gluteus medius* plays a key role in normal gait by stabilizing the pelvis when the contralateral leg is lifted off the ground; weakness results in contralateral dropping of the pelvis (Trendelenburg gait)
- Contracture or chronic tightness of *gluteus medius* can result in a functional short leg & corresponding compensatory scoliosis
- *Gluteus medius* is considered to be "the deltoid" of the hip joint because of all its actions
- ***ADL:*** walking & running (maintain level pelvis), side stepping on a court
- ***Common injuries:*** blunt trauma from a fall or impact, repetitive stress hip extension activities, sitting or sleeping in one position
- ***DDx:*** sacroiliac joint dysfunction or pathology, MFTPs in quadratus lumborum, bursitis (subgluteus medius bursa), pain referred by the lumbar zygapophyseal (facet) joints, lumbar, sacroiliac or hip joint pathology pain referral, intermittent claudication (related to muscle activity)

Palpation

1. Patient sidelying or prone
2. Place palpating fingers along fiber direction between iliac crest & greater trochanter
3. Ask patient to abduct hip
4. Note muscle tissue contraction
5. Palpate from origin to insertion



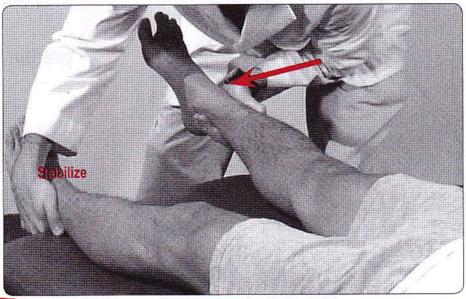
Note: it may be difficult to distinguish gluteus medius fibers from TFL (anterior) & gluteus maximus (posterior)

Muscle Test

Patient position
- Supine, hip flexed 5° & slightly abducted (no rotation)

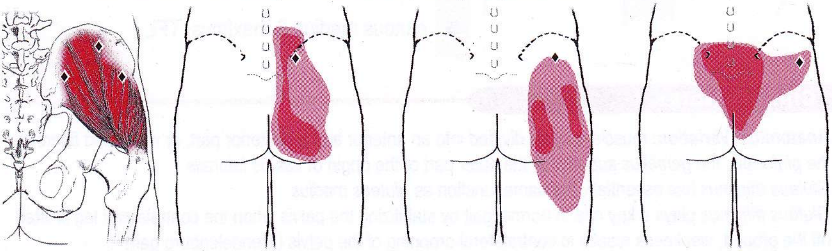
Examiner's force
- Diagonal towards opposite angle (adduction of hip)

Stabilization
- Opposite ankle

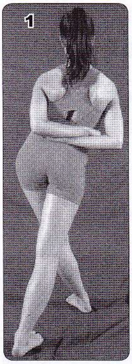


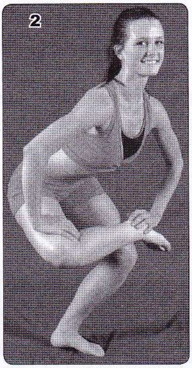
Trigger Point Referral

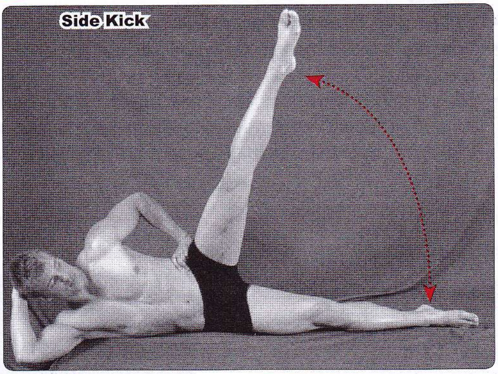
- MFTPs are usually located in 3 common regions
  - *Near PSIS*: refers pain to gluteal cleft, gluteal fold & sacroiliac joint
  - *Mid iliac crest*: refers pain to entire buttock & posterior proximal thigh
  - *Lateral iliac crest*: refer pain over sacrum, coccyx & gluteal cleft



Stretch & Strengthen



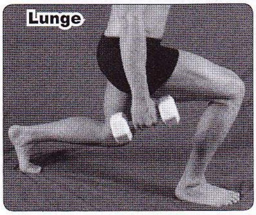




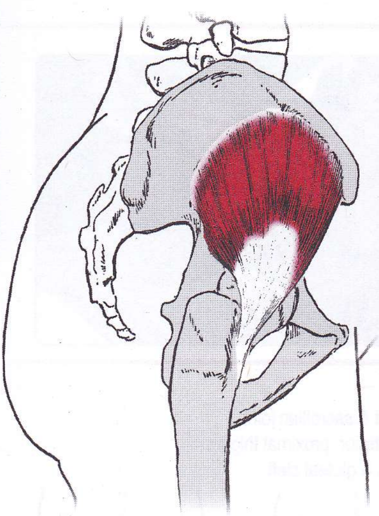
Self Stretch 1:
- Place one leg in front of other & adduct anterior thigh

Self Stretch 2:
- Cross ankle of other leg over thigh & pull knee to chest (may be done seated, supine or standing)

Strengthen
- Resisted thigh abduction
- Lunge
- Side kicks



Gluteus Minimus



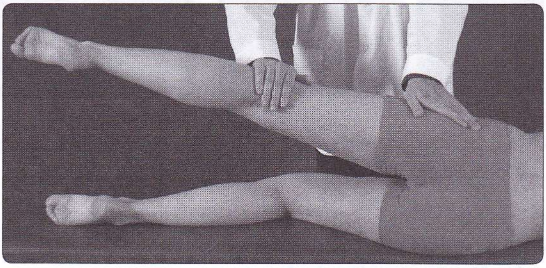
O	**outer ilium** (between anterior & inferior gluteal lines)
I	**greater trochanter** (anterior surface)
A	**abduction of hip** medial rotation & flexion of hip (anterior fibers) lateral rotation & extension (posterior fibers) stabilizes pelvis & prevents free limb from dropping during gait
N	**superior gluteal nerve** (L4, L5, S1)
B	superior gluteal artery
S	gluteus medius & maximus, TFL

Clinical Notes

- ***Anatomical Variation:*** muscle may be divided into an anterior and a posterior part, or may send fibers to the *piriformis*, the *gemellus superior* or the outer part of the origin of *vastus lateralis*
- *Gluteus minimus* has essentially the same function as *gluteus medius*
- *Gluteus minimus* plays a key role in normal gait by stabilizing the pelvis when the contralateral leg is lifted off the ground; weakness results in contralateral dropping of the pelvis (Trendelenburg gait)
- A chronically tight *gluteus minimus* can contribute to a functional short leg & corresponding compensatory scoliosis
- ***ADL:*** walking & running (maintain level pelvis), side stepping on a court
- ***Common injuries:*** blunt trauma from a fall, repetitive stress hip extension activities, sitting or sleeping in one position
- ***DDx:*** sacroiliac joint dysfunction or pathology, MFTPs in quadratus lumborum, trochanteric bursitis, pain referred by the lumbar zygapophyseal (facet) joints, lumbar, sacroiliac or hip joint pathology pain referral, intermittent claudication (related to muscle activity), lumbar disc herniation

Palpation

1. Patient sidelying or prone
2. Place palpating fingers along fiber direction between iliac crest & greater trochanter
3. Ask patient to abduct hip
4. Note muscle tissue contraction
5. Palpate from origin to insertion



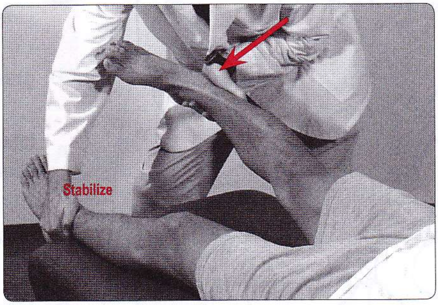
Note: it may be difficult to distingush gluteus minimus fibers from gluteus medius

Muscle Test

Patient position
- Supine, hip flexed 20°, slightly abducted & internally rotated

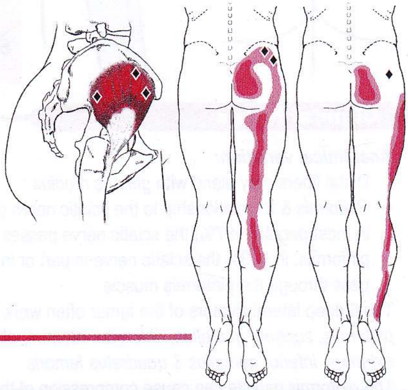
Examiner's force
- Diagonal towards the opposite ankle (adduction & extension of the hip)

Stabilization
- Opposite ankle

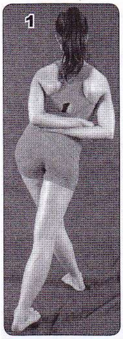


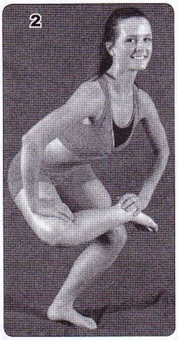
Trigger Point Referral

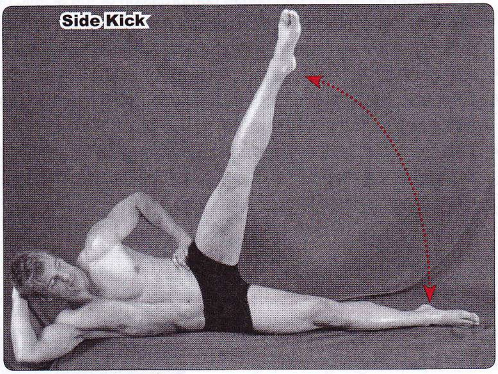
- MFTPs are usually located in 2 common regions
  - *Anterior muscle*; refers pain down lateral leg, thigh & medial buttock
  - *Posterior muscle:* refers pain down the posterior leg, thigh & medial buttock



Stretch & Strengthen



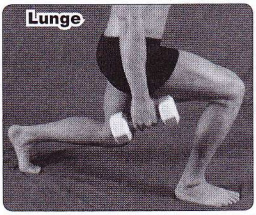




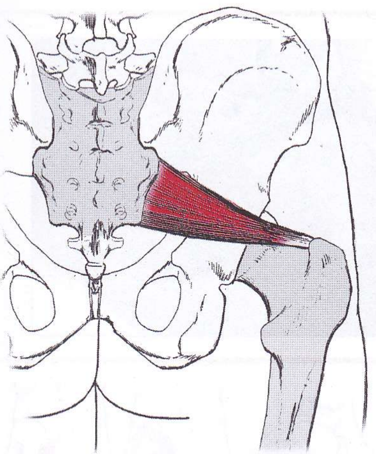
Self Stretch 1:
- Place one leg in front of other & adduct anterior thigh

Self Stretch 2:
- Cross ankle of other leg over thigh & pull knee to chest (may be done seated, supine or standing)

Strengthen
- Resisted thigh abduction
- Lunge
- Side kicks



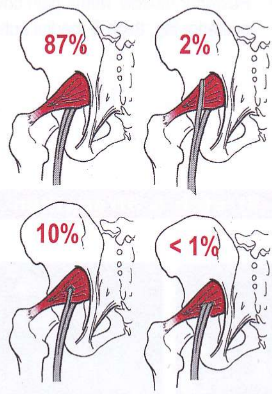
Piriformis



O	**anterior sacrum** (occasionally sacrotuberous ligament)
I	**greater trochanter** (superiomedial surface)
A	**lateral rotation of hip** abduction of hip when thigh is flexed
N	**nerve to piriformis** (L5, **S1**, S2)
B	superior gluteal & inferior gluteal arteries
S	gemellus superior & inferior, obturator internus & externus, quadratus femoris

Clinical Notes

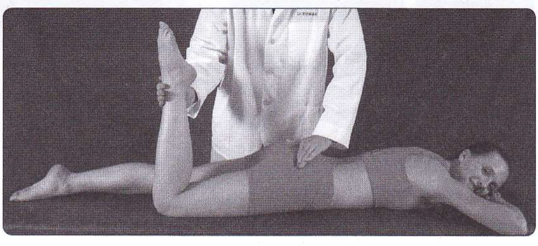
- ***Anatomical variation:***
  - Distal fibers may blend with *gluteus medius*
  - *Piriformis* & its relationship to the sciatic nerve (grey in image); in most people (~87%) the sciatic nerve passes below the piriformis; in ~13% the sciatic nerve in part or in entirety can pass through the piriformis muscle
- The 6 deep lateral rotators of the femur often work together; *piriformis, superior gemellus, obturator internus, obturator externus, inferior gemellus & quadratus femoris*
- The *piriformis* muscle can cause compression of the sciatic nerve resulting in a condition known as piriformis syndrome (sciatica), although a true piriformis syndrome is considered quite rare
- ***ADL:*** walking up stairs, soccer, running & twisting lower body
- ***Common injuries:*** blunt trauma from a fall, piriformis syndrome, sitting or sleeping in one position
- ***DDx:*** sacroiliac joint dysfunction or pathology, MFTPs in quadratus lumborum, bursitis, pain referred by the lumbar zygapophyseal (facet) joints, lumbar, sacroiliac or hip joint pathology pain referral, intermittent claudication (related to muscle activity)



Palpation

1. Patient sidelying or prone
2. Place palpating fingers along fiber direction between PSIS & greater trochanter
3. Ask patient to laterally rotate hip
4. Note muscle tissue contraction
5. Palpate from origin to insertion

Note: piriformis is deep to gluteus maximus

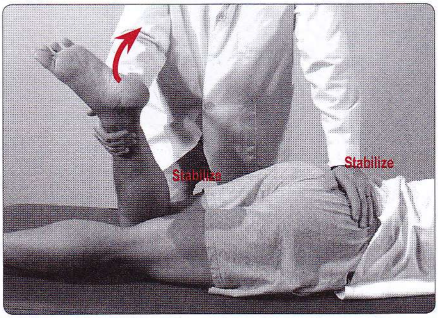


Muscle Test

Patient position
- Prone, knee flexed 90°, femur externally rotated

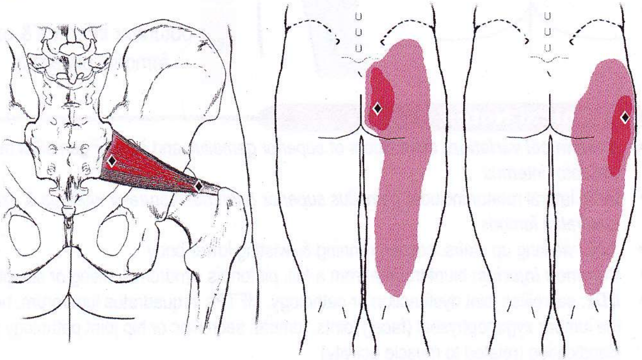
Examiner's force
- Toward internal rotation of femur (pull ankle laterally)

Stabilization
- Patient's lateral knee & PSIS

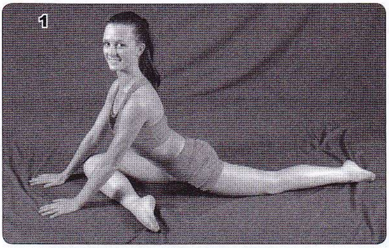


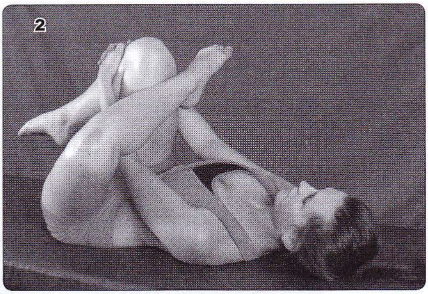
Trigger Point Referral

- MFTPs are usually located in 2 common regions
- *Medial muscle*: refers pain down posterior thigh & medial buttock
- *Lateral muscle:* refers pain down the posterior thigh & lateral buttock



Stretch & Strengthen

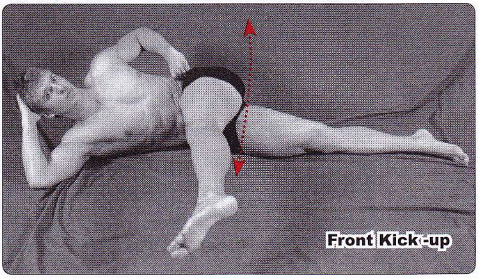




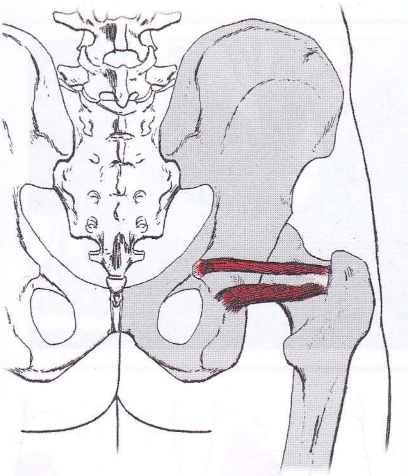
Self Stretch 1:
- Seated, place one leg with knee bent in front of body, extend other leg posteriorly; lean body forward to provide more pressure

Self Stretch 2:
- Cross ankle of other leg over thigh & pull knee to chest (may be done seated, supine or standing)

Strengthen
- Resisted thigh horizontal abduction with hip flexed - Front kick up



Superior & Inferior Gemellus



O *superior:* **ischial spine**
inferior: **ischial tuberosity** (superior aspect)

I **greater trochanter** (medial surface)

A **lateral rotation of hip**
abduction of thigh when hip is flexed

N **nerve to obturator internus** (L5, **S1**, S2)

B inferior gluteal artery

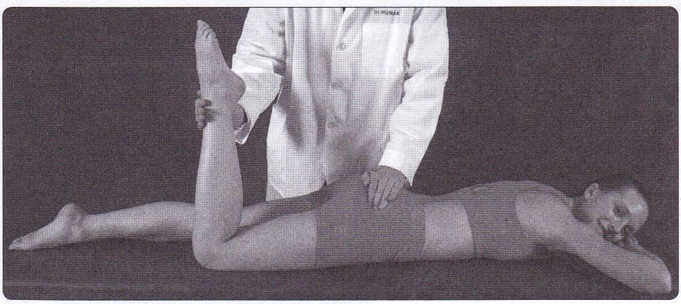
S obturator internus & externus, quadratus femoris, piriformis

Clinical Notes

- ***Anatomical variation:*** distal fibers of *superior gemellus* and *inferior gemellus* may blend with fibers of *obturator internus*
- Deep lateral rotator include: *gemellus superior & inferior, obturator internus & externus, piriformis & quadratus femoris*
- ***ADL:*** walking up stairs, soccer, running & twisting lower body
- ***Common injuries:*** blunt trauma from a fall, piriformis syndrome, sitting or sleeping in one position
- ***DDx:*** sacroiliac joint dysfunction or pathology, MFTPs in quadratus lumborum, bursitis, pain referred by the lumbar zygapophyseal (facet) joints, lumbar, sacroiliac or hip joint pathology pain referral, intermittent claudication (related to muscle activity)

Palpation

1. Patient sidelying or prone
2. Place palpating fingers along fiber direction between inferior sacrum & greater trochanter
3. Ask patient to laterally rotate hip
4. Note muscle tissue contraction
5. Palpate from origin to insertion



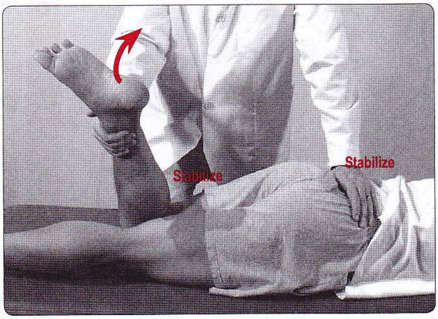
Note: the gemellus muscles are deep to gluteus maximus

Muscle Test

Patient position
- Prone, knee flexed 90°, femur externally rotated

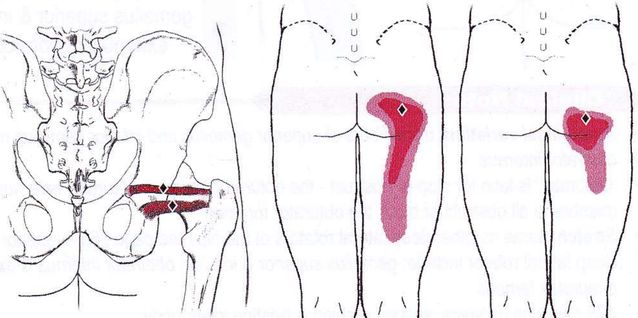
Examiner's force
- Toward internal rotation of femur (pull ankle laterally)

Stabilization
- Patient's lateral knee & PSIS

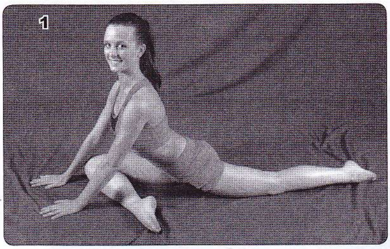


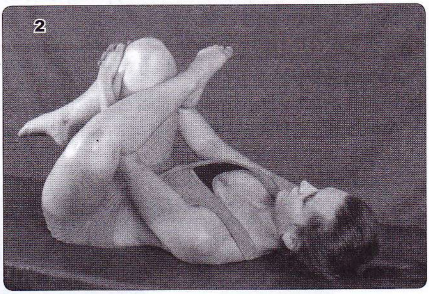
Trigger Point Referral

- MFTPs are usually located in the middle of the muscle bellies
- *Gemellus superior*: refers pain to down posterior thigh & buttock
- *Gemellus inferior:* refers pain down the buttock & upper posterior thigh



Stretch & Strengthen

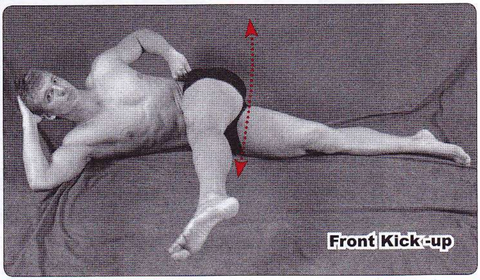




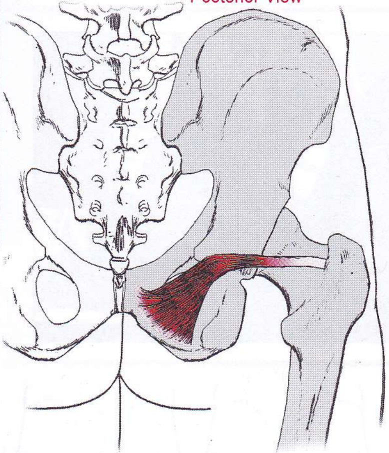
Self Stretch 1:
- Seated, place one leg with knee bent in front of body, extend other leg posteriorly; lean body forward to provide more pressure

Self Stretch 2:
- Cross ankle of other leg over thigh & pull knee to chest (may be done seated, supine or standing)

Strengthen
- Resisted thigh horizontal abduction with hip flexed - Front kick up



Obturator Internus



O	**obturator foramen & obturator membrane** (internal/posterior surface of pelvis)
I	**greater trochanter** (medial aspect)
A	**lateral rotation of hip joint** abduction of thigh when hip is flexed
N	**nerve to obturator internus** (L5, **S1**, S2)
B	inferior gluteal artery
S	gemellus superior & inferior, obturator externus, quadratus femoris, piriformis

Clinical Notes

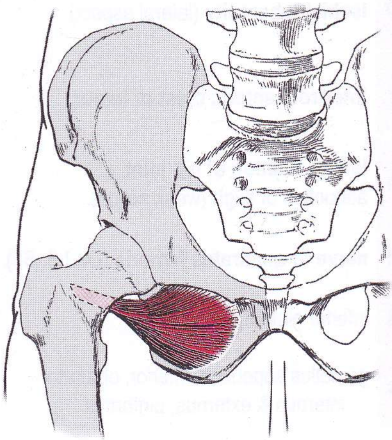
- ***Anatomical variation:*** distal fibers of *superior gemellus and inferior gemellus* may blend with fibers of *obturator internus*
- 'Obturator' is latin for stop or obstruct - the *obturator internus, obturator externus* & the obturator membrane all obstruct or block the obturator foramen
- ***Stretch:*** same as other deep lateral rotators of the hip (see page 265 - superior & inferior gemellus)
- Deep lateral rotator include: *gemellus superior & inferior, obturator internus & externus, piriformis & quadratus femoris*
- ***ADL:*** walking up stairs, soccer, running & twisting lower body
- ***Common injuries:*** blunt trauma from a fall, sitting or sleeping in one position
- ***DDx:*** sacroiliac joint dysfunction or pathology, MFTPs in quadratus lumborum, bursitis, pain referred by the lumbar zygapophyseal (facet) joints, lumbar, SI or hip joint pathology pain referral, intermittent claudication (related to muscle activity)

Palpation

1. Patient sidelying or prone
2. Place palpating fingers along fiber direction just *posterior & superior to ischial tuberosity*
3. Ask patient to laterally rotate hip against resistance
4. Note muscle tissue contraction
5. Palpate from origin to insertion

Note: due to surrounding tissues it may be difficult to distinguish this muscle from other lateral rotators of the hip

Anterior View



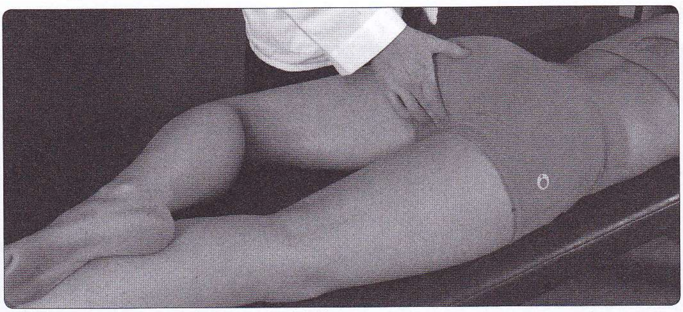
O	**obturator foramen & obturator membrane** (external/anterior surface)
I	**trochanteric fossa of femur**
A	**lateral rotation of hip joint** adduction of thigh (weak action)
N	**obturator nerve** (L2, L3, **L4**)
B	obturator artery

Clinical Notes

- ***Anatomical variation:*** fibers of *obturator externus* may blend with fibers of the capsule of the hip joint
- Being innervated by the obturator nerve makes obturator externus the only deep lateral rotator of the thigh not directly innervated by the lumbosacral plexus
- ***Stretch:*** same as other deep lateral rotators of the hip (see page 265 - superior & inferior gemellus)
- Deep lateral rotator include: *gemellus superior & inferior, obturator internus & externus, piriformis & quadratus femoris*
- ***ADL:*** walking up stairs, soccer, running & twisting lower body
- ***DDx:*** sacroiliac joint dysfunction or pathology, MFTPs in quadratus lumborum, bursitis, pain referred by the lumbar zygapophyseal (facet) joints, lumbar, sacroiliac or hip joint pathology pain referral, intermittent claudication (related to muscle activity)

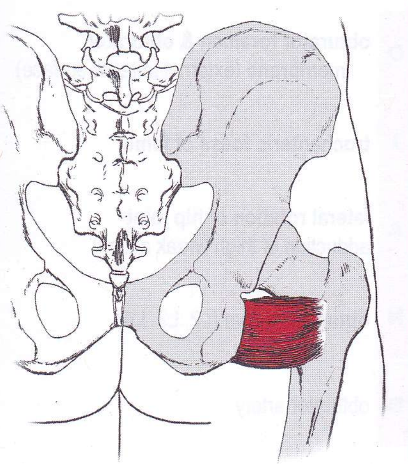
Palpation

1. Patient sidelying or prone
2. Place palpating fingers along fiber direction just *anterior & superior to ischial tuberosity*
3. Ask patient to laterally rotate hip
4. Note muscle tissue contraction
5. Palpate from origin to insertion



Note: due to surrounding tissues it may be difficult to distinguish this muscle from other lateral rotators of the hip

Quadratus Femoris



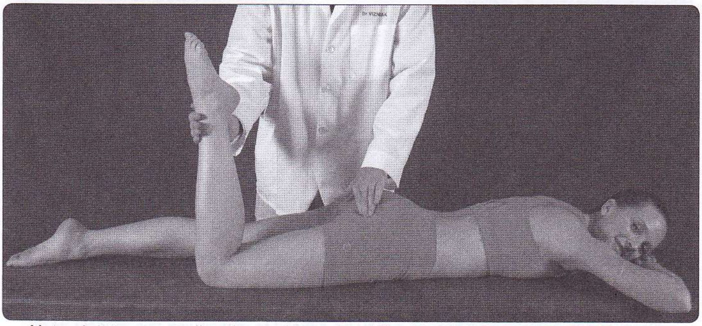
O	**ischial tuberosity** (lateral aspect)
I	**intertrochanteric crest of femur**
A	**lateral rotation of hip joint** adduction of thigh (weak action)
N	**nerve to quadratus femoris** (L4, L5, S1)
B	inferior gluteal artery
S	gemellus superior & inferior, obturator internus & externus, piriformis

Clinical Notes

- ***Anatomical variation:*** *quadratus femoris* is on rare occasions absent & may also blend with the upper fibers of *adductor magnus*
- Deep lateral rotator include: *gemellus superior & inferior, obturator internus & externus, piriformis & quadratus femoris*
- ***ADL:*** walking up stairs, soccer, running & twisting lower body
- ***Common injuries:*** blunt trauma from a fall, piriformis syndrome, sitting or sleeping in one position
- ***DDx:*** sacroiliac joint dysfunction or pathology, MFTPs in quadratus lumborum, bursitis, pain referred by the lumbar zygapophyseal (facet) joints, lumbar, sacroiliac or hip joint pathology pain referral, intermittent claudication (related to muscle activity)

Palpation

1. Patient sidelying or prone
2. Place palpating fingers along fiber direction just lateral to ischial tuberosity & medial to the greater trochanter
3. Ask patient to laterally rotate hip against resistance
4. Note muscle tissue contraction
5. Palpate from origin to insertion



Note: due to surrounding tissues it may be difficult to distinguish this muscle from other lateral rotators of the hip

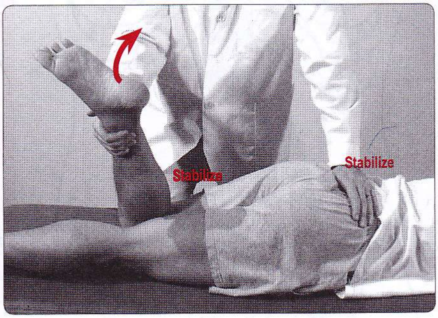
Muscle Test

Patient position
- Prone, knee flexed 90°, femur externally rotated

Examiner's force
- Toward internal rotation of femur (pull ankle laterally)

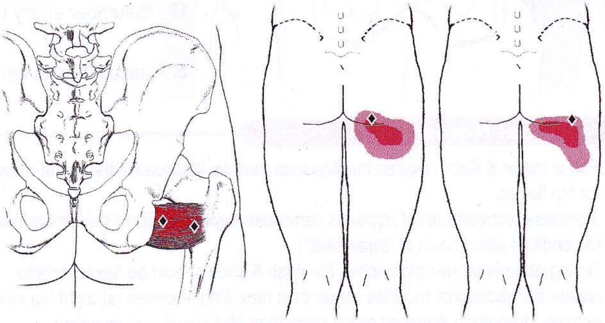
Stabilization
- Patient's lateral knee & PSIS

It is very difficult to individually assess the 6 deep lateral rotators of the thigh - they are clinically tested as a group

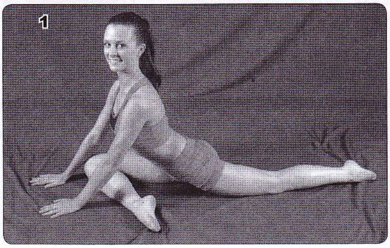


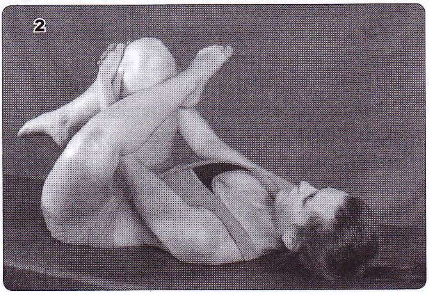
Trigger Point Referral

- MFTPs are usually located near the attachment points of the muscle
- *Medial muscle*: refers pain down buttock & upper posterior thigh
- *Lateral muscle:* refers pain near the gluteal fold & upper posterior thigh



Stretch & Strengthen

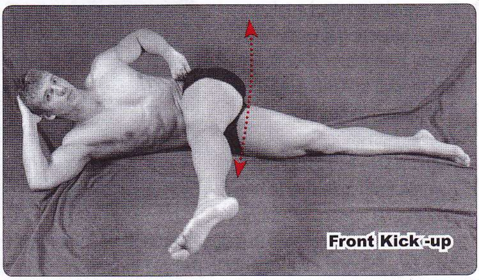




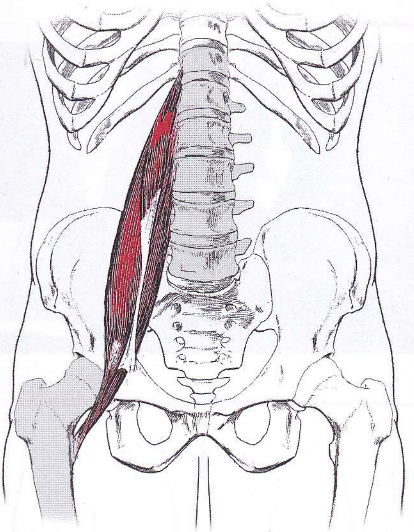
Self Stretch 1:
- Seated, place one leg with knee bent in front of body, extend other leg posteriorly; lean body forward to provide more pressure

Self Stretch 2:
- Cross ankle of other leg over thigh & pull knee to chest (may be done seated, supine or standing)

Strengthen
- Resisted thigh horizontal abduction with hip flexed - Front kick up



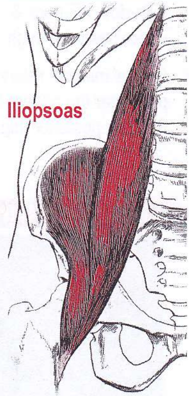
Psoas Major & Minor



Psoas Major

O	**TPs of L1-L5, vertebral bodies of T12-L5 & intervening intervertebral discs**
I	**lesser trochanter of femur**
A	**flexion & lateral rotation of hip** **flexion & lateral flexion of spinal joints** anterior pelvic tilt (hip joint)
N	lumbar plexus ventral rami (L1, L2, L3)
B	iliolumbar artery (branch of internal iliac)
S	iliacus, rectus femoris, pectineus

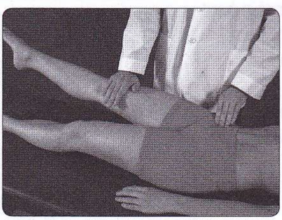
Clinical Notes

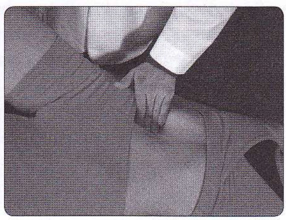


- *Psoas major & iliacus* makes the *iliopsoas* muscle; iliopsoas is the prime mover for hip flexion
- Tightness (contracture) of *iliopsoas* can cause hyperlordosis of the lumbar spine (a condition also known at 'sway back')
- During abdominal sit-up/crunches the thigh & knee should be flexed to help isolate the abdominal muscles rather than recruiting iliopsoas (straight leg sit-ups actually strengthen *iliopsoas* much more than abdominal wall muscles)
- **Psoas minor** (see image above): absent in ~50% of the population; when present it originates from the vertebral bodies of T12-L1, inserts on the pectineal line of pubis, and very weakly assists with flexion of the trunk or posterior pelvic tilt (psoas minor is clinically insignificant)
- ***ADL:*** walking up stairs or up hill, hiking, soccer
- ***Common injuries:*** contracture (anatomical shortening) due to prolonged seated postures (students & office workers), repetitive stress (straight leg sit-ups, climbing steep grade, gymnastics), iliopsoas tendonitis
- ***DDx:*** often associated with low back pain, lumbar, sacroiliac or hip joint dysfunction or pathology pain referral, MFTP from erector spinae or anterior thigh muscles, abdominal or gastrointestinal pathology, intermittent claudication (related to muscle activity)

Palpation

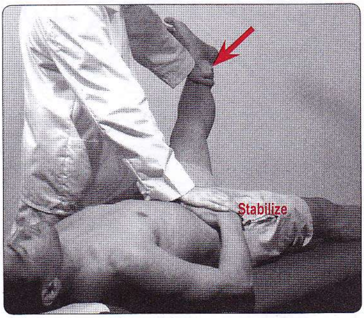
1. Patient sidelying or supine
2. Place palpating fingers gently along fiber direction just medial to ASIS & AIIS
3. Ask patient to flex hip against resistance
4. Note muscle tissue contraction
5. Palpate from insertion to origin





Patient must be relaxed to palpate through abdomen; when palpating toward the origin it may become increasing difficult or impossible to palpate the muscle belly depending on the size & flexibility of the patient

Muscle Test



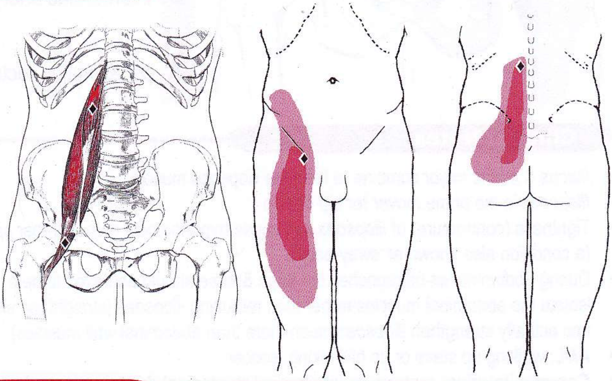
Patient position
- Supine, hip flexed 60°
- Leg abducted & laterally rotated

Examiner's force
- Diagonal medial to lateral, towards hip extension

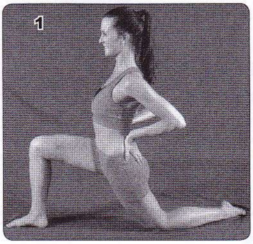
Stabilization
- Examiner stabilizes over patient's opposite ASIS
- Consider having patient cover ASIS with free hand to avoid potential inappropriate contact

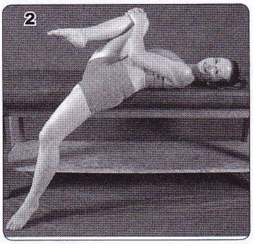
Trigger Point Referral

- MFTPs are usually located in 2 common regions
- *Upper muscle*: refers pain to posterior low back & upper medial buttock
- *Lower muscle:* refers pain down anterior thigh & inguinal region



Stretch & Strengthen

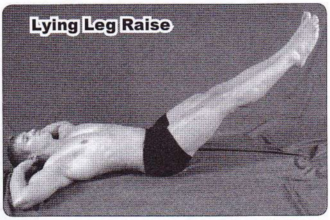


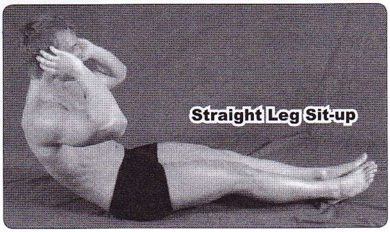


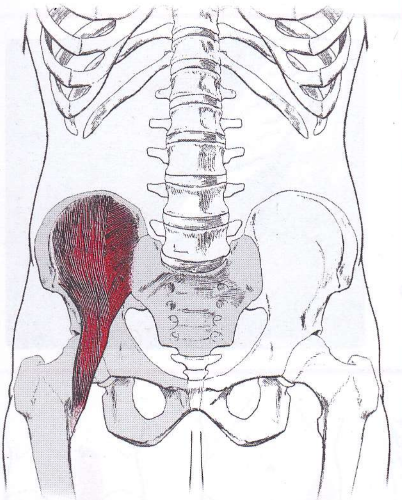
Self Stretch 1:
- While kneeling extend hip & tilt pelvis posteriorly (may also be performed standing)

Self Stretch 2:
- While supine extend hip off the side of bed or table & tilt pelvis posteriorly

Strengthen
- Resisted thigh flexion
- Lying leg raise (knee bent or straight)
- Straight leg sit-up







O **inner surface of iliac fossa & sacral ala**

I **lesser trochanter of femur**

A **flexion & lateral rotation of hip joint**
anterior pelvic tilt

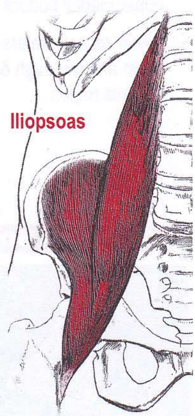
N **femoral nerve** (L2, L3)

B internal iliac artery

S psoas major, rectus femoris, pectineus

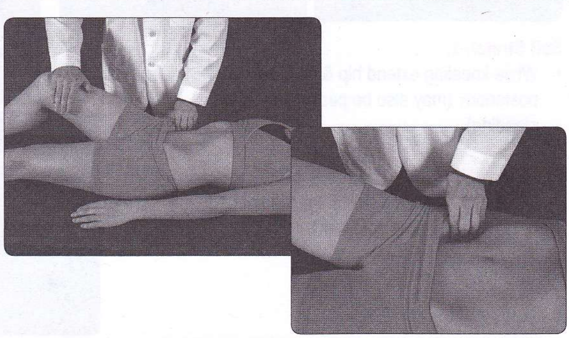
Clinical Notes

- *Iliacus & psoas major* combine to form the iliopsoas muscle
- *Iliopsoas* is the prime mover for hip flexion
- Tightness (contracture) of *iliopsoas* can cause hyperlordosis of the lumbar spine (a condition also known at 'sway-back')
- During abdominal sit-up/crunches the thigh & knee should be flexed to help isolate the abdominal muscles rather than recruiting iliopsoas (straight leg sit-ups actually strengthen *iliopsoas* much more than abdominal wall muscles)
- ***ADL:*** walking up stairs or up hill, hiking, soccer
- ***Common injuries:*** contracture (anatomical shortening) due to prolonged seated postures (students & office workers), repetitive stress (straight leg sit-ups, climbing steep grade, gymnastics), iliopsoas tendonitis
- ***DDx:*** often associated with low back pain, lumbar, sacroiliac or hip joint dysfunction or pathology pain referral, MFTP from erector spinae or anterior thigh muscles, abdominal or gastrointestinal pathology, intermittent claudication (related to muscle activity)



Palpation

1. Patient sidelying or supine
2. Place palpating fingers along fiber direction just medial to ASIS & along internal aspect of iliac crest & fossa
3. Ask patient to flex hip against resistance
4. Note muscle tissue contraction
5. Palpate from origin to insertion

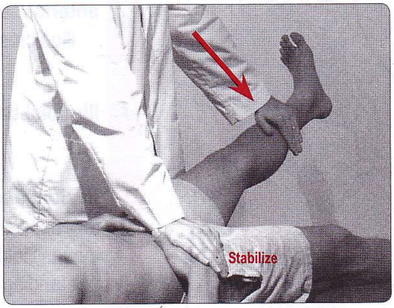


Muscle Test

Patient position
- Supine, hip flexed 30-40°
- Leg laterally rotated (not abducted)

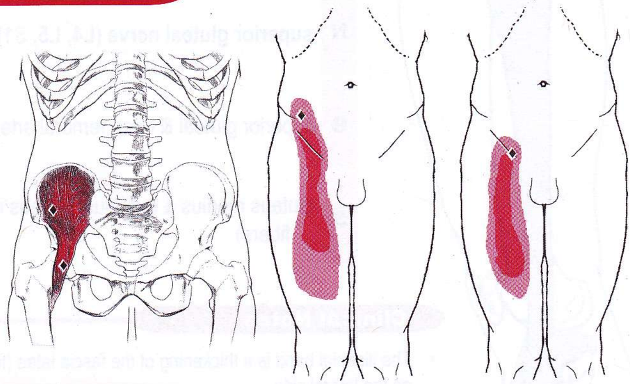
Examiner's force
- Towards hip extension

Stabilization
- Examiner stabilizes over patient's opposite ASIS
- Consider having patient cover ASIS with free hand to avoid potential inappropriate contact

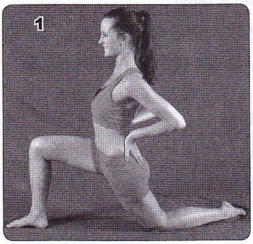


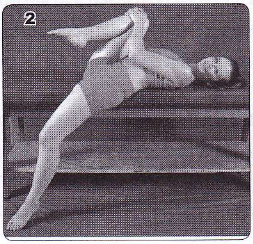
Trigger Point Referral

- MFTPs may be located in the upper muscle & lower muscle, both of which refer pain to the anterior thigh & inguinal region

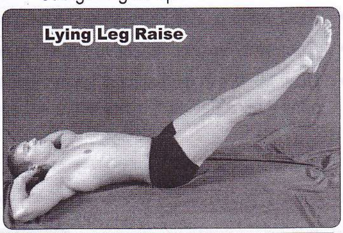


Stretch & Strengthen



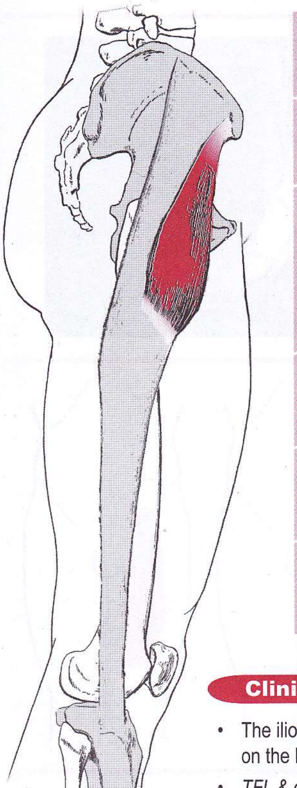


Strengthen
- Resisted thigh flexion
- Lying leg raise (knee bent or straight)
- Straight leg sit-up



Self Stretch 1:
- While kneeling extend hip & tilt pelvis posteriorly (may also be performed standing)

Self Stretch 2:
- While supine extend hip off the side of bed or table & tilt pelvis posteriorly



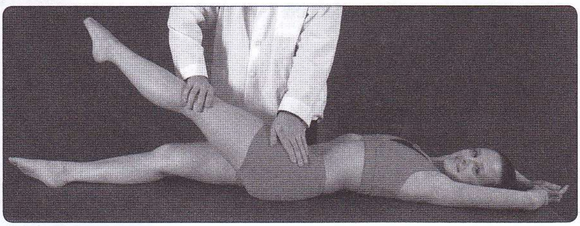
O	**anterior superior iliac spine (ASIS)** & anterior aspect of iliac crest
I	**iliotibial band** (below greater trochanter)
A	**flexion, abduction & medial rotation of hip joint** anterior pelvic tilt tenses iliotibial band to support femur on tibia during standing
N	**superior gluteal nerve** (**L4, L5,** S1)
B	superior gluteal & deep femoral arteries
S	gluteus medius & minimus, gluteus maximus (upper fibers)

Clinical Notes

- The iliotibial band is a thickening of the fascia latae (fascia around the thigh) on the lateral side
- *TFL & gluteus maximus* both insert into the iliotibial band
- The iliotibial band ultimately inserts onto Gerdy's tubercle of the tibia
- TFL has been used in reconstructive surgeries of the deltoid muscle, as the length of the muscle belly & muscle fiber arrangement are similar
- ***ADL:*** walking, side kicks, side-stepping on a court, soccer (side pass), skating
- ***Common injuries:*** repetitive stress hip flexion & abduction activities (running, aerobics), ITB syndrome
- ***DDx:*** MFTPs in gluteal muscles or vastus lateralis, trochanteric bursitis, ITB friction syndrome, meralgia paresthetica (lateral femoral nerve entrapment), lumbar, sacroiliac or hip joint dysfunction

Palpation

1. Patient supine
2. Place palpating fingers along fiber direction posterior & inferior to the ASIS & iliac crest
3. Ask patient to medially rotate hip
4. Note muscle tissue contraction
5. Palpate from origin to insertion

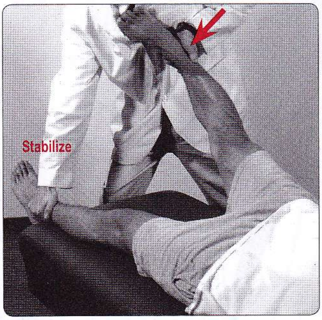


Muscle Test

Patient position
- Supine, hip flexed 45-60°
- Abducted 30° & internally rotated

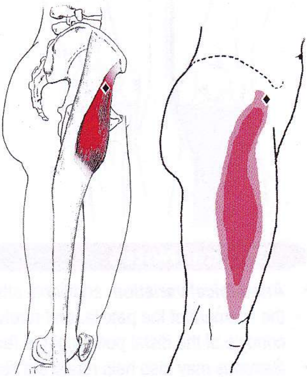
Examiner's force
- Diagonal towards opposite ankle (adduction & extension of hip)

Stabilization
- Opposite ankle

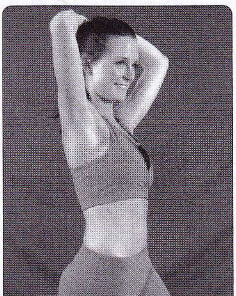


Trigger Point Referral

- Most common MFTP is located in the superior & anterior muscle belly
- Pain is usually referred to the hip joint, down the lateral thigh to the knee



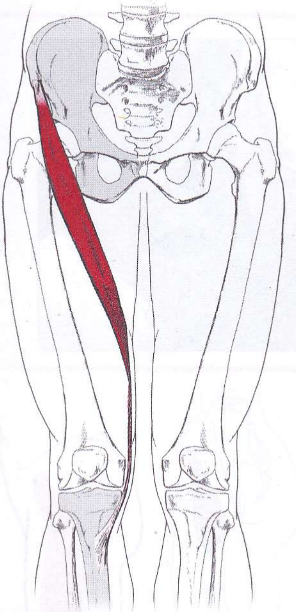
Stretch & Strengthen



Self Stretch:
- Extend, adduct & medially rotate thigh

Strengthen
- Resisted abduction & flexion
- Side lying leg raise (knee bent or straight)
- 45° leg raises
- Figure 8 in air with legs

Sartorius



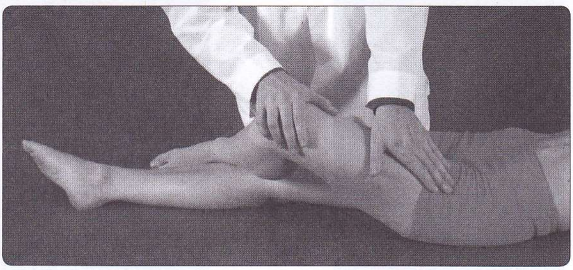
O	**anterior superior iliac spine (ASIS)**
I	**proximal anteromedial tibia** (pes anserine)
A	**flexion, abduction & lateral rotation of hip joint** flexion of knee joint anterior pelvic tilt
N	**femoral nerve** (L2, L3)
B	femoral artery
S	biceps femoris, semitendinosus, semimembranosus, gracilis

Clinical Notes

- ***Anatomical variation:*** additional attachments may extend to the outer end of the inguinal ligament & to the ligament of the patella, and rarely extend to the tendon of the *semitendinosus* muscle, or to the medial condyle of the distal portion of the femur
- *Sartorius* may also help rotate the tibia medially when the knee is flexed
- *Sartorius* is 'notorious' as the longest muscle in the body
- *Sartorius* is also known as the "tailor's muscle;" before the 1900s, when seated cross-legged tailors would use this muscles actions extensively while producing their goods
- The pes anserine (goose foot) is the insertion point for 3 muscles: *sartorius, gracilis & semitendinosus*
- ***ADL:*** sitting cross-legged, soccer, ballet, skating
- ***Common injuries:*** overstretched due to excessive force into hip extension, 'Hip pointer" - contusion of ASIS, avulsion fractures from ASIS
- ***DDx:*** rarely is the sartorius the only pain generator, vastus medialis MFTP (especially when examining lower sartorius), meralgia paresthetica (lateral femoral nerve entrapment), ASIS avulsion fracture, lumbar, sacroiliac, hip or knee joint dysfunction

Palpation

1. Patient supine with leg in figure-4 position
2. Place palpating fingers along fiber direction just inferior & medial to the ASIS
3. Ask patient to flex & laterally rotate their hip
4. Note muscle tissue contraction
5. Palpate from origin to insertion

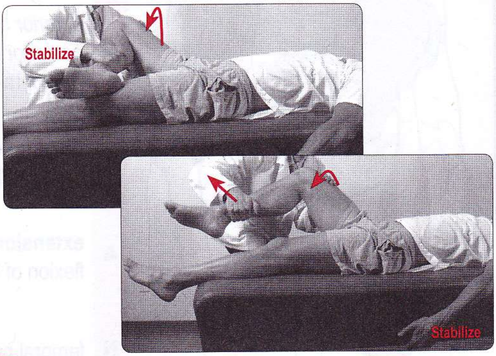


Muscle Test

Patient position
- Supine, leg in "figure-4" position

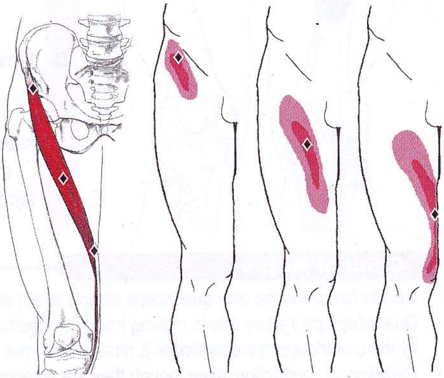
Examiner's force
- Toward adduction & internal rotation, & secondarily toward knee extension & hip extension

Stabilization
- Patient stabilizes by gripping side of examination table

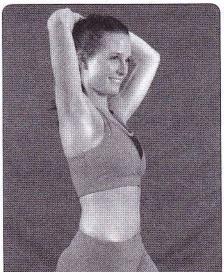


Trigger Point Referral

- MFTPs are usually located in 3 common regions
  - *Upper muscle*: refers pain to the upper anterior thigh & inguinal region
  - *Middle muscle:* refers pain over the anterior middle thigh
  - *Lower muscle:* refers pain over medial thigh and knee

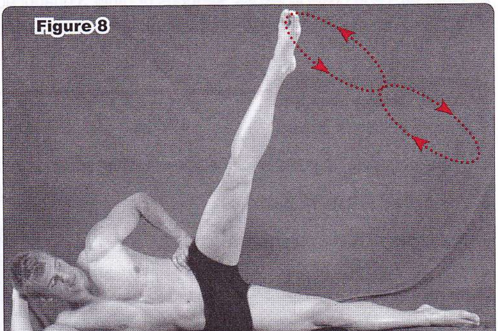


Stretch & Strengthen

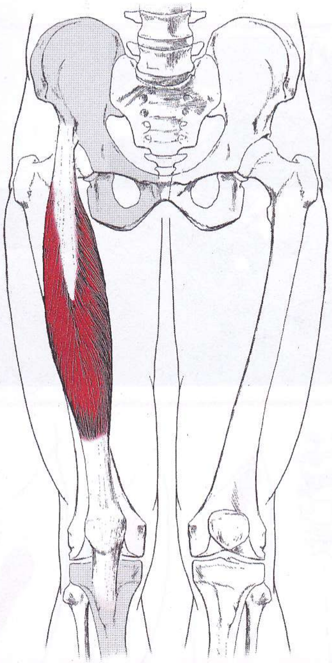


Self Stretch:
- Extend, adduct & medially rotate thigh

Strengthen
- Resisted abduction & flexion
- Side lying leg raise (knee bent or straight)
- 45º leg raises
- Figure 8 in air with legs



Rectus Femoris



O *anterior head:* **anterior inferior iliac spine (AIIS)**
posterior head: **superior to rim of acetabulum** (supra-acetabular groove)

I **tibial tuberosity** (via common quadriceps tendon & patellar ligament)

A **extension of knee**
flexion of hip

N femoral nerve (L2 , **L3, L4**)

B femoral artery

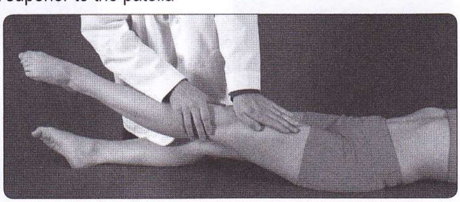
S *knee extension:* vastus intermedius, vastus medialis & lateralis
hip flexion: iliopsoas, pectineus, sartorius

Clinical Notes

- *Rectus femoris* is the only quadriceps muscle to act at two joints (hip & knee)
- Quadriceps play a key role in moving from a seated to a standing position; straightening of the leg is done by the quadriceps; the quadriceps & gluteus maximus are considered 'anti-gravity' muscles
- *Paradoxical contraction:* even though they are antagonists the hamstring muscles and quadriceps contract at the same time when moving from and to a seated position; this allow for increased stability of the knee
- *Rectus femoris contracture test:* have the patient supine with hip and knee off the side of the table; if the knee is straight it signifies tightness of the muscle, if the knee is bent then no contracture is indicated (see Physical Assessment Handbook for details)
- ***ADL:*** walking up stairs, rising from a seated position, cycling, skiing, all jumping sports
- ***Common injuries:*** quadriceps strain - overstretched due to excessive force into hip extension or knee flexion, contusion (blunt force trauma)
- ***DDx:*** MFTP in distal iliopsoas, sartorius or other 3 quadriceps, lumbar, SI, hip, knee joint pathology or dysfunction, meralgia paresthetica (lateral femoral nerve entrapment), patellar tracking dysfunction

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction just superior to the patella
3. Ask patient to extend their knee
4. Note muscle tissue contraction
5. Palpate from insertion to origin

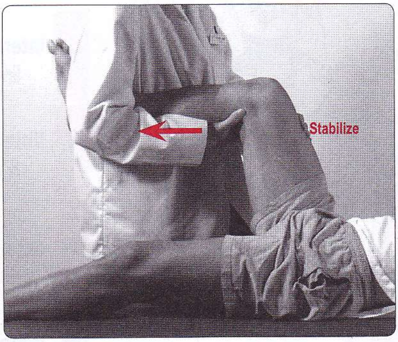


Muscle Test

Patient position
- Supine, hip & knee flexed 90°

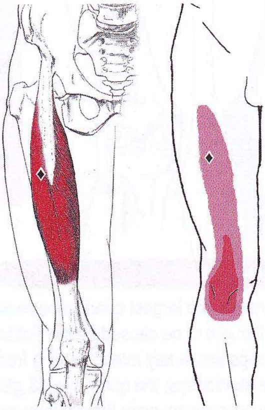
Examiner's force
- Towards hip & knee extension

Stabilization
- Distal thigh, patient stabilizes by gripping side of examination table



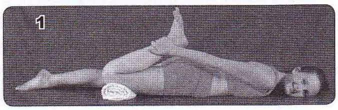
Trigger Point Referral

- MFTPs are usually located in the upper 1/3 of the muscle belly
- Generally pain is referred over anterior distal thigh & over the patella

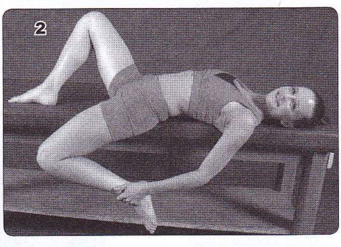


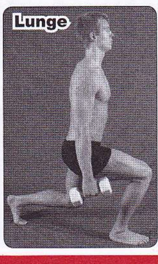
Stretch & Strengthen

Self Stretch 1:
- Lying prone, place pad under flexed knee & extend hip

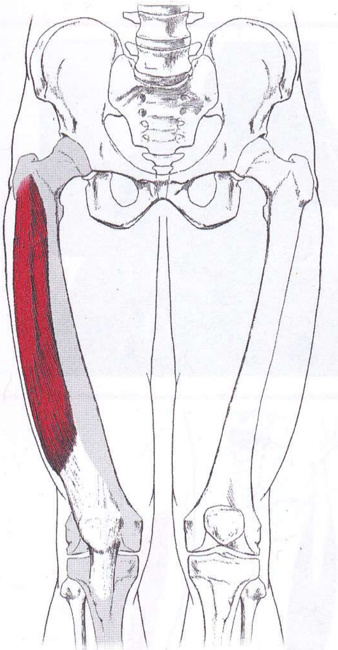


Self Stretch 2:
- Lying supine, flex knee, extend hip & posteriorly tilt pelvis; ipsilateral hand may be used to apply over pressure
- Because rectus femoris crosses the hip joint, both hip extension & posterior pelvic tilt are needed to preferentially stretch the muscle





Strengthen
- Resisted knee extension
- Squat
- Lunge
- Split squat
- Step up



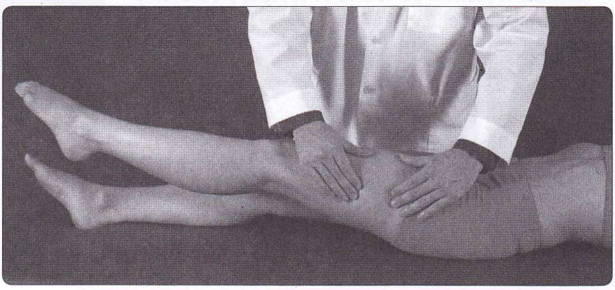
O	**lateral lip of linea aspera** (also intertrochanteric line & lateral intermuscular septum)
I	**tibial tuberosity** (via common quadriceps tendon & patellar ligament)
A	**extension of knee joint**
N	**femoral nerve** (L2 , **L3, L4**)
B	femoral artery
S	rectus femoris, vastus intermedius, vastus medialis

Clinical Notes

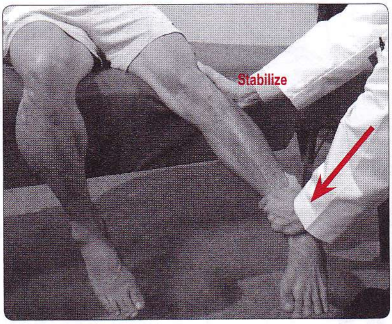
- *Vastus lateralis* is the largest quadriceps muscle
- Often pain thought to be caused by the iliotibial band may be due to tightness of *vastus lateralis*
- The quadriceps play a key role in moving from a seated to a standing position; straightening of the leg is done by the quadriceps; the quadriceps & *gluteus maximus* are considered 'anti-gravity' muscles
- *Paradoxical contraction:* even though they are antagonists the hamstring muscles and quadriceps contract at the same time when moving from and to a seated position; this allow for increased stability of the knee
- Fibers of *vastus lateralis* & the iliotibial band (ITB) fan out to form the lateral patellar retinaculum
- ***ADL:*** walking up stairs, rising from a seated position, cycling, skiing, all jumping sports
- ***Common injuries:*** quadriceps strain - overstretched due to excessive force into hip extension or knee flexion, contusion (blunt force trauma); decreased quadricep flexibility or strength may cause knee instability
- ***DDx:*** MFTP in distal iliopsoas, sartorius or other 3 quadriceps, lumbar, SI, hip, knee joint pathology or dysfunction, meralgia paresthetica (lateral femoral nerve entrapment), patellar tracking dysfunction

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction over lateral thigh
3. Ask patient to extend their knee
4. Note muscle tissue contraction
5. Palpate from insertion to origin



Muscle Test



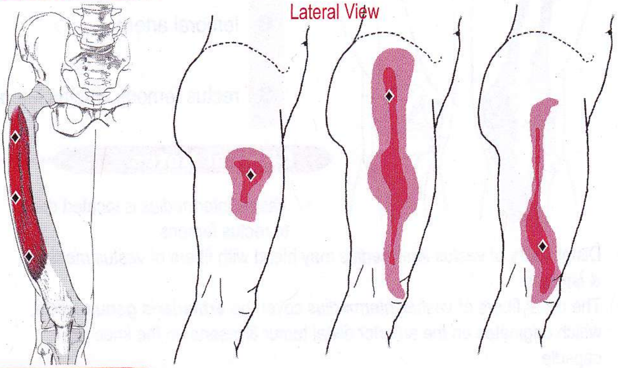
Patient position
- Seated, knee flexed 30°-40°
- Tibia internally rotated

Examiner's force
- Towards knee flexion

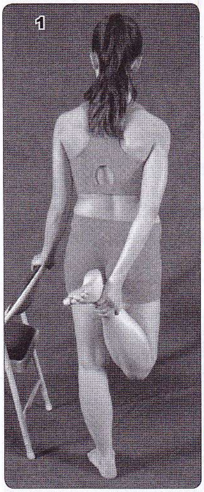
Stabilization
- Posterior knee, consider gently palpating muscle with thumb

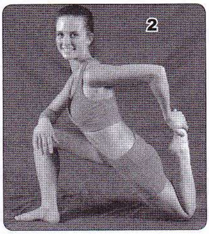
Trigger Point Referral

- MFTPs may be located anywhere in the muscle belly
- Generally pain is referred over the lateral thigh, both superiorly & inferiorly from the site of the MFTP



Stretch & Strengthen

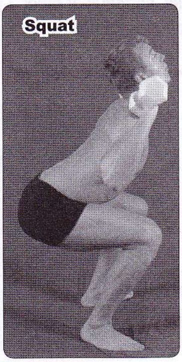


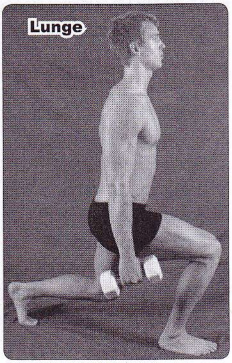


Self Stretch 1:
- Standing, pull ankle to buttock (consider pulling leg medially to further stretch lateral fibers)

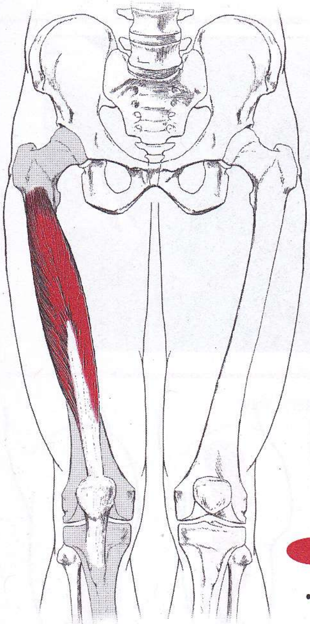
Self Stretch 2:
- While kneeling, flex knee

Strengthen
- Resisted knee extension
- Squat
- Lunge
- Split squat
- Step up





Vastus Intermedius



O **anterior lateral surface of femur**

I **tibial tuberosity** (via common quadriceps tendon & patellar ligament)

A **extension of knee**

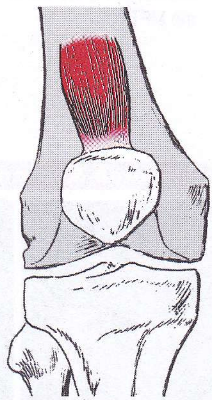
N **femoral nerve** (L2 , **L3, L4**)

B femoral artery

S rectus femoris, vastus lateralis, vastus medialis

Clinical Notes

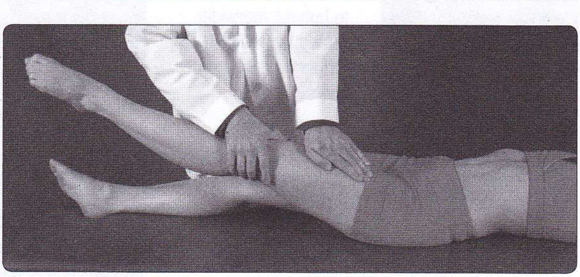
Articularis Genu



- *Vastus intermedius* is located deep to rectus femoris
- Distal fibers of *vastus intermedius* may blend with fibers of *vastus medialis & lateralis*
- The distal fibers of *vastus intermedius* cover the ***articularis genu*** muscle, which originates on the anterior distal femur & inserts on the knee joint capsule
  - The action of *articularis genu* is to pull the knee joint capsule out of the joint during knee extension
  - Articularis *genu muscle* is sometimes a distinct muscle or may blend with the distal fibers *vastus intermedius*
- ***ADL:*** walking up stairs, rising from a seated position, cycling, skiing, all jumping sports
- ***Common injuries:*** quadriceps strain - overstretched due to excessive force into hip extension or knee flexion, contusion (blunt force trauma); decreased quadricep flexibility or strength may cause knee instability
- ***DDx:*** MFTP in distal iliopsoas, sartorius or other 3 quadriceps, lumbar, SI, hip, knee joint pathology or dysfunction, meralgia paresthetica (lateral femoral nerve entrapment), patellar tracking dysfunction

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction just proximal to patella
3. Ask patient to extend their knee, & palpate deep to rectus femoris
4. Note muscle tissue contraction
5. Palpate from insertion to origin

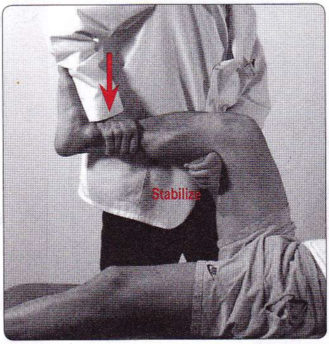


Muscle Test

Patient position
- Supine, hip & knee flexed 90°

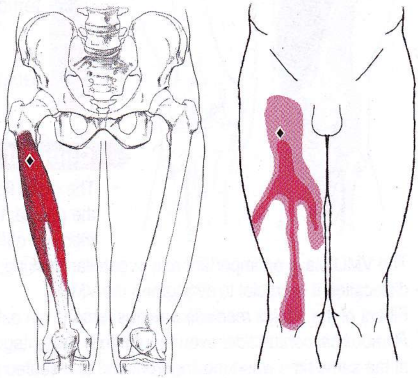
Examiner's force
- Towards knee flexion

Stabilization
- Under knee

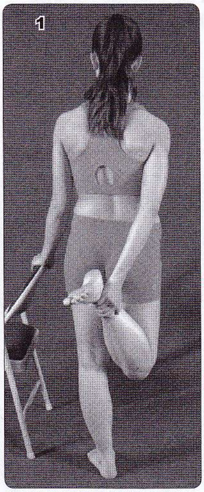


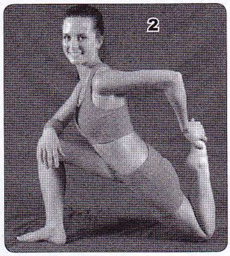
Trigger Point Referral

- MFTPs are usually located in the upper muscle belly
- MFTPs are often difficult to palpate as the vastus intermedius muscle is directly below rectus femoris
- Generally pain is referred over the anterior thigh in a "3-pronged" area that extends distally along the midline, medially & laterally



Stretch & Strengthen

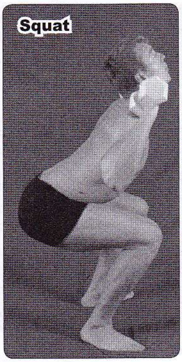


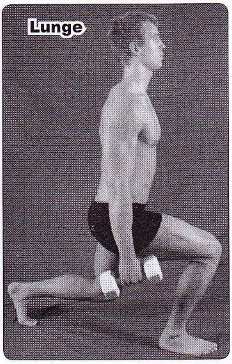


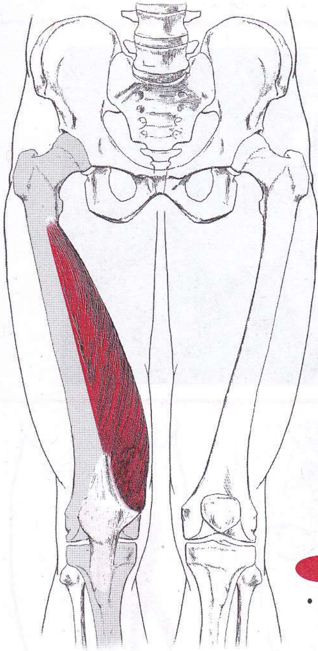
Self Stretch 1:
- Standing, pull ankle to buttock

Self Stretch 2:
- While kneeling, flex knee

Strengthen
- Resisted knee extension
- Squat
- Lunge
- Split squat
- Step up







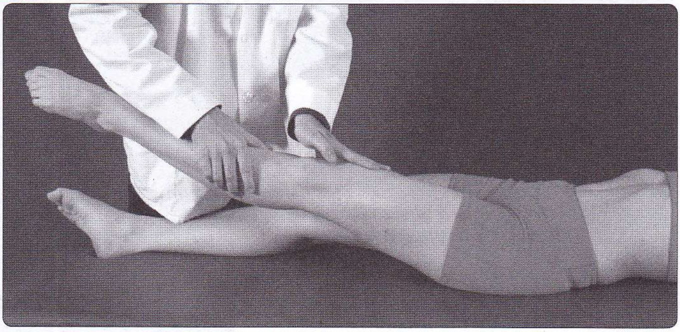
O	**medial lip of linea aspera** (intertrochanteric line)
I	**tibial tuberosity** (via common quadriceps tendon & patellar ligament)
A	**extension of knee**
N	**femoral nerve** (L2 , **L3, L4**)
B	femoral artery
S	rectus femoris, vastus lateralis, vastus intermedius

Clinical Notes

- The distal fibers of *vastus lateralis* run in an oblique direction near the patella; these fibers make up a subdivision, know as *vastus medialis oblique* (VMO)
- The VMO plays an important role in patellar tracking; during rehabilitation following lateral patellar dislocation it is crucial to strengthen the VMO
- Fibers of the *vastus medialis & rectus femoris* fan out to form the medial patellar retinaculum
- *Paradoxical contraction:* even though they are antagonists the hamstring muscles and quadriceps contract at the same time when moving from and to a seated position; this allow for increased stability of the knee
- ***ADL:*** walking up stairs, rising from a seated position, cycling, skiing, all jumping sports
- ***Common injuries:*** quadriceps strain - overstretched due to excessive force into hip extension or knee flexion, contusion (blunt force trauma); decreased quadricep flexibility or strength may cause knee instability
- ***DDx:*** MFTP in distal iliopsoas, sartorius or other 3 quadriceps, lumbar, SI, hip, knee joint pathology or dysfunction, meralgia paresthetica (lateral femoral nerve entrapment), patellar tracking dysfunction

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction over medial thigh
3. Ask patient to extend their knee
4. Note muscle tissue contraction
5. Palpate from insertion to origin

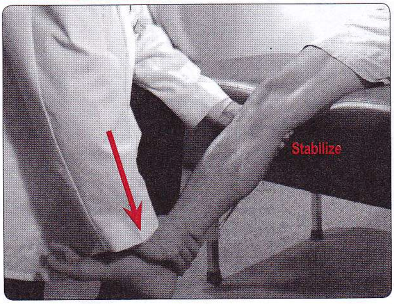


Muscle Test

Patient position
- Seated, knee flexed 10°-20°
- Tibia externally rotated

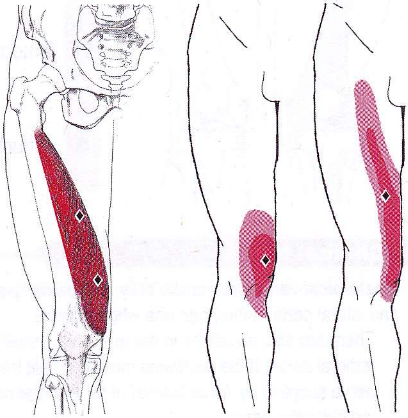
Examiner's force
- Towards knee flexion

Stabilization
- Posterior knee, consider gently palpating muscle with thumb

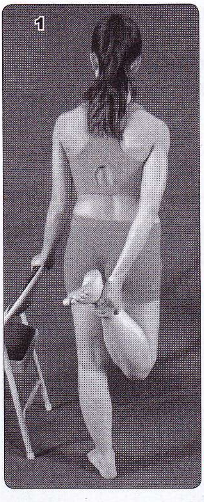


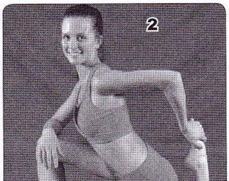
Trigger Point Referral

- MFTPs are usually located in the middle & distal muscle belly
- Generally pain is referred over the medial thigh, both superiorly & inferiorly from the site of the MFTP
- Distal MFTPs may produce "toothache-like" pain deep in the knee joint (pain may wake patient from sleep)



Stretch & Strengthen

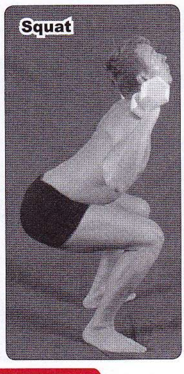


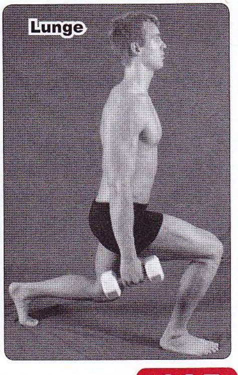


Self Stretch 1:
- Standing, pull ankle to buttock (consider pulling leg laterally to further stretch medial fibers)

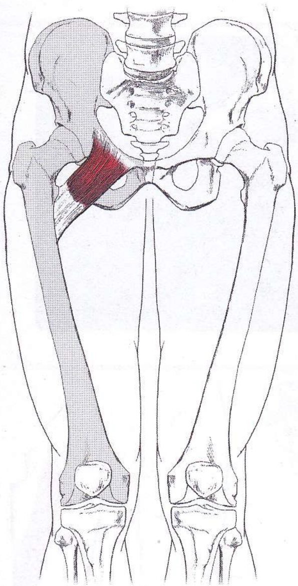
Self Stretch 2:
- While kneeling, flex knee

Strengthen
- Resisted knee extension
- Squat
- Lunge
- Split squat
- Step up





Pectineus



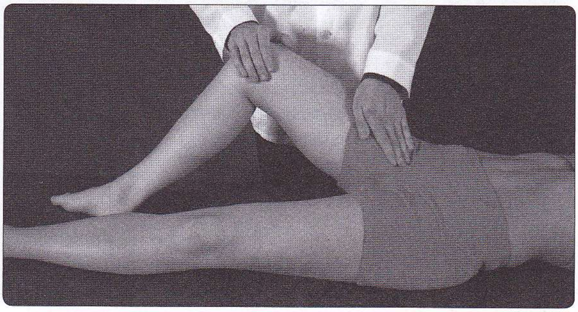
O	**pectineal line of pubis** (superior pubic ramus)
I	**pectineal line of femur** (just below lesser trochanter on posterior aspect of femur)
A	**adduction & flexion of hip**
N	**femoral nerve** (**L2**, L3) and/or **obturator nerve** (**L2**, L3, L4)
B	femoral artery
S	adductor brevis & longus, adductor magnus, gracilis

Clinical Notes

- ***Anatomical variation:*** muscle belly may be completely divided into superficial and deep, or into medial and lateral parts, rather than one whole muscle
  - There are also variations in nerve supply. Usually, *pectineus* muscle is supplied by branches of the femoral nerve; if the *pectineus* muscle is split into medial and lateral parts, the lateral portion may be nerve supplied by either branch of the femoral nerve or the obturator nerve, and the medial branch, by the obturator nerve.
- Electromyography (emg) studies also show that *pectineus* is mildly active during medial rotation of the hip
- ***ADL:*** tandem walking, soccer (side pass), side-stepping on a court, horse riding
- ***Common injuries:*** groin strain (may also involve other adductors)
- ***DDx:*** MFTPs in other 3 thigh adductors, iliopsoas & gracilis; obturator or genitofemoral nerve entrapment; obturator hernia (elderly women more commonly); hip joint or pubic symphysis pathology pain referral; pubic stress symphysitis (Osteitis Pubis)

Palpation

1. Patient supine, ask patient to point out pubic symphysis
2. Place palpating fingers along fiber direction just inferior & lateral to the pubic tubercle
3. Ask patient to adduct & flex hip
4. Note muscle tissue contraction
5. Palpate from origin to insertion

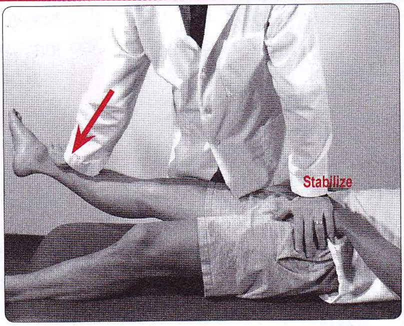


Muscle Test

Patient position
- Supine, hip flexed 20º & slightly abducted, leg externally rotated

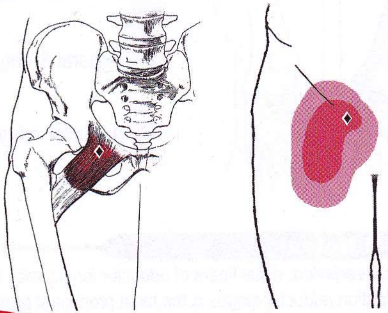
Examiner's force
- Diagonal toward extension & abduction

Stabilization
- Opposite ASIS
- Consider having patient cover ASIS with free hand to avoid potential inappropriate contact



Trigger Point Referral

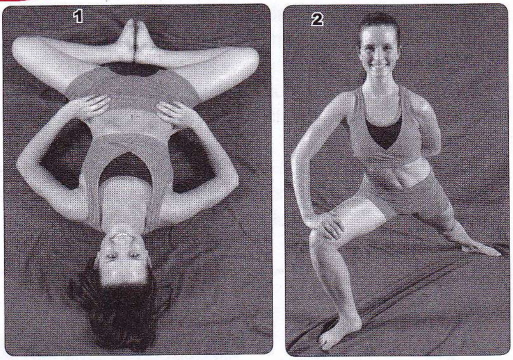
- MFTPs are usually located in the upper 1/3 of the muscle belly
- Generally pain is referred over the groin & anterior proximal thigh
- Pectineus MFTPs usually occur in combination with MFTPs in other functionally related muscles (the 3 *adductor muscles, longus, brevis and magnus,* as well as *iliopsoas & gracilis*)



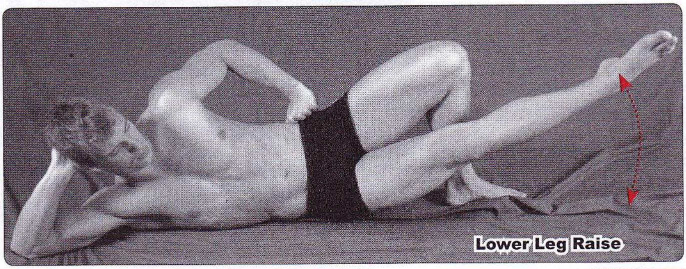
Stretch & Strengthen

Self Stretch 1:
- Lying supine, flex knees & touch soles of feet together & drop knees to floor
- Over pressure may be applied by hands

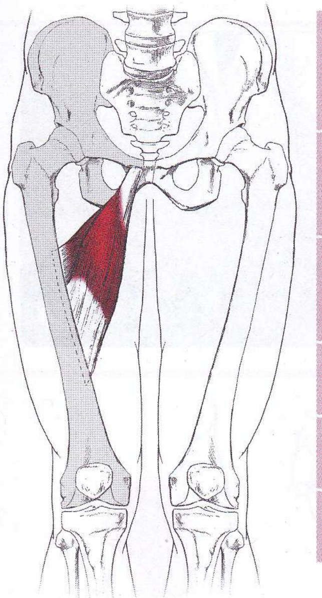
Self Stretch 2:
- Standing, step forward & laterally to abduct posterior thigh
- Laterally tilt & rock pelvis to stretch specific fibers



Strengthen
- Resisted thigh adduction
- Thigh master
- Leg raise (inferior leg)



Adductor Longus & Brevis



O *brevis:* **body & inferior ramus of pubis**
longus: **anterior surface of pubis** (inferior to pubic tubercle)

I *brevis:* **medial lip of linea aspera** (proximal 1/3)
longus: **medial lip of linea aspera** (middle 1/3)

A **adduction & flexion of hip joint**
lateral rotation of thigh

N **obturator nerve (L2, L3**, L4)

B femoral & obturator arteries

S adductor magnus, pectineus, gracilis

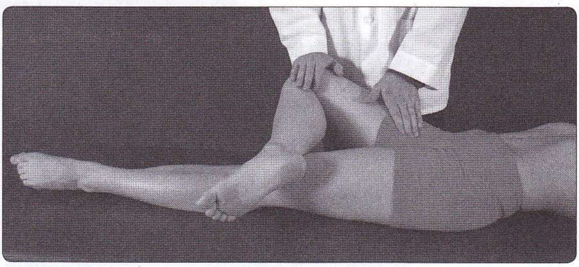
Clinical Notes

- ***Anatomical variation:*** distal fibers of *adductor longus* may blend with *vastus medialis* near linea aspera
- During palpation *adductor longus* is the most prominent proximal tendon in the groin region
- When patients complain of a "pulled groin," *adductor longus* and/or *adductor brevis* may be involved
- In patients with cerebral palsy (who have marked spasticity of the adductor group of muscles), sometimes a surgical procedure known as "tenotomy" is performed in which the tendon of *adductor longus* and/or the anterior division of obturator nerve are cut
- ***ADL:*** soccer (side pass), judo, side-stepping on a court, horse riding, sitting with knees pressed together
- ***Common injuries:*** groin strain - may also involve other adductors (hockey, soccer, football, horse riding & sprinting)
- ***DDx:*** MFTPs in other thigh adductors, *iliopsoas & gracilis*; obturator or genitofemoral nerve entrapment; obturator hernia; hip joint or pubic symphysis pathology pain referral; pubic stress symphysitis (Osteitis Pubis); L3, L4, or L5 radiculopathy

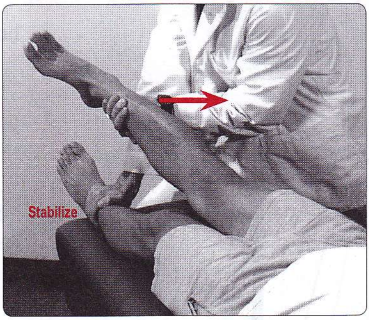
Palpation

1. Patient supine
2. Place palpating fingers along fiber direction over medial proximal thigh
3. Ask patient to adduct hip against resistance
4. Note muscle tissue contraction
5. Palpate from origin to insertion

Note: to distinguish *adductor brevis* from *longus*, repeat as above palpating lateral & deep to *adductor longus*



Muscle Test



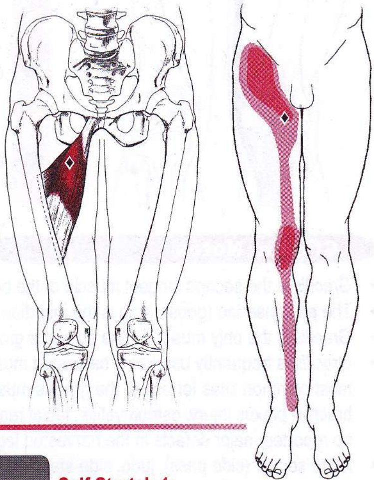
Patient position
- Supine, hip internally rotated & flexed 25º

Examiner's force
- Toward hip abduction

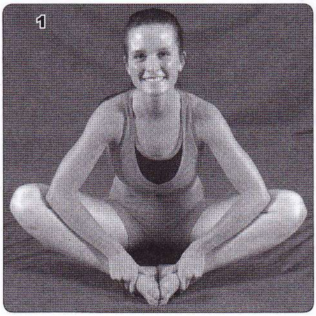
Stabilization
- Opposite ankle

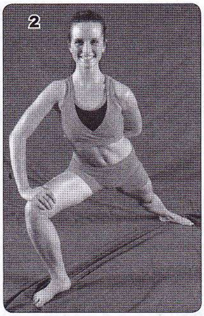
Trigger Point Referral

- MFTPs are usually located in the middle of the muscle belly
- Generally pain is referred upward to the groin and down toward the medial knee and shin



Stretch & Strengthen

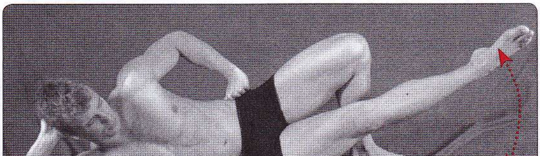




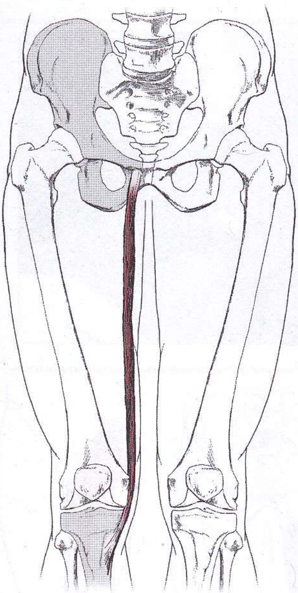
Self Stretch 1:
- Seated, flex knees & touch soles of feet together
- Over pressure may be applied by elbows

Self Stretch 2:
- Standing, step forward & laterally to abduct posterior thigh
- Laterally tilt & rock pelvis to stretch specific fibers

Strengthen
- Resisted thigh adduction
- Thigh master
- Leg raise (inferior leg)



Gracilis



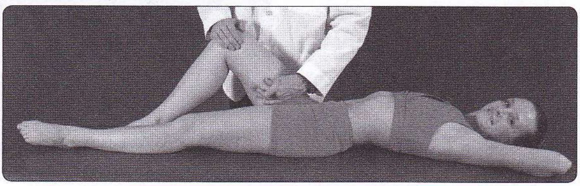
O	**body & inferior ramus of pubis**
I	**proximal anterior medial tibia** (pes anserine)
A	**adduction & flexion of hip** flexion & medial rotation of knee
N	**obturator nerve** (L2, L3, L4)
B	obturator & femoral arteries
S	adductor brevis/longus, adductor magnus, pectineus

Clinical Notes

- *Gracilis* is the second longest muscle of the body (next to *sartorius*) & is the most medial thigh muscle
- The pes anserine (goose foot) is the insertion point for 3 muscles: *sartorius, gracilis & semitendinosus*
- *Gracilis* is the only muscle of the adductor group to act on two joints (hip & knee)
- *Gracilis* is frequently used as a harvested muscle in upper and lower extremity surgical reconstruction; most common sites for use of the gracilis muscle are limb salvage after a sarcoma (cancer), trauma, brachial plexus injury, osteomyelitis, facial reanimation and functional perianal reconstructions; there are no reported major defects in the harvested leg after removal of the gracilis muscle
- ***ADL:*** soccer (side pass), judo, side-stepping on a court, horse riding, sitting with knees pressed together
- ***Common injuries:*** groin strain - may also involve other adductors (hockey, soccer, football, horse riding & sprinting)
- ***DDx:*** MFTPs in other thigh adductors, iliopsoas & gracilis; obturator or genitofemoral nerve entrapment; obturator hernia; hip joint or pubic symphysis pathology pain referral; pubic stress symphysitis (Osteitis Pubis); L3, L4, or L5 radiculopathy

Palpation

1. Patient supine with knee flexed
2. Place palpating fingers along fiber direction over the medial thigh
3. Ask patient to bend knee or adduct hip
4. Note muscle tissue contraction
5. Palpate from origin to insertion

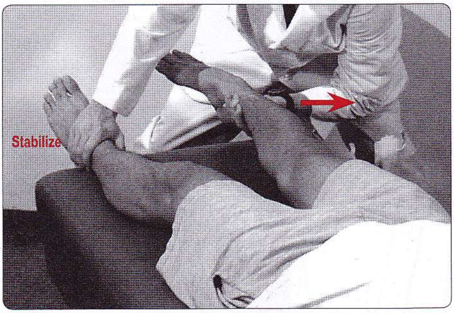


Muscle Test

Patient position
- Supine, hip internally rotated

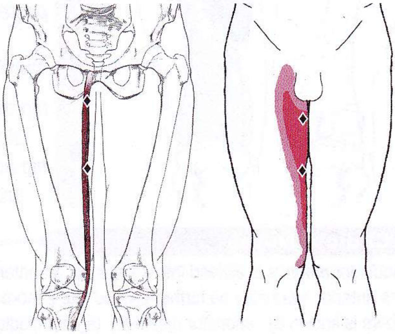
Examiner's force
- Toward abduction

Stabilization
- Opposite ankle



Trigger Point Referral

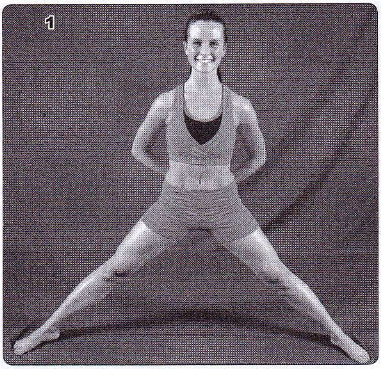
- MFTPs are usually located in the middle & upper muscle belly
- Generally pain is referred over the medial groin & thigh as far down as the knee
- Gracilis MFTPs are often described as a hot & stinging, superficial pain that moves up and down on the inside of the thigh

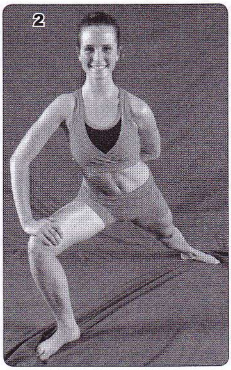


Stretch & Strengthen

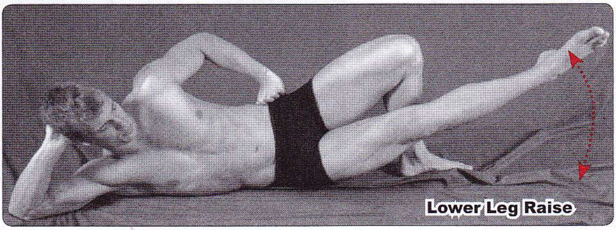
Self Stretch 1:
- Standing, abduct both thighs as if attempting to do the splits

Self Stretch 2:
- Standing, step forward & laterally to abduct posterior thigh
- Laterally tilt & rock pelvis to stretch specific fibers

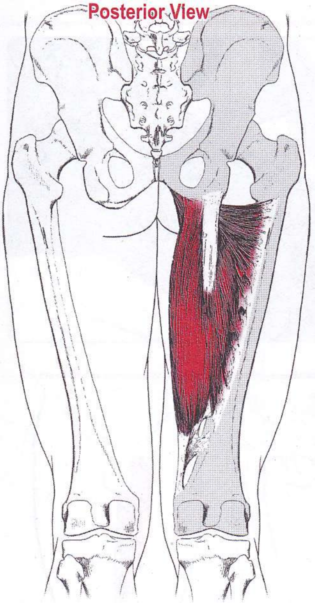




Strengthen
- Resisted thigh adduction
- Thigh master
- Leg raise (inferior leg)



Adductor Magnus



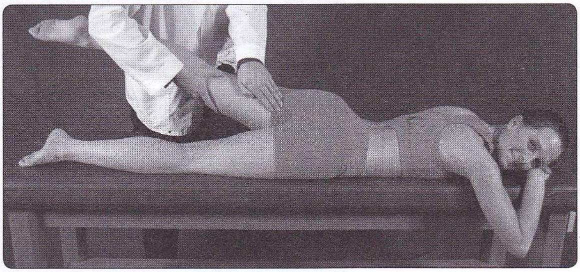
O	*anterior head (adductor part):* **inferior pubic ramus & ischial ramus** *posterior head (hamstring part):* **ischial tuberosity**
I	*anterior head:* **linea aspera** *posterior head:* **adductor tubercle of femur** (above medial epicondyle)
A	**adduction & extension of hip** laterally rotation of thigh (anterior head)
N	*anterior head:* **obturator nerve** (**L2, L3**, L4) *posterior head:* **sciatic nerve**, tibial division (**L4**, L5)
B	femoral & deep femoral arteries
S	*hip extension:* semitendinosus, semimembranosus, biceps femoris (hamstrings) *hip adduction:* adductor brevis & longus, pectineus, gracilis

Clinical Notes

- *Adductor magnus* is divided into 2 sections, an anterior (adductor part) & posterior head (hamstring part); the anterior head may be further divided into 2 more sections: (i) superior portion containing horizontal fibers is known as "*adductor minimus*" (ii) the middle portion containing oblique fibers
- Occasionally some clinicians classify "*adductor minimus*" as its own muscle
- The adductor hiatus separates the anterior & posterior heads of adductor magnus near its distal insertions
- *Adductor magnus* is also known as the 4th hamstring because it attaches the ischial tuberosity & extends the hip joint (like other hamstring muscles)
- Sometimes calcium salts are deposited in the tendon of adductor muscles (especially *adductor magnus*)
- ***ADL:*** soccer (side pass), judo, side-stepping on a court, horse riding, sitting with knees pressed together
- ***Common injuries:*** groin strain - may also involve other adductors (hockey, soccer, football, judo, horse riding & sprinting)
- ***DDx:*** MFTPs in other thigh adductors, iliopsoas & gracilis; obturator or genitofemoral nerve entrapment; obturator hernia; hip joint or pubic symphysis pathology pain referral; pubic stress symphysitis (Osteitis Pubis); L2, L3, or L4 radiculopathy

Palpation

1. Patient prone
2. Place palpating fingers along fiber direction just inferior to the ischial tuberosity
3. Ask patient to extend hip against resistance
4. Note muscle tissue contraction
5. Palpate from origin to insertion



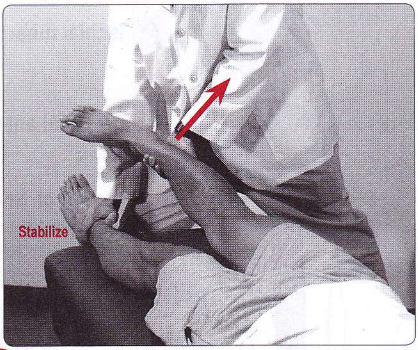
Adductor magnus may also be located with the patient supine by palpating just posterior to gracilis

Muscle Test

Patient position
- Supine, hip flexed 10º & internally rotated

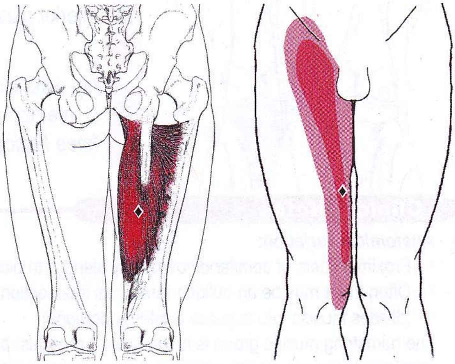
Examiner's force
- Diagonal toward abduction & flexion

Stabilization
- Opposite ankle



Trigger Point Referral

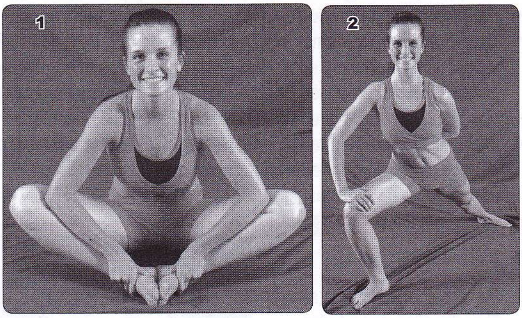
- MFTPs are usually located in the middle of the muscle belly
- Generally pain is referred upward to the groin & down the medial thigh
- Pain can be referred deep into the pelvis



Stretch & Strengthen

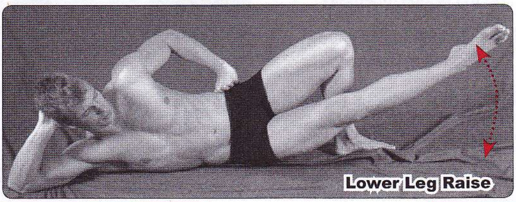
Self Stretch 1:
- Seated, flex knees & touch soles of feet together
- Over pressure may be applied by elbows

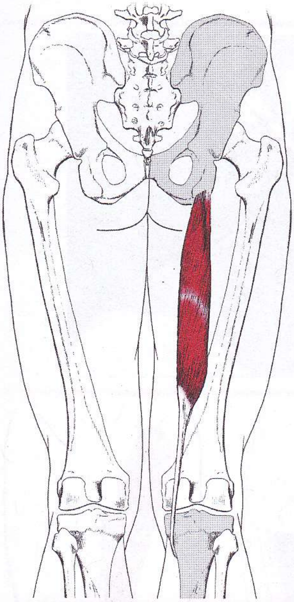
Self Stretch 2:
- Standing, step forward & laterally to abduct posterior thigh
- Laterally tilt & rock pelvis to stretch specific fibers



Hamstring stretches will stretch hamsting portion of Adductor Magnus

Strengthen
- Resisted thigh adduction
- Thigh master
- Leg raise (inferior leg)





O **ischial tuberosity**

I **proximal anterior medial tibia (pes anserine)**

A **flexion of knee, extension of hip**
medial rotation of knee (tibia) when knee is flexed

N **sciatic nerve**, tibial division (**L5, S1**, S2)

B inferior gluteal & deep femoral arteries

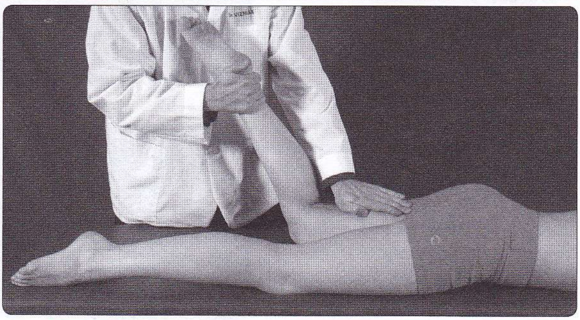
S *hip extension & knee flexion:* biceps femoris, semimembranosus
knee flexion: gastrocnemius, gracilis, sartorius

Clinical Notes

- ***Anatomical variation***:
  - Proximal fibers of *semitendinosus* may blend with biceps femoris long head
  - Often there may be an oblique tendinous intersection within the muscle belly of *semitendinosus* (divides muscle into superior & inferior portions)
- The hamstring muscle group is made up of 3 muscles; *biceps femoris, semitendinosus & semimembranosus*; *semitendinosus & semimembranosus* are also known as the medial hamstrings
- The pes anserine (goose foot) is the insertion point for 3 muscles: *sartorius, gracilis & semitendinosus*
- ***ADL:*** running (slow forward swing of leg & prevent trunk flexion)
- ***Common injuries:*** hamstring strain (pull) following ballistic activity without proper warm-up (hurdler, weight lifting, sprinting, soccer), excessive tightness of hamstrings may predispose to low back pain issues & restrict stride length when walking or running; hamstrings are usually 20%-30% weaker than quadriceps - muscle strength imbalance predisposes people to injury
- ***DDx:*** MFTPs in other hamstrings, piriformis, obturator internus, gluteus medius, vastus medialis; SI, hip or knee joint pain referral; mild radiculopathy (disc herniation, SOL, sciatica); hamstring flexibility must be assessed as a predisposing factor to any posterior thigh injury or low back pain

Palpation

1. Patient prone
2. Place palpating fingers along fiber direction just inferior to the ischial tuberosity
3. Ask patient to flex knee against resistance
4. Note muscle tissue contraction
5. Palpate from origin to insertion



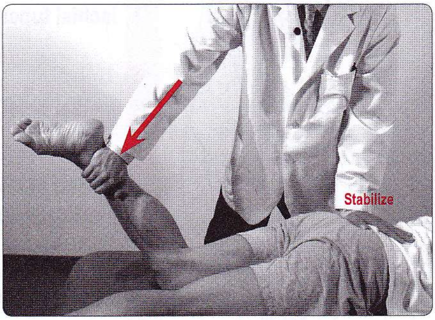
Muscle Test

Patient position
- Prone, knee flexed 80º, hip slightly abducted & internally rotated

Examiner's force
- Toward knee extension

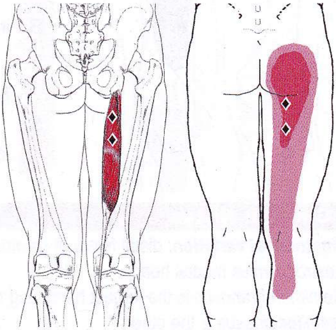
Stabilization
- Sacral base

- Test is the same for *semimembranosus*

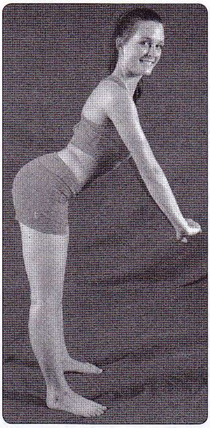


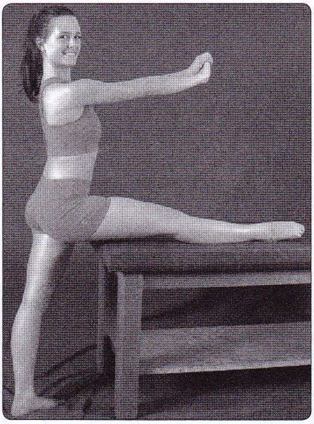
Trigger Point Referral

- MFTPs are usually located in the middle of the muscle belly
- Generally pain is referred upward to the lower gluteal region
- Pain can be referred inferiorly over the upper medial calf

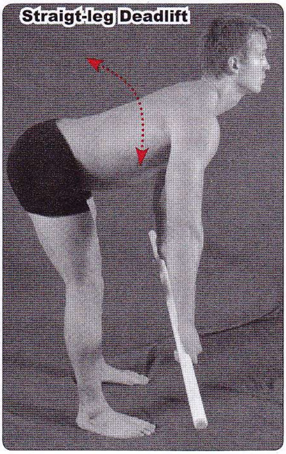


Stretch & Strengthen



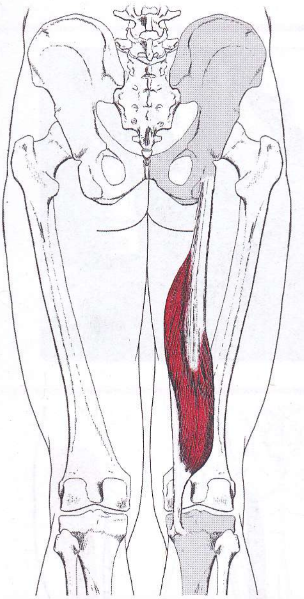


Strengthen
- Resisted hip extension or knee flexion
- Leg curls
- Straight leg dead-lift



Self Stretch 1:
- Standing, extend back, anteriorly tilt pelvis & flex thighs
- Externally rotate hips to further stretch medial fibers

Self Stretch 2:
- Standing, place straight leg up on bench & lean forward



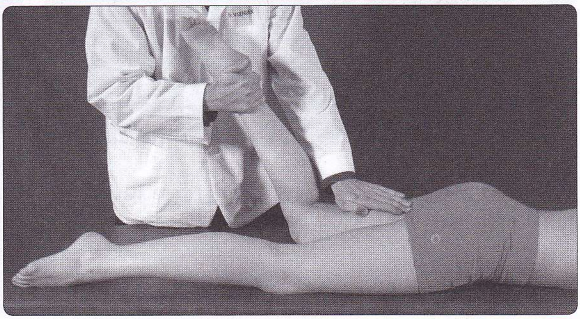
O	**ischial tuberosity**
I	**medial tibial condyle** (posterior medial aspect)
A	**flexion of knee, extension of hip** medial rotation of knee (tibia) when knee is flexed
N	**sciatic nerve**, tibial division (L5, **S1**, S2)
B	inferior gluteal & deep femoral arteries
S	*hip extension & knee flexion:* biceps femoris, semitendinosus *knee flexion:* gastrocnemius, gracilis, sartorius

Clinical Notes

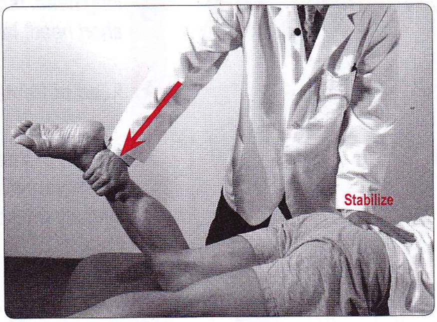
- ***Anatomical variation:*** distal fibers of *semimembranosus* may blend with the proximal fibers of *gastrocnemius* medial head
- *Semimembranosus* is the largest hamstring muscle, and is also known as one of the medial hamstrings (*semitendinosus* is the other)
- Distal fibers fan out & join to the medial meniscus, where it helps to pull the medial meniscus posteriorly during knee flexion (this helps prevent impingement of meniscus); *popliteus* does the same action for the lateral meniscus
- ***ADL:*** running (slow forward swing of leg & prevent trunk flexion)
- ***Common injuries:*** hamstring strain (pull) following ballistic activity without proper warm-up (hurdler, weight lifting, sprinting, soccer), excessive tightness of hamstrings may predispose to low back pain issues & restrict stride length when walking or running; hamstrings are usually 20%-30% weaker than quadriceps - muscle strength imbalance predispose people to injury
- ***DDx:*** MFTPs in other hamstrings, piriformis, obturator internus, gluteus medius, vastus medialis; SI, hip or knee joint pain referral; mild radiculopathy (disc herniation, SOL, sciatica); hamstring flexibility must be assessed as a predisposing factor to any posterior thigh injury or low back pain

Palpation

1. Patient prone
2. Place palpating fingers along fiber direction just inferior to the ischial tuberosity
3. Ask patient to flex knee against resistance
4. Note muscle tissue contraction
5. Palpate from origin to insertion



Muscle Test



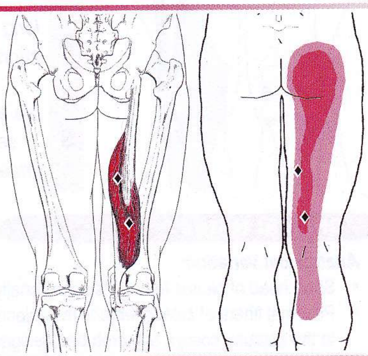
Patient position
- Prone, knee flexed 80º, hip slightly abducted & internally rotated

Examiner's force
- Toward knee extension

Stabilization
- Sacral base

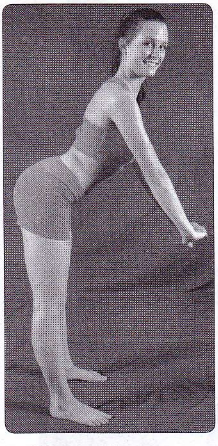
- Test is the same for *semitendinosus*

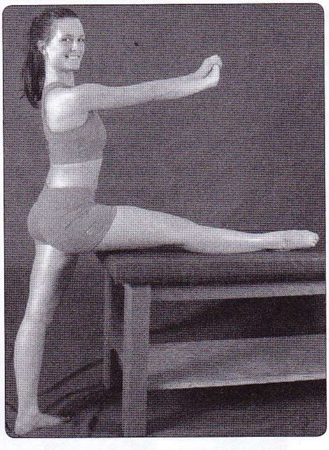
Trigger Point Referral



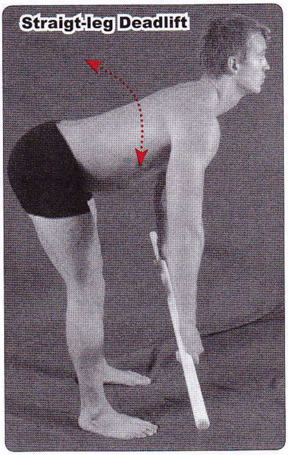
- MFTPs are usually located in the middle of the muscle belly
- Generally pain is referred upward to the lower gluteal region
- Pain can be referred inferiorly over the upper medial calf

Stretch & Strengthen





Strengthen
- Resisted hip extension or knee flexion
- Leg curls
- Straight leg deadlift

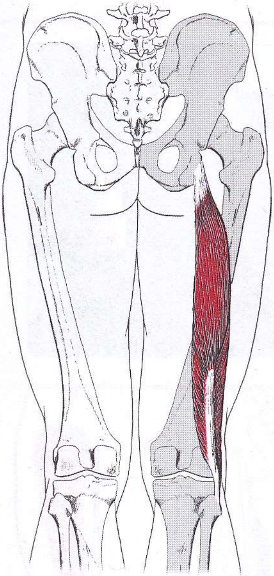


Self Stretch 1:
- Standing, extend back, anteriorly tilt pelvis & flex thighs
- Externally rotate hips to further stretch medial fibers

Self Stretch 2:
- Standing, place straight leg up on bench & lean forward

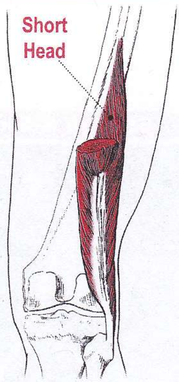
Biceps Femoris

ProHealth



O	*long head:* **ischial tuberosity** *short head:* **lateral lip of linea aspera**
I	**head of fibula** (occasionally to lateral tibial condyle)
A	**flexion of knee** (both long & short head) **extension of hip joint** (long head only) laterally rotation of knee (tibia) when the knee is flexed
N	**sciatic nerve** (*long head* - tibial division (L5, **S1**, S2); *short head* - common peroneal division (**S1**, S2)
B	*long head:* inferior gluteal & deep femoral arteries *short head:* deep femoral artery (perforating branch)
S	*hip extension & knee flexion:* semitendinosus, semimembranosus *knee flexion:* gastrocnemius, gracilis, sartorius

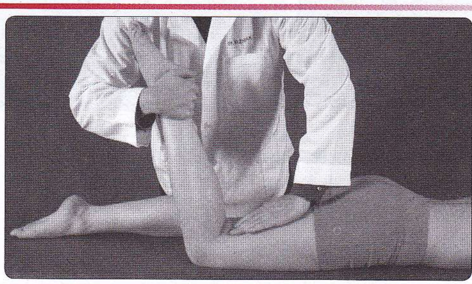
Clinical Notes



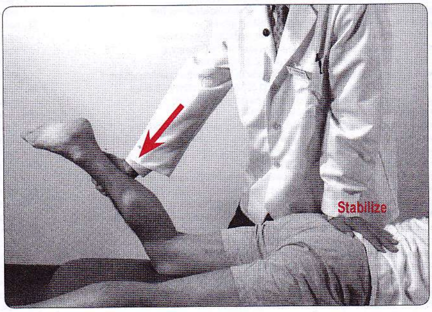
- ***Anatomical Variation***:
  - Short head of *biceps femoris* is occasionally absent or doubled
  - Proximal fibers of *biceps femoris* may blend with *semitendinosus* or attach to the sacrum, coccyx & sacrotuberous ligament
- The hamstring muscle group is made up of 3 muscles; *biceps femoris, semitendinosus & semimembranosus*
- *Biceps femoris* is also known as the lateral hamstring
- *Biceps femoris* is the only hamstring muscle to have 2 heads & is the only muscle of the body that may assist with lateral rotation of the tibia at the knee
- ***ADL:*** running (slow forward swing of leg & prevent trunk flexion)
- ***Common injuries:*** hamstring strain (pull) following ballistic activity without proper warm-up (hurdler, weight lifting, sprinting, soccer), excessive tightness of hamstrings may predispose to low back pain issues & restrict stride length when walking or running; hamstrings are usually 20%-30% weaker than quadriceps - muscle strength imbalance predisposes people to injury
- ***DDx:*** MFTPs in other hamstrings; SI, hip or knee joint pain referral; mild radiculopathy; hamstring flexibility must be assessed as a predisposing factor to any posterior thigh injury or low back pain

Palpation

1. Patient prone
2. Place palpating fingers along fiber direction just inferior to the ischial tuberosity
3. Ask patient to flex knee against resistance
4. Note muscle tissue contraction
5. Palpate from insertion to origin



Muscle Test



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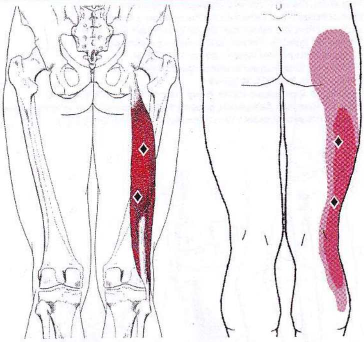
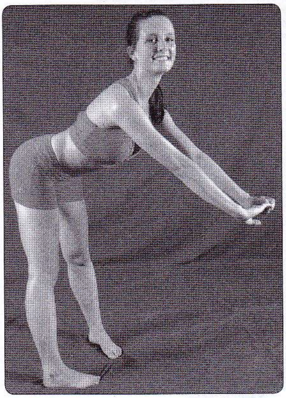
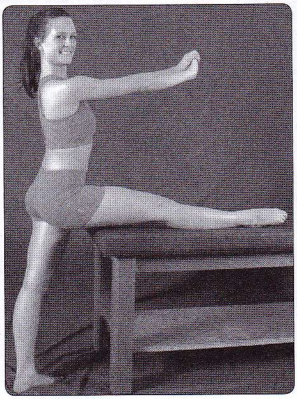
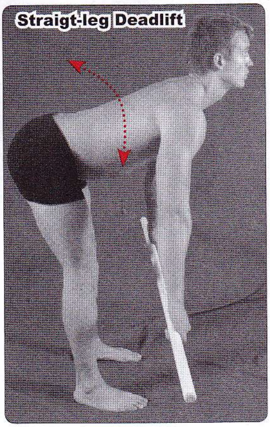


Stretch & Strengthen





Strengthen
- Resisted hip extension or knee flexion
- Leg curls
- Straight leg deadlift

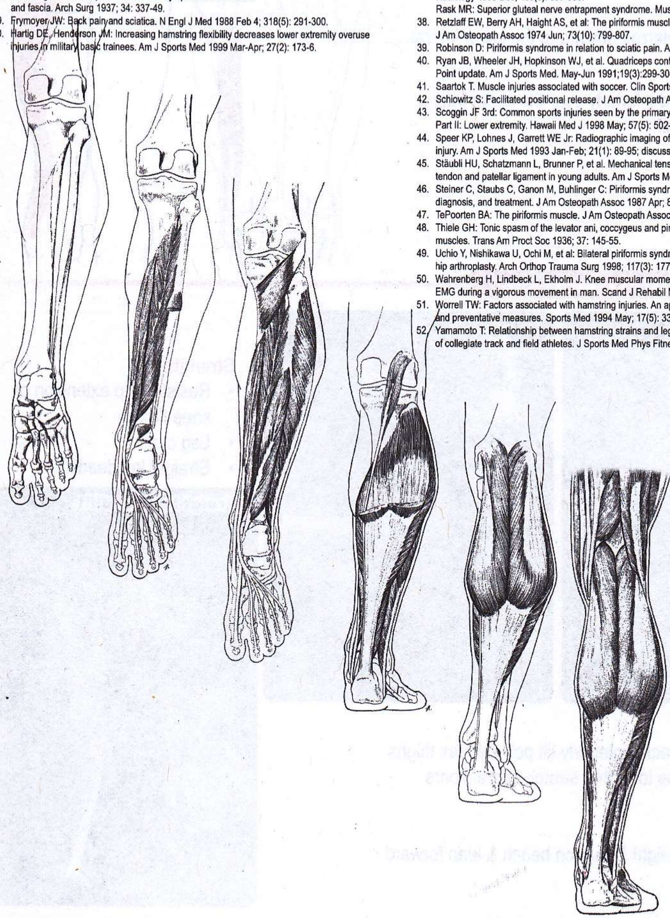


Self Stretch 1:
- Standing, extend back, anteriorly tilt pelvis & flex thighs
- Internally rotate hips to further stretch lateral fibers

Self Stretch 2:
- Standing, place straight leg up on bench & lean forward

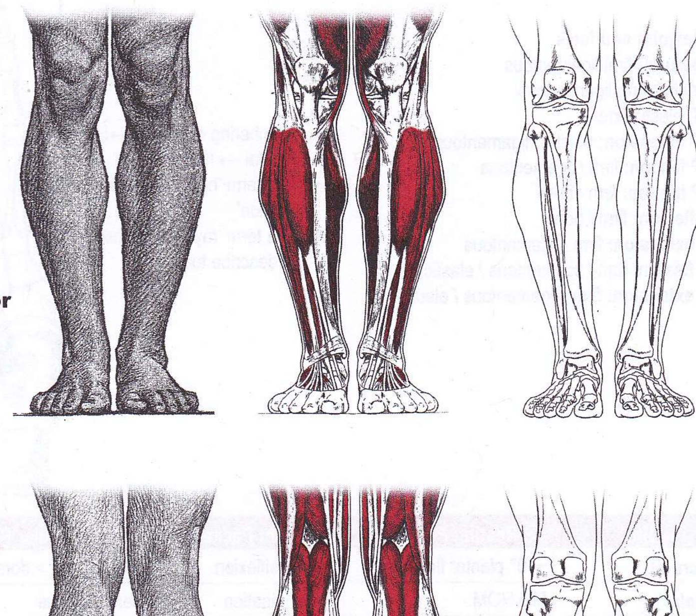
Hip & Thigh

1. Cummings, M. Referred knee pain treated with electroacupuncture to iliopsoas. Acupunct Med. 2003 Jun;21(1-2):32-5.
2. Winters, Michael V., et al, Passive vs. Active Stretching of Hip Flexor Muscles in Subjects with Limited Hip Extension: A Randomized Clinical Trial, Physical Therapy, Vol.84, No. 9, September 2004, pp 800-807
3. Schoeller, Thomas and Wechselberger, Gottfried, Versatility of the Gracilis Free Flap: Experience and Technical Innovation after 140 Flap Transfers, Journal of Reconstructive Surgery. Issue 07, Vol. 21, Oct. 2005
4. Chen Q.S., Zhu L.X., Chen X., Application of Sartorius Muscle in the Quadricepsplasty, Zhongquo Xiu Fu Chong Jian Wai Ke Za Zhi, 13 (6), November 1999, pp 355-358
5. Agre JC: Hamstring injuries. Proposed aetiological factors, prevention, and treatment. Sports Med 1985 Jan-Feb; 2(1): 21-33.
6. Baquie P, Reid G: Management of hamstring pain. Aust Fam Physician 1999 Dec; 28(12): 1269-70.
7. Barton PM: Piriformis syndrome: a rational approach to management. Pain 1991 Dec; 47(3): 345-52.
8. Beatty RA: The piriformis muscle syndrome: a simple diagnostic maneuver. Neurosurgery 1994; 34: 512-514.
9. Beauchesne RP, Schutzer SF: Myositis ossificans of the piriformis muscle: an unusual cause of piriformis syndrome. A case report. J Bone Joint Surg Am 1997 Jun; 79(6): 906-10.
10. Bewyer, Dennis and Chen, Joseph. Gluteus Medius Tendon Rupture as a Source for Back, Buttock and Leg Pain: Case Report, The Iowa Orthopaedic Journal. 188. Accessed Jan 2008.
11. Broadhurst NA, Simmons DN, Bond MJ: Piriformis syndrome: Correlation of muscle morphology with symptoms and signs. Arch Phys Med Rehabil 2004 Dec; 85(12): 2036-9.
12. Brown JA, Braun MA, Namey TC: Pyriformis syndrome in a 10-year-old boy as a complication of operation with the patient in the sitting position. Neurosurgery 1988 Jul; 23(1): 117-9.
13. Brukner P: Hamstring injuries. Aust Fam Physician 1996 Jul; 25(7): 1109-12.
14. Clanton TO, Coupe KJ: Hamstring strains in athletes: diagnosis and treatment. J Am Acad Orthop Surg 1998 Jul-Aug; 6(4): 237-48.
15. Durrani Z, Winnie AP: Piriformis muscle syndrome: an underdiagnosed cause of sciatica. J Pain Symptom Manage 1991 Aug; 6(6): 374-9.
16. Fishman LM, Konnoth C, Rozner B: Botulinum neurotoxin type B and physical therapy in the treatment of piriformis syndrome: a dose-finding study. Am J Phys Med Rehabil 2004 Jan; 83(1): 42-50; quiz 51-3.
17. Fishman LM, Zybert PA: Electrophysiologic evidence of piriformis syndrome. Arch Phys Med Rehabil 1992 Apr; 73(4): 359-64.
18. Freidberg AH: Sciatic pain and its relief by operation on muscle and fascia. Arch Surg 1937; 34: 337-49.
19. Frymoyer JW: Back pain and sciatica. N Engl J Med 1988 Feb 4; 318(5): 291-300.
20. Hartig DE, Henderson JM: Increasing hamstring flexibility decreases lower extremity overuse injuries in military basic trainees. Am J Sports Med 1999 Mar-Apr; 27(2): 173-6.
21. Hennessey L, Watson AW: Flexibility and posture assessment in relation to hamstring injury. Br J Sports Med 1993 Dec; 27(4): 243-6.
Hughes C 4th, Hasselman CT, Best TM, et al. Incomplete, intrasubstance strain injuries of the rectus femoris muscle. Am J Sports Med. Jul-Aug 1995;23(4):500-6. .
22. Jankiewicz JJ, Hennrikus WL, Houkom JA: The appearance of the piriformis muscle syndrome in computed tomography and magnetic resonance imaging. A case report and review of the literature. Clin Orthop 1991 Jan; (262): 205-9.
23. Karl RD Jr, Yedinak MA, Hartshorne MF, et al: Scintigraphic appearance of the piriformis muscle syndrome. Clin Nucl Med 1985 May; 10(5): 361-3.
24. Kirici, Y. and Ozan, H. Double gluteus maximus muscle with associated variations in the gluteal region. Surgical and Radiologic Anatomy. 21 (6): Paris: Springer, 2000.
25. Lang AM: Botulinum toxin type B in piriformis syndrome. Am J Phys Med Rehabil 2004 Mar; 83(3): 198-202.
26. Laskowski E: Concepts in sports medicine. In: Braddom RL, ed. Physical Medicine and Rehabilitation. Philadelphia, Pa: WB Saunders; 1996: 930-1.
27. Martinez SF, Steingard MA, Steingard PM. The compartment syndrome - a limb-threatening emergency. In: The Physician and Sports Medicine. Vol 21. New York, NY: McGraw-Hill; 1993:94-104.
28. Mayrand, Fortin, Descarreaux and Normand. Diagnosis and Management of Posttraumatic Piriformis Syndrome: A Case Study, Journal of Manipulative and Physiological Therapeutics, Volume 29, Issue 6, Jul-Aug, Pages 486-491. 2006.
29. Medical Economics Staff: Physician's Desk Reference. 55th ed. Medical Economics Co; 2000:2631-4.
30. Mizuguchi T: Division of the pyriformis muscle for the treatment of sciatica. Postlaminectomy syndrome and osteoarthritis of the spine. Arch Surg 1976 Jun; 111(6): 719-22.
31. Noftal F: The Piriformis Syndrome. Can J Surg 1988 Jul; 31(4): 210.
32. Novak PJ, Bach BR, Schwartz JC. Diagnosing acute thigh compartment syndrome. In: The Physician and Sports Medicine. Vol 20. New York, NY: McGraw-Hill; 1992:100-107.
33. Pace JB, Nagle D: Piriform syndrome. West J Med 1976 Jun; 124(6): 435-9.
34. Papadopoulos EC, Khan SN: Piriformis syndrome and low back pain: a new classification and review of the literature. Orthop Clin North Am 2004 Jan; 35(1): 65-71.
35. Papadopoulos SM, McGillicuddy JE, Albers JW: Unusual cause of "piriformis muscle syndrome". Arch Neurol 1990 Oct; 47(10): 1144-6.
36. Parziale JR, Hudgins TH, Fishman LM: The piriformis syndrome. Am J Orthop 1996 Dec; 25(12): 819-23.
37. Pomeranz SJ, Heidt RS Jr: MR imaging in the prognostication of hamstring injury. Work in progress. Radiology 1993 Dec; 189(3): 897-900.
Rask MR: Superior gluteal nerve entrapment syndrome. Muscle Nerve 1980 Jul-Aug; 3(4): 304-7.
38. Retzlaff EW, Berry AH, Haight AS, et al: The piriformis muscle syndrome. J Am Osteopath Assoc 1974 Jun; 73(10): 799-807.
39. Robinson D: Piriformis syndrome in relation to sciatic pain. Am J Surg 1947; 73: 355-8.
40. Ryan JB, Wheeler JH, Hopkinson WJ, et al. Quadriceps contusions. West Point update. Am J Sports Med. May-Jun 1991;19(3):299-304. .
41. Saartok T. Muscle injuries associated with soccer. Clin Sports Med. Oct 1998;17(4):811-7, viii.
42. Schiowitz S: Facilitated positional release. J Am Osteopath Assoc 1990 Feb; 90(2): 145-6, 151-5.
43. Scoggin JF 3rd: Common sports injuries seen by the primary care physician. Part II: Lower extremity. Hawaii Med J 1998 May; 57(5): 502-5.
44. Speer KP, Lohnes J, Garrett WE Jr: Radiographic imaging of muscle strain injury. Am J Sports Med 1993 Jan-Feb; 21(1): 89-95; discussion 96.
45. Stäubli HU, Schatzmann L, Brunner P, et al. Mechanical tensile properties of the quadriceps tendon and patellar ligament in young adults. Am J Sports Med. Jan-Feb 1999;27(1):27-34. .
46. Steiner C, Staubs C, Ganon M, Buhlinger C: Piriformis syndrome: pathogenesis, diagnosis, and treatment. J Am Osteopath Assoc 1987 Apr; 87(4): 318-23.
47. TePoorten BA: The piriformis muscle. J Am Osteopath Assoc 1969 Oct; 69(2): 150-60.
48. Thiele GH: Tonic spasm of the levator ani, coccygeus and piriformis muscles. Trans Am Proct Soc 1936; 37: 145-55.
49. Uchio Y, Nishikawa U, Ochi M, et al: Bilateral piriformis syndrome after total hip arthroplasty. Arch Orthop Trauma Surg 1998; 117(3): 177-9.
50. Wahrenberg H, Lindbeck L, Ekholm J. Knee muscular moment, tendon tension force and EMG during a vigorous movement in man. Scand J Rehabil Med. 1978;10(2):99-106.
51. Worrell TW: Factors associated with hamstring injuries. An approach to treatment and preventative measures. Sports Med 1994 May; 17(5): 338-45.
52. Yamamoto T: Relationship between hamstring strains and leg muscle strength. A follow-up study of collegiate track and field athletes. J Sports Med Phys Fitness 1993 Jun; 33(2): 194-9.

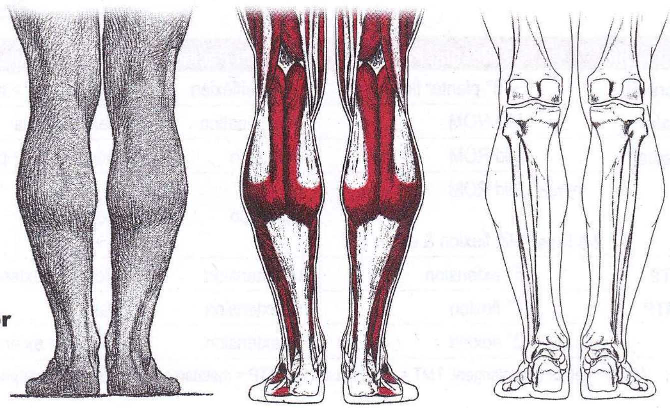


Leg & Foot

Anterior



Posterior



Leg, Ankle & Foot Kinematics

Joint type: synovial
- Hinge (talocrural, metatarsalphalangeal & interphalangeal)
- Gliding (subtalar, midtarsal joints)

AROM

Talocrural (talotibial)
- **Plantar flexion** .... **40°**
- **Dorsiflexion** .... **20°**

Subtalar (talocalcaneal) *- hindfoot only*
- **Inversion** .... **30°**
- **Eversion** .... **15°**

Metatarsophalangeal
- **Flexion** .... **75°**
- **Extension** .... **35°**

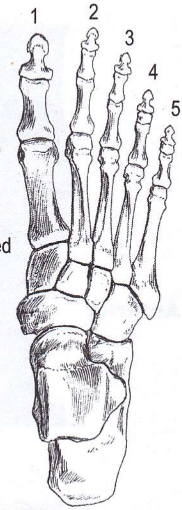
Interphalangeal
- **Flexion** .... **~60°**
- **Extension** .... **~20°**

Normal joint end feels
- **Talocrural:** firm ligamentous
- **Subtalar:** firm ligamentous
- **TMT:** elastic firm
- **MTP extension:** elastic / ligamentous
- **MTP flexion:** firm / ligamentous
- **MTP big toe:** firm / bony
- **PIP flexion:** firm / bony
- **PIP extension:** firm / ligamentous
- **DIP flexion:** firm / ligamentous / elastic
- **DIP extension:** firm / ligamentous / elastic

Main muscle actions
- **Plantar flexion:** soleus, gastrocnemius, tibialis posterior, flexor digitorum longus, flexor hallicus longus
- **Dorsiflexion:** tibialis anterior, extensor digitorum longus
- **Inversion:** tibialis anterior, tibialis posterior
- **Eversion:** fibularis longus, brevis & tertius

- **1st toe flexion:** flexor hallicus longus & brevis
- **Toe 2-5 flexion:** flexor digitorum longus & brevis, lumbricales
- **1st toe extension:** extensor hallicus l. & brevis
- **Toe extension:** extensor digitorum longus & brevis
- **Abduction:** dorsal interossei
- **Adduction:** palmar interossei

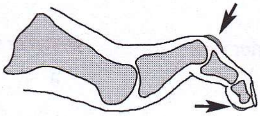
- Numbering of digits 1→5, medial → lateral
- The term 'hallux' means 'big toe'
- The term 'ray' may be used to describe toe/digit



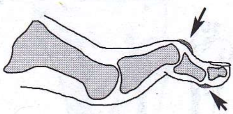
Joint	Resting Position	Tight Packed	Capsular Pattern
Talocrural	~10° plantar flexion	Full dorsiflexion	Plantar flex. > dorsiflex.
Subtalar	Mid ROM	Full supination	Varus, valgus
Midtarsal	Mid ROM	Supination	Dorsiflexion > plantarflex
TMT **1st toe** **2-5 toes**	Mid ROM Mid flexion & exten.	Supination	None
1st MTP	5° extension	Full extension	Flexion > extension
2-5 MTP	2° flexion	Full extension	Variable
IP	2° flexion	Full extension	Flexion > extension

MTP = metatarsophalangeal, TMT = tarsometatarsal, MTP = metatarsophalangeal, IP = interphalangeal

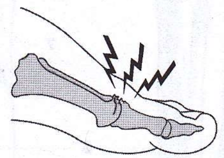
Claw Toe: hyperextension of the MTP joint & hyperflexion of the PIP & DIP joints (associated with pes cavus foot design)



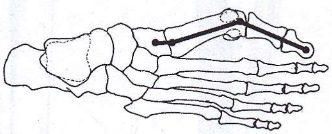
Hammer Toe: Hyperflexion deformity of the PIP joint with some extension of the MTP joint (most commonly involves the 2nd toe)



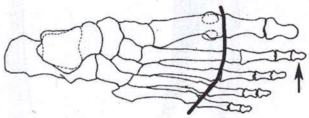
Hallux Rigidus: degenerative arthritic condition involving decreased range of motion in dorsiflexion of the hallux occurring at the MTP joint & resulting in pain in the hallux with excessive or repeated dorsiflexion (synonym: hallux limitus)



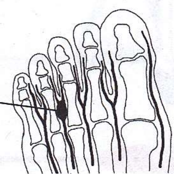
Hallux Valgus: anatomical variant of the 1st ray involving medial deviation (abduction) of the 1st metatarsal & lateral deviation (adduction) of the proximal phalanx of the hallux; often listed under bunion which is commonly associated with hallux valgus



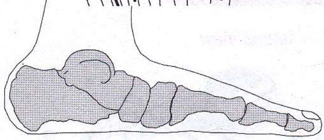
Morton's Foot: shortened 1st metatarsal or elongated 2nd metatarsal resulting in a relatively short first toe compared with the second toe (synonym: Morton's Syndrome; not to be confused with Morton's Toe or Morton's Neuroma)



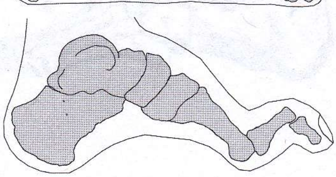
Morton's Neuroma: entrapment neuropathy of an interdigital nerve resulting in the formation of a neuroma between distal metatarsals (between digits 3-4 55%, between digits 2-3 45%) (synonyms: interdigital neuroma or Morton's Toe)



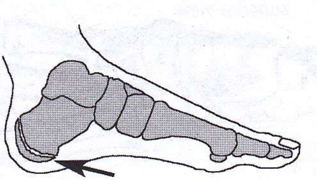
Pes Planus: weight bearing foot that has low or absent medial longitudinal arches (synonyms - flat foot, pes valgus, hyper-pronated foot, splay foot)

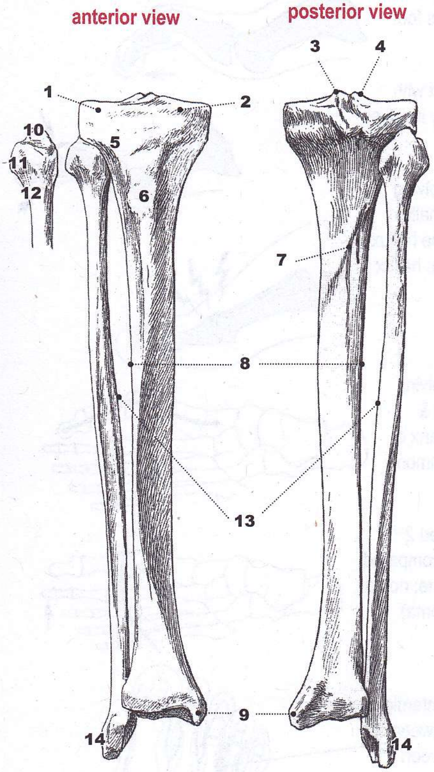


Pes Cavus: weight-bearing foot that has excessively high arch; often there is an accompanying claw toe deformity with dorsiflexion of PIP & plantar flexion of the DIP; the apex of the arch is at the navicular cuneiform joint



Sever's Disease: traction apophysitis of the calcaneal tuberosity, appears at ~10 years old; usually fuses by age 15-16





Tibia

1. Lateral condyle
2. Medial condyle
3. Medial intercondylar tubercle
4. Lateral intercondylar tubercle
5. Gerdy's tubercle
6. Tibial tuberosity
7. Soleal line
8. Interosseous border
9. Medial malleolus

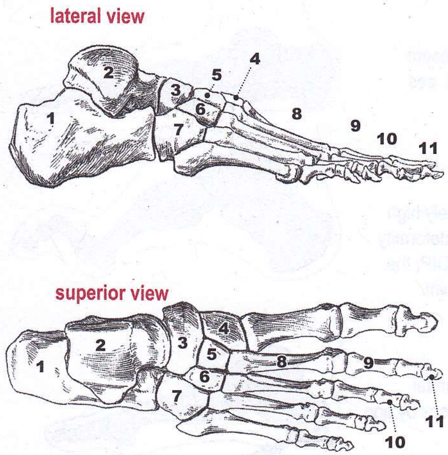
Fibula

10. Apex of head
11. Head
12. Neck
13. Interosseous border
14. Lateral malleolus

Clinical Note

Repetitive stress on the tibia, navicular & metatarsals can cause stress fractures (more common in runners & ballet dancers)

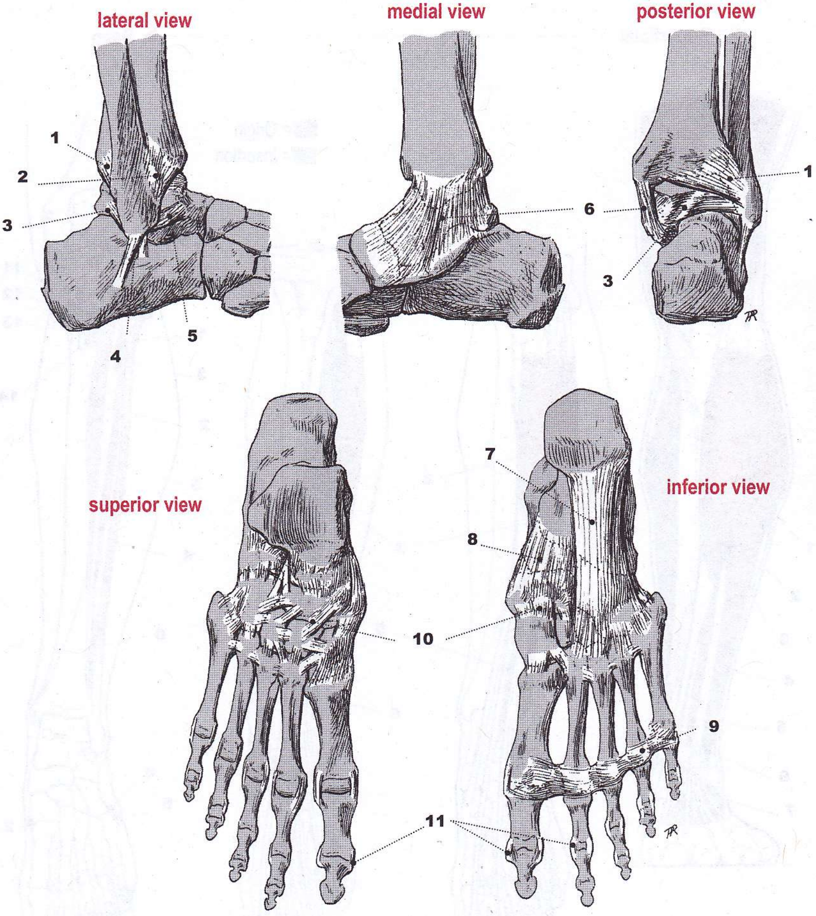
Foot



Tarsal bones

1. Calcaneus
2. Talus
3. Navicular
4. Medial (1st) Cuneiform
5. Intermediate (2nd) Cuneiform
6. Lateral (3rd) Cuneiform
7. Cuboid

8. Metatarsals
9. Proximal phalanges
10. Middle phalanges
11. Distal phalanges



Lateral ankle

1. Posterior tibiofibular ligament
2. Anterior tibiofibular ligament
3. Posterior talofibular ligament
4. Calcaneofibular ligament
5. Anterior talofibular ligament

Medial ankle

6. Deltoid (medial collateral) ligament

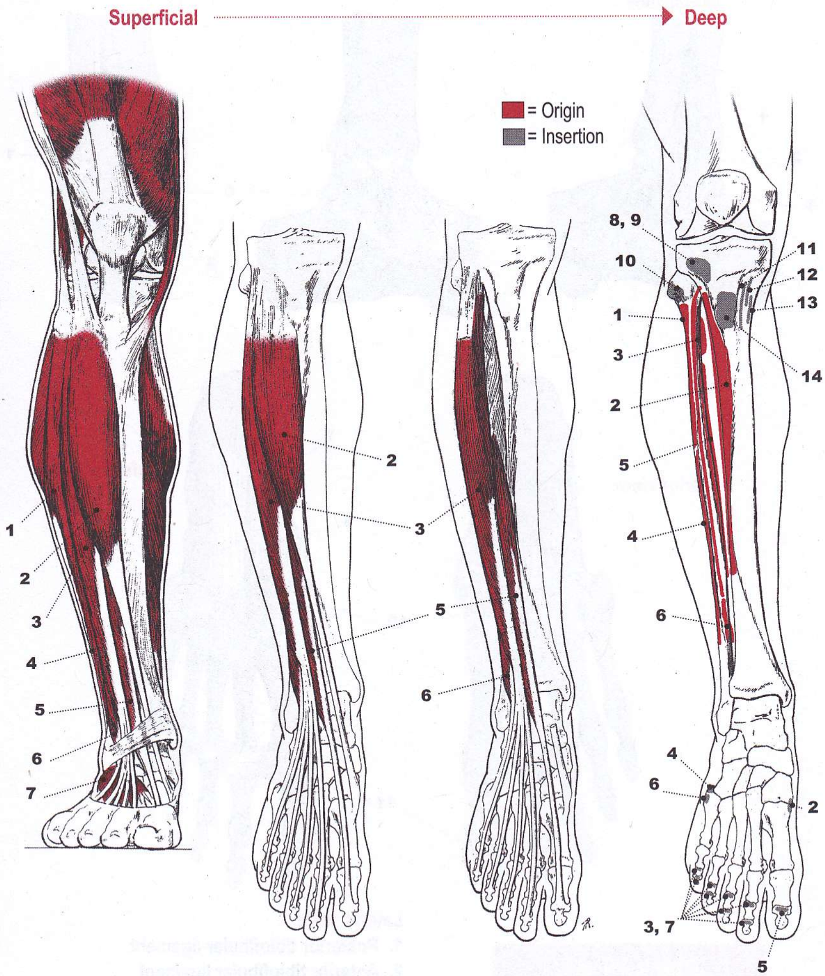
Sole of foot

7. Long plantar ligament
8. Spring (plantar calcaneonavicular) ligament
9. Transverse metatarsal ligament

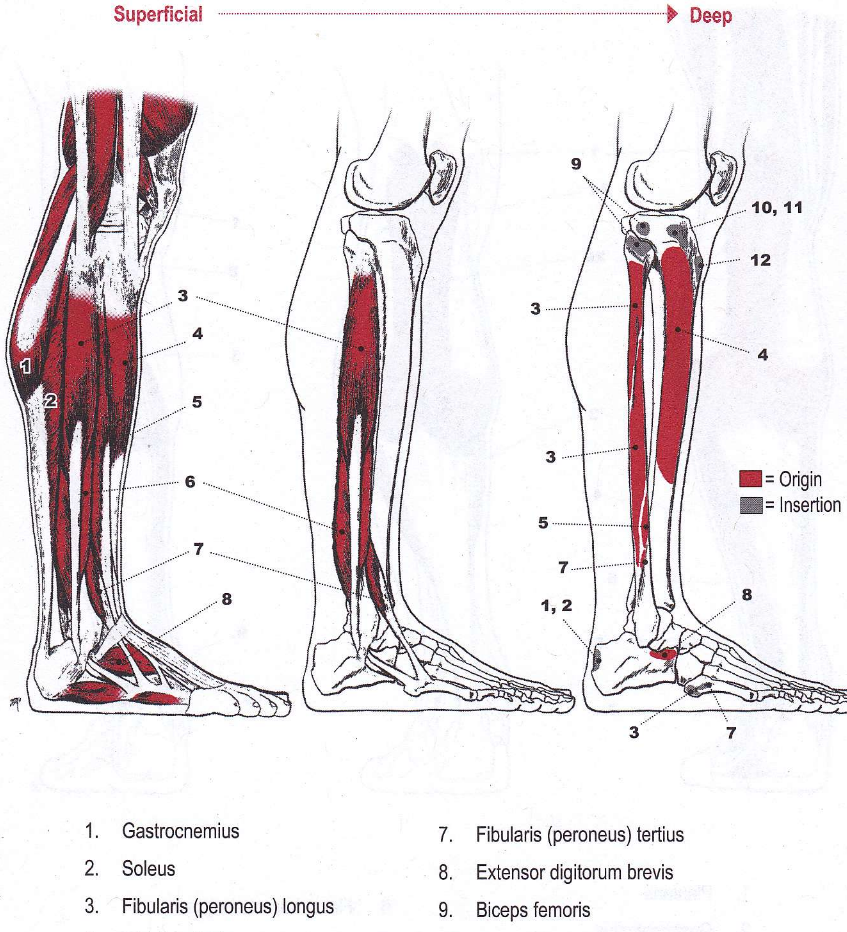
10. Intertarsal ligaments
11. Interphalangeal collateral ligaments

Clinical Note

During an inversion ankle sprain any or all of the 5 lateral ligaments may be damaged

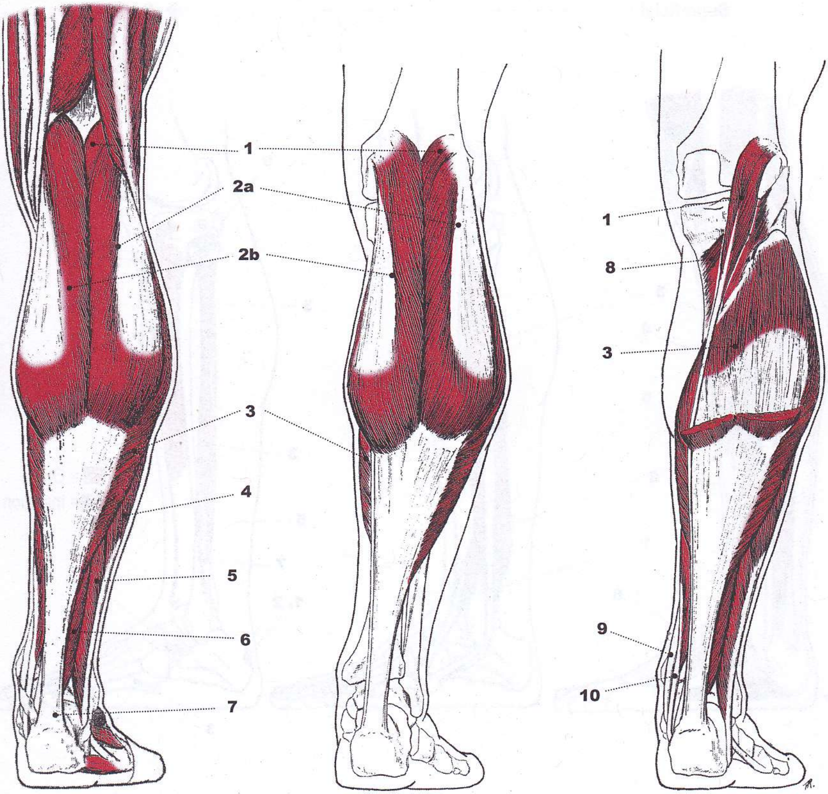


1. Fibularis (peroneus) longus
2. Tibialis anterior
3. Extensor digitorum longus
4. Fibularis (peroneus) brevis
5. Extensor hallucis longus
6. Fibularis (peroneus) tertius
7. Extensor digitorum brevis
8. Gluteus maximus (ITB)
9. Tensor fasciae latae (ITB)
10. Biceps femoris
11. Sartorius
12. Gracilis
13. Semitendinosus
14. Quadriceps femoris tendon

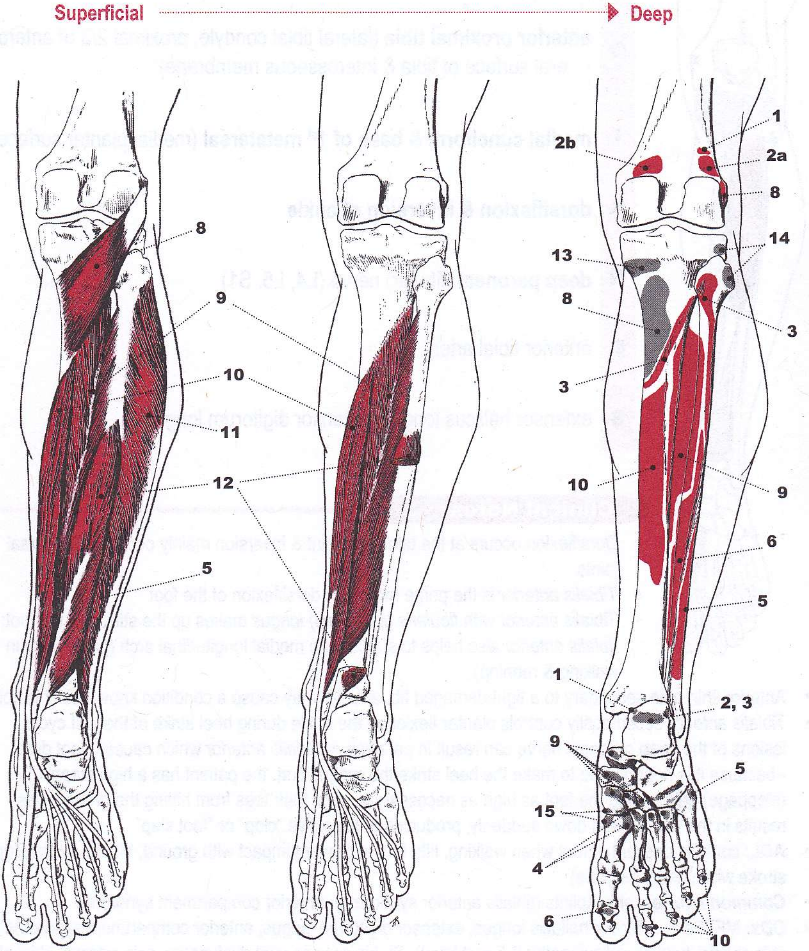


1. Gastrocnemius
2. Soleus
3. Fibularis (peroneus) longus
4. Tibialis anterior
5. Extensor digitorum longus
6. Fibularis (peroneus) brevis
7. Fibularis (peroneus) tertius
8. Extensor digitorum brevis
9. Biceps femoris
10. Gluteus maximus
11. Tensor fasciae latae
12. Quadriceps femoris tendon

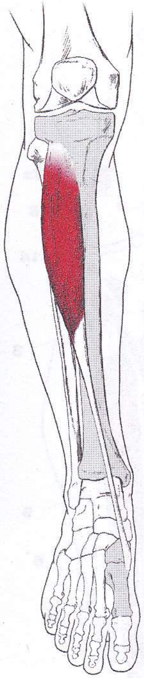
Superficial → Deep



1. Plantaris
2. Gastrocnemius
   a. Lateral head
   b. Medial head
3. Soleus
4. Fibularis (peroneus) longus
5. Fibularis (peroneus) brevis
6. Flexor hallucis longus
7. Achilles (calcaneal) tendon
8. Popliteus
9. Tibialis posterior
10. Flexor digitorum longus



1. Plantaris
2. Gastrocnemius
   a. Lateral head
   b. Medial head
3. Soleus
4. Fibularis (peroneus) longus
5. Fibularis (peroneus) brevis
6. Flexor hallucis longus
7. Achilles tendon (not shown)
8. Popliteus
9. Tibialis posterior
10. Flexor digitorum longus
11. Fibularis (peroneus) longus
12. Flexor hallucis longus
13. Semimembranosus
14. Biceps femoris
15. Tibialis anterior



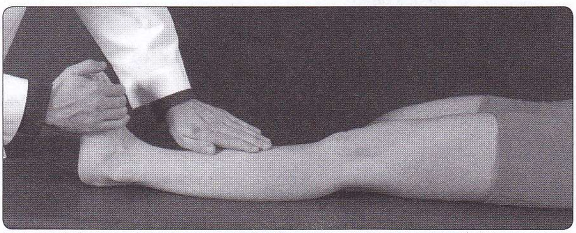
O	**anterior proximal tibia** (lateral tibial condyle, proximal 2/3 of anterolateral surface of tibia & interosseous membrane)
I	**medial cuneiform & base of 1st metatarsal** (medial plantar surfaces)
A	**dorsiflexion & inversion of ankle**
N	**deep peroneal** (fibular) nerve (**L4**, L5, S1)
B	anterior tibial artery
S	extensor hallicus longus, extensor digitorum longus

Clinical Notes

- Dorsiflexion occurs at the talocrural joint & inversion mainly occurs at the tarsal joints
- *Tibialis anterior* is the prime mover for dorsiflexion of the foot
- *Tibialis anterior* with *fibularis (peroneus) longus* makes up the stirrup of the foot; *tibialis anterior* also helps to support the medial longitudinal arch (particularly in walking & running)
- Anterior shin pain secondary to a tight/damaged tib. anterior may cause a condition known as shin splints
- *Tibialis anterior* eccentrically controls plantar flexion at the ankle during heel strike of the gait cycle; lesions of the deep peroneal nerve can result in paralysis of *tibialis anterior* which causes "foot drop" - because it is not possible to make the heel strike the ground first, the patient has a high stepping (steppage) gait; raising the foot as high as necessary to keep their toes from hitting the ground, this results in the foot coming down suddenly, producing a distinctive "clop" or "foot slap"
- ***ADL:*** controls descent of foot when walking, lifts foot to prevent impact with ground, hiking, cycling (up stroke when using toe clips)
- ***Common injuries:*** shin splints (tibialis anterior syndrome), anterior compartment syndrome
- ***DDx:*** MFTPs in extensor hallucis longus, extensor digitorum longus, anterior compartment syndrome, shin splints, lumbar radiculopathy (L5 root level), SI, hip or knee joint dysfunction pain referral, tibial stress fracture

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction just lateral to the anterior tibia
3. Ask patient to dorsi flex their ankle & curl toes down (flexion of toes eliminates contraction of extensor digitorum longus)
4. Note muscle tissue contraction
5. Palpate from origin to insertion



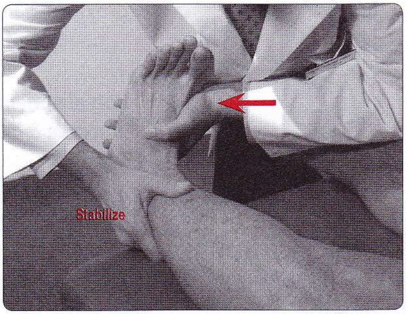
Leg & Foot

Muscle Test

Patient position
- Supine, ankle dorsiflexed & inverted

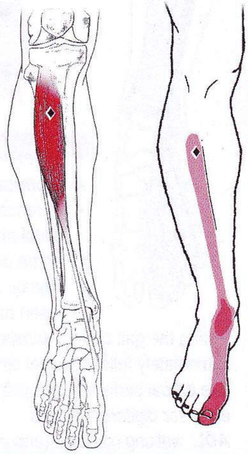
Examiner's force
- Diagonal from medial to lateral & toward plantar flexion

Stabilization
- Laterally above ankle joint



Trigger Point Referral

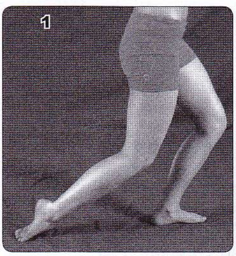
- MFTPs are usually located in the proximal 1/3 of the muscle belly
- Generally pain is referred downward toward the anterior medial ankle & big toe
- MFTPs of tibialis anterior may also be associated with MFTPs in fibularis longus

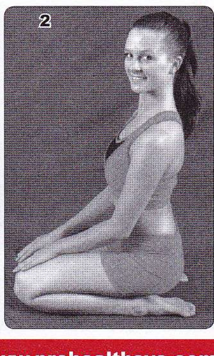


Stretch & Strengthen

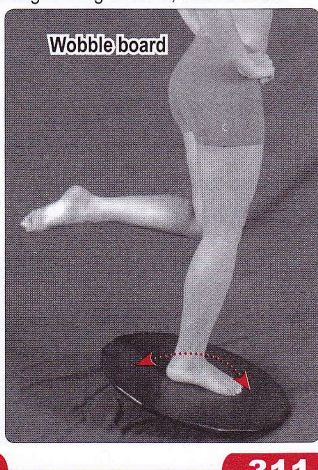
Stretch 1
- Place dorsum of foot on ground & apply pressure into plantarflexion & eversion

Stretch 2
- Sit with ankle plantar flexed under buttocks

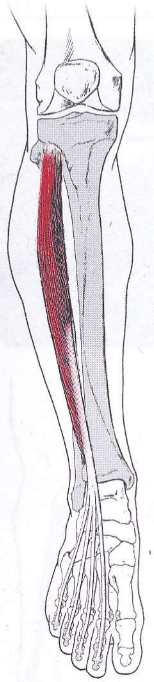




Strengthen
- Dorsiflxion with rubber band
- Walking/running on sand, wobble board



Extensor Digitorum Longus



O	**proximal 2/3 of fibula, interosseous membrane, lateral condyle of tibia** (anterior surfaces)
I	**dorsal surface of digitis 2-5** (via dorsal expansion to middle & distal phalanges)
A	**extension of digits 2-5** (at MTP & IP joints) dorsiflexion & eversion of foot
N	**deep peroneal** (fibular) nerve, (L4, **L5**, S1)
B	anterior tibial artery
S	extensor digitorum brevis

Clinical Notes

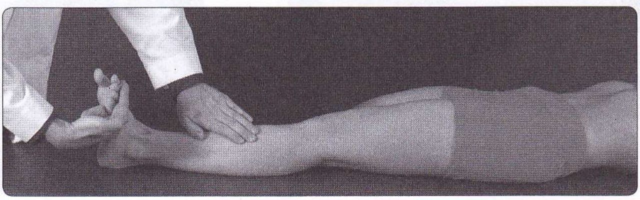
Anatomical variation:

- *Extensor digitorum longus* often has an additional tendon that originates from its distal end & inserts onto the base of the 5th metatarsal; this tendon is given the name peroneus tertius
- Rarely, a muscle named *peroneus quadratus* may originate from the distal fibula & insert on the calcaneus, cuboid or 5th metatarsal

- During the gait cycle *extensor digitorum longus* assists in controlling deceleration of the forefoot immediately following heel strike
- The dorsal pedis artery is palpable in front of the ankle between the tendons of *extensor hallucis longus & extensor digitorum longus*
- ***ADL:*** walking up stairs (ensures toes clear step or other objects), hiking, cycling (upstroke)
- ***Common injuries:*** injuries specific to extensor digitorum longus are rare
- ***DDx:*** MFTPs in extensor hallucis longus or tibialis anterior, anterior compartment syndrome, shin splints, lumbar radiculopathy (L5 root level), SI, hip or knee joint dysfunction pain referral, tibial stress fracture

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction over dorsum of foot
3. Ask patient to extend their toes & mildly resist action
4. Note muscle tissue contraction
5. Palpate from insertion to origin



Muscle Test

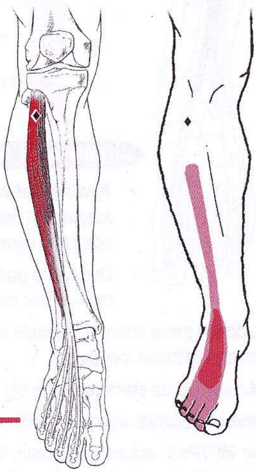
Patient position
- Supine, ankle in neutral position, digits 2-5 extended

Examiner's force
- Toward flexion of digits 2-5

Stabilization
- Over big toe

Trigger Point Referral

- MFTPs are usually located in the proximal 1/3 of the muscle belly
- Generally pain is referred downward toward the anterior ankle & toes 2-4

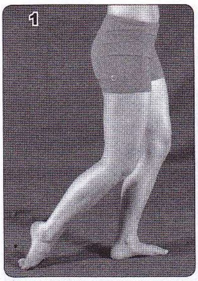


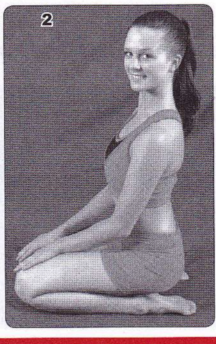
Stretch & Strengthen

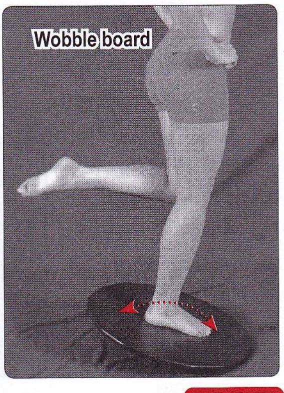
Stretch 1
- Place dorsum of toes on ground & apply pressure into flexion of digits 2-5

Stretch 2
- Sit with ankle plantar flexed under buttocks

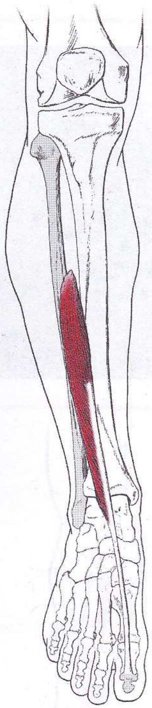
Strengthen
- Toe raises
- Dorsiflexion with rubber band, wobble board







Extensor Hallucis Longus



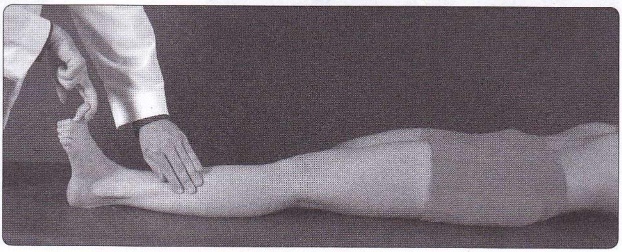
O	**anterior middle 1/3 of fibula & interosseous membrane**
I	**base of distal phalanx of big toe** (dorsal surface)
A	**extension of big toe** (at MTP, IP joints) dorsiflexion & inversion of foot
N	**deep peroneal** (fibular) nerve (L4, **L5**, S1)
B	anterior tibial artery
S	extensor hallucis brevis

Clinical Notes

- ***Anatomical variation:*** Often there are separate muscle fibers of *extensor hallucis longus* that branch off & insert onto the distal end of the 1st metatarsal; the muscular branch is known as *extensor hallucis accessorius*
- During the gait cycle *extensor hallucis longus* assists in controlling deceleration of the forefoot immediately following heel strike
- The dorsal pedis artery is palpable in front of the ankle between the tendons of *extensor hallucis longus & extensor digitorum longus*
- ***ADL:*** walking up stairs (ensures big toe clears step or other objects), hiking, cycling (upstroke)
- ***Common injuries:*** injuries specific to extensor hallicus longus are rare
- ***DDx:*** MFTPs in extensor digitorum longus, tibialis anterior, anterior compartment syndrome, shin splints, lumbar radiculopathy (L5 root level), SI, hip or knee joint dysfunction pain referral, tibial stress fracture, hallux valgus

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction just lateral to the anterior distal tibia
3. Ask patient to extend their big toe
4. Note muscle tissue contraction
5. Palpate from insertion to origin



Muscle Test

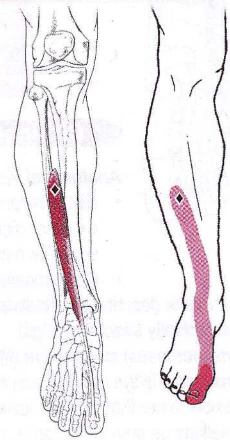
Patient position
- Supine, ankle neutral position, big toe extended

Examiner's force
- Toward flexion of the big toe

Stabilization
- Over digits 2-5

Trigger Point Referral

- MFTPs are usually located in the distal 1/3 of the muscle belly
- Generally pain is referred downward toward the big toe

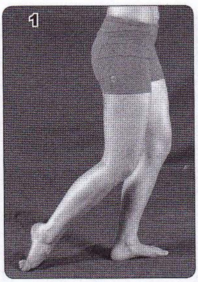


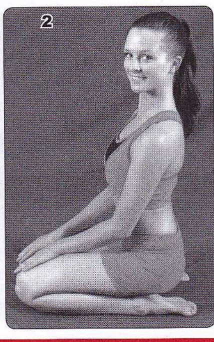
Stretch & Strengthen

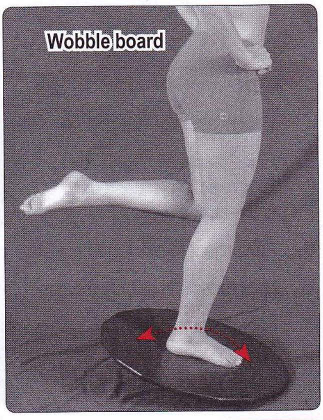
Stretch 1
- Place dorsum of big toe on ground & apply pressure into flexion of big toe

Stretch 2
- Sit with ankle plantar flexed under buttocks

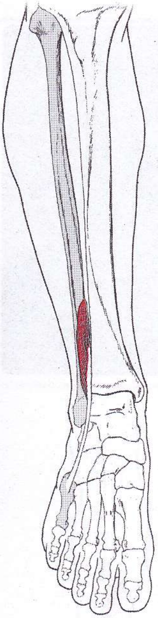
Strengthen
- Toe raises
- Dorsiflexion with rubber band, wobble board







Fibularis (Peroneus) Tertius



O	**distal 1/3 of anterior fibula** (distal & lateral aspect of extensor digitorum longus)
I	**base of 5th metatarsal** (dorsal surface)
A	**dorsiflexion & eversion of foot**
N	**deep peroneal** (fibular) nerve (L5, S1)
B	anterior tibial artery
S	*eversion:* fibularis longus & brevis *dorsiflexion:* extensor digitorum longus

Clinical Notes

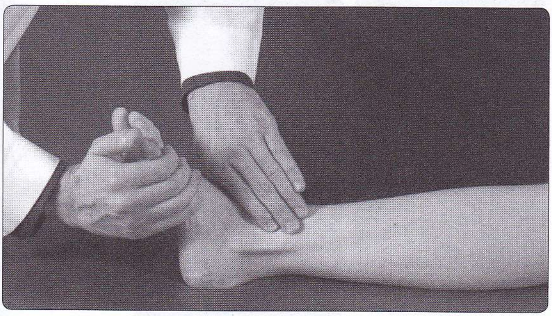
Anatomical variation:

- *Fibularis (peroneus) tertius* is most commonly a branch off of the distal fibers of *extensor digitorum longus*, but because it does not attach to the digits it is given a separate name
- Occasionally *fibularis tertius* may be absent or have its own tendon of origin

- Most clinicians describe the *fibularis tertius* as the "fifth tendon" of *extensor digitorum longus* (though it does not actually attach to a digit)
- *Fibularis (peroneus)* muscles are often grouped together because they all cause eversion of the foot
- *Fibularis tertius* is the only fibularis muscle that runs anterior to the lateral malleolus, resulting in dorsiflexion rather than plantar flexion as the other fibularis muscle do
- ***ADL:*** walking on uneven surfaces, soccer, jumping
- ***Common injuries:*** injuries specific to fibularis tertius are rare, may be damaged during an inversion sprain with plantar flexion
- ***DDx:*** MFTPs in fibularis longus, fibularis brevis, lateral compartment syndrome, shin splints, lumbar radiculopathy (S1 root level), SI, hip or knee joint dysfunction pain referral, tibial stress fracture

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction just anterior to the lateral malleolus
3. Ask patient to evert their ankle
4. Note muscle tissue contraction
5. Palpate from insertion to origin

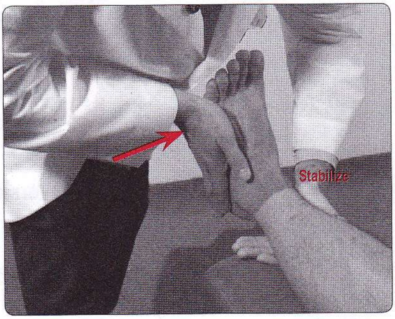


Muscle Test

Patient position
- Supine, ankle dorsiflexed & everted

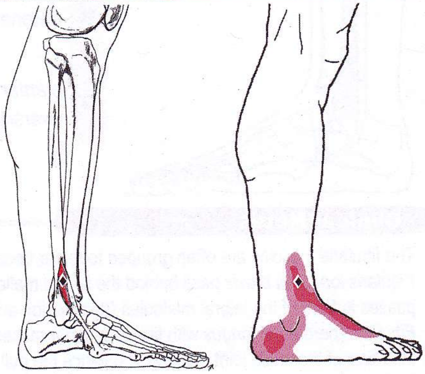
Examiner's force
- Diagonal from lateral to medial & towards plantar flexion

Stabilization
- Medially above ankle joint



Trigger Point Referral

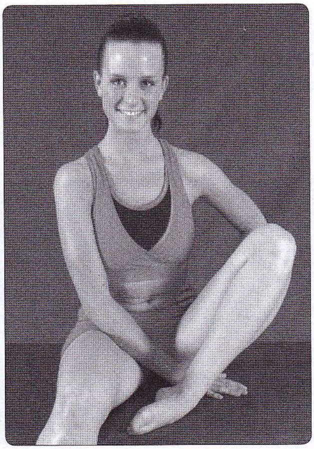
- MFTPs are usually located in the muscle belly
- Generally pain is referred downward over the dorsum of the foot & ankle
- Occasionally, pain may also refer over the heel

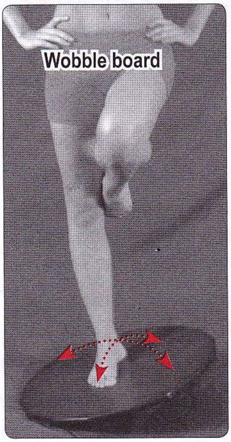


Stretch & Strengthen

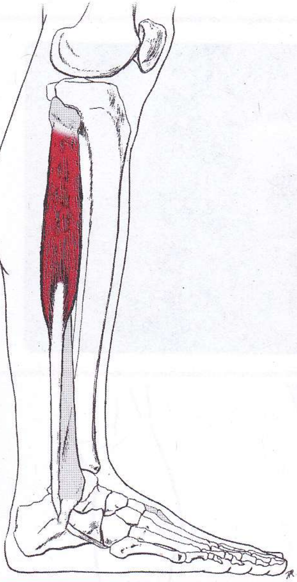
Self Stretch
- Patient seated, invert & plantar flex ankle with mild over pressure
- Note: stretching of fibularis muscles is usually NOT indicated as over stretching may predispose to chronic inversion ankle sprains

Strengthen
- Reverse calf raise
- Running on sand
- Wobble board movements





Fibularis (Peroneus) Longus



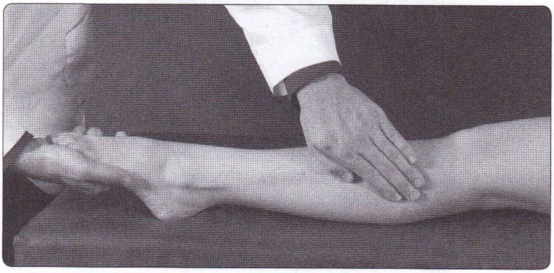
O	**head & proximal lateral shaft of fibula**
I	**medial cuneiform & base of 1st metatarsal** (plantar surfaces)
A	**eversion & plantar flexion of foot**
N	**superficial peroneal** (fibular) nerve (L5, S1)
B	peroneal (fibular) artery
S	*plantar flexion:* gastrocnemius, soleus *eversion:* fibularis brevis & tertius

Clinical Notes

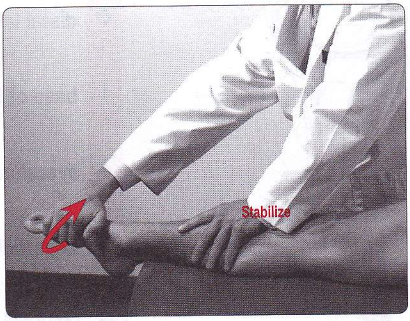
- The fibularis muscles are often grouped together because they evert of the foot
- *Fibularis longus & brevis* pass behind the lateral malleolus (plantar flexion action) & peroneus tertius passes in front of the lateral malleolus (dorsiflexion action)
- *Fibularis (peroneus) longus* with tibialis anterior makes up the stirrup of the foot; fibularis longus is a key stabilizer of the ankle joint, helping to balance the pull of the ankle invertors
- In patients with chronic inversion ankle sprains, strengthening of the fibularis muscles is crucial to ensure full recovery & decrease the chance of recurrence
- Tenosynovitis of the *fibularis longus & brevis* can occur because of the forces they resist & their sharp angle around the lateral malleolus
- There is also a chance of anterior displacement of these tendons secondary to rupture of superior fibular retinaculum
- ***ADL:*** walking on uneven surfaces, soccer, jumping
- ***Common injuries:*** strain following inversion sprain, peroneal tendonitis
- ***DDx:*** MFTPs in *fibularis brevis, fibularis tertius*, lateral compartment syndrome, lumbar radiculopathy (S1 root level), SI, hip or knee joint dysfunction pain referral, peroneal tendonitis

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction just inferior to the head of the fibula
3. Ask patient to evert & plantar flex their ankle
4. Note muscle tissue contraction
5. Palpate from origin to insertion



Muscle Test



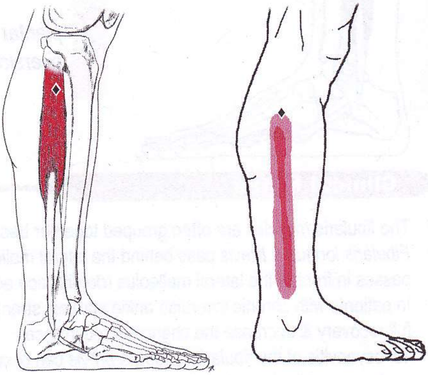
Patient position
- Supine, plantar flexed & everted

Examiner's force
- Rotational from medial to lateral & towards dorsiflexion ("motor bike" motion)

Stabilization
- Anteriorly above ankle joint

Trigger Point Referral

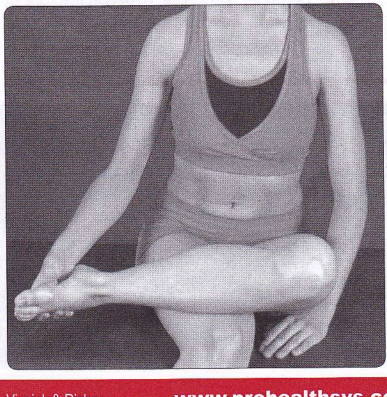
- MFTPs are usually located in the upper muscle belly
- Generally pain is referred downward over the lateral leg (over middle fibula)

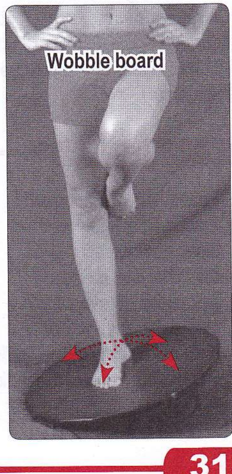


Stretch & Strengthen

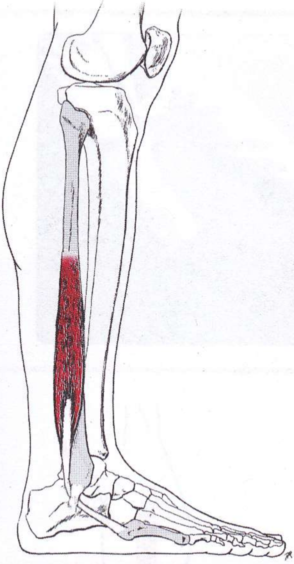
Self Stretch
- Invert ankle with mild over pressure
- Note: stretching of the fibularis muscles is usually NOT indicated as over stretching can lead to chronic recurrent ankle sprains

Strengthen
- Reverse calf raise
- Running on sand
- Wobble board or rocker board





Fibularis (Peroneus) Brevis



O **distal lateral 1/2 of fibula**

I **base of 5th metatarsal** (lateral aspect)

A **eversion & plantar flexion of foot**

N **superficial peroneal** (fibular) nerve (L5, S1)

B peroneal (fibular) artery

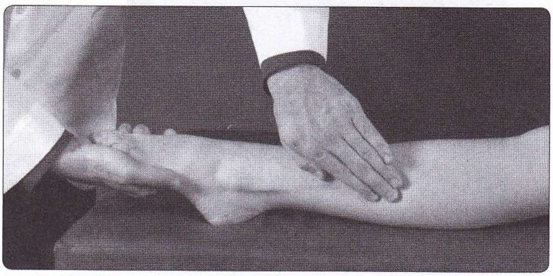
S *plantar flexion:* gastrocnemius, soleus
eversion: fibularis longus & tertius

Clinical Notes

- The fibularis muscles are often grouped together because they cause eversion of the foot
- *Fibularis longus & brevis* pass behind the lateral malleolus (plantar flexion action) & peroneus tertius passes in front of the lateral malleolus (dorsiflexion action)
- In patients with chronic inversion ankle sprains, strengthening of the fibularis muscles is crucial to ensure full recovery & decrease the chance of recurrence
- Tenosynovitis of the *fibularis longus & brevis* can occur because of the forces they resist and their sharp angle around the lateral malleolus
- There is also a chance of anterior displacement of these tendons secondary to rupture of superior fibular retinaculum
- In severe (grade 3) inversion ankle sprain it is possible for the tendon of *peroneus brevis* to pull away from the bone, resulting in an avulsion fracture at the base or styloid process of the 5th metatarsal
- ***ADL:*** walking on uneven surfaces, soccer, jumping
- ***Common injuries:*** strain following inversion sprain, peroneal tendonitis
- ***DDx:*** MFTPs in fibularis longus, fibularis tertius, lateral compartment syndrome, lumbar radiculopathy (S1 root level), SI, hip or knee joint dysfunction pain referral, peroneal tendonitis, avulsion fracture of 5th metatarsal

Palpation

1. Patient supine or seated
2. Place palpating fingers along fiber direction over the distal lateral fibula
3. Ask patient to evert & plantar flex their ankle
4. Note muscle tissue contraction
5. Palpate from origin to insertion

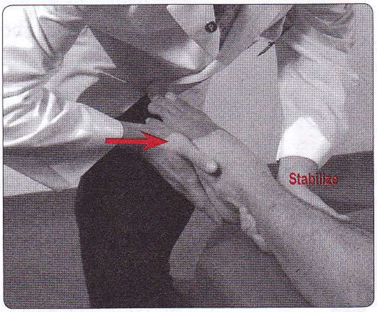


Muscle Test

Patient position
- Supine, ankle plantar flexed & everted

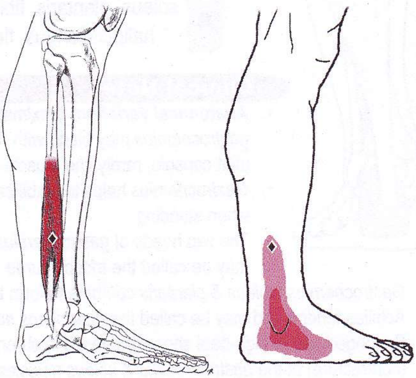
Examiner's force
- Straight lateral to medial

Stabilization
- Medially above ankle joint



Trigger Point Referral

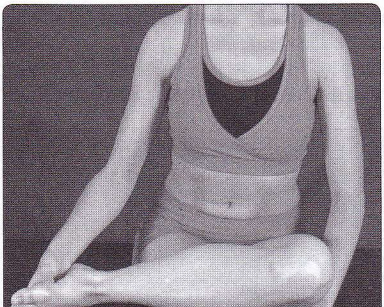
- MFTPs are usually located in the middle muscle belly
- Generally pain is referred downward over the lateral distal leg & ankle

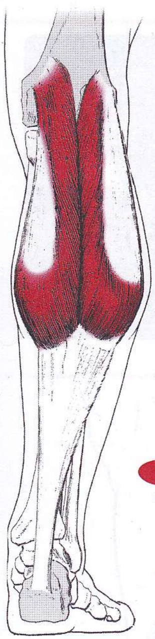


Stretch & Strengthen

Self Stretch
- Invert ankle with mild over pressure
- Note: stretching of the fibularis muscles is usually NOT indicated as over stretching can lead to chronic recurrent ankle sprains

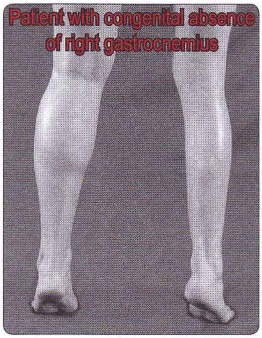
Strengthen
- Reverse calf raise
- Running on sand
- Wobble board or rocker board





O	*medial head:* **above medial condyle of femur** (posterior surface) *lateral head:* **above lateral condyle of femur** (posterior surface)
I	**calcaneus** (via calcaneal or Achilles tendon)
A	**plantar flexion of foot** knee flexion & inversion of foot (weak actions)
N	**tibial nerve** (**S1**, S2)
B	sural branches of popliteal artery
S	soleus, plantaris, tibialis posterior, fibularis longus & brevis, flexor hallucis longus, flexor digitorum longus

Clinical Notes

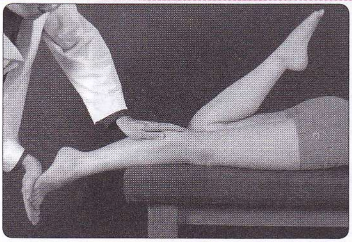


Patient with congenital absence of right gastrocnemius

- ***Anatomical variation:*** proximal fibers of the *gastrocnemius* may blend with the posterior knee joint capsule; rarely, the muscle may be absent
- *Gastrocnemius* helps to stabilize the ankle & knee when standing
- The two heads of *gastrocnemius & soleus* together may be called the *triceps surae*
- *Gastrocnemius, soleus & plantaris* combine to form the calcaneal or Achilles tendon and may be called the *quadriceps surae*
- Prolonged use of high-heel shoes can result in chronic shortening (contracture) of the *gastrocnemius & soleus* muscles
- Occasionally there is a sesamoid bone between the lateral head & the posterior aspect of lateral femoral condyle known as "fabella"
- The deep tendon reflex (DTR) of the calcaneal tendon tests spinal level S1
- *Gastrocnemius & soleus* acts as a 'venous pump'; when they contract deep veins in the posterior compartment of the leg are compressed, forcing blood against gravity towards the heart
- ***Common injuries:*** cramping, tennis leg, calcaneal tendon rupture
  - Gastrocnemius strain ("tennis leg") is due to partial tearing of the upper medial head of the muscle; results in an abrupt onset of stabbing calf pain (caused by over stretching of the muscle with simultaneous rapid full extension of the knee & dorsiflexion of the ankle)
  - Rupture of the calcaneal tendon is common in middle-aged men and frequently occurs in tennis players; the tendon usually ruptures 5 cm above its insertion (narrowest part)
- ***DDx:*** MFTPs in soleus, intermittent claudication or thrombophlebitis, tennis leg, Baker's cyst, posterior compartment syndrome, retrocalcaneal bursitis, Achilles tendon rupture, lumbar radiculopathy

Palpation

1. Patient prone, knee extended
2. Place palpating fingers along fiber direction over posterior leg
3. Ask patient to plantar flex ankle
4. Note muscle tissue contraction
5. Palpate from origin to insertion

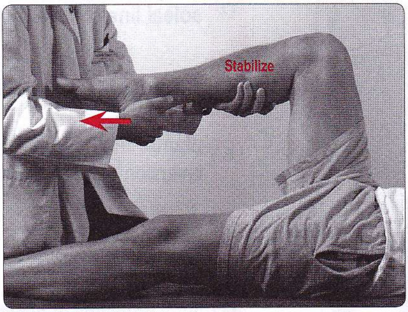


Muscle Test

Patient position
- Supine, knee & hip flexed 90°, ankle plantar flexed

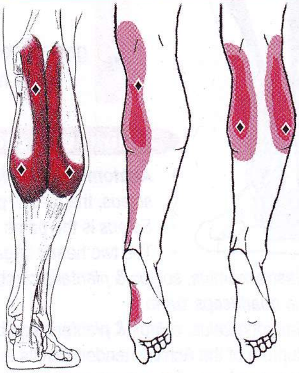
Examiner's force
- Pull calcaneus towards dorsiflexion

Stabilization
- Proximal to ankle joint



Trigger Point Referral

- MFTPs are usually located in the upper medial head, but may also occur in the lateral head
- *Upper medial head:* generally refers pain over the medial calf & medial longitudinal arch of the foot
- *Medial & lateral head:* generally refers pain over the local area superiorly & inferiorly on the ipsilateral side

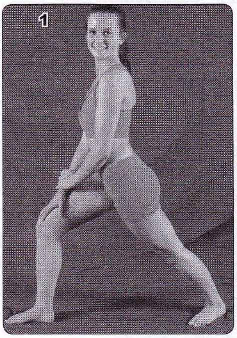


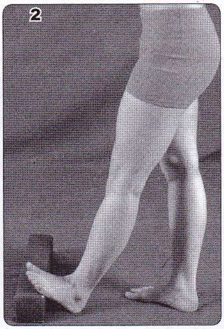
Stretch & Strengthen

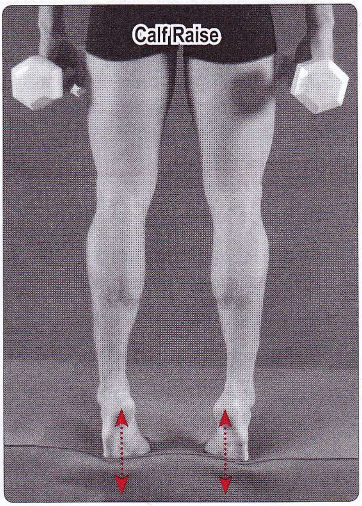
Stretch 1
- With posterior knee straight, lean body forward
- Consider internally or externally rotating leg to stretch medial & lateral fibers preferentially

Stretch 2
- With knee straight, dorsiflex ankle against step or wall

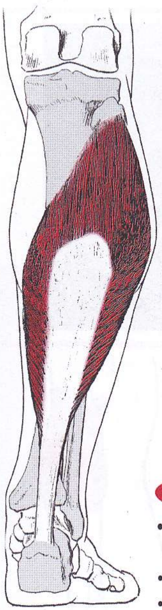
Strengthen
- Calf raise
- Running on sand
- Wobble board







Soleus



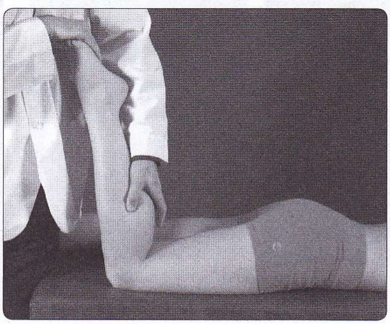
O	**soleal line of tibia & upper fibula**
I	**calcaneus** (via calcaneal or Achilles tendon)
A	**plantar flexion of foot** inversion of foot (weak action)
N	**tibial nerve** (**S1**, S2)
B	sural branches of popliteal artery
S	gastrocnemius, plantaris, tibialis posterior, fibularis longus & brevis, flexor hallucis longus, flexor digitorum longus

Clinical Notes

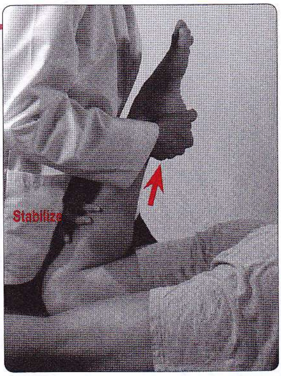
- ***Anatomical variation:*** rare, but may include an extra belly called the *accessory soleus,* the medial portion of the muscle may also be absent
- *Soleus* is the prime mover for plantar flexion
- The two heads of *gastrocnemius & soleus* together may be called the *triceps surae*
- *Gastrocnemius, soleus & plantaris* combine to form the calcaneal or Achilles tendon and may be called the *quadriceps surae*
- *Gastrocnemius, soleus & plantaris* combine to form the calcaneal or Achilles tendon
- Rupture of the Achilles tendon results in the loss of ability to walk or run
- Prolonged use of high-heel shoes can result in chronic shortening (contracture) of the *gastrocnemius & soleus* muscles
- The deep tendon reflex (DTR) of the calcaneal tendon tests spinal level S1
- Along with *gastrocnemius, soleus* acts as a 'venous pump'; when they contract deep veins in the posterior compartment of the leg are compressed, forcing blood against gravity towards the heart
- ***Common injuries:*** cramping, calcaneal tendon rupture
  - Rupture of the calcaneal tendon is common in middle-aged men and frequently occurs in tennis players; the tendon usually ruptures 5 cm above its insertion (narrowest part)
- ***DDx:*** MFTPs in gastrocnemius, intermittent claudication or thrombophlebitis, Baker's cyst, posterior compartment syndrome, retrocalcaneal bursitis, Achilles tendon rupture, lumbar radiculopathy, joint dysfunction (SI, hip, knee or ankle)

Palpation

1. Patient prone with knee flexed 90°
2. Place palpating fingers along fiber direction over posterior leg
3. Ask patient to plantar flex ankle
4. Note muscle tissue contraction
5. Palpate deep to gastrocnemius from origin to insertion



Muscle Test

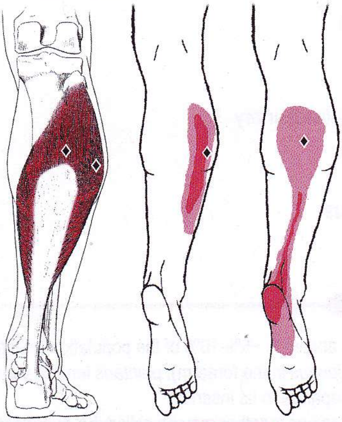


Patient position
- Prone, knee flexed 110°, ankle plantar flexed

Examiner's force
- Lift calcaneus towards dorsiflexion

Stabilization
- Proximal to the ankle joint

Trigger Point Referral

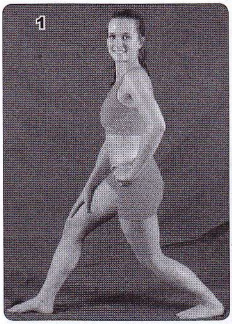


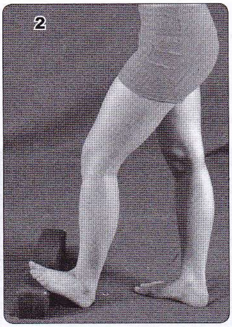
- MFTPs are usually located in the mid muscle belly & upper lateral belly
- *Mid belly:* generally refers pain over the mid calf, heel & proximal sole of the foot
- *Lateral belly:* generally refers pain over the local area superiorly & inferiorly on the ipsilateral side

Stretch & Strengthen

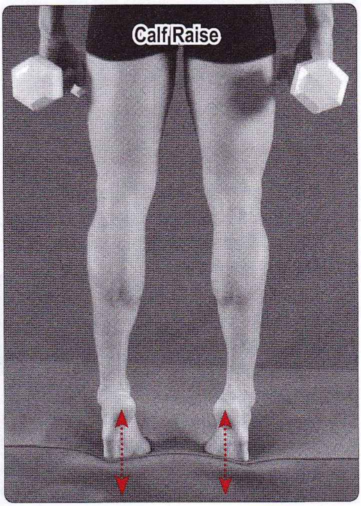
Self Stretch 1
- With posterior knee bent, lean body forward

Self Stretch 2
- With knee bent, dorsiflex ankle against step or wall
- By bending the knee, gastrocnemius fibers are not stretched

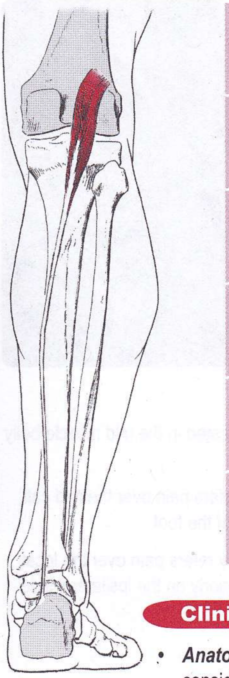




Strengthen
- Bent knee calf raise, running on sand
- Wobble board or rocker board



Plantaris



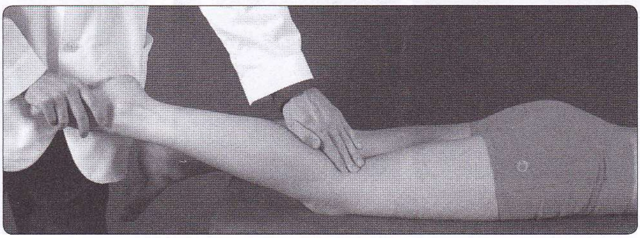
O	**distal posterolateral femur** (above lateral head of gastrocnemius)
I	**calcaneus** (via calcaneal or Achilles tendon)
A	**plantar flexion of foot** knee flexion (very weak action)
N	**tibial nerve** (**S1**, S2)
B	sural branches of popliteal artery
S	gastrocnemius, soleus

Clinical Notes

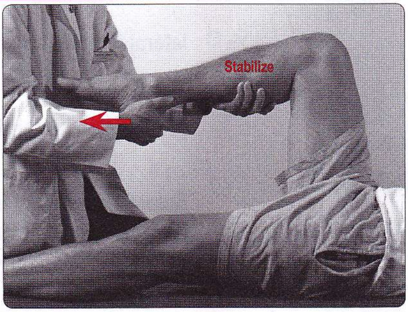
- ***Anatomical variation:*** *plantaris* is absent in ~5%-10% of the population (*plantaris* is considered analogous to *palmaris longus* in the forearm); *plantaris* tendon may fuse with the calcaneal tendon or stay separate to its insertion
- *Plantaris* along with the two heads of *gastrocnemius & soleus* together may be called the *quadriceps surae*
- *Gastrocnemius, soleus & plantaris* may combine to form the calcaneal or Achilles tendon
- During cadaver dissection, because *plantaris* has such a long slender tendon, junior anatomists are often fooled into thinking it is a nerve, hence the nickname "freshman's nerve" ☺
- ***Common injuries:*** injuries are rare, plantaris tendonitis may occur
- ***DDx:*** MFTPs in gastrocnemius lateral head, intermittent claudication or thrombophlebitis, Baker's cyst, posterior compartment syndrome, retrocalcaneal bursitis, Achilles tendon rupture, lumbar radiculopathy, joint dysfunction (SI, hip, knee or ankle)

Palpation

1. Patient prone with knee extended
2. Place palpating fingers along fiber direction just medial to biceps femoris & above the lateral head of gastrocnemius
3. Ask patient to flex knee & plantar flex ankle
4. Note muscle tissue contraction
5. Palpate from origin to insertion (very difficult to distinguish from gastrocnemius)



Muscle Test

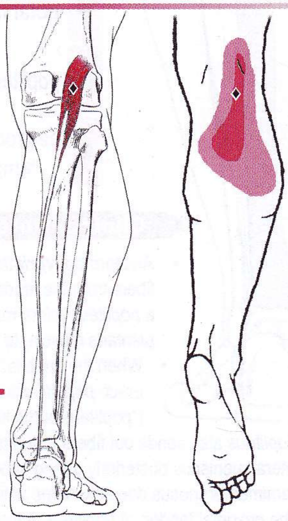


Patient position
- Supine, knee & hip flexed 90°, ankle plantar flexed

Examiner's force
- Pull calcaneus towards dorsiflexion

Stabilization
- Proximal to ankle joint

Trigger Point Referral



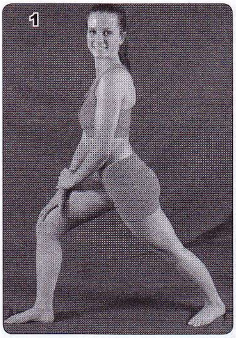
- MFTPs are usually located in the mid muscle belly
- Generally refers pain over the back of the knee & upper half of the calf

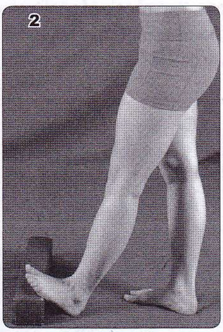
Stretch & Strengthen

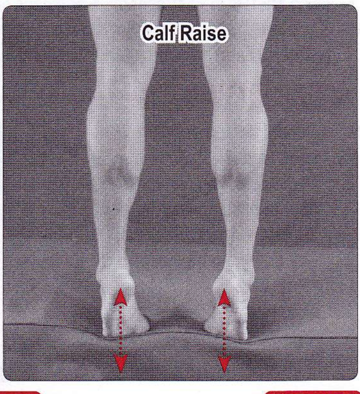
Stretch 1
- With posterior knee straight, lean body forward

Stretch 2
- With knee straight, dorsiflex ankle against step or wall
- Eversion of the ankle may more specifically stretch plantaris over gastrocnemius

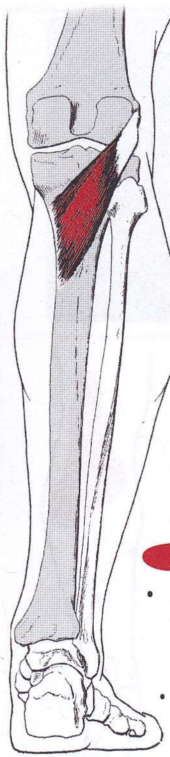
Strengthen
- Calf raise
- Running on sand
- Wobble board or rocker board







Popliteus



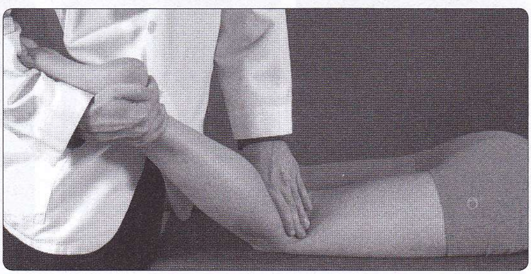
O	**lateral femoral condyle**
I	**proximal posterior tibia** (medial side above soleal line)
A	**unlocks knee from extended position** lateral rotation of femur on tibia or medial rotation of tibia on femur & flexion of knee
N	**tibial nerve** (L4, **L5**, S1)
B	popliteal artery
S	gastrocnemius, semitendinosus, semimembranosus, biceps femoris (hamstrings)

Clinical Notes

- ***Anatomical variation:*** *popliteus* can have minor attachments to the head of the fibula, fibers from the tendon may also attach to the lateral meniscus of the knee; rarely, a *popliteus minor* muscle has been found running from the femur underneath the *plantaris* muscle, to the posterior capsule of the knee joint
  - When the knee is "locked" (in full extension) little muscular activity is required to stand erect; *popliteus* is responsible for unlocking the knee; initiating flexion of the knee ("popliteus is the key that unlocks the knee")
- *Popliteus* also sends out fibers that attach to the lateral meniscus, where it helps to pull the lateral meniscus posteriorly during knee flexion (this helps prevent impingement of the meniscus); semimembranosus does the same action for the medial meniscus
- The proximal tendon of *popliteus* actually runs through the lateral joint capsule of the knee
- *Popliteus* also plays a crucial role in the posterior stability of the knee
- ***Common injuries:*** popliteus is often overlooked as a pain generator in the back of the leg
  - Strain following a fall with the knee extended, sever cruciate ligament tears can be associated with popliteus damage, tendonitis in overuse/imbalance syndromes
- ***DDx:*** MFTPs in gastrocnemius or biceps femoris, thrombosis of popliteal vein, Baker cyst, anteromedial & posterolateral instability of the knee, knee joint pathology pain referral (meniscus tear, capsule, cruciate ligament tears), popliteus tendinitis, joint dysfunction (SI, hip, knee or ankle)

Palpation

1. Patient seated or prone with knee flexed 45°-80°
2. Place palpating fingers along fiber direction over posterior knee on origin & insertion
3. Ask patient to medially rotate their tibia
4. Note muscle tissue contraction
5. Palpate deep to gastrocnemius from origin to insertion

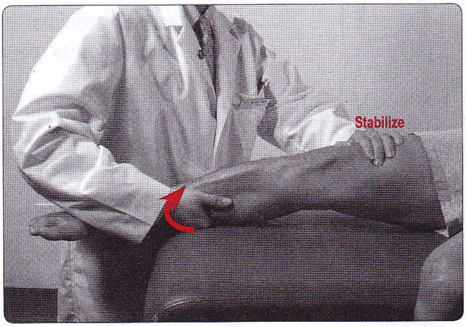


Muscle Test

Patient position
- Supine, leg extended & medially rotated with knee flexed 10°-20°

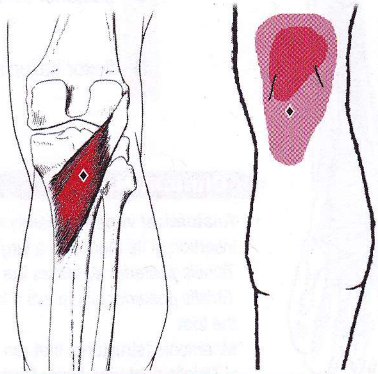
Examiner's force
- Towards external rotation

Stabilization
- Proximal to the knee joint



Trigger Point Referral

- MFTPs are usually located in the mid muscle belly
- Generally refers pain over the back of the knee & upper calf
- Popliteus MFTPs rarely occur on their own & usually occur in conjunction with MFTPs in gastrocnemius or biceps femoris

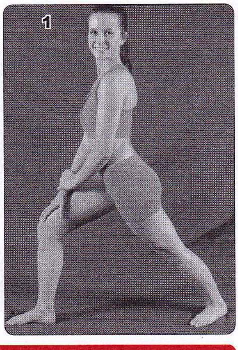


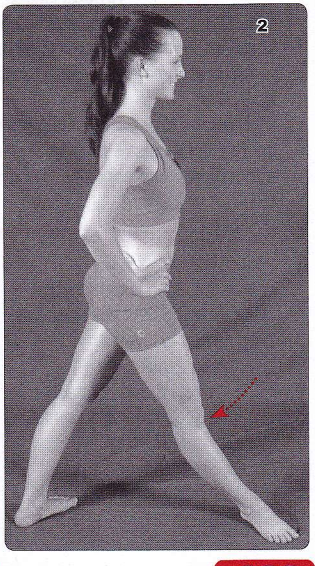
Stretch

Stretch 1
- With posterior knee straight, lean body forward

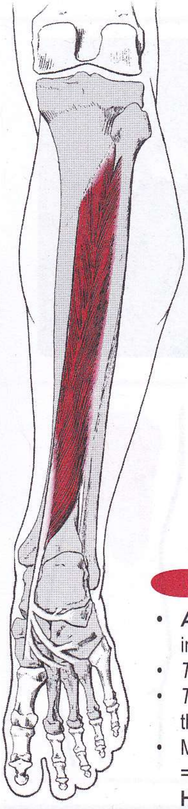
Stretch 2
- Stand with knee straight, consider gently applying a mild knee extension force

Popliteus rarely requires stretching & is difficult to stretch; it usually responds best to hands-on treatment





Tibialis Posterior



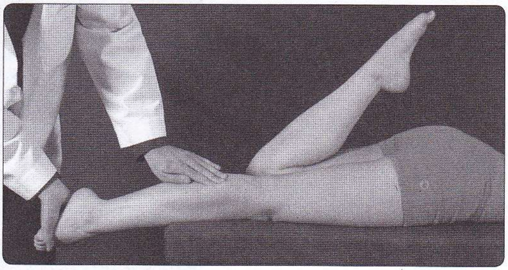
O	**posterior proximal 2/3 of tibia, fibula & interosseous membrane**
I	**fans out over plantar surface of foot** (navicular, all 3 cuneiforms, 2^{nd}-4^{th} metatarsals, cuboid & calcaneus)
A	**plantar flexion & inversion of foot**
N	**tibial nerve** (L4, L5, S1)
B	posterior tibial artery
S	flexor hallucis longus, flexor digitorum longus

Clinical Notes

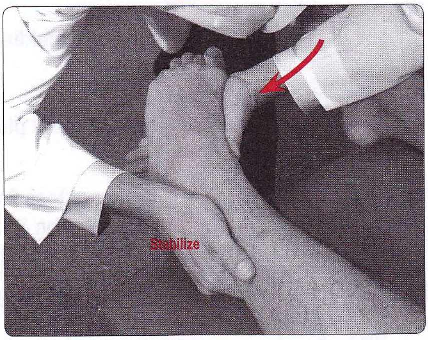
- ***Anatomical variation:*** rarely muscle may be doubled, or may have an irregular insertion of its tendon to a larger navicular tuberosity
- *Tibialis posterior* stabilizes the ankle & prevents over-pronation during the gait cycle
- *Tibialis posterior* also plays a key role in supporting the medial longitudinal arch of the foot
- Mnemonic (structures that run behind the medial malleolus): "**T**om, **D**ick **a**nd **H**arry" = **T**ibialis posterior, flexor **D**igitorum longus, posterior tibial **a**rtery, tibial **n**erve, flexor **H**allucis longus
- ***ADL:*** standing on tiptoes, pushing down car or bike pedals or sewing machine petal
- ***Common injuries:*** posterior tibial tendon dysfunction (over stretch or inflammation of tendon), with poor lower leg alignment the medial longitudinal arch of the foot may collapse resulting in increased stress on the muscle
- ***DDx:*** shin splints; posterior compartment syndrome; intermittent claudication or thrombophlebitis; "Tennis leg" (gastrocnemius strain); knee joint pathology pain referral (meniscus tear, capsule, cruciate ligament tears); SI, hip, knee or ankle joint dysfunction

Palpation

1. Patient prone
2. Place palpating fingers along fiber direction over posterior calf
3. Ask patient to invert & plantar flex ankle
4. Note muscle tissue contraction
5. Palpate deep to gastrocnemius/ soleus from origin to insertion behind medial malleolus to sole of foot



Muscle Test



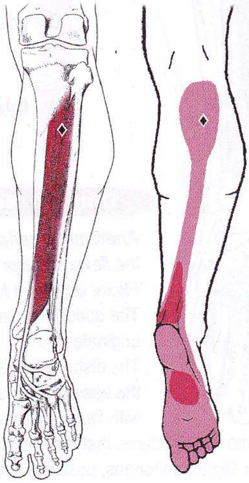
Patient position
- Supine, ankle plantar flexed & inverted

Examiner's force
- Diagonal from medial to lateral & towards dorsiflexion

Stabilization
- Laterally above ankle joint

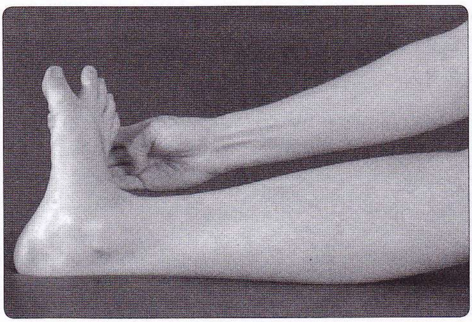
Trigger Point Referral

- MFTPs are usually located in the upper muscle belly
- Generally refer pain over the back of the calf, achilles tendon & plantar surface of the foot
- Palpation of MFTPs may be difficult as this muscle is deep to both gastrocnemius & soleus

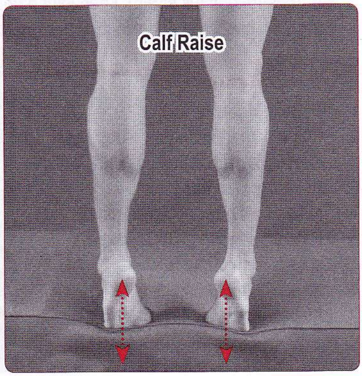


Stretch & Strengthen

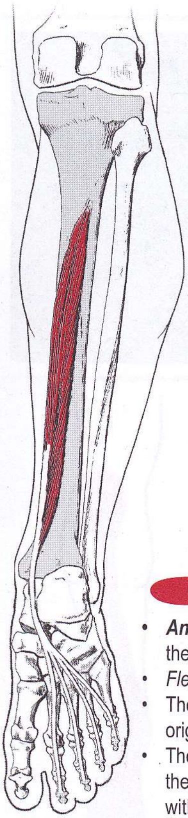
Self Stretch
- Patient seated with knee bent, dorsiflex & evert ankle, use ipsilateral hand to apply over pressure



Strengthen
- Bent knee calf raise, running on sand
- Wobble board or rocker board



Flexor Digitorum Longus



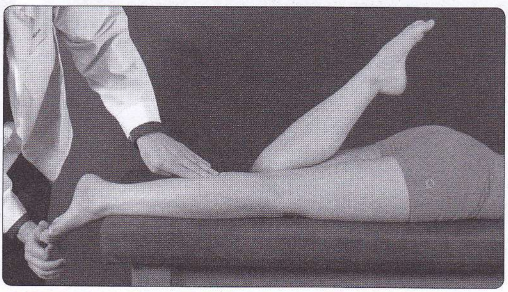
O	**posterior middle 1/3 of tibia**
I	**base of distal phalanges 2-5** (plantar surface)
A	**flexion of toes 2-5** (at MTP & IP joints) plantar flexion & inversion of foot (weak action)
N	**tibial nerve** (L5, **S1, S2**)
B	posterior tibial artery
S	flexor digitorum brevis, flexor hallucis longus, tibialis posterior

Clinical Notes

- ***Anatomical variation:*** an additional slip of tendon may run from the *flexor digitorum* to the *flexor hallucis longus*
- *Flexor digitorum longus* (FDL) helps to support the medial longitudinal arch of the foot
- The *quadratus plantae* muscle inserts onto the FDL tendon & the *lumbricals* of the foot originate from it
- The distal tendons of FDL pass through the tendons of *flexor digitorum brevis* to reach the base of the distal phalanges (in the same manner *flexor digitorum profundus* does with *flexor digitorum superficialis* in the hand)
- Mnemonic (structures that run behind the medial malleolus): "**T**om, **D**ick **and** **H**arry = **T**ibialis posterior, flexor **D**igitorum longus, posterior tibial **a**rtery, tibial **n**erve, flexor **H**allucis longus
- ***ADL:*** pushing off with toes during walking (gripping ground when walking bare-foot, standing on tiptoes
- ***Common injuries:*** tendonitis with overuse (ballet dancers, rock climbing), flexor digitorum longus may also contribute to the development of hammer toe of toes #2-5
- ***DDx:*** shin splints; posterior compartment syndrome; intermittent claudication or thrombophlebitis; "Tennis leg" (gastrocnemius strain); knee joint pathology pain referral (meniscus tear, capsule, cruciate ligament tears); SI, hip, knee or ankle joint dysfunction

Palpation

1. Patient prone
2. Place palpating fingers along fiber direction over medial posterior calf
3. Ask patient to flex their toes
4. Note muscle tissue contraction
5. Palpate deep to gastrocnemius/ soleus from origin to insertion behind medial malleolus to sole of foot

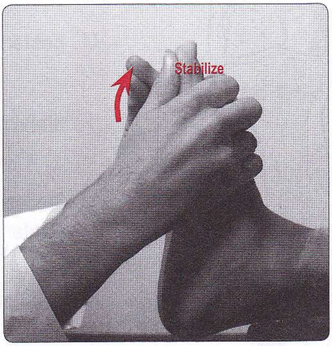


Muscle Test

Patient position
- Supine, ankle in neutral position, digits 2-5 flexed

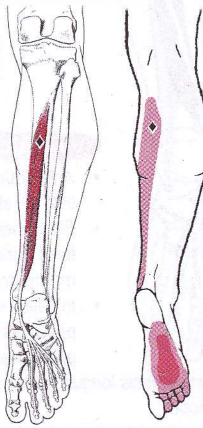
Examiner's force
- Toward extension of digits 2-5

Stabilization
- Over big toe



Trigger Point Referral

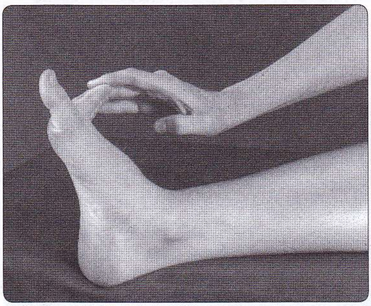
- MFTPs are usually located in the upper muscle belly
- Generally refers pain over the medial back of the calf, achilles tendon & lateral plantar surface of the foot
- Palpation of MFTPs may be difficult as this muscle is deep to both gastrocnemius & soleus

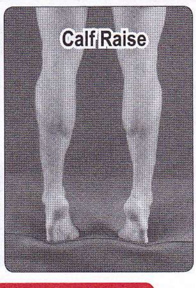


Stretch & Strengthen

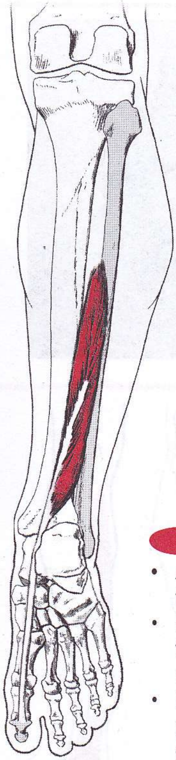
Self Stretch
- Patient seated with knee bent, dorsiflex ankle & extend toes 2-5, use ipsilateral hand to apply over pressure

Strengthen
- Calf raise pushing up on toes
- Walking or running on sand
- Short foot exercise
  - Place a foot on a small wet towel on the floor
  - Use toes #2-5 to slowly pull towel toward body





Flexor Hallucis Longus

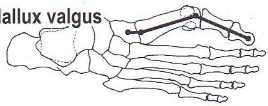


O	**posterior inferior 2/3 of fibula & interosseous membrane**
I	**distal phalanx of big toe** (plantar surface)
A	**flexion of big toe** (at MTP & IP joints) plantar flexion & inversion of foot
N	**tibial nerve** (L5, **S1, S2**)
B	posterior tibial artery
S	flexor hallucis brevis

Clinical Notes

- ***Anatomical variation:*** occasionally, *flexor hallucis longus* will send fibers & tendons that will attach to the 2nd & 3rd toes
- *Flexor hallucis longus* is a relatively large muscle that helps to generate propulsive force during the "push-off" or "toe-off" phase of gait; *flexor hallucis longus* shows maximum EMG activity during mid-stance & toe-off during the gait cycle
- In hallux valgus (see image), where the big toe points laterally, the efficiency of this muscle is greatly reduced

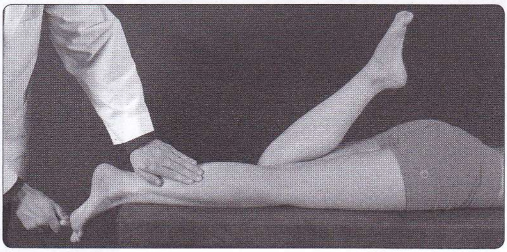
Hallux valgus



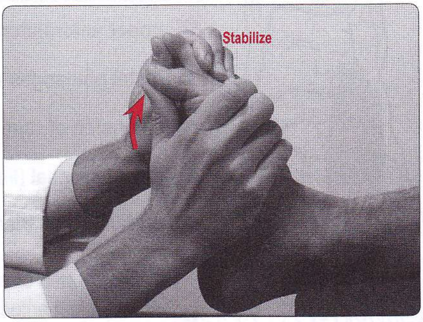
- *Flexor hallucis longus* helps maintain the medial longitudinal arches of the foot
- Mnemonic (structures that run behind medial malleolus): "**T**om, **D**ick **and** **H**arry = **T**ibialis posterior, flexor **D**igitorum longus, posterior tibial **a**rtery, tibial **n**erve, flexor **H**allucis longus
- ***ADL:*** pushing off with toe during walking, standing on tiptoes
- ***Common injuries:*** tendonitis with overuse (ballet dancers, rock climbing, running), *flexor hallucis longus* may also contribute to the development of hammer toe of the 1st digit
- ***DDx:*** Gout; shin splints; posterior compartment syndrome; intermittent claudication or thrombophlebitis; "Tennis leg" (gastrocnemius strain); knee joint pathology pain referral (meniscus tear, capsule, cruciate ligament tears); SI, hip, knee or ankle joint dysfunction

Palpation

1. Patient prone
2. Place palpating fingers along fiber direction over distal posterior calf
3. Ask patient to flex their big toe
4. Note muscle tissue contraction
5. Palpate deep to gastrocnemius/ soleus from origin to insertion behind medial malleolus to sole of foot



Muscle Test



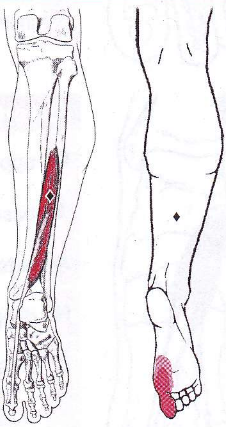
Patient position
- Supine, ankle in neutral position, big toe flexed

Examiner's force
- Toward extension of the big toe

Stabilization
- Over digits 2-5

Trigger Point Referral

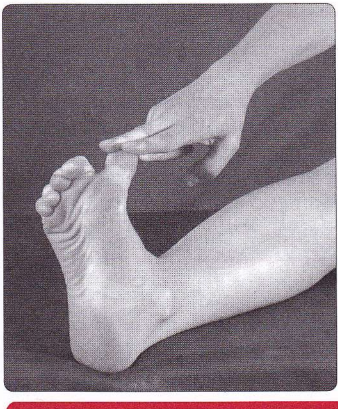
- MFTPs are usually located in the mid muscle belly
- Generally refers pain over the medial plantar surface of the foot & big toe
- Palpation of MFTPs may be difficult as this muscle is deep to soleus

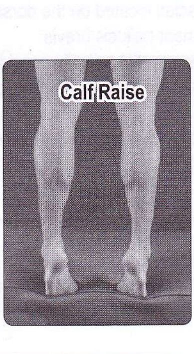


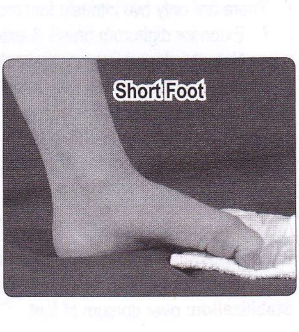
Stretch & Strengthen

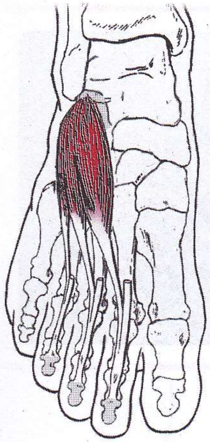
Self Stretch
- Patient seated with knee bent, dorsiflex ankle & extend 1st toe, use ipsilateral hand to apply over pressure

Strengthen
- Calf raise pushing up on toes
- Walking or running on sand
- Short foot exercise
  - Place a foot on a small wet towel on the floor
  - Use big toe to slowly pull towel toward body



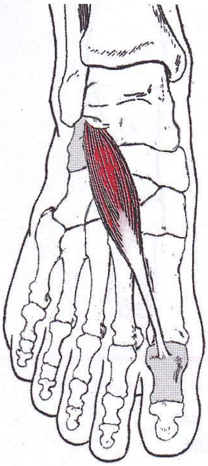






Extensor Digitorum Brevis

O	**upper anterolateral calcaneus**
I	**distal phalanges of toes 2-4** (via EDL & extensor expansion)
A	**extension of toes 2-4** (at MTP & IP joints)
N	**deep peroneal** (fibular) nerve (L5, **S1**)
B	dorsalis pedis artery
P	Patient seated or supine, place palpating fingers along fiber direction just anterior to the lateral malleolus, ask patient to extend toes, note muscle contraction, palpate from origin to insertion



Extensor Hallucis Brevis

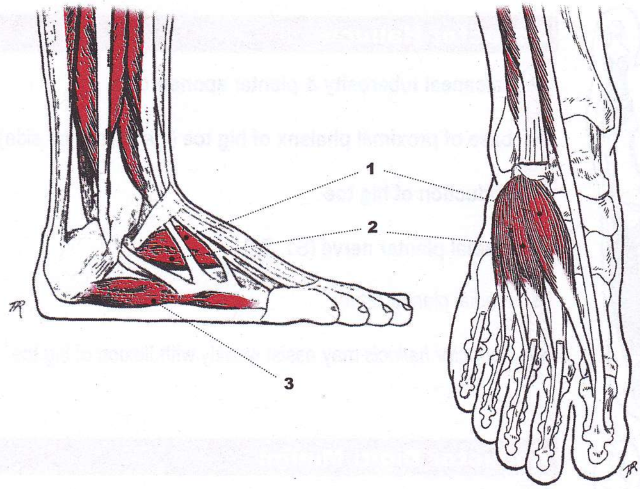
O	**upper anterolateral calcaneus**
I	**base of proximal phalange of big toe**
A	**extension of big toe** (at MTP joint)
N	**deep peroneal** (fibular) nerve (L5, **S1**)
B	dorsalis pedis artery
P	Patient seated or supine, place palpating fingers along fiber direction just anterior & medial to the lateral malleolus, ask patient to extend big toe, note muscle contraction, palpate from origin to insertion

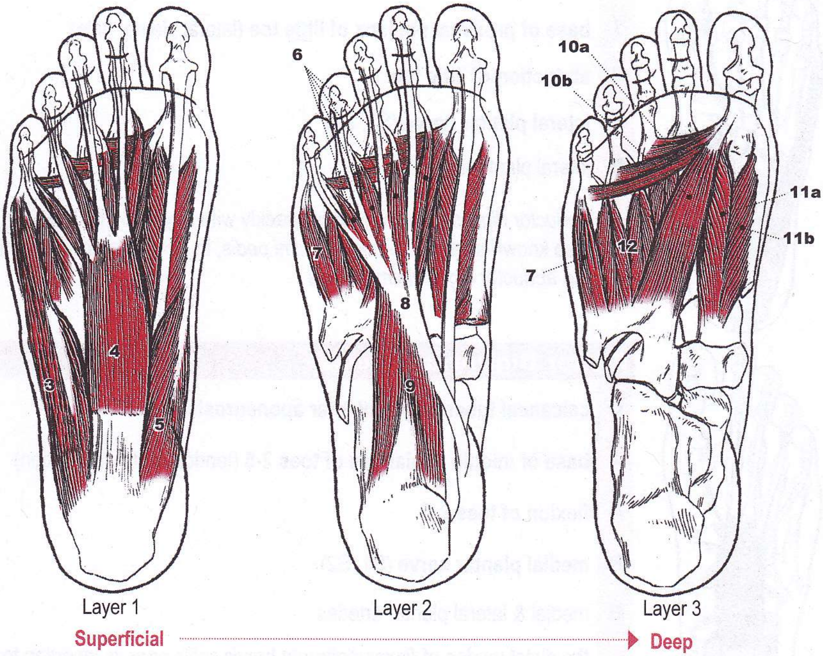
Clinical Notes

- There are only two intrinsic foot muscles located on the dorsal (superior) side of the foot:
  - Extensor digitorum brevis & extensor hallucis brevis
  - Note the dorsal interossei are deep and classically considered part of the plantar surface of the foot
- Extensor hallucis brevis may attach to the base of the distal phalange via the extensor expansion & tendon of extensor hallucis longus
- These muscles are useful markers to evaluate swelling following an ankle sprain (muscle margins may be less obvious with edema & swelling)

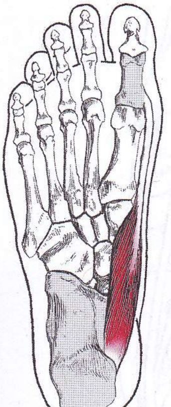
Muscle Test

Patient position: seated or supine, ankle fully dorsiflexed
Examiner's force: EDB: toward flexion of toes 2-4, EHB: toward flexion of big toe
Stabilization: over dorsum of foot



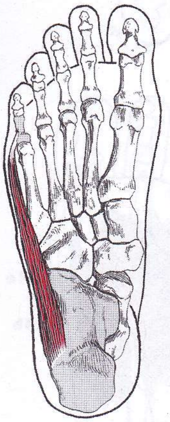


1. Extensor hallucis brevis
2. Extensor digitorum brevis
3. Abductor digiti minimi
4. Flexor digitorum brevis
5. Abductor hallucis
6. Lumbricals
7. Flexor digiti minimi
8. Flexor digitorum longus tendon
9. Quadratus plantae
10. Adductor hallucis
    a. Transverse head
    b. Oblique head
11. Flexor hallucis brevis
    a. Lateral head
    b. Medial head
12. Interossei muscles



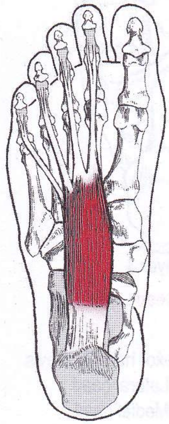
Abductor Hallucis

O	**calcaneal tuberosity & plantar aponeurosis**
I	**base of proximal phalanx of big toe** (medial plantar side)
A	**abduction of big toe**
N	**medial plantar nerve** (S1, S2)
B	medial plantar artery
C	*abductor hallucis* may assist weakly with flexion of big toe



Abductor Digiti Minimi

O	**calcaneal tuberosity**, flexor retinaculum & plantar aponeurosis
I	**base of proximal phalanx of little toe** (lateral plantar side)
A	**abduction of little toe**
N	**lateral plantar nerve** (S1, S2)
B	lateral plantar artery
C	*abductor digiti minimi* may assist weakly with flexion of the little toe; also known as *abductor digiti minimi pedis*, to help differentiate from the *abductor digiti minimi manus*

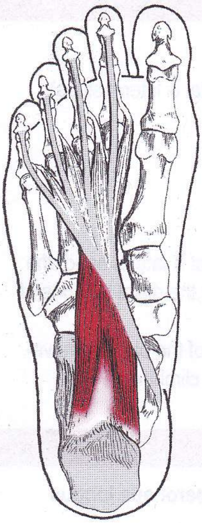


Flexor Digitorum Brevis

O	**calcaneal tuberosity & plantar aponeurosis**
I	**base of middle phalanges of toes 2-5** (tendon splits at insertion)
A	**flexion of toes 2-5**
N	**medial plantar nerve** (S1, S2)
B	medial & lateral plantar arteries
C	the distal tendon of *flexor digitorum brevis* splits near its insertion to allow the tendon of *flexor digitorum longus* to reach the distal phalanx

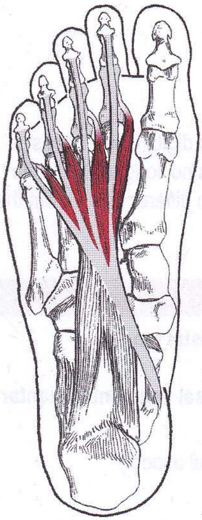
Abductor ossis metatarsi quinti (not shown) is a muscle of the foot that is often absent; when present, it is located in or below the outer margin of the plantar fascia -

- O: fibers of the abductor digiti minimi muscle, I: 5*th* metatarsal (tuberosity)
- A: abducts 5th ray
- N: lateral plantar nerve (S1, S2), B: lateral plantar artery



Quadratus Plantae

O	**medial & lateral calcaneus**
I	**flexor digitorum longus tendon** (lateral margin)
A	**flexion of distal phalanges 2-5**
N	**lateral plantar nerve** (S1, S2)
B	medial & lateral plantar arteries
C	quadratus plantae has two heads of origin: medial head from the medial calcaneus & lateral head from the lateral calcaneus & long plantar ligament the main action of quadratus plantae helps correct flexor digitorum longus from pulling toes medially quadratus plantae is also known as the *flexor digitorum accessorius* or plantar head of flexor digitorum

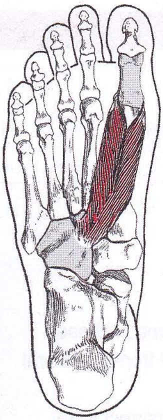


Lumbricals

O	*1st:* **medial aspect of FDL tendon to 2nd toe** *2-4:* **two heads between tendons of flexor digitorum longus**
I	**base of proximal phalanges of toes 2-5** (medial side)
A	**extension of toes 2-5** (at PIP & DIP joint) **flexion of toes 2-5** (at MTP joints)
N	*1st:* **medial plantar nerve** (S1, S2, S3) *2-4:* **lateral plantar nerve** (S1, S2, S3)
B	*1st:* medial plantar artery *2-4:* lateral plantar artery
C	insertion fibers may extend to the tendon of extensor digitorum longus & extensor expansion (on the dorsal medial side) lumbricals of the foot are much more variable than lumbricals of the hand; in the foot they may be absent or occasionally there may be more than 4

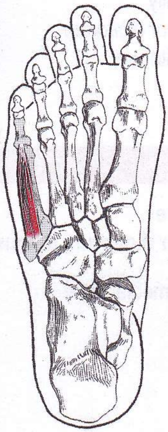
Palpation/Muscle Test

- Place palpating fingers along fiber direction over the muscle belly and ask the patient to perform the action of the muscle, note contraction & palpate from origin to insertion (deeper layers are more difficult to differentiate)
- **Testing foot muscles** - resist the action of the muscle



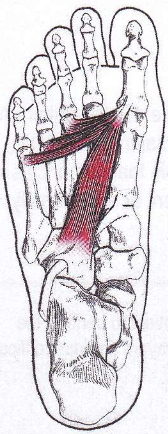
Flexor Hallucis Brevis

O	**cuboid & lateral cuneiform**
I	**base of proximal phalanx of big toe** (medial & lateral sides)
A	**flexion of big toe** (at MTP joint)
N	**medial plantar nerve** (S1, S2)
B	medial plantar artery
C	flexor hallucis brevis has two heads, a medial & lateral head; the sesamoid bones of the foot are located in the distal tendons of flexor hallucis brevis flexor hallucis brevis is important for flexion of the big toe; movements that occur in walking, ballet & rock climbing



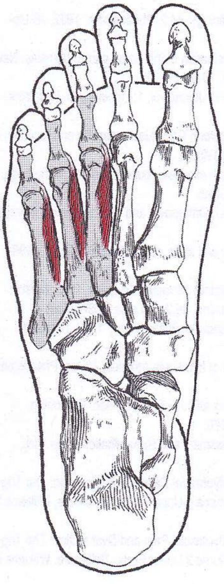
Flexor Digiti Minimi

O	**base of 5th metatarsal & distal tendon of peroneus longus**
I	**base of proximal phalanx of little toe** (5th toe)
A	**flexion of little toe** (at MTP joint)
N	**lateral plantar nerve** (S2, S3)
B	lateral plantar artery
C	extensor digiti minimi is also known as flexor digiti minimi brevis or flexor digiti minimi pedis; because there is no 'longus' the name 'brevis' is not required; pedis may be used to differentiate it from the flexor digiti minimi of the hand (manus)



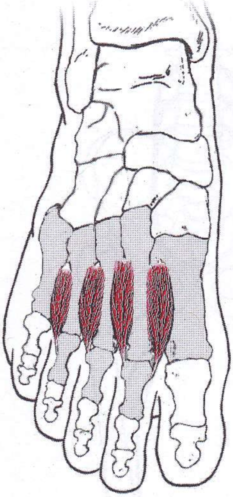
Adductor Hallucis

O	*oblique head:* **base of metatarsals 2-4 & distal tendon of peroneus longus** *transverse head:* **deep transverse metatarsal ligament & plantar ligaments at MTP joints**
I	**base of proximal phalanx of big toe** (lateral aspect)
A	**adduction of big toe**
N	**lateral plantar nerve** (S2, S3)
B	lateral plantar artery
C	adductor hallucis also acts as a tensor of the plantar arches to help maintain the arches of the foot; if a person has "lateral feet" or "fallen arches" this may be one of the intrinsic foot muscles that when strengthened can help restore the arch of the foot (short foot exercises)



Plantar Interossei

O	**medial aspect of metatarsals 3-5** (each muscle has a single head)
I	**medial aspect of base of proximal phalanx of same ray**
A	**adduction of toes 3-5** (at MTP joint)
N	**lateral plantar nerve** (S2, S3)
B	lateral plantar artery
P	Patient seated or supine, place palpating fingers along fiber direction between metatarsals, ask patient to adduct toes, note muscle contraction, palpate from origin to insertion (palpation may be difficult)



Dorsal Interossei

O	**from both metatarsals between which they lie**
I	**1st medial side of 2nd proximal phalanx** **2-4 lateral side of 2nd-4th proximal phalanges**
A	**abduction of toes 2-4** (at MTP joint)
N	**lateral plantar nerve** (S2, S3)
B	lateral plantar artery
P	Patient seated or supine, place palpating fingers along fiber direction between metatarsals, ask patient to abduct toes, note muscle contraction, palpate from origin to insertion (palpation may be difficult)

Clinical Notes

- Dorsal & plantar interossei of the foot have the same action as dorsal & plantar interossei of the hand; DAB & PAD (Dorsal ABduct & Plantar ADduct)
- Dorsal interossei of the foot are also known as dorsal interossei pedis to help distinguish them from dorsal interossei manus (of the hand)

1 Martini, Frederic H., Timmons, Michael J., Tallitsch, Robert B. Human Anatomy 5th Edition. San Francisco, California: Pearson Education Inc., 2006 p 306-309, 312, 329

2 Pichler, W., Tesch, NP., Grechenig, W., Leithgoeb, O., Windisch, G. Anatomic variations of the musculotendinous junction of the soleus muscle and its clinical implications. Clinical Anatomy 2006 Oct: 4 [E.Pub ahead of print]

3 Woll, TS. Posterior tibial tendon dysfunction. West J Med. 1993 October; 159(4): 485–486.

4 Hansen ST Jr, Clark W. Tendon transfer to augment the weakened tibialis posterior mechanism. J Am Podiatr Med Assoc. 1988 Aug;78(8):399–402.

5 Holmes GB Jr, Mann RA. Possible epidemiological factors associated with rupture of the posterior tibial tendon. Foot Ankle. 1992 Feb;13(2):70–79.

6 Canale ST: Campbell's operative orthopaedics, vol 1-4, ed 9, St Louis, 1998, Mosby.

7 Cantu, RL,& Grodin, A. 1992: Myofascial manipulation - Theory and Clinical Application, Aspen Publishers Inc. 1992.

8 Cash, M. Pocket Atlas of the Moving Body : For All Students of Human Biology, Medicine, Sports and Physical Therapy, Ebury House, 2000.

9 Chaitow, L. Palpation Skills Assessment and Diagnosis Through Touch, Churchill-Livingston, 1996.

10 Cyriax J. Textbook of orthopaedic medicine. Vol. 1. Diagnosis of soft tissue lesions.

11 Cyriax, JH. & Cyriax, PJ. Cyriax's Illustrated Manual of Orthopedic Medicine, 3rd ed., Butterworth-Heinemann, 1996.

12 Dambro MR, Griffith JA: Griffith's 5 minute clinical consult, Baltimore, 2008, Williams & Wilkins.

13 Dandy DJ: Essential orthopaedics and trauma, Edinburgh, 1989, Churchill Livingstone.

14 Gartland, I.I.: Fundamentals of Orthopaedics. Philadelphia, W.B. Saunders Co., 1979.

15 Greenman, PE. Principles of Manual Medicine, 2nd ed., Williams & Willkins, 1995.

16 Greenspan A: Orthopedic radiology, ed 2, Philadelphia, 1992, JB Lippincott.

17 Hoppenfeld, S.: Physical Examination of the Spine and Extremities. New York, Appleton-Century-Crofts, 1976.

18 Kapandji, I.A.: The Physiology of Joints, vol. 1: Upper Limb. New York, Churchill Livingstone, 1970.

19 Kendall HO, Kendall FP, Wadsworth GE: Muscles testing and function, ed 4, Baltimore, 2003, Williams & Wilkins.

20 Kisner C, Colby LA: Therapeutic exercise; foundations and techniques, ed 2, Philadelphia, 1990, FA Davis.

21 Malone TR, McPoil TG, Nitz AJ: Orthopedic and sports physical therapy, ed 3, St Louis, 1997, Mosby.

22 Martin JH: Neuroanatomy text and atlas, ed 2, Stamford, Conn, 1996, Appleton & Lange.

23 Mathers LH, et al: Clinical anatomy principles, St Louis, 1996, Mosby.

24 Mellion MB: Office sports medicine, ed 2, St Louis, 1996, Mosby.

25 Mellion MB: Sports medicine secrets, Philadelphia, 1994, Hanley & Belfus.

26 O'Donoghue, D.H.: Treatment of Injuries to Athletes, 4th ed. Philadelphia. W.B. Saunders Co., 1984.

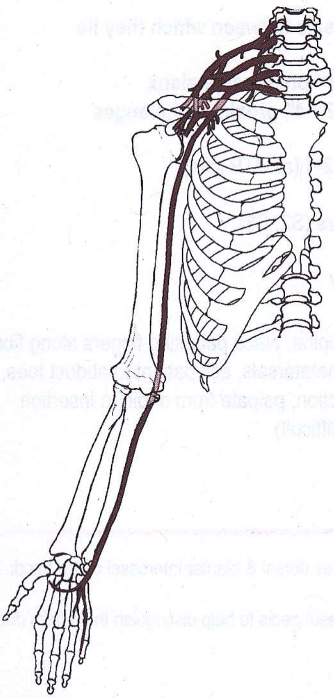
27 Reid, D.C.: Functional Anatomy and Joint Mobilization. Edmonton, University of Alberta Press, 1970.

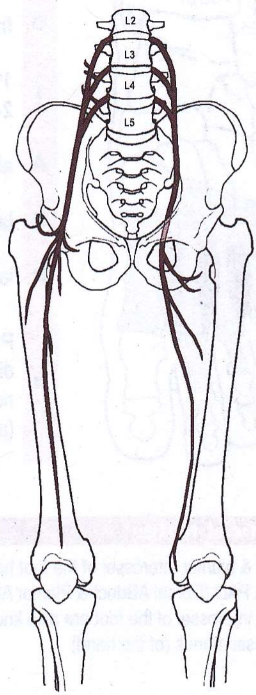
28 Reid, D.C.: Sports Injury Assessment and Rehabilitation. New York, Churchill Livingstone, 1992.

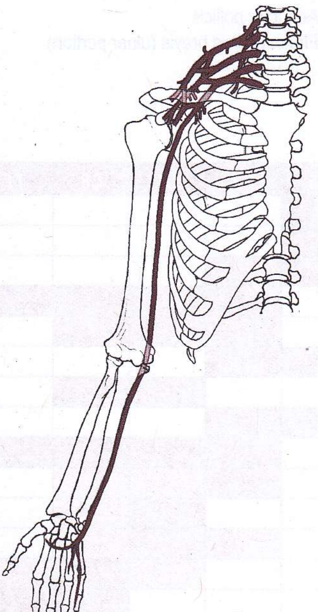
29 Travell, TG., & Simons, LS. Myofascial Pain and Dysfunction: The Trigger Point Manual. 2nd ed. Volume 1 Upper Body. Baltimore, Williams & Wilkins, 1993.

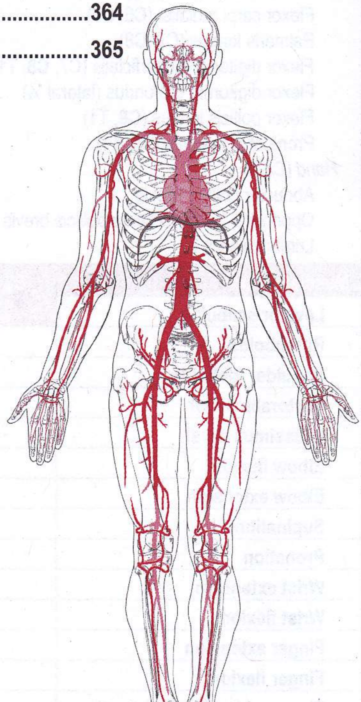
30 Travell, TG., & Simons, LS. Myofascial Pain and Dysfunction: The Trigger Point Manual. 2nd ed. Volume 2 Lower Body. Baltimore, Williams & Wilkins, 1993.

31 Vizniak, NA. Gross Anatomy: Human Cadaver Dissections. 1999-2008









Suprascapular nerve
- Supraspinatus (C4, **C5**)
- Infraspinatus (C5, **C6**)

Long thoracic nerve
- Serratus anterior (C5-C7)

Dorsal scapular nerve
- Levator scapulae
- Rhomboid major & minor

Axillary nerve
- Deltoid (**C5**, C6)
- Teres minor (C5, **C6**)

Musculocutaneous nerve
- Biceps brachii (C5, **C6**)
- Brachialis (C5, **C6**)
- Coracobrachialis (C5, **C6**, C7)

Median nerve

Forearm
- Pronator teres (C6, **C7**)
- Flexor carpi radialis (C6, **C7**)
- Palmaris longus (C7, C8)
- Flexor digitorum superficialis (C7, **C8**, T1)
- Flexor digitorum profundus (lateral ½)
- Flexor pollicis longus (**C8**, T1)
- Pronator quadratus (**C8**, T1)

Hand (C8-T1)
- Abductor pollicis brevis
- Opponens pollicis & flexor pollicis brevis
- Lumbricals I & II

Radial nerve

Arm
- Brachioradialis (C5, **C6**, C7)
- Extensor carpi radialis longus (C6-C7)
- Anconeus (C7, C8, T1)
- Triceps (long/lateral/medial head) (C6-**C8**)

Forearm
- Supinator (**C5**, C6)
- Extensor carpi radialis brev. (**C7**, C8)
- Extensor digitorum (**C7**, C8)
- Extensor digiti minimi (**C7**, C8)
- Extensor carpi ulnaris (**C7**, C8)
- Abductor pollicis longus (C7, **C8**)
- Extensor pollicis longus (C7, **C8**)
- Extensor pollicis brevis (C7, **C8**)
- Extensor indicis (C7, **C8**)

Ulnar nerve

Forearm
- Flexor carpi ulnaris (C7, **C8**)
- Flexor digitorum profundus (medial 1/2)

Hand (C8-T1)
- Flexor & abductor digiti minimi brevis
- Opponens digiti minimi
- Lumbricals III & IV, interossei
- Adductor pollicis
- Flexor pollicis brevis (ulnar portion)

Muscle/Action	C3	C4	C5	C6	C7	C8	T1
Levator scapulae							
Rhomboids							
Shoulder (deltoid)							
Pectoralis major							
Latissimus dorsi							
Elbow flexion							
Elbow extension							
Supination							
Pronation							
Wrist extension							
Wrist flexion							
Finger extension							
Finger flexion							
Finger adduction & abduction							
Intrinsic hand muscles							

Superior gluteal nerve
- Tensor fasciae latae (L4, L5)
- Gluteus medius (**L5**, S1)
- Gluteus minimus (**L5**, S1)

Inferior gluteal nerve
- Gluteus maximus (L5, **S1**, **S2**)

Femoral nerve

Thigh
- Pectineus (**L2**, L3)
- Sartorius (L2, L3)

Quadriceps:
- Rectus femoris (L2, **L3, L4**)
- Vastus lateralis (L2, **L3, L4**)
- Vastus intermedius (L2, **L3, L4**)
- Vastus medialis (L2, **L3, L4**)

Obturator nerve
- Gracilis (**L2**, L3)
- Adductor longus (L2, **L3**, L4)
- Adductor brevis (L2, **L3**, L4)
- Adductor magnus (L2, **L3, L4**)
- Obturator externus (L3, **L4**)

Sciatic nerve (tibial division)
- Popliteus (**L4, L5**, S1)
- Semitendinosus (**L5, S1**, S2)
- Semimembranosus (**L5, S1**, S2)
- Biceps femoris (long head) (L5, **S1**, S2)

Leg
- Tibialis posterior (L4, L5)
- Gastrocnemius (S1, **S2**)
- Plantaris & Soleus (S1, **S2**)
- Flexor digitorum longus (**S2**, S3)
- Flexor hallicus longus (**S2**, S3)

Foot
- Abductor hallicus & abductor digiti minimi
- Dorsal interossei

Sciatic nerve (fibular/peroneal division)
- Biceps femoris (short head) (L5, **S1**, S2)

Leg (deep fibular nerve)
- Tibialis anterior (**L4**, L5)
- Extensor hallicus longus (**L5**, S1)
- Extensor digitorum longus (L5, S1)
- Fibularis tertius (L5, S1)

Foot (superficial fibular nerve)
- Extensor digitorum brevis
- Fibularis longus (**L5, S1**, S2)
- Fibularis brevis (**L5, S1**, S2)

Muscle group/Action	L1	L2	L3	L4	L5	S1	S2
Hip extension & external rotation							
Hip external rotation							
Hip abduction & internal rotation							
Hip abduction							
Hip extension							
Hip flexion							
Knee flexion							
Knee extension							
Extensor hallicus							
Toe extension							
Plantarflexion							
Dorsiflexors							
Ankle inversion							
Ankle eversion							

Neurovascular

<table>
<tr><th>Upper body</th><th colspan="9">Spinal level & main muscles</th><th colspan="2" rowspan="2">Nerve</th></tr>
<tr><th>Action tested</th><th>C1</th><th>C2</th><th>C3</th><th>C4</th><th>C5</th><th>C6</th><th>C7</th><th>C8</th><th>T1</th></tr>
<tr><td>Neck flexion</td><td colspan="4" rowspan="4">deep neck muscles, sub-occipitals, SCM, trapezius (accessory n.)</td><td></td><td></td><td></td><td></td><td></td><td rowspan="5">Cervical</td><td rowspan="6">Cervical plexus</td></tr>
<tr><td>Neck extension</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Neck rotation</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Neck lat. flexion</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rib elevation</td><td></td><td></td><td colspan="3">scalenes</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Inspiration</td><td></td><td></td><td colspan="3">diaphragm</td><td></td><td></td><td></td><td></td><td>Phrenic</td></tr>
<tr><td>Scapular protract.</td><td></td><td></td><td></td><td></td><td colspan="3">serratus anterior</td><td></td><td></td><td>Long thoracic</td><td rowspan="31">Brachial plexus</td></tr>
<tr><td>Scapular elevation</td><td></td><td></td><td colspan="4">levator scapula</td><td></td><td></td><td></td><td rowspan="2">Dorsal scapular</td></tr>
<tr><td>Scapular adduction</td><td></td><td></td><td></td><td colspan="2">rhomboids</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">GH abduction</td><td></td><td></td><td></td><td colspan="3">supraspinatus</td><td></td><td></td><td></td><td>Suprascapular</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">deltoid</td><td></td><td></td><td></td><td rowspan="2">Axillary</td></tr>
<tr><td rowspan="2">GH lateral rotation</td><td></td><td></td><td></td><td colspan="3">teres minor</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="3">infraspinatus</td><td></td><td></td><td></td><td>Suprascapular</td></tr>
<tr><td rowspan="3">GH medial rotation</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">teres major</td><td></td><td></td><td rowspan="2">Subscapular</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">subscapularis</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="3" rowspan="2">latissimus dorsi</td><td></td><td rowspan="2">Thoracodorsal</td></tr>
<tr><td>GH adduction</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>GH horizontal add.</td><td></td><td></td><td></td><td></td><td></td><td colspan="4">pectoralis major</td><td>med/lat pectoral</td></tr>
<tr><td rowspan="3">Elbow flexion</td><td></td><td></td><td></td><td></td><td colspan="2">biceps</td><td></td><td></td><td></td><td rowspan="2">Musculocutan.</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">brachialis</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">brachiorad.</td><td></td><td></td><td></td><td>Radial</td></tr>
<tr><td rowspan="2">Supination</td><td></td><td></td><td></td><td></td><td colspan="2">biceps</td><td></td><td></td><td></td><td>Musculocutan.</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">supinator</td><td></td><td></td><td></td><td>Radial</td></tr>
<tr><td rowspan="2">Pronation</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">pro. teres</td><td></td><td></td><td rowspan="2">Median</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">pro. quad.</td></tr>
<tr><td rowspan="2">Elbow extension</td><td></td><td></td><td></td><td></td><td></td><td colspan="3">triceps</td><td></td><td rowspan="2">Radial</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">anconeus</td></tr>
<tr><td rowspan="3">Wrist flexion</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">F.C.R.</td><td></td><td></td><td rowspan="2">Median</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">palmaris longus</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3" rowspan="2">F.C.U.</td><td rowspan="2">Ulnar</td></tr>
<tr><td>Ulnar flexion</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Radial flexion</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">F.C.R.</td><td></td><td></td><td>Median</td></tr>
<tr><td>Wrist extension</td><td></td><td></td><td></td><td></td><td></td><td colspan="3">ECU, ECR, ED</td><td></td><td>Radial</td></tr>
<tr><td>Finger flexion</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">FDS, FDP</td><td>Median/ulnar</td></tr>
<tr><td>Finger extension</td><td></td><td></td><td></td><td></td><td></td><td colspan="3">ext. digitorum</td><td></td><td>Radial</td></tr>
<tr><td>Finger add/abd</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">interossei</td><td>Ulnar</td></tr>
<tr><td>Opposition</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">opponens pollicis</td><td>Median</td></tr>
</table>

brachiorad. = brachioradialis, pro. = pronator, quad. = quadratus, FCR = flexor carpi radialis, FCU = flexor carpi ulnaris, ECU = extensor carpi ulnaris, ECR = extensor carpi radialis, ED = extensor digitorum, FDS = flexor digitorum superficialis, FDP = flexor digitorum profundus, Ext. = Extensor, add = adduction, med/lat = medial & lateral, GH = glenohumeral

Neurovascular

<table>
<tr><th>Lower body</th><th colspan="7">Spinal level & main muscles</th><th rowspan="2">Nerve</th></tr>
<tr><th>Action tested</th><th>L1</th><th>L2</th><th>L3</th><th>L4</th><th>L5</th><th>S1</th><th>S2</th></tr>
<tr><td rowspan="3">Hip flexion</td><td colspan="3">iliopsoas</td><td></td><td></td><td></td><td></td><td rowspan="3">Femoral</td></tr>
<tr><td></td><td colspan="2">sartorius</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="3">rectus femoris</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Hip extension</td><td></td><td></td><td></td><td></td><td colspan="3">glut. maximus</td><td>Inf. gluteal</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">gemelli</td><td></td><td>N. to obt. int.</td></tr>
<tr><td rowspan="2">Hip abduction</td><td></td><td></td><td></td><td colspan="3">glut. med/minimus</td><td></td><td rowspan="2">Sup. gluteal</td></tr>
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<tr><td rowspan="3">Hip adduction</td><td></td><td colspan="2">pectineus</td><td></td><td></td><td></td><td></td><td rowspan="3">Obturator</td></tr>
<tr><td></td><td colspan="3">adductors, gracilis</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">obt. externus</td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td colspan="3">gluteus minimus</td><td></td></tr>
<tr><td rowspan="4">Knee extension</td><td></td><td colspan="3">rectus femoris</td><td></td><td></td><td></td><td rowspan="4">Femoral</td></tr>
<tr><td></td><td colspan="3">vastus lateralis</td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td colspan="3">semitendinosus</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="4">biceps femoris</td></tr>
<tr><td rowspan="3">Ankle dorsiflexion</td><td></td><td></td><td></td><td colspan="2">tib. anterior</td><td></td><td></td><td rowspan="3">Deep peroneal</td></tr>
<tr><td></td><td></td><td></td><td colspan="3">ext. digitorum longus</td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="3">ext. hallucis longus</td><td></td></tr>
<tr><td rowspan="2">Ankle plantarflexion</td><td></td><td></td><td></td><td colspan="2">tib. posterior</td><td></td><td></td><td rowspan="2">Tibial</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">gastroc. & soleus</td></tr>
<tr><td>Ankle inversion</td><td></td><td></td><td></td><td colspan="2">tib. anterior</td><td></td><td></td><td>Deep peroneal</td></tr>
<tr><td rowspan="3">Ankle eversion</td><td></td><td></td><td></td><td colspan="2">tib. posterior</td><td></td><td></td><td>Tibial</td></tr>
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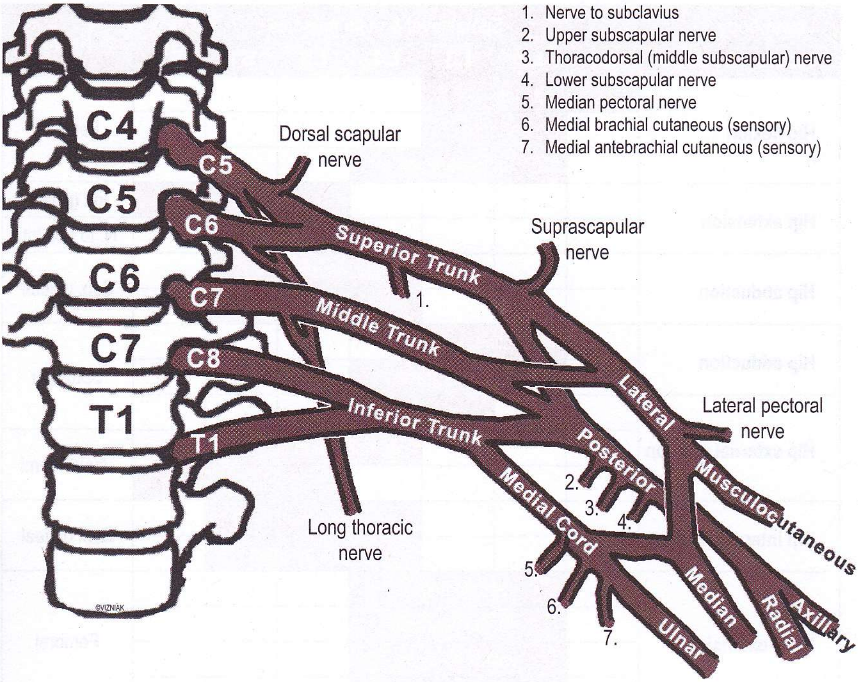
<tr><td></td><td></td><td></td><td></td><td colspan="2">peroneus brev.</td><td></td></tr>
<tr><td rowspan="2">Toe flexion</td><td></td><td></td><td></td><td></td><td colspan="3">flex. digitorum long.</td><td rowspan="2">Tibial</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">flex. hallucis long.</td></tr>
<tr><td rowspan="2">Toe extension</td><td></td><td></td><td></td><td colspan="3">ext. digitorum longus</td><td></td><td rowspan="2">Deep peroneal</td></tr>
<tr><td></td><td></td><td></td><td colspan="3">ext. hallucis longus</td><td></td></tr>
<tr><td>Toe add/abduction</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">interossei</td><td>Tibial</td></tr>
</table>

glut. = gluteus, med/ = medius, obt. = obturator, tib. = tibialis, ext. = extensor, gastroc. = gastrocnemius, long. = longus, brev. = brevis, flex. = flexor

Neurovascular



Brachial Plexus Lesions

- Injuries may result in paralysis (muscle weakness) &/or paresthsia (altered sensation) or even anesthesia (lack of sensation)

Superior part of the plexus (C5, C6 usually)

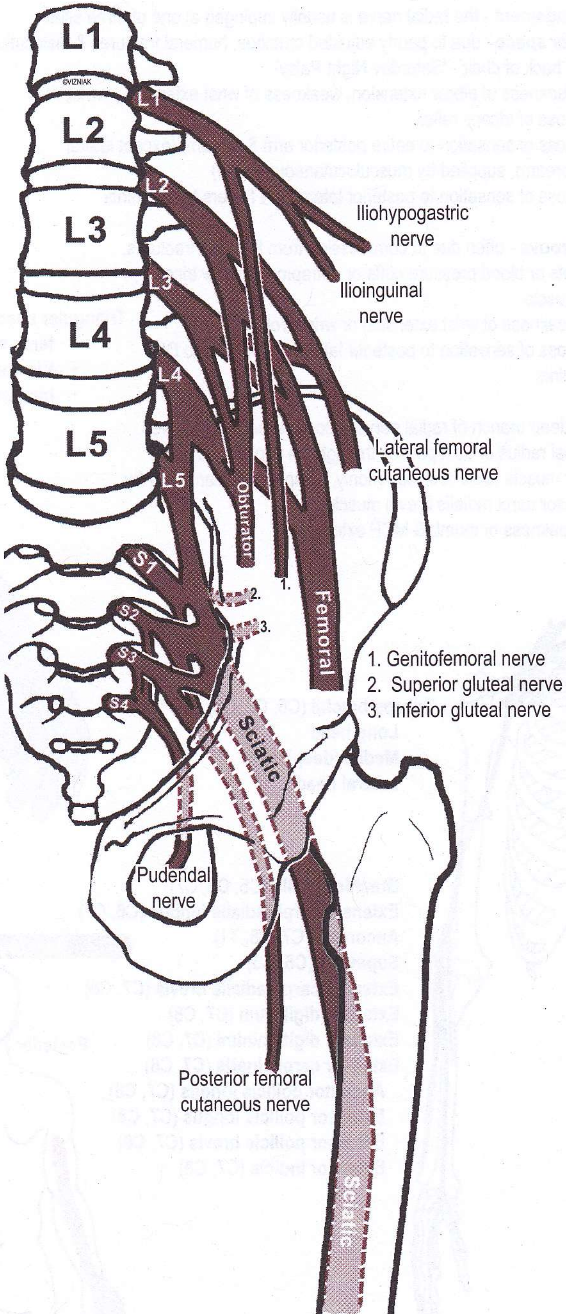
- Typically result from an excessive increase in the angle between the neck & the shoulder
- Injuries can result when an adult is thrown from a motorcycle or horse & their shoulder hits the ground first; may also occur during birth if excessive stretching of the neck occurs on the newborn (result is stretching or tearing of the upper brachial plexus)
- ***Erb's (Erb-Duchenne) palsy*** may result; due to paralysis of the deltoid, biceps, brachialis & brachioradialis, the patient will present with the shoulder medially rotated & elbow extended, there may also be a loss of sensation over the upper lateral arm ('waiter's tip' deformity)
- ***Backpacker's palsy*** - repetitive microtrauma from carrying a heavy backpack can also result in upper plexus damage

Compression of the cords (lateral, posterior, medial)

- Compression of the cord can result from prolonged hyperabduction of the shoulder during overhead activities (e.g. painting); the cords are compressed between the coracoid process of the scapula & pectoralis minor; space occupying lesions (cancer) may also compress cords

Inferior part of the plexus (C8, T1 usually)

- Typically results when the upper limb is suddenly pulled superiorly (e.g. when a person grabs something to break a fall, or a baby's arm is pulled excessively during birth)

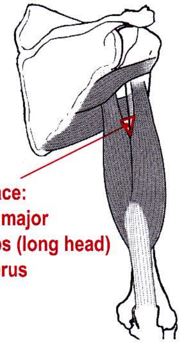

L1
L2
L3
L4
L5
©VIZNIAK
L1
L2
L3
L4
L5
S1
S2
S3
S4
Iliohypogastric nerve
Ilioinguinal nerve
Lateral femoral cutaneous nerve
Obturator
Femoral
1.
2.
3.
1. Genitofemoral nerve
2. Superior gluteal nerve
3. Inferior gluteal nerve
Sciatic
Pudendal nerve
Posterior femoral cutaneous nerve
Sciatic

Radial Nerve

Sites of impingement - the radial nerve is usually impinged at one of three sites

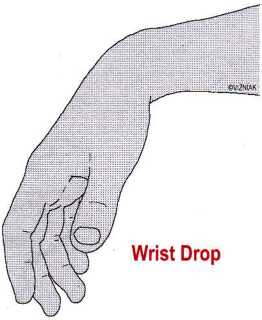
1. ***Triangular space*** - due to poorly adjusted crutches, humeral fractures & dislocations, falling asleep with arm over back of chair - 'Saturday Night Palsy'
   SSx: weakness of elbow extension, weakness of wrist extension - wrist drop
   - Loss of triceps reflex
   - Loss of sensation to entire posterior arm & forearm (except lateral forearm, supplied by musculocutaneous nerve)
   - Loss of sensation to posterior lateral 3 ½ fingers to DIP joints

2. ***Radial groove*** - often due to compression from humeral fractures, tourniquets or blood pressure cuffs or entrapment below triceps brachii muscle
   SSx: weakness of wrist extension or wrist drop
   - Loss of sensation to posterior lateral 3 ½ fingers to DIP joints

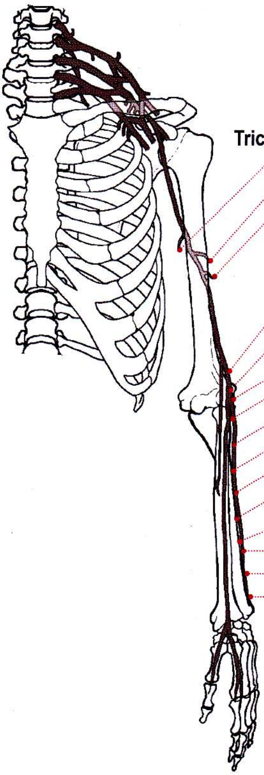


Triangular space:
- **teres major**
- **triceps (long head)**
- **humerus**

3. ***Elbow*** - deep branch of radial nerve is compressed by fractures of proximal radius or as it passes through the two planes of the supinator muscle (also, less commonly, compression can occur by the extensor carpi radialis brevis muscle)
   SSx: weakness of thumb & MCP extension



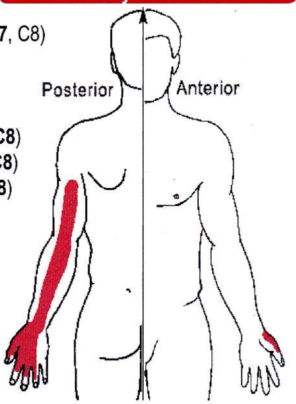
Wrist Drop



Triceps brachii (C6, **C7**, **C8**)
Long head
Medial (deep) head
Lateral head

Brachioradialis (C5, **C6**, C7)
Extensor carpi radialis longus (C6, C7)
Anconeus (C7, C8, T1)
Supinator (**C5**, C6)
Extensor carpi radialis brevis (**C7**, C8)
Extensor digitorum (**C7**, C8)
Extensor digiti minimi (**C7**, C8)
Extensor carpi ulnaris (**C7**, C8)
Abductor pollicis longus (C7, **C8**)
Extensor pollicis longus (C7, **C8**)
Extensor pollicis brevis (C7, **C8**)
Extensor indicis (C7, **C8**)

Sensory distribution



Musculocutaneous nerve

Sites of impingement

- Axillary fold or coracobrachialis muscle belly

Signs/symptoms

- Weakness of elbow flexion
- Loss of cutaneous sensation to anterior & lateral forearm (lateral antebrachial cutaneous nerve)
- Loss of biceps reflex
- When examining patients with traumatic injury involving the axillary nerve, it is important to search for paralysis of the long head of the triceps brachii. If present, it is a sign of a severe axillary nerve lesion requiring early surgical repair at 3 months

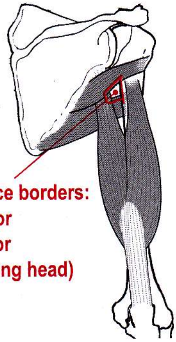
Axillary nerve

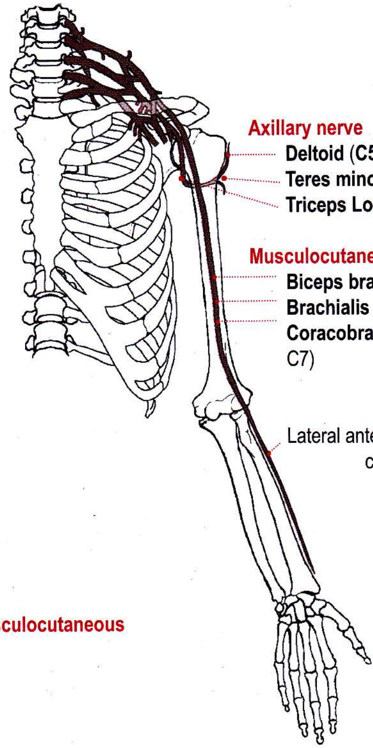
Sites of impingement

- ***Quadrangular space*** - often due to fractures of humerus, dislocations & poorly adjusted crutches
  - Borders of the quadrangular space: teres major, teres minor, triceps (long head) & humerus (see image)
  - Quadrangular space contains:
    - Axillary nerve
    - Posterior humeral circumflex artery

Signs/symptoms

- Weakness in deltoid & teres minor muscles
  - results in weak abduction of arm
- Loss of cutaneous sensation to superior posterior & lateral arm

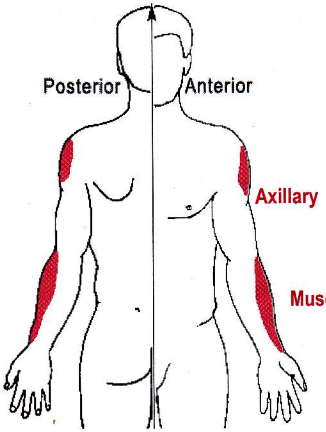




Axillary Nerve & Triceps Brachii

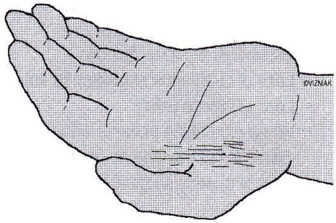
More recent studies show triceps brachii long head may be innervated by the axillary nerve
(de Seze, 2006; Rezzouk, 2002)

Sensory distribution



Sites of impingement: the median nerve is compressed usually at one of three sites

1. ***Elbow*** - occasionally compression due to sleeping on elbow, or medial supracondylar fractures
   SSx: weakness of forearm & wrist pronation, weakness of wrist flexion
   - Ape hand deformity
   - Loss of sensation to palm & palmar surface of lateral 3 ½ fingers including posterior distal interphalangeal joints

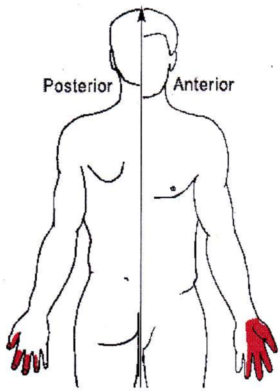


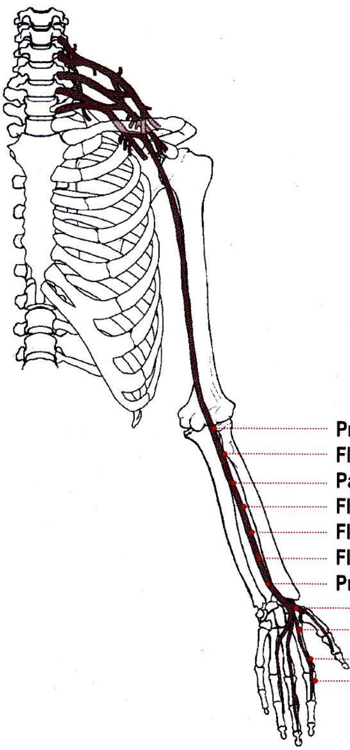
Ape Hand Deformity
(atrophy of thenar muscles)

2. Passage of the nerve through two heads of hypertonic ***pronator teres muscle*** - Pronator Teres Syndrome
   SSx: throbbing/aching pain in wrist & forearm, weakness in gripping & holding objects
   - Pain with forearm pronation, pain with wrist flexion
   - Ape hand deformity
   - Loss of sensation to palm & palmar surface of lateral 3 ½ fingers including posterior DIPs
3. ***Wrist*** - most commonly due to carpal tunnel syndrome, possibly secondary to lacerations or puncture wounds
   SSx: ape hand deformity
   - Loss of sensation to palm & palmar surface of lateral 3 ½ fingers including posterior DIPs

Note: injury of median nerve through carpal tunnel results in loss of sensation to palmar surface of lateral 3 ½ fingers to DIPs but NOT the palm of the hand; this may help to differentiate injury of median nerve above carpal tunnel vs. injury within carpal tunnel

Sensory distribution



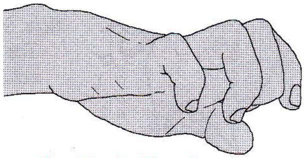


Sites of impingement: the ulnar nerve is usually compressed at one of two sites

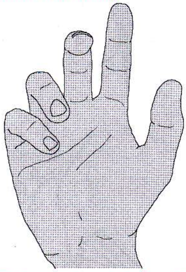
1. ***Elbow*** - *cubital tunnel syndrome*, compression due to fractures at medial epicondyle or sustained pressure &/or anomalies in the anconeus muscle (anconeus epitrochlearis muscle); when one hits their 'funny bone' it is usually a sensation due to the compression of the ulnar nerve as it passes posterior to the medial epicondyle

   SSx: weakness of wrist flexion (ulnar side)
   - Claw hand deformity with normal PROM
   - Loss of sensation to medial 1 ½ fingers

   The cubital tunnel is formed by the tendinous arch joining the humeral & ulnar heads of the flexor carpi ulnaris; thus inflammation or swelling of the flexor carpi ulnaris may compress the ulnar nerve resulting in the signs & symptoms below



Claw hand deformity

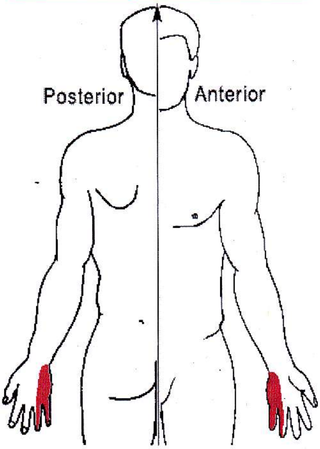


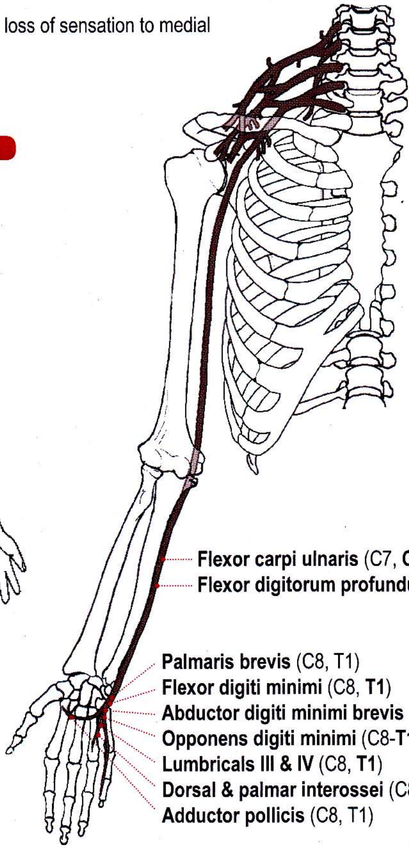
Bishop's hand deformity

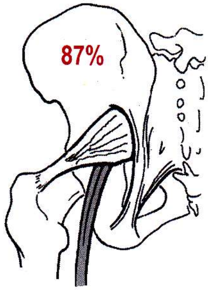
2. ***Wrist*** - *cubital tunnel syndrome*, defensive wounds from cuts, stab wounds or other trauma

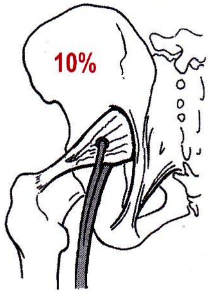
   SSx: Bishops or claw hand deformity; loss of sensation to medial 1 ½ fingers, with normal PROM

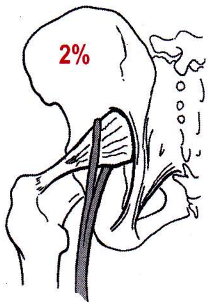
Sensory distribution

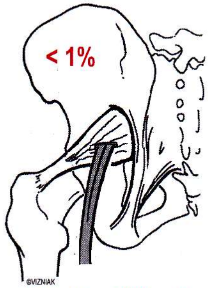












Based on 2250 cadaver limb studies

(Beaton & Anderson. The relationship of the sciatic nerve & its subdivisions to the piriformis muscle. Anat Rec 70 (Suppl.):1-5, 1937)

Sciatic nerve

Note: Sciatic nerve is composed of common fibular (peroneal) & tibial nerves
The following information refers to sciatic nerve from the greater sciatic notch to popliteal fossa where it splits into its component nerves

Sites of impingement

- May be compromised anywhere along course of nerve from greater sciatic notch to popliteal fossa
- Common causes include nerve root irritation from disc herniations, osteoarthritis, or lumbar facet dysfunction
- Less common causes are misplaced intramuscular injections, pelvic tumors, back labor, vertebral/pelvic fractures, hip dislocations

Signs/symptoms

- Most common for the more superficial common fibular/peroneal portion of sciatic nerve to be affected
- Pain or loss of sensation along course of nerve from buttocks, posterior thigh, leg & foot (except medial leg, supplied by saphenous nerve)
- Weakness of hip extension & knee flexion
- Foot drop with subsequent steppage gait

Tibial nerve (from popliteal fossa to leg & foot)

Sites of impingement

- Less often affected due to nerve being well protected
- If affected, often due to direct trauma but possible compromise from nerve root irritation

Signs/symptoms

- Pain or loss of sensation to sole of foot
- Weakness of plantar flexion

Common fibular (peroneal) nerve

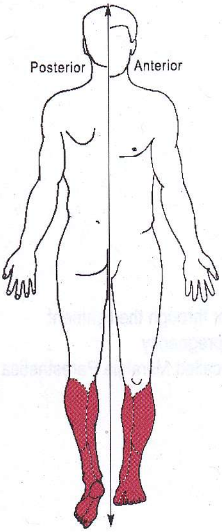
Sites of impingement

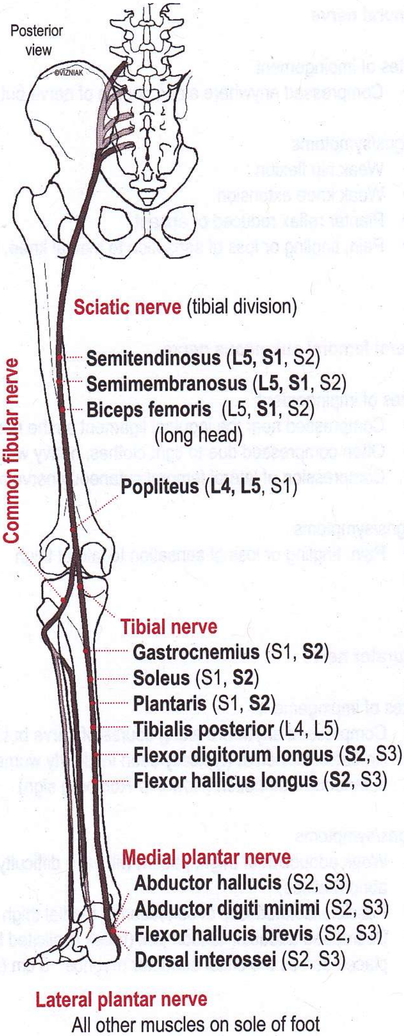
- Most often affected at the head or neck of fibula where it splits into superficial & deep branches
- Common causes include anterior compartment syndrome (esp. by extensor digitorum longus), fractures & dislocations of fibula
- May also be affected due to tight cast, splint or brace of knee/leg

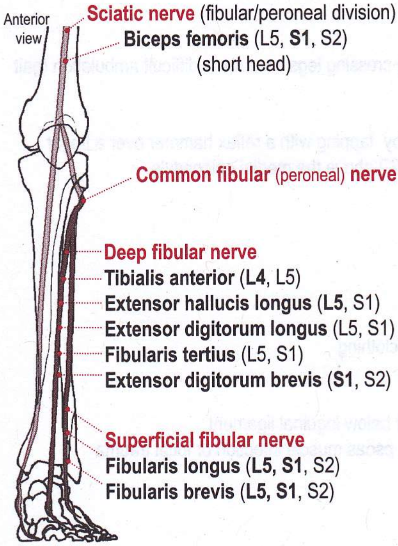
Signs/symptoms

- Mild pain or loss of sensation to anterolateral leg & dorsum of foot
- Foot drop with subsequent steppage gait
- Anterior compartment syndrome (shin splints) may compromise the deep branch of common peroneal nerve resulting in isolated sensation loss to web space between 1st & 2nd toe

Sensory distribution







Femoral nerve

Sites of impingement
- Compressed anywhere along course of nerve but often compromised due to nerve root irritation

Signs/symptoms
- Weak hip flexion
- Weak knee extension
- Plantar reflex reduced or absent
- Pain, tingling or loss of sensation to medial knee, leg & foot

Lateral femoral cutaneous nerve

Sites of impingement
- Compressed near the inguinal ligament as the nerve passes under or through the ligament
- Often compressed due to tight clothes, heavy work belts, obesity or pregnancy
- Compression of lateral femoral cutaneous nerve results in condition called Meralgia Paresthetica

Signs/symptoms
- Pain, tingling or loss of sensation to lateral thigh

Obturator nerve

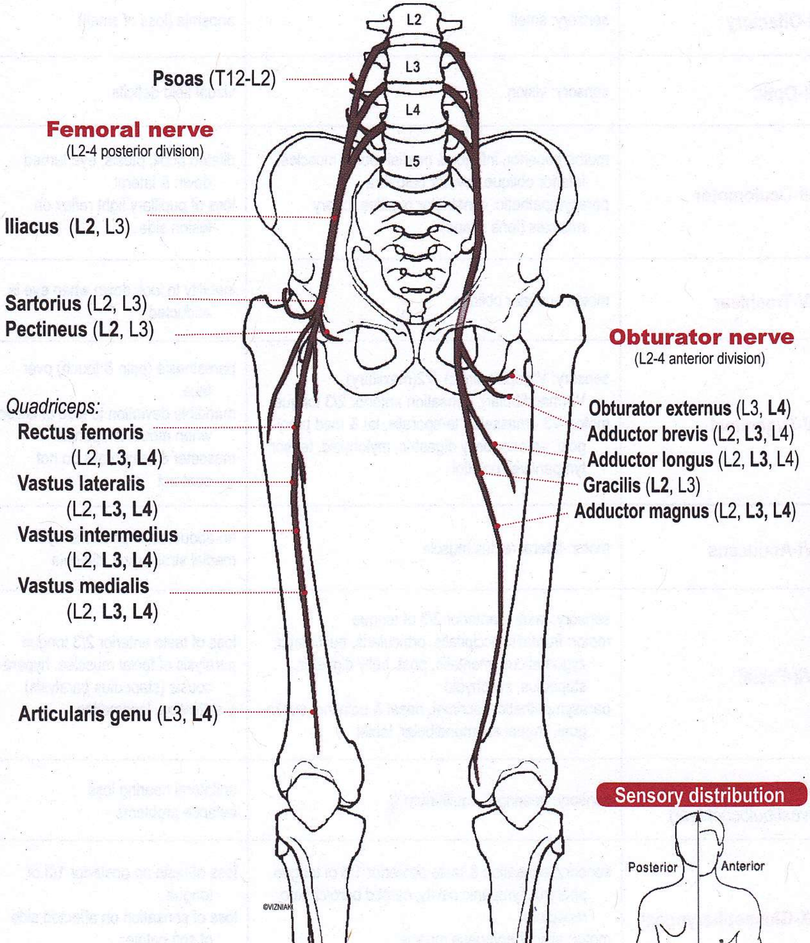
Sites of impingement
- Compressed anywhere along course of nerve but often compromised due to nerve root irritation
- An obturator hernia (typically seen in elderly women) may also result in pain or tingling over the cutaneous distribution (Howship-Romberg sign)

Signs/symptoms
- Weak adduction of thigh, patient will have difficulty crossing legs - results in difficult ambulation (gait abnormalities)
- Possible isolated loss of sensation to medial thigh
- Decreased adductor tendon jerk (reflex is elicited by tapping with a reflex hammer over a finger placed across the distal adductor magnus ~5 cm (2″) above the medial epicondyle

Genitofemoral nerve

Sites of impingement
- Typically compressed at inguinal ligament by tight clothing

Signs/symptoms
- Pain &/or numbness over anterior medial thigh just below inguinal ligament
- Patient may have a prior history of appendectomy, psoas muscle infection or local trauma


L2
L3
L4
L5
Psoas (T12-L2)
Femoral nerve
(L2-4 posterior division)
Iliacus (L2, L3)
Sartorius (L2, L3)
Pectineus (L2, L3)
Quadriceps:
Rectus femoris (L2, L3, L4)
Vastus lateralis (L2, L3, L4)
Vastus intermedius (L2, L3, L4)
Vastus medialis (L2, L3, L4)
Articularis genu (L3, L4)
Obturator nerve
(L2-4 anterior division)
Obturator externus (L3, L4)
Adductor brevis (L2, L3, L4)
Adductor longus (L2, L3, L4)
Gracilis (L2, L3)
Adductor magnus (L2, L3, L4)
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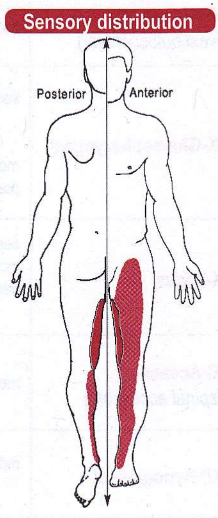
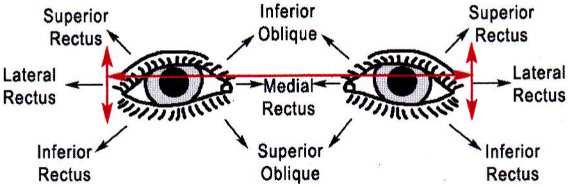

Sensory distribution
Posterior
Anterior

Cranial Nerve Exam

Nerve	Function	Lesion/Pathology
I-Olfactory	sensory: smell	anosmia (loss of smell)
II-Optic	sensory: vision	visual field deficits
III-Oculomotor	motor: superior, inferior & medial rectus muscles; inferior oblique, levator palpebra parasympathetic: constrictor pupillae, cillary muscles (lens shape)	dilated pupil, ptosis, eye turned down & lateral loss of pupillary light reflex on lesion side
IV-Trochlear	motor: superior oblique	inability to look down when eye is adducted
V-Trigeminal	sensory: V1(ophthalmic), V2(maxillary), V3(mandibular), sensation anterior 2/3 tongue motor: V3 - masseter, temporalis, lat & med pterygoid, anterior belly digastric, mylohyoid, tensor tympani/veli palatini	paresthesia (pain & touch) over face mandible deviation to side of lesion when mouth is opened masseter & temporalis do not contract
VI-Abducens	motor: lateral rectus muscle	no abduction if ipsilateral eye medial strabismus, diplopia
VII-Facial	sensory: taste – anterior 2/3 of tongue motor: frontalis, occipitalis, orbicularis, buccinator, zygomaticus, mentalis, post. belly digastric, stapedius, stylohyoid parasympathetic: lacrimal, nasal & palatine, sublingual, lingual submandibular, labial	loss of taste anterior 2/3 tongue paralysis of facial muscles, hyperacousis (stapedius paralysis) ↓ salivation, lacrimation
VIII-Acoustic *(vestibulocochlear)*	sensory: hearing & equilibrium	unilateral hearing loss balance problems
IX-Glossopharyngeal	sensory: sensation & taste posterior 1/3 of tongue, pharynx, tympanic cavity, carotid baro/chemo receptors motor: stylopharyngeus muscle parasympathetic: parotid gland	loss of taste on posterior 1/3 of tongue loss of sensation on affected side of soft palate ↓ salivation
X-Vagus	sensory: pinna of ear, GI distension motor: muscles of palate, pharynx & larynx parasympathetic: heart, esophagus, GI tract up to distal 2/3 of transverse colon	ipsilateral: uvula deviates to opposite side of lesion, dyspnea, hoarse voice bilateral: death
XI-Accessory *(spinal accessory)*	motor: SCM, trapezius	paralysis of SCM & superior fibers of trapezius → drooping of shoulder
XII-Hypoglossal	motor: intrinsic muscles of tongue, genioglossus, styloglossus, hyoglossus	tongue deviates toward side of lesion on protrusion (action of genioglossus)

I. Olfactory
- Scent (coffee, mint)



II. Optic Nerve
- Visual acuity (eye chart)
- Visual fields
- Pupillary constriction (III)
- Fundiscopic exam

III. Oculomotor (patient holds head still - tracking 'H' pattern with eye movement only)

IV. Trochlear (patient holds head still - tracking 'H' pattern with eye movement only)

VI. Abducens
- Patient holds head still - tracking 'H' pattern with eye movement only
- Smooth tracking & nystagmus? - Finish with convergence & observe pupil constriction

V. Trigeminal
- Motor: pterygoids = lateral deviation of the jaw against resistance
- Masseters = palpation of masseters while patient clenches jaw or patient 'bites down'
- Sensory: sensory perception of the face & buccal mucosa - bilaterally equal?
- Sensory: test afferent fibers of the **corneal reflex**
  - Examiner lightly brushes cotton across surface of the patient's cornea
    - *Normal:* lid closure of both eyes when one eye is touched
    - *Abnormal:* V. afferent deficit or VII. efferent deficit

VII. Facial
- Motor: all voluntary & involuntary movements of the face - does not include jaw movements; includes elevation of the eyebrows, wrinkle forehead, smile, frown, grimace, puff out cheeks with air
- Sensory: taste anterior 2/3 of tongue
- Note: VII also innervates lacrimal glands, submandibular & submaxillary glands; these are not routinely tested, but be aware of presence or absence of saliva & tears

VIII. Vestibulocochlear (Acoustic)
- Vestibular division tested with Romberg's
- Cochlear division: auditory acuity (watch test); Weber & Rinne tests

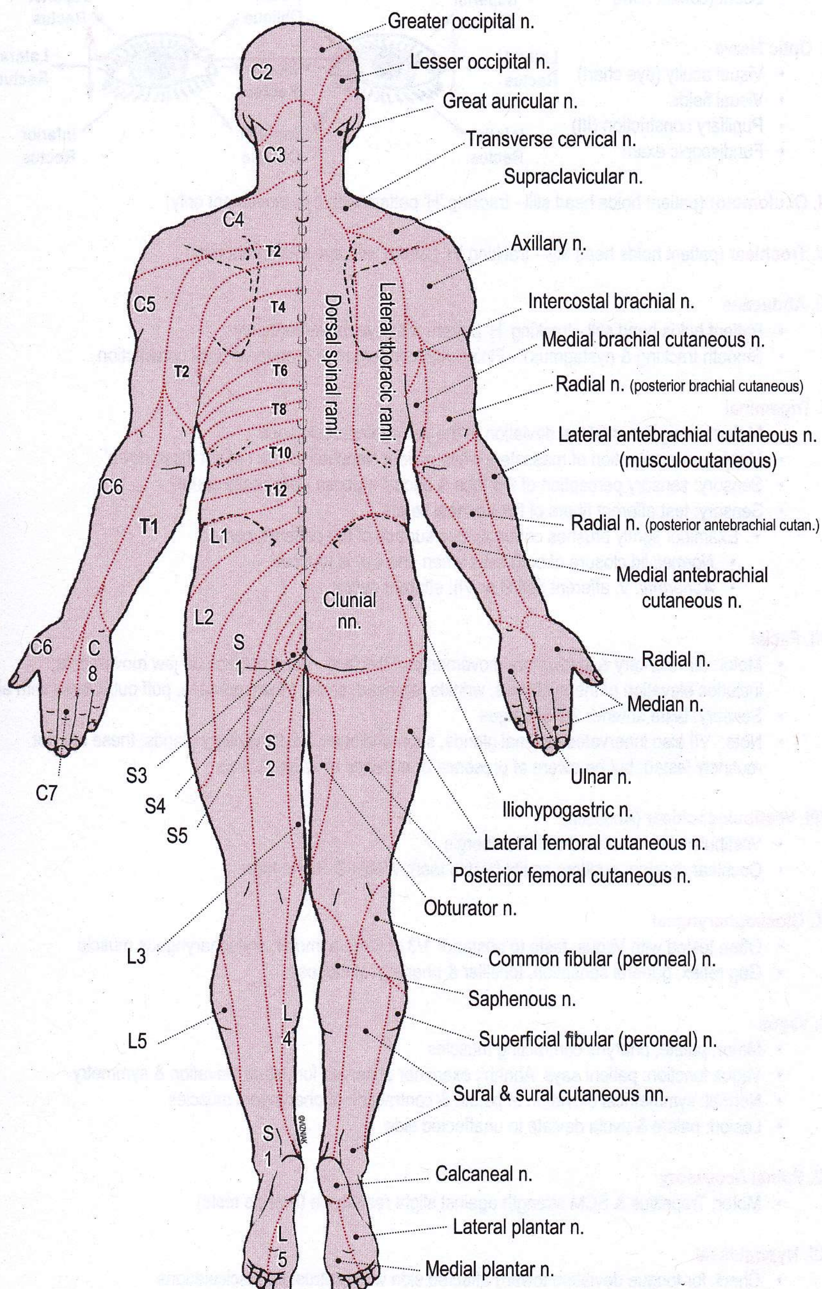
IX. Glossopharyngeal
- Often tested with Vagus; taste to posterior 1/3 of tongue; motor: stylopharyngeus muscle
- Gag reflex: general sensation, tonsillar & pharyngeal mucosa

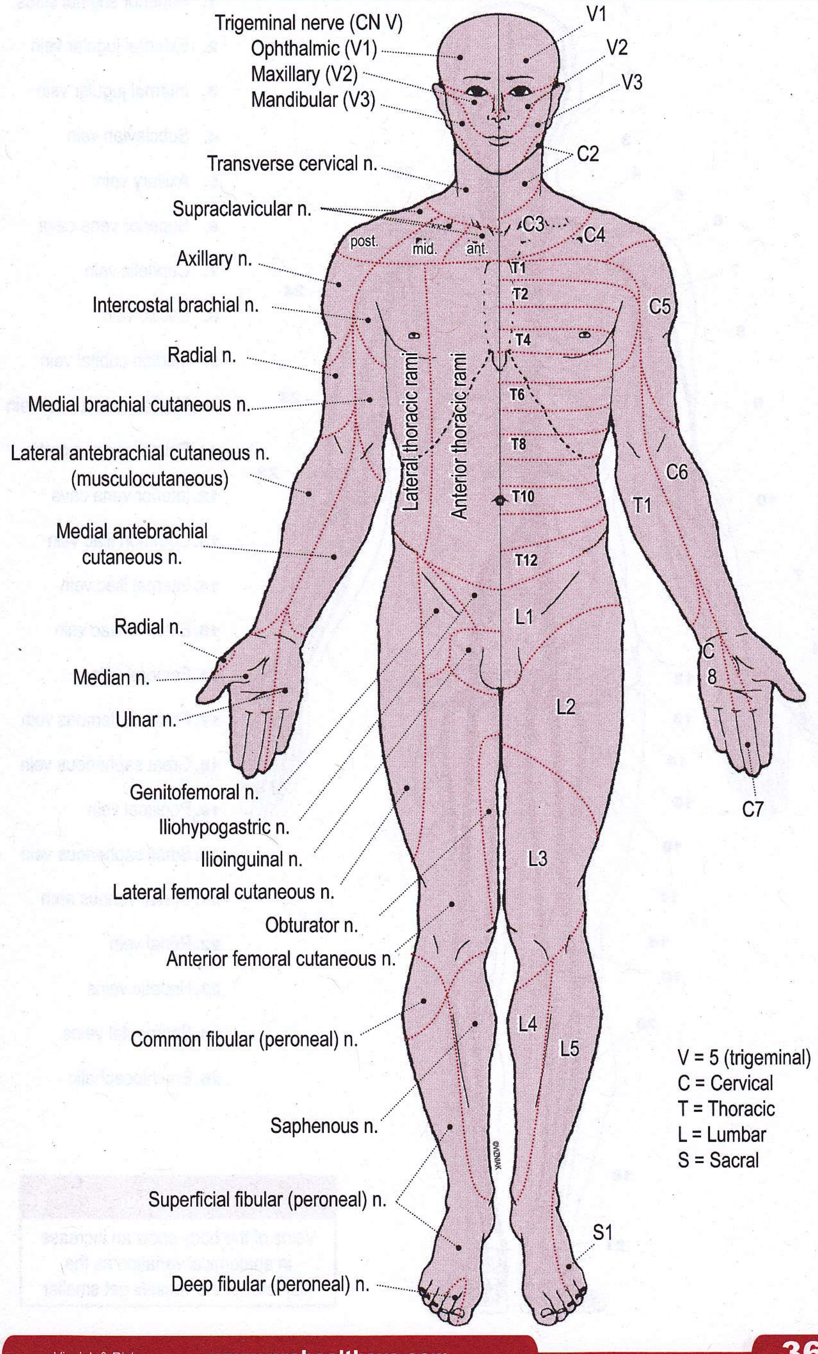
X. Vagus
- Motor: palate, pharynx contracting muscles
- Vagus function: patient says 'Ahhhh'; examiner observes for palate elevation & symmetry
- Normal: symmetrical elevation of palate & contraction of pharyngeal muscles
- Lesion: palate & uvula deviate to unaffected side

XI. Spinal Accessory
- Motor: Trapezius & SCM strength against slight resistance (muscle tests)

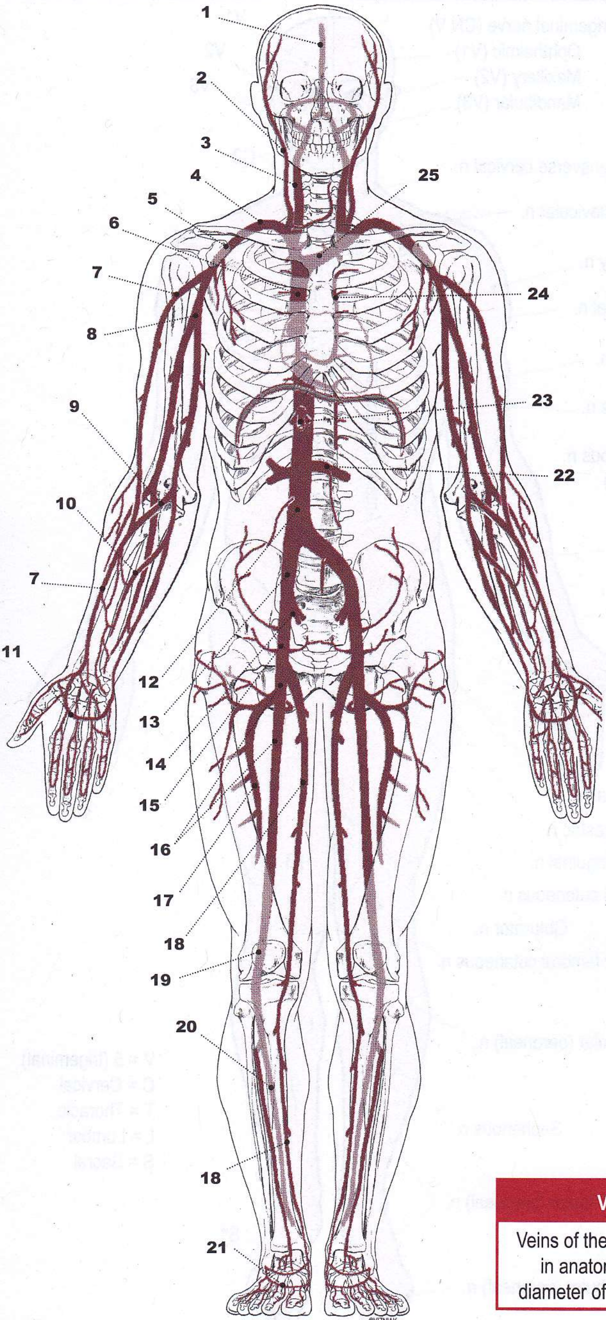
XII. Hypoglossal
- Check for tongue deviation toward affected side with protrusion, fasciculations
- Check tongue ROM, muscle tone; patient laterally deviates tongue against cheek

Dermatome Level | Peripheral Nerve





Neurovascular

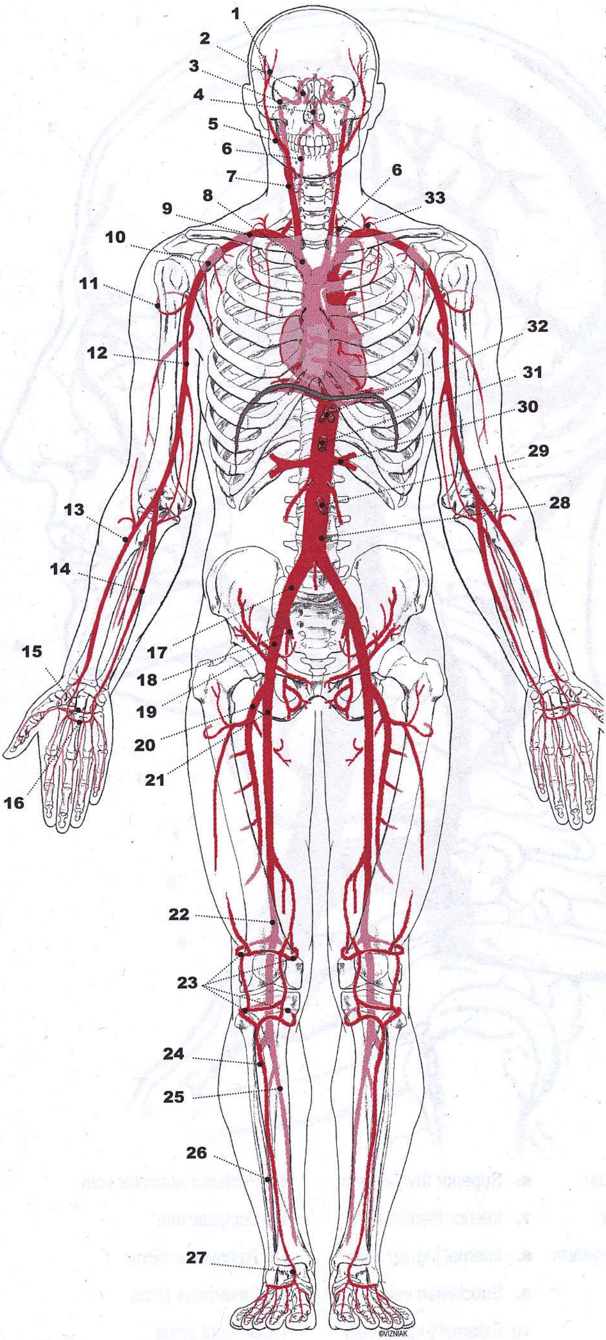


1. Superior sagittal sinus
2. External jugular vein
3. Internal jugular vein
4. Subclavian vein
5. Axillary vein
6. Superior vena cava
7. Cephalic vein
8. Basilic vein
9. Median cubital vein
10. Median antecubital vein
11. Palmar venous arch
12. Inferior vena cava
13. Common iliac vein
14. Internal iliac vein
15. External iliac vein
16. Femoral vein
17. Profunda femoris vein
18. Great saphenous vein
19. Popliteal vein
20. Small saphenous vein
21. Dorsal venous arch
22. Renal vein
23. Hepatic veins
24. Segmental veins
25. Brachiocephalic

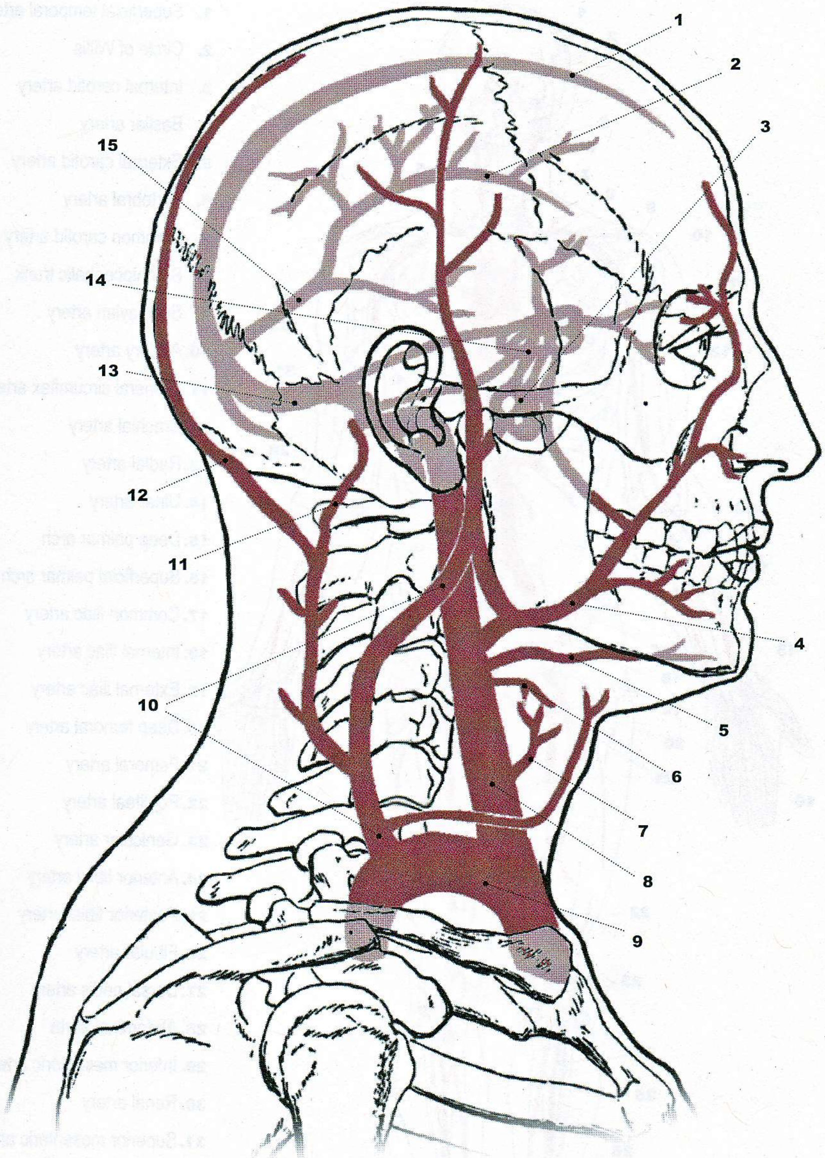
Vein Variation

Veins of the body show an increase in anatomical variation as the diameter of the vessels get smaller

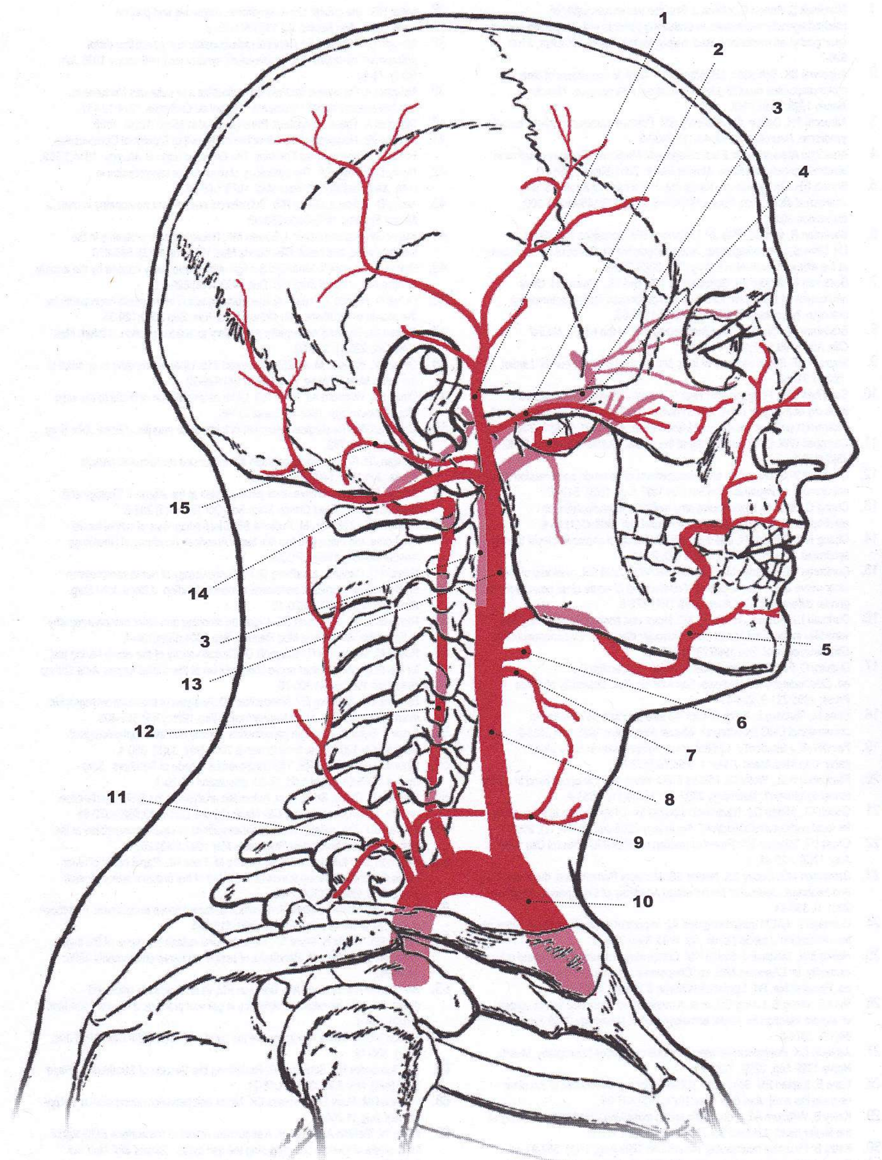
Arteries of the Body



1. Superficial temporal artery
2. Circle of Willis
3. Internal carotid artery
4. Basilar artery
5. External carotid artery
6. Vertebral artery
7. Common carotid artery
8. Brachiocephalic trunk
9. Subclavian artery
10. Axillary artery
11. Humeral circumflex artery
12. Brachial artery
13. Radial artery
14. Ulnar artery
15. Deep palmar arch
16. Superficial palmar arch
17. Common iliac artery
18. Internal iliac artery
19. External iliac artery
20. Deep femoral artery
21. Femoral artery
22. Popliteal artery
23. Genicular artery
24. Anterior tibial artery
25. Posterior tibial artery
26. Fibular artery
27. Dorsal pedis artery
28. Abdominal aorta
29. Inferior mesenteric artery
30. Renal artery
31. Superior mesenteric artery
32. Celiac trunk
33. Thyrocervical trunk



1. Superior sagittal sinus
2. Inferior sagittal sinus
3. Hypophyseal portal system
4. Facial vein
5. Lingual vein
6. Superior thyroid vein
7. Inferior thyroid vein
8. Internal jugular vein
9. Subclavian vein
10. External jugular vein
11. Posterior auricular vein
12. Occipital vein
13. Transverse sinus
14. Cavernous sinus
15. Straight sinus



1. Superficial temporal artery
2. Transverse facial artery
3. Internal carotid artery
4. Maxillary artery
5. Facial artery
6. Lingual artery
7. Superior thyroid artery
8. Common carotid artery
9. Inferior thyroid artery
10. Brachiocephalic trunk
11. Costocervical trunk
12. Vertebral artery
13. External carotid artery
14. Occipital artery
15. Posterior auricular artery

1. Marciniak C, Armon C, Wilson J: Practice parameter: utility of electrodiagnostic techniques in evaluating patients with suspected peroneal neuropathy: an evidence-based review. Muscle Nerve 2005 Apr; 31(4): 520-7.
2. Aggarwal SK, Schneider LB, Ahmad BK. Clinical usefulness of ulnar motor responses recording from first dorsal interosseous. *Muscle Nerve.* 1995;18(9):1043.
3. Altrocchi PH, Daube JR, Frishberg BM: Practice parameter: carpal tunnel syndrome. Neurology 1993; 43(11): 2406-9.
4. American Association of Electrodiagnostic Medicine. Glossary of terms in electrodiagnostic medicine. *Muscle Nerve.* 2001;Suppl 10:S1-50.
5. Bartels RH, Grotenhuis JA, Kauer JM. The arcade of Struthers: an anatomical study. *Acta Neurochir (Wien).* Apr 2003;145(4):295-300; discussion 300.
6. Beekman R, Van Der Plas JP, Uitdehaag BM, Schellens RL, Visser LH. Clinical, electrodiagnostic, and sonographic studies in ulnar neuropathy at the elbow. *Muscle Nerve.* Aug 2004;30(2):202-8.
7. Beekman R, Wokke JH, Schoemaker MC, Lee ML, Visser LH. Ulnar neuropathy at the elbow: follow-up and prognostic factors determining outcome. *Neurology.* Nov 9 2004;63(9):1675-80.
8. Bradshaw DY, Shefner JM. Ulnar neuropathy at the elbow. *Neurol Clin.* Aug 1999;17(3):447-61, v-vi.
9. Buzzard EF. Some varieties of toxic and traumatic ulnar neuritis. *Lancet.* 1922;1:317â€.
10. Campbell WW, Pridgeon RM, Riaz G, Astruc J, Sahni KS. Variations in anatomy of the ulnar nerve at the cubital tunnel: pitfalls in the diagnosis of ulnar neuropathy at the elbow. *Muscle Nerve.* Aug 1991;14(8):733-8.
11. Campbell WW. Ulnar neuropathy at the elbow. *Muscle Nerve.* Apr 2000; 23(4):450-2.
12. Campbell WW: Diagnosis and management of common compression and entrapment neuropathies. Neurol Clin 1997 Aug; 15(3): 549-67.
13. Chang C, Shen M. Mononeuropathy multiplex in hemophilia: an electrophysiologic assessment. *Eur Neurol.* Jul 1998;40(1):15-8.
14. Chang MH, Chiang HT, Lee SS, et al: Oral drug of choice in carpal tunnel syndrome. Neurology 1998 Aug; 51(2): 390-3.
15. Contreras MG, Warner MA, Charboneau WJ, Cahill DR. Anatomy of the ulnar nerve at the elbow: potential relationship of acute ulnar neuropathy to gender differences. *Clin Anat.* 1998;11(6):372-8.
16. Dorfman LJ, Howard JE, McGill KC. Motor unit firing rates and firing rate variability in the detection of neuromuscular disorders. *Electroencephalogr Clin Neurophysiol.* Sep 1989;73(3):215-24.
17. Dumitru D. Focal peripheral neuropathies. In: Dumitru D, ed. *Electrodiagnostic Medicine.* San Antonio, Tex: University of Texas Press; 1995:221-9, 236-41.
18. Ertas M, Stalberg E, Falck B. Can the size principle be detected in conventional EMG recordings?. *Muscle Nerve.* Apr 1995;18(4):435-9.
19. Feindel W, J Stratford J. Cubital tunnel compression in tardy ulnar palsy. *Can Med Assoc J.* Mar 1 1958;78(5):351-3.
20. Fleckenstein JL, Wolfe GI: MRI vs EMG: which has the upper hand in carpal tunnel syndrome?. Neurology 2002 Jun 11; 58(11): 1583-4.
21. Gooch CL, Mitten DJ: Treatment of carpal tunnel syndrome: is there a role for local corticosteroidinjection?. Neurology 2005 Jun 28; 64(12): 2006-7.
22. Gross PT, Tolomeo EA: Proximal median neuropathies. Neurol Clin 1999 Aug; 17(3): 425-45, v.
23. Grossman MG, Ducey SA, Nadler SS: Meralgia Paresthetica: diagnosis and treatment. Journal of the American Academy of Orthopaedic Sugeons 2001; 9: 336-44.
24. Gutmann L. AAEM minimonograph #2: important anomalous innervations of the extremities. *Muscle Nerve.* Apr 1993;16(4):339-47.
25. Halikis MN, Taleisnik J, Szabo RM. Compression neuropathies of the upper extremity. In: Chapman MW, ed. *Chapman's Orthopaedic Surgery.* 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2001:40-99.
26. Hui AC, Wong S, Leung CH, et al: A randomized controlled trial of surgery vs steroid injection for carpal tunnelsyndrome. Neurology 2005 Jun 28; 64(12): 2074-8.
27. Jablecki CK: Postoperative lateral femoral cutaneous neuropathy. Muscle Nerve 1999 Aug; 22(8): 1129-31.
28. Kane E, Kaplan EB, Spinner M. [Observations of the course of the ulnar nerve in the arm]. *Ann Chir.* May 1973;27(5):487-96.
29. Katirji B, Wilbourn AJ: High sciatic lesion mimicking peroneal neuropathy at the fibular head. J Neurol Sci 1994 Feb; 121(2): 172-5.
30. Katirji B: Peroneal neuropathy. Neurol Clin 1999 Aug; 17(3): 567-91, vii.
31. Krendel DA, Zacharias A, Younger DS: Autoimmune diabetic neuropathy. Neurol Clin 1997 Nov; 15(4): 959-71.
32. Levine BP, Jones JA, Burton RI: Nerve entrapments of the upper extremity: A surgical perspective. Neurol Clin 1999 Aug; 17(3): 549-65, vii.
33. Llewelyn JG, Thomas PK, King RH: Epineurial microvasculitis in proximal diabetic neuropathy. J Neurol 1998 Mar; 245(3): 159-65.
34. Marin R, McMillian D. Ulnar neuropathy associated with subdermal contraceptive implant. *South Med J.* Sep 1998;91(9):875-8.
35. Masoorli S, Angeles T, Barbone M. Danger points. How to prevent nerve injuries from venipuncture. *Nursing.* Sep 1998;28(9):34-9; quiz 40.
36. Massey EW: Sensory mononeuropathies. Semin Neurol 1998; 18(2): 177-83.
37. Miller RG. The cubital tunnel syndrome: diagnosis and precise localization. *Ann Neurol.* Jul 1979;6(1):56-9.
38. Morgan G, Wilbourn AJ: Cervical radiculopathy and coexisting distal entrapment neuropathies: double-crush syndromes? Neurology 1998 Jan; 50(1): 78-83.
39. Mouchet A. Paralysies tardives du nerfcubital a la suite des fractures du condyle externe de lâ€™humerus. *Journal de Chirurgie.* 1914;12:437.
40. Mouchet A. These de docteur, Paris (as cited in Miller, 1924). 1898.
41. Murphy JB. Neuroma of the Ulnar Nerve, Result of Cicatricial Compression Following Unrecognised Fracture. *The Clinics of John B. Murphy.* 1914;3:369.
42. Neary D, Eames RA. The pathology of ulnar nerve compression in man. *Neuropathol Appl Neurobiol.* 1975;1:69-88.
43. Neary D, Ochoa J, Gilliatt RW. Sub-clinical entrapment neuropathy in man. *J Neurol Sci.* Mar 1975;24(3):283-98.
44. Nuber GW, Assenmacher J, Bowen MK: Neurovascular problems in the forearm, wrist, and hand. Clin Sports Med 1998 Jul; 17(3): 585-610.
45. Ochiai N, Hayashi T, Ninomiya S. High ulnar nerve palsy caused by the arcade of Struthers. *J Hand Surg* [Br]. Dec 1992;17(6):629-31.
46. Ochiai N, Honmo J, Tsujino A. Electrodiagnosis in entrapment neuropathy by the arcade of Struthers. *Clin Orthop Relat Res.* Sep 2000;129-35.
47. Olesen LL: Femoral neuropathy secondary to anticoagulation. J Intern Med 1989 Oct; 226(4): 279-80.
48. Olney RK, Hanson M. AAEE case report #15: ulnar neuropathy at or distal to the wrist. *Muscle Nerve.* Aug 1988;11(8):828-32.
49. Olney RK, Wilbourn AJ, Miller RG. Ulnar neuropathy at or distal to the wrist (abstr). *Neurology.* 1983;33(Suppl 2):185.
50. Osborne GV. The surgical treatment of tardy ulnar neuritis. *J Bone Joint Surg Am.* 1957;39B:782.
51. Petajan JH. AAEM minimonograph #3: motor unit recruitment. *Muscle Nerve.* Jun 1991;14(6):489-502.
52. Posner MA. Compressive ulnar neuropathies at the elbow: I. Etiology and diagnosis. *J Am Acad Orthop Surg.* Sep-Oct 1998;6(5):282-8.
53. Preston DC, Shefner JM, Rutkove SB: Electrodiagnosis of carpal tunnel syndrome: too many and too few tests. American Academy of Neurology Annual Meeting 1999; 2PC003.
54. Rempel D, Dahlin L, Lundborg G. Pathophysiology of nerve compression syndromes: response of peripheral nerves to loading. *J Bone Joint Surg Am.* Nov 1999;81(11):1600-10.
55. Richardson JK, Jamieson SC. Cigarette smoking and ulnar mononeuropathy at the elbow. *Am J Phys Med Rehabil.* Sep 2004;83(9):730-4.
56. Rosati M, Martignoni R, Spagnolli G. Clinical validity of the elbow flexion test for the diagnosis of ulnar nerve compression at the cubital tunnel. *Acta Orthop Belg.* Dec 1998;64(4):366-70.
57. Sanders DB, Stalberg EV, Nandedkar SD. Analysis of the electromyographic interference pattern. *J Clin Neurophysiol.* Sep 1996;13(5):385-400.
58. Seror P, Seror R: Meralgia paresthetica: clinical and electrophysiological diagnosis in 120 cases. Muscle Nerve 2006 May; 33(5): 650-4.
59. Siqueira MG, Martins RS. The controversial arcade of Struthers. *Surg Neurol.* 2005;64 Suppl 1:S1:17-20; discussion S1:20-1.
60. Stalberg E, Chu J, Bril V, et al. Automatic analysis of the EMG interference pattern. *Electroencephalogr Clin Neurophysiol.* Dec 1983;56(6):672-81.
61. Stewart JD. The variable clinical manifestations of ulnar neuropathies at the elbow. *J Neurol Neurosurg Psychiatry.* Mar 1987;50(3):252-8.
62. Swenson JD, Hutchinson DT, Bromberg M, Pace NL. Rapid onset of ulnar nerve dysfunction during transient occlusion of the brachial artery. *Anesth Analg.* Sep 1998;87(3):677-80.
63. Turner OA, Taslitz N, Ward S: Common peroneal nerve entrapment. Handbook of peripheral nerve entrapments 1990; 119-124.
64. Turner OA, Taslitz N, Ward S: Lateral femoral cutaneous nerve of the thigh (meralgia paresthetica). Handbook of peripheral nerve entrapments 1990; 143-150.
65. van Slobbe AM, Bohnen AM, Bernsen RM, et al: Incidence rates and determinants in meralgia paresthetica in general practice. J Neurol 2004 Mar; 251(3): 294-7.
66. Verdon ME: Overuse syndromes of the hand and wrist. Prim Care 1996 Jun; 23(2): 305-19.
67. von Schroeder HP, Scheker LR. Redefining the "Arcade of Struthers". *J Hand Surg* [Am]. Nov 2003;28(6):1018-21.
68. Wallace DM, Ross BH, Thomas CK. Motor unit behavior during clonus. *J Appl Physiol.* Aug 11 2005;.
69. Wang W, Stefano AD, Allen R. A simulation model of the surface EMG signal for analysis of muscle activity during the gait cycle. *Comput Biol Med.* Jul 16 2005;.
70. Wehrli L, Oberlin C. The internal brachial ligament versus the arcade of Struthers: an anatomical study. *Plast Reconstr Surg.* Feb 2005;115(2):471-7.
71. Wilbourn AJ: AAEE case report #12: Common peroneal mononeuropathy at the fibular head. Muscle Nerve 1986 Nov-Dec; 9(9): 825-36.
72. Williams FH, Johns JS, Weiss JM, et al: Neuromuscular rehabilitation and electrodiagnosis. 1. Mononeuropathy. Arch Phys Med Rehabil 2005 Mar; 86(3 Suppl 1): S3-10.

Manual Technique Contents

Free on-line videos demonstrating selected techniques are available at
http://www.prohealthsys.com/education/index.php

Infections & Hygiene

In any clinical environment where patients are receiving treatments on a regular basis - wash your hands & clean your table between every patient visit. The following protocol is MANDATORY in order to prevent the transmission of communicable diseases. If you have a transmittable condition, such as a cold or flu, use a mask to prevent or reduce the chances of spreading this disease to your patients, classmates & instructors. If you have an open wound on your hand, protect yourself from infection & spreading possible infection to your patient. If your condition is a concern do NOT offer treatment.

Practitioners must set an example of good health practices. Performing manual medicine procedures can & will cause you to perspire heavily on occasion. In order to avoid dripping perspiration on your patient keep a towel or tissue nearby to wipe your brow. If you perspire profusely during a treatment, apply a clean sweatband to your head before you wash your hands in preparation for the treatment. Shower, bath, or wash more than once daily if required & use a deodorant or facsimile (baking soda; natural deodorants; etc.) If perspiration continues to be a problem for you, try a regime of dry skin brushing to regulate perspiration. Strong breath odours resulting from some herbs & seasonings (e.g. garlic & onions) or cigarettes can also be offensive to others in close proximity. Either brush your teeth (and tongue) or use natural fresheners.

As manual medicine providers we also need to pay particular attention to the cleanliness & smoothness of our hands & finger nails. Finger nails must be cleaned, trimmed & filed regularly; callouses need to be filed. Longer nails can carry bacteria & along with exposed nails, unfiled nails or rough skin, can be uncomfortable for the patient when performing many techniques.

Before treatment: always wash hands, remove all jewellery & watch, ensure that your equipment is clean & ready, have a towel available to wipe your hands or wipe off perspiration.

After treatment: wipe tables down, especially the face piece, with viral/bacterial cidal solution; wash hands, first with warm or hot water, then finish with cool or cold, leave room neat & tidy!

Manual Medicine Tips

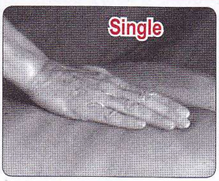
Biomechanics

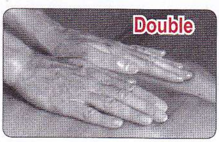
- **Manual medicine providers must always be aware of their biomechanics**, especially your back
- Pick the correct table height:
  - Massage - with arms relaxed at sides, fingers or knuckles should brush table top when standing
  - Osseous manipulation - base of patella should be level with the table top when standing
- Anticipate direction of movement & try not to finish in an awkward position
- Adjust posture & biomechanics according to the technique being applied, & the body part being treated, to facilitate smooth transition from one body part to another, & from one technique to another
- **Keep shoulders relaxed**. There is a tendency to raise shoulders when trying too hard or when the therapist is fatigued
- Elbows are flexed & wrists are relaxed for all light & moderate techniques; be careful not to "whip" or "snap" wrists during rapid applications (hyper-radial/ulnar deviation)
- Stand with a feet shoulder width apart, place feet in the direction of movement; knees & hips should be slightly flexed, back is straight, shoulders relaxed
- Lift heavy limbs close to your body; use other parts of your body (legs, arms), bolsters, pillows or the table to support whenever possible

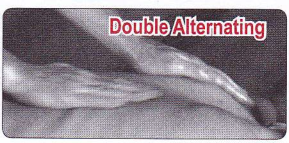
Passive Patient Movement

- Physical contact creates non-verbal communication that can be sensed by the patient; if you are nervous or unconfident patients can sense it
- Clinicians must overcome the patient's tendency to muscle guard or 'help' move the limb
- Support joints with your hands, another part of your body (arms, leg, etc.) or the table; this mainly refers to proximal joints (elbows or knees), which can become very unstable if not supported
- Distal joints (ankle & wrists) may not have to be supported at all times through the whole range, provided that there is no threat of compromising the joint
- **Other patient movement tips:**
  - **Practice:** continually refining your skills makes you more proficient
  - Teach the patient to have **awareness of when they are guarding** or moving the limbs for us. The majority of the time the patient does not even realize they're guarding or moving the limb for you
  - **Firm & solid hand contacts:** this will communicate to the patient that the limb is secure & that you have complete control of the limb.
  - **Voice commands** to the patient are helpful. "Let me take the weight of your arm," "Let your body sink into the table," "Take a nice deep breath," "Close your eyes," "Rest your tongue on the roof of your mouth," These phrases are all helpful cues that do **not** include the word **RELAX,** which may make it even more difficult for the patient to prevent guarding.
  - **Smooth movements:** jerky movement will stimulate joint proprioceptors which results in the muscles contracting around that joint to stabilize it. This prevents smooth mobilization of the limb.
  - **Always support injured joints:** prevents further injury & helps relax the patient
  - Slight **axial distraction (traction)** of the limb may help inhibit stimulation of joint receptors, which will in turn prevent muscle guarding

Therapist Contacts







Goals of Massage Therapy

- Help improve general health, promote stress reduction & relaxation
- Restore optimal function where possible; prevent further injury or dysfunction
- Address compensatory changes due to injury or dysfunction, help prevent complications related to trauma, overuse or disease

Above Goals are accomplished through

Maintaining or increasing:	• Circulation & tissue fluid exchange • Respiratory function • Joint range of motion • Muscle tone & flexibility • Sedative response / parasympathetic nervous system stimulation
Preventing or decreasing:	• Adhesive tissue formation • Edema (swelling) • Pain • Muscle hypertonicity & muscle spasm • Decrease sympathetic nervous system firing (promote relaxation)

Basic Principles of Massage Therapy Application

1. General to Specific to General

- **Area of body:** a rhythmical flow of massage is best achieved by working from a larger area of the body into a smaller area, & then gradually back to a larger area. To reduce guarding & minimize patient discomfort begin with general overall contact of larger areas before progressing to specific areas related to the clinical findings/chief complaint. Return to the larger structure, linking the specific to the whole before progressing to another area.
- **Techniques:** general to specific also pertains to the choice of techniques. The therapist should commence application with broader strokes, progress to more specific techniques & then finish with the broader strokes.
- **Part of therapist's hands:** palmar, whole hand contact acclimatizes the patient to touch & allows them to relax. It also allows the therapist to palpate & recognize painful areas. With digits & thumbs, more specific work can be done to affect more specific structures. Return to general with full palmar contact, ensure sufficient venous & lymphatic return.

2. Superficial to Deep to Superficial: Begin movements with relatively superficial light pressure; progress to deeper and/or firmer pressure once the soft tissues have relaxed & circulation increases, then back to a superficial contact.

3. Proximal to Distal to Proximal: when discussing treatment of the limbs, the heart is the most proximal. Begin at the most proximal part of the limb, which is closer to the heart, progress distally, farther from the heart & then return proximally. For example when massaging the leg begin at the hip (proximal) & progress down to the thigh, calf & then the feet (distal) & then finish with general strokes towards the proximal area. As well, intermittently incorporate general strokes to the proximal area to maintain relaxation & circulation.

4. Peripheral to Central: in general, avoid treating the area of pain or source of dysfunction first, even though it will be the main focus. Include this area in general techniques such as effleurage to acknowledge & palpate it for heat, tenderness & swelling. *If this area is approached too deeply too soon it will only exacerbate the patient's discomfort & a protective mechanism will prevent effective treatment*. Therefore, treat the unaffected side or surrounding area first; this will help to address compensatory changes & reflexly relax the affected soft tissue.

- **Pressure:** deep pressure is usually applied towards the heart to support venous flow, with more pressure on the upward stroke of the limb & less on the return stroke. Adjust the pressure according to patient tolerance & the stage of dysfunction and/or injury. Generally, light pressure over bony areas, abdomen & spine & heavy over larger tissue mass. Patients are often able to tolerate deeper pressure with each successive treatments as they become used to treatment & the condition improves. The more relaxed the muscle is the deeper the pressure can be applied.
- **Rate:** dependent on the desired effect; generally, faster rates stimulate the nervous system & slower rates soothe & relax the nervous system
- **Rhythm:** should be even, smooth, flowing, consistent, fluid & continuous. Constant contact is important during a treatment. If the connection is broken, re-establishing the contact must be gentle & careful. The transition between two different massage techniques must be smooth.
- **Duration:** local treatments last 20-30 minutes & full body treatments last 45-90 minutes maximum. Treatments on infants, children or geriatrics should be shorter. Treatments longer than 90 minutes can be debilitating & excessive treatments may manifest as increased pain due to inflammation, muscle spasm, headache, or nausea. Watch for changes in the patient's condition (pallor, breathing changes).

Considerations		
Therapist	**Patient**	**Other**
• What are the goals of treatment • Confidence with particular technique based on skill level & prior experience • Specialized knowledge • Physical fitness, i.e. stamina, strength & flexibility • Level of energy at that time • Extent of reach based on height, length of arms, girth, etc. • Size of hands & digits in relation to size of structure being treated	• Overall health of patient • Age of the patient • Presenting condition/ pathology & stage of dysfunction • Side effects of medication • Personal goals of treatment & preference • Prior massage experience • Pain threshold/ level of sensitivity • Tissue: type, tone, texture, location (depth), shape, contour, resistance, size, pliability, reaction	• Physiological effects of technique • Length of treatment • Phase of treatment, i.e. at the beginning or end of the treatment • Type of lubricant used (oil, lotion, powder, etc.), without lubricant • Clothed massage • Height of table and/or surface being treated • Seated massage e.g. patient is in a wheelchair, scooter or massage chair

Uses, Indications & Effects of Massage Therapy

- A **USE** is the ***purpose*** *of the technique(s)* that is employed for a given situation or condition in which this known physiological response would be most beneficial. For example, if we know that effleurage increases blood flow to an area, it would be appropriate if we applied or "**used**" effleurage when a patient presents with a condition of poor or sluggish circulation.
- An **INDICATION** is the ***condition*** that dictates the appropriate technique(s) to be employed. For example, if a patient presents with a condition of inefficient circulation, effleurage would be ***indicated*** to increase local blood flow.
- An **EFFECT** is primarily the ***physiological response*** to a technique(s). For example, effleurage (the stimulus) increases blood flow through an area (the physiological response).
  1. **Mechanical effects** are those that result from a direct physical stimulus such as pressure or movement. Example: compression causes a draining & refilling of vascular vessels
  2. **Reflex effects** are those that result from a neurological response to a mechanical stimulus. Example: relaxation of muscle tissue is a result of a neural response
  3. **Chemical effects** are those that result from a chemical response to a mechanical stimulus. Example: deep pressure on the skin causes a release of histamine, which in turn, causes an increase in capillary permeability & local blood flow. (If you run your nail down your forearm the skin will turn red.)

Contraindications (CIs) exists when therapy or certain therapeutic techniques is ***NOT*** indicated for a given condition or situation. When massage therapy is contraindicated, a therapist must **modify or omit** the type of treatment given. Common sense should be applied in the treatment of all conditions. The value of the treatment must be considered with respect to the risk to the patient & to the therapist. Contraindication guidelines exist to protect the patient from further exacerbation of a condition, & to help avoid legal action being taken against the therapist.

Any illness or injured area should be considered contraindicated & treatment should be **modified or omitted** depending on the risk factor. If ever in doubt as to whether a condition or situation is contraindicated, it is best to omit the involved area or the treatment altogether until you are sure you can safely treat the patient. As clinicians gain experience & knowledge in clinical sciences & pathologies, some of the **absolute** contraindications **may** become **relative** contraindications.

Types of contraindications

- **General or systemic contraindication** exists when the situation or condition affects the whole body
- **Local contraindication** is when the situation or condition affects a particular region or body part
- **Absolute contraindication:** pathological conditions or symptoms that cannot be treated under any circumstances. Absolute contraindications can be *systemic or local.*
- **Relative contraindication:** pathological conditions or symptoms that are generally less acute or in a state of remission may be treated with caution and/or modification of technique(s). Relative contraindications can be *systemic or local.*

Systemic (General) Contraindications	
Absolute	**Relative**
• Contagious infections • Temperature of two or more degrees above normal (99°F/37°C) • Severe, active cardiovascular disease (arteriosclerosis, congestive heart failure, high blood pressure (160/115) • Cancer (if metastatic) • Acute rheumatoid arthritis • Any condition that requires immediate first aid or medical attention • Hemophilia • Patient under the influence of alcohol or recreational drugs	• A mildly contagious infection • Temperature of less than two degrees above normal (99°F/37°C) • History of cardiovascular diseases or controlled by medication • Cancer if in remission or terminal (palliative care may be approved by attending physician) • Rheumatoid arthritis if in remission or managed by medication • Neurologic conditions that alter a patient's perception of touch or pain (quadriplegic, multiple sclerosis) • Medication that alters pain perception or circulatory responses

Local Contraindications	
Absolute	**Relative**
• Undiagnosed lump (possibly cancerous) • Infectious & contagious diseases of the skin • Recent wounds, burns &/or scars • Severe varicose veins (elevated & painful) • Thrombosis (blood clot within vascular system) • Phlebitis (inflammation of a vein) • *Abdominal Massage:* high blood pressure (160/115); acute colitis; diarrhea, nausea &/or vomiting, undiagnosed or malignant tumor; first trimester of pregnancy (if known)	• Benign tumor/cyst - dependent on condition • Sprain/fracture – modify treatment • Healing wounds, burns, scars • Visible but not elevated or painful varicose veins • Muscle contusion (depends on stage of healing) • *Abdominal Massage:* high blood pressure; chronic colitis; abdominal hernia; benign tumour/cyst; dysmenorrhea (difficult or painful menstruation); 2nd/3rd Trimester (placenta previa)

Effleurage

Definition
- A continuous gliding motion applied to the body with the palmar surface of the hands in constant contact with the body. Pressure is applied evenly on the "up stroke" with light pressure on the "return stroke."

Uses of Effleurage
- Introduction of touch, spreads oil or lotion
- Ensure hands are relaxed flexible
- Introduction to a new part of the body being treated or a finishing stroke
- Blending stroke between techniques

Indications & Contraindications

Indications	Contraindications
• Palpation assessment • Sluggish circulation • Edema, muscle tension, pain control • Prevention of adhesions & fibrosis	• High blood pressure • DVT/varicose veins • Unhealed wound • All local & general CI's

Physiological Effects
- **Chemical Effects**
  - Vasodilation & local blood flow are increased as a result of the release of histamine

- **Mechanical Effects**
  - Increase venous flow - compression of the tissue empties venous beds, lowering venous pressure & increasing capillary flow
  - Increase lymphatic flow
  - Reduces edema

- **Reflex Effects**
  - Stimulates large cutaneous mechanoreceptors that moderate pain & therefore has a soothing effect
  - Increases blood pressure initially, then decreases it
  - Stimulates large mechanoreceptors which modulate pain perception

Pressure is applied evenly on the "up stroke"

Light pressure is applied on the "return stroke"

Manual Techniques

Definition

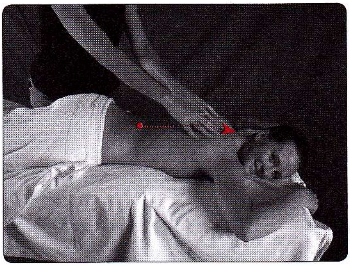
- Movement of the therapist contact points over a comparatively extended area of the body, with pressure maintained more or less constant throughout the stroke. Pressure may be applied varying from the light touch to deep pressure depending on desired effect & patient tolerance.
  - **Light Stroking:** minimal pressure applied with the palmar surface or fingertips of one hand or with both hands simultaneously or alternatively
  - **Deep Stroking:** moderate or deep pressure, usually in the direction of venous drainage; may be applied with the palmar surface of hands, forearm or thumbs, with one hand or with both hands simultaneously or alternatively

Uses & Indications of Stroking

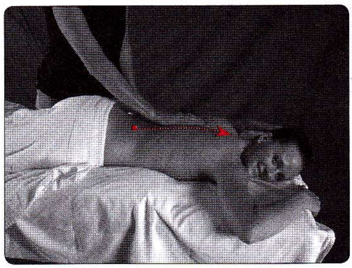
Light Stroking	Deep Stroking
• Pain moderation through reflex effects • Conditions created by nervous exhaustion (insomnia) • Painful conditions (muscle spasm, neuralgia) • Finishing stroke to end session • Stimulation of cutaneous sensory neurons • Increases lymphatic return when applied in the direction of venous & lymphatic return	• Introduction to a new part of the body • Blending stroke between techniques • Hypertoned muscles • Flushing or clearing stroke • Similar to effleurage

Contraindications: all general & local
Physiological Effects: same as effleurage

Clinical Application



- For lighter applications, the therapist maintains a stable yet relaxed position that allows for rhythmical, even coverage of the body part being treated. For deep stroking the therapist leans into the stroke, "pushing off" from the posterior leg to increase the force of application.
- **Light Stroking:** hands & wrists should be relaxed but not floppy; hand(s) makes contact with the body using minimal pressure; one or both hands may be used, moving in a rhythmical fashion
  - The return stroke is off the body. This will assist with the control of rhythm, as the return stroke should take as long as the contact stroke.
  - Direction of movement may be in several directions though not at the same time; maintain consistent direction. Stimulating towards the head (cephalic). Sedating is towards the feet (caudal).
- **Deep Stroking:** when treating specific muscle fiber, the therapist may intentionally choose to follow the direction of the tissue & not necessarily that of blood flow. In these cases the therapist should finish treatment of the area with strokes that do follow the direction of venous return.
  - Pressure is not continuous; start lightly & increase gradually, then decrease pressure towards the end of the stroke.



Therapist Contacts for Body Region

- **Palmar**: full back, arms, legs
- **Ulnar Border:** along erector spinae group, hamstrings, quadriceps
- **Knuckles (closed fist):** deep technique to be used only on larger muscles (gluteals, thigh, erectors)
- **Fingertip/Thumb:** specific smaller areas (scapula, around sacrum)

Petrissage

Definition

- Alternate pressure & release of soft tissue applied with compressing towards underlying structures or by lifting soft tissues
- 5 Types of Petrissage
  - *Compressive Techniques*
    - ***Kneading***
    - ***Muscle compressions***
  - *Lifting Techniques*
    - ***Wringing***
    - ***Picking Up***
    - ***Skin Rolling***

Type	Indications/Use	Contraindications	Effects
Kneading	• Sluggish circulation, edema • Decreased AROM • Hypertoned muscle • Muscle contractures • Stimulated motor nerves • Digestive disorders • Insomnia, spastic paralysis	• Avoid knuckle kneading over boney prominences • Severely atrophied or flaccid tissue • Severe varicosities	• Loosens adhesive muscle tissue, stretches muscle fibers • Decrease effects of fibrous thickenings & adhesions • Maintain/improve muscle tone • Increases circulation to nerves
Muscle Comp.	• Increase local circulation • ↓ edema & muscle spasm • ↓ muscle guarding • Quick application can be used in pre-event sports massage	• Avoid applying deep sudden pressure • All local & general CI's	• Empties venous beds, ↓ venous pressure & ↑ capillary flow • Relaxation of hypertoned tissue – reset muscle spindle and/or golgi tendon organ • ↑ parasympathetic stimulation
Wringing	• Poor or sluggish circulation • Edema • Hypertoned muscle tissue	• All local & general CI's	• ↓ stiffness due to ischemia • Loosens adhesive muscle tissue • Stretches muscle fibers • Maintain/improve muscle tone • Increases circulation to nerves
Picking-Up	• Generally used in extremities	• All local & general CI's	• Loosens adhesive muscle tissue • Stretches muscle fibers • Maintain/improve muscle tone • Increases circulation to nerves
Skin Rolling	• Cutaneous or subcutaneous adhesions • Scar tissue formation • Cutaneous or subcutaneous circulation & tissue mobility • Overuse, Misuse • Prolonged absence of use	• Hypersensitive to pain • Increased histamine response • All local & general CI's	• Loosens adhered cutaneous & fascial layers • Stretching fascia • ↓ resistance to superficial lymph & venous flow • ↑ local skin temperature due to local hyperemia

Kneading

Definition: compressive petrissage using palms, thumbs, finger tips or knuckles applied in rhythmical circular motions with alternating pressure & release. There are 5 kneading subtypes:

1. **Palmar:** single, single reinforced, double alternating
2. **Thumb:** double simultaneous, double alternating, single reinforced
3. **Fingertip:** single, single reinforced
4. **Knuckle:** single, double alternating, reinforced
5. **Open-C:** double alternating

Palmar, Thumb, Fingertip, Knuckle

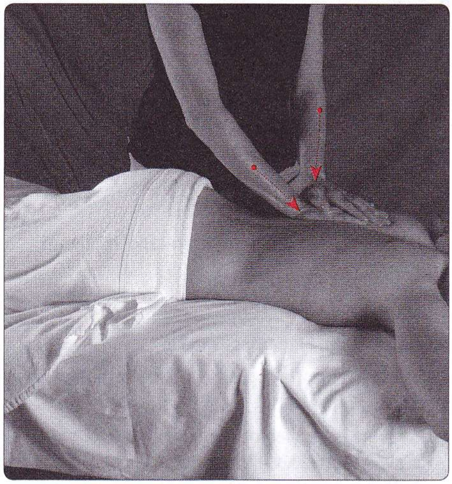
- Hand movement is applied in a **circular motion** with continuous contact
- **Pressure is applied on the upward stroke of the circle** & released on the downward stroke of the circle, **rhythm is constant** & rate is dependent upon the treatment goals
- The size of the **circular motion** & the part of the hand being used depends on the size of the body part being treated, or treatment goals.
- When applied to the limbs, the progression of strokes is from **proximal to distal** with the pressure on the upstroke (direction of venous return)
- When applying **knuckle kneading**, contact is made between the dorsal aspect of the metacarpophalangeal (MCP) joints & proximal interphalangeal (PIP) joints
- Remember "**The four S's**" of kneading - **S**low, **S**mall , **S**pecific & **C**ircular (phonetic 'S' ☺)

Open-C

- Hands in an open 'C' position with the thumb in abduction & slight flexion, the fingers are cupped to fit the body region being massaged
- Pressure is exerted in a scooping fashion with the palmar surface of the hand molding to the contour of the part of the body being treated.
- **Pressure & release alternates from one hand to another** in a wavelike motion
- When applied to the extremities, pressure is slightly more on the upstroke to follow venous return
- Hand position & specific shape will change according to the size & shape of the body region being treated & the size of the therapist's hands

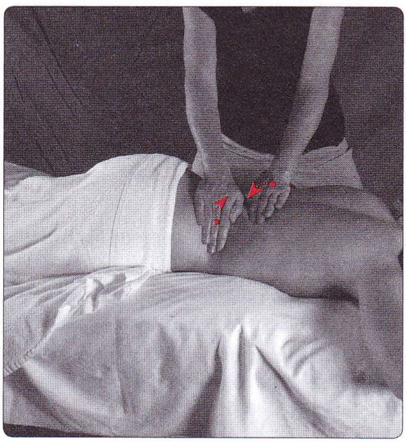
Muscle Compressions

- **Definition:** pressing & releasing of soft tissues with fingers & palms of hands
- Pressure in exerted downward towards belly of muscle or underlying tissue
- No oil is required, may be done through clothing or sheets
- Full palmar contact, pressure is progressively increased with subsequent hand contacts
- Therapist sinks their hands into the muscle tissue
- No hyperextension of wrists



Wringing

- **Definition:** applying equal pressure on opposite sides of the tissue structure, lifting & pushing in opposite directions
- Hands firm but able to mold to body shape, & are placed on opposing sides of the structure being treated with equal pressure being applied by the palmar aspect
  - Thumbs may be adducted (avoiding hyperabduction, maintain a soft 'V' position, not an 'L') to accommodate the following factors:
    - Size & shape of the area being treated
    - Size & strength of the therapist's hands.
- With the opposing force, the hands lift the tissue up & gradually release when tissues are lifted to their maximum height
- As pressure releases, the hands glide past each other towards the opposite side of the part being treated
- Technique is applied to the limbs from proximal to distal; this principle does not apply when treating the back or abdomen
- Avoid contact with the breast tissue when applying wringing to the upper back



Picking-Up

- **Definition:** applying equal pressure on the sides of the tissue structure & lifting it away from the body
- Hands parallel to the limb being treated, avoiding hyperextension of the outer wrist
- Application begins at the proximal aspect of the limb, applying pressure in the direction of venous flow
- Tissues are simultaneously compressed together & lifted away from underlying structures
- Lift the tissues smoothly, keeping the majority of the weight of the limb as close to the centre of your body as possible
- Pressure is released on the upward & returning stroke of the circular motion while contact remains continuous throughout the whole movement
- You can use a single hand picking up smaller areas (eg. deltoid & forearm)
- Picking up is applied in a proximal to distal direction (from the proximal to the distal aspect of the limb with pressure being applied in the direction of venous return).Therapist sinks their hands into the muscle tissue.


Picking-up Deltoid


Picking-up Quadriceps

Skin Rolling

- **Definition:** cutaneous & subcutaneous tissues are grasped & lifted away from underlying tissues & then rolled between fingers with pressure towards the underlying structures
- Using little or no oil, establish a comfort / pain scale with the patient
- Grasp & lift skin between the thumb & fingers of both hands (maintain the thumb in a neutral position - no "L" formations)
- Use fingers to mobilize skin tissue towards the thumbs; a sustained gliding force is applied through the thumbs while maintaining constant pressure on the underlying tissue
- Fingers walk, the thumbs move as a "snowplow" - may be applied in any direction
- Skin rolling works well adjacent to the spinous processes, with thumbs exerting pressure into the paraspinal muscles; avoid pressure directly over bony prominences
- Intersperse & finish skin rolling with general, soothing techniques
- Monitor patient closely for reactions, as skin rolling can cause discomfort in some individuals

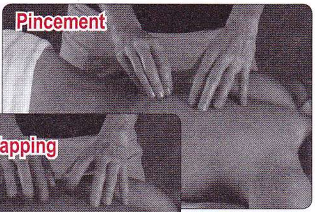

Thumb Method

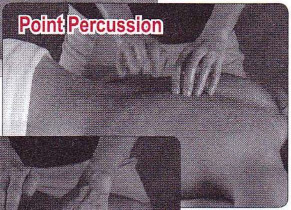

Finger Method

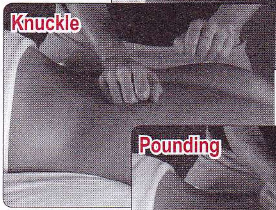
Tapotement

Definition: drumming hand movements on broad areas using fists, fingertips & heels, ulnar border or flat hand over fleshy areas. There are 9 subtypes of tapotement techniques:

1. **Pincement**: quick, light pinching movements using the thumbs & fingertips
2. **Fingertip tapping:** alternating percussive movements of each finger using the fingertips pads
3. **Point percussion**: percussive movements performed with the fingertips, one hand alternating after the other
4. **Clapping:** performed with the palmar surface & the fingers striking flat against the surface of the body
5. **Cupping**: percussive movements performed with the palms held in a cupped position creating a light vacuum & suction effect between the hand & the body
6. **Loose digital ulnar border percussion**: percussive movements applied to the body part being treated using the ulnar border of the hand & dorsal aspect of the 3rd, 4th & 5th digits
7. **Hard digital ulnar border percussion:** percussive movements applied with the ulnar border of the hand with fingers extended
8. **Knuckle percussion:** percussive movements performed with the hand held in a loosely closed fist. Contact is made with the dorsal aspect of the middle phalanges & the hypothenar & thenar eminences
9. **Pounding**: percussive movements performed with the ulnar border of the hand & 5th digit held in a loosely closed fist







Application & Indications

- Pressure varies from light, moderate to heavy
- Stimulatory less than 30 sec/ sedative 30 sec - 3 minutes
- Stimulation of tissue, nervous & muscle
- Congested lungs/dislodge mucus (bronchitis)
- Decrease fatigue, decrease hypertonicity
- Maintain tone in hypotonic muscle
- Atonic constipation

Contraindications

- All general CI's
- Aggressive tapotement of flaccid tissue or decreased neurological sensation
- Over bony prominences
- Acute inflammatory areas
- Cyst or tumours, severe varicose veins
- Kidney area, lumbar area while menstruating or pregnant

Definition

- Tremulous movement of palms or fingertips against a body part causing it to vibrate; may be fine or coarse depending on the degree of movement, rate of vibration & pressure; may be static or running (localized or moving along length of surface being treated)

Indications	Contraindications
• Fine – pain relief, acute muscle spasm, neuralgia, cutaneous inflammation, sinus congestion, nervous exhaustion, insomnia • Course – flaccid or atrophied tissue, atonic constipation, chronic pulmonary disease	• All local & general CI's • Coarse - acute muscle spasm, insomnia, lumbar or abdomen during pregnancy

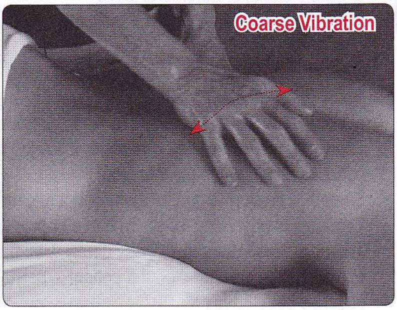
Physiological effects (vibrations)

- Fine – increases superficial lymphatic return, decreases lymph node congestion, soothing effect on cutaneous nerves, sedative over nerve plexus
- Coarse – mild stimulation to cutaneous nerves, stimulate peristalsis, decrease flatulence, increase expectoration
- Maintain muscular tonus
- Increases peristalsis

Free on-line videos demonstrating available at
http://www.prohealthsys.com/education/index.php

Clinical application

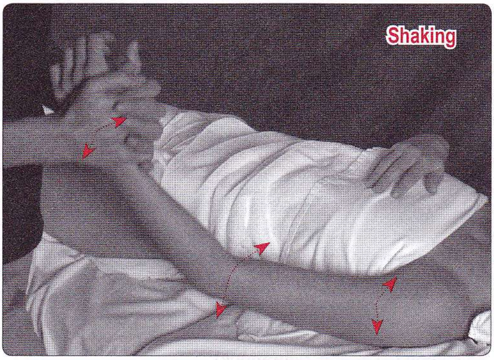
- The "key" in this application is that the therapist remains relaxed & focused through breathing & concentration
- The palmar surface of one or both hands are rested & molded around the body part being treated.
- If the entire palm is used, the fingers are slightly abducted, the wrists & hands are held firmly, the elbow(s) slightly flexed
- The rhythmical vibration is created by simultaneous isometric contractions of the flexors & extensors of the forearm & to a lesser degree than those of the upper arm
- Since applying vibrations takes a considerable amount of arms strength & endurance, frequent short breaks are recommended. If needed, after 15 - 20 seconds of application, shake your arm(s) & hand(s) before resuming the application
- Vibration may oscillate in angular directions, medial to lateral, superior to inferior or even superficial to deep



Manual Techniques

Shaking, Jostling & Rocking

Definition Shaking & Jostling
- A course vibration applied to muscle groups, limbs or torso with constant contact & physically shaking tissue



Indications & Physiologic Effects
- Reduce muscle hypertonicity & guarding
- Improve digestive dysfunction
- Pre & post event sports application

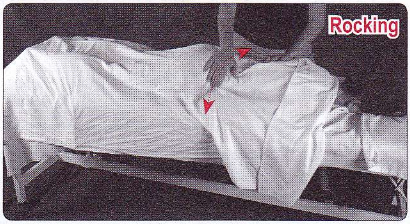
Contraindications
- All general & local CI's
- Muscle atrophy accompanied by flaccid paralysis
- Joint pathology, disc herniation
- Severe muscle spasm
- Reduce muscle or joint guarding

Clinical application
- Hold limb securely & muscle group being shaken or jostled are held loosely
- Movement is either rhythmically up & down or side to side
- Apply slight traction to limbs
- Shaking may be applied to the abdomen

Rocking

Definition: an introductory or ending rhythmical oscillating massage technique applied to the body

Indications & Physiologic Effects
- Can be stimulating or sedative; depending on the rate of application
- Reduce muscle guarding, tension & hypertonicity
- General soft tissue mobilization



Contraindications
- All general & local CI's
- Unstable spinal or peripheral joints
- Nausea, dizziness, inner ear infections

Clinical application
- No oil applied; technique is applied over the sheets/drapes or clothing full palmar contact to the area of application with hands molded to fit the contours of the patient's body
- Therapists hands are soft & relaxed, following the rhythm of the patient's body (don't push/rock until the patient's body comes back to you)
- Smooth & flowing; a gentle push, with a release phase, in order to rock the patient's body smoothly
- Therapist is observing for an "s" curve or production of a wave through the patient's body
- Therapist rocks the patient body gently with: both hands, alternating hands, can work on the same side, opposite side, one hand on the patient's pelvis stationary, while the other hand travels up & down the patient's body & legs

Definition

- Frictions are small longitudinal, transverse or circular movements that involve moving a specific segment of tissue against the underlying structure. No gliding takes place over the skin. The pressure is directed towards the underlying structures

Indications	Contraindications
• Joint restriction (decreased ROM) • Tissue adhesions • Tendonitis • Ligament sprains	• All general & local CI's • Local infections, contagious skin conditions, tumors, cysts, severe varicose veins • Conditions of acute inflammation where the condition is too painful to be touched & accompanied by severe swelling, redness & heat • Hypersensitivity (patient's tolerance to treatment)

Physiological effects

- Restores & maintains tissue mobility in conditions of chronic tendonitis, sub-acute or chronic ligamentous sprains
- Increases tissue mobility & extensibility, improves tissue blood supply
- Reduces joint restriction, decreases fibrous adhesions

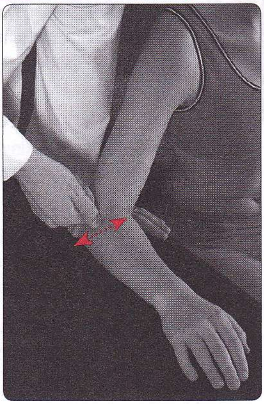
Clinical application

- Area being treated should be properly supported to reduce muscle guarding; only use minimal amount of lubrication to avoid skin burning or hair pulling, otherwise lubrication is not required.
- The pad of the index or middle finger or thumb, single or reinforced, are placed directly over the tissue being treated. Hands or fingers not involved with the friction may be used to support the working hand and/or the surrounding structures.
- Frictions may be applied in a circular, longitudinal, or cross fiber direction to the muscle & or tendon fibers; friction direction is dependent upon the presenting condition of the patient, & the treatment goals
- Pressure is applied according to the general principle of superficial to deep; begin with light pressure & progressively increase to the point of patient tolerance and/or tissue resistance
- The amplitude of the movement is minimal, while the rate may vary from moderate to fast; pressure should never be released suddenly
- At the beginning of the technique, the patient may experience mild discomfort. This is acceptable providing the discomfort does not increase. If pain does increase, do not apply deeper pressure and/or discontinue with the application

Clinical tip: this is an extremely effective treatment for lateral epicondylitis (tennis elbow)

Lateral Epicondylitis Technique

- Use reinforced thumb, index finger or knuckle, depending on patient tolerance (see image)
- 2-3 cycles per second, for 6-20 minutes (each cycle should be a movement of 1 cm or less)
- Always remain within patient's tolerance
- As patient tolerance increases, increase pressure used



Frequency

- 2-3x/wk for 6-10 treatments
- Do not do treatment two days in a row (allow time for healing)

After Treatment Considerations

- Ultrasound (5-7 min, 1 W/cm^2)
- Ice Massage (up to 7min) - CBAN - cold, burning, achy, numbness
- Warn patients of potential side effects soreness & mild bruising

Manual Techniques

Myofascial Release

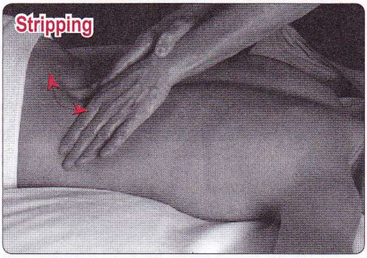
Definition
- Therapeutic stretching & loosening of tight fascial layers surrounding muscle & functional groups

Clinical application
- Muscle should be in neutral position or slack position
- Slow application of technique, stop & wait for release
- Pain should decrease with each application
- Clear area well with flushing technique (deep stroking & effeurage)

Indications	Contraindications
• Adhesive scar tissue due to trauma • Adhesive fascial restriction due to postural abnormalities or immobilization • Joint restriction due to immobilization	• Acute inflammation or inflammatory conditions • Excessive hyperemia or heat • Unhealed wounds, burns & acute skin conditions

Physiological effects
- Fascial tissue is separated from adhered muscle fibers

Types of Myofascial Release

Shearing	**Definition:** parallel forces are applied to the tissue & against the tissue that is causing the restriction **Application:** hand contact is flat & broad applied with parts of hand & in any direction **Effect:** fascial tissue is separated from adhered muscle fibers	
Stripping	**Definition:** deep thumb or finger stroking directed to the deeper subdermal & muscle layers **Application:** slow, progressive deep strokes applied parallel to the muscle fiber direction **Effect:** fascial tissue is separated from adhered muscle fibers; stretches small sections of myofascial tissue	
Rolling	**Definition:** deeper skin rolling directed at deeper subdermal layers by physically picking up tissue & rolling it **Application:** Grasp tissue between index finger & thumbs & lift tissue off underlying tissue; slowly roll through the elevated tissue **Effect:** Underlying fascia is picked up & rolled away from its adherence to surrounding tissue	

Definition

- Treatment of hyperirritable spots within taut bands of muscle or muscle's fascia

Clinical application

- Produces a characteristic tenderness, referred pain pattern, or autonomic phenomena
- Treatment consists of distraction stimulus followed by stretch of involved muscle or ischemic compression
- Treatment follow-up includes non-weight bearing exercise & stretch

Indications	Contraindications
• Direct muscle or joint injury • Chronic muscle strain or muscle compensation • Arthritis, unconscious muscle holding • Sedatary lifestyle may lead to latent trigger points	• Brachial neuralgia • Sciatica • Beware of post treatment reactions • Excessive pain that is not diminishing • Exacerbation with extreme heat or cold

Selected MFTP Treatment

	Pressure Point Release	Ice & stretch
Definition	• Palpation of hyperirritability, pressure is progressively increased over the spot until tenderness diminishes & referred pain decreases; release of the pressure then allows hyperemic flushing of area	• The pattern of pain referral is first exposed to a brief cryogenic distraction stimulus followed by a slow & gradual sustained stretch
Application	• Palpate for the location of trigger point • Slow progressive build up pressure within pain tolerance • Maintain pressure & wait for tissue change • Stretch & clear tissues after treatment	• Position & support patient comfortably ensuring smooth & fluid handling • Take the muscle to the point of tissue resistance, ensure the patient breathes during ice application • Sweep the initial ice pattern • Take up the slack & hold • Repeat cycle minimum three times • Re-warm tissue
Effects	• Firm digital pressure applied to the TP, deep stripping, kneading causing blanching ischemia with hypoxia followed by a reactive hyperemia	• Muscle containing the trigger point is put into the stretch position the ice or cold spray is used to distract the nervous system & stimulate circulation to allow the stretch to increase thereby allowing the taut band to release its contraction

Nimmo Technique

1. Effleurage applied to remove "satellite trigger points"
2. Muscle is relaxed (origin & insertion approximated)
3. Pressure applied to patient's tolerance, 3-7 sec.
4. Trigger point is released. Others are treated
5. Trigger points are retreated several times per session
6. Patient instructed to move muscles through normal range of motion

Travell's Technique

1. Stretch involved muscle to verge of discomfort
2. Apply sustained tolerable pressure directly to trigger point
3. Increase pressure as discomfort increases
4. Hold up to 20 lbs. for 10 sec. or until trigger point "melts," but, no longer than 60 sec.
5. Area is heated with hot pack
6. Patient instructed to move muscles through normal range of motion

Definition
- Stretching & softening of muscle & their attachment sites

Clinical application
- Assess functional length
- Muscle in slack/shortened position
- Treat muscle belly before attachment, from origin to insertion or from most stable to least stable
- Apply frictions on short strokes at attachment sites
- Begin frictions with longitudinal then progress to cross fiber apply in one direction at a time
- Always work within patient pain tolerance
- Reset neuromuscular feedback mechanisms with passive stretch & active range of motion after treatment

Indications	Contraindications
• Motion restriction • Adhered, contracted muscles & attachment sites • Muscular hypertonicity • Old injury • Overuse	• Tissue inflammation • Edema • Flaccid paralysis • Pre-existing pathology sprain, strain, fractures • Onset of unexplained or unusual symptoms, nausea, extreme pain

Physiological effects
- Reduces neuromuscular fixation due to the effect of muscular hypertonicity & irritability on attachment fiber, by using mechanical properties & stimulating neural feedback mechanisms

Muscle Stretching Techniques

Stretching is a fundamental way to improve your overall health & fitness, possible effects include:

- Increased flexibility & circulation; muscle relaxation
- Reduced risk for injury, reduced muscle imbalance
- Decreased anxiety & stress; can give patients an overall feeling of well being

Warm up - do a large muscle warm-up such as brisk walking for 5-10 minutes before stretching

Basic technique - simply move the origin & insertion of a muscle away from each other until tension is felt in the muscle (this is can be applied to every muscle in the body)

Perform balanced stretching - always stretch the muscles on both sides of your body evenly; do not stretch one side more than the other side

Avoid over stretching - never stretch to the point of pain or discomfort (overs stretching can cause a muscle strain or even ligament sprain). Recent studies have shown that over stretching before physical activity may actually increase the chance of injury (sprain/strain)

Go slow - stretch slowly & hold the stretch for about ~30 seconds & release slowly as well

Never bounce or jerk while stretching - this can cause injury as a muscle is pushed beyond its normal anatomical range (stretches should be smooth, & slow)

Breathe - flexibility exercises should be relaxing; deep easy, even breathing is key to relaxation (never hold your breath while you stretch)

Stretching Types

Passive stretching is a form of static stretching in which an external force exerts upon the limb to move it into the new position. Passive stretching resistance is normally achieved through the force of gravity on the limb or on the body weighing down on it.

Active stretching involves the use of muscle contraction to facilitate increased stretching & is usually based around the two main principles of reciprocal inhibition & autogenic inhibition (See PNF section page 388-389)

Static stretching is used to stretch muscles while the body is at rest. Muscles are gradually lengthen to an elongated position (to the point of mild discomfort) & hold that position for 10-30 seconds. When done properly, static stretching slightly lessens the sensitivity of tension receptors, which allows the muscle to relax & to be stretched to greater length – this may also predispose to potential injury if long stretches are held prior to vigorous physical activity.

Dynamic stretching is a form of moving stretches similar to what one does when they wake from sleep; the body is moving through range of motion. Dynamic stretches are useful in developing neuro-muscular coordination for movements such as leg lifts, dance movements, kicks, & development of speed & power. Forcing static-passive stretching ability beyond this range of motion becomes ballistic stretching.

Ballistic stretching (or bouncing stretches) forces the limb into an extended range of motion when the muscle has not relaxed enough to enter it. This may cause injury if not controlled properly or there is no adequate preparation, like warming up. Some believe that controlled ballistic stretching in the form of bouncing can increase flexibility. This is true to a certain extent, but this could cause injury & is not the safest method of stretching (though it may lead to quick gains). It may also lead to higher levels of flexibility that may not normally be attainable.

Definitions

- Resistance training = gradually & progressively overload the musculoskeletal system so it gets stronger. Research shows that regular resistance training will strengthen & tone muscles & increase bone mass
- Rep (repetition) = one complete movement of muscle (concentric & eccentric)
- Set = number of times a group of repetitions is performed
- RM = Repetition Maximum (the most weight that can be done for one rep)
- 10 RM = maximum weight that can be done for 10 complete, controlled repetitions

Resistance Exercise Protocols

	Set	Repetitions	% of repetition maximum
Progressive Resistance Exercise (PRE)	1	10	50% of 10 RM
	2	10	75% of 10 RM
	3	10	100% of 10 RM
Oxford Protocol	1	10	100% of 10 RM
	2	10	75% of 10 RM
	3	10	50% of 10 RM
Berger Protocol	1	6	100% of 6 RM
	2	6	100% of 6 RM
	3	6	100% of 6 RM

Daily Adjustable Progressive Resistive Exercise (DAPRE) Part I

Set	Repetitions	% of repetition maximum
1	10	50% of 6 RM
2	6	75% of 6 RM
3	maximum	100% of 6 RM
4	maximum	*Adjusted working weight

DAPRE Part II

Number of repetitions performed during 3rd set	*Adjusted working weight for 4th set	*Adjusted working weight for next exercise session
0-2	Decrease 5-10 lb	Decrease 5-10 lb
3-4	Decrease 0-5 lb	No weight change
5-7	No weight change	Increase 5-10 lb
8-12	Increase 5-10 lb	Increase 5-15 lb
> 12	Increase 10-15 lb	Increase 10-20 lb

*Adjusted working weight for the 4th set is based on total number of repetitions of full working weight performed during third set

Repetition numbers for given treatment/training goals

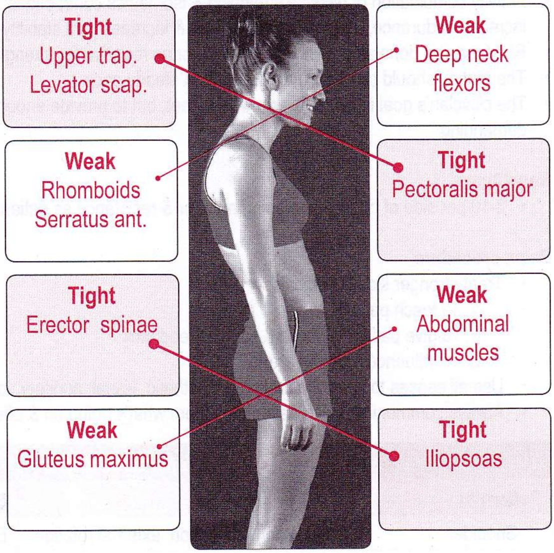
Reps < 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 > 20

Training goal
POWER
STRENGTH
MUSCLE ENDURANCE
HYPERTROPHY

Indication

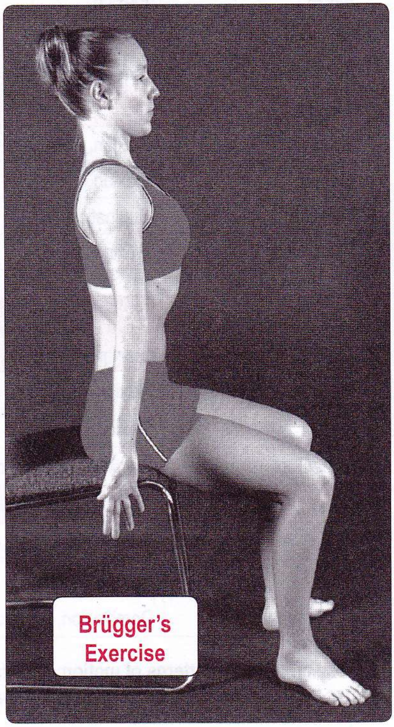
- Many conditions of the desk-bound worker are secondary to poor posture (headaches, rotator cuff syndromes, carpal tunnel syndrome)
- Common faults observed in standard sitting posture
  - Upper back rounded forward, shoulders become shrugged
  - Head pushes forward & chin pokes (extension of cervical spine)
  - Chest breathing predominates over belly breathing
- These postural faults result in standard muscle patterns of tightness & weakness referred to as **upper & lower cross syndromes**
- Brügger's exercise routine is devised to activate muscles weakened & simultaneously stretch those tightened by a prolonged sitting posture

Upper & Lower Cross Syndromes



Application

1. Patient performs exercises once or twice for every 20-30 minutes of prolonged sitting; position is held for ~30-60 seconds
2. While sitting at the chair the patient pushes away from their desk and,
   - Sits at the edge of their chair with their feet slightly farther apart than their hips & turns their feet out slightly
   - Tuck chin in slightly (as if nodding "yes") & breathe through the abdomen
   - Slowly exhale actively by blowing the breath out through their lips while rotating their arms laterally, & spread fingers
   - Lift sternum slightly & pull shoulders back
   - Some clinicians describe it as if there are strings pulling the patient's neck up, shoulders back & sternum forward



PNF = Proprioceptive Neuromuscular Facilitation

- Exercise technique based on diagonal patterns of extremity & spine movement
- Activity combination of passive stretching & isometrics contractions; it can also strengthen muscles, increase endurance, neuromuscular control & increase joint stability
- ROM may be done as a passive technique or as resistive for strength & coordination
- The motion should be performed at a slow & steady pace
- The clinician's goal is ***not*** to overpower patient, but to provide enough resistance to make activity mildly demanding

Repetitions

- 3-10 per side of body – increasing number & resistance as patient strength & coordination improve

Basic procedure

- Treat stronger side first; goals:
    1. To teach patient
    2. To give patient success & positive feedback
    3. To influence problem areas
- Use all senses to integrate motion (kinesthetic, visual, auditory, touch - manual contacts)
- Always communicate with patient, tell them what's going on & offer positive reinforcement

Upper Extremity		
Pattern #1	**Start position**	**End position**
Shoulder	Flexion, abduction, external rotation	Extension, abduction, int. rotation
Elbow	Flexion	Extension
Forearm	Supination	Pronation
Wrist/hand	*Extension*	*Flexion*
Pattern #2		
Shoulder	Flexion, abduction, external rotation	Extension, abduction, int. rotation
Elbow	Flexion	Extension
Forearm	Supination	Pronation
Wrist/hand	*Flexion*	*Extension*

Lower Extremity		
Pattern #1	**Start position**	**End position**
Hip	Flexion, abduction, int. rotation	Extension, adduction, ext. rotation
Knee	Flexion	Extension
Ankle/Foot	Dorsiflexion, eversion	Plantar flexion, inversion
Pattern #2		
Hip	Flexion, abduction, *ext. rotation*	Extension, adduction, *int. rotation*
Knee	Flexion	Extension
Ankle/Foot	Dorsiflexion, eversion	Plantar flexion, inversion

These are sample patterns of motion; clinicians must create their own patterns to address each patient's specific region of imbalance, lack of coordination or strength

- **Hold Relax (post isometric relaxation - PIR):** clinician asks patient to fire the tight muscle or group isometrically against the clinician's resistance for 15-20 seconds. Then, patient relaxes & clinician lengthens the tight muscle & applies a stretch in to the newly found end range. Technique utilizes the golgi-tendon organ, which relaxes a muscle after a sustained stretch has been applied to it for longer than 6 seconds. Verbal cues for the patient should include, "Hold. Hold. Hold...relax"
  Technique:
  1. < 20% isometric contraction: 15-20 seconds
  2. WAIT 3-5 seconds
  3. Stretch & feel for new barrier
- **Post Facilitation:** patient gives 100% contraction for 7-10 seconds, clinician then allows patient to fully relax, followed by RAPID stretch & hold for 12-15 seconds. Wait 20 seconds before repeating; may be repeat up to 5x a session
- **Hold Relax, Contract Relax:** patient gives 50-80% concentric contraction of tight muscle or group for 7-10 seconds, clinician then slowly stretches into new barrier & patient is then instructed to concentrically contract with 10% of strength for another ~15 seconds
- **Agonist Contract:** passively lengthen the tight muscle to it end range. Then, have patient concentrically contract the antagonist muscle or group to acquire a new end range. The clinician applies mild resistance during the concentric contraction, making sure to allow for movement to occur. This technique incorporates reciprocal inhibition, which is controlled by muscle spindles. When one muscle contracts, the muscle spindle causes its antagonist to relax. Verbal cues for the patient should include, "Push. Push. Push into my hand."
- **Hold-Relax with Agonist Contract:** Same as Hold-Relax. Patient isometrically contracts the tight muscle or group against the therapist's resistance. After a 15-20 second hold has been achieved, the clinician removes his/her hand & the patient concentrically contracts the antagonist muscle or muscle group in order to gain increased range of motion. At the end of this new range, the clinician applies a static stretch before repeating the process again.
- **Rhythmic Initiation:** Developed for patients with Parkinsonism suffering from rigidity. Clinician moves the patient through the desired movement using passive range of motion, followed by active-assistive, active, & finally active-resisted range of motion.
- **Slow Reversal:** technique involves the patient moving an extremity through the desired range of motion with continuous resistance with ***no*** rest periods occur between contractions. For example, the clinician applies resistance to the patient's arm as he/she moves it from its starting position to the desired end range. Then, the clinician applies immediate resistance as the patient returns his/her arm back to the original starting position.
- **Rhythmic Stabilization (alternating isometrics):** technique improves stability of the trunk, hip, & shoulder girdle. Patient holds a position while the clinician applies manual resistance, no motion should occur from the patient. The patient should simply resist the therapist's movements. The patient can be in seated, kneeling, half-kneeling, standing or standing on a wobble board when the clinician applies manual resistance to the shoulders. Usually, the clinician applies simultaneous resistance to the anterior left shoulder & posterior right shoulder for 2-3 seconds before switching the resistance to the posterior left shoulder & the anterior right shoulder. The clinician's movements should be smooth, fluid & continuous & challenge the patient from a variety of vectors & angles.
- **Muscle Energy Technique:**
  1. Clinician gently stretches patient into direction of restriction/decreased motion
  2. Patient gently (10% of maximum) contracts in exact opposite motion
  3. Patient holds contraction for 3-7 seconds & completely relaxes
  4. On relaxation, clinician moves to new resistive barrier
  5. Repeat 3-5 times & reassess

Physiological Effects

1. Local ↑ temperature, metabolism, perspiration, phagocytosis
2. Local vasodilation with hyperemia (due to ↑ metabolism, histamine release)
   a. Heat penetrates only a few muscles deep
   b. Deeper reactions are due to reflexes & require > 15 min of heat application
3. Deeper blood vessels: initial vasoconstriction followed by vasodilatation
   a. Law of Van't-Hoff: temperature increase of 10° → metabolism increase of 2-3x
   b. Not desirable in the presence of cancer or infection (contraindications)
4. Muscle relaxation
5. Decreased sensation of sensory nerve endings if heat is mild
6. Increase capillary pressure, cell permeability: may cause edema
7. Long term effects: ↑ body temperature, respiration, pulse rate & ↓ BP to disperse heat
8. Repeated strong doses, chronic use over years may cause *erythema ab igne* = mottled pigmentation due to RBC destruction & paralysis of arterioles

Indications

1. Sub acute & chronic traumatic & inflammatory conditions of superficial joints & muscles
2. Indirect heating for peripheral vascular disease or infection (increasing blood flow to an area without heating it directly = *reflex heating*)
3. Promote tissue healing by increasing blood circulation & nutrients to the area

Contraindications

1. ACUTE INFLAMMATORY CONDITIONS
2. Fever
3. Malignancies & infections
4. Active bleeding may be promoted
5. Patients with cardiac insufficiency may not tolerate additional stress on heart
6. Adults >60, children <4: unreliable thermoregulation, may get fever
7. Patient with peripheral vascular disease

Precautions

1. Pre-existing edema that may be aggravated with heat
   a. Acute edema: painful, puffy, clearly circumscribed
   b. Chronic edema: not clearly circumscribed, pitting
2. Patient with sensory loss: monitor carefully!!
3. Confused patients: monitor carefully

Clinical Notes

1. Maximum penetration of heat reached after 3-4 min
2. Check on patient every 5 minutes (look at skin)
3. Slight pink hyperemia is OK, deep/cherry red color is ***too hot***
4. Adjust temperature with patient. positioning & adding/removing towels

Practice Builder Tip

Elderly patients like heat!!!

Most elderly patients enjoy a long treatment with hot packs prior to any osseous or soft tissue treatment, in addition it helps to relax the musculature making the clinicians job easier

Hot Packs (hydrocollator packs)

1. Temperature 60°-77 °C (140° F - 170° F)
2. Canvas filled with silica gel, heated in water; retain heat for ~½ h.; moist heat (studies show there is no physiological difference between moist & dry heat)
3. **Procedure:**
   a. Examine area to be treated (skin, temperature, sensation)
   b. Wrap pack in cover, add 4-6 layers of towels
   c. Instruct patient to ask for assistance if it feels too hot
   d. Treatment time is 15-30 min (~20 min)

Electrical Heating Pads

1. Usually used by patients as a home remedy
2. Treatment time: 10-20 min
3. Patients should receive the following instructions:
   a. Select a medium setting (not high)
   b. Do not to fall asleep with pad on
   c. Set an alarm to inform of treatment time completion

Paraffin Bath

1. Temperature 48°-54° C (118° F - 130° F)
2. Mixture of paraffin & mineral oil, ~6:1; oil lowers the melting point of the wax & helps to remove it from the skin more easily
3. Used to deliver heat to areas that are difficult to reach, esp. distal extremities
4. Indications: *non-acute arthritis, osteoarthritis, Dupuytren's contracture, Raynaud's*
5. Contraindications: open wounds, infections, burns, fungal infections
6. **Procedure:**
   a. Remove all jewelry, wash & examine area (skin, temp. sensation)
   b. Prepare two towels plus wax paper / plastic wrap
   c. Patient dips the part in paraffin 6-8x, letting wax harden in between each dip.
   d. Wrap the part in wax paper & toweling to retain heat
   e. Let patient sit for ~20 min
   f. Peel off the paraffin

Infrared

1. Heat lamp is placed 45-75 cm (18-30 in) from treatment area
2. Treatment time: 10 min- 1 hour, no towels are needed
3. Indications: use when superficial heat is indicated (provides dry heat)
4. Contraindications: patients with light sensitive skin conditions

Physiological effects

1. Local vasoconstriction
   a. Once cold stimulus is removed there will be an immediate vasodilation
2. ↓ Local inflammation, edema, hemorrhage, metabolism & oxygen demand
3. ↓ Nerve conduction velocity (pain relief/analgesia)
4. ↓ Heart & respiratory rate
5. Relief from muscle spasms due to decreased muscle tone
6. May decrease tissue healing (due to ↓ decreased cellular nutrition)
7. Prolonged exposure to cold will cause an increase metabolism in order to produce heat & maintain homeostasis
8. ***Hunting reaction:*** when cooling is extreme (less than 10°C/50°F for more than 10 min) the body will respond with regular bursts of vasodilation then vasoconstriction (this is the only instance where the application of cold can create edema)

Indications	Contraindications
1. Acute or chronic pain due to muscle spasm 2. Acute injury, inflammation or edema 3. Reduction of fever 4. New burns 5. Inhibit bleeding 6. Muscle spasticity	1. Patients with angina pectoris, cardiac dysfunctions or arterial insufficiency 2. Open wounds over 48-72h after injury (due to vasoconstriction) 3. Hypersensitivity to cold (Raynaud's, uticaria, MS) 4. Patients with areas of cutaneous anesthesia (loss of sensation)

Precautions

1. Do not use cold longer than 2-3 days after injury (may delay healing time)
2. Confused patients: monitor carefully
3. Generally elderly patients prefer heat to the application of cold

Clinical notes

1. Switch to a hot/cold contrast or heat as soon as clinically possible
2. General application time: 10-20 minutes on & one full hour off
3. Give patients **written** home instructions if they are to apply cold outside of the clinic
4. If a patient's duration of exposure to cold is too great tissue damage (frostbite) can occur

Cold Pack 0°-12°C (32°-55° F)

1. Cover the area to be treated with one layer of moist towel, & place cold pack over the towel
2. Cover other side of cold pack with several layers of dry towel
3. Treatment time: 10-20 minutes for pain, edema, bleeding
   a. During emergencies (eg. after a burn or severe fever) treatment time may be up to hours
4. Treatment goal: reduction of edema & inflammation
5. Typically applied immediately following acute musculoskeletal injuries

Practice Builder Tip

An excellent clinical method to lessen the shock of cold therapy: or apply a warm moist towel next to the skin & place the cold pack above it, this results in a much more pleasant & gradual cooling of the area to be treated

Ice Massage

1. Examine the area where ice massage is to be applied
2. *Contraindications:* do not use if there is a history of frostbite, or over an open wound, directly on bony prominence
3. Apply ice directly to skin & proceed to continually move ice over the treatment area
   a. Application of ice will create reactive hyperemia, increased pain threshold (decreased sensation), decreased nerve conduction
   b. Ice massage will not reduce edema (requires application of cold pack for at least 10 min)
4. Treatment time: 5 minutes or until the patient notes numbness over the treatment area (whichever comes first)
5. Patient sensation progression during ice massage treatment (C-BAN)
   a. C - cold
   b. B - burning
   c. A - aching
   d. N – numbness

Vapocoolant Spray (spray & stretch)

1. Vapocoolant spray (fluoromethane) is applied to the skin; cooling is accomplished through evaporation
2. Physiologic effects: temporary analgesia, reflexive muscle relaxation below the treatment area
3. Indications: myofascial trigger points (MFTP), spasms, ↓ROM, stretching
4. Contraindications: contact with mucous membranes, eyes & the patient history of frostbite
5. Application
   a. Locate MFTP, direction of muscle fibers, area of referred pain
   b. Start 45-60 cm (18-24 in.) from the skin & sweep area 3x in direction of muscle fibers
   c. Stretch the muscle
   d. Repeat procedure 3-4x
   e. Apply hot pack for 5-15 min when done
   f. Have patient move area through active range of motion

Contrast Hot / Cold

1. Used as vascular exercise that causes alternating vasodilation & vasoconstriction
2. Stimulates & promotes peripheral blood flow & soft tissue healing

Indications	Contraindications
• During transition between acute & subacute phases • Sinus & congestive headaches (apply to hands & feet) • Musculoskeletal conditions: OA, RA, sprains, strains • Chronic edema & impaired venous circulation	• All contraindications for heat & cold alone (although adverse effects are generally milder) • Small vessel disease (advanced diabetes) • Patients with insufficient thermoregulatory systems (very young or very old patients) • Decreased cutaneous sensation (local anesthesia)

3. Application
   a. Examine area to be treated
   b. Start treatment with heat & end treatment with cold
   c. Treatment time:
      i. Heat 4-6 minutes
      ii. Cold 1-2 minutes
      iii. Hot:cold ratio = 3:1 or 4:1 (4 minutes hot : 1 minute cold)
   d. Apply heat first; ~37°-45°C (~100°-112°F); not as hot as regular hot pack
   e. Apply cold; ~5°-12°C (~50°-65°F); not as cold as regular cold pack
   f. Duration of treatment: 20-30 minutes

Definition: use of water for the treatment of disease or discomfort

Physiologic Effects
- Thermal: ↑ temperature, metabolism, leukocytosis, perspiration
- Mechanical: massaging, stimulation, removal of debris from open wounds
- Buoyancy: relieve the stress of weight bearing
- Viscosity: use as resistance for exercise (water aerobics)
- Prolonged exposure to heated water causes: increased heart rate, mild increase in body temperature & hyperemia, slight rise in alkalinity of tissues, blood & urine

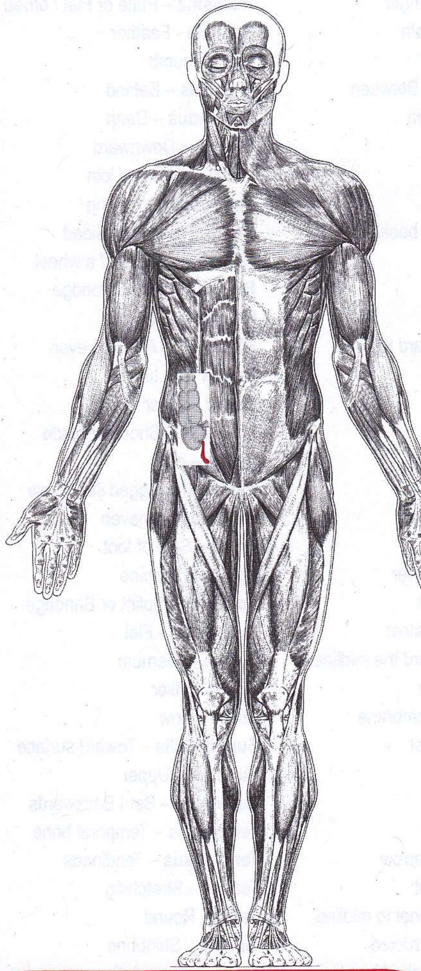
Indications	Contraindications
• Sub-acute & chronic traumatic conditions • Promote tissue healing by increasing blood circulation • RA, OA, fibromyalgia, general body muscle & joint soreness • Hypothermia	• Immersion in pregnancy • Young or elderly with inefficient thermoregulation • Heart & vascular conditions, hypertension • Diabetes • Rashes, dermatological conditions (contagious) • Dizziness, nausea, weakness

Whirlpools/Hubbard Tanks
- Whirlpools: most commonly used to treat the distal body segments of the upper & lower extremities
- Hubbard tank: used to treat one or both of the upper or lower extremities, plus the trunk
- Both units can provide pain relief & an increase in the range of motion
- 37°-40°C (99°-104°F) for full body immersion
- Consider cold for acute musculoskeletal complaints; Treatment time: 15-20 min

Sitz Baths
1. Sitz bath (also called a hip bath) is a bath in which only the hips & buttocks are soaked in water or saline solution (from the German verb "sitzen" meaning "to sit")
2. Precautions: some patients may become dizzy when standing up after sitting in hot water
3. Application:
   - Treatment time: 20 minutes (or until the water gets cool)
   - Bath filled with 8-10 cm (3-4 in) of water (usually nothing else should be added)
   - Warm sitz bath: pain of hemorrhoids, genital herpes, uterine cramps
   - Cool sitz bath (10 min) helps ease inflammation, constipation, vaginal discharge
   - Other conditions respond to a "contrast bath" of both hot & cold
     i. One tub of hot water ~43°C (110°F) & one tub of ice water
     ii. Patient sits in the hot water for 3-4 min & in the cold for 30-60 sec
     iii. Cycle repeated 3-5x, always ending with the cold water

Foot or Hand Baths: Treatment time: 20-30 min
- Hot foot bath for congested pelvis; hot hand bath for congestive headache, nosebleeds

Steam Tent/Sauna
- Steam tents use 100% humidity while a sauna is relatively dry, at about 20-25% average humidity (when water is used)
- Steam tents operates at a lower temperature than a sauna (~40°C)
- Specific indications: upper respiratory congestion, sinusitis
- Heat water, add white vinegar, peppermint, wintergreen or eucalyptus oil
- Have patient inhale through his nose
- Warn patient not to fall asleep in steam tent or sauna (potentially fatal)
- Also check in on the patient regularly & pay close attention to heart rate



Manual Medicine References

1. Yates, J. Physician's Guide to Therapeutic Massage, 3rd Edition. Curties-Overzet. 2004
2. Weerapong, Pornratshanee, Patria A. Hume, & Gregory S. Kolt. "Stretching: Mechanisms & Benefits for Sports Performance & Injury Prevention." Physical Therapy Reviews 9.4(2004): 189-206.
3. LaRoche, Dain, & Declan A. J. Connolly. "Effects of Stretching on Passive Muscle Tension & Response to Eccentric Exercise." American Journal of Sports Medicine 34.6(2006): 1000-1007.
4. Witvrouw, Erik, Nele Mahieu, Lieven Danneels, & Peter McNair. "Stretching & Injury Prevention An Obscure Relationship." Sports Medicine 34.7(2004): 443-449.
5. Andersen, J. C.. "Stretching Before & After Exercise: Effect on Muscle Soreness & Injury Risk." Journal of Athletic Training 40(2005): 218-220.
6. Nelson, Arnold G., Joke Kokkonen, & David A. Arnall. "Acute Muscle Stretching Inhibits Muscle Strength Endurance Performance." Journal Of Strength & Conditioning Research / National Strength & Conditioning Association 19.2(2005): 338-343.
7. Yessis, Michael . "Runners Need Active Stretching." AMAA Journal Winter 18.2(2006): 8-18.
8. Sharman, Melanie J. , Andrew G. Cresswell, & Stephan Riek. "Proprioceptive Neuromuscular Facilitation Stretching: Mechanisms & Clinical Implications." Sports Medicine 36.11(2006): 929-939.
9. Shrier, Ian. "When & Whom to Stretch?." Physician & Sportsmedicine 33.3(2005): 22-26.
10. Cheung, Karoline , Patria A. Hume, & Linda Maxwell. "Delayed Onset Muscle Soreness: Treatment Strategies & Performance Factors." Sports Medicine 33.2(2003): 145-164.

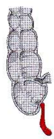
A-, An- Denotes an absence of
Abdomen – Belly
Abductus – Led away
Adductus – Brought toward
Ante – Before
Anconeal – Elbow
Arthro - Joint, Articulation
Bi – Twice or Two
Brachium – Arm
Brachia – Arm
Brevis – Brief or Short
Buccinator – Trumpeter
Cranium – Skull
Corrugator – Wrinkle
Caput – Head
Cervicalis – Neck
Carpi – Wrist
Cleido – Clavicle
Colli – Collar
Contra - Opposite
Costae – Rib
Costals – Rib
Coraco – Coracoid process
Delta – Triangular Shaped
Diaphragma – A partition
Digastric – Two bellies
Digitus – Finger or toe
Dorsum – Back
Epi – Above
Extensio – Extend
Exturnus – Outside
Fascia – Band
Femoralis – Femur
Fidus – To split
Flexus – Bent
Forma – Shape
Frons – Brow or Frontal bone
Gaster – Belly
Gemellus – Twin
Genu - Knee
Gloutos – Buttock
Gracilis – Slender
Glosso – Tongue
Hallex – Large toe
Hemat - Blood
Hyper - More, Excessive
Hypo - Less, Lower
Iliacus – Ilium
Ilium – Flank
Indices – Forefinger
Inferus – Beneath
Infra – Beneath
Inter – Internal, Between
Internus – Within
Iso - Equal
Karpos – Wrist
Kneme – Leg
Korax – Crow's beak
Labii – Lip
Lata – Broad
Latae – Wide
Lateralis – Toward the side
Latus – Broad
Levator – Lifter
Longus – Long
Lumbus – Loins
Magnum – Large
Major – Larger
Manus - Hand
Masseter – Chewer
Mastos – Breast
Maximus – Greatest
Medialis – Toward the midline
Medius – Middle
Membrana – Membrane
Minimum – Least
Minor – Smaller
Multus – Many
Myo - Muscle
Myelo - Bone marrow
Obliquus – Slant
Oblique – Diagonal to midline
Obturare – Obstructed
Occipitalis – Back of head
Oculus – Eye
Opponens – Opposing
Ortho - Straight, correct
Palpebrae – Eyelid
Palma – Hand
Peri – Around
Pecten – Comb
Pectoralis – Chest
Pedis - Foot
Perone – Pin
Pirum – Pear
Planta – Sole
Platysma – Plate or Flat / broad
Pennate - Feather
Poll – Thumb
Posterus – Behind
Profundus – Deep
Pronus – Downward
Psoa – Muscle of loin
Pterygodes – A Wing
Quadratus – Four Sided
Radialis – Spoke of a wheel
Ramus - Branch or bridge
Rectus – Straight
Rhombos – All sides even
Rotare – To turn
Sartor – Tailor
Scapulae – Shoulder blade
Semis – Half
Serratus – Jagged like a saw
Skalenos – Uneven
Solea – Sole of foot
Spinatus – Spine
Splenion – Splint or Bandage
Squamous - Flat
Steron – Sternum
Stylos - Pillar
Sub – Below
Superficialis – Toward surface
Superus – Upper
Supinatus – Bent Backwards
Temporalis – Temporal bone
Tendinosus – Tendinous
Tensor – Stretching
Teres – Round
Tibialis – Shinbone
Transversus – Lying across
Trapezoeides – Table like
Tri - Three
Uni - One
Ulna – Elbow
Valgum - Distal bone lateral
Varum - Distal bone medial
Vastus – Immense, Large
Vertex – Whirlwind
Viscero - Internal organs
Zygotos – To Connect

Appendix

Abductor Digiti Minimi Manus (ab-DUCK-tor DIH-jih-tee MIN-ih-mee MAN-us) - Lead away, digits, smallest & hand
Abductor Digiti Minimi Pedis (ab-DUCK-tor DIH-jih-tee MIN-ih-mee PEE-dis) - Lead away, digits, smallest & foot
Abductor Hallucis (ab-DUCK-tor HAL-uh-siss) - Lead away & big toe
Abductor Pollicis Brevis (ab-DUCK-tor POLL-is-iss BREV-us) - Lead away, thumb & short
Abductor Pollicis Longus (ab-DUCK-tor POLL-is-iss LONG-us) - Lead away, thumb & long
Adductor Brevis (ad-DUCK-tor BREV-us) - Toward midline & short
Adductor Hallucis (ad-DUCK-tor HAL-uh-siss) - Toward midline, big toe
Adductor Longus (ad-DUCK-tor LONG-us) - Toward midline & long
Adductor Magnus (ad-DUCK-tor MAG-nus) - Toward midline & great
Adductor Pollicis (ad-DUCK-tor POLL-is-iss) - Toward midline & thumb
Anconeus (an-KO-nee-us) - Elbow
Auricularis (aw-RIK-u-lar-iss) - Related to ear
Auricularis Posterior (aw-RIK-u-lar-iss) - Belonging to the ear
Auricularis Superior (aw-RIK-u-lar-iss) - Belonging to the ear
Biceps Brachii (BI-seps BRAY-kee-eye) - Two heads & of the arm
Biceps Femoris (BI-seps FEM-or-iss) - Two headed & thigh
Brachialis (BRAY-kee-AL-iss) - Arm
Brachioradialis (BRAY-kee-oh-RAY-dee-AL-iss) - Arm & radius
Buccinator (BUK-sin-ate-or) - Trumpeter
Bulbospongiosus (BUL-bo-SPON-jee-oh-sus) - Bulb & spongy
Coccygeus (kok-SIH-jee-us) - Coccyx
Coracobrachialis (KORE-a-koe-BRAY-kee-AL-iss) - Crow's beak of the arm
Corrugator Supercilii (kor-U-GA-tor su-per-SIL-ee-eye) - Wrinkle the eye brow
Cremaster (KREE-mast-er) - Suspender
Deep Transverse Perineals (pair-i-NEE-als) - Crossing & defecate
Deltoid (DEL-toyd) - Triangular
Depressor Anguli Oris (de-PRESS-or ANG-you-il OR-iss) - Press down the corner of the mouth
Depressor Labii Inferioris (de-PRESS-or LAY-bee-eye in-FEAR-ee-or-iss) - Press down the lip
Diaphragm (DYE-ah-fram) - Partition or wall
Digastric (dye-GAS-trik) - Two bellies
Extensor Carpi Radialis Brevis (ex-STEN-sur KAR-pee RAY-dee-AL-iss BREV-us) - Stretches, wrist, radial & short
Extensor Carpi Radialis Longus (ex-STEN-sur KAR-pee- RAY-dee-AL-iss LONG-us) - Stretches, wrist, radius & long
Extensor Carpi Ulnaris (ex-STEN-sur KAR-pee ul-NAR-iss) - Stretches, wrist, & ulna
Extensor Digiti Minimi (ex-STEN-sur DIH-jih-tee MIN-ih-mee) - Stretches, digits & smallest
Extensor Digitorum (ex-STEN-sur DIH-jih-TOR-um) - Stretches, digits
Extensor Digitorum Brevis (ex-STEN-sur DIH-jih-TOR-um BREV-us) - Stretch, digits & short
Extensor Digitorum Longus (ex-STEN-sur DIH-jih-TOR-um LONG-us) - Stretches, digits & long
Extensor Hallucis Brevis (ex-STEN-sur HAL-uh-iss BREV-us) - Stretches, big toe & short
Extensor Hallucis Longus (ex-STEN-sur HAL-uh-iss LONG-us) - Stretches, big toe & long
Extensor Indicis (ex-STEN-sur IN-dih-siss) - Stretches & index finger
Extensor Pollicis Brevis (ex-STEN-sur POLL-is-iss BREV-us) - Stretches, thumb, & short
Extensor Pollicis Longus (ex-STEN-sur POLL-is-iss LONG-us) - Stretches, thumb & long
External Abdominal Oblique (ab-DAHM-in-al oh-BLEEK) - Abdomen & slant
External Intercostals (inter-KOS-talz) - Between ribs
External Sphincter Ani (SFINK-tor AIN-eye) - Band & anus
Fibularis (Peroneus) Brevis (fib-you-LAR-iss BREV-us) - Related to fibula & shorter
Fibularis (Peroneus) Longus (fib-you-LAR-iss LONG-us) - Related to fibula & long
Fibularis (Peroneus) Tertius (fib-you-LAR-iss TER-she-us) - Related to fibula & third
Flexor Carpi Radialis (FLEXS-or KAR-pee- RAY-dee-AL-iss) - Bend, wrist & radius
Flexor Carpi Ulnaris (FLEXS-or KAR-pee- ul-NAR-iss) - Bend, wrist & ulna
Flexor Digiti Minimi Manus (FLEXS-or DIH-jih-tee MIN-ih-mee MAN-us) - Bend, digits, smallest & hand
Flexor Digiti Minimi Pedis (FLEKS-or DIH-jih-tee MIN-ih-mee PEE-dis) - Bend, digits, smallest & foot
Flexor Digitorum Brevis (FLEKS-or DIH-jih-TOR-um BREV-us) - Bend, digits & short
Flexor Digitorum Longus (FLEKS-or DIH-jih-TOR-um LONG-us) - Bend, digits & long
Flexor Digitorum Profundus (FLEKS-or DIH-jih-TOR-um pro-FUND-us) - Bend, digits & deep
Flexor Digitorum Superficialis (FLEKS-or DIH-jih-TOR-um SOO-per-fish-ee-AL-us) - Bend, digits & top of surface
Flexor Hallucis Brevis (FLEKS-or HAL-uh-siss BREV-us) - Bend, big toe & short

Flexor Hallucis Longus (FLEKS-or HAL-uh-siss LONG-us) - Bend, big toe & long
Flexor Pollicis Brevis (FLEXS-or POLL-is-iss BREV-us) - Bends, thumb & short
Flexor Pollicis Longus (FLEKS-or POLL-is-iss LONG-us) - Bend, thumb & long
Gastrocnemius (GAS-trok-NEEM-ee-us) - Belly & shin
Gemellus Inferior (JEM-ell-us) - Twin, above
Gemellus Superior (JEM-ell-us) - Twin, below
Geniohyoid (JEEN-ee-oh-HY-oyd) - Chin & 'U' shaped
Gluteus Maximus (GLUE-tee-us MAX-ih-mus) - Buttocks, biggest
Gluteus Medius (GLUE-tee-us MEED-ee-us) - Buttocks, midsized
Gluteus Minimus (GLUE-tee-us MIN-ih-mus) - Buttocks, smallest
Gracilis (gra-SIL-iss) - Slender
Iliacus (ILL-ee-AK-us) - Hip
Iliocostalis Cervicis (ILL-ee-oh-kos-TAL-iss SIR-vih-siss) - Connecting to ilium, ribs & neck
Iliocostalis Lumborum (ILL-ee-oh-kos-TAL-iss lum-BOR-um) - Connecting to ilium & lumbar
Iliocostalis Thoracis (ILL-ee-oh-kos-TAL-iss thor-AH-siss) - Connecting to ilium & chest
Infraspinatus (in-fra-spy-NAH-tus) - Below the spine of the scapula
Internal Abdominal Oblique (ab-DAHM-in-al oh-BLEEK) - Inside, abdomen & slant
Internal Intercostals (inter-KOS-talz) - Inside, between ribs
Interossei Dorsales Manus (INT-er-OSS-ee-y door-SAL-es MAN-us) - Between bones, back & hand
Interossei Dorsales Pedis (INT-er-OSS-ee-eye door-SAL-es PEE-dis) - Between bones, near back & foot
Interossei Palmar (INT-er-OSS-ee-eye pal-MAR) - Between bones & palm
Interossei Plantar (INT-er-OSS-ee-eye plan-TAR) - Between bones & sole of foot
Interspinalis cervicis (inter-spy-NAL-iss SIRivih-siss) - Between spine & neck
Interspinalis lumborum (inter-spy-NAL-iss lum-BOR-um) - Between spine & loins
Interspinalis Thoracis (inter-spy-NAL-iss thor-AH-siss) - Between spine & thorax
Intertransversarii Cervicis (INTER-TRANS-ver-SAIR-ee-ee SIRivih-siss) - Between transverse vertebrae & neck
Intertransversarii Lumborum (INTER-TRANS-ver-SAIR-ee-I lum-BOR-um) - Between transverse vertebrae & loins
Intertransversarii Thoracis (INTER-TRANS-ver-SAIR-ee-I thor-AH-siss) - Between transverse vertebrae & thorax
Ischiocavernosus (ISS-she-oh-KAV-em-oh-sus) – Hip & cave-like
Lateral Pterygoid (TER-ih-goyd) - Wing shaped
Latissimus Dorsi (la-TISS-ih-mus DOR-see) - Widest & back
Levator Anguli Oris (le-VAY-tor ANG-you-li OR-iss) - Raises the corner of the mouth
Levator Ani (le-VAY-tor AIN-eye) - Raise & anus
Levator Labii Superioris (le-VAY-tor LAY-bee-eye su-PEER-ee-OR-is) - Raise & lip
Levator Labii Superioris alaeque nasi (le-VAY-tor LAY-bee-eye su-PEER-ee-OR-is AL-ek-wee NAY-see) - Raise the lip & wing of the nose
Levator Scapulae (le-VAY-tor SKAP-you-lee) - Elevate the scapula
Longissimus Capitis (lon-GISS-ih-mus KAP-ih-tiss) - Longest & head
Longissimus Cervicis (lon-GISS-ih-mus SIR-vih-siss) - Longest & neck
Longissimus Thoracis (lon-GISS-ih-mus thor-AH-siss) - Longest & thorax
Longus Capitis (LONG-us KAP-ih-tiss) - Long & head
Longus Colli (LONG-us KOAL-ee) - Long & neck
Lumbricales Manus (LUM-brih-kal-es MAN-us) - Earthworm & hand
Lumbricales Pedis (LUM-brih-kal-es PEE-dis) - Earthworms & foot
Masseter (MAS-sit-er) - Chew
Medial Pterygoid (TER-ih-goyd) - Wing shaped
Mentalis (men-TAL-iss) - Chin
Multifidus (mul-tih-FYE-dus) - Many split parts
Mylohyoid (MY-lo-HY-oyd) - Molar & U shaped
Nasalis (nay-SAL-iss) - Nose
Obliquus Capitis Inferior (oh-BLI-kwus KAP-ih-tiss) - Slanting & head
Obliquus Capitis Superior (oh-BLI-kwus KAP-ih-tiss) - Slanting & head
Obturator Externus (OB-tor-ATE-or ex-STIR-nus) - One that covers an opening
Obturator Internus (OB-tor-ATE-or in-TER-nus) - One that covers an opening
Occipitofrontalis (ok-SIP-ih-toe-fron-TAL-iss) - Back of head & forehead
Omohyoid (OH-MO HY-royd) - Shoulder & U shaped
Opponens Digiti Minimi (oh-PONE-ens DIH-jih-tee MIN-ih-mee) - Opposing, digits & smallest
Opponens Pollicis (oh-PONE-ens POLLis-iss) - Opposing & thumb
Orbicularis Oculi (or-BIK-you-LAR-iss OK-you-li) - Small disk belonging to the eye
Orbicularis Oris (or-BIK-you-LAR-iss OR-iss) - Small disk belonging to the mouth
Palmaris Longus (pal-MAR-iss LONG-us) - Palm & long

Pectineus (PEK-tih-NEE-us) - Pubic bone
Pectoralis Major (PEK-tor-al-iss) - Chest, large
Pectoralis Minor (PEK-tor-al-iss) - Chest, small
Piriformis (PEER-ih-FOR-miss) - Pear shaped
Plantaris (plan-TAR-iss) - Sole of foot
Platysma (PLAH-tiz-ma) - Flat plate
Popliteus (pop-LIT-ee-us) - Hollow of knee
Procerus (pro-SEHR-us) - Tall
Pronator Quadratus (PRO-nay-tor quad-RATE-us) - Causes pronation & square shaped
Pronator Teres (PRO-nay-tor TER-eez) - Causes pronation & round/smooth
Psoas Major (SO-as) - Loins, large
Psoas Minor (SO-as) - Loins, small
Pyramidalis (peer-AM-id-al-iss) - Pyramid shaped
Quadratus Femoris (kwad-RATE-us FEM-or-iss) - Square shape & relates to the thigh
Quadratus Lumborum (kwad-RATE-us lum-BOR-um) - Square shaped & loins
Quadratus Plantae (kwad-RATE-us PLAN-tie) - Square shaped & sole of foot
Rectus Abdominis (REK-tus ab-DAHM-in-iss) - Straight & abdomen
Rectus Capitis Posterior Major (REK-tus KAP-ih-tiss) - Straight & head
Rectus Capitis Posterior Minor (REK-tus KAP-ih-tiss) - Straight & head
Rectus Femoris (REK-tus FEM-or-iss) - Straight & relates to the thigh
Rhomboideus Major (rom-BOYD-ee-us) - Diamond shaped, larger
Rhomboideus Minor (rom-BOYD-ee-us) - Diamond shaped, smaller
Risorius (rih-ZOR-ee-us) - Causes one to laugh
Rotatores (ro-TA-to-reez) - One that rotates
Sartorius (sar-TOR-ee-us) - Tailor
Scalenus Anterior (skay-LEE-nus) - Triangular with unequal sides, front
Scalenus Medius (skay-LEE-nus) - Triangular with unequal sides, middle
Scalenus Posterior (skay-LEE-nus) - Triangular with unequal sides
Semimembranosus (SEM-ee-MEM-bran-oh-sus) - Half membrane
Semispinalis Capitis (sem-ee-spy-NAL-us KAP-ih-tiss) - Half spine & head
Semispinalis Cervicis (sem-ee-spy-NAL-us SIR-vih-siss) - Half spine & neck
Semispinalis Thoracis (sem-ee-spy-NAL-us thor-AH-siss) - Half spine & chest
Semitendinosus (SEM-ee-TEN-din-oh-sus) - Half tendon
Serratus Anterior (suhr-RATE-us) - Saw like, front
Serratus Posterior Inferior (suhr-RATE-us) - Saw like, back, below
Serratus Posterior Superior (suhr-RATE-us) - Saw like, back, above
Soleus (SOL-ee-us) - Sole of foot
Spinalis Capitis (spy-NAL-iss KAP-ih-tiss) - Spine & head
Spinalis Cervicis (spy-NAL-iss SIR-vih-siss) - Spine & neck
Spinalis Thoracis (spy-NAL-iss thor-AH-siss) - Spine & chest
Splenius Capitis (SPLEEN-ee-us KAP-ih-tiss) - Bandage & head
Splenius Cervicis (SPLEEN-ee-us SIR-vih-siss) - Bandage & neck
Sternocleidomastoid (STER-no-CLY-do-mas-toyd) - Connecting to sternum, clavicle & mastoid process
Sternohyoid (STERN-oh-HY-oyd) - Chest & U shaped
Sternothyroid (STERN-oh-THY-royd) - Chest & shield shaped
Stylohyoid (STY-low-HY-oyd) - Pen & U shaped
Subclavius (sub-KLAVE-ee-us) - Below the clavicle
Subscapularis (sub-SKAP-you-LAR-iss) - Under the shoulder blade
Supinator (SOOP-in-ATE-or) - Causes supination
Supraspinatus (SOO-prah-spy-NAH-tus) - Above the spine of the scapula
Temporalis (TEMP-OR-al-ISS) - Temple of head
Tensor Fasciae Latae (TEN-sore FAH-she-a LAT-uh) - One that stretches & wide bandage
Teres Major (TER-eze) - Smooth & round & large
Teres Minor (TER-eze) - Smooth & round & small
Thyrohyoid (THY-ro-HY-oyd) - Shield shaped & U shaped
Tibialis Anterior (TIB-ee-AL-iss) - Related to shin bone & front
Tibialis Posterior (TIB-ee-AL-iss) - Related to shin bone & back
Transversus Abdominis (Trans-VER-sus ab-DAHM-in-iss) - Lying crosswise & abdomen
Transversus Thoracis (Trans-VER-sus thor-AH-siss) - Lying crosswise & chest
Trapezius (TRA-PEE-zee-us) - Figure with 4 unequal sides
Triceps Brachii (TRY-seps BRAY-kee-eye) - Three heads & of the arm
Vastus Intermedius (VAS-tus inter-MEE-dee-us) - Large, in the middle
Vastus Lateralis (VAS-tus LAT-ter-al-us) - Large, lateral
Vastus Medialis (VAS-tus MEE-dee-al-us) - Large, medial
Zygomaticus Major (ZYE-go-MAT-ik-us) - Connected to the connector & large
Zygomaticus Minor (ZYE-go-MAT-ik-us) - Connected to the connector & small



Soft Tissue Healing Stages

Phase 1: Acute Inflammatory Phase (Hyperemia or active congestion)

1. May last up to 5 days (depends on tissue affected & severity of injury)
2. Involves both cellular & humoral elements
   - Homeostasis - vasoconstriction, platelet aggregation, thromboplastin clot
   - Inflammation - vasodilation, phagocytosis
3. Cardinal Signs (SHARP)
   - Swelling
   - Heat
   - A loss of function
   - Redness; warmth
   - Pain (chemical irritation & nerve pressure)

Clinical Objectives: relieve pain; initiate vasoconstriction; disperse fluids; increase circulation; maintain normal muscle tone; maintain normal ROM

Phase 2: Repair Phase (Stage of consolidation &/or formation of fibrin coagulate)

1. May last from 48 hours up to 6 weeks
2. Involves synthesis & deposition of collagen
   - Granulation - fibroblasts lay bed of collagen, fill defect & produce new capillaries
   - Contraction - wound edges pull together to reduce defect
   - Epithelialization - cells travel about 3 cm from point of origin in all directions
3. Macrophages/phagocytes remove cell debris, erythrocytes, & fibrin clot
4. Collagen is not fully oriented in the direction of tensile strength
5. The quality of the collagen is inferior to the original

Clinical Objectives: prevent early adhesions; orient repair tissue along line of tension; relieve pain; maintain normal muscle tone; maintain normal range of motion

Phase 3: Remodeling (Stage of fibroblastic activity & fibrosis)

1. May last from 3 weeks to 12 months or more
2. Collagen is remodeled to increase the functional capabilities of the tendon or ligament to withstand the stresses imposed upon it
3. Tensile strength of ligaments is greatest in direction of the forces imposed on it
   - New collagen forms which increases tensile strength of wounds
   - Scar tissue is only 80 percent as strong as original tissue

Clinical Objectives: proper alignment of repair collagen (type III); increase elasticity of scar tissue; break down fibrotic adhesions; relieve muscle spasms; increase strength; increase range of motion; normalize joint & muscle activity

Factors which SLOW healing	Factors which IMPROVE healing
• Increased age	• Adequate nutrition
• Malnourishment	• Healthy aerobic fitness & activity level
• Smoking	• Vitamin A, C, E, calcitonin, water
• Corticosteroids/NSAIDs	• Joint mobilization & massage
• Diabetes	• Anabolic Steroids
• Anti-coagulants	• Electrotherapeutic stimulation (MENS, ultrasound)
• Prolonged immobilization/rigid fixation	• Injectable growth factors
• Excessive soft tissue gap (complete tear)	• Surgical gap closure
• Excessive motion or stress/repeat injury	• Laughter & positive mood

Skeletal muscles contain two main types of contractile (extrafusal) fibers, which differ in the mechanism they use to produce ATP. The amount of each type of fiber varies from muscle to muscle and from person to person, depending upon genetic predisposition and training.

Red ("slow-twitch") fibers: have more mitochondria, store oxygen in myoglobin, rely on aerobic metabolism, have a greater capillary to volume ratio and are associated with endurance; these produce ATP more slowly. Marathon runners tend to have more red fibers, generally through a combination of genetics and training.

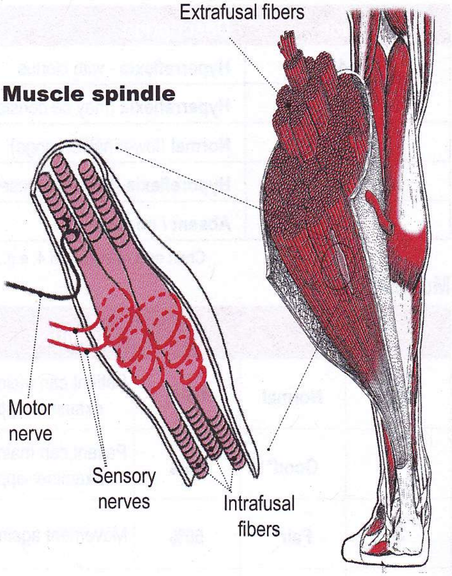
White ("fast-twitch") fibers: have fewer mitochondria, are capable of more powerful (but shorter) contractions, metabolize ATP more quickly, have a lower capillary to volume ratio, and are more likely to accumulate lactic acid. Weight lifters and sprinters tend to have more white fibers.

Muscle Spindles

In order to control movements, the nervous system must receive continuous sensory information from muscles and joints. Joints have proprioceptors (Pacini & Ruffini) that give information on movement & position. Muscles contain spindles which have sensory nerve receptors & *intrafusal muscle fibers*. Muscle spindles are sensitive to muscle length (stretch) because they are parallel with the contractile fibers. Specifically, they measure the amount of muscle stretch & the rate or speed of lengthening.

Muscle spindle fibers are walled off from the rest of the muscle by a collagen sheath. This sheath has a spindle or "fusiform" shape, hence the name "intrafusal." Intrafusal fibers are still able to contract and are wrapped with sensory receptors; *extrafusal muscle fibers* are far more numerous and are responsible for generating power.

As a muscle is lengthened, the spindle sends impulses to the CNS and brain letting it know the muscle is being stretched. To prevent overstretching or tearing of the muscle, there is a reflex stimulation that results in contraction of the muscle to help protect it from excessive lengthening. This reflex is known as a 'myotatic reflex,' 'stretch reflex,' 'muscle spindle reflex' or 'deep tendon reflex.'



Golgi Tendon Organ

Another type of proprioceptor is the Golgi tendon organ (GTO). Unlike muscle spindles (which are located in parallel with muscle fibers), the Golgi tendon organs are in series with muscle fibers, located in the tendons that attach muscle to bone. The sensory endings of the Golgi tendon organ are interwoven with collagen fibrils in the tendon. If the muscle contracts hard enough to be in danger of tearing the GTO is triggered to make the muscle 'let go' - acting like a breaker or safety switch .

Because changes in muscle tension will provide different degrees of pull on the tendon, the Golgi tendon organ provides information about muscle tension. Many think that a muscle stretch would also pull on the tendons and stimulate the Golgi tendon organ; however, most of the force of a stretch is absorbed by the muscle itself, so a muscle contraction is a much better stimulus for the Golgi tendon organ.

Both muscle spindles & Golgi tendon organs act to protect muscles. Muscle spindles do it by contraction, Golgi tendon organs do it by relaxation

Sprain (ligament) or Strain (muscle)

Grade	Clinical Findings
1	• Mild strain/sprain (~1%-10% fibers damaged) • Minimal disruption of adjacent fibers, minimal pain & guarding • Myofascial trigger points, some loss of range of motion • Fixation & decreased joint play in spine
2	• Moderate strain/sprain (~11%-50% fiber damage) • Partial tearing of the ligaments or muscle, hemorrhage, marked pain & splinting • Athletic injury, lifting, trauma, same clinical picture as above but more severe • Moderate decrease in AROM
3	• Severe strain/sprain (51%-100% fiber damage) • Rapid swelling, ecchymosis, marked dysfunction, decreased AROM • Palpate torn muscle (possibly) • Patient senses instability; firm painful endpoint on partial tear; empty end point on complete tear, muscle may "ball-up" - **refer for surgical evaluation**

Deep Tendon Reflexes

Grade	Description
4	**Hyperreflexia** - with clonus
3	**Hyperreflexia** (may be considered within normal limits)
2	**Normal** (lower half of range)
1	**Hyporeflexia** (trace response)
0	**Absent / no response**

Chart as a rating out of 4; e.g.; 4/4, 3/4, 2/4, 1/4, 0/4

Muscle Strength

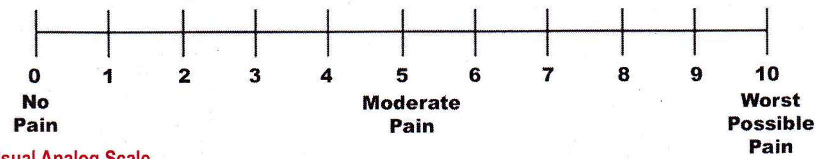
Grade		%	Definition
5	Normal	100%	Patient can maintain position against gravity & against *full* examiner-applied resistance
4	Good*	75%	Patient can maintain position against gravity & against *minimal* examiner-applied resistance
3	Fair*	50%	Movement against gravity but not against examiner's resistance
2	Poor*	25%	Movement possible, not against gravity
1	Trace	~5%	Evidence of slight contractility; *little* or *no joint motion*
0	Zero	0%	No palpable or perceivable evidence of contractility (*flaccid*)

ROM = range of motion - *Pain, muscle spasm or contracture may limit ROM.

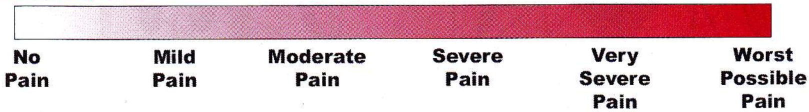
It is important to always use a well understood pain scale when working during any physical treatment (massage, stretching, muscle energy technique, myofascial release, etc). The pain scale should be established at the beginning of each treatment (even if you have treated this patient, they may not always remember). Keep in mind that telling the patient the pain scale doesn't mean that they will use it. Sometimes people feel like they should be able to deal with the pain, or they are too modest to tell you that they are in pain. Therefore, it is imperative that you not only use the pain scale and always check in with them but also watch their body language and facial expressions.

Subjective Pain Scale (verbal analog scale rating from 0-10)

Descriptive Pain Intensity Scale



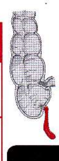
Visual Analog Scale



Subjective Tenderness/Pain Scale for use with Palpation/Massage

Grade	Description
1	"Feel the pressure of my hand"
2	"A little pressure, but feels comfortable"
3	"Pressure, but is a good pain"
4	"Considerable pressure that is painful but you can breathe through it"
5	**"STOP"** - the pressure is too much & no longer tollerable beyond

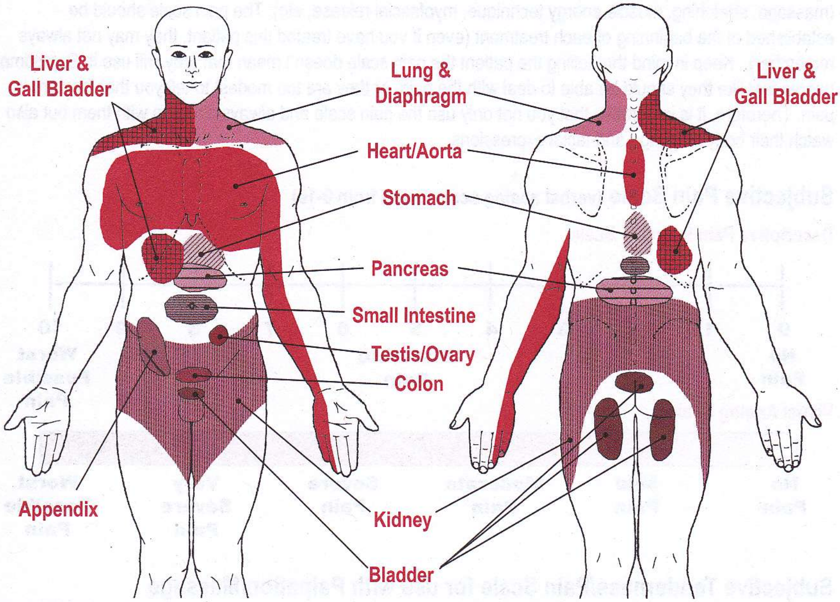
Objective Soft Tissue Tenderness/Pain Scale



Grade	Description
4	Withdrawal from non-noxious stimuli (eg. light palpation)
3	Tenderness with withdrawal (= jump sign)
2	Tenderness with grimace and/or flinch
1	Tenderness with no physical response
0	No tenderness

Consistent pressure needs to be applied by the clinician - pressure should be just enough to blanch fingernail capillary bed - chart as a rating out of 4; e.g.; 0/4, 3/4, 2/4, 1/4, 0/4

Visceral Pain Referral



Pain Parameters

Pain Patterns

- **Dermal Pain:** from superficial soft tissues, usually well localized (eg. cut in skin)
- **Sclerotomic Pain:** from deep somatic tissues typically deep, aching & somewhat localized (eg. muscle strain)
- **Visceral pain:** from internal organ capsule distension, deep achy, cramping pain that may be sharp at times, often poorly localized and may be immobilizing in more severe cases (eg. intestinal cramps, PMS)
- **Radicular Pain:** from nerve roots, often described as shooting, electrical and/or burning and in a dermatomal pattern (nerve root compression) - Nerve compression distal to the nerve roots may result in a peripheral nerve distribution pattern of pain
- **Phantom pain:** arises from direct changes in neural pathways & perception of the brain, felt by amputees in the area of the missing limb

Pain Duration

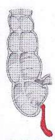
- **Acute Pain:** generally refers to pain associated with the acute stage of inflammation, however can be described as pain that is unbearable, usually first 48-72 hours.
- **Sub Acute:** pain after the acute stage but not yet chronic (> 72 hrs)
- **Chronic Pain:** refers to pain associated with the stages healing after the resolution of the inflammatory response. - is commonly used in reference to pain of long duration i.e. more than 3 months

Spinal Joint Motions

Motion Segment	Combined Flexion & Extension	Lateral Flexion (One side)	Rotation (One side)
C0-1	25°	5°	5°
C1-2	20°	5°	40°
C2-3	10°	10°	3°
C3-4	15°	11°	7°
C4-5	20°	11°	7°
C5-6	20°	8°	7°
C6-7	17°	7°	6°
C7-T1	9°	4°	2°
Cervical	**136°**	**61°**	**77°**
T1-2	4°	2.5°	9°
T2-3	4°	3°	8°
T3-4	4°	2.5°	8°
T4-5	4°	3°	8°
T5-6	4°	3°	8°
T6-7	5°	3°	7°
T7-8	6°	3°	7°
T8-9	6°	3°	6°
T9-10	6°	3°	4°
T10-11	9°	3.5°	2°
T11-12	12°	4.5°	2°
T12-L1	12°	4°	2°
Thoracic	**76°**	**37°**	**71°**
L1-2	12°	6°	2°
L2-3	14°	6°	2°
L3-4	16°	8°	2°
L4-5	16°	6°	2°
L5-S1	17°	3°	5°
Lumbar	**75°**	**29°**	**13°**
SI Joint	0°-10°	EX/IN	5°- 10°
MCP Joint		**PIP Joint**	
Flexion	90°	Flexion	70°
Extension	35°	Extension	5°
Abduction	20°	**DIP Joint**	
Adduction	20°	Flex/Ext	80°/20°

Peripheral Joint Motions

Joint	Motion Range
Shoulder	
Flexion	170°- 180°
Extension	50°- 60°
Abduction	175°- 185°
Adduction	25°- 35°
Internal rotation	80°- 90°
External rotation	80°- 90°
Horizontal Abd.	35°- 45°
Horizontal Add.	135°- 145°
Elbow Flexion	150°- 160°
Radioulnar	
Pronation	80°-90°
Supination	80°-90°
Wrist	
Flexion	70°- 80°
Extension	65°- 75°
Ulnar Flexion	30°- 40°
Radial Flexion	25°- 35°
Hip	
Flexion (SLR)	80°- 90°
Flex (bent knee)	120°- 130°
Extension	25°- 35°
Abduction	40°- 50°
Adduction	25°- 35°
Internal rotation	35°- 45°
External rotation	45°- 55°
Knee	
Flexion	140°- 150°
Ankle	
Plantarflexion	40°- 50°
Dorsiflexion	15°- 20°
Subtalar Joint	
Inversion	20°- 30°
Eversion	10°- 15°



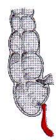
Adapted from: White, A & Panjabi, M. Clinical Biomechanics of the Spine. Lippincott, 1978. Hoppenfeld, S. Physical Examination of the Spine & Extremities. New York: Appleton-Century Crofts, 1976. Kapandji, LA. Physiology of the Joints. Vols. 1& 2, second edition. Churchhill Livingstone, 1970. Demeter et al. Disability Evaluation. American Medical Association, Mosby 2001.

By carefully evaluating AROM, PROM and muscle testing clinician's can easily distinguish the type of musculoskeletal pathology

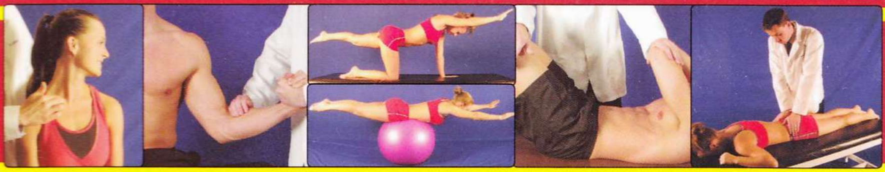
Condition	AROM	PROM	Muscle Test	Comments
Arthritis	↓ (painful)	↓ (painful)	WNL (painless)	• Early arthritis may have no loss of ROM or pain • Scour tests may show crepitus • AROM may show repeatable 'snapping' & 'popping'
Capsulitis	↓ (painful)	↓ (painful)	WNL (painless)	• Pain with any movement or stretching of joint capsule
Instability	↑ or WNL	↑	WNL	• End play may show an empty end feel • AROM & PROM may cause repeatable 'click or clunk'
Tendonitis	WNL (pain at end)	WNL (pain at end)	Pain	• There may be pain at end ROM both active & passive as the tendon is stressed or stretched
Tendon Rupture	None	WNL	Weak	• Complete tendon rupture will also be accompanied by "balling-up" of tissue
Ligament Sprain	↓ (painful)	↓ (painful)	WNL (painless)	• Stretching of the ligament, especially with over pressure, causes pain
Muscle Strain	↓ (painful)	WNL	Pain	• Stretching or tension of the muscle causes a painful loss of ROM
Intra-articular Loose Body ('joint mice')	↓ (painful)	↓ (painful)	WNL (painless)	• ROM assessment will result in sudden onset of pain, usually in one direction (typically extension), other movements are WNL

↑ = increase, ↓ = decrease, WNL = within normal limits

Ⓟ	pain
Ⓡ	right
Ⓛ	left
↑	increase
↓	decrease
→	causes / may indicate or suggest
(-)	negative
(+)	positive
<	less than
>	greater than
∅	none, no
AC	acromioclavicular joint
ADL	activity of daily living
AF	acetabulofemoral joint
AIS	adolescent idiopathic scoliosis
AP	anterior to posterior
AROM	active range of motion
AAROM	active assisted range of motion
AS	ankylosing spondylitis
ASIS	anterior superior iliac spine
BHK	bachelor of human kinetics
BP	blood pressure
C	clinical note
CA	cancer
CAT(C)	certified athletic therapist (Canada)
cc	chief complaint, chief concern
CI	contra-indication
CMC	carpometacarpal joint
C/S	cranial-sacral therapy
CSCS	certified strength & conditioning specialist
CT	computed tomography
CTS	carpal tunnel syndrome
DC	doctor of chiropractic
DDx	differential diagnosis
DIP	distal interphalangeal joint
DJD	degenerative joint disease
DMARD	disease-modifying anti-rheumatic drugs
DO	doctor of osteopathy
DOI	date of injury
DTR	deep tendon reflex
DVT	deep vein thrombosis
Dx	diagnosis
EMS	electrical muscle stimulation
ext	extension/external
flex	flexion
Fx	fracture
GERD	gastroesophageal reflux disease
GH	glenohumeral
HA	headache
HTN	hypertension
Hx	history
ICD	international classification of disease
IFC	interferential current
IUD	intrauterine device
IVD	intervertebral disc
IVF	intervertebral foramen
KMP	key movement pattern
Lats	latissimus dorsi
LBP	low back pain
LD	lymphatic drainage
LMNL	lower motor neuron lesion
MCP	metacarpophalangeal joint
MD	medical doctor
Meds	medications
MET	muscle energy technique
MFR	myofascial release
MFTP	myofascial trigger point
MLD	manual lymphatic drainage
MRI	magnetic resonance imaging
MVA	motor vehicle accident
NCV	nerve conduction velocity
ND	naturopathic doctor
NMJ	neuromuscular junction
NMS	neuromusculoskeletal
NSAID	non-steroidal anti-inflammatory medication
OA	osteoarthritis
OM	osseous manipulation
OT	occupational therapist
OTC	over the counter (medication)
P	palpation
PA	psoriatic arthritis / posterior to anterior
PAR	procedures, alternatives, risk
PDA	personal data assistant
PhD	doctor of philosophy
PFROM	pain free ROM
PIP	proximal interphalangeal joint
PRICE	protect, rest, ice, compress, elevate
PRN	patient return as needed
PROM	passive range of motion
PSIS	posterior superior iliac spine
pt	patient
PT	physical therapy (therapist)
PTR	patient to return
Px	prognosis
QL	quadratus lumborum
RA	rheumatoid arthritis
RMT	registered massage therapist
ROF	review of findings
ROM	range of motion
SC	sternoclavicular joint
SCM	sternocleidomastoid
SI	sacroiliac
SP	spinous process
STM	soft tissue manipulation
Sw. M	Swedish massage
TIA	transient ischemic attack
TOS	thoracic outlet syndrome
tp	tender point
TP, TvP	transverse process
Tx	treatment
UA	urinalysis
UMNL	upper motor neuron lesion
US	ultrasound
VAS	visual analog scale (0-10 pain rating)
VBI	vertebral basilar insufficiency
WNL	within normal limits
x	times



Appendix



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The *Clinical Consultant Muscle Manual* is designed as a quick reference guide for health care students, therapist, practitioners, doctors & instructors, and as a companion to the *Physical Assessment, Physical Medicine & Conditions Manual*.

This text bridges the gap between classroom education and practical clinical application. It contains current, easily accessible information on topics including musculoskeletal anatomy, anatomical variation, kinesiology, muscle testing, palpation, osteology, biomechanics, trigger point referral patterns, peripheral neurology, differential diagnosis, treatment techniques and much more.

In addition, this text is a valuable study guide for students, therapists and doctors preparing for board exams, oral practical exams, objective structured clinical examinations (OSCE) and many other licensure examinations.

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