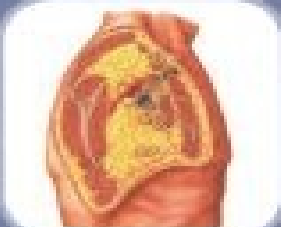
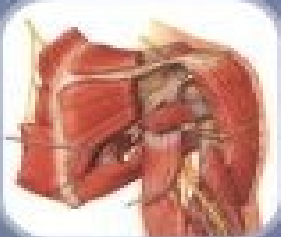


# Netter's Concise Atlas of Orthopaedic Anatomy

Jon C. Thompson, MD

Illustrated by  
Frank H. Netter, MD



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Jon C. Thompson, M.D.

Dedication

To my parents, for their unwavering faith in me.  
To my in-laws, for their continual support.  
To my daughters, who make it meaningful and fun.  
Especially to my wife Tiffany, who inspires me in every aspect of my life.

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## **PREFACE**

While working on the Orthopedic Service as a medical student I found myself in need of a quick, but comprehensive reference to help me get through my busy clinics and morning rounds. Having had success with pocket references, I searched the bookstores for something similar for orthopedics. Several were available, but none of them had the quick and easy-to-read format I wanted. As a result, I made pocket-sized note cards for my own use.

These cards started with basic anatomy such as diagrams of the Brachial plexus or fascial compartments of the leg. I then added cards for various conditions including notes on pertinent History and Physical Exam findings and treatment options. Many years later, when the growing stack of note cards was too big, unwieldy and tattered to use any longer, I converted the information into a more usable book format. That original hand-assembled book is the foundation of the atlas you are now holding.

*One well-drawn anatomic picture often explains far more than several pages of detailed text.*

This concise, quick-reference atlas covers the spine and extremities as well as diagnosis and treatment of orthopedic conditions with primary emphasis on illustrations that educate, oftentimes without the need for explanatory text. Text, when necessary, is presented in tabular form to allow for fast review of essential information.

The first nine chapters are divided anatomically. Because I believe quite strongly that the treatment of orthopedic problems is based in anatomy, I have incorporated an extensive review of the anatomy of both the spine and extremities. There are also subsections within each chapter to help in the clinical diagnosis and treatment of the orthopedic patient. For example, the History table offers help in developing a differential diagnosis while the Trauma and Disorder tables assist in the work-up and treatment options of many orthopedic conditions. Chapter Ten is a brief introduction to orthopedic-related basic science.

From the first time I opened Frank Netter's Atlas of Human Anatomy, I was impressed, and even inspired, by the clarity and the incredible amount of information contained within each of his illustrations. I consider his work incomparable. As the basis for this text is also deeply rooted in its extensive use of illustrations, you can imagine how pleased I was when Icon Learning Systems asked me to combine our efforts to create this new publication. I thank them for their diligence, expertise, and patience with this project. I would also like to thank Dr. Jim Heckman for lending his wisdom and years of publishing experience to this effort.

This book is the result of several years of accumulating and condensing Orthopedic-related data. Indeed, as it stands now, this is truly the reference I had searched for as a medical student, but was never able to find. The information inside these covers served to help me synthesize and retain a large body of information when I was a student and young physician. I trust its readers will be as equally well served.

**Jon C. Thompson, MD**



# Thompson: Netter's Concise Atlas of Orthopaedic Anatomy, 1st ed.

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## ABOUT THE AUTHOR

Jon Thompson, MD, received his medical degree from the Uniformed Services University of the Health Sciences in Bethesda, Maryland. He received his undergraduate degree from Dartmouth College. Dr. Thompson has worked as both an emergency room physician and a research assistant in the Extremity Trauma Branch of the Institute of Surgical Research. Currently, he is a resident in orthopedic surgery in the San Antonio Uniformed Services Health Education Consortium at Brooke Army Medical Center and is a corresponding member of the Department of Surgery at the Uniformed Services University of the Health Sciences.

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## INTRODUCTION

Netter's Concise Atlas of Orthopedic Anatomy is an easy-to-use reference and compact atlas of orthopedic anatomy for students and clinicians. Using images from both the Atlas of Human Anatomy and the 13-Volume Netter Collection of Medical Illustrations, this book brings together over 450 Netter images together for the first time in one book.

Tables are used to highlight the Netter images and offer key information on bones, joints, muscles and nerves, and surgical approaches. Clinical material is presented in a clear and straightforward manner with emphasis on trauma, minor procedures, history and physical exam, and disorders.

Users will appreciate the unique color-coding system that makes information look-up even easier. Key material is highlighted in black, red, and green to provide quick access to clinically relevant information.

BLACK for standard text

RED highlights key information that if missed could result in morbidity or mortality

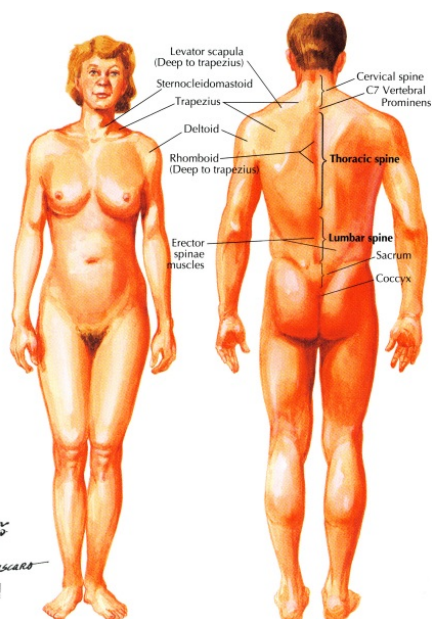
GREEN highlights "must know" clinical information.

## CHAPTER 1 - SPINE

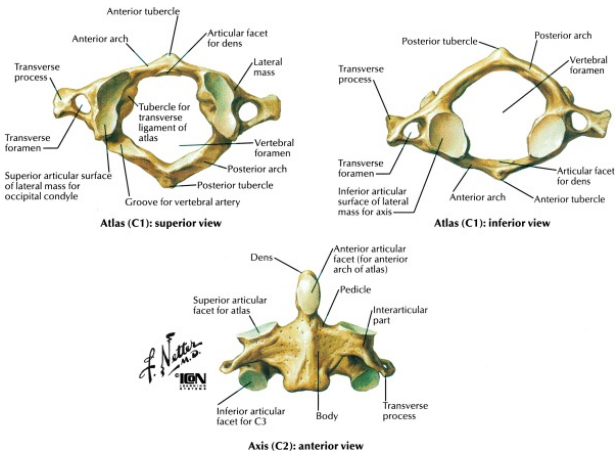
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- [PEDIATRIC DISORDERS](#)
- [SURGICAL APPROACHES](#)

## CHAPTER 1 – SPINE

### TOPOGRAPHIC ANATOMY



OSTEOLOGY



CHARACTERISTICS	OSSIFY	FUSE		COMMENT
C1 ATLAS				
<ul style="list-style-type: none"><li>• Ring shaped</li><li>• Two lateral masses with facets on them</li><li>• No body, no spinous process</li><li>• Post. Arch has a sulcus/groove</li></ul>	Anterior arch (1) Posterior arch (2) (1 for each half)		6 yrs Birth	<ul style="list-style-type: none"><li>• Superior facet articulates with occiput, anterior arch articulates with dens</li><li>• Fractures: most have 2 sites</li><li>• Vertebral artery runs in groove on posterior arch</li></ul>
C2 AXIS				
<ul style="list-style-type: none"><li>• Dens/odontoid articulates w/atlas at median atlantoaxial joint</li></ul>	Lower body (2) Dens (2) Arch (2)	Body Tip	6yrs Birth  12yrs Birth	<ul style="list-style-type: none"><li>• Odontoid has precarious vascular supply watershed area): increased incidence of nonunion with fractures</li><li>• Rotation in neck mostly occurs between C1 and C2</li></ul>
CERVICAL (C3-7)				
<ul style="list-style-type: none"><li>• Foramina in transverse process</li><li>• Facets: “semi-coronal” allow flex/extension, no rotation</li><li>• Narrow intervertebral foramina</li><li>• Bifid spinous processes</li></ul>	Primary Arch Body Secondary	7-8wk (fetal)  11-14 yr	1-2 yr 7-10 yr 18-25 yr	<ul style="list-style-type: none"><li>• Vertebral artery runs through transverse foramina</li><li>• Nerve roots at risk of compression</li><li>• No foramina in transverse process of C7</li><li>• C7 is <i>vertebral prominens</i>, nonbifid spinous process</li><li>• Klippel-Feil syndrome: congenital fusion of cervical vertebrae</li></ul>
THORACIC				
<ul style="list-style-type: none"><li>• Facets: form semi-circle: allow rotation</li></ul>		7-		<ul style="list-style-type: none"><li>• T1 spinous process is as</li></ul>

Costal facets (for ribs)

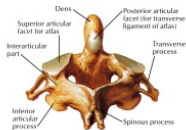
- T1-9: on the transverse process
- T10-12: on the pedicle

Primary Arch  
Body  
Secondary

8wk (fetal)  
1-2 yr  
7-10 yr  
18-25 yr  
11-14 yr

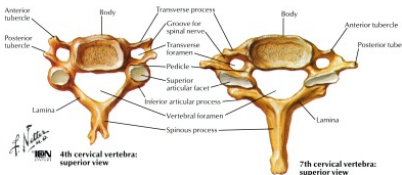
prominent as that of C7

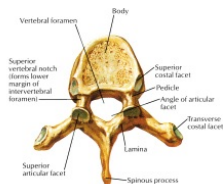
- Rotation of spine occurs within the thoracic region
- Spinous processes overlap the next lower vertebrae



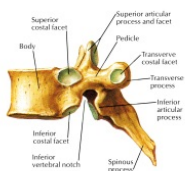
Axis (C2): posteroinferior view

#### First and Second Cervical Vertebrae at Birth

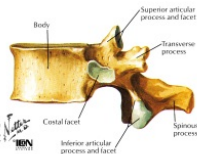




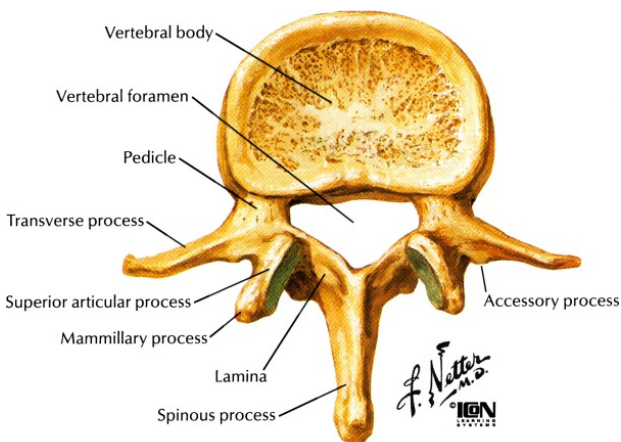
**T6 vertebra:  
superior view**



**T6 vertebra:  
lateral view**



**T12 vertebra:  
lateral view**



**L2 vertebra:  
superior view**

CHARACTERISTICS	OSSIFY	FUSE	COMMENT
LUMBAR			
<ul style="list-style-type: none"> <li>Large vertebral bodies</li> <li>Short lamina and pedicles</li> </ul>	Primary Arch	7-8	<ul style="list-style-type: none"> <li>L5 is the largest vertebra</li> </ul>

<ul style="list-style-type: none"> <li>• Mammillary and accessory processes</li> <li>• Facets: sagittal: good for flexion/extension, not rotation</li> <li>• No costal facets</li> </ul>	Body	7-8 wk (fetal)	7-10 yrs	vertebrae
	Secondary Mammillary process	11-14 yrs	18-25 yrs	<ul style="list-style-type: none"> <li>• Large vertebral bodies capable of bearing weight</li> <li>• L5 has a ligamentous attachment to the ilium</li> </ul>

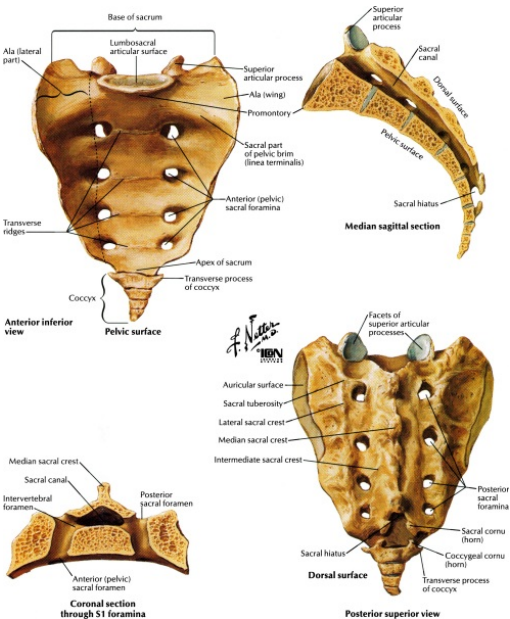
SACRAL				
<ul style="list-style-type: none"> <li>• 5 vertebrae are fused</li> <li>• 4 pairs of sacral foramina</li> <li>• Sacral canal opens to hiatus</li> </ul>	Body	8 wk (fetal)	2-8 yrs	<ul style="list-style-type: none"> <li>• Transmits weight of body to the pelvis</li> <li>• Nerves exit through the sacral foraminae</li> <li>• Segments fuse to each other at puberty</li> </ul>
	Arches		2-8 yrs	
	Cpsal elements	11-14 yrs	2-8 yrs	
	Secondary		20 yrs	

COCCYGEAL				
<ul style="list-style-type: none"> <li>• 4 vertebrae are fused</li> <li>• Lacks most of the features of typical vertebrae</li> </ul>	Primary Arch	7-8 wk (fetal)	1-2 yrs	<ul style="list-style-type: none"> <li>• Is attached to Gluteus maximus and coccygeal muscle</li> </ul>
	Body		7-10 yrs	

Ossification: Typically 3 primary (body each arch), 5 secondary ossification centers (spinous process, transverse process (2), upper and lower plates of the body (2))

The arches fuse dorsally; spina bifida occurs when it does not fuse

The arches unite with the bodies (6-10years old) in order: thoracic, cervical, lumbar, sacral (7 years). Neurocentral joint (fusion of arch and body) is in the body

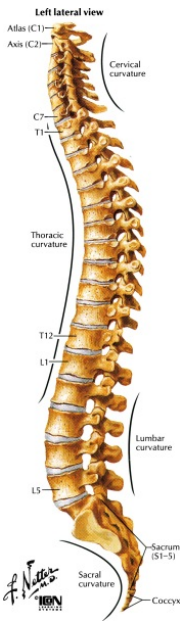


## GENERAL INFORMATION

- 33 Vertebrae: 7 cervical, 12 thoracic, 5 lumbar, 5 sacral (fused), 4 coccygeal

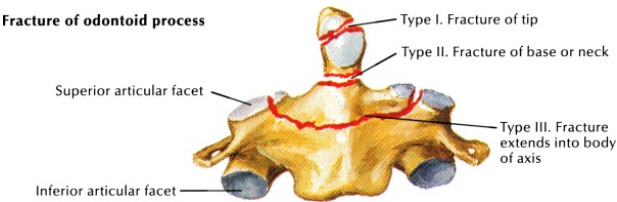


• Cancellous bone in cortical shell	
• Vertebral canal between body and lamina: houses the spinal cord.	
• Spinal Curves: Cervical: lordosis Thoracic: kyphosis (increase in Scheuermann's disease) Lumbar: lordosis	
• Vertebrae:	<ol style="list-style-type: none"> <li>1. Body (centrum): have articular cartilage on superior/inferior aspects; get larger inferiorly</li> <li>2. Arch (pedicles lamina) [no arch develops in spina bifida]</li> <li>3. Processes: spinous, transverse, costal, mamillary</li> <li>4. Foramina: vertebral, intervertebral, transverse</li> </ol>
• 3 Columns	
Anterior	ALL, anterior half of body annulus
Middle	PLL, posterior half of body annulus
Posterior	Ligamentum flavum, lamina, pedicles, facets
LEVEL	CORRESPONDING STRUCTURE
C2-3	Mandible
C3	Hyoid cartilage
C4-5	Thyroid cartilage
C6	Cricoid cartilage
C7	Vertebral prominens
T3	Spine of scapula
T7	Xiphoid, tip of scapula
T10	Umbilicus
L1	End of spinal cord
L3	Aorta bifurcation
L4	Iliac crest

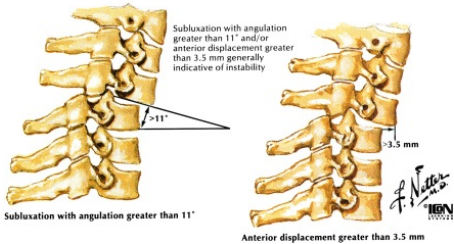
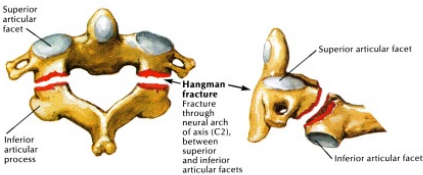
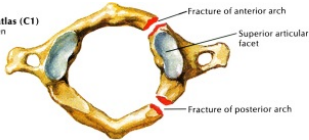


TRAUMA

Fracture of odontoid process



Jefferson fracture of atlas (C1)  
Each arch may be broken in one or more places



DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
CERVICAL FRACTURE			
<ul style="list-style-type: none"><li>High energy injury:<ul style="list-style-type: none"><li>Young - MVA, old - fall</li></ul></li><li>Axial compression (most common mech-anism) results in burst fracture</li></ul>	<p>HX: Trauma. Pain, worse with movement, +/- numbness weakness.</p> <p>PE: Tender to palpation, +/- "step off" neurologic or</p>	<p>Based on level location:</p> <p>C1-Jefferson fracture: both arches fractured</p> <p>C1-Lateral mass fracture</p> <p>C2-Hangman's (isthmus):</p>	<p>Immobilize all fractures, traction on unstable, lower c-spine fractures</p> <p>C1 and 2:</p> <p>Stable: Collar or halo</p> <p>Unstable: Halo for 3 months</p>

- Flexion/distraction injury results in dislocation
- Neurologic injury rare (esp. with C12 fracture) seen
- Often have associated injuries
- 9 criteria checklist predicts instability

myelopathic signs. Do rectal genital exams.

XR: AP, lateral, odontoid: note anterior soft tissue

CT: Shows canal (fragments may compress canal)

MR: Evaluate soft tissues

Levine classification

C2-  
Odontoid:  
Type 1,2,3

C3-7  
Fracture

Spinous process (Clay shoveler's fracture): C6, 7, T1 (C7 most common)

and/or fusion

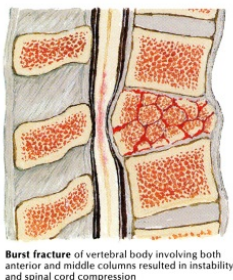
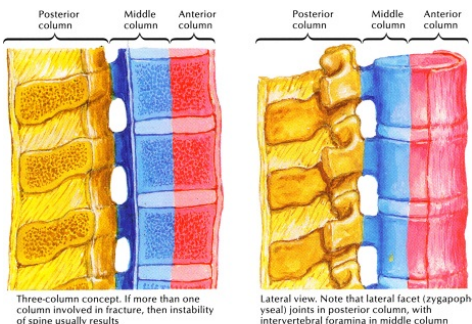
Odontoid type 2:  
ORIF (worse with traction)

C3-7:  
Stable:  
Collar or halo

Unstable:  
Fusion

Spinous process:  
Symptomatic

COMPLICATIONS: Neurologic injury (e.g., CN VIII with C1 fracture, etc.); Residual pain; Osteoarthritis; Nonunion (especially odontoid type 2 fracture)



Three-Column Concept of Spinal Stability

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
THORACOLUMBAR FRACTURE			
<ul style="list-style-type: none"> <li>Mechanism: MVA, fall</li> <li>1 column fracture: stable</li> <li>2 column fracture: unstable</li> <li>Anterior column (Wedge) fracture</li> <li>50% height loss is</li> </ul>	<p>HX: Trauma. Pain, +/- numbness weakness</p> <p>PE: Tender to palpation, +/- "step off" neurologic or myelopathic signs.</p> <p>Do rectal genital</p>	<p>Mechanism:</p> <p>Compression/wedge: anterior column</p> <p>Burst: fragments displace posteriorly; anterior middle columns (unstable)</p>	<p>Stable fractures: bed rest, orthosis (TLSO)</p> <p>Unstable (or with</p>

considered 2 columns

Compression/wedge fracture: (most common)

- Chance fracture: rare

Neurologic deficits rare, but seen with Burst fractures

exams

XR: AP, lateral T-L spine: body height, splaying pedicle

CT: Shows any canal impingement

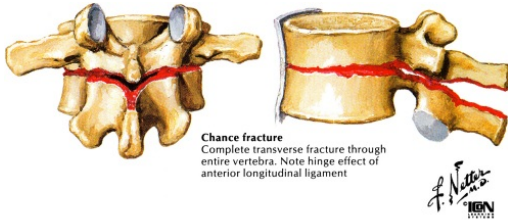
MR: Evaluate soft tissues

Flexion/distraction (Chance/seatbelt fracture): 2 (or 3) columns: posterior middle (anterior).

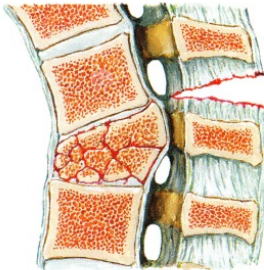
Fracture/dislocation: all 3 columns involved.

neurologic symptoms/compressed canal): Spinal canal decompression and spinal fusion

COMPLICATIONS: Neurologic injury; Osteoarthritis; Associated injuries.



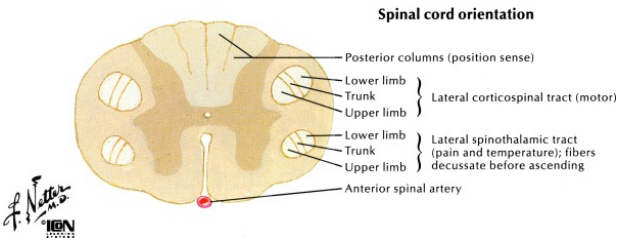
**Chance fracture**  
Complete transverse fracture through entire vertebra. Note hinge effect of anterior longitudinal ligament



**Fracture/Dislocation:** All 3 columns moved

Stable Fracture

SPINAL CORD TRAUMA



Cervical Spine Injury: Incomplete Spinal Syndromes

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
<ul style="list-style-type: none"> <li>Young males most common</li> <li>Complete cord injury: no function AND</li> <li>bulbocavernosus reflex has returned. (spinal shock over)</li> <li>Incomplete cord injury: 4 types</li> <li>Anterior cord: #2.</li> <li>Flexion injury; worst prognosis</li> <li>Central cord: most common. Hyperextension injury, seen in elderly (who fall), associated with spondylosis</li> <li>Posterior: very rare (may not exist)</li> <li>Brown-Sequard: rare, best prognosis</li> </ul>	<p>HX: Trauma. Symptoms depend on injury/lesion.</p> <p>PE: Depends on injury</p> <p>Complete: no motor or sensory function below injury level.</p> <p>Anterior: LEUE paralysis, pain temperature sensory loss, vibratory proprioception intact.</p> <p>Central: Weakness UELE, sacral sensation spared.</p> <p>Posterior: Loss of vibratory sensation and proprioception.</p> <p>B-S: <i>Ipsilateral</i> motor, vibratory, proprioception loss; <i>contralateral</i> pain temperature loss.</p> <p>XR: C-spine series, +/- TL spine</p> <p>CT: if evidence of fracture</p>	<p>Complete cord injury: cord severed, no function (spinal shock must be resolved to diagnose it)</p> <p>Incomplete:</p> <p>Anterior: Spinothalamic corticospinal tracts out, posterior columns spared.</p> <p>Central: gray matter injury</p> <p>Posterior: posterior columns disrupted</p> <p>Brown-Séquard (lateral): hemi-section of cord</p>	<p>Treat associated injuries: lifethreatening first.</p> <p>Mannitol and early IV steroids may improve neurologic function</p> <p>Immobilization is the key to treatment</p> <p>Stable injuries: collar, brace</p> <p>Unstable injuries: Halo vest or internal fixation</p>

COMP: Neurogenic shock; Autonomic dysreflexia (requires urinary catheterization and/or fecal disimpaction); Neurologic sequelae

Spinal Shock: Physiologic cord injury/dysfunction (often from compression or swelling) including paralysis areflexia. Return of bulbocavernosus reflex (arc reflexes) marks the end of spinal shock.

Neurogenic Shock: *Hypotension with bradycardia*. Cord injury results in decreased sympathetic release (unopposed vagal tone)

**Central cord syndrome**  
Central cord hemorrhage and edema. Parts of 3 main tracts involved on both sides. Upper limbs more affected than lower limbs



**Anterior spinal artery syndrome**  
Artery damaged by bone or cartilage spicules (shaded area affected). Bilateral loss of motor function and pain sensation below injured segment; position sense preserved

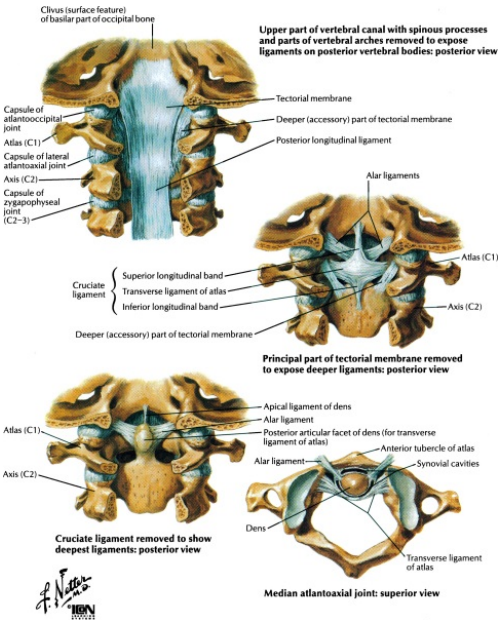


**Brown-Séquard's syndrome**  
One side of cord affected. Loss of motor function and position sense on same side, and of pain sensation on opposite side



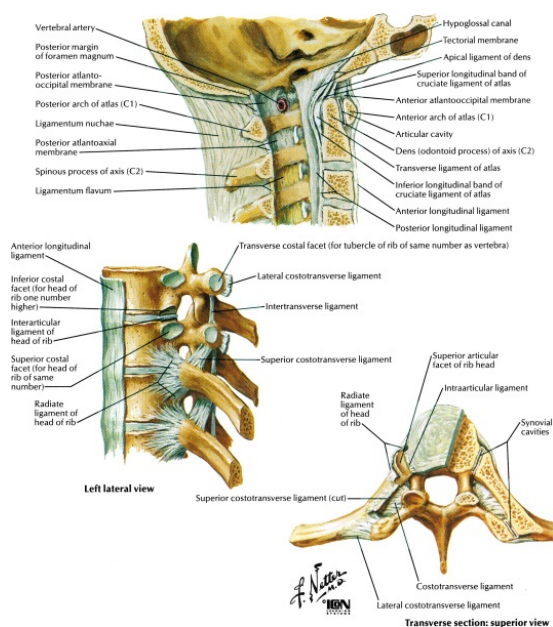
**Posterior column syndrome (uncommon)**  
Position sense lost below lesion; motor function and pain sensation preserved

JOINTS



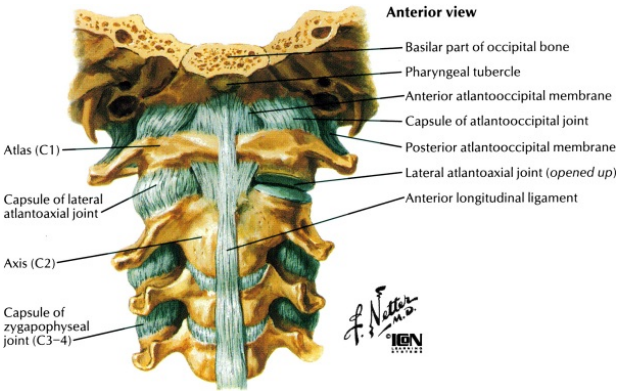
LIGAMENT	ATTACHMENT	COMMENT
ATLANTOOCIPITAL (Ellipsoid)		
Primarily involved in flexion, extension, lateral bending movements		
Tectorial membrane Anterior/Posterior capsule	Axis body to occiput around facets	Extension of the PLL Joint stabilized by attachment to dens; known to be weak in Down's Syndrome
MEDIAN ATLANTOAXIAL C1-2 (Plane and Pivot)		
Primarily involved in rotation; dependent on ligaments for stability; instability in Down's syndrome		
Transverse Apical Alar Superior Longitudinal Inferior Longitudinal	Lateral mass-dens-lateral mass Dens to occiput Dens to occiput condyles Dens to basilar occiput Dens to axis body	Strongest ligament: holds dens in place Part of cruciate ligament Prevent excessive head rotation With transverse apical forms cruciate ligament



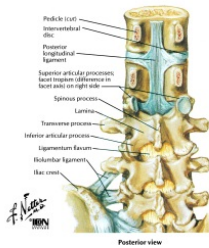
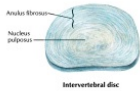
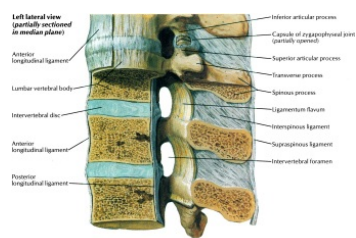


LIGAMENT	ATTACHMENT	COMMENT
<b>ZYGAPOPHYSEAL (Facet Plane)</b>		
Has articular discs: this joint allows the most mobility in the spine		
Capsule	Around facets	Changes orientation at different vertebral levels Orientation dictates plane of motion; C5-6 most mobile (#1 degeneration site) L4-5 most flexion
<b>INTERVERTEBRAL</b>		
Intervertebral disc ALL PLL	Inferior superior aspect of bodies Anterior: body to body Posterior: body to body	Strongest attachments of bodies Thicker than PLL Thinner, disc herniation usually posterolateral.
<b>COSTOVERTEBRAL (Luschka)</b>		
Capsule Intraarticular Radiate	Surrounds rib head joint Head of rib to disc Anterior head to both bodies	Holds head to vertebrae Reinforces joint anteriorly

LIGAMENTS



LIGAMENT	LOCATION	COMMENT
Anterior Longitudinal [ALL]	Anterior surface of vertebral bodies	
Posterior Longitudinal [PLL]	Posterior surface of bodies (connects discs)	Strong; thicker in center of body
Intertransverse	Between transverse processes	Weaker thinner [herniation occurs laterally or posterolaterally]
Apophyseal joint capsule	Around facet joint	Weak, adds little support
Ligamentum Flavum	Connects anterior surfaces of laminae	Weak, adds little support
Ligamentum Nuchae	C7 to occipital protuberance	Strong; constantly in tension
Supraspinous	Along dorsal spinous processes to C7	Extension of supraspinous ligament
Interspinous	Between spinous processes	Unknown contribution to stability
Tectoral membrane	Posterior aspect of bodies dens to clivus	Unknown contribution to stability
Transverse ligament	Lateral mass to dens to lateral mass	Part of cruciate ligament, major stabilizer
Alar	Dens to occiput tubercles	Resists excessive rotation
Iliolumbar	L5 transverse process to ilium	Avulsion fracture can occur in trauma
INTERVERTEBRAL DISCS [made of fibrocartilage]		
Annulus fibrosis	Outside, type I collagen, connects to vertebral hyaline cartilage, buffers compression	
Nucleus pulposus	Inside, type II collagen, high water content until old age, derived from notochord, can protrude/herniate through annulus, is avascular	



HISTORY

Lower back pain

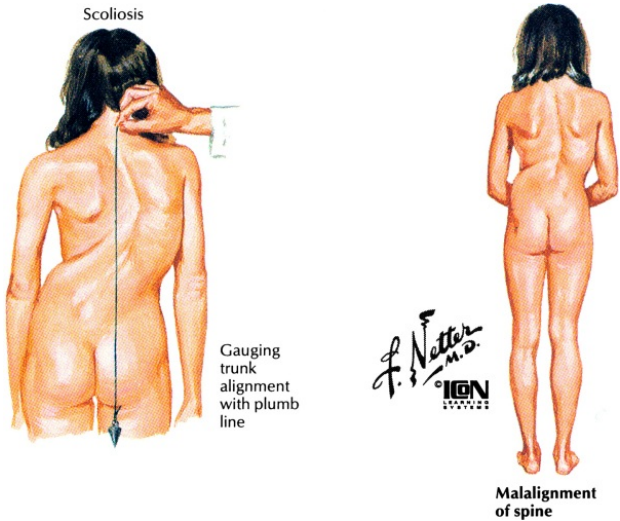


Head-on collision with stationary object or oncoming vehicle may, if seat belts not used, drive forehead against windshield. This sharply hyperextends neck, resulting in dislocation with or without fracture of cervical vertebrae

QUESTION	ANSWER	CLINICAL APPLICATION
1. AGE	Young Middle age Elderly	Disc injuries, spondylolisthesis Sprain/strain, herniated disc, degenerative disc disease Spinal stenosis, herniated disc, degenerative disc disease, arthritis
2. PAIN		
a. Character	Radiating (shooting) Diffuse, dull, non-radiating	Radiculopathy (Herniated disc, spondylosis) Cervical or lumbar strain (soft tissue injury)
b. Location	Unilateral vs. bilateral Neck Arms (+/- radiating) Lower back Legs (+/- radiation)	Unilateral: herniated disc; Bilateral: systemic or metabolic disease;space occupying lesion Cervical spondylosis, neck sprain or muscle strain Cervical spondylosis (+/- myelopathy), herniated disc Degenerative Disc Disease, back sprain or muscle strain, spondylolisthesis, tumor Herniated disc, spinal stenosis
c. Occurrence	Night pain With activity	Tumor Usually mechanical etiology
d. Alleviating	Arms elevated Sit down	Herniated cervical disc Spinal stenosis (stenosis relieved)
e. Exacerbating	Back extension	Spinal stenosis (e.g. going down stairs)
3. TRAUMA	MVA (seatbelt?)	Cervical strain (whiplash), cervical fractures, ligamentous injury
4. ACTIVITY	Sports (stretching injury)	"Burners/stingers" (especially in football)
5. NEUROLOGIC SYMPTOMS	Pain, numbness, tingling Spasticity, clumsiness Bowel or bladder symptoms	Radiculopathy, neuropathy Myelopathy Cauda equina syndrome
6. SYSTEMIC	Excess weight	

6. SYSTEMIC COMPLAINTS	Fever, weight loss	Infection, tumor
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PHYSICAL EXAM



EXAM		TECHNIQUE	CLINICAL APPLICATION
INSPECTION			
Gait		Leaning forward Wide-based	Spinal stenosis Myelopathy
Alignment		Malalignment	Dislocation, scoliosis, lordosis, kyphosis
Posture		Head tilted Pelvis tilted	Dislocation, spasm, spondylosis, torticollis Loss of lordosis: spasm
Skin		Disrobe patient	Cafe-au-lait spots, growths: possibly neurofibromatosis Port wine spots, soft masses: possibly spina bifida
PALPATION			
Bony structures		Spinous processes	Focal/point tenderness: fracture. Step-off: dislocation/spondylolisthesis
Soft tissues		Cervical facet joints Coccyx-via rectal exam Paraspinal muscles Supraclavicular fossa Skin	Tenderness: osteoarthritis, dislocation Tenderness: fracture or contusion Diffuse tenderness indicates sprain/muscle strain. Trigger point: spasm Swelling suggests clavicle fracture Fatty masses: possibly spina bifida
RANGE OF MOTION			
Flexion/extension:	Cervical	Chin to chest/occiput back	Normal: Flexion: chin within 3-4cm of chest; Extension 70 degrees
	Lumbar	Touch toes with straight legs	Normal: 45-60 degrees in flexion, 20-30 degrees in extension
Lateral flexion:	Cervical	Ear to shoulder	Normal: 30-40 degrees in each direction
	Lumbar	Bend to each side	Normal: 10-20 degrees in each direction
		Stabilize	

Rotation:	Cervical Lumbar	shoulders: rotate Stabilize hip: rotate	Normal: 75 degrees each direction Normal: 5-15 degrees in each direction
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NEUROVASCULAR

A complete neurologic examination should be performed

Sensory

CERVICAL

Supraclavicular (C2-3)	Anterior neck	Deficit indicates corresponding nerve/root lesion
Axillary nerve (C5)	clavicle area	Deficit indicates corresponding nerve/root lesion
Musculocutaneous nerve (C6)	Lateral shoulder	Deficit indicates corresponding nerve/root lesion
Radial Nerve (C6)	Lateral forearm	Deficit indicates corresponding nerve/root lesion
Median Nerve (C7)	Dorsal thumb web space	Deficit indicates corresponding nerve/root lesion
Ulnar Nerve (C8)	Radial border mid finger	Deficit indicates corresponding nerve/root lesion
Medial Cutaneous nerve forearm(T1)	Ulnar border small finger	Deficit indicates corresponding nerve/root lesion
	Medial forearm	



Extend knee, hip relaxed



*F. Netter M.D.*

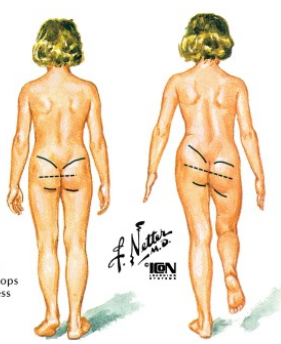
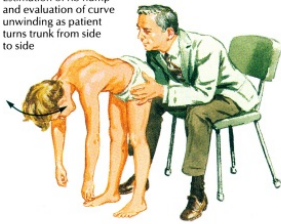
Straight Leg Test

EXAM	TECHNIQUE	CLINICAL APPLICATION
<b>LUMBAR</b>		
Femoral/Saphenous nerve (L4) Superficial/Deep Peroneal Nerve (L5) Tibial/sural nerve (S1) Sacral nerves (S 2, 3, 4)	Medial leg ankle Dorsal foot 1 <sup>st</sup> -2 <sup>nd</sup> toe web space Lateral foot Perianal sensation	Deficit indicates corresponding nerve/root lesion Deficit indicates corresponding nerve/root lesion Deficit indicates corresponding nerve/root lesion Deficit indicates corresponding nerve/root lesion Deficit indicates corresponding nerve/root lesion
<b>Motor</b>		
<b>CERVICAL</b>		
Spinal accessory (CN11) Axillary nerve (C5) Musculocutaneous nerve (C5-6) Radial nerve (PIN) (C7) Median nerve (C8) Ulnar nerve (Deep branch) (T1)	Neck flexion rotation Resisted shoulder abduction Resisted elbow flexion Finger extension Thumb flexion, opposition, abduction Finger cross (abduct/adduct)	Weakness = Sternocleidomastoid or nerve/root lesion Weakness = Deltoid or nerve/root lesion Weakness = Brachialis or nerve/root lesion Weakness = EDC, EIP, EDM or nerve/root lesion Weakness = FPL/thenar muscles or corresponding nerve/root lesion Weakness = DIO/VIO or nerve/root lesion
<b>LUMBAR</b>		
Deep Peroneal nerve (L4) Deep Peroneal nerve (L5) Superficial Peroneal nerve (L5)	Foot inversion dorsiflexion Great toe extension Foot eversion	Weakness = Tibialis anterior or nerve/root lesion Weakness = Extensor hallucis longus or nerve/root lesion Weakness = Peroneus longus/brevis or

Superficial peroneal (S1) Tibial nerve (S1)	Great toe flexion	nerve/root lesion Weakness = Flexor hallucis longus or nerve/root lesion
<b>Reflexes</b>		
C5 C6 C7 L4 S1 S1, 2, 3	Biceps Brachioradialis Triceps Patellar Achilles reflex Bulbocavernosus	Hypoactive/absence indicates C5 radiculopathy Hypoactive/absence indicates C6 radiculopathy Hypoactive/absence indicates C7 radiculopathy Hypoactive/absence indicates L4 radiculopathy Hypoactive/absence indicates S1 radiculopathy Finger in rectum, squeeze/pull penis (Foley), anal sphincter contracts
UMN	Babinski/clonus	Upgoing toe is consistent with upper motor neuron lesion
<b>Pulses</b>		
Upper extremity Lower extremity	Brachial, radial, ulnar Femoral, popliteal, dorsalis pedis, posterior tibial	Diminished/absent = vascular injury or compromise Diminished/absent = vascular injury or compromise

Forward Bending Test

Estimation of rib hump and evaluation of curve unwinding as patient turns trunk from side to side



**Trendelenburg test**  
With weight on affected side normal right side drops down indicating weakness of left hip.

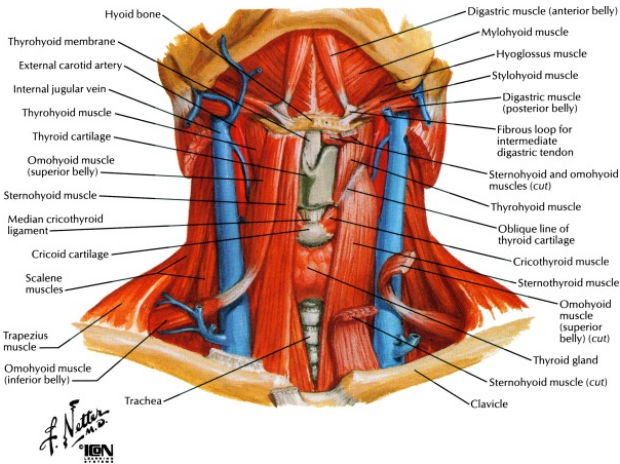
Forward Bending Test

EXAM	TECHNIQUE	CLINICAL APPLICATION
SPECIAL TESTS		
<u>CERVICAL</u>		
Spurling	Axial load, then laterally flex rotate neck	Radiating pain indicates nerve root compression
Distraction	Upward distracting force	Relief of symptoms indicates foraminal compression of nerve root
<u>LUMBAR</u>		
Straight leg	Flex hip to pain, dorsiflex foot	Symptoms reproduced (pain below knee) indicative of radicular etiology
Straight leg 90/90	Supine: flex hip knee 90°, extend knee	20° of flexion = tight hamstrings: source of pain
Prone	Raise leg, flex knee,	Radicular pain with popliteal pressure indicates sciatic



Dowsing	apply popliteal pressure	nerve etiology
Sitting root (flip sign)	Sit: distract patient, passively extend knee	Patient with sciatic pain will arch or flip backward on knee extension
Kernig	Supine: flex neck	Pain in or radiating to legs indicates meningeal irritation or infection
Brudzinski	Supine: flex neck, flex hip	Pain reduction with knee flexion indicates meningeal irritation.
Forward Bending	Standing, bend at waist	Asymmetry of back (scapula/ribs) is indicative of scoliosis
Trendelenburg	Stand on one leg	Drooping pelvis on elevated leg side: gluteus medius weakness
Hoover	Supine: hands under heels, patient then raises one leg	Pressure should be felt under opposite heel (not being raised). No pressure indicates lack of effort, not true weakness
Waddell signs	Presence indicates non-organic pathology: <b>1)</b> exaggerated response or overreaction, <b>2)</b> pain to light touch, <b>3)</b> non-anatomic pain localization, <b>4)</b> negative flip sign with positive straight leg test.	

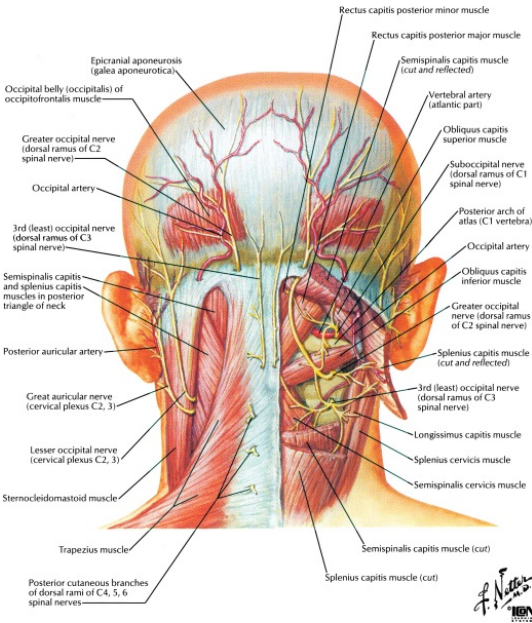
**MUSCLES: ANTERIOR NECK**



MUSCLE	ORIGIN	INSERTION	ACTION	NERVE
ANTERIOR NECK				
Platysma	Fascia: Deltoid/pectoralis major	Mandible; skin	Depress jaw	CN 7
SUPRAHYOID MUSCLES				
Digastric	Anterior: Mandible Posterior: Mastoid notch	Hyoid body	Elevate hyoid, depress mandible	Anterior: Mylohyoid (CN 5) Posterior: Facial (CN 7)
Mylohyoid	Mandible	Raphe on hyoid	Same as above	Mylohyoid (CN 5)
Stylohyoid	Styloid process	Body of hyoid	Elevate hyoid	Facial nerve (CN 7)
Geniohyoid	Genial tubercle of mandible	Body of hyoid	Elevate hyoid	C1 Via CN 12
INFRAHYOID MUSCLES [STRAP MUSCLES INCLUDES THE SCM]				
SUPERFICIAL				
Sternohyoid	Manubrium clavicle	Body of hyoid	Depress hyoid	Ansa cervicalis (C1-3)
Omohyoid	Suprascapular notch	Body of hyoid	Depress hyoid	Ansa cervicalis (C1-3)
DEEP				
Thyrohyoid	Thyroid cartilage	Greater horn of hyoid	Depress/retract hyoid/larynx	C1 via CN 12
Sternothyroid	Manubrium	Thyroid cartilage	Depress/retract hyoid/larynx	Ansa cervicalis (C1-3)
Sternocleidomastoid	Manubrium clavicle	Mastoid process	Turn head opposite side	CN 11

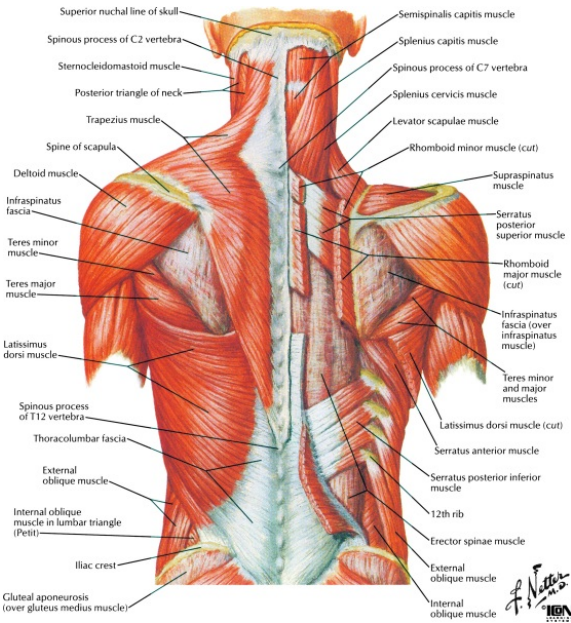


MUSCLES: POSTERIOR NECK



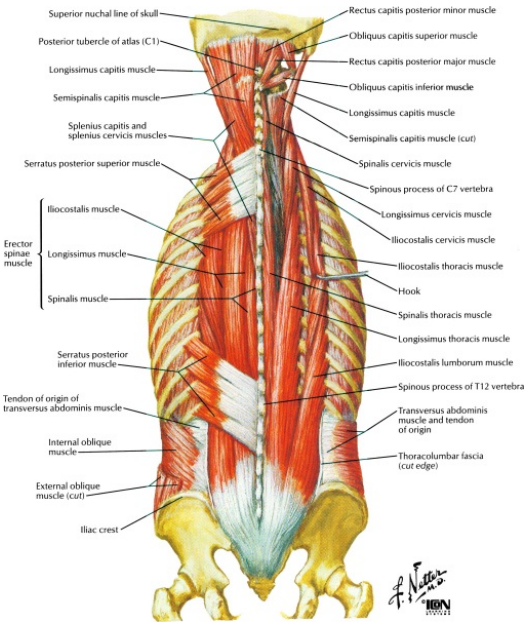
MUSCLE	ORIGIN	INSERTION	ACTION	NERVE
POSTERIOR NECK: SUBOCCIPITAL TRIANGLE				
Rectus capitis posterior: major	Spine of axis	Inferior nuchal line	Extend, rotate, laterally flex	Suboccipital nerve
Rectus capitis posterior: minor	Posterior tubercle of atlas	Occipital bone	Extend, laterally flex	Suboccipital nerve
Obliquus capitis superior	Atlas transverse process	Occipital bone	Extend, rotate, laterally flex	Suboccipital nerve
Obliquus capitis inferior	Spine of axis	Atlas transverse process	Extend, laterally rotate	Suboccipital nerve

SUPERFICIAL MUSCLES: POSTERIOR NECK AND BACK

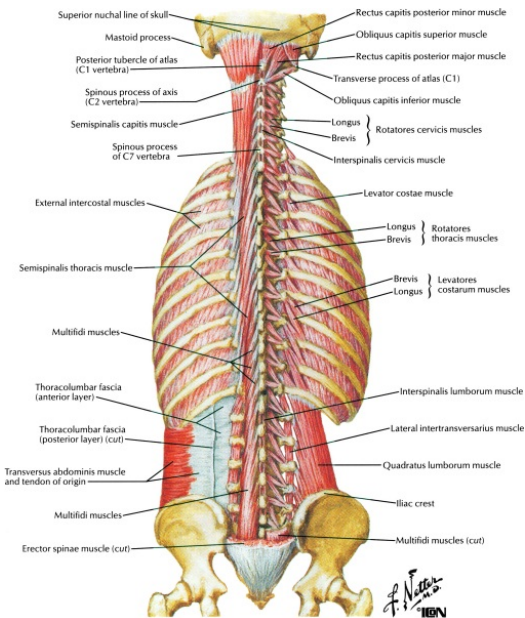


MUSCLE	ORIGIN	INSERTION	ACTION	NERVE
SUPERFICIAL (EXTRINSIC)				
Trapezius	Spinous process C7-T12	Clavicle; Scapula (AC, SP)	Rotate scapula	CN 11
Latissimus dorsi	Spinous process T6-S5	Humerus	Extend, adduct, IR arm	Thoracodorsal
Levator scapulae	Transverse process C1-4	Scapula (medial)	Elevate scapula	C3, 4, Dorsal scapular
Rhomboid minor	Spinous process C7-T1	Scapula (spine)	Adduct scapula	Dorsal scapular
Rhomboid major	Spinous process T2-T5	Scapula (medial border)	Adduct scapula	Dorsal scapular
Serratus posterior superior	Spinous process C7-T3	Ribs 2-5 (upper border)	Elevate ribs	Intercostal nerve (T1-4)
Serratus posterior inferior	Spinous process T11-L3	Ribs 9-12 (lower border)	Depress ribs	Intercostal nerve (T9-12)

DEEP MUSCLES: POSTERIOR NECK AND BACK

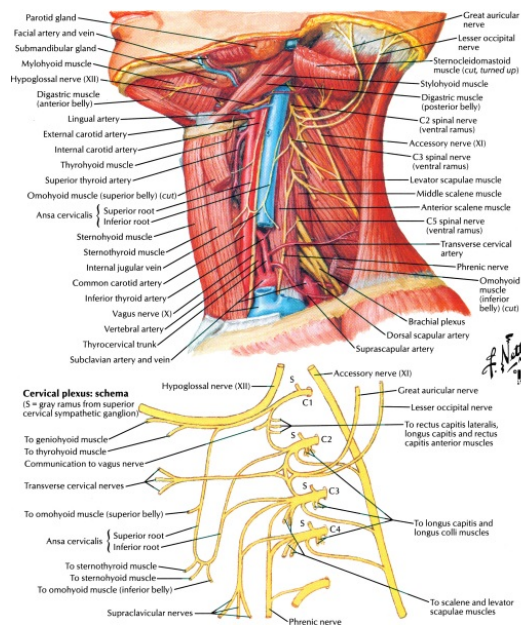


MUSCLE	ORIGIN	INSERTION	ACTION	NERVE
DEEP (INTRINSIC)				
SUPERFICIAL LAYER: SPINOTRANSVERSE GROUP				
Splenius capitis	Ligamentum nuchae	Mastoid nuchal line	Both: laterally flex rotate neck to same side	Dorsal rami of inferior cervical nerves
Splenius cervicis	Spinous process T1-6	Transverse process C1-4		
INTERMEDIATE LAYER: SACROSPINALIS GROUP (Erector spinae) All have 3 parts: thoracis, cervicis and capitis				
Iliocostalis Longissimus Spinalis	Common origin: Sacrum, iliac crest, and lumbar spinous process.	Ribs TC spinous process, mastoid process T-spine: spinous process	Laterally flex, extend, rotate head (to same side) and vertebral column	Dorsal rami of spinal nerves



MUSCLE	ORIGIN	INSERTION	ACTION	NERVE
DEEP (INTRINSIC)				
DEEP LAYERS: TRANSVERSOSPINALIS GROUP				
Semispinalis (CT)	Transverse process	Spinous process	Extend, rotate opposite side	Dorsal primary rami
Semispinalis capitis	Transverse process T1-6	Nuchal ridge		Dorsal primary rami
Multifidi [C2-S4]	Transverse process	Spinous process	Flex laterally, rotate opposite	Dorsal primary rami
Rotatores	Transverse process	Spinous process +1	Rotate superior vertebrae opposite	Dorsal primary rami
Interspinales	Spinous process	Spinous process +1	Extend column	Dorsal primary rami
Intertransversarii	Transverse process	Transverse process +1	Laterally flex column	Dorsal primary rami

## NERVES OF THE UPPER EXTREMITY: CERVICAL PLEXUS



### CERVICAL PLEXUS (C1-C4 ventral rami) Behind IJ and SCM

**Lesser Occipital Nerve (C2-3):** arises from posterior border of SCM

Sensory: Superior region behind auricle

Motor: NONE

**Great Auricular Nerve (C2-3):** exits inferior to Lesser Occipital nerve, then ascends on SCM

Sensory: Over parotid gland and below ear

Motor: NONE

**Transverse Cervical Nerve (C2-3):** exits inferior to Greater Auricular nerve, then to anterior neck

Sensory: Anterior triangle of the neck

Motor: NONE

**Supraclavicular (C2-3):** splits into 3 branches: anterior, middle, posterior

Sensory: Over clavicle, outer trapezius deltoid

Motor: NONE

1.

2.

**Ansa Cervicalis (C1-3):** superior (C1-2) inferior (C2-3) roots form loop

Sensory: NONE



3.

Motor:	Omothyoid Sternothyoid Sternothyroid
--------	--

4.

**Phrenic Nerve** (C3-5): On anterior scalene, into thorax between subclavian artery and vein

5.

6.

Sensory:	Pericardium and mediastinal pleura
Motor:	Diaphragm

NERVES: BRACHIAL PLEXUS

BRACHIAL PLEXUS (C5-T1 ventral rami) [variations: C4-T2] (also see Shoulder)

SUPRACLAVICULAR [approach through posterior triangle]

ROOTS

**Dorsal Scapular** (C5): pierces middle scalene, deep to Levator Scapulae Rhomboids.

Sensory:	NONE
Motor:	Levator scapulae Rhomboid Minor and Major

**Long Thoracic** (C5-7): on anterior surface of Serratus Anterior with Lateral Thoracic artery.

Sensory:	NONE
Motor:	Serratus Anterior (wing scapula with nerve dysfunction)

UPPER TRUNK

**Suprascapular** (C5-6): through scapular notch, under superior transverse scapular ligament.

Sensory:	Shoulder joint
Motor:	Supraspinatus Infraspinatus

**Nerve to Subclavius** (C5-6): descends anterior to plexus, posterior to clavicle

Sensory:	NONE
Motor:	Subclavius

INFRACLAVICULAR [approach through axilla]

LATERAL CORD

- Lateral root to Median nerve

**Lateral Pectoral** (C5-7): named for lateral cord, is medial to Medial Pectoral nerve runs with pectoral artery.

Sensory:	NONE
Motor:	Pectoralis Major Pectoralis Minor (via loop to MPN)

**Musculocutaneous** (C5-7): pierces coracobrachialis, runs between biceps brachialis.

Sensory:	Lateral forearm [via Lateral cutaneous nerve]
Motor:	ANTERIOR COMPARTMENT OF ARM Coracobrachialis Biceps brachialis Brachialis

INFRACLAVICULAR [approach through axilla]

MEDIAL CORD

- Medial root to Median nerve

**Medial Pectoral** (C8-T1): named for medial cord, is lateral to Lateral Pectoral nerve

Sensory:	NONE
Motor:	Pectoralis Minor Pectoralis Major (overlying muscle)

**Medial Cutaneous Nerve of Arm** (Brachial, C8-T1): joins Intercostalbrachial

Sensory:	Medial (inner) arm
Motor:	NONE

**Medial Cutaneous Nerve of Forearm** (Antibrachial, C8- T1): runs with basilic vein.

Sensory:	Medial forearm anterior arm
Motor:	NONE

**Ulnar** (C (7) 8-T1): runs behind medial epicondyle in groove. Multiple sites of possible compression

Sensory:	Medial palm 1 1/2 digits via: palmar palmar digital branches Medial dorsal hand 1 1/2 digits via: dorsal, dorsal digital, proper palmar digital branches
Motor:	FOREARM [runs between the two muscles] Flexor carpi ulnaris Flexor digitorum profundus [digits 4,5] HAND [divides at hypothenar eminence] <b>Superficial Branch</b> [lateral to pisiform] Palmaris brevis <b>Deep (Motor) Branch</b> [around hook of hamate] Adductor pollicis <b>THENAR MUSCLES</b> Flexor pollicis brevis[FPB][with median] <b>HYPOTHENAR MUSCLES</b> Abductor digiti minimi [ADM] Flexor digiti minimi brevis [FDMB] Opponens digiti minimi [ODM] <b>INTRINSIC MUSCLES</b> Dorsal interossei [DIO] [abduct DAB] Volar interossei [VIO] [adduct PAD] Lumbricals [medial two (3,4)]

INFRACLAVICULAR [approach through axilla]

MEDIAL AND LATERAL CORDS

**Median** (C 5) 6-T1): runs anteromedial, no branches in arm Multiple sites of possible compression

Sensory: Dorsal distal phalanges of lateral 3 1/2 digits via: proper palmar digital branches  
Volar 3 1/2 digits and lateral palm via: palmar palmar digital branches

ANTERIOR COMPARTMENT OF FOREARM

Superficial Flexors

Pronator Teres [PT]  
Flexor Carpi Radialis [FCR]  
Palmaris longus [PL]  
Flexor digitorum superficialis [FDS] [sometimes considered a "middle" flexor]

Deep Flexors: **AIN** (Anterior Interosseous Nerve)

Flexor digitorum profundus [digits 2,3]  
Flexor pollicis longus [FPL]  
Pronator Quadratus [PQ]

HAND: **Motor Recurrent** (Thenar motor) **Thenar**

Abductor pollicis brevis [APB]  
Opponens pollicis  
Flexor pollicis brevis [FPB][with ulnar]

Intrinsic

Lumbricals [lateral two (1,2)]

POSTERIOR CORD

Upper Subscapular (C5-6)

Sensory: NONE

Motor: Subscapularis [upper portion]

Lower Subscapular (C5-6)

Sensory: NONE

Motor: Subscapularis [lower portion]  
Teres major

Thoracodorsal (C7-8): runs with Thoracodorsal artery

Sensory: NONE

Motor: Latissimus dorsi

Axillary (C5-6): runs with Posterior Circumflex Humeral artery in axilla

Sensory: Lateral upper arm: via Superior lateral cutaneous nerve

Motor: Deltoid (Deep branch)  
Teres minor (Superficial branch)

Radial (C5-T1): runs with Deep Artery of Arm in Triceps

Lateral arm: via Inferior lateral cutaneous nerve  
Posterior arm: via Posterior cutaneous nerve

Sensory: Posterior forearm: via Posterior cutaneous nerve  
Dorsal 3 1/2 digits and hand: via superficial branches

POSTERIOR COMPARTMENT OF ARM

Triceps [medial, long, lateral heads]  
Anconeus

MOBILE WAD: (Radial nerve-Deep branch)

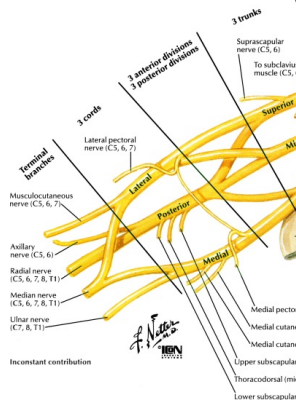
Brachioradialis [BR]  
Extensor carpi radialis longus [ECRL]  
Extensor carpi radialis brevis [ECRB]

POSTERIOR COMPARTMENT OF FOREARM

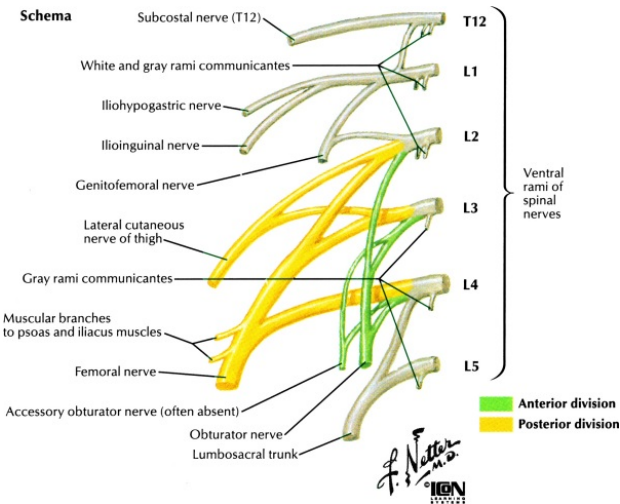
**AIN** Multiple possible compression sites (see Forearm)

Motor: Superficial Extensors  
Extensor carpi ulnaris [ECU]  
Extensor digiti minimi [EDM]  
Extensor digitorum [ED]  
Deep Extensors  
Supinator  
Abductor pollicis longus  
Extensor pollicis longus  
Extensor pollicis brevis  
Extensor indicis proprius

15.



NERVES: LUMBAR PLEXUS



LUMBAR PLEXUS (Deep to Psoas muscle)

ANTERIOR DIVISION

Subcostal (T12):

Sensory:	Subxiphoid region
Motor:	NONE

Iliohypogastric (L1):

Sensory:	Above pubis Posterolateral buttocks
Motor:	Transversus abdominus Internal Oblique

Ilioinguinal (L1):

Sensory:	Inguinal region
Motor:	NONE

**Genitofemoral** (L1-2): pierces Psoas, lies on anteromedial surface.

Sensory:	Scrotum/mons
Motor:	Cremaster

**Obturator** (L2-4): exits via obturator canal, splits into anterior posterior divisions. Can be injured by retractors placed behind the transverse acetabular ligament.

Sensory:	Inferomedial thigh via cutaneous branch of Obturator nerve
	External oblique Adductor longus (anterior division)

Motor:	Adductor brevis (ant post division) Adductor magnus (posterior division) Gracilis (anterior division) Obturator externus (posterior division)
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#### **Accessory *Obturator* (L2-4): inconsistent**

Sensory:	NONE
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Motor:	Psoas
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#### **POSTERIOR DIVISION**

#### **Lateral Femoral Cutaneous**

[LFCN](L2-3): crosses ASIS, can be compressed at ASIS

Sensory:	Lateral thigh
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Motor:	NONE
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**Femoral** (L2-4): lies between psoas major and iliacus

Sensory:	Anteromedial thigh via anterior intermediate cutaneous nerves Medial leg foot via medial cutaneous nerves ( <i>Saphenous Nerve</i> )
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Motor:	Psoas Iliacus Pecineus <u>Quadriceps</u> Rectus femoris Vastus lateralis Vastus intermedialis Vastus Medialis Sartorius Articularis genu
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NERVES: SACRAL PLEXUS

SACRAL PLEXUS

ANTERIOR DIVISION

**Tibial (L4-S3):** descends between heads of Gastrocnemius to medial malleolus

Sensory:	Posterolateral proximal calf: via Medial sural Posterolateral distal calf: via Sural
	Medial plantar heel: via Medial calcaneal Medial plantar foot: via Medial plantar Lateral plantar foot: via Lateral plantar
Motor:	<u>POSTERIOR THIGH</u> Biceps femoris [long head] Semitendinosus Semimembranosus
	<u>SUPERFICIAL POST. COMPARTMENT OF LEG</u> Soleus: via nerve to Soleus Gastrocnemius Plantaris
	<u>DEEP POSTERIOR COMPARTMENT OF LEG</u> Popliteus: via nerve to Popliteus Tibialis posterior [TP] (Tom) Flexor digitorum longus [FDL] (Dick) Flexor hallucis longus [FHL] (Harry)
	<u>FIRST PLANTAR LAYER of FOOT</u> Abductor hallucis: Medial plantar Flexor digitorum brevis [FDB]: Medial plantar Abductor digiti minimi: Lateral plantar
	<u>SECOND PLANTAR LAYER of FOOT</u> Quadratus plantae: Lateral plantar Lumbricals: Medial lateral plantar
	<u>THIRD PLANTAR LAYER of FOOT</u> Flexor hallucis brevis [FHB]: Medial plantar Adductor hallucis: Lateral plantar Flexor digitorum minimus brevis [FDMB]: Lateral plantar
	<u>FOURTH PLANTAR LAYER of FOOT</u> Dorsal interosseous: Lateral plantar Plantar interosseous: Lateral plantar

**Nerve to Quadratus femoris (L4-S1):**

Sensory:	NONE
Motor:	Quadratus femoris Inferior gemelli

**Nerve to Obturator internus (L5-S2):** exits greater sciatic foramen

Sensory:	NONE
Motor:	Obturator internus Superior gemelli

**Pudendal (S2-4):** exit greater then re-enters lesser sciatic foramen

Sensory:	Perineum: via Perineal (scrotal/labial branches) via Inferior rectal nerve via Dorsal nerve to penis/clitoris
	Bulbospongiosus: Perineal nerve Ischiocavernosus: Perineal nerve Urethral sphincter: Perineal nerve Urogenital diaphragm: Perineal nerve Sphincter ani externus: Inferior rectal nerve

**Nerve to Coccygeus (S3-4)**

Sensory:	NONE
Motor:	Coccygeus

Motor:	Levator ani
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## POSTERIOR DIVISION

Common Peroneal (L4-S2): in groove between biceps lateral head of Gastrocnemius. Wraps around fibular head, deep to peroneus longus; the divides

Sensory:	Proximal lateral leg: via Lateral sural nerve Distal lateral leg dorsal foot: via Superficial peroneal Lateral foot: via Sural (lateral calcaneal dorsal cutaneous branches) 1st/2nd interdigital space: Deep peroneal
Motor:	<u>POSTERIOR THIGH</u> Biceps femoris [short head] <u>ANTERIOR COMPARTMENT of LEG:</u> <b>Deep Peroneal</b> Tibialis anterior [TA] Extensor hallucis longus [EHL] Extensor digitorum longus [EDL] Peroneus tertius <u>LATERAL COMPARTMENT of LEG:</u>  <b>Superficial Peroneal</b> Peroneus longus Peroneus brevis <u>FOOT: Deep Peroneal</u> Extensor hallucis brevis [EHB] Extensor digitorum brevis [EDB]

Superior Gluteal (L4-S1):

Sensory:	NONE
Motor:	Gluteus medius Gluteus minimus Tensor fascia lata

**Inferior Gluteal (L5-S2):**

Sensory:	NONE
Motor:	Gluteus maximus

**Nerve to piriformis (S2):**

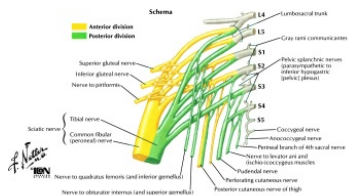
Sensory:	NONE
Motor:	Piriformis

**Posterior Femoral Cutaneous Nerve [PFCN] (S1-3)**

10. Sensory:	Posterior thigh
Motor:	NONE

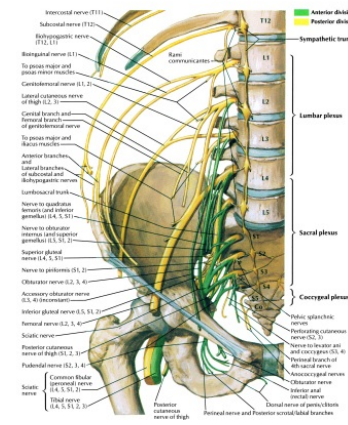


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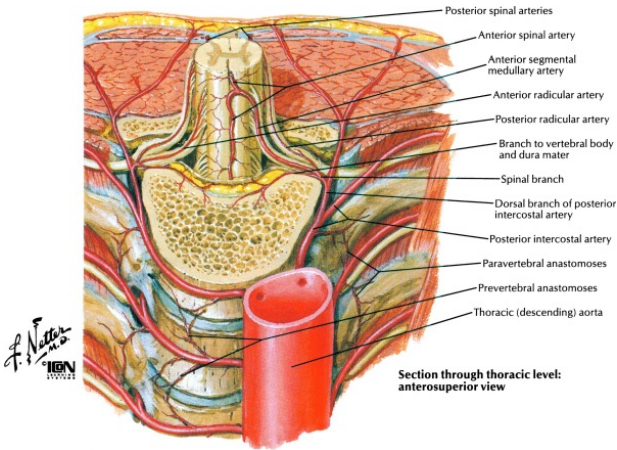


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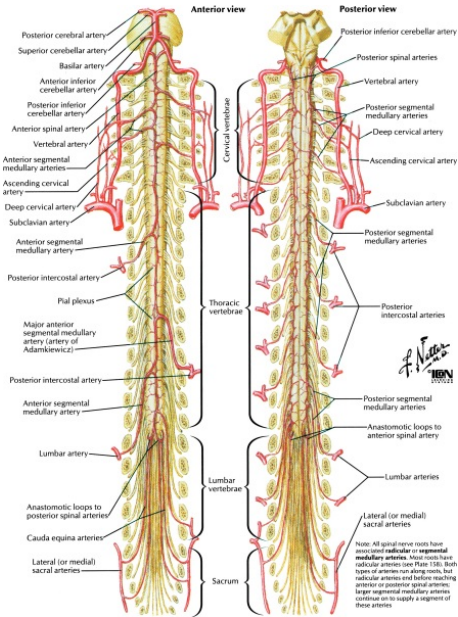


ARTERIES

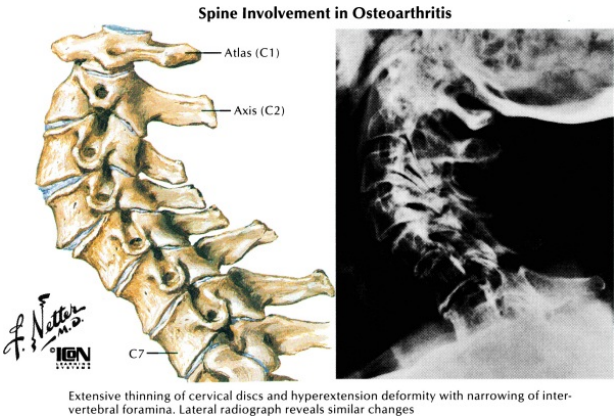


ARTERY	COURSE	BRANCHES	COMMENT
Vertebral	Major arterial supply of cervical spine and cord.		
	Off both subclavian through transverse foramen of C1-6	Anterior and posterior segmental medullary	Feed Anterior Posterior spinal arteries respectively
		Anterior spinal	Forms superiorly from both vertebrals
		Posterior spinal	Each branch superiorly from vertebrals
Ascending cervical	From Thyrocervical	Contributes to Anterior Posterior spinal arteries via segmental medullary arteries	
Deep cervical	From Costocervical	Contributes to Anterior Posterior spinal arteries via segmental medullary arteries	
Segmental/Intercostal	Branch from aorta	Dorsal branch Dorsal branch Spinal branch Ventral branch Major anterior segmental medullary (Adamkiewicz Artery)	Supplies dura, posterior elements Supplies cord and bodies Supplies vertebral bodies Supplies inferior thoracic superior, L-spine, feeds anterior spinal artery in L-spine
Spinal branch	Along vertebral bodies	Anterior segmental medullary Posterior segmental medullary Radicular arteries (Anterior Posterior)	On ventral root; feeds anterior spinal artery Feeds posterior spinal arteries Along nerve roots, do not feed spinals
		Anterior segmental medullary On Posterior	On ventral root; feeds anterior

Lumbar arteries	Branch from aorta	segmental medullary Radicular arteries (Anterior Posterior)	spinal artery Feeds Posterior spinal arteries
Anterior segmental medullary	Along nerve roots	Anterior spinal artery Anterior radicular arteries	Single artery, runs midline Do not feed spinal arteries
Posterior segmental medullary	Along nerve roots	Posterior spinal artery Posterior radicular arteries	Paired arteries (left/right) Do not feed spinal arteries
Anterior spinal	Midline anterior surface of cord	Supplies anterior 2/3 of cord; has multiple contributions from segmental arteries	
		Sulcal branches Pial arterial plexus	Supplies center of cord Supplies cord peripheries
Posterior spinal	Off midline (L R)	Supplies post 1/3 of cord; has multiple contributions from segmental arteries	
Each nerve root has either a segmental medullary or a radicular artery associated with it.			



DISORDERS



DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
CAUDA EQUINA SYNDROME			
<ul style="list-style-type: none"><li>• Compression of cauda equina</li><li>• Etiology: usually a large midline disc herniation</li><li>• A surgical emergency</li></ul>	HxPE: Back, buttock, leg pain. Bladder (#1) and bowel dysfunction. Leg numbness paralysis	XR: no emergent need MR (or myelography): to show compression	Immediate surgical decompression (when diagnosis is confirmed)
CERVICAL SPONDYLOSIS			
<ul style="list-style-type: none"><li>• Disc degeneration with vertebral and facet arthritis</li><li>• 3 pain sources: disc, ligament, root (HNP)</li><li>• C5-6 #1 site</li><li>• PLL ossifies, results in stenosis (most common in Asians)</li></ul>	Hx: Older, men. Neck UE pain, stiffness or grinding. PE: Decreased ROM, midline neck TTP. Radicular or myelopathic signs if HNP or cord compressed	XR: AP, lateral: <ol style="list-style-type: none"><li>1. Osteophytes</li><li>2. Spinal stenosis</li><li>3. Disc space narrowed</li><li>4. Facet osteoarthritis</li><li>5. Instability</li></ol>	<p>Discogenic: soft collar, NSAID, Physical therapy, +/- traction</p> <p>Persistent radiculopathy or myelopathy: decompression and fusion (not for discogenic pain)</p> <ol style="list-style-type: none"><li>1.</li><li>2.</li></ol>
CERVICAL STRAIN/MUSCLE STRAIN (Whiplash)			
<ul style="list-style-type: none"><li>• Not a sprain. Soft tissue (muscle/ligament) strain</li><li>• Etiology: trauma or some minor movement</li></ul>	Hx: Stiffness, pain (dull/nonradiating) in neck traps PE: Paraspinal muscles tender to palpation (+/- spasm). Spurling test	XR: if history of trauma or neurologic or persistent symptoms	<p>Soft collar immobilization (Philadelphia collar)</p> <ol style="list-style-type: none"><li>1.</li><li>2.</li><li>3.</li></ol> <p>NSAID, muscle relaxant +/- Ice, heat, massage</p>
DEGENERATIVE DISC DISEASE (DDD)			

<p>Aging process: disc desiccates</p> <ul style="list-style-type: none"> <li>and tears. Facet degeneration and sclerosis</li> <li>Associated with tobacco use</li> </ul>	<p>Hx: Chronic LBP (+/- buttock), stiffness (worse with activity) PE: Back tender to palpation +/- Waddell's signs.</p>	<p>XR: AP, lateral: aging, osteophytes, disc space narrowed, "vacuum sign"</p>	<ol style="list-style-type: none"> <li>1. NSAIDs (no narcotics)</li> <li>2. Antidepressants if indicated</li> <li>3. Physical therapy, exercise, weight control</li> </ol>
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**HERNIATED CERVICAL DISC (Herniated nucleus pulposus)**

<p>Nucleus pulposus protrudes presses on root.</p> <p>Usually posterolateral at C5-6 or C6-7.</p>	<p>Hx: Young or middle age. Numbness radiating pain. PE: 1 weakness, decreased sensation reflexes, 1 Spurling test</p>	<p>XR: AP, lateral: spondylosis MR: bulging nucleus pulposus</p>	<ol style="list-style-type: none"> <li>1. Soft collar, rest</li> <li>2. Physical therapy, NSAIDs</li> <li>3. Surgical decompression</li> </ol>
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**Degenerative Disc Disease**



Radiograph of thoracic spine shows narrowing of intervertebral spaces and spur formation



Degeneration of lumbar intervertebral discs and hyperostrophic changes at vertebral margins with spur formation. Osteophytic encroachment on intervertebral foramina compresses spinal nerves

**Lumbar Disc Herniation**



Schematic cross section showing compression of nerve root

*A. Netter M.D.*  
100021

DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
<b>HERNIATED LUMBAR DISC (HNP)</b>			
<p>DDD annulus tear: nucleus herniates, +/- root or cauda compression.</p> <ul style="list-style-type: none"> <li>Can be Asymptomatic</li> <li>L4-5 most common</li> <li>Most posterolateral (PLL weak)</li> </ul>	<p>Hx: DDD sx (+/- radicular sx). Increased with sneeze, decreased with hip flexion PE: Root weakness, decreased sensation reflexes, 1 straight leg bowstring tests.</p>	<p>XR: AP, lateral: age changes EMG/NCS: + after 3 weeks MR: shows herniation</p>	<ol style="list-style-type: none"> <li>1. Bed rest, NSAIDs</li> <li>2. Physical therapy, fitness program</li> <li>3. Discectomy</li> <li>4. Cauda Equina Syndrome: a surgical emergency</li> </ol>

DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
LUMBAR BACK SPRAIN/MUSCLE STRAIN			
<ul style="list-style-type: none"> <li>Strain or lifting injury</li> <li>Soft tissue injury (muscle spasm, ligament or tendon injury, disc tear-without bulge)</li> </ul>	Hx: LBP (+/- radiation to buttock, not leg), paraspinous spasm tenderness PE: Normal neurologic exam	XR: if neurologic symptoms present or refractory to treatment	Rest (1-2 day bed rest), NSAIDs (no narcotics) 1. Physical therapy 2. Increase fitness
SCHEUERMANN'S DISEASE			
<ul style="list-style-type: none"> <li>Increased thoracic kyphosis (Cobb angle 45°) with 3 vertebrae with anterior wedging</li> <li>Unknown etiology</li> <li>Schmorl nodes (cartilage) in the vertebral body</li> </ul>	Hx: Adolescent with poor posture, +/-back pain PE: "rounded back" on examination, usually nontender to palpation	XR: AP, lateral T-spine: 1. Increased kyphosis 2. Anterior wedging (3) 3. Schmorl nodes	Immature: exercise, brace or orthosis Mature: Anterior release and posterior fusion
SCOLIOSIS			
<ul style="list-style-type: none"> <li>Lateral spine curve (+/- rotation)</li> <li>Multiple etiologies: #1 idiopathic</li> <li>Girls.boys (needing tx)</li> <li>Find on school screening</li> <li>Progression: based on skeletal maturity, curve angle</li> </ul>	Hx: +/-pain, fatigue, visible physical deformity. PE: Neurologic exam usually normal. 1forward bend test. Determine plumb line (hang string from C7)	XR: Full length AP, lateral: Lateral curve on AP. Measure Cobb angle: angle between lines drawn perpendicular to most superior inferior affected vertebrae	Curves: 1. 30° observation 2. 30-40° bracing 3. 40° surgery: spinal fusion.
SPINAL STENOSIS			
<ul style="list-style-type: none"> <li>Congenital vs. acquired (most common)</li> <li>Canal narrowing with symptoms</li> <li>Etiology: DDD or facet osteoarthritis ligament laxity</li> </ul>	Hx: Neurogenic claudication (fatigue), +/-pain; Back extension reproduces sx. PE: Weakness, decreased pin prick reflexes	XR: AP, lateral: age changes CT/MR: better to evaluate canal, shows stenosis	Physical Therapy: abdominal strength back flexion exercises 1. NSAIDs (+/- steroids) 2. Laminectomy
SPONDYLOLISTHESIS			
<ul style="list-style-type: none"> <li>Forward slipped vertebrae</li> <li>6 Types (common sites):</li> <li>1. Congenital: facet defect (S1)</li> <li>Isthmic (most common): pars</li> </ul>	Hx: Type: I (peds), II (young), III (elderly). Mechanical back pain, +/-radicular symptoms	XR: AP, lateral: measure forward slippage for grade (I-V, 0-100°) Type: 1. Scottie dog: long	Activity modification, rest, NSAIDs 1. Flexion exercises 2. Surgical

<ol style="list-style-type: none"> <li>2. defect (L5-S1; associated with hyperextension); Degenerative: facet arthropathy (L4-5)</li> <li>3. Traumatic</li> <li>4. Pathologic</li> <li>5. Post-surgical</li> </ol>	<p>PE: +/-palpable step-off spasm. +/-radicular signs (e.g. weakness, decreased sensation reflexes)</p>	<ol style="list-style-type: none"> <li>neck</li> <li>2. Scottie dog: broken neck</li> <li>3. Facet arthritis</li> </ol>	<ol style="list-style-type: none"> <li>3. Surgical decompression and fusion for progressive slippage or radicular symptoms</li> </ol>
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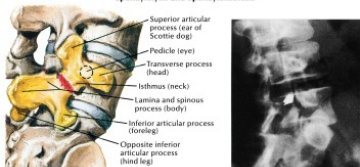
### SPONDYLOLYSIS

<ul style="list-style-type: none"> <li>Defect or stress fracture (without slippage) in pars interarticularis</li> <li>Leads to spondylolisthesis</li> <li>L5 most common site</li> </ul>	<p>Hx: Young, athlete (football, gymnast). Low back pain, worse with activity (#1 cause in pediatrics)</p>	<p>XR: Oblique L-spine "Scottie dog has a collar"</p>	<ol style="list-style-type: none"> <li>1. Symptomatic treatment</li> <li>2. Activity restriction, +/- brace</li> <li>3. Back muscle strengthening</li> </ol>
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### TUMORS

Metastatic are most common. Most common primary: Multiple Myeloma (malignant)

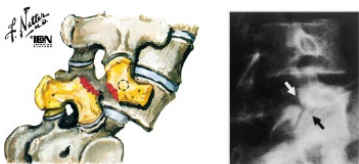
Spondylolysis and Spondylolisthesis



**Spondylolysis without spondylolisthesis.** Posterolateral view demonstrates formation of radiographic Scottie dog. On lateral radiograph, dog appears to be wearing a collar

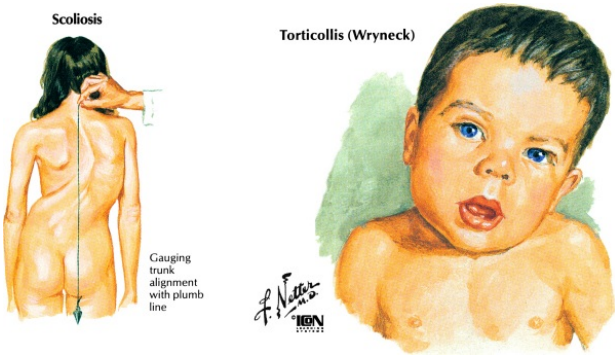


**Dysplastic (congenital) spondylolisthesis.** Luxation of L5 on sacrum. Dog's neck (isthmus) appears elongated



**Isthmic type spondylolisthesis.** Anterior luxation of L5 on sacrum due to fracture of isthmus. Note that gap is wider and dog appears decapitated

PEDIATRIC DISORDERS



DESCRIPTION	EVALUATION	TREATMENT/COMPLICATIONS
MYELODYSPLASIA		
<ul style="list-style-type: none"><li>Neural tube (closure) defect; No function below level of lesion; level determines function (L1 paraplegic/S1 near normal)</li><li>Associated with increased AFP</li><li>Associated with many deformities</li></ul>	<p>Hx: Some have family history PE/XR: Depends on type of defect:</p> <ol style="list-style-type: none"><li>Spina bifida occulta</li><li>Meningocele</li><li>Myelomeningocele</li><li>Rachischisis</li></ol>	<p>Must individualize for each patient: Most need ambulation assistance, orthoses, surgical releases, etc. Common problems requiring treatment: Deformities and/or contractures of spine, hips, knees, ankles, and feet</p>
SCOLIOSIS		
<ul style="list-style-type: none"><li>Lateral spine curve +/- rotation</li><li>Multiple etiologies: #1 idiopathic</li><li>Cases needing tx: girls boys</li><li>Curve progression predicted:<ol style="list-style-type: none"><li>Angle of curve</li><li>Skeletal maturity (Risser stages: iliac Apophysis)</li></ol></li></ul>	<p>Hx: +/- pain fatigue, visible deformity, found in school screening PE: + forward bend test (asymmetric). Neurologic exam usually normal. Determine plumb line from C7 XR: AP full length: measure Cobb angle. (See Disorder Table)</p>	<p>Based on curves and Risser stage;</p> <ol style="list-style-type: none"><li>30°: observation (most) 30-40°: bracing (Boston, for apex below T8 vs. Milwaukee brace)</li><li>40°: spinal fusion</li></ol>
TORTICOLLIS		
<ul style="list-style-type: none"><li>Contracture of SCM</li><li>Associated with other disorders</li><li>Associated with intrauterine position</li></ul>	<p>Hx: Parents note deformity PE: Head tilted to one side, chin to opposite side, 1/2 facial asymmetry XR: Spine hints rule out</p>	<ol style="list-style-type: none"><li>Physical therapy/stretching of the sternocleidomastoid Surgical release if persistent</li><li>Complication: poor eye</li></ol>



malauricular position

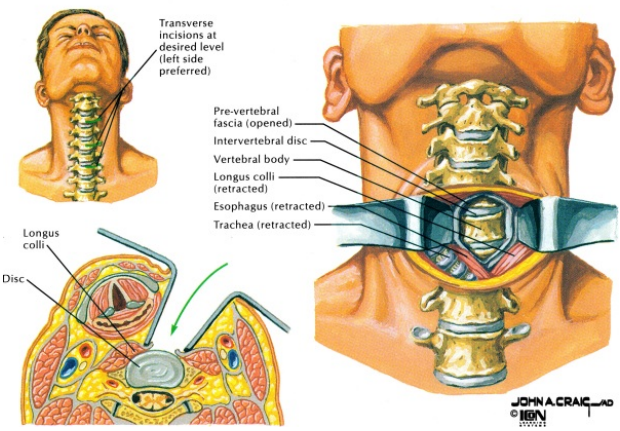
with epimeric position and  
other anomalies

development

- Etiology: several theories

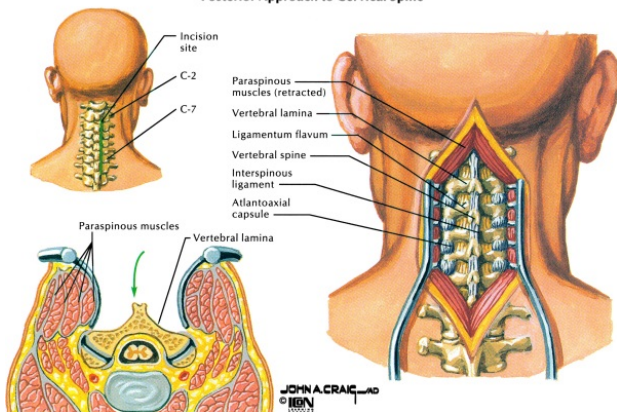
SURGICAL APPROACHES

Anterior Approach to Cervical Spine



USES	INTERNEUROUS PLANE	DANGERS	COMMENT
ANTERIOR APPROACH			
<div>1. Herniated disc removal</div> <div>2. Vertebral fusion</div> <div>3. Osteophyte removal</div> <div>4. Tumor or biopsy</div>	<div>Superficial:</div> <div>1. SCM (CN 11)</div> <div>Strap muscles (C1-3)</div> <div>Deep:</div> <div>2. Between left and right Longus colli muscles</div>	<div>1. Recurrent laryngeal nerve</div> <div>2. Sympathetic nerve</div> <div>3. Carotid artery</div> <div>4. Internal jugular</div> <div>5. Vagus nerve</div> <div>6. Inferior thyroid artery</div>	<div>• Access C3 to T1</div> <div>Right recurrent laryngeal nerve more susceptible</div> <div>• to injury-most choose approach on left side.</div> <div>Thyroid arteries</div> <div>• limit extension of the approach</div>

## Posterior Approach to Cervical Spine



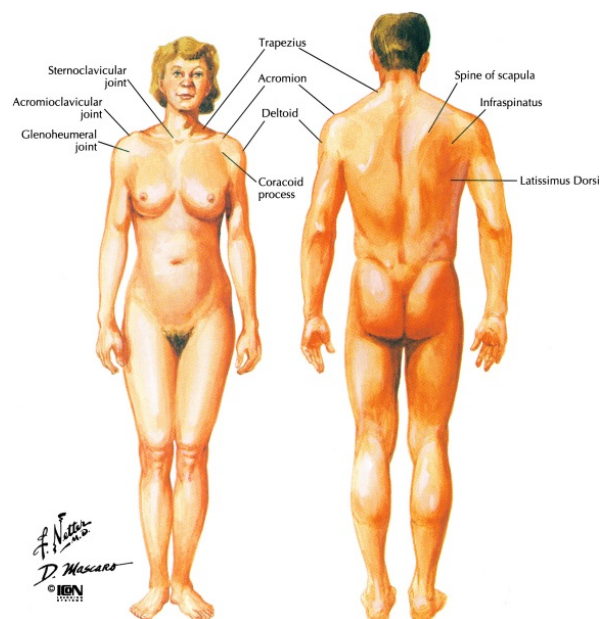
USES	INTERNERVOUS PLANE	DANGERS	COMMENT
POSTERIOR APPROACH			
<b><u>CERVICAL</u></b> <ol style="list-style-type: none"> <li>Posterior fusion</li> <li>Herniated disc</li> <li>Facet dislocation</li> </ol>	Left and Right paracervical muscles (posterior cervical rami)	<ol style="list-style-type: none"> <li>Spinal cord</li> <li>Nerve roots</li> <li>Posterior rami</li> <li>Vertebral artery</li> <li>Segmental vessels</li> </ol>	<ol style="list-style-type: none"> <li>Most common c-spine approach Mark the level of pathology with a radiopaque marker pre-op to assist finding the appropriate level intraoperatively</li> </ol>
<b><u>LUMBAR</u></b> <ol style="list-style-type: none"> <li>Herniated disc</li> <li>Explore nerve roots</li> </ol>	Left and Right paraspinal muscles (dorsal rami)	Segmental vessels to paraspinals	Incision is along the spinous processes.

## **CHAPTER 2 - SHOULDER**

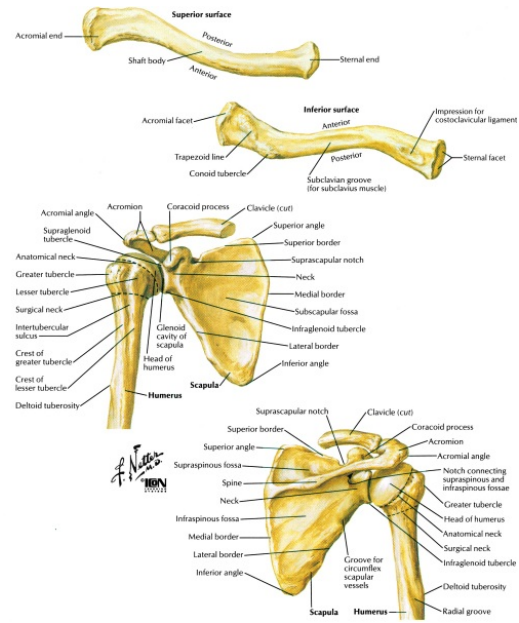
- [TOPOGRAPHIC ANATOMY](#)
- [OSTEOLOGY](#)
- [TRAUMA](#)
- [JOINTS](#)
- [MINOR PROCEDURES](#)
- [HISTORY](#)
- [PHYSICAL EXAM](#)
- [MUSCLES: INSERTIONS AND ORIGINS](#)
- [MUSCLES: BACK/SCAPULA REGION](#)
- [MUSCLES: ROTATOR CUFF](#)
- [MUSCLES: DELTOID/PECTORAL REGION](#)
- [NERVES](#)
- [ARTERIES](#)
- [DISORDERS](#)
- [SURGICAL APPROACHES](#)

## CHAPTER 2 – SHOULDER

### TOPOGRAPHIC ANATOMY

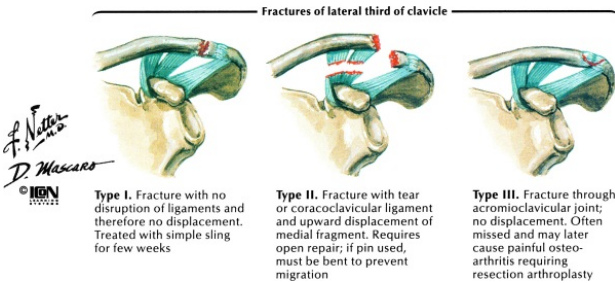


OSTEOLOGY



CHARACTERISTICS	OSSIFY	FUSE	COMMENT
CLAVICLE			
<ul style="list-style-type: none"><li>Cylindrical; S shaped</li><li>Middle: narrowest, no ligament attachments</li></ul>	<p>Primary (2) (medial/lateral)</p> <p>Secondary (sternal/acromial)</p>	<p>7 weeks fetal</p> <p>18-20 years</p>	<p>9 weeks fetal</p> <p>25 years (sternal)</p> <p>19-20 yrs (acromial)</p> <ul style="list-style-type: none"><li>Clavicle is first to ossify, last to fuse</li><li>It starts as intramembranous ossification, ends as membranous.</li></ul>
SCAPULA			
<ul style="list-style-type: none"><li>Flat, triangular shape</li><li>Only attachments to axial skeleton are muscular.</li></ul>	<p>1. Body</p> <p>2. Coracoid</p> <p>3. Coracoid/glenoid</p> <p>4. Acromion</p> <p>5. Inferior angle</p>	<p>8 weeks (fetal)</p> <p>1 year</p> <p>15 yrs</p> <p>15 yrs</p> <p>16 yrs</p>	<p>Blood supply:</p> <p>Subscapular (and circumflex scapular arteries)</p> <p>1. Suprascapular artery</p> <p>2. Suprascapular artery</p>

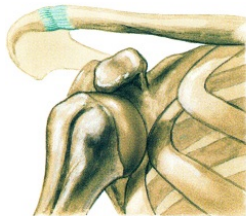
TRAUMA



DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
CLAVICLE FRACTURE			
<ul style="list-style-type: none"><li>Most common fracture</li><li>Fall on shoulder or direct blow.</li><li>Football, hockey</li><li>Rare</li><li>neurovascular damage (subclavians)</li></ul>	<p>HX: Trauma. Cannot raise arm. Pain.</p> <p>PE: Gross deformity at fracture site with ttp. Must do neurological and vascular exams.</p> <p>XR: AP and 45° cephalad Group II: stress views</p>	<p>I. Middle 1/3: 80%</p> <p>II Distal 1/3: 15%</p> <p>Type I: minimally displaced; between ligaments.</p> <p>Type II: Displaced, fracture medial to CC ligament.</p> <p>Type IIA: CC ligaments both attached to distal fragment</p> <p>Type IIB: Conoid ruptured Trapezoid ligament attached.</p> <p>Type III: Fracture through AC joint. Ligaments intact.</p> <p>III Proximal 1/3: 5%</p>	<p>Closed treatment (no reduction) with figure of eight brace or sling for mid/ proximal 1/3, distal 1/3 (Types I and III) (3-4 weeks; ROM)</p> <p>Open treatment for Type II to prevent nonunion. (also open fracture, vascular injury)</p>
COMPLICATIONS: Nonunion: esp. with distal 1/3: type II injury; Brachial plexus (medial cord/ulnar nerve) or subclavian injury; Pneumothorax.			
SCAPULAR FRACTURE			
<ul style="list-style-type: none"><li>Relatively uncommon</li><li>Males-young</li><li>High-energy trauma</li><li>85% w/associated injuries (including</li></ul>	<p>HX: Trauma. Pain in back and/or shoulder.</p> <p>PE: Swelling and tenderness to palpation</p> <p>XR: AP/Axillary</p>	<p>Anatomic classification: A-G</p> <p>Idleberg (glenoid fracture)</p> <p>Type I: Anterior avulsion fracture</p> <p>Type II: Transverse/oblique fracture thru glenoid; exits inferiorly</p> <p>Type III: Oblique</p>	<p>Closed treatment with a sling for 2 weeks for most fractures. Then early ROM.</p> <p>ORIF for intra-articular fr</p>

severe) Dx often delayed due to associated injuries (esp pulmonary great vessels).	AC/CL: Axillary lateral/ scapular Y; CXR CT: intraarticular glenoid	fracture through glenoid, exits superiorly Type IV: Transverse fracture exits through the scapula body Type V: Types II + IV	CT: intraarticular and/or large displaced (25%) fragments
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COMPLICATIONS: Associated injuries: Rib fracture #1, pneumothorax, pulmonary contusion, vascular injury, brachial plexus injury; AC injury (esp w/type III; acromion fx); Suprascapular nerve injury



Subcoracoid dislocation (most common)



Anteroposterior radiograph. Subcoracoid dislocation

*F. Netter*  
*D. Macera*  
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DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
ACROMIOCLAVICULAR (AC) SEPARATION			
<ul style="list-style-type: none"> <li>Separation is subluxation or dislocation of AC joint</li> <li>Fall onto acromion</li> <li>Contact sports: hockey football, wrestling</li> <li>Males</li> </ul>	<p>HX: Trauma. Range of pain: minimal to severe.</p> <p>PE: AC joint TTP, gross deformity with grade III up.</p> <p>XR: AP, stress view: grade II vs. grade III</p> <p>I: normal, II: minimal separation, III and up: clavicle displaced.</p>	<p>6 Grades: (based on ligament tear clavicle position)</p> <p>Grade I: Sprain, AC ligament intact</p> <p>Grade II: AC tear, CC sprain</p> <p>Grade III: AC/CC (both) torn AC joint is dislocated.</p> <p>Grade IV: III with clavicle posterior into/thru trapezius muscle</p> <p>Grade V: III with clavicle elevated 100% superiorly</p> <p>Grade VI: III with clavicle inferior</p>	<p>Grade I, II: sling until pain subsides (+/- injection/pain medication) for 1-2 wks, then increase ROM</p> <p>Grade III: nonoperative for most; operative for laborers/athletes</p> <p>Grade IV-VI: Open reduction and repair.</p>
COMPLICATIONS: Permanent deformity; Stiffness, early OA; Distal clavicle osteolysis (pain); Associated injuries: Fracture, pneumothorax.			



# GLENOHUMERAL DISLOCATION

Anterior: Abd/ER injury 2 mechanisms

1. TUBS [Traumatic Unilateral, Bankart lesion, Surgery]

• AMBRI [Atraumatic Multi-directional, Bilateral, responds to Rehab, Inferior capsule repair] 20 yo: 80% recur

Hill Sachs Bankart lesions predisposed to recurrence

• Posterior: after seizure often missed

HX: Trauma or hx of shoulder slipping out. Intense pain.

PE: Deformity, flattened shoulder silhouette. Exquisitely tender. Do full neurovascular PE

XR: AP/axillary lateral (also Stryker notch) Anterior: Hill Sacks Lesion Posterior: Rev Hill Sachs, "empty glenoid"

MRI: Bankart lesion (anterior/inferior labral tear)

Anatomic Classification: where humeral head is:

- Anterior (90%)
- Posterior (5%)
- Inferior (luxatio erecta) very rare
- Superior: very, very rare

Reduce dislocation:

Pre and Post neurological exam

Conscious sedation (IV benzo + narcotic)

Methods:

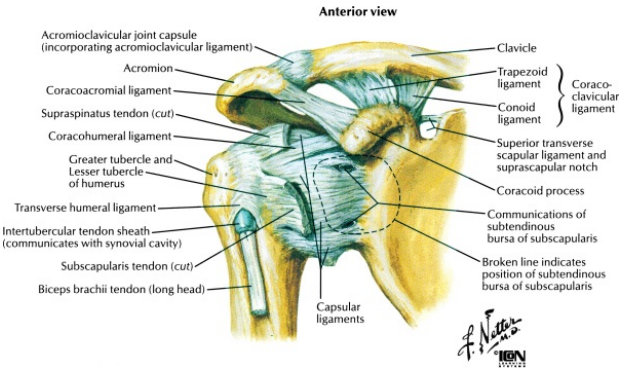
1. Traction/counter-traction
2. Hippocratic
3. Stimson
4. Milch

Immobilize (2-6 weeks), rehabilitation

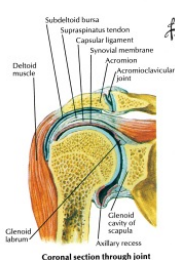
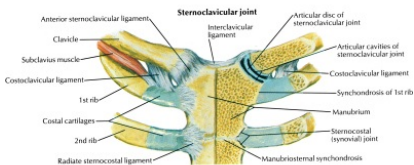
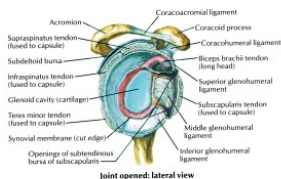
Surgery for recurrent/TUBS, posterior dislocation 3 wks

COMPLICATIONS: Recurrence rate (young age predicts it, decreases w/increased age); Axillary nerve injury; Rotator cuff tear; Glenoid/Greater tuberosity fracture; Dead arm syndrome

JOINTS



JOINT	TYPE	LIGAMENTS	COMMENTS
Glenohumeral	Spheroidal Ball and Socket	Highly mobile, decreased stability (needs Rotator cuff); #1 dislocated joint (anterior 90%)	
		Capsule	Loose, redundant, with gaps; minimal support
		Coracohumeral	Provides anterior support
		Glenohumeral	Discrete capsular thickenings; 3 ligaments: superior, middle, inferior- strongest
		Glenoid labrum	Increases surface area depth of glenoid. Injuries: SLAP lesion/Bankart lesion
		Transverse humeral	Holds biceps (LH) tendon in groove
Sternoclavicular	Double sliding	Capsule	
		Anterior and Posterior SC ligaments	Posterior stronger; Anterior dislocation more common
		Interclavicular	
		Costoclavicular	Strongest SC ligament
Acromioclavicular [AC joint]	Plane/Gliding	Capsule has a disc in joint;	
		Acromioclavicular	Horizontal stability; torn in Grade II AC injury
		Coracoacromial	Can cause impingement
		Coracoclavicular	Vertical stability; torn in Grade III AC injury
		Trapezoid	Anterior/lateral position
		Conoid	Posterior/medial position; stronger
Scapulothoracic	not an articulation	Allows scapula to move along the posterior rib cage.	
Other ligaments		Superior transverse	Separates Suprascapular Artery



STRUCTURE	FUNCTION
-----------	----------

MUSCLES	
---------	--

<b>ROTATOR CUFF</b>	Holds humeral head in glenoid
---------------------	-------------------------------

Supraspinatus	Most commonly torn tendon
---------------	---------------------------

Infraspinatus	
---------------	--

Teres Minor	
-------------	--

Subscapularis	Anterior support
---------------	------------------

LIGAMENTS	
-----------	--

Capsule	Rotator cuff tendons fused to it
---------	----------------------------------

Glenohumeral	Superior: resists inferior translation
--------------	--

	Middle: resists anterior translation
--	--------------------------------------

	Inferior: resists ant/inf translation
--	---------------------------------------

Coracohumeral	Resists post/inferior translation
---------------	-----------------------------------

Labrum	Deepens glenoid
--------	-----------------

**MINOR PROCEDURES**

**STEPS**

**INJECTION OF THE ACROMIOCLAVICULAR (AC) JOINT**

1. Ask patient about allergies
2. Palpate clavicle distally to AC joint (sulcus)
3. Prepare skin over AC joint (iodine/antiseptic soap)
4. Anesthetize skin with local (quarter size spot)  
Use 21 gauge or smaller, insert needle into joint vertically. Aspirate to ensure not in a vessel, then inject 2ml of 1:1 local/ corticosteroid preparation into AC joint. (You will feel the needle "pop/give" into the joint)
6. Dress injection site

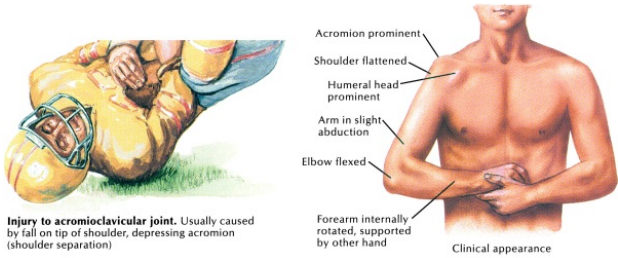
**INJECTION OF SUBACROMIAL SPACE**

1. Ask patient about allergies
2. Palpate the acromion: define it's borders
3. Prepare skin over shoulder (iodine/antiseptic soap)
4. Anesthetize skin with local (quarter size spot)  
Hold finger (sterile glove) on acromion, insert needle under posterior acromion w/cephalad tilt. Aspirate to ensure not in a vessel, then inject 5-10cc of preparation-will flow easily if in joint). Use:
  - a. diagnostic injection: local only
  - b. therapeutic injection: local/corticosteroid 5:1
6. Dress injection site

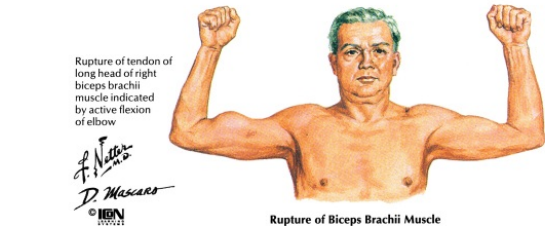
**GLENOHUMERAL ARTHROCENTESIS**

1. Palpate the coracoid process/humeral head
2. Prepare skin over shoulder (iodine/antiseptic soap)
3. Anesthetize skin (quarter size spot)
4. Abduct arm/downward traction (by an assistant)
5. Insert needle between humeral head and coracoid process
6. Synovial fluid should aspirate easily
7. Dress insertion site

HISTORY



**Injury to acromioclavicular joint.** Usually caused by fall on tip of shoulder, depressing acromion (shoulder separation)



**Rupture of Biceps Brachii Muscle**

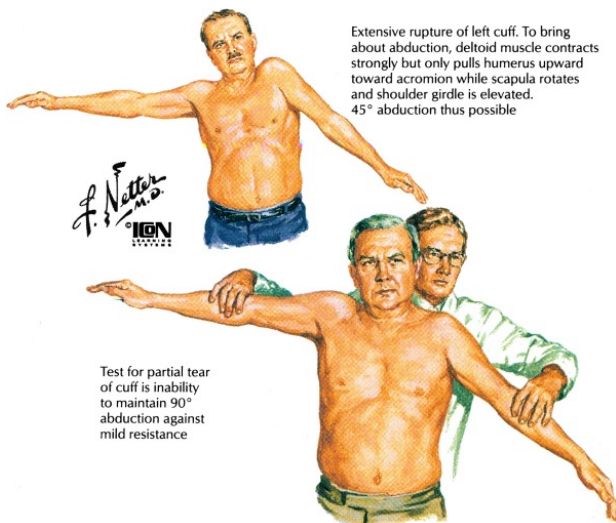
QUESTION	ANSWER	CLINICAL APPLICATION
1. AGE	OLD YOUNG	Rotator cuff tear/impingement, arthritis (OA), adhesive capsulitis (frozen shoulder), humerus fracture (after trauma)  Instability, AC injury, osteolysis, impingement in athletes
PAIN  2. a. Onset b. Location c. Occurrence d. Exacerbating /relieving	Acute Chronic On top/AC joint Night pain Overhead worse Overhead better	Fracture, rotator cuff tear, acromioclavicular injury, dislocation Impingement, arthritis AC joint arthrosis Classic for Rotator Cuff tear, tumor Rotator Cuff tear Cervical radiculopathy
3. STIFFNESS	Yes	Osteoarthritis, adhesive capsulitis
4. INSTABILITY	"Slips in and out"	Dislocation: 90% anterior - occurs with abduction external rotation (e.g. throwing motion)
5. TRAUMA	Direct blow Fall on outstretched hand	Acromioclavicular injury Glenohumeral dislocation
	Overhead usage	Osteolysis (distal clavicle)

6. WORK/ACTIVITY	Weight lifting Athlete: throwing type Long term manual labor	Rotator cuff tear/impingement Arthritis (OA)
7. Neurologic Symptoms	Numbness/tingling/ "heavy"	Thoracic outlet syndrome, brachial plexus injury
8. PMHx	Cardiopulmonary/GI	Referred pain to shoulder

PHYSICAL EXAM

EXAM	TECHNIQUE/FINDINGS	CLINICAL APPLICATION
INSPECTION		
Symmetry	Compare both sides	
Wasting	Loss of contour/muscle mass	Rotator Cuff tear
Gross deformity	Superior displacement	Acromioclavicular injury (separation)
Gross deformity	Anterior displacement	Anterior dislocation (glenohumeral joint)
Gross deformity	"Popeye" arm	Biceps tendon rupture (usually proximal end of long head)
PALPATION		
AC joint	Feel for end of clavicle	Pain indicates Acromioclavicular pathology
Subacromial bursa	Feel acromion-down to acromiohumeral sulcus	Pain: bursitis and/or supraspinatus tendon rupture
Coracoclavicular ligament	Feel between acromion coracoid	Pain indicates impingement
Greater tuberosity	Prominence on lateral humeral head	Pain indicates Rotator Cuff tendinitis
Biceps tendon	Feel proximal insertion on humerus	Pain indicates biceps tendinitis
RANGE OF MOTION		
Forward flexion	Arms from sides forward	0-160° normal
Abduction	Arms from sides outward	0-160/180° normal
Internal rotation	Reach thumb up back-note level	Mid thoracic normal-compare sides
External rotation	<div><div>1. Elbow at side, rotate forearms lateral</div><div>2. Abduct arm to 90°, externally rotate up</div></div>	<div>30-60° normal</div> <div>External rotation decreased in adhesive capsulitis</div>
Rotator Cuff tear: AROM decreased, PROM ok, Adhesive Capulitis: both are decreased		
NEUROVASCULAR		
Sensory	Light touch, pin prick, 2 pt	
Supraclavicular nerve (C4)	Superior shoulder/ clavicular area	Deficit indicates corresponding nerve/root lesion
Axillary nerve (C5)	Lateral shoulder	Deficit indicates corresponding nerve/root lesion
T2 segmental nerve	Axilla	Deficit indicates corresponding nerve/root lesion
Motor		
Spinal accessory (CN11)	Resisted shoulder shrug	Weakness = Trapezius or corresponding nerve lesion.
Suprascapular (C5-6)	Resisted abduction	Weakness = Supraspinatus or corresponding nerve/root lesion.
	Resisted external rotation	Weakness = Infraspinatus or corresponding nerve/root lesion.
Axillary nerve (C5)	Resisted abduction	Weakness = Deltoid or corresponding nerve/root lesion.
	Resisted external rotation	Weakness = Teres minor or corresponding nerve/root lesion.
Dorsal scapular	Shoulder shrug	Weakness = Lev Scap/Rhomboid or

nerve (C5)	Shoulder shrug	nerve/root lesion.
Thoracodorsal nerve (C7-8)	Resisted adduction	Weakness = Latissimus dorsi or nerve/root lesion.
Lateral pectoral nerve (C5-7)	Resisted adduction	Weakness = Pectoralis major or corresponding nerve/root lesion.
U/L subscapular nerve (C5-6)	Resisted internal rotation	Weakness = Teres min or subscapularis or nerve/root lesion.
Long thoracic nerve (C5-7)	Scapular protraction /reach	Weakness = Serratus anterior or nerve/root lesion

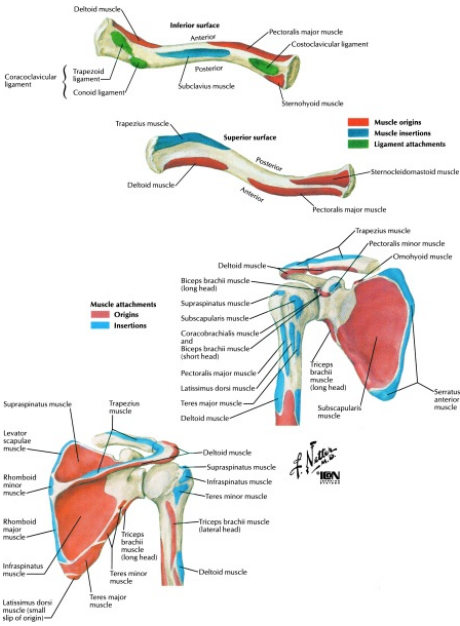


EXAM	TECHNIQUE/FINDINGS	CLINICAL APPLICATION
SPECIAL TESTS		
Supraspinatus (empty can)	Bilateral: 30° add, 90° FF, IR, resist down force	Weakness indicates Rotator cuff (supraspinatus) tear, impingement
Drop Arm	Passively abduct 90°, lower slowly	Weakness or arm drop indicates rotator cuff tear
Lift off	Hand behind back, push posteriorly	Weakness or inability indicates subscapularis rupture
Speed	Resist forward flexion of arm	Pain indicates biceps tendinitis
Yergason	Hold hand, resist supination	Pain indicates biceps tendinitis, biceps tendon subluxation
Impingement sign (Neer)	Forward flex greater than 90°	Pain indicates Impingement Syndrome
Hawkins sign	Forward flex 90°, elbow @ 90°, then IR	Pain indicates Impingement Syndrome
Cross Body Adduction	90° Forward flex then adduct arm across body	Pain indicates Acromioclavicular pathology, Decreased ROM indicates tight posterior capsule
AC Shear	Cup hands over clavicle/scapula: then squeeze	Pain/movement indicates AC pathology



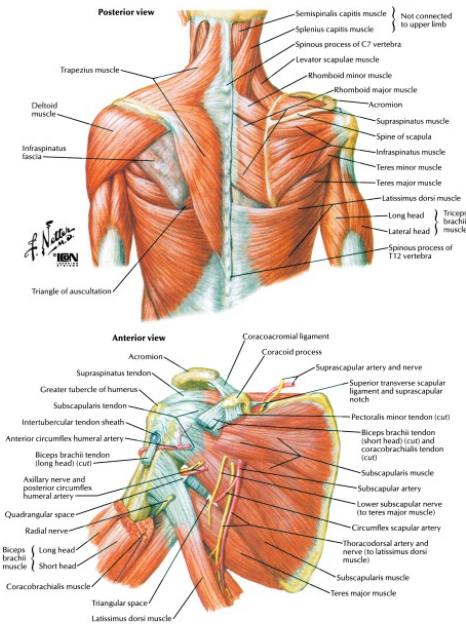
Active Compression (O'Brien's)	90°FF, max IR, then adduct/flex	Pain or pop indicates a SLAPlesion
Load and shift	Push into glenoid, translate ant/post	Motion indicates instability in that direction (anterior vs. posterior)
Apprehension sign	Throwing position- continue to externally rotate	Apprehension indicates anterior instability
Relocation (Jobe)	90°abd, full ER, posterior force on humeral head	Relief of pain/apprehension, or increased externalrotation indicates anterior instability
Posterior Apprehension sign	FF 90°,internally rotate, posterior force	Apprehension indicates posterior instability
Inferior instability	Abd 90°, downward force on mid- humerus	Slippage of humeral head or apprehension: inferior instability or Multidirectional instability
Sulcus sign	Arm to side, downward traction	Increased acromiohumeral sulcus: inferior instability or <b>Multidirectional instability</b>
Adson	Palpate radial pulse, rotate neck to ipsilateral side	Reproduction of symptoms indicates thoracic outlet syndrome
Roo (EAST)	Bilateral arm: abduct/ER, open and close fist 3 minutes	Reproduction of symptoms indicates thoracic outlet syndrome
Spurling	Lateral flex/axial compression of neck	Reproduction of symptoms indicates cervical disc pathology

MUSCLES: INSERTIONS AND ORIGINS



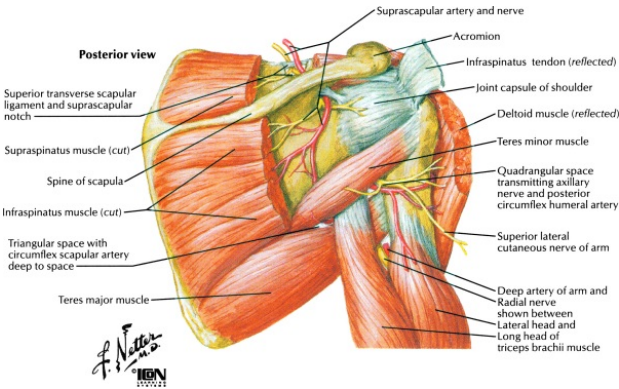
CORACOID PROCESS	GREATER TUBERCLE	ANTERIOR PROXIMAL	MEDIAL EPICONDYLE	LATERAL EPICONDYLE
ORIGINS	INSERTIONS	INSERTIONS	ORIGINS	ORIGINS
Biceps (SH)	Supraspinatus	Pectoralis major	Pronator Teres	Anconeus
Coracobrachialis	Infraspinatus	Latissimus dorsi	Common Flexor	Common. Extensor
INSERTIONS	Teres minor	Teres major	Tendon [FCR, PL,	Tendon [ECRB, ED,
Pectoralis minor			FCU, FDS]	EDM, ECU]

MUSCLES: BACK/SCAPULA REGION



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Trapezius	C7-T12 spinous process	Clavicle, Acromion spine of scapula	Cranial nerve XI	Elevate rotate scapula	Connect UE to spine
Latissimus dorsi	T7-T12, iliac crest	Humerus (intertubercular groove)	Thoracodorsal	Adduct, extend arm, IR humerus	Connect UE to spine
Levator scapulae	C1-C4 transverse process	Superior medial scapula	Dorsal scapular/ C3-4	Elevates scapula	Connect UE to spine
Rhomboid minor	C7-T1 spinous process	Medial scapula (at the spine)	Dorsal scapular	Adduct scapula	Connect UE to spine
Rhomboid major	T2-T5 spinous process	Medial scapula	Dorsal scapular	Adduct scapula	Connect UE to spine

MUSCLES: ROTATOR CUFF

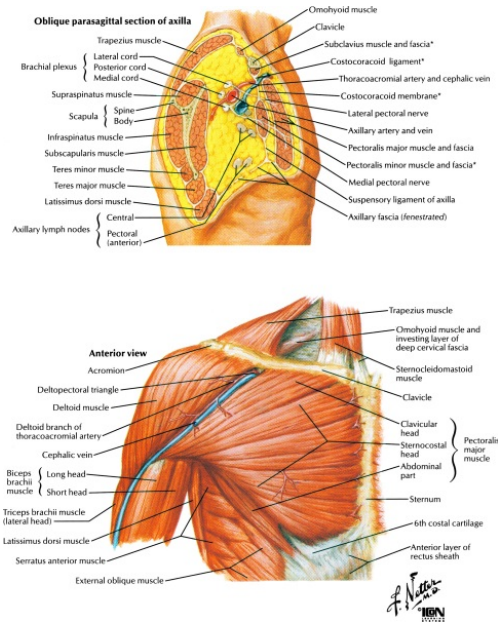


SPACE	BORDERS	STRUCTURES
Triangular Space	Teres Minor	Circumflex Scapular Artery
	Teres Major	
	Triceps (Long Head)	
Quadrangular Space	Teres Minor	Axillary Nerve
	Teres Major	Posterior Circumflex Artery
	Triceps (Long Head)	Humeral Artery
Triangular Interval	Triceps (Lateral Head)	
	Teres Major	Radial Nerve
	Triceps (Long Head)	Deep Artery of Arm
	Triceps (Lateral Head)	

MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Deltoid	Clavicle, Acromion spine of scapula	Humerus (Deltoid tuberosity)	Axillary	Abduct arm	Atrophy: Axillary nerve damage
Teres major	Inferior angle of the scapula	Humerus (intertubercular groove)	Lower subscapular	IR, adduct arm	Protects radial nerve in posterior approach
Rotator Cuff(4)					
1.Supraspinatus	Supraspinatus fossa (scapula)	Greater tuberosity (superior)	Suprascapular	Abduct arm (initiate),	Trapped in impingement #1 torn tendon (RC tear)
2.Infraspinatus	Infraspinatus fossa (scapula)	Greater tuberosity (middle)	Suprascapular	ER arm, stability	Weak ER: damage to nerve. lesion in notch
					Dislocation

3.Teres Minor	Lateral scapular	Greater tuberosity (inferior)	Axillary	ER arm, stability	Dissection can damage circum-flex vessels
4.Subscapularis	Subscapular fossa (scapula)	Lesser tuberosity	Upper Lower Subscapular	IR, adduct arm, stability	<b>Can rupture in anterior dislocation</b>

MUSCLES: DELTOID/PECTORAL REGION



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Deltoid	Clavicle, Acromion, spine of scapula	Humerus (Deltoid tuberosity)	Axillary	Abduct arm	<b>Atrophy: Axillary nerve damage</b>
Pectoralis major	1.Clavicle 2.Sternum	Humerus (intertubercular groove)	Lateral/medial pectoral	Adducts arm, IR humerus	<b>Can rupture during weight lifting</b>
Pectoralis minor	Ribs 3-5	Coracoid process (scapula)	Medial pectoral	Stabilizes scapula	Divides Axillary artery into 3 parts
Serratus anterior	Ribs 1-8 (lateral)	Scapula (antero-medial border)	Long thoracic	Holds scapula to chest wall	Paralysis indicates wing scapula
Subclavius	Rib 1 (and costal cartilage)	Clavicle (inferior border/mid 3rd)	Nerve to subclavius	Depresses clavicle	Cushions sub-clavian vessels

- C5-T1 ventral rami Variations: C4 (prefixed) T2 (post-fixed)
- Rami (Roots), Trunks, Divisions, Cords, Branches (**Rob Taylor Drinks Cold Beer**)

Supraclavicular (rami trunks) portion in posterior triangle of neck **Rami exit**

- **between Anterior Medial Scalene**, then travel with Subclavian artery in axillary sheath

Divisions occur under (posterior) to clavicle and subclavius muscle

- Anterior Divisions: Flexors
- Posterior Divisions: Extensors

- Infraclavicular (cords branches) portion in the axilla

Dorsal scapular nerve (C5)

Suprascapular nerve (C5, 6)

Axillary nerve (C5, 6)

Superior lateral cutaneous nerve of arm

Radial nerve (C5, 6, 7, 8, T1)

Inconstant contribution

*F. Netter M.D.*  
*C. Machado M.D.*  
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1. **Spinal Accessory** (CN11,C1-C6): in posterior cervical triangle on levator scapulae

Sensory: NONE

Motor: Trapezius, Sternocleidomastoid

## CERVICAL PLEXUS

2. **Supraclavicular**(C2-3): splits into 3: anterior middle, posterior branches

Sensory: over clavicle, outer trap, deltoid

Motor: NONE

## BRACHIAL PLEXUS

SUPRACLAVICULAR  
 [approach through posterior triangle]

INFRACLAVICULAR [approach through axilla]

## LATERAL CORD

## ROOTS

•Lateral root to Median nerve

3. **Dorsal Scapular** (C3, 4, 5): pierces middle scalene, deep to Levator

7. **Lateral Pectoral**(C5-7): named for cord, runs with pectoral artery

Sensory: NONE

Scapulae

Motor: Pectoralis Major

Sensory: NONE

Pectoralis Minor

Motor: Levator scapulae

## MEDIAL CORD

Rhomboid Minor and Major

•Medial root to Median nerve

4. **Long Thoracic**(C5-7): on anterior surface of Serratus Anterior. Runs with lateral thoracic artery

8. **Medial Pectoral**(C8-T1): named for cord

Sensory: NONE

Motor: Pectoralis Minor

Sensory: NONE

Pectoralis Major (overlying muscle)

Motor: Serratus Anterior

## POSTERIOR CORD

## UPPER TRUNK

9. **Upper Subscapular**(C5-6)

5. **Suprascapular**(C5-6): thru scapular notch, under ligament

Sensory: NONE

Motor: Subscapularis [upper portion]

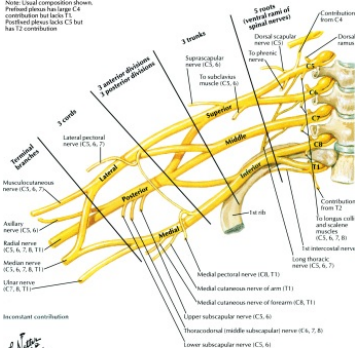
Sensory: Shoulder joint

10. **Lower Subscapular**(C5-6)

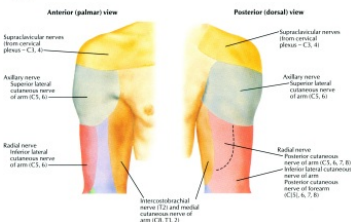


Motor:	Supraspinatus	Sensory:	NONE
	Infraspinatus	Motor:	Subscapularis [lower portion]
<b>6. Nerve to Subclavius (C5-6):</b> descends anterior to plexus, posterior to clavicle			Teres major
		<b>11. Thoracodorsal(C7-8):</b> runs with thoracodorsal artery	
		Sensory:	NONE
Sensory:	NONE	Motor:	Latissimus dorsi
<b>Motor:</b> Subclavius		<b>12. Axillary(C5-6):with posterior circumflex humeral artery</b> through Quadranglar space. <b>Injured in Anterior dislocations, or proximal humerus fractures</b>	
		Sensory:	Lateral upper arm: via Superior Lateral Cutaneous Nerve of arm
		Motor:	Deltoid: via deep branch
			Teres minor: via superficial branch

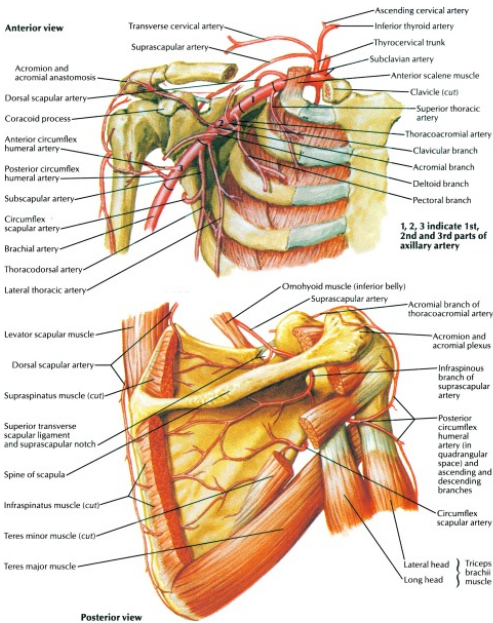
Note: Usual composition shown.  
Posterior plexus has large C4 contribution but lacks T1.  
Posterior plexus lacks C3 but has T2 contribution



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ARTERIES



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TRUNK	BRANCH	COURSE/COMMENT
Thyrocervical Trunk	Suprascapular	Over superior transverse scapular ligament.
	Infraspinatus branch	Bends around spine of scapula
Subclavian artery comes off: Left - aorta, Right - brachiocephalic. Then goes between anterior and middle scalene muscles with brachial plexus		
Subclavian Artery	Dorsal Scapular	Splits around levator scapulae; descends medial to scapula
<b>Parts determined by pectoralis minor. Part I of the axillary artery has 1 branch, Part II has 2 branches, Part III has 3 branches</b>		
Axillary (Part I)	Superior thoracic	To serratus anterior and pectoralis muscles
Axillary (Part II)	Thoracoacromial	
	Clavicular branch	
	Acromial branch	
	Deltoid branch	Courses with basilic vein
	Pectoral branch	
Axillary (Part III)	Lateral thoracic	To serratus anterior with Long Thoracic nerve.
	Subscapular	

	Circumflex scapular	Seen posteriorly in Triangular space
	Thoracodorsal	Follows Thoracodorsalnerve
	Anterior circumflex	Supplies humeral head ( anterior humerus)
	Posterior circumflex	<b>Seen posteriorly in Quadrangular space. Injury in proximal humeral fracture.</b>

DISORDERS

DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
ADHESIVE CAPSULITIS (FROZEN SHOULDER)			
•Inflammatoryprocess; leads to joint fibrosis	Hx: Middle age women, DM Slow onset: pain/stiffness	XR: Usually normal	1.NSAIDs
		Arthrogram: <b>decreased joint volume.</b>	2.Physical therapy and home therapy program (3 month minimum)
•3 stages: 1. Pain, 2. Stiffness3. Resolving;	PE: <b>Decreased active ROM</b> <b>passive ROM</b>		
•Associated with old Colles fracture			
ARTHRITIS:ACROMIOCLAVICULAR (AC) JOINT			
•Usually osteoarthritis	Hx: Pain at AC, esp. with motion	XR: Osteophytes, joint narrowing	1.NSAIDs, rest
			2.Distal clavicle resection (Mumford)
	PE: Tender to palpation		
ARTHRITIS:GLENOHUMERAL JOINT			
•Multiple etiologies: OA, RA, post-traumatic	Hx: Older, pain increases with activity	XR: True AP,axillary lateral: joint space narrowed	1. NSAIDs, ice/heat, ROM steroid inject controversial
•Often overuse condition	PE: +/- wasting, crepitus, decreased AROM		2.Refractory: hemi vs.total joint arthroscopy
BICEPS TENDINITIS			
•Associated with impinge- ment or subluxation/transverse humeral ligament tear	Hx : Pain in shoulder	XR: Normal views: usually normal	1.Treat the impingement
	PE: Tenderness along groove		2.Biceps strengthening
	+Speed, + Yergason		3.Tenodesis (rare procedure)
BICEPS TENDON RUPTURE			
•Long Head of biceps rupture	Hx: Old, or young weight lifter, sudden pain	XR: Normal; rule out fracture	1.Old: conservative treatment
		Arthrogram: rule out RC tear	2.Young/laborer: surgery
•Due to impingement, micro- trauma or trauma	PE: Proximal arm bulge (Popeye arm)		
•Associated with RC tear			
BRACHIAL PLEXUS INJURY			
•Traction of brachial plexus	Hx: Football players, parathesias in	XR: Shoulder series: normal	Most resolve with rest

arm

## BURSITIS: SUBACROMIAL

•Often from impingement	Hx/PE: Pain at shoulder		Treat the impingement
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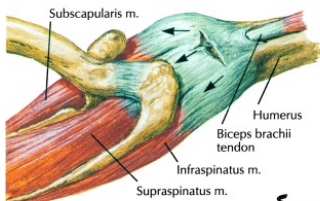
## IMPINGEMENT

•RC (supraspinatus), Biceps tendon trapped under acromion or coracoacromial ligament	Hx: Older, or athlete. Pain/inability to do overhead activity.	XR: Normal views <b>+outlet view:</b> type III acromion or subacromial spur	<ol style="list-style-type: none"> <li>1. Decrease/modify activity</li> <li>2. NSAID, ROM, strengthen</li> <li>3. Corticosteroid injection</li> <li>4. Subacromial decompression</li> </ol>
•Associated with Type III acromion	PE: +Neer, +Hawkins		

## INSTABILITY/DISLOCATION: GLENOHUMERAL JOINT TWO TYPES

1. TUBS [Trauma Unilateral Bankart lesion, Surgery]	Hx: Pain, "arm slips out" TUBS history	XR: Trauma (+/- Stryker) Bankart/Hill Sachs lesion	1. Reduce (if dislocated): 3 ways. Immobilize in IR for 4 weeks, RC strengthening, then ROM
•90% anterior (posterior after seizure)	PE: +PE for unilateral instability (e.g. +	Axillary nerve injury (esp. with anterior)	
•Pts 20yrs: 80% recur	Apprehension, relocation)		2. Surgical repair for recurrence (not in posterior)
2. AMBRI A traumatic Multi- directional, Bilateral, Rehab responsive, Inferior capsule repair	Hx: Pain, "arms slip out" + AMBRI history	XR: Trauma series	1. Reduce if dislocated: 3 ways 2. Long term conservative treatment
	PE: +sulcus, general joint laxity in MDI		3. Life style modifications

## Rotator Cuff Tear



Acute rupture (superior view). Often associated with splitting tear parallel to tendon fibers. Further retraction results in crescentic defect as shown at right

*J. Netter M.D.*  
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Communication between shoulder joint and subdeltoid bursa is pathognomonic of cuff tear

## DESCRIPTION

## H P

## WORK-UP/FINDINGS

## TREATMENT

## INSTABILITY/DISLOCATION: STERNOCLAVICULAR JOINT

•Tear of capsule

Hx: Large force: sports/MVA, pain (anterior: ant prominence, posterior: +/- pulm,

XR: May not show injury

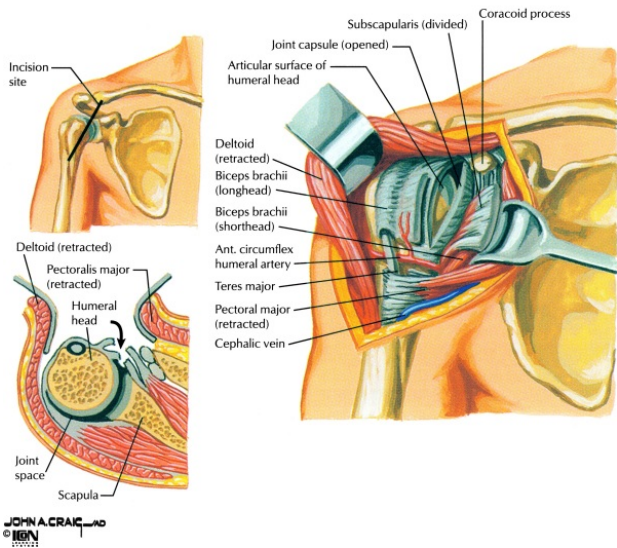
Anterior: sling/closed reduction

•Most anterior; Posterior rare, has increased Complications (great vessels)	GI)	CT: Helpful in diagnosis	Posterior: early closed reduction immobilize, PT
LABRUM INJURY (SLAP LESION)			
Bicep tendon attachment injury I. Bicep fraying/anchor intact II. Tear in anchor (labrum) III. Bucket handle tear IV. III 1 tear in bicep	Hx: Pain, 1/2 instability symptoms PE: 1 O'Brien test	XR: Shoulder series MR/Arthroscopy to diagnose SLAP lesion	By type: I. Debridement II. Reattachment III. Debridement IV. Repair vs. tenodesis
LONG THORACIC NERVE INJURY			
•Nerve injury results in serratus anterior dysfunction	Hx: Usually trauma PE: Winged scapula	NONE	Conservative treatment, most resolve within weeks/ months
OSTEOLYSIS			
•Often in weight- lifters	Hx: Pain in shoulder	XR: Distal clavicle lucency	1. Activity modification.
			2. Mumford
PECTORALIS MAJOR RUPTURE			
•Maximal eccentric contraction	Hx/PE: Sudden, pain, palpable defect	NONE	Surgical repair
ROTATOR CUFF TEAR			
•Due to poor vascularity, overuse, micro or macro trauma, degeneration, or abnormal acromion	Hx: Older; pain is deep at night, worse with overhead activity	XR: Trauma series: high- riding humerus	1. Conservative: NSAID, rest, activity modification, ROM, RC strengthening
•Supraspinatus most common	PE: Atrophy, decreased AROM, normal PROM, + drop arm/empty can, +lift off (subscapular tear)	Arthrogram (or MR/Arthrogram): Gold standard: shows communication with subdeltoid bursa	2. Surgical repair with subacromial decompression for complete tears
THORACIC OUTLET SYNDROME			
•Compression of neuro- vascular structure (vein, artery, or plexus) between first rib and scalene muscle•Also seen with cervical ribs	Hx: Women 20-50 yo. Worse with overhead activity Vein: edema, discolor, stiff Artery: cool, claudication Plexus: parathesias	XR: Shoulder usually normal C- spine: Rule out mass CXR: Rule out mass	1. Activity modification (until symptoms resolve) 2. Posture training 3. Surgery: especially for a cervical rib
	PE: +Adson, +Roos tests		

---

SURGICAL APPROACHES

Deltopectoral Approach to Shoulder Joint



USES	INTERNEUROUS PLANE	DANGERS	COMMENT
ANTERIOR (DELTOPECTORAL) APPROACH (HENRY)			
1.Shoulder reconstruction	1.Deltoid [Axillary]	1.Musculocutaneous nerve	1.Keep arm adducted to avoid bringing brachial plexus into the field.
2.Biceps tendon repair.	2.Pectoralis major [lat/med pectoral]	2.Cephalic vein	
3.Arthroplasty		3.Axillary nerve	
			2.Keep dissection to lateral side of coracobrachialis: protect MC nerve.
ARTHROSCOPY PORTALS			
1.Anterior	"Soft spot" between biceps tendon, anterior glenoid, superior edge of subscapular tendon	1.Musculocutaneous nerve	1.Usually placed AFTER the posterior portal
		2.Cephalic vein	
		3.Axillary nerve	
2.Posterior	"Soft spot"between teres minor and infraspinatus	1.Superior AC ligament	1.Primary portal for shoulder
		2.RC tendons	2.Aim to coracoid when placing



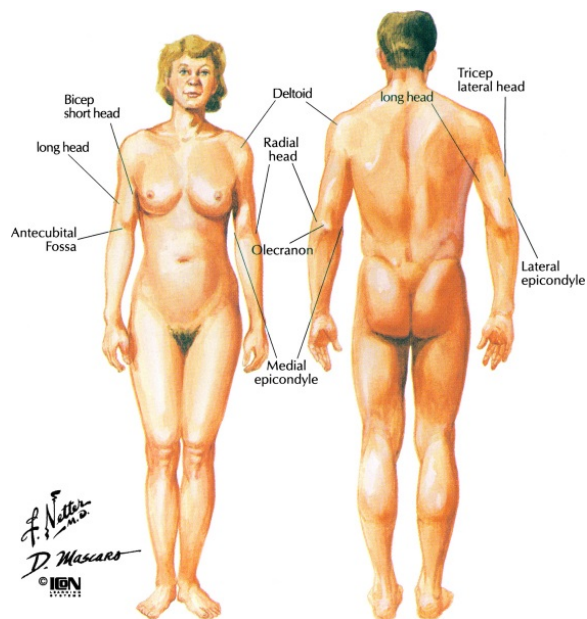
3.Lateral	Through deltoid	1.Axillary nerve	1.To access subacromial space
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## CHAPTER 3 - ARM

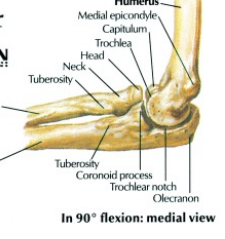
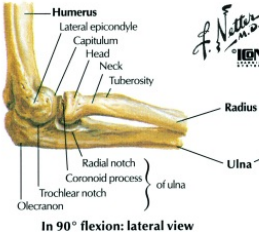
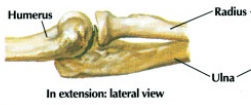
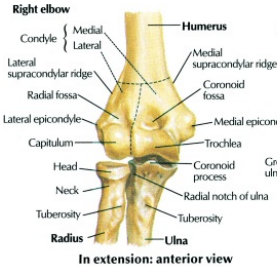
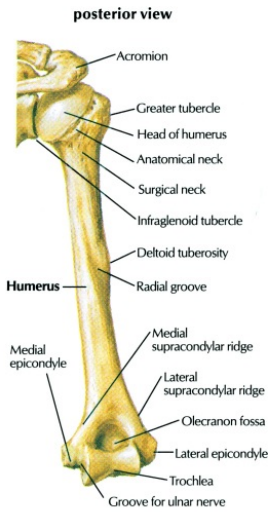
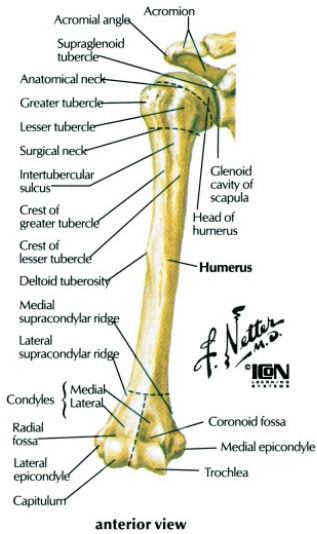
- [TOPOGRAPHIC ANATOMY](#)
- [OSTEOLOGY](#)
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- [HISTORY](#)
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## CHAPTER 3 – ARM

### TOPOGRAPHIC ANATOMY










OSTEOLOGY



CHARACTERISTICS	OSSIFY	FUSE		COMMENT
HUMERUS				
• Long bone characteristics	Primary: Shaft	8-9 <sup>th</sup> wk (fetal)	By birth	• Surgical neck: common fracture site
• Lateral condyle				• Blood supply
1. Epicondyle: non-articular	Secondary Proximal (3):			Proximal: Anterior/Posterior circumflex
2. Capitellum: articular	1. Head		17-20 yrs	Middle: Nutrient artery (from Deep artery)
• Medial condyle	2. Tuberosities (2)	Birth		
1. Epicondyle: non-articular		3-5 yrs		Distal: Branches from anastomosis
2. Trochlea: articular				• Elbow ossification order: Capitellum, Radial head, Medial epicondyle, Trochlea, Olecranon, Lateral epicondyle ( <b>Captain Roy Makes Trouble On Leave</b> )
3. Cubital tunnel: covered with Osbourne's fascia.	Distal (4):			
	1. Capitellum	1 yr		
	2. Medial epicondyle	4-6 yr	13-14 yrs	
	3. Trochlea	9-10 yr		
	4. Lateral epicondyle	12 yr	15-20 yrs	

TRAUMA

Neer Classification of Proximal Humerous Fractures		
2 Part	3 Part	4 Part
Anatomical neck 		
Surgical neck 		
Greater tuberosity 	Greater tuberosity 	Greater and lesser tuberosity 
Lesser tuberosity 	Lesser tuberosity 	

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
PROXIMAL HUMERUS FRACTURE			
• Common fracture	HX: Fall/trauma. Pain worse with movement	Neer: based on number of fragments(parts) 1-4	1 part: sling, early motion.
• Osteoporosis, elderly, female	PE: Swelling, ecchymosis, good neurovascular exam	Multiple combinations of fractures possible	2 part: closed reduction splint. Irreducible, intraarticular anatomic neck fx: ORIF. Greater tuberosity fx: ORIF and Rotator Cuff repair
• Mechanism:			
1. Elderly: fall on outstretched hand	XR: Trauma series	Also fracture dislocation, and intraarticular fx	3 4 part : ORIF or hemiarthroplasty (elderly)
	CT: shows intraarticular glenoid involvement		
2. Young: high energy trauma (e.g. MVA, fall)	MR: sensitive for AVN	4 parts: head, shaft, greater and lesser tuberosities	Fracture/Dislocation:
• 80% non or minimally displaced (1 part fx)		Each part: 1cm displaced or 45° angulated	2 part: closed treatment except when displaced
• Most heal well			3-4 part: ORIF or hemiarthorplasty

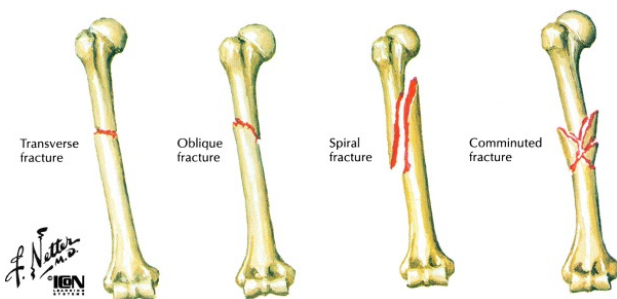
• Early pendulum motion is key for full ROM

Fragment displacement due to attached muscle

Intraarticular: ORIF or hemiarthroplasty

COMPLICATIONS: Stiffness/adhesive capsulitis; Avascular necrosis (AVN); 4 part anatomic neck, axillary nerve and brachial plexus injury; axillary artery injury, nonunion

### Humerus Shaft Fractures



DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
HUMERUS SHAFT FRACTURE			
• Common fracture	HX: Trauma, fall. Severe pain, swelling	Descriptive:	Closed: Most fractures: coaptation splint or fracture brace for 6-8 weeks
• Mechanism: direct blow or fall on outstretched arm	PE: Swelling, deformity + / - radial nerve findings	Location: level of humerus	Open Neurovascular injury, multitrauma, pathologic fracture. Severe comminution requires plates/screws or intermedullary (IM) nail
• Displacement based on fracture site relation to deltoid pectoralis major insertion	XR: AP lateral arm, shoulder and elbow series	Pattern: oblique, spiral, transverse	
• Almost 100% union		Displacement or comminution	
• Site of pathologic fx			
COMPLICATIONS: Radial nerve injury (esp. Holstein/Lewis fracture, spiral fracture of distal third) most resolve. Malunion is rare.			
DISTAL HUMERUS FRACTURE			
• Uncommon	HX: Pain, deformity, discoloration, swelling	Displaced vs. nondisplaced	Early motion important to avoid loss of motion
• High morbidity	PE: Swelling, ecchymosis crepitus, tenderness, good neurovascular exam	Multiple types:	Intercondylar: ORIF or total joint arthroplasty (closed treatment if comminuted or elderly)
• Often intraarticular	XR: AP lateral: posterior fat pad/sail sign	Intercondylar	Transcondylar: reduce, percutaneous pinning
• Mechanism: fall onto hand, ulna forced into humerus	CT: Optional: useful in pre-operative planning	Transcondylar	Others:

• Intercondylar most common in adults		Supracondylar	Nondisplaced: closed treatment; 10-14 days and early motion.
• Condylar, capitellum, Trochlea, Epicondylar all rare		Condylar	Displaced or comminuted (or elderly) require ORIF
		Capitellum	
		Trochlea	
		Epicondylar (medial or lateral)	

COMPLICATIONS: Stiffness/arthritis; Compartment syndrome; Median/Ulnar nerve injury; Brachial artery injury; Nonunion

### Supracondylar Fractures



**Extension type**  
Posterior displacement of distal fragment (most common)



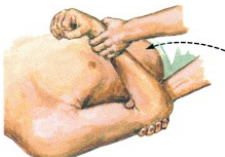
Lateral radiograph



**Flexion type**  
Anterior displacement of distal fragment (uncommon)



**Supracondylar Fracture**  
Examiner grasps patient's wrist and applies traction to forearm; assistant supplies countertraction.



**Elbow Dislocation (Posterior)**  
With other hand, apply gentle downward pressure on proximal forearm to release coronoid process from olecranon fossa. While maintaining traction, gently flex the elbow. A slight "click" is usually heard as reduction occurs. Check neurovascular status.

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
SUPRACONDYLAR FRACTURE			
• Common childhood fracture	HX: Fall. Pain, swelling, will not use arm.	Extension (common): Undisplaced Partially displaced Fully displaced	Neurovascularly intact: closed reduction and percutaneous pinning under general anesthesia (fluoroscopy)
• Occurs at metaphysis, above growth plate	PE: Swelling, point tenderness, + / - neurovascular signs: check distal pulses do neurologic exam	Flexion (rare)	Pulseless/Perfused: same
• Extension type			



most common(90%): shaft is anterior, distal fragment is posterior	XR: AP lateral (note capitellum position to anterior humeral line)	Pulseless/Unperfused: open reduction exploration
• Associated with significant morbidity; prompt treatment essential.	Arteriogram: if pulseless	

COMPLICATIONS: Neurovascular injury: brachial artery; AIN injury; Compartment syndrome can lead to Volkmann's ischemic contracture; Deformity: cubitus varus

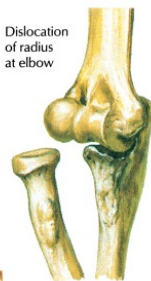
## Elbow Dislocation



Posterior dislocation of elbow with disruption of ligaments of posterior capsule. Note prominence of olecranon posteriorly.



## Radial Head Subluxation



Dislocation of radius at elbow

*F. Netter M.D.*  
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### Reduction:

With thumb in antecubital space as a fulcrum, the forearm is supinated and flexed

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
ELBOW DISLOCATION			
• Common in children and young adults	HX: Fall/trauma. Pain, inability to flex elbow	Location of ulna (radius) Posterior (common) Posterolateral (90%) Anterior Lateral Medial	Closed reduction: + / - local anesthesia and/or conscious sedation
• Younger, sports related fall on hand	PE: Deformity, tenderness, + / - neurovascular signs. Check distal pulses neurologic exam		Splint 7days for comfort, then early ROM
• Associated with radial head fracture, brachial artery, median	XR: AP lateral: rule out fracture		Open: if unstable or with entrapped

artery, median nerve injury			bone or soft tissue
• Both collateral ligaments ruptured			
		Divergent (ulna and radius opposite)	

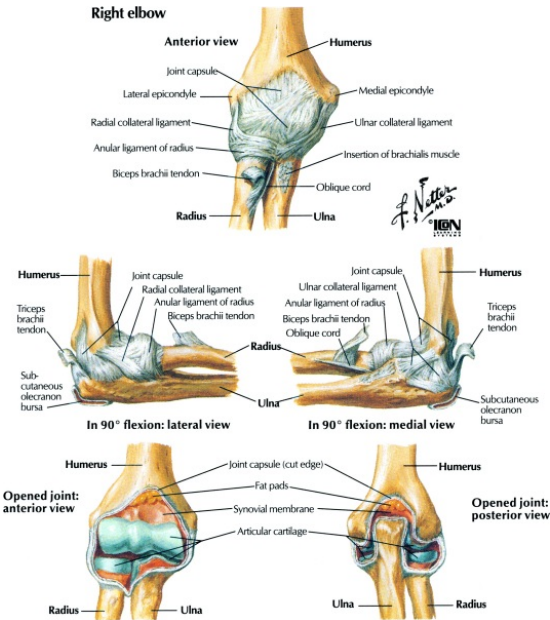
COMPLICATIONS Neurovascular injury: brachial artery; median or ulnar nerve; Loss of extension; Instability/redislocation; Heterotopic ossification

#### RADIAL HEAD SUBLUXATION (NURSEMAID'S ELBOW)

• Common in children Usually ages 2-4, 7 rare	Hx: Pulled by hand, child will not use arm.	NONE	Reduce: with gentle, full supination and flexion (should feel it "pop" in).
• Mechanism: child pulled or swung by hand or forearm	PE: Arm held pronated/flexed. Radial head supination tender.		Immobilize a recurrence
• Annular ligament stretches, radial head lodges within it.	XR: only if suspect fracture		

COMPLICATIONS: Recurrence

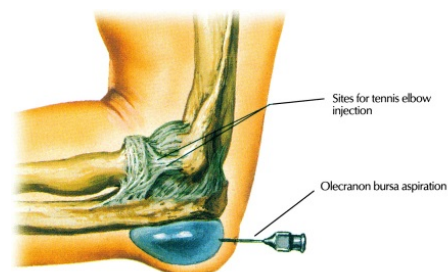
ELBOW JOINTS



JOINT	TYPE	ARTICULATION	LIGAMENTS	COMMENTS
ELBOW		Includes 3 joints	Capsule (common to all 3)	Carrying angle: 10-15° valgus
Ulnohumeral "Trochlear joint"	Ginglymus [Hinge]	Trochlea and trochlear notch	Ulnar(medial) collateral: <ol style="list-style-type: none"><li>1. Anterior band</li><li>2. Posterior band</li><li>3. Transverse band</li></ol>	Torn in posterior dislocation Strongest: resists valgus stress
Radiohumeral	Trochoid [Pivot]	Capitellum radial head	Radial (lateral) collateral: <ol style="list-style-type: none"><li>1. Ulnar part</li><li>2. Radial part</li></ol>	Weak Gives posterolateral stability
Proximal radioulnar		Radial head radial notch	Annular	Keeps head in radial notch
			Oblique cord	
			Quadrates	Supports rotary movements



## MINOR PROCEDURES



### STEPS

#### ELBOW ARTHROCENTESIS

1. Extend elbow, palpate lateral condyle, radial head and olecranon laterally; feel triangular sulcus between all three
2. Prepare skin over sulcus (iodine/antiseptic soap)
3. Anesthetize skin locally (quarter size spot)
4. May keep arm in extension or flex it. Insert needle in the "triangle" between bony landmarks
5. Fluid should aspirate easily
6. Dress injection site

#### OLECRANON BURSAASPIRATION

1. Prepare skin over olecranon (iodine/antiseptic soap)
2. Anesthetize skin locally (quarter size spot)
3. Insert 18 gauge needle into bursa and aspirate fluid.
4. If suspicious of infection, send fluid for Gram stain and culture
5. Dress injection site

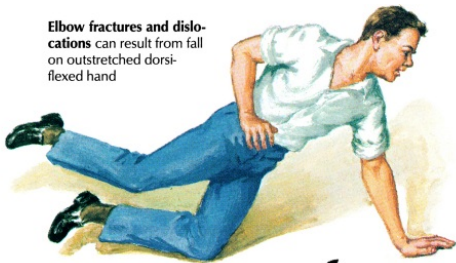
#### TENNIS ELBOW INJECTION

1. Ask patient about allergies
2. Flex elbow 90°, palpate ERCB distal to lateral epicondyle.
3. Prepare skin over lateral elbow (iodine/antiseptic soap)
4. Anesthetize skin locally (quarter size spot)

- Insert 22 gauge or smaller needle into ERCB tendon at its insertion just distal to the lateral epicondyle. Aspirate to ensure needle is not in a vessel, then inject 2-3ml of 1:1 local/corticosteroid preparation.
- 5.
  6. Dress insertion site
  7. Annotate improvement in symptoms

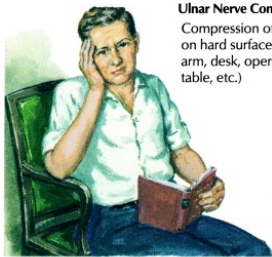
HISTORY

Elbow fractures and dislocations can result from fall on outstretched dorsiflexed hand



F. Netter M.D.  
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Ulnar Nerve Compression  
Compression of nerve on hard surface (chair arm, desk, operating table, etc.)



Numbness and tingling in ulnar nerve distribution in hand. Interosseous wasting between thumb and index finger

QUESTION	ANSWER	CLINICAL APPLICATION
1. AGE	Young	Dislocation, fracture
	Middle age, elderly	Tennis elbow (epicondylitis), arthritis
2. PAIN		
a. Onset	Acute	Dislocation, fracture, tendon avulsion/rupture, ligament injury
	Chronic	Cervical spine pathology
b. Location	Anterior	Biceps tendon rupture, arthritis
	Posterior	Olecranon bursitis
	Lateral	Lateral epicondylitis, fracture (especially radial head-hard to see on x-ray)
	Medial	Medial epicondylitis, nerve entrapment, fracture, MCL strain
c. Occurrence	Night pain/at rest	Infection, tumor
	With activity	Ligamentous and/or tendinous etiology
3. STIFFNESS	Without locking	Arthritis, effusions (trauma)
	With locking	Loose body, Lateral collateral ligament injury
4. SWELLING	Over olecranon	Olecranon bursitis. Other: dislocation, fracture, gout

5. TRAUMA	Fall on elbow, hand	Dislocation, fracture
6. ACTIVITY	Sports, repetitive motion	Epicondylitis, ulnar nerve palsy
7. NEUROLOGIC SYMPTOMS	Pain, numbness, tingling	Nerve entrapments (multiple possible sites), cervical spine pathology, thoracic outlet syndrome
8. HISTORY OF ARTHRITIDES	Multiple joints involved	Lupus, rheumatoid arthritis, psoriasis



PHYSICAL EXAM



EXAM/OBSERVATION TECHNIQUE		CLINICAL APPLICATION
INSPECTION		
Gross deformity, swelling	Compare both sides	Dislocation, fracture, bursitis
Carrying angle (normal 5-15°)	Negative ( 5 degrees)	Cubitus varus: physeal damage (e.g. malunion supracondylar fracture)
	Positive ( 15 degrees)	Cubitus valgus: physeal damage (e.g. lateral epicondyle fracture)
PALPATION		
Medial	Epicondyle supracondylar line	Pain: medial epicondylitis (Golfer's elbow), fracture, MCL rupture
	Ulnar nerve in ulnar groove	Parathesias indicate ulnar nerve entrapment
Lateral	Epicondyle supracondylar line	Pain: lateral epicondylitis (Tennis elbow), fracture
	Radial head	Pain: arthritis, fracture, synovitis
Anterior	Biceps tendon in antecubital fossa	Pain can indicate biceps tendon rupture
Posterior	Flex elbow: olecranon olecranon fossa	Olecranon bursitis, triceps tendon rupture

EXAM/OBSERVATION	TECHNIQUE	CLINICAL APPLICATION
RANGE OF MOTION		
	Elbow at side, flex/extend	Normal: 0-5° to 140-150°

Flex and extend	Elbow at side, flex/extend at elbow	Normal: 0-90 to 140-150°, note if PROM/AROM
Pronate and supinate	Tuck elbows, pencils in fists, rotate wrist	Normal: supinate 90 degrees, pronate 80-90 degrees
NEUROVASCULAR		
<b>Sensory</b>	(LT, PP, 2 pt)	
Axillary nerve (C5)	Superolateral arm	Deficit indicates corresponding nerve/root lesion
Radial nerve (C5)	Inferolateral and posterior arm	Deficit indicates corresponding nerve/root lesion
Medial Cutaneous nerve of the Arm (T1)	Medial arm	Deficit indicates corresponding nerve/root lesion
<b>Motor</b>		
Musculocutaneous n. (C5-6)	Resisted elbow flexion	Weakness = Brachialis/biceps or corresponding nerve/root lesion.
Musculocutaneous n. (C6)	Resisted supination	Weakness = Biceps or corresponding nerve/root lesion.
Median nerve (C6)	Resisted pronation	Weakness = Pronator Teres or corresponding nerve/root lesion.
Median nerve (C7)	Resisted wrist flexion	Weakness = FCR or corresponding nerve/root lesion.
Radial nerve (C7)	Resisted elbow extension	Weakness = Triceps or corresponding nerve/root lesion.
Radial nerve/PIN (C6-7)	Resisted wrist extension	Weakness = ECRL-B/ECU or corresponding nerve/root lesion.
Ulnar nerve (C8)	Resisted wrist flexion	Weakness = FCU or corresponding nerve/root lesion.
<b>Reflexes</b>		
C5	Biceps	Hypoactive/absence indicates corresponding radiculopathy
C6	Brachioradialis	Hypoactive/absence indicates corresponding radiculopathy
C7	Triceps	Hypoactive/absence indicates corresponding radiculopathy
<b>Pulses</b>	Brachial, Radial, Ulnar	
<b>SPECIAL TESTS</b>		
Tennis Elbow	Make fist, pronate, extend wrist and fingers against resistance	Pain at lateral epicondyle suggests lateral epicondylitis
Golfer's Elbow	Supinate arm, extend wrist Elbow	Pain at medial epicondyle suggests medial epicondylitis
Ligament Instability	25° flexion, apply varus/valgus stress	Pain or laxity indicates LCL/MCL damage
Tinel's Sign (at the elbow)	Tap on ulnar groove (nerve)	Tingling in ulnar distribution indicates entrapment
Elbow Flexion	Maximal elbow flexion for	Tingling in ulnar distribution

ELBOW FLEXION

3-5min

indicates entrapment

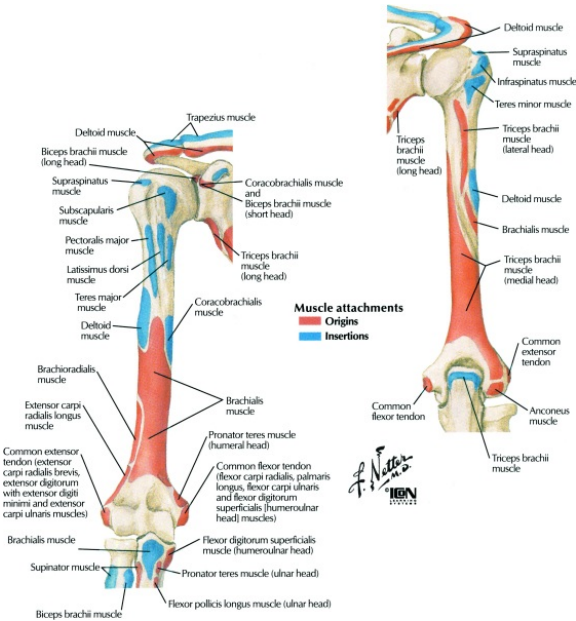
Pinch Grip

Pinch tips of thumb and  
index finger

Inability (or pinching of pads,  
not tips) indicates AIN  
pathology

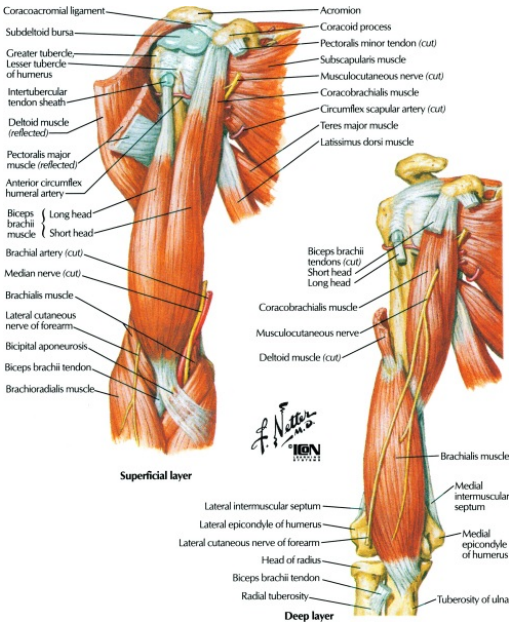
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MUSCLES: INSERTIONS AND ORIGINS



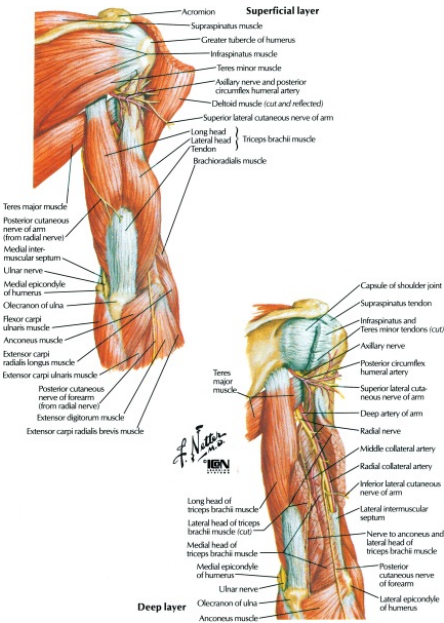
CORACOID PROCESS	GREATER TUBEROSITY	ANTERIOR PROXIMAL HUMERUS	MEDIAL EPICONDYLE	LATERAL EPICONDYLE
ORIGINS	INSERTIONS	INSERTIONS	ORIGINS	ORIGINS
Biceps (SH)	Supraspinatus	Pectoralis major	Pronator Teres	Anconeus
Coracobrachialis	Infraspinatus	Latissimus dorsi	Common Flexor Tendon	Common Extensor Tendon
INSERTIONS	Teres minor	Teres major	[FCR, PL, FCU, FDS]	[ECRB, ED, EDM, ECU]
Pectoralis minor				

ANTERIOR MUSCLES



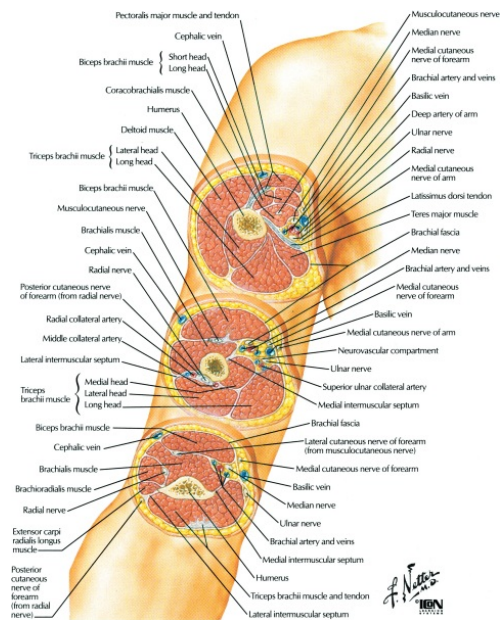
MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Coracobrachialis	Coracoid process	Middle humerus	Musculocutaneous	Flex and adduct arm	
Brachialis	Distal anterior humerus	Ulnar tuberosity	Musculocutaneous	Flex forearm	Often split in anterior surgical approach
Biceps brachii					
Long Head	Supraglenoid tubercle	Radial tuberosity (proximal radius)	Musculocutaneous	Flex supinate forearm	Can rupture proximally- results in Popeye arm
Short Head	Coracoid process	Radial tuberosity (proximal radius)	Musculocutaneous	Flex supinate forearm	Covers brachial artery

POSTERIOR MUSCLES

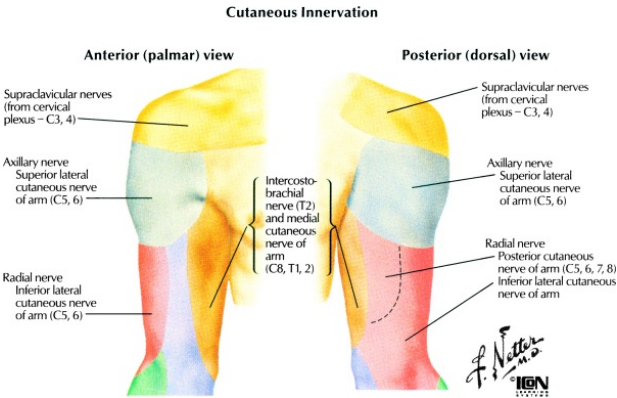


MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Triceps Brachii					
Long Head	Infraglenoid tubercle	Olecranon (proximal)	Radial n.	Extends forearm	Border of quadrangular triangular space interval
Lateral Head	Posterior humerus (proximal)	Olecranon (proximal)	Radial n.	Extends forearm	Border in lateral approach
Medial Head	Posterior humerus (distal)	Olecranon (proximal)	Radial n.	Extends forearm	One muscular plane in posterior approach

## MUSCLES: CROSS SECTION



NERVES



INFRACLAVICULAR [approach through axilla]

LATERAL CORD

**1. Musculocutaneous** (C5-7): pierces coracobrachialis between bicep and brachialis. At risk for injury during anterior approach to shoulder.

Sensory:	NONE (in arm)
Motor:	<u>ANTERIOR COMPARTMENT OF ARM</u>
	Coracobrachialis
	Biceps brachii
	Brachialis

MEDIAL CORD

**2. Medial Cutaneous Nerve of Arm** (C8-T1): joins intercostal-brachial nerve

Sensory:	Medial (inner) arm
Motor:	NONE

**3. Ulnar** (C7)8-T1): travels from anterior to posterior compartment via arcade of Struthers<sup>[1]</sup>, then to cubital tunnel<sup>[1]</sup>.

Sensory:	NONE (in arm)
Motor:	NONE (in arm)

POSTERIOR CORD

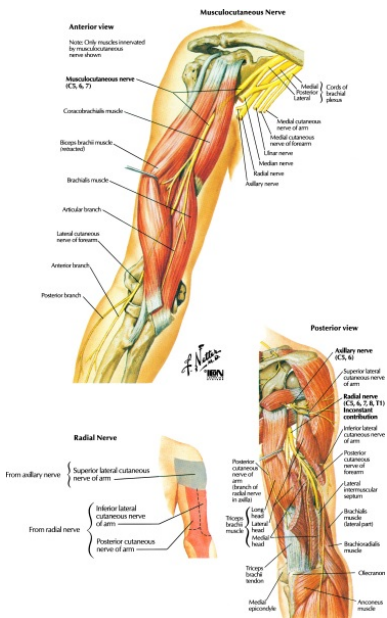
**4. Radial** (C5-T1): runs with deep artery of arm in triangular interval, then spiral groove 15cm from elbow (injured in shaft fx; at risk in surgery), then it divides at the elbow: 1. PIN (motor), 2. superficial radial nerve (sensory)

Sensory:	Lateral arm: via Inferior Lateral Cutaneous Nerve of arm
	Posterior arm: via Posterior Cutaneous Nerve of arm
Motor:	<u>POSTERIOR COMPARTMENT OF ARM</u>
	Triceps [medial, long, lateral heads]

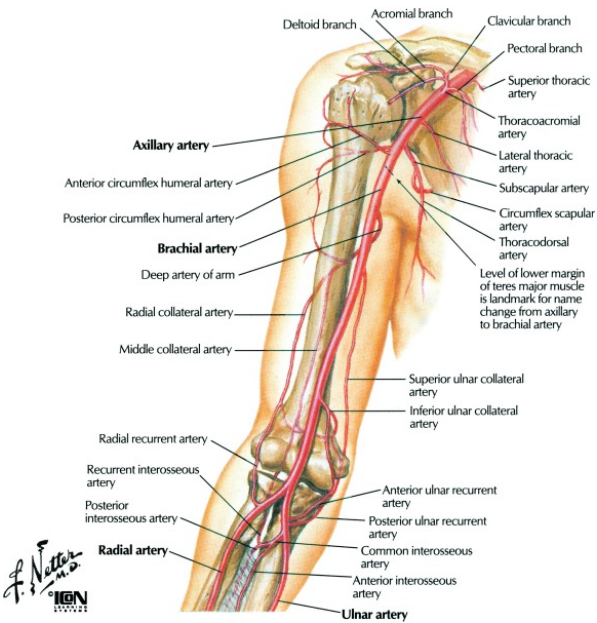


# Anconeus

- possible compression site



ARTERIES



ANASTOMOSES AROUND THE ELBOW

SUPERIOR	INFERIOR
Superior Ulnar Collateral	Posterior Ulnar Recurrent
Inferior Ulnar Collateral	Anterior Ulnar Recurrent
Middle Collateral (branch of Deep Artery)	Interosseous Recurrent
Radial Collateral (branch of Deep Artery)	Radial Recurrent

TRUNK	BRANCH	COURSE/COMMENT
Brachial Artery	Continuation of axillary artery	Medial to biceps, runs with median nerve
	1. Deep artery of arm	Runs with radial nerve in radial groove (posterior humerus)
	2. Nutrient humeral artery	Enters nutrient canal
	3. Superior ulnar collateral	Branches in middle of arm, runs with ulnar nerve
		*Anastomosis with posterior ulnar collateral at elbow
	4. Inferior ulnar collateral	*Anastomosis with anterior ulnar collateral at elbow Brachial artery can be clamped below this branch: collateral circulation is usually sufficient.
	5. Muscular	

	5. Muscular branches	Variable, usually branch laterally
	6. Radial artery	These are the two terminal branches of Brachial artery, it divides in the cubital fossa.
	7. Ulnar artery	
<b>Deep Artery of arm</b>	Radial collateral	*Anastomosis with Radial recurrent artery at elbow
	Middle collateral	*Anastomosis with Recurrent interosseous artery at elbow
<b>Radial Artery</b>	Radial Recurrent	*Anastomosis with radial collateral artery at elbow
<b>Ulnar Artery</b>	Anterior ulnar recurrent	*Anastomosis with inferior ulnar collateral artery at elbow
	Posterior ulnar recurrent	*Anastomosis with superior ulnar collateral artery at elbow
	Common interosseous artery Recurrent interosseous artery	
		*Anastomosis with middle collateral artery at elbow
Collateral branches are all superior branches, recurrent branches are all inferior branches of the anastomosis at the elbow		

DISORDERS

DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
ARTHRITIS			
• Uncommon condition	Hx: Chronic pain stiffness	XR: OA vs. inflammatory	1. Conservative (rest, NSAID)
• Osteoarthritis seen in athletes	PE: Decreased ROM tenderness	Blood: RF, ESR, ANA	2. Debridement
• Site for arthritides		Joint fluid: crystals, cells, culture	3. Joint replacement
BICEPS TENDON RUPTURE			
• Trauma: forced elbow flexion against resistance	Hx: Acute onset of pain	XR: usually normal	Surgical reattachment
• Rare (proximal distal)	PE: Decreased or absent elbow flexion		
CUBITAL TUNNEL SYNDROME			
• Trauma or stretching of ulnar nerve in cubital tunnel	Hx: Numbness/tingling (+ / - pain) in ulnar distribution	XR: Usually negative	1. Rest, ice, NSAID
• Occurs near FCU origin	PE: + / - decreased grip strength, Tinel's and/or elbow flexion test	Nerve conduction: gives objective data, but often not necessary	2. Splints (day and/or night)
• Can also be trapped at arcade of Struthers			3. Casting
			4. Nerve decompression and transposition
LATERAL EPICONDYLITIS (Tennis Elbow)			
• Degeneration of common extensor tendons (esp. ECRB)	Hx: Age 30-60, chronic pain at lateral elbow, worse with wrist finger extension	XR: Rule out fracture OA. Calcification of tendons can occur (esp. ECRB)	1. Activity modification, ice, NSAIDs
• Due to overuse (e.g. tennis) or injury (microtrauma)	PE: +Tennis elbow test		2. Use of brace or strap
			3. Stretching/strengthening
			4. Corticosteroid injection
			5. Surgical release of tendon
LCL SPRAIN			
• Rare condition	Hx: + / - catching and locking	XR: Usually negative	Conservative unless recurrent subluxation, then surgical reconstruction
	PE: + instability with varus stress, + posterolateral (pivot shift) drawer		

### MCL SPRAIN

• Due to single traumatic or repetitive valgus stress	Hx: Young, throwing athletes, chronic pain or acute onset of pain at MCL, + / - "pop"	XR: occasional spur; rule out fracture (+ / - stress view)	Grade I II: conservative (rest, ice, NSAID)
• Usual mechanism: throwing	PE: + / - instability with valgus stress	MRI: before surgery	Grade III (complete tear): surgical repair (use PL)
• Anterior Band is affected			

### MEDIAL EPICONDYLITIS (Golfer's Elbow)

• Degeneration of pronator/ flexor group (PT FCR)	Hx: Medial elbow pain	XR: Rule out fracture OA. Calcification of tendons can occur	Same as Tennis elbow
• Due to injury or overuse	PE: Focal medial epicondyle tenderness, + Golfer's elbow test		Surgery is less effective than for lateral epicondylitis

### OLECRANON BURSITIS

• Inflammation of bursa (Infection/trauma/other)	Hx: Swelling, acute or chronic	Aspirate bursa: send purulent fluid for culture and Gram stain	1. Compressive dressing
	PE: Palpable mass at olecranon		2. Reaspirate if recurs
			3. Corticosteroid injection

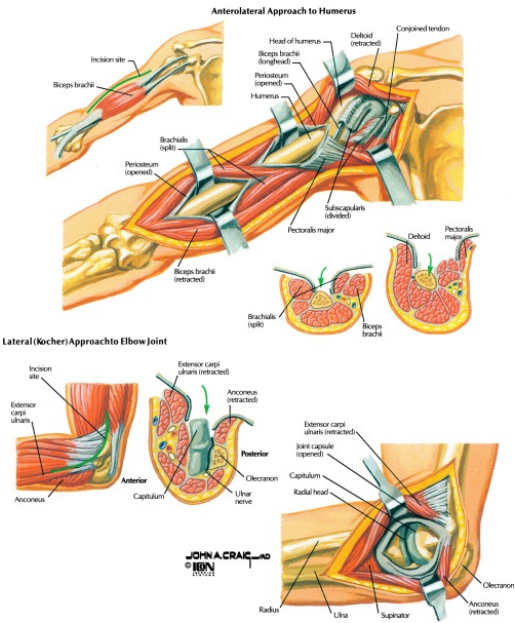
### OSTEOCHONDRITIS DISSECANS OF ELBOW: OCD

• Repetitive valgus stresses (e.g. throwing or gymnastics)	Hx: Young, active (thrower or gymnast), lateral elbow pain	XR: lucency and/or loose body	Type I (fragment stable): Ice, discontinue activity, NSAID
• Vascular compromise and microtrauma of capitellum	PE: + / - catching and/or locking, crepitus with pronation and supination	CT/MRI: determine articular and subchondral involvement	Type II-III (loose fragment): Drill or curette fragment

### TRICEPS TENDON RUPTURE

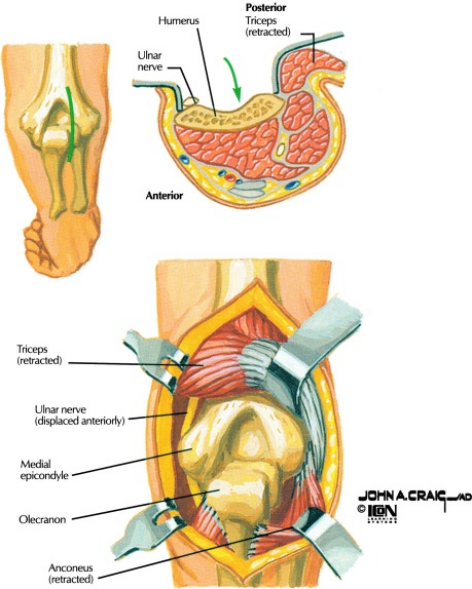
• Trauma: forced elbow extension against resistance	Hx: Pain in posterior elbow	XR: usually normal	Surgical reattachment
	PE: Loss of active elbow extension		

SURGICAL APPROACHES



USES	INTERNEUROUS PLANES	DANGERS	COMMENT
HUMERUS: ANTERIOR APPROACH			
1. ORIF of fractures	Proximal 1. Deltoid [Axillary] 2. Pectoralis Major [Pectoral]	Proximal 1. Axillary nerve 2. Humeral circumflex artery	• Anterior humeral circumflex artery may need ligation.
2. Bone biopsy or tumor removal.			• The brachialis has a split innervation which can be used for an internervous plane.
	Distal 1. Brachialis splitting Lateral [Radial] Medial [MC]	Distal 1. Radial nerve	
ELBOW: LATERAL APPROACH (KOCHER)			
Most radial head procedures	1. Anconeus [Radial] 2. ECU [PIN]	1. PIN 2. Radial nerve	• Protect PIN: stay above annular ligament; keep forearm pronated

Posterior Approach to Elbow Joint



USES	INTERNEUROUS PLANES	DANGERS	COMMENT
ELBOW: POSTERIOR APPROACH (BRYAN/MORREY)			
1. Arthroplasty 2. Distal humerus and olecranon fractures 3. Loose body removal	No planes	Ulnar nerve	<ul style="list-style-type: none"><li>• Triceps is detached from the olecranon.</li><li>• MCL release may be necessary.</li></ul>

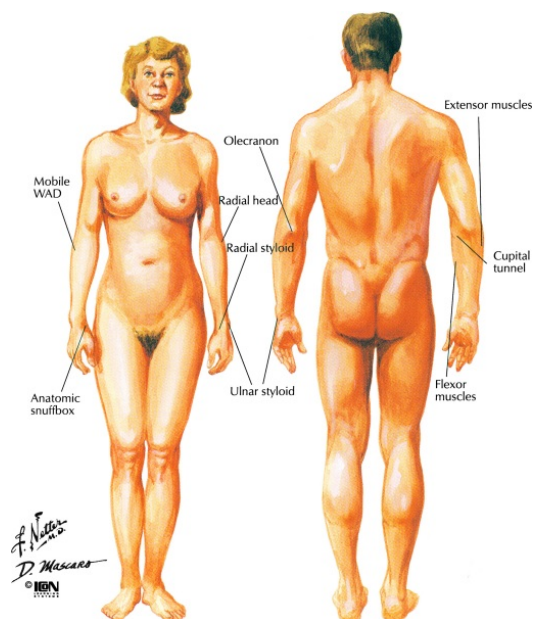
## CHAPTER 4 - FOREARM

- [TOPOGRAPHIC ANATOMY](#)
- [OSTEOLOGY OF THE FOREARM](#)
- [OSTEOLOGY OF THE WRIST](#)
- [TRAUMA](#)
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- [POSTERIOR COMPARTMENT MUSCLES: SUPERFICIAL EXTENSORS](#)
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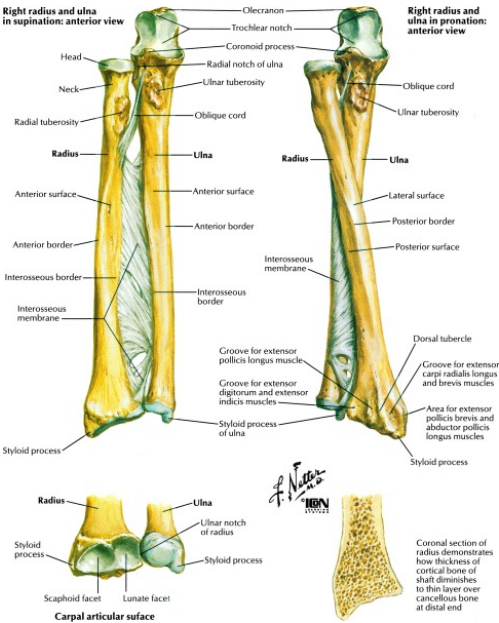


## CHAPTER 4 – FOREARM

### TOPOGRAPHIC ANATOMY



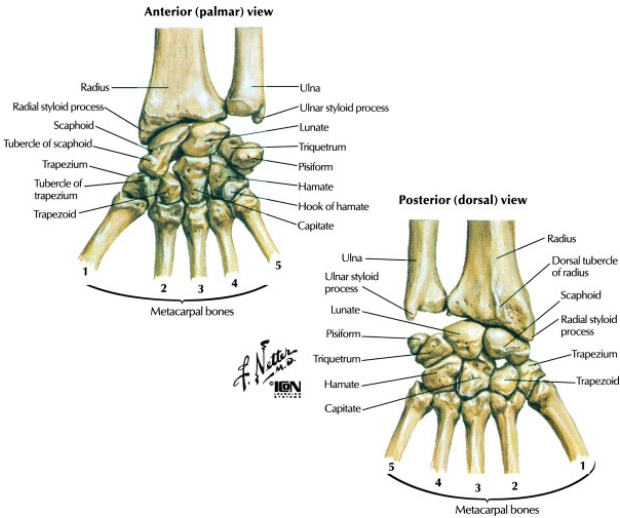
OSTEOLOGY OF THE FOREARM



CHARACTERISTICS	OSSIFY	FUSE	COMMENT
RADIUS			
<ul style="list-style-type: none"><li>Cylindrical long bone</li><li>Head within elbow joint</li><li>Tuberosity outside joint</li><li>Palpate head laterally</li><li>Styloid is distal</li></ul>	<p>Primary: Shaft</p> <p>Secondary</p> <ol style="list-style-type: none"><li>Proximal epiphysis</li><li>Distal epiphysis</li></ol>	<p>8-9 weeks (fetal)</p> <p>14-21 years</p>	<p>Elbow ossification: used to determine bone age in peds</p> <p>Elbow ossification order: Capitellum, Radial head, Medial epicondyle,</p> <ul style="list-style-type: none"><li>Trochlea, Olecranon, Lateral Epicondyle (Captain Roy Makes Trouble On Leave)</li></ul>
ULNA			
<ul style="list-style-type: none"><li>Cylindrical long bone</li></ul> <p>Olecranon</p>	<p>Primary: Shaft</p>	<p>8-9 weeks</p>	<p>Olecranon</p>

<ul style="list-style-type: none"> <li>• palpable posteriorly at elbow</li> <li>• Styloid process distally</li> </ul>	<p>Secondary</p> <ol style="list-style-type: none"> <li>1. Olecranon</li> <li>2. Distal epiphysis</li> </ol>	<p>(fetal)</p> <p>10 years</p> <p>5-6 yrs</p>	<p>16-20 years</p>	<ul style="list-style-type: none"> <li>• and coronoid give the elbow bony stabilization.</li> </ul>
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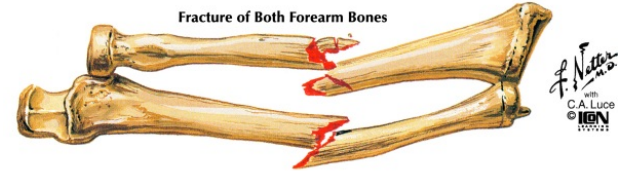
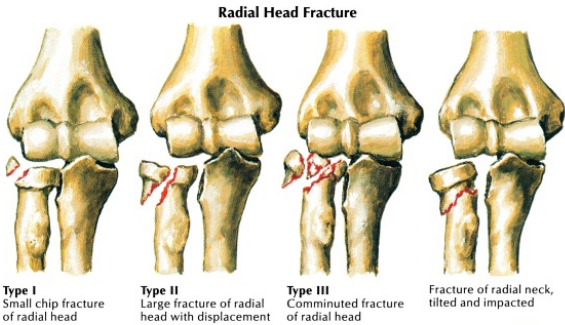
OSTEOLOGY OF THE WRIST



CHARACTERISTICS	OSSIFY FUSE	COMMENT	
PROXIMAL ROW			
<b>Scaphoid:</b> boat shaped, 80% of surface is articular (not the waist)	5th 5 years	14-16 yrs	<ul style="list-style-type: none"><li>Lies beneath the anatomic snuffbox</li><li>Distal (to waist) blood supply (radial artery); proximal pole is susceptible to necrosis if injured</li></ul>
<b>Lunate:</b> moon shaped	4th 4 years	14-16 yrs	<ul style="list-style-type: none"><li>Dislocations often missed</li><li>Blood supply is palmar: palmar fractures need ORIF to protect against osteonecrosis; dorsal fractures treated nonsurgically</li></ul>
<b>Triquetrum:</b> pyramid shaped	3rd 3 years	14-16 yrs	
<b>Pisiform:</b> large sesamoid bone	8th 9-12 years	14-16 yrs	<ul style="list-style-type: none"><li>In the FCU tendon; TCL attaches</li></ul>
DISTAL ROW			
<b>Trapezium:</b> most radial	6th 5-6 years	14-16 yrs	<ul style="list-style-type: none"><li>Articulates with 1st metacarpal; TCL attaches, FCR</li></ul>
<b>Trapezoid:</b> wedge shape	7th 5-6 years	14-16 yrs	<ul style="list-style-type: none"><li>Articulates with 2nd metacarpal</li></ul>
<b>Capitate:</b> largest carpal bone	1st 1 year	14-16 yrs	<ul style="list-style-type: none"><li>First to ossify</li></ul>
<b>Hamate:</b> has a hook	2nd 1-2	14-16 yrs	<ul style="list-style-type: none"><li>TCL, FCU attach to the hook</li></ul>

Hamate: has a hook	years	10 yrs	- TCL, FCU attach to the hook
Ossification: each from a single center: counterclockwise (anatomic position) starting with capitate			
Carpal tunnel borders: Roof: Transverse carpal ligament; Lateral wall: scaphoid trapezium; Medial wall: pisiform hamate Contents: Median nerve, flexor tendons			
Guyon's canal: Roof: volar carpal ligament; Floor: TCL; Lateral wall: hamate (hook); Medial wall: pisiform Contents: Ulnar nerve and artery			
Anatomic snuffbox: Between tendons of EPL and EPB; Contents: Radial artery (scaphoid directly deep to snuffbox)			

TRAUMA



Fracture of both radius and ulna with angulation, shortening, and comminution of radius

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
OLECRANON FRACTURE			
<ul style="list-style-type: none"><li>Mechanism: fall directly on elbow; fall on hand</li><li>Articular surface always involved</li><li>Triceps tendon pulls fragment</li></ul>	<p>HX: Fall/trauma. Swelling, pain, +/- numbness.</p> <p>PE: Effusion, tenderness +/- decreased elbow extension. Good neurovascular exam (esp. ulnar nerve)</p> <p>XR: AP/lateral</p>	<p>Colton:</p> <p>Undisplaced: 2mm</p> <p>Displaced</p> <ul style="list-style-type: none"><li>-avulsion</li><li>-transverse/oblique</li><li>-comminuted</li><li>-fracture/dislocation</li></ul>	<p>Undisplaced: Cast at 45-90° for 3 weeks, then gentle ROM</p> <p>Displaced: ORIF with tension band wires or bicortical screw. (comminuted fracture: excise bone then reattach triceps)</p>
COMPLICATIONS: Ulnar nerve injury (most resolve); Decreased ROM; Arthritis			
RADIAL HEAD FRACTURE			
<ul style="list-style-type: none"><li>Common</li><li>Fall on outstretched arm radius pushed into capitulum</li><li>Intraarticular fracture</li><li>Can be associated with elbow dislocation</li></ul>	<p>HX: Fall. Pain, swelling, decreased function.</p> <p>PE: Tenderness of radial head, decreased ROM especially pronation/supination. Test MCL stability</p> <p>XR: AP/lateral: +fat pad</p>	<p>Mason: 4 Types</p> <ul style="list-style-type: none"><li>I: Undisplaced</li><li>II: Displaced</li><li>III: Comminuted (head)</li><li>IV: Fracture with elbow dislocation</li></ul>	<p>Type I: Splint for 3 days, then early ROM</p> <p>Type II: If motion intact-splint, then early ROM.</p> <p>If 1/3 of head involved or 3mm displaced-ORIF or excision</p>

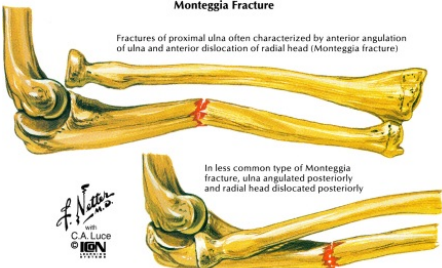
COMPLICATIONS: Decreased ROM; Instability

### BOTH BONE FRACTURE

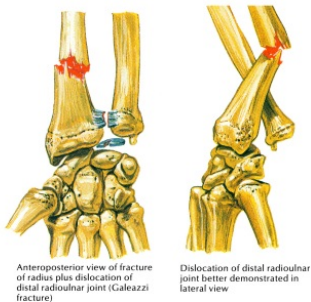
<ul style="list-style-type: none"> <li>Mechanism: high energy injuries</li> <li>Fractures in shaft of single bone shorten, resulting forces cause fracture in other bone</li> <li>Nightstick fracture: ulnar shaft fracture only</li> </ul>	<p>HX: Trauma. Pain, swelling.</p> <p>PE: Tenderness, deformity. Check compartments and do neurovascular PE</p> <p>XR:AP/lateral: including wrist and elbow</p>	<p>Descriptive:</p> <ul style="list-style-type: none"> <li>Undisplaced</li> <li>Displaced</li> <li>Comminuted</li> </ul>	<p>ORIF (usually plates and screws) through two separate incisions.</p> <p>Nightstick: Undisplaced-closed treatment; Displaced-ORIF</p> <p>Peds: closed, LAC 6-8wks</p>
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COMPLICATIONS: Loss of Pronation and supination; Nonunion

#### Monteggia Fracture



#### Galeazzi Fracture



DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
<b>MONTEGGIA FRACTURE</b>			
<ul style="list-style-type: none"> <li>Proximal ulna fracture, shortening forces result in radial head dislocation.</li> </ul>	<p>HX: Fall. Pain, swelling.</p> <p>PE: Tenderness, deformity. Check compartments and</p>	<p>Bado (based on radial head location):</p> <ul style="list-style-type: none"> <li>I: Anterior (common)</li> <li>II: Posterior</li> </ul>	<p>Ulna: ORIF (plates/screws)</p> <p>Radial head: closed reduction (open if irreducible or</p>

Mechanism: direct • blow or fall on outstretched hand.	neurovascular exam. XR: AP/lateral: including wrist and elbow series.	III: Lateral IV: Anterior with associated both bone fracture.	irreducible or unstable). Peds: closed reduction cast.
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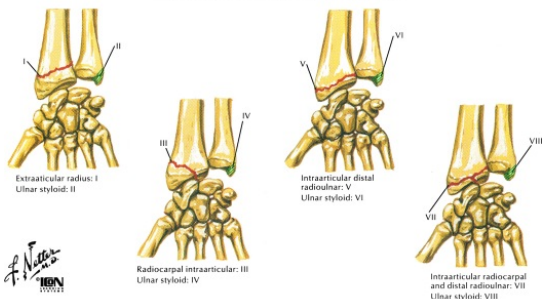
COMPLICATIONS: Radial nerve/PIN injury (most resolve); Decreased ROM; Compartment Syndrome; Nonunion

### GALEAZZI/PIEDMONT FRACTURE

• Mechanism: fall on outstretched hand. Distal radial shaft fracture, shortening • forces result in distal radioulnar dislocation.	HX: Fall. Pain, swelling. PE Tenderness, deformity. Check compartments and do neurovascular exam. XR: AP/lateral: including wrist and elbow	By mechanism: Pronation: Galeazzi Supination: Reverse Galeazzi (ulna shaft fracture with DRUJ dislocation)	Radius: ORIF (plate/screws) DRUJ: closed reduction, +/- percutaneous pins. (open treatment if unstable) Cast immobilization for 4-6wks. Peds: closed reduction, cast.
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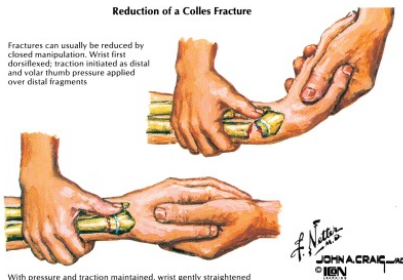
COMPLICATIONS: Nerve injury; Decreased ROM; Nonunion; Distal radioulnar joint (DRUJ) arthrosis

### Frykman Classification of Fractures of Distal Radius



### Reduction of a Colles Fracture

Fractures can usually be reduced by closed manipulation. Wrist first dorsiflexed; traction initiated as distal and volar thumb pressure applied over distal fragments



With pressure and traction maintained, wrist gently straightened

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
<b>DISTAL RADIUS FRACTURE</b>			
• Very common (Colles#1) • Fall on outstretched arm	HX: Fall. Pain, swelling. PE: Swelling,	Frykman (for Colles): Type I, II: extraarticular	Close reduce, immobilize with WELL molded cast. (volar flexion ulnar



- Colles fracture: dorsal displacement (apex volar), radial shortening, dorsal angulation.
- Smith fracture: volar displacement (apex dorsal)
- Barton fracture: radial rim carpus displace together
- Radial styloid (chauffeur fracture)

deformity, tenderness to palpation. Good neurovascular exam.

XR: AP/lateral: normal radius:

1. 23° radial inclination
2. 13 mm radial height
3. 11° volar tilt

Type III, IV: radiocarpal joint.

Type V, VI: radioulnar joint

Type VII, VIII: radiocarpal and radioulnar joints involved (even numbers also have ulna styloid fx)

Barton:

1. Dorsal
2. Volar (most common)

deviation).

If unstable add percutaneous pins, ORIF or external fixation.

Smith: closed treatment +/- percutaneous pinning (often unstable needs ORIF)

Barton fracture: Most need ORIF

Styloid fracture: ORIF

COMPLICATIONS: Loss of motion; Deformity; Median nerve injury; Malunion; Scapholunate dislocation

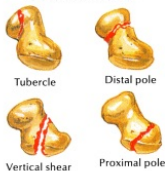
### Scaphoid Fracture

with  
C.A. Luce  
© IIGM

Fracture of middle third (waist) of scaphoid (most common)



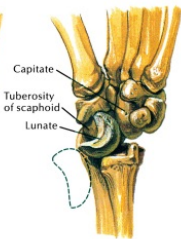
Less common fractures



### Carpal Dislocation



Palmar view shows (A) lunate rotated and displaced volarly, (B) scapholunate space widened, (C) capitate displaced proximally and dorsally



Lateral view shows lunate displaced volarly and rotated. Broken line indicates further dislocation to volar aspect of distal radius

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
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### SCAPHOID FRACTURE

- Most common carpal fracture
- Fall on outstretched arm
- High complication rate

HX: Fall. Pain worse with gripping, swelling.

PE: "Snuffbox" tenderness, swelling on radial wrist

XR: AP/lateral:

By location:

- Proximal pole
- Middle ("waist") most common
- Distal pole

If clinical symptoms with negative xray: thumb spica for 10-14 days then re-evaluate.

Nondisplaced: cast 6-12 wks

Displaced:

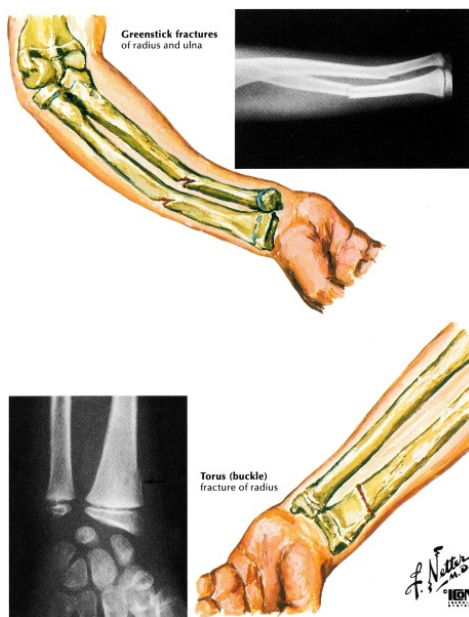
<ul style="list-style-type: none"> <li>Proximal pole with tenuous blood supply</li> </ul>	also PA with ulnar deviation/oblique	Displaced. ORIF (K-wire or Herbert screw)
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COMPLICATIONS: Nonunion/malunion; Osteonecrosis: especially of proximal pole; Degenerative Joint Disease (DJD)

### CARPAL DISLOCATION: PERILUNATE INSTABILITY

<ul style="list-style-type: none"> <li>Uncommon: hyperextension supination injury</li> <li>Injury determined by a progression of ligament disruption (see joint chart)</li> <li>Space of Poirer is weak (Capitate-lunate joint)</li> </ul>	HX: Fall. Pain. PE: Wrist pain, + Watson sign. XR: AP/lateral: 3mm SL gap is Terry Thomas sign. +/- 2 Scaphoid ring sign Cinearthrogram: definitive diagnosis	Mayfield (4 stages): <b>I:</b> Scapholunate diastasis <b>II:</b> Perilunate dislocation <b>III:</b> Lunotriquetral diastasis <b>IV:</b> Volar lunate dislocation.	Closed reduction and cast simple cases. Open reduction, pin fixation, and primary ligament repair usually required.
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COMPLICATIONS: Wrist instability and/or pain; SLAC wrist

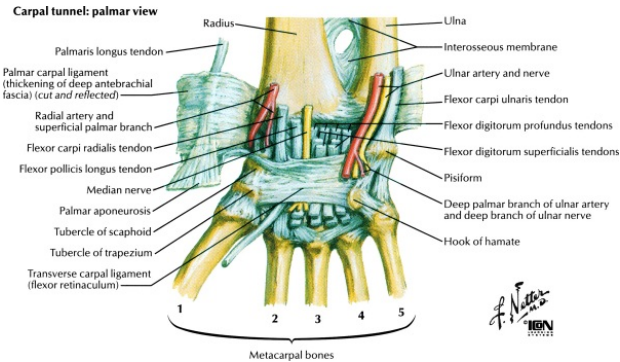


DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
<b>INCOMPLETE FRACTURE: TORUS GREENSTICK FRACTURE</b>			
<ul style="list-style-type: none"> <li>Common in children (usually ages 6-12)</li> </ul>	Hx: Trauma. Pain, inability to use arm	Torus(Buckle):concave cortex compresses	Torus: reduction rarely needed

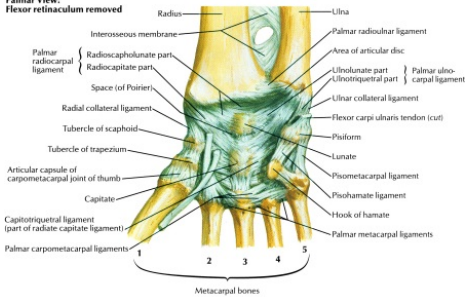
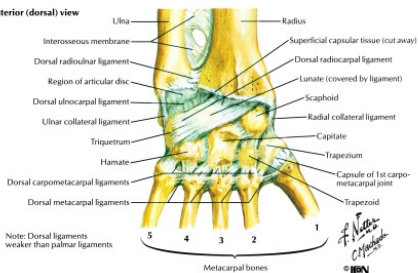
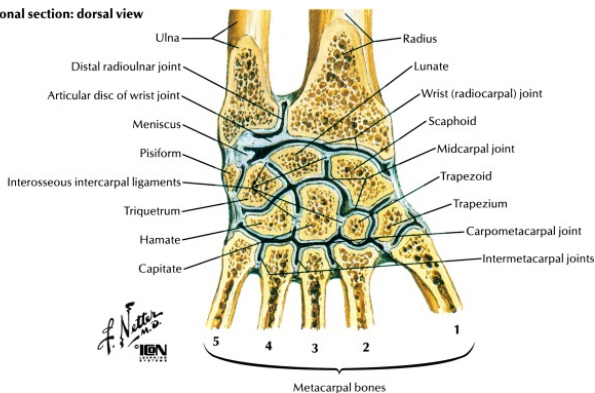
<ul style="list-style-type: none"> <li>mechanism.</li> <li>fall on hand most common</li> <li>Distal radius most common</li> <li>Increased flexibility of pediatric bone allows only one cortex to be involved</li> </ul>	<ul style="list-style-type: none"> <li>PE: +/- deformity. Point tenderness swelling.</li> <li>XR: AP and lateral: only one cortex involved.</li> </ul>	<ul style="list-style-type: none"> <li>(buckles), convex/tension side: intact</li> <li>Greenstick: concave cortex intact, convex/tension side fracture/plastic deformity</li> </ul>	<ul style="list-style-type: none"> <li>needed, splint 2-4 weeks</li> <li>Greenstick: reduce if 10° of angulation. Long arm cast for 6 weeks.</li> </ul>
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COMPLICATIONS: Deformity; Malunion; Neurovascular injury (rare)

JOINTS: WRIST

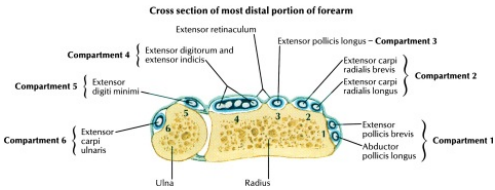
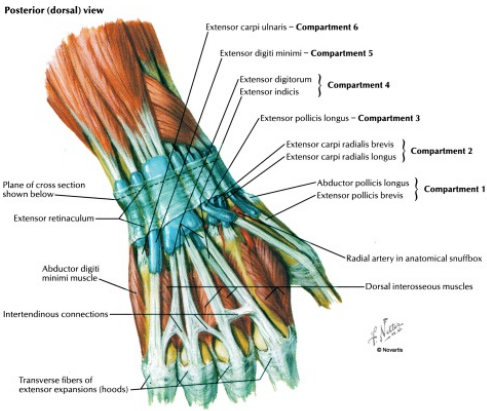


LIGAMENTS	ATTACHMENTS	COMMENTS
RADIOCARPAL (Ellipsoid type)		
Bones: radius, scaphoid, lunate, triquetrum		
Capsule	Surrounds joint	Loose, provides little support
Volar radiocarpal [VRC]	Multiple intracapsular ligaments	Strong; space of Poirier (lunocapitate) is weak. Injury leads to instability.
Radioscaphocapitate [RCL]	Radial styloid to capitate	Stabilizes radial wrist, distal row, midcarpal joint. Disrupted in perilunate instability stage II.
Radioscapholunate [RSL]	Radial styloid to lunate	Stabilizes radial wrist, scapholunate joint; Disrupted in DISI, perilunate instability stage I.
Radiolunotriquetral [RTL]	Radial styloid to triquetrum	Largest, volar sling for lunate, lunotriquetral joint stabilizer. Disrupted in perilunate instability stage III.
Dorsal radiocarpal [DRC]	Radius, scaphoid, lunate, triquetrum	Weak; stabilizes proximal row, radiolunate joint. Disrupted in perilunate instability stage IV.
Radial collateral	Radius, scaphoid, trapezium, TCL	Stabilizes proximal row. Radial artery runs adjacent to it.
RADIOULNAR (Pivot type)		
Triangular Fibrocartilage Complex (TFCC): Multiple components stabilize joint, absorbs axial load; any tear or injury results in pain		
COMPONENT	ORIGIN	INSERTION
Dorsal Volar Radioulnar	Ulnar radius	Caput ulna
Triangular fibrocartilage (disc)	Radius/ulna	Triquetrum
Meniscus homologue	Ulna/disc	Triquetrum
Ulnar collateral/ECU	Ulna	Fifth metacarpal
OTHER LIGAMENTS		
Ulnocarpal:	Often considered part of TFCC; Stabilizes proximal row of carpus	
Ulnolunate	Ulna	Lunate

**Palmar View:****Flexor retinaculum removed****Posterior (dorsal) view****Coronal section: dorsal view****JOINT  
TYPE****LIGAMENTS****ATTACHMENTS****COMMENTS****INTERCARPAL**Dorsal  
stronger

Proximal Row	Gliding	2 Dorsal intercarpal 2 Palmar intercarpal 2 Interosseous	Scapholunate, lunotriquetral Scapholunate, lunotriquetral Scapholunate, lunotriquetral.	Stabilize SL or LT joints DIST: SL ligament injury VISI: LT ligament injury
Pisiform Articulation		Capsule Ulnar collateral Volar radiocarpal Pisohamate Pisometacarpal	Pisiform triquetrum Ulna to pisiform RCL to pisiform Pisiform to hamate Pisiform to 5 <sup>th</sup> metacarpal	Holds it proximally Holds it proximally Assists FCU; roof of Guyon's canal Assists FCU flexion
Distal Row	Gliding	3 Dorsal intercarpal 3 Palmar intercarpal 2 interosseous	All four bones in distal row All four bones in distal row Trapezoid to capitate to hamate	Thicker than proximal
<b>MIDCARPAL</b>				
	Ellipsoid	Palmar (Volar) intercarpal Carpal collaterals Capitotriquetral (CTL)	Proximal distal carpal rows Capitate to triquetrum	1/3 of wrist extension, 2/3 of wrist flexion occurs here Radial stronger than ulnar Stabilizes distal row

OTHER WRIST STRUCTURES

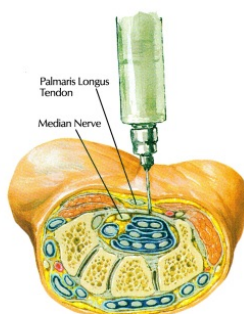
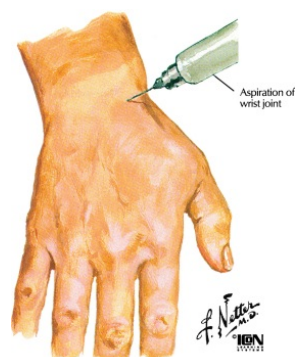


STRUCTURE	FUNCTION	COMMENT
Extensor Retinaculum Dorsal Compartments	Covers dorsum of the wrist I: APL, EPB II: ECRL, ECRB III: EPL IV: EDC, EIP V: EDM VI: ECU	Forms six fibroosseous dorsal compartments DeQuervain's tenosynovitis can develop here Tendinitis (carpal bossing) Around Lister's tubercle: tendon can rupture Tenosynovitis, ganglions Jackson-Vaughn syndrome (rupture from RA) Tendon can "snap" over ulnar styloid
Transverse Carpal Ligament (TCL, Flexor Retinaculum)	Covers volar wrist Attaches to: Medial: pisiform hook of hamate Lateral: scaphoid trapezium	Roof of carpal tunnel, floor of Guyon's canal (ulnar nerve can entrap here)





## MINOR PROCEDURES



### STEPS

#### WRIST ASPIRATION/INJECTION

1. Ask patient about allergies
2. Palpate radiocarpal joint dorsally for EPL, ECRB, Lister's tubercle and the space ulnar to them
3. Prepare skin over dorsal wrist (iodine/antiseptic soap)
4. Anesthetize skin locally (quarter size spot)  
Aspiration: Insert 20 gauge needle into space ulnar to Lister's tubercle/ECRB and radial to EDC, aspirate.
5. Injection: Insert 22 gauge needle into same space, aspirate to ensure not in vessel, then inject 1-2ml of local or local/steroid preparation into RC joint.
6. Dress injection site
7. If suspicious for infection, send fluid for Gram stain culture

#### CARPAL TUNNEL INJECTION/MEDIAN NERVE BLOCK

1. Ask patient about allergies  
Ask patient to pinch thumb and small finger tips, Palmaris longus (PL) tendon will protrude (10-20% do not have one) median nerve is directly beneath PL, just ulnar to FCR
2. Prepare skin over volar wrist (iodine/antiseptic soap)
3. Anesthetize skin locally (quarter size spot)
4. Insert 22 gauge or smaller needle into wrist under PL at flexion crease. Aspirate to ensure needle is not in a vessel. Inject 1-2ml of local or local/steroid preparation.
5. Dress injection site

HISTORY



QUESTION	ANSWER	CLINICAL APPLICATION
1. AGE	Young Middle age- elderly	Trauma: fractures and dislocations, ganglions Arthritis, nerve entrapments, overuse
2. PAIN a. Onset b. Location	Acute Chronic Dorsal Volar Radial Ulnar	Trauma Arthritis Kienbock's disease, ganglion Carpal tunnel syndrome (CTS), ganglion (especially radiovolar) Scaphoid fracture, DeQuervain's tenosynovitis, arthritis Triangular Fibrocartilage Complex(TFCC) tear, tendinitis
3. STIFFNESS	with dorsal pain with volar pain (at night)	Kienbock's disease Carpal tunnel syndrome
4. SWELLING	Joint: after trauma Joint: no trauma Along tendons	Fracture or sprain Arthritides, infection, gout Flexor or extensor tendinitis (calcific), DeQuervain's disease
5. INSTABILITY	Popping, snapping	Scapholunate dissociation

6. MASS	Along wrist joint	Ganglion
7. TRAUMA	Fall on hand	Fractures: distal radius, scaphoid; Dislocation: lunate, ulna TFCC tear
8. ACTIVITY	Repetitive motion (typing)	Carpal Tunnel Syndrome (CTS), DeQuervain's tenosynovitis
9. NEUROLOGIC SYMPTOMS	Numbness, tingling Weakness	Nerve entrapment, thoracic outlet syndrome, radiculopathy Nerve entrapment (median (e.g. CTS), ulnar, or radial)
10. HISTORY OF ARTHRITIDES	Multiple joints involved	Arthritides

PHYSICAL EXAM

Distal Radius Fracture



Clinical appearance of deformity due to severely displaced fracture of distal radius

Fracture Scaphoid

Clinical findings. Pain, tenderness, and swelling in anatomic snuffbox



Netter  
with  
C.A. LUCO  
© ILEN

Carpal Dislocation

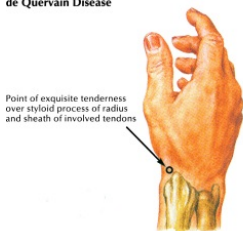


Typical deformity. Anterior bulge of dislocated lunate

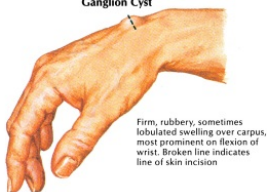
EXAMINATION	TECHNIQUE	CLINICAL APPLICATION
INSPECTION		
Gross deformity Swelling	Bones and soft tissues Especially dorsal or radial Diffuse	Fractures, dislocations: forearm and wrist Ganglion Trauma, infection
PALPATION		
Skin changes	Warm, red Cool, dry	Infection, gout Neurovascular compromise
Radial and Ulnar styloids	Palpate each separately	Tenderness may indicate fracture
Carpal bones	Both proximal and distal row	Snuffbox tenderness: scaphoid fracture; lunate tenderness: Kienbock's disease.
	Proximal row Pisiform	Scapholunate dissociation Tenderness: pisotriquetral arthritis or FCU tendinitis
Soft tissues	6 dorsal extensor compartments TFCC: distal to ulnar styloid Compartments	Tenderness over 1 <sup>st</sup> compartment: DeQuervain's disease Tenderness indicates TFCC injury Firm/tense compartments: compartment syndrome
RANGE OF MOTION		
Flex and extend	Flex (toward palm), extend opposite	Normal: flexion 80°, extension 75°
Radial/ulnar deviation Pronate and supinate	In same plane as the palm Flex elbow 90°: hold pencil, rotate wrist	Normal: radial 15-20°, ulnar 30-40° Normal: supinate 90°, pronate 80-90° (only 10-15° is in the wrist, most motion is in elbow)
NEUROVASCULAR		
Sensory	(LT, PP, 2 pt)	
Musculocutaneous nerve (C6)	Lateral forearm	Deficit indicates corresponding nerve/root lesion
Medial Cutaneous nerve of forearm (T1)	Medial forearm	Deficit indicates corresponding nerve/root lesion
Motor		

Radial Nerve (C6-7)	Resisted wrist extension	Weakness=ECRL/B or corresponding nerve/root lesion
PIN (C6-7)	Resisted ulnar deviation	Weakness=ECU or corresponding nerve/root lesion
Ulnar Nerve (C8)	Resisted wrist flexion	Weakness=FCR or corresponding nerve/root lesion
Median Nerve (C7)	Resisted wrist flexion	Weakness=FCR or corresponding nerve/root lesion
Median Nerve (C6)	Resisted pronation	Weakness=Pronator Teres or nerve/root lesion
Musculocutaneous (C6)	Resisted supination	Weakness=Biceps or corresponding nerve/root lesion
<b>Reflex</b>		
C6	Brachioradialis	Hypoactive/absence indicates corresponding radiculopathy
<b>Pulses</b>	Radial, Ulnar	Diminished/absent = vascular injury or compromise (perform Allen test)

de Quervain Disease



Ganglion Cyst

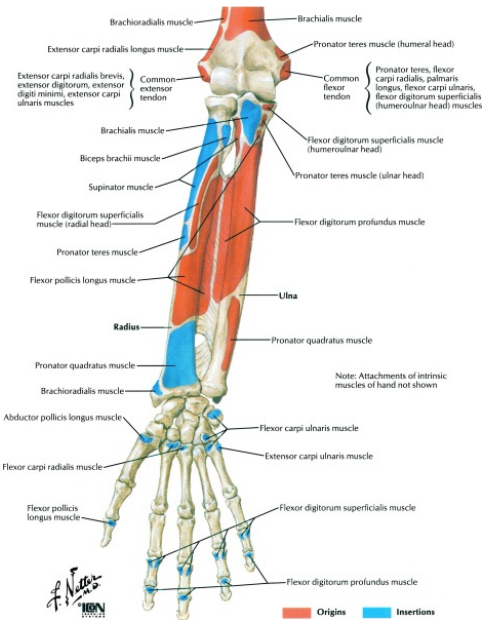


*F. Netter M.D.*  
ILLUSTRATIONS

EXAMINATION	TECHNIQUE	CLINICAL APPLICATION
<b>SPECIAL TESTS</b>		
Phalen	Maximal flexion of both wrists for several minutes	Reproduction of symptoms (numbness or tingling): Carpal Tunnel Syndrome (CTS)
Tinel	Tap volar wrist (carpal tunnel/TCL)	Pain, numbness suggests Median nerve compression (CTS)
Finkelstein	Make fist with thumb inside, then ulnar deviation	Pain over 1 <sup>st</sup> compartment (APL, EPB) suggests DeQuervain's tenosynovitis

Watson	Push scaphoid anteroposterior with wrist in radial or ulnar deviation	Positive if scaphoid subluxes or reduces: carpal ligament injury
Allen	Occlude radial ulnar arteries, pump fist then release one artery only	Delay or absent of “pinking up” of palm suggest arterial compromise of artery released

MUSCLES: ORIGINS INSERTIONS



PROXIMAL ULNA      PROXIMAL RADIUS

ANTERIOR

INSERTIONS

Brachialis

INSERTIONS

Biceps

Supinator

ORIGINS

Flexor Digitorum

ORIGINS

Flexor Digitorum

Superficialis [1 head]

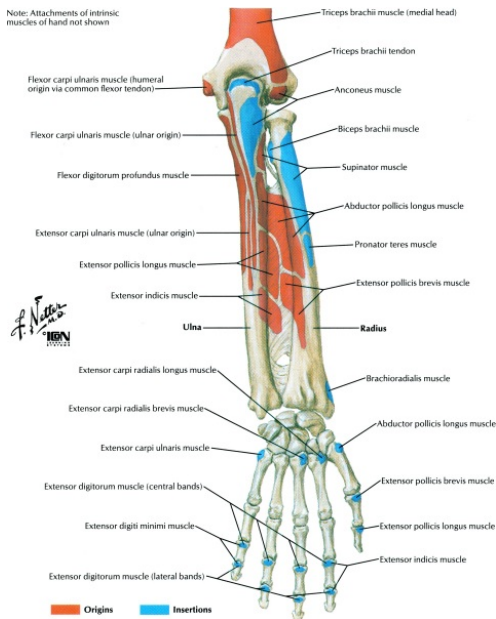
Superficialis [1 head]

Pronator teres

Flexor Pollicis longus

Supinator

Note: Attachments of intrinsic muscles of hand not shown



## PROXIMAL ULNA PROXIMAL RADIUS

### POSTERIOR

#### INSERTIONS

Triceps

Anaconeus

#### ORIGINS

Flexor carpi ulnaris

#### INSERTIONS

Biceps

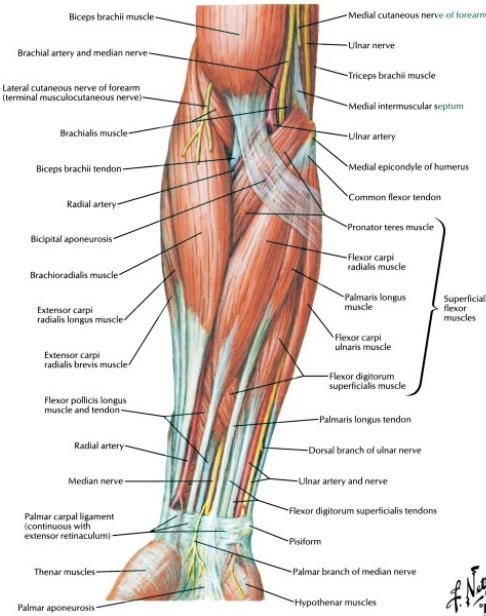
Supinator

#### ORIGINS

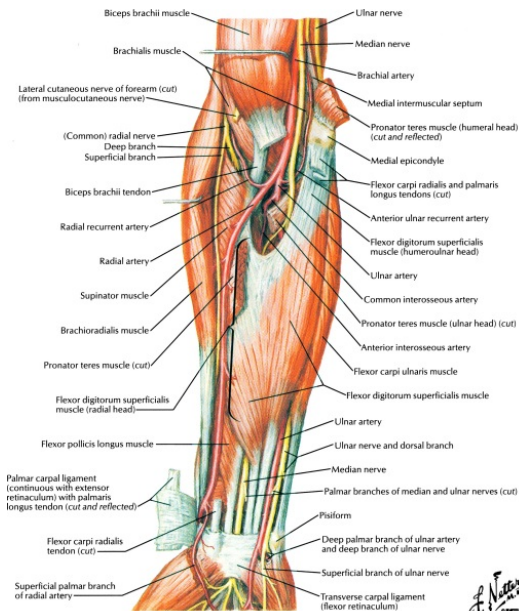
NONE



ANTERIOR COMPARTMENT MUSCLES: SUPERFICIAL FLEXORS



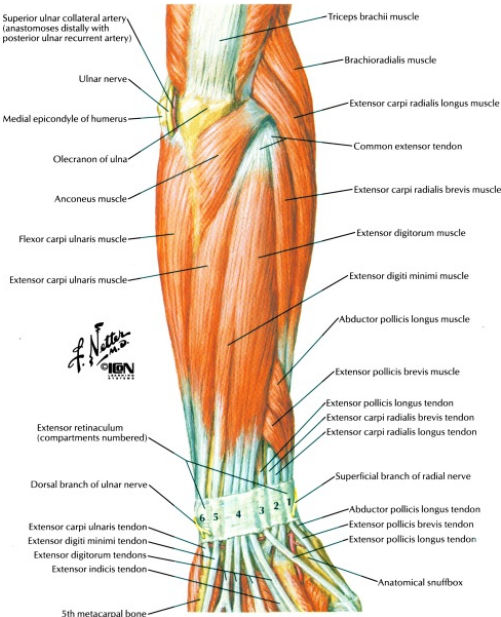
MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Pronator Teres [PT]	Medial epicondyle coronoid process	Lateral radius-middle 1/3	Median	Pronate and flex forearm	May trap AIN (AIN syndrome)
Flexor carpi radialis [FCR]	Medial epicondyle	Base of 2nd 3rd metacarpal	Median	Flex wrist, radial deviation	Radial artery is immediately lateral
Palmaris Longus [PL]	Medial epicondyle	Flexor retinaculum palmar aponeurosis	Median	Flex wrist	Used for tendon transfers. 10% congenitally absent
Flexor carpi ulnaris [FCU]	Medial epicondyle posterior ulna	Pisiform, hook of hamate, 5th MC	Ulnar	Flex wrist, ulnar deviation	Most powerful wrist flexor



*F. Netter*  
MD

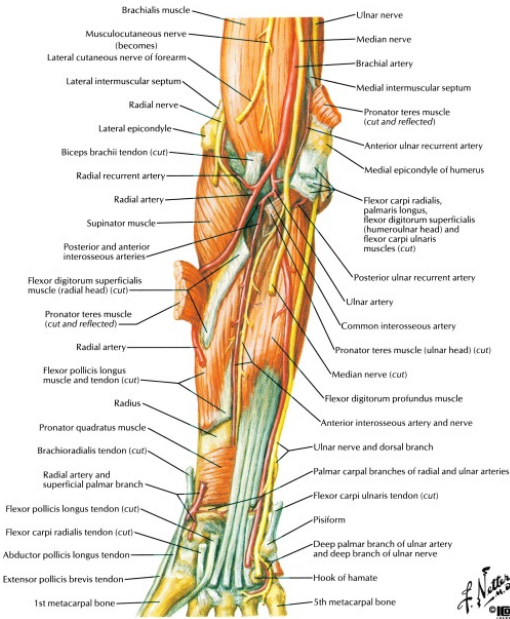
MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Flexor digitorum superficialis [FDS]	1. Medial epicondyle, coronoid process	Middle phalanges of digits (not thumb)	Median	Flex PIP (also flex digit and hand)	Sublimus test will isolate test function
	2. Anteroproximal radius				

POSTERIOR COMPARTMENT MUSCLES: SUPERFICIAL EXTENSORS



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Flexor digitorum profundus [FDP]	Anterior ulna Interosseus membrane	Distal phalanx (IF/MF)	Median/AIN	Flex DIP (also flex digit and hand)	Avulsion: Jersey finger.
		Distal phalanx (RF/SF)	Ulnar		FDP and FPL are most susceptible to Volkmann's contracture.
Flexor pollicis longus [FPL]	Anterior radius coronoid process	Distal phalanx of thumb	Median/AIN	Flex thumb (IP)	
Pronator quadratus [PQ]	Medial distal ulna	Anterior distal radius	Median/AIN	Pronate forearm	Primary pronator (initiates pronation)

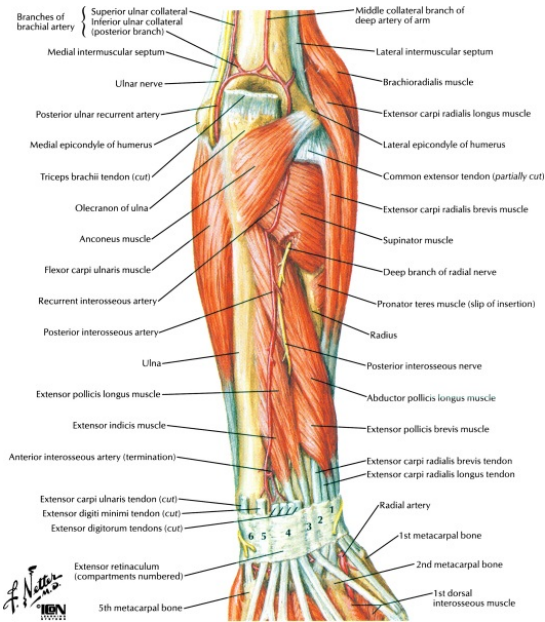
ANTERIOR COMPARTMENT MUSCLES: DEEP FLEXORS



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Anaoneus	Posterior-lateral epicondyle	Posterior-poximal ulna	Radial	Forearm extension	Must retract on Kocher approach
Mobile Wad(3)					
Brachioradialis [BR]	Lateral supra-condylar humerus	Lateral distal radius	Radial	Forearm flexion	Is a deforming force in radius fractures.
Extensor carpi radialis longus [ECRL]	Lateral supra-condylar humerus	Base of 2nd MC	Radial	Wrist extension	Used for tendon transfer
Extensor carpi radialis brevis [ECRB]	Lateral epicondyle	Base of 3rd MC	Radial	Wrist extension	Inflamed in Tennis elbow, can compress PIN
Extensor digitorum [ED]	Lateral epicondyle	Sagittal bands, central slip, distal phalanx	Radial-PIN	Digit extension	Distal avulsion is mallet finger injury
Extensor digiti minimi [EDM]	Lateral epicondyle	Sagittal bands, central slip, distal phalanx of SF	Radial-PIN	SF extension	In 5th dorsal compartment.
Extensor carpi ulnaris [ECU]	Lateral epicondyle	Base of 5th MC	Radial-PIN	Hand extension and	Must retract on Kocher approach



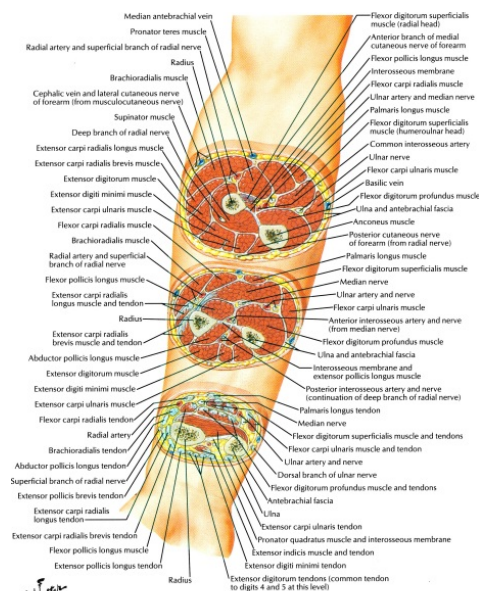
POSTERIOR COMPARTMENT MUSCLES: DEEP EXTENSORS



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Supinator	Posterior medial ulna	Proximal lateral radius	Radial-PIN	Forearm supination	Can compress PIN
Abductor pollicis longus [APL]	Posterior radius/ulna	Base of 1st MC	Radial-PIN	Abduct and extend thumb (CMC)	1st compartment: DeQuervain Disease
Extensor pollicis brevis [EPB]	Posterior radius	Base of proximal phalanx of thumb	Radial-PIN	Extend thumb (MCP)	Same as above, radial border of snuffbox
Extensor pollicis longus [EPL]	Posterior ulna	Base of thumb distal phalanx	Radial-PIN	Extend thumb (IP)	Tendon turns 45° on Lister's tubercle
					Border of snuffbox
Extensor indicis proprius [EIP]	Posterior ulna	Sagittal bands, central slip, distal phalanx of index finger	Radial-PIN	Index finger extension	Used in tendon transfer

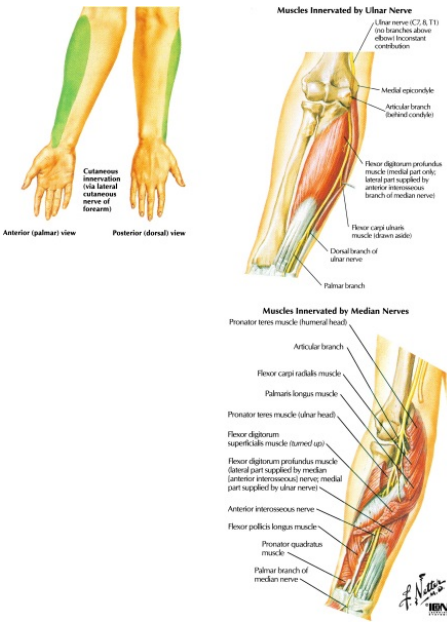
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## MUSCLES: CROSS SECTIONS





NERVES



INFRACLAVICULAR

LATERAL CORD

**Musculocutaneous (C5-7):** only sensory in the forearm

Sensory:	Lateral forearm [via Lateral cutaneous nerve of forearm]
Motor:	NONE (in forearm)

MEDIAL CORD

**Medial Cutaneous Nerve of Forearm (Antibrachial) (C8-T1):** runs with basilic vein

Sensory:	Medial forearm anterior arm
Motor:	NONE

**Ulnar (C7)8-T1):** runs behind medial epicondyle in groove and between 2 heads of ECU [?], then under FCU [?], then to Guyon's canal [?].

Sensory:	NONE (in forearm)
Motor:	Flexor carpi ulnaris
	Flexor digitorum profundus [digits 4, 5]

**MEDIAL AND LATERAL CORDS**

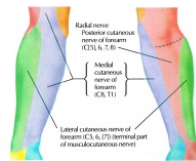
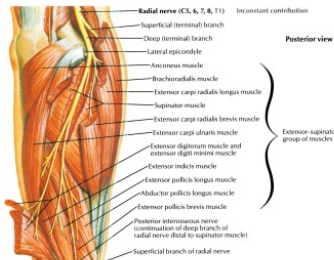
**Median**(C(5)6-T1): runs between 2 heads of PT[?], through ligament of Struthers[?] and lacertus fibrosus[?], under FDS[?] into carpal tunnel[?]  
(Martin Gruber formation: ulnar motor branches run with median nerve then branch to ulnar nerve distally). In wrist, median divides to Motor branch and palmar cutaneous (runs between FCR/PL): at risk in CTS release

3.

4.

<b>Sensory:</b>	NONE (in forearm)
<b>Motor:</b>	<p><u>ANTERIOR COMPARTMENT OF FOREARM</u>  <u>Flexors</u> Pronator Teres [PT]Flexor Carpi Radialis [FCR]Palmaris longus [PL]Flexor digitorum superficialis[FDS][sometimes considered a "middle" flexor]</p> <p><u>Deep Flexors</u> <b>Anterior Interosseous N. (AIN)</b> AIN compressed by PT in forearm, injured in supracondylar fractures  Flexor digitorum profundus [digits 2, 3]  Flexor pollicis longus [FPL]  Pronator Quadratus [PQ]</p>

\* Potential nerve compression site



## INFRACLAVICULAR

### POSTERIOR CORD

**Radial** (C5-T1): Divides into 2 branches:

superficial radial (sensory) and 2. deep (motor)-which then pierces supinator and becomes PIN)

Sensory:	Posterior forearm: via Posterior Cutaneous Nerve of forearm
Motor:	MOBILE WAD(3): <b>Radial Nerve</b> (deep branch): runs around radius into posterior compartment, through radial tunnel[*] becomes PIN
	Superficial Extensors Brachioradialis [BR] Extensor carpi radialis longus [ECRL] Extensor carpi radialis brevis [ECRB]
	POSTERIOR COMPARTMENT: <b>PIN- Posterior/Interosseous Nerve</b> Multiple sites of compression: 1. fibrous tissue of radial head, 2. leash of Henry, 3. Arcade of Frohse, 4. distal supinator, 5. ECRB
	Superficial Extensors Extensor carpi ulnaris [ECU] Extensor digiti minimi [EDM] Extensor digitorum communis [EDC]
	Deep Extensors Supinator Abductor pollicis longus Extensor pollicis longus Extensor pollicis brevis Extensor indicis proprius

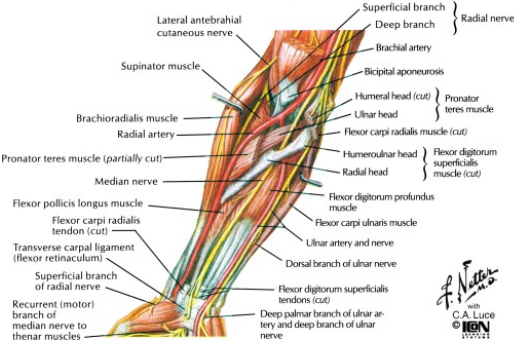
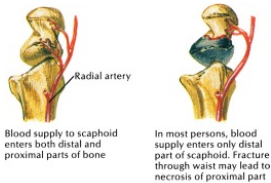
\* Potential nerve compression site



ARTERIES

ARTERY COURSE		BRANCHES
Radial	over PronatorTeres, underBrachioradialis.	Radial recurrent muscularbranches (leash of Henry)
Ulnar	on FDP, underFDS	Anterior ulnar recurrentPosterior ulnar recurrentCommon interosseousAnterior interosseousPosterior interosseousRecurrent interosseousMuscular branches

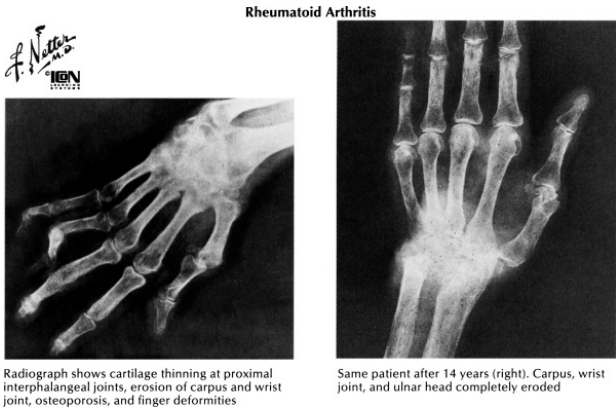
See Arm chapter for arterial anastomosis around the elbow



ARTERY	COURSE	BRANCHES	COMMENT
Radial	Volar: lateral to FCRDorsal: between EPL APL/EPB	3 branchesPalmar carpal branchDorsal carpal branchSuperficial palmar branchDeep palmar arch	Is in anatomic snuffboxDeep to flexor tendonsDeep to extensor tendonsAnastomoses with ulnar artery completes superficial palmar archTerminal branch of radial artery
Ulnar	on the TCL, lateral to pisoform.	4 branchesPalmar carpal branchDorsal carpal branchDeep palmar branch	Deep to FDSDeep to extensor tendonsAnastomoses with radial artery completes deep palmar arch

		Superficial palmar arch	Terminal branch of ulnar artery
Allen test			
	Occlude both radial and ulnar arteries at wrist		
1.			
	Patient should squeeze fist several times		
2.			
	Release pressure on one artery		
3.			
	Repeat releasing other artery		
4.			Hand perfusion ("pinking up") after release indicates patent arches collateral circulation.

DISORDERS: ARTHRITIS INSTABILITY

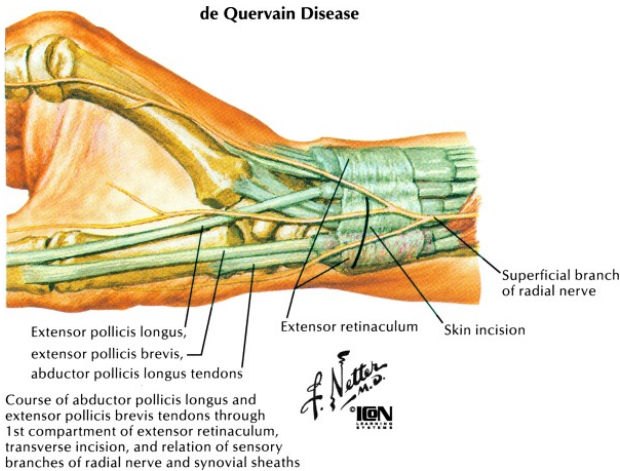


DESCRIPTION	H P	WORK-UP/FINDING	TREATMENT
ARTHRITIS			
OSTEOARTHRITIS/DEGENERATIVE JOINT DISEASE			
<p>"Wear tear":</p> <ul style="list-style-type: none"><li>articular cartilage loss</li><li>1° or 2° (e.g. trauma.)</li><li>Seen in SLAC wrist</li></ul>	<p>Hx: Older, women, pain (worse with activity)</p> <p>PE: Swelling, decreased ROM</p>	<p>XR: OA findings: spurs, joint space loss, sclerosis</p>	<ol style="list-style-type: none"><li>NSAID, splint, steroid injection</li><li>Arthrodesis (pain relief)</li></ol>
DEQUERVAIN'S DISEASE			
<ul style="list-style-type: none"><li>Stenosing tenosynovitis of 1st dorsal compartment (APL/EPB)</li></ul>	<p>Hx: Often history of tennis or golf. Pain, swelling.</p> <p>PE: 1Finkelstein test</p>	<p>XR: Possible calcified tendons</p> <p>Lab: Uric acid (rule out gout)</p>	<ol style="list-style-type: none"><li>Splint, NSAID, injection</li><li>Surgical release</li></ol>
RHEUMATOID ARTHRITIS			
<ul style="list-style-type: none"><li>Systemic inflammatory disorder affecting synovium, destroys joint</li><li>Wrist common site</li><li>Associated with tenosynovitis CTS</li></ul>	<p>Hx: Pain, stiffness (worse In AM)</p> <p>PE: Swelling throughout joint. Decreased ROM, ulnar drift at MCPs.</p>	<p>XR: Hand series: joint destruction erosion</p> <p>Labs: RF, ANA, WBC, ESR, uric acid</p>	<ol style="list-style-type: none"><li>Medical management, splint joints</li><li>Synovectomy (single joint)</li><li>Tendon transfer or repair</li><li>Arthrodesis or arthroplasty</li></ol>
INSTABILITY			
SLAC: SCAPHOLUNATE ADVANCED COLLAPSE			

<ul style="list-style-type: none"> <li>Degenerative arthritis secondary to instability (SL ligament disruption or scaphoid fracture/injury)</li> </ul>	Hx/PE: Chronic pain, remote history of trauma.	XR: Radioscaphoid OA: (CL joint also involved, RL joint spared)	<ol style="list-style-type: none"> <li>Scaphoid excision, capitolunate fusion</li> <li>Proximal row carpectomy or fusion</li> </ol>
SCAPHOLUNATE DISSOCIATION: (static/dynamic)			
<ul style="list-style-type: none"> <li>SL/RCL ligament disrupted: lunate displaced dorsally</li> <li>[DIS: Dorsal Intercalated Segment Instability]</li> <li>LT ligament disrupted: lunate displaced volarly [VIS:Volar ISI]</li> </ul>	Hx: Fall (extension supination wrist injury). Pain in wrist.  PE: 1Watson's test	XR: SL space .3mm 5 "Terry Thomas" sign. Closed fist: increases SL gap	Early: closed reduction, splint/cast. Repair ligament if full tear Late: STT fusion, carpectomy, or wrist fusion.
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DISORDERS: NERVE COMPRESSION



DESCRIPTION	H P	WORK-UP/FINDING	TREATMENT
<b>AIN (Anterior Interosseous Nerve) SYNDROME</b>			
<ul style="list-style-type: none"><li>• AIN trapped under:<ol style="list-style-type: none"><li>1. PT</li><li>2. FDS</li><li>3. FCR</li></ol></li></ul>	Hx: No sensory findings	XR: Rule out other pathology	1. Conservative treatment
	PE: decreased thumb flexion, no "OK" sign (+ Kiloh-Nevinsign)		2. Surgical release if does not resolve
<b>CARPAL TUNNEL SYNDROME (CTS)</b>			
<ul style="list-style-type: none"><li>• Median nerve trapped in carpal tunnel</li></ul>	Hx: Repetitive motion, night pain, parathesias, clumsy	XR: Rule out other pathology	1. Activity modification
<ul style="list-style-type: none"><li>• Most common nerve entrapment</li></ul>	PE: Weak thenar muscles, + Tinel Phalen tests	EMG/NCS: Localize the lesion	2. Cock-up splint, NSAID, steroid injection
<ul style="list-style-type: none"><li>• Associated with metabolic disease (DM, EtOH, pregnancy, thyroid disease)</li></ul>			3. Carpal tunnel release [avoid palmar branch]
<b>PIN SYNDROME (Saturday Night Palsy)</b>			
<ul style="list-style-type: none"><li>• PIN trapped by:<ol style="list-style-type: none"><li>1. Supinator (proximal border most common)</li><li>2. Arcade of Frohse</li><li>3. Leash of Henry</li><li>4. Fibrous bands</li><li>5. ECRB</li></ol></li></ul>	Hx: +/- pain	XR: Rule out other pathology	1. Observe. It may resolve
	PE: No sensory findings. Wrist drops	EMG/NCS:	2. Surgical

findings. wrist drop, decreased wrist digit extension	Localize the lesion	decompression if symptoms persist
---	------------------------	--------------------------------------

### PRONATOR SYNDROME

• Median nerve trapped by: 1. PT, 2. Ligament of Struther, 3. Lacertus fibrosus, 4. FDS	Hx: Forearm pain, increases with activity	XR: Rule out other pathology	1. NSAID, rest, splint
	PE: Thenar weakness, Tinel Phalen tests	EMG/NCS: Localize the lesion	2. Surgical release after 3-4 months

### RADIAL TUNNEL SYNDROME

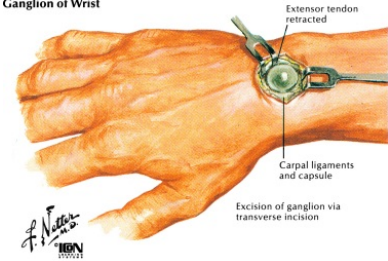
• Radial nerve trapped in radial tunnel (1 of 4 places)	Hx: Pain in lateral forearm	XR: Rule out other pathology	1. Rule out lateral epicondylitis
	PE: No motor/sensory findings		2. Activity modification, splinting
			3. Surgical exploration/release

### ULNAR TUNNEL SYNDROME

• Ulnar nerve trapped in Guyon's canal	Hx: Pain, numbness, intrinsic weakness	XR: not indicated	1. Activity modification, rest, immobilize
• Can be trauma related	PE: +Tinel of ulnar nerve at wrist	EMG/NCS: will localize lesion	2. Surgical decompression

OTHER DISORDERS

Ganglion of Wrist



Kienböck's Disease

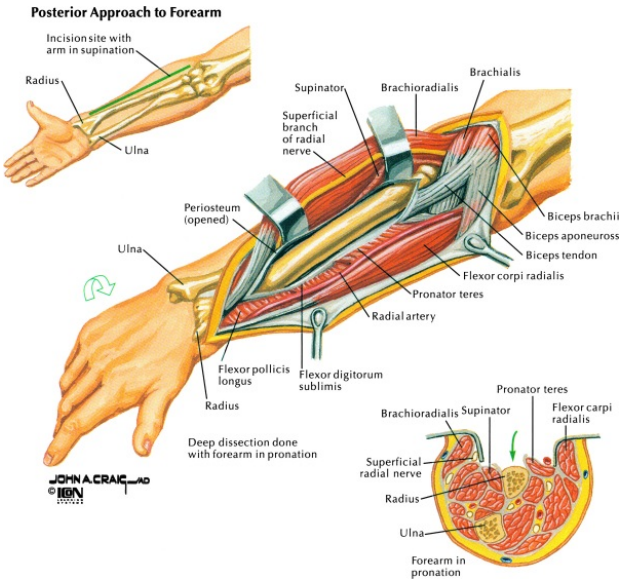


Radiograph of wrist shows characteristic sclerosis of lunate

DESCRIPTION	H P	WORK-UP/FINDING	TREATMENT
GANGLION			
• Cyst with mucinous/joint fluid	Hx/PE: Round, large or small transilluminating mass, +/-pain	XR: Wrist series, no radiographic evidence of ganglion	1. Asymptomatic: reassurance
• Communicates with joint			2. Symptomatic: aspirate or surgically excise (with stalk or it will recur)
• Most common mass in wrist1. Dorsal (SL)2. Volar (ST)			
KIENBÖCK'S DISEASE			
• Osteonecrosis of lunate	Hx: Pain, swelling, stiffness	XR: Opacity of lunate	I. NSAID, splinting
• Wrist trauma or short ulna	PE: Grip strength may be reduced.	Bone scan/MRI: will confirm diagnosis	II/III. Joint leveling procedure/carpal fusion
• 4 stages: based on collapse			IV. Proximal row carpectomy or fusion



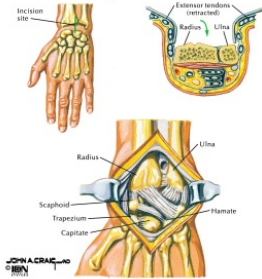
SURGICAL APPROACHES



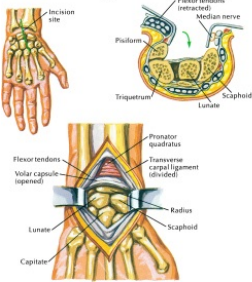
USES	INTERNEUROUS PLANE	DANGERS	COMMENT
FOREARM: ANTERIOR APPROACH (HENRY)			
1. ORIF fractures	Distal1. Brachioradialis [Radial]2. FCR [Median]	1. PIN	1. Radial recurrent artery (Leash of Henry) vein need ligation.
2. Osteotomy	Proximal1. Brachioradialis [Radial]2. Pronator Teres [Median]	2. Superficial radial nerve	2. If not ligated, hemorrhage could result in Compartment syndrome and/or Volkmann's contracture
3. Biopsy bone tumors		3. Radial artery	
WRIST: DORSAL APPROACH			
1. Fusion	1. 3rd dorsal compartment [EPL]	Radial nerve (Superficial)	1. Incise to the extensor retinaculum. This leaves cutaneous nerves intact in the subcutaneous fat.
2. Stabilization	2. 4th dorsal compartment [EDC, EIP]		2. Neuroma can develop from cutting cutaneous nerves.
3. ORIF fractures			
4. Carpectomy			
WRIST: VOLAR APPROACH			
1. Carpal tunnel	No plane	1. Median nerve• Palmar cutaneous	1. Retract PL/FPL radially

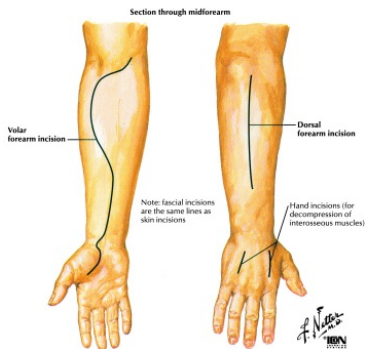
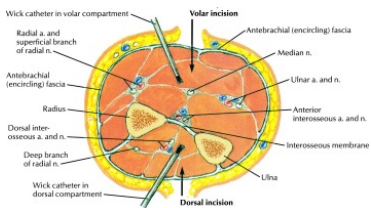
decompression	two planes	branch• Recurrent motor	Retract FDS/FDP ulnarly
2. ORIF volar fracture		2. Palmar arch	2. Dissect TCL carefully to avoid nerve damage.
3. Dislocated lunate			
4. Tendon laceration			

#### Dorsal Approach to Wrist Joint



#### Volar Approach to Wrist Joint





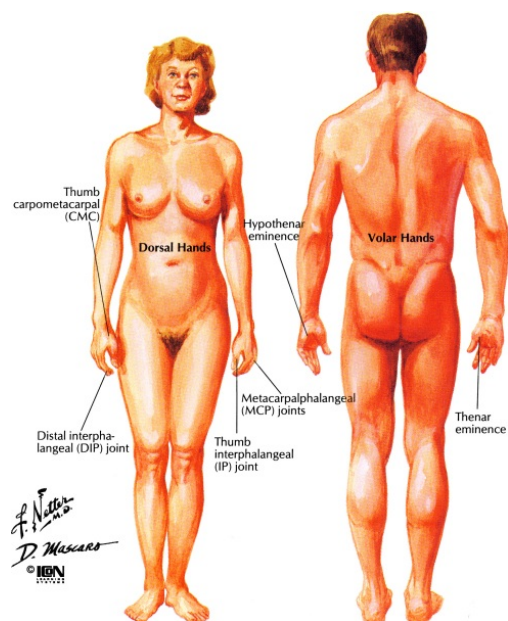
## CHAPTER 5 - HAND

- [TOPOGRAPHIC ANATOMY](#)
- [OSTEOLOGY OF THE HAND](#)
- [TRAUMA](#)
- [JOINTS](#)
- [OTHER STRUCTURES: FLEXOR TENDON SHEATH AND PULLEYS](#)
- [OTHER STRUCTURES: HAND SPACES](#)
- [OTHER STRUCTURES: FINGER](#)
- [FLEXOR TENDON INJURY ZONES](#)
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- [MUSCLES](#)
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- [DISORDERS: INFECTIONS](#)
- [DISORDERS: MASSES & TUMORS](#)
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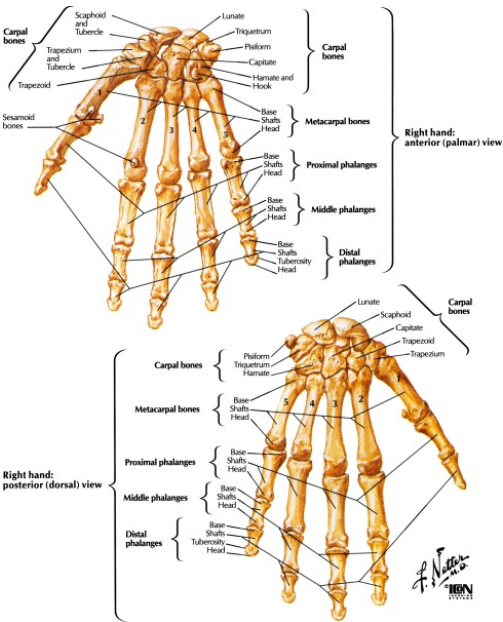


## CHAPTER 5 – HAND

### TOPOGRAPHIC ANATOMY



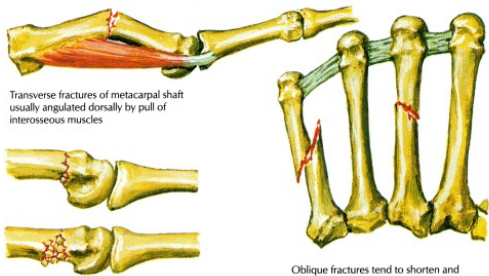
OSTEOLOGY OF THE HAND



CHARACTERISTICS	OSSIFY	FUSE	COMMENT
METACARPALS			
• Triangular in cross section: gives 2 volar muscular attachment sites	Primary: Body	9 wks (fetal) 18 yrs	• Named I-V (thumb to small finger)
• Thumb MC has saddle shaped base: increases it mobility	Epiphysis	2 yrs	• Only one epiphysis per bone in the head. In thumb MC it is in the base.
PHALANGES			
• Palmar surface is almost flat	Primary: Body	8 wks (fetal) 14-18 years	• 3 phalanges in each digit except thumb
• Tubercles and ridges are sites for attachment.	Epiphysis	2-3 yr	• Only one epiphysis per bone in base.
Nomenclature for digits: thumb, index finger, middle finger, ring finger, small finger			

TRAUMA

Metacarpal Fractures

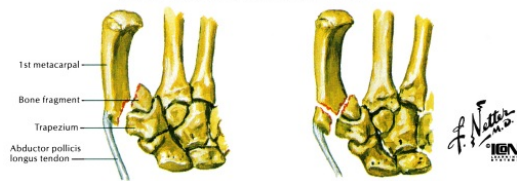


Transverse fractures of metacarpal shaft usually angulated dorsally by pull of interosseous muscles

Oblique fractures tend to shorten and rotate metacarpal, particularly in index and little fingers because metacarpals of middle and ring fingers are stabilized by deep transverse metacarpal ligaments

In fractures of metacarpal neck, volar cortex often comminuted, resulting in marked instability after reduction, which often necessitates pinning

Fracture of Base of Metacarpals of Thumb



**Type I (Bennett fracture).** Intra-articular fracture with proximal and radial dislocation of 1st metacarpal. Triangular bone fragment sheared off

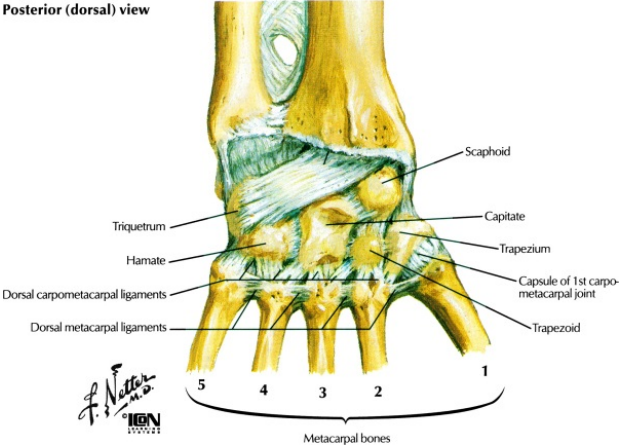
**Type II (Rolando fracture).** Intra-articular fracture with Y-shaped configuration

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
METACARPAL FRACTURES			
<ul style="list-style-type: none"><li>• Common in adults</li><li>• 5<sup>th</sup> MC most common (Boxer's fracture at neck)</li><li>• 1<sup>st</sup> MC base. Bennett Rolando fracture: displaced, intra-articular.</li><li>• 4<sup>th</sup> 5<sup>th</sup> MC tolerate angulation; 2<sup>nd</sup> 3<sup>rd</sup> do not</li></ul>	<p>HX: Trauma. Swelling, pain, deformity.</p> <p>PE: Swelling, tenderness, +/- rotational deformity, shortening. Decreased ROM.</p> <p>XR: PA, lateral, oblique</p>	<p>By location:</p> <ul style="list-style-type: none"><li>• Head</li><li>• Neck (most common)</li><li>• Shaft (transverse, spiral, Oblique)</li><li>• Base (Bennett, Rolando, "Baby Bennett"-base of 5<sup>th</sup> MC)</li></ul>	<p>Nondisplaced: ulnar gutter splint 4 weeks, then ROM.</p> <p>Severely Angulated or shortened: percutaneous pins or ORIF</p> <p>Displaced or intra-articular: reduce then pin. Unstable: ORIF</p>
COMPLICATIONS: Rotational deformity grip abnormalities (malunion)			
PHALANGEAL FRACTURES			
	HX: Trauma.	<p>Descriptive/location:</p> <ul style="list-style-type: none"><li>• Intra vs extraarticular</li><li>• Displaced/undisplaced</li></ul>	<p>Extraarticular</p> <p>Undisplaced: buddy tape and/or splint</p>

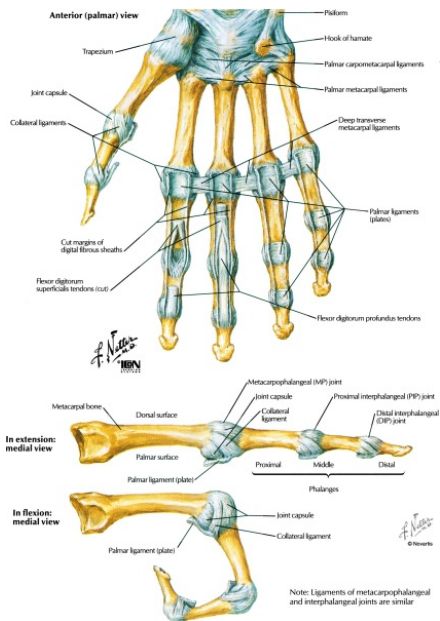
• Children/adults	Swelling, pain, deformity.	<ul style="list-style-type: none"> <li>• Open/closed</li> <li>• Transverse/oblique</li> <li>• Base, shaft, neck, condyle</li> </ul>	Displaced: reduce, splint Unstable: pin or ORIF
• <b>Distal phalanx most common (MF)</b>	PE: Swelling, tenderness, +/- rotational deformity, shortening. Decreased		
• Early ROM important for good results	ROM, 2 pt discrimination, capillary refill.		
• Articular surfaces do not Tolerate incongruity. <b>Close follow up is critical for intraarticular fractures</b>	XR: AP, lateral, blique		Splint must have MCP in flexion, IPs extended
			Intraarticular: ORIF
			Repair nail bed if needed
COMPLICATIONS: Rotational deformity (malunion); Decreased motion; Degenerative Joint Disease (DJD)			
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JOINTS

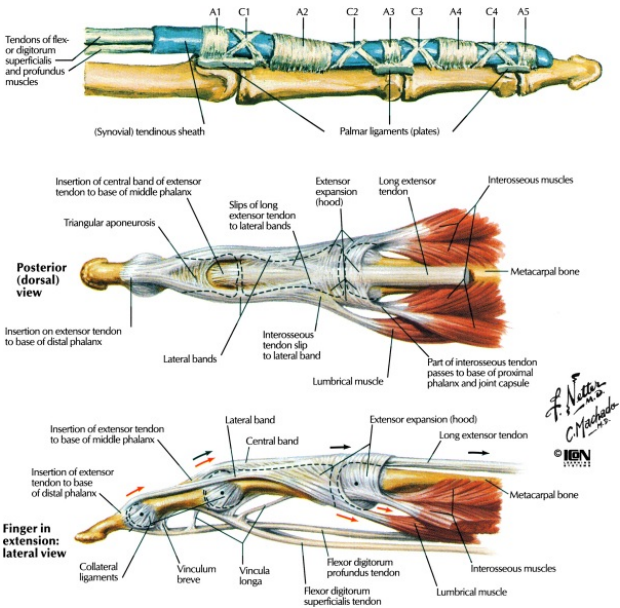
Posterior (dorsal) view



JOINT	TYPE	LIGAMENTS	ATTACHMENTS	COMMENTS
CARPOMETACARPAL				
Thumb	Saddle	Capsule		Highly mobile; common site for arthritis
		Dorsal, palmar, radial CMC	Trapezium to metacarpals	
Finger	Gliding	Capsule		
		Dorsal palmar CMC	Carpal to metacarpal bones	Dorsal strongest
		Interosseous CMC		
METACARPOPHALANGEAL				
	Ellipsoid	Capsule	Metacarpal to proximal phalanx	
		2 collateral (radial and ulnar)	Metacarpal to proximal phalanx	Loose in extension, tight in flexion
				Cast in flexion or ligaments will shorten
				Thumb ulnar collateral: <ul style="list-style-type: none"><li>• stabilizes pinch</li><li>• injury is Gamekeeper's</li></ul>
		Palmar [volar plate]	Metacarpal to proximal phalanx	
		Deep transverse metacarpal		
INTERPHALANGEAL				
	Hinge	Capsule		
		2 collateral	Adjacent phalanges	Obliquely oriented
		Palmar [volar	Adjacent phalanges	Prevents hyperextension



OTHER STRUCTURES: FLEXOR TENDON SHEATH AND PULLEYS

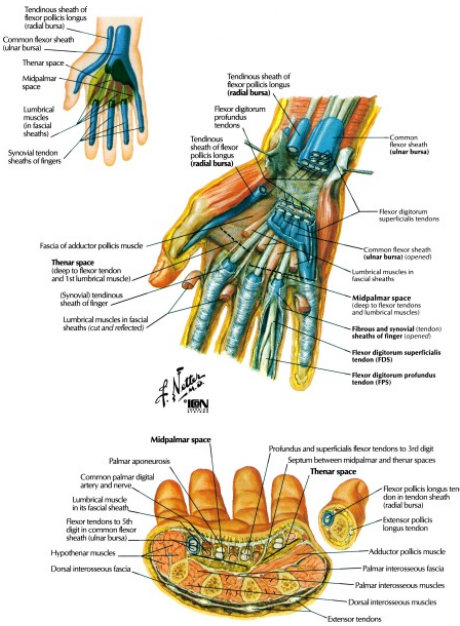


STRUCTURE	CHARACTERISTICS	COMMENT
Flexor tendon sheath	Fibroosseous tunnel, lined with tenosynovium	Pulleys (5 annular, 3 cruciate) are thickenings of sheath. <b>A2, A4 most important mechanically.</b> A1, 3, 5 cover joints; <b>A1 common cause of triggering.</b>
	Protect, lubricate, nourish tendons	
	In sheath: vinculae are vascular supply to tendons	
		Site of potential infection: <b>Kanavel signs often present</b> (see Disorders)
Intrinsic Apparatus	Sagittal bands	EDC attaches extends MCP
	Central Slip	EDC attaches extends PIP: injury can result in Boutonniere deformity
	Lateral bands	Lumbricals attach extend PIP
	Volar plate (transverse fibers)	FDS attaches flexes PIP
	Oblique retinacular ligaments	Interossei attach flex MCP
		EDC attaches extends DIP



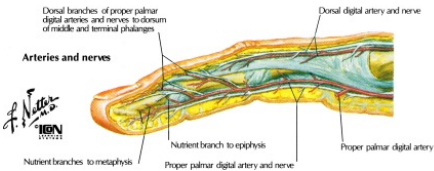
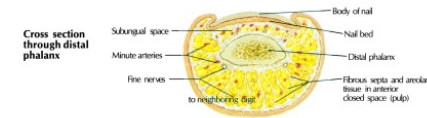
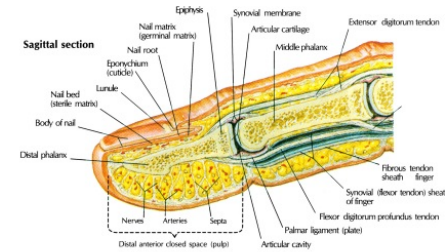


OTHER STRUCTURES: HAND SPACES



STRUCTURE	CHARACTERISTICS	COMMENT
HAND SPACES		
Thenar	Between flexor tendon and Adductor pollicis	Potential space: <b>site of possible infection</b>
Mid-palmar	Between flexor sheath and metacarpal	Potential space: <b>site of possible infection</b>
Radial bursa	Proximal extension of FPL sheath	Infection can track proximally
Ulnar bursa	Communicates with SF, FDS, FDP flexor tendon sheath	Flexor sheath infection can track proximally into bursa

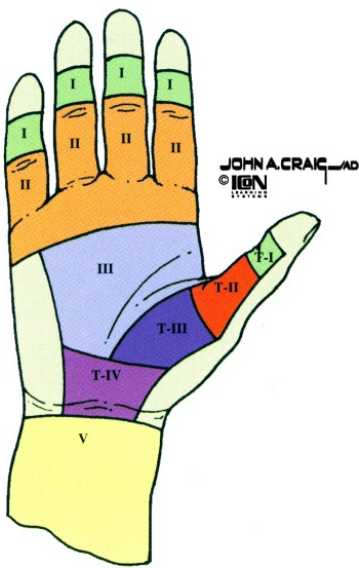
OTHER STRUCTURES: FINGER



STRUCTURE CHARACTERISTICS		COMMENT
FINGERTIP		
Nail	Cornified epithelium	If completely avulsed, replace to keep eponychium and matrix separated until nail can grow back.
Nail bed/Matrix	Germinal: to lunula, under eponychium	Where nail grows (1mm a week), <b>must be intact (repaired) for nail growth</b>
	Sterile: distal to lunula	If injured, does not need repair to function
Pulp	Multiple septae, nerves, arteries	Felon is an infection of the pulp

FLEXOR TENDON INJURY ZONES

Flexor Zones of Hand

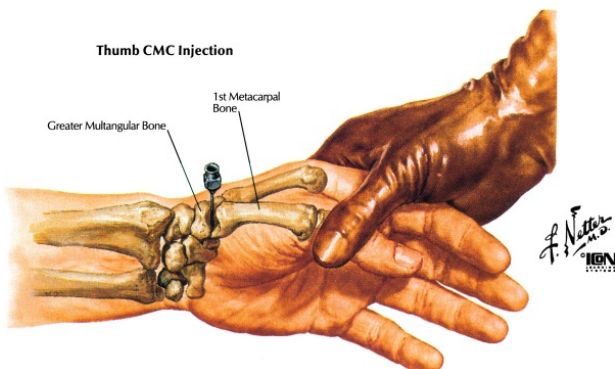


ZONE	BOUNDARIES	COMMENT
I	FDS insertion to distal tip	Injuries amenable to repair (e.g. Jersey finger)
II	Midpalm fibroosseous tunnel to FDS insertion	Called <b>"No man's land"</b> because high rate of complications. Careful PE is required for diagnosis, the injury may not be at skin laceration site . FDS FDP may both require repair. A2, A4 must be preserved.
		<b>Repair in zones 3-5 should be immediate</b>
III	Transverse Carpal ligament to fibro-osseous tunnel	Injuries often associated with Median nerve or arterial arch injuries. Explore and repair all.
IV	Transverse carpal ligament (carpal tunnel)	Uncommon site of injury. Repair usually requires carpal tunnel release and repair. <b>Median nerve at risk.</b>
V	Proximal to the TCL	Injuries require end-to-end repair
Thumb I	Thumb IP to distal tip	Similar to finger
Thumb II	Thumb CMC to IP	Similar to finger
Thumb III	Thenar eminence	Repair may require lengthening or graft procedure



## MINOR PROCEDURES

### Thumb CMC Injection



#### STEPS

##### INJECTION OF THUMB CMC JOINT

1. Ask patient about allergies
2. Palpate thumb CMC joint on volar radial aspect
3. Prepare skin over CMC joint (iodine/antiseptic soap)
4. Anesthetize skin locally (quarter size spot)  
Palpate base of thumb MC, pull axial distraction on thumb with slight flexion to open joint. Use 22 gauge or smaller needle, and insert into joint. **Aspirate to ensure needle is not in a vessel.** Inject 2-3ml of 1:1 local (**without epinephrine**)/corticosteroid preparation into CMC joint. (**The fluid should flow easily if needle is in joint**)
5. Dress injection site

##### FLEXOR TENDON SHEATH BLOCK

1. Ask patient about allergies
2. Palpate the flexor tendon at the distal palmar crease.
3. Prepare skin over palm (iodine/antiseptic soap)  
Insert 22 gauge needle into flexor tendon at the level of the distal palmar crease.
4. Withdraw needle so it is just outside tendon, but inside sheath. Inject 2-5ml of **local anesthetic without epinephrine.**
5. Dress injection site


##### DIGITAL BLOCK

1. Prepare skin over dorsal proximal finger web space (iodine/antiseptic soap)  
Insert 22 gauge needle between metacarpal heads on both sides of finger. **Aspirate to ensure needle is not in a vessel.** Inject 2- 5ml of **local anesthetic without epinephrine.** The dorsum of the proximal digit may also require anesthesia for adequate anesthesia.
3. Care should be taken not to inject too much fluid into the closed space of the proximal digit
4. Dress injection site

HISTORY

**"Jersey Finger"**

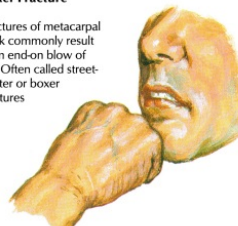
Avulsion of flexor digitorum profundus tendon



Caused by violent traction on flexed distal phalanx, as in catching on jersey of running football player

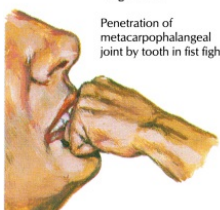
**Boxer Fracture**

Fractures of metacarpal neck commonly result from end-on blow of fist. Often called street-fighter or boxer fractures




**"Fight Bite"**


Penetration of metacarpophalangeal joint by tooth in fist fight



**Mallet finger**



Usually caused by direct blow on extended distal phalanx, as in baseball, volleyball



QUESTION	ANSWER	CLINICAL APPLICATION
1. HAND DOMINANCE	Right or left	Dominant hand injured more often
2. AGE	Young	Trauma, infection
	Middle age, elderly	Arthritis, nerve entrapments
3. PAIN		
a. Onset	Acute	Trauma, infection
	Chronic	Arthritis
b. Location	<b>CMC (thumb)</b>	<b>Arthritis (OA) especially in women</b>
	Volar (fingers)	Purulent tenosynovitis (1 Kanavel signs)
4. STIFFNESS	In AM, with "catching"	<b>Trigger finger</b> , rheumatoid arthritis
5. SWELLING	After trauma	Infection (e.g. purulent tenosynovitis, felon, paronychia)
	No trauma	Arthritides, gout, tendinitis
6. MASS		<b>Ganglion</b> , Dupuytren's contracture, giant cell tumor
7. TRAUMA	Fall, sports injury in dirty environment	Fracture, tendon avulsion
		Infection
8. ACTIVITY	Sports, mechanic	Trauma (e.g. fracture, dislocation, tendon rupture)
9. NEUROLOGIC SYMPTOMS	Pain, numbness, tingling	Nerve entrapment (e.g. carpal tunnel), thoracic outlet syndrome, radiculopathy
	Weakness	Nerve entrapment (usually in wrist or more

wedness

proximal)

10. HISTORY OF  
ARTHRITIDES

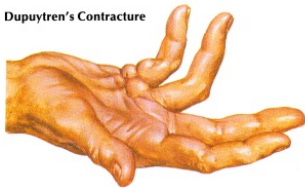
Multiple joints  
involved

Rheumatoid arthritis, Reiter syndrome, etc.

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PHYSICAL EXAM

Dupuytren's Contracture



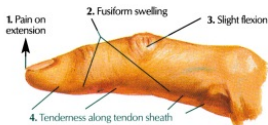
Flexion contracture of 4th and 5th fingers (most common).  
Dimpling and puckering of skin. Palpable fascial nodules near flexion crease of palm at base of involved fingers with cordlike formations extending to proximal palm

Rheumatoid Arthritis



Boutonniere deformity of index finger with swan-neck deformity of other fingers

Purulent Tenosynovitis.  
Four cardinal signs of Kanavel



Osteoarthritis

Heberden's nodes seen in index and middle finger distal interphalangeal joints. Bouchard's nodes seen in proximal interphalangeal joints of the ring and small finger.



*F. Netter M.D.*  
H&M

EXAMINATION	TECHNIQUE	CLINICAL APPLICATION
INSPECTION		
Gross deformity	Ulnar drift or swan neck	Rheumatoid arthritis
	Rotational or angular deformity	Fracture
Finger position	Flexion	Dupuytren contracture, purulent tenosynovitis
Skin, hair, nail changes	Cool, hairless, spoon nails, etc.	Neurovascular disorders: Raynaud's, diabetes, nerve injury
Swelling	DIPs	Nodes from osteoarthritis: <b>Heberden's (at DIPs: #1)</b> , Bouchard's (at PIPs)
	PIPs	
	MCP's	Rheumatoid arthritis
	Fusiform shape finger	Purulent tenosynovitis
Muscle wasting	Thenar eminence	Median nerve injury, CTS, C8/T1 pathology, CMC arthritis
	Hypothenar eminence or intrinsics	Ulnar nerve injury

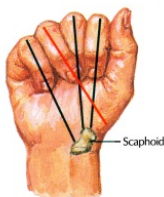




Paronychia



Felon



Scaphoid

Rotation displacement of ring finger. All fingers should point toward scaphoid when clenched

*F. Netter M.D.*  
 ILLUSTRATIONS

Stenosing Tenosynovitis (Trigger Finger)



Patient unable to extend affected finger. It can be extended passively, and extension occurs with distinct and painful snapping action. Circle indicates point of tenderness where nodular enlargement of tendons and sheath is usually palpable

EXAMINATION	TECHNIQUE	CLINICAL APPLICATION
<b>PALPATION</b>		
Skin	Warm, red	Infection
	Cool, dry	Neurovascular compromise
Metacarpals	Each along its length	Tenderness may indicate fracture
Phalanges finger joints	Each separately	Tenderness: fracture, arthritis; Swelling: arthritis
Soft tissues	Thenar hypothenar eminences	Wasting indicates median ulnar nerve injury respectively
	Palm (palmar fascia)	Nodules: Dupuytren's contracture; Snapping with finger extension: Trigger finger
	Flexor tendons: along volar finger	Tenderness suggests purulent tenosynovitis
	Sides of finger	Giant cell tumors
	All aspects of finger tip	Tenderness: paronychia or felon
<b>RANGE OF MOTION</b>		
Finger: MCP joint	Flex 90°, extend 0°, Add/abd 0-20°	Decreased flexion if casted in extension (collateral ligaments shorten)
PIP joint	Flex 110°, extend 0°	Hyperextension leads to swan-neck deformity
DIP joint	Flex 80°, extend 10°	All fingers should point to scaphoid at full flexion
Thumb: CMC joint	Radial abduction: Flex 50°, extend 50°	Motion is in plane of palm
	Palmar abduction: Abduct 70°, adduct 0°	Motion is perpendicular to plane of the palm
MCP joint	In plane of palm: Flex 50°, extend 0°	
IP joint	In plane of palm: Flex 90°, extend 10°	
Opposition	Touch thumb to small fingertip	Motion is mostly at CMC joint

## Motor Testing



Thumb extension.  
Extensor pollicis longus.  
Radial nerve (PIN).



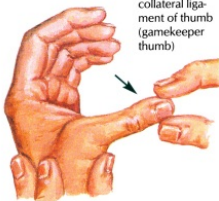
Finger flexion.  
Flexor digitorum  
superficialis and  
profundus. Median  
nerve. C8



Finger extension. Extensor  
digitorum. Radial nerve  
(PIN). C7

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## Thumb Instability Test

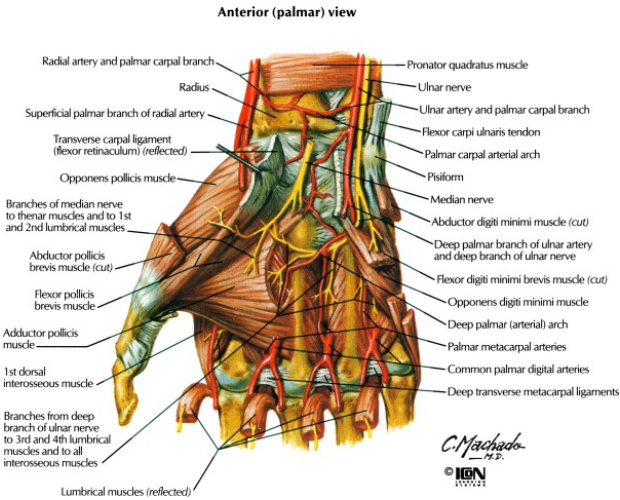


Stress test for  
ruptured ulnar  
collateral liga-  
ment of thumb  
(gamekeeper  
thumb)

EXAMINATION	TECHNIQUE	CLINICAL APPLICATION
<b>NEUROVASCULAR</b>		
<b>Sensory</b>	Light touch pinprick, 2 point	
Radial Nerve (C6)	Dorsal thumb web space	Deficit indicates corresponding nerve/root lesion
Median Nerve (C6-7)	Radial border middle finger	Deficit indicates corresponding nerve/root lesion
Ulnar Nerve (C8)	Ulnar border small finger	Deficit indicates corresponding nerve/root lesion
<b>Motor</b>		Number in parenthesis indicates compartment
Radial nerve/PIN (C7)	Finger extension	Weakness 5 EDC(4), EIP(4), EDM(5) or nerve lesion
	Thumb abduction extension	Weakness 5 APL(1) / EPL(3) or nerve/root lesion
Median nerve/AIN (C8)	PIP flexion	Weakness 5 FDS or corresponding nerve/root lesion
	DIP flexion	Weakness 5 FDP (1/2 of muscle) or nerve lesion
	Thumb IP flexion	Weakness 5 FPL or corresponding nerve/root lesion
Motor Recurrent Branch	"OK" sign	Weakness 5 APB, OP, 1/2 FPB or nerve lesion; (CTS)
	MCP flexion (index/middle fingers)	Weakness 5 IF, MF lumbricals or c nerve/root lesion
Ulnar nerve (Deep branch) (T1)	Finger cross (abduct/adduct)	Weakness 5 Dorsal/Volar interosseous or nerve lesion
	Small finger abduction	Weakness 5 FDM, ODM, ADM or nerve/root lesion
	MCP flexion (ring/small fingers)	Weakness 5 RF, SF lumbricals or nerve/root lesion
<b>Reflex:</b> Hoffmann	Tap a finger distal phalanx	Only pathologic (1 if different phalanx flexes): UMN syndrome
		Tests ulnar and radial artery patency
<b>Pulses/capillary</b> refill	Allen's test	
	Doppler: arches, digital pulses	
<b>SPECIAL TESTS</b>		
	Stabilize DR in	

Profundus	Stabilize PIP in extension, flex DIP only	Inability to flex DIP alone indicates <b>FDP pathology</b>
Sublimis	Extend all fingers, flex a single finger at PIP	Inability to flex PIP of isolated finger indicates <b>FDS pathology</b>
Froment's sign	Hold paper with thumb index finger, pull paper	Thumb PIP flexion is positive, suggest Adductor Pollicis or Ulnar nerve palsy
CMC grind	Axial compress rotate CMC joint	Pain indicates arthritis at CMC and/or MCP joints of thumb
Finger instability	Stabilize proximal joint, apply varus valgus stress	Laxity indicates collateral ligament damage
Thumb instability	Stabilize MCP, apply valgus stress	Laxity indicates <b>ulnar collateral ligament strain (Gamekeeper's thumb)</b>
Murphy sign	Make fist, observe height of MCP's	If 3 <sup>rd</sup> MC (normally elevated) is flat with 2 <sup>nd</sup> 4 <sup>th</sup> MC, suggests lunate dislocation
Bunnel-Littler	Extend MCP, passively flex PIP	Tight or inability to flex PIP, improved with MCP flexion indicates tight intrinsic muscles

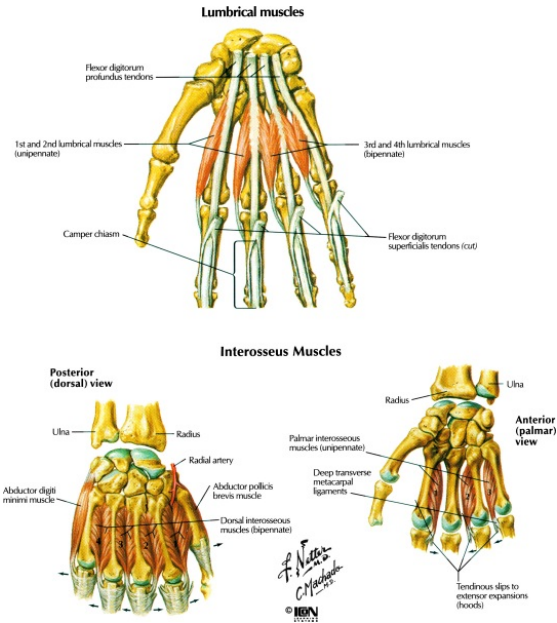
MUSCLES



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
THENAR COMPARTMENT					
Abductor pollicis brevis [APB]	Scaphoid, trapezium	Lateral proximal phalanx of thumb	Median	Thumb abduction	Palpable in lateral thenar eminence
Flexor pollicis brevis [FPB]	Trapezium	Base of proximal phalanx of thumb	Median	Thumb MCP flexion	Palpable in medial thenar eminence
Opponens pollicis	Trapezium	Lateral thumb MC	Median	Oppose thumb, rotate medially	Opposition is most important action
ADDUCTOR COMPARTMENT					
Adductor pollicis	1. Capitate, 2 nd 3rd MC	Base of proximal phalanx of thumb	Ulnar	Thumb adduction	Radial artery between its two heads
	2. 3rd Metacarpal				
HYPOTHENAR COMPARTMENT					
Palmaris brevis [PB]	Transverse carpal ligament [TCL]	Skin on medial palm	Ulnar	Wrinkles skin	Protects ulnar nerve
Abductor digiti minimi [ADM]	Pisiform	Base of proximal phalanx of SF	Ulnar	SF abduction	Palpable laterally
Flexor digiti minimi brevis [FDMB]	Hamate, TCL	Base of proximal phalanx of SF	Ulnar	SF MCP flexion	Palpable medially
				Oppose SF	Deep to other

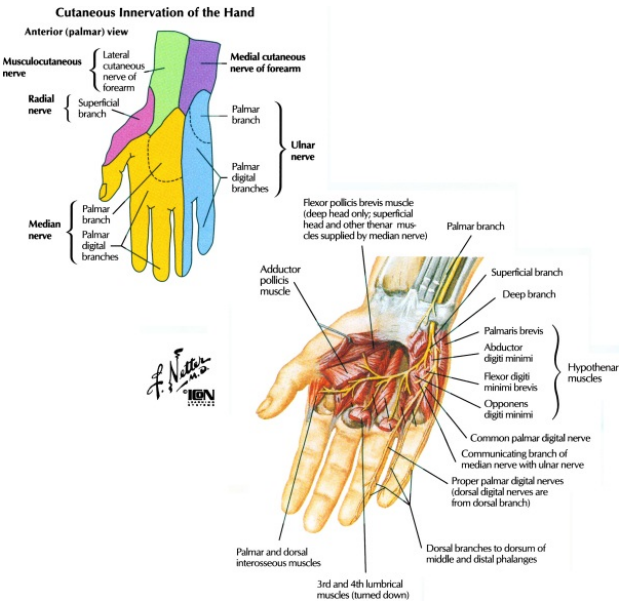
Opponens digiti minimi [ODM]	Hamate, TCL	Medial side 5 <sup>th</sup> MC	Ulnar	Oppose or, rotate laterally	Deep to other muscles in the group
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INTRINSIC MUSCLES



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
INTRINSICS					
Lumbricals 1 2	FDP tendons (lateral 2)	Lateral bands	Median	Extend PIP, flex MCP	Only muscles in body to insert on their own antagonist.
Lumbricals 3 4	FDP tendons (medial 3)	Lateral bands	Ulnar	Extend PIP, flex MCP	
Interosseous: Dorsal [DIO]	Adjacent metacarpals	Proximal phalanx extensor expansion	Ulnar	Digit abduction	DAB: Dorsal ABduct
Interosseous: Volar [VIO]	Adjacent metacarpals	Proximal phalanx extensor expansion	Ulnar	Digit adduction	PAD: Palmar Adduct (volar 5 palmar)

NERVES



INFRACLAVICULAR

MEDIAL CORD

1. **Ulnar** (C(7)8-T1): through Guyon's canal, past hook of hamate

Sensory: Medial palm 1 1/2 digits via: palmar, palmar digital branches

Medial dorsal hand 1 1/2 digits via: dorsal, dorsal digital, proper digital branches

Nerve divides at hypothenar eminence

Motor: **Superficial Branch** @[lateral to pisiform]

Palmaris brevis

**Deep (Motor) Branch** [around hook of hamate]

Adductor pollicis

THENAR MUSCLES

Flexor pollicis brevis [FPB] [with median]

HYPOTHENAR MUSCLES

Abductor digiti minimi [ADM]

Flexor digiti minimi brevis[FDMB]

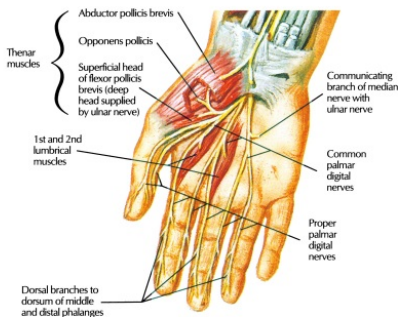
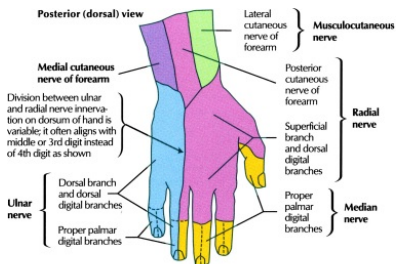
Opponens digiti minimi [ODM]

INTRINSIC MUSCLES

Dorsal interossei [DIO] [abduct DAB]

Volar interossei [VIO] [adduct PAD]

Lumbricals [medial two (3,4)]



## INFRACLAVICULAR

### MEDIAL AND LATERAL CORDS

2. **Median** (C5/6-T1): runs through carpal tunnel, then cutaneous branches off at (risk in Carpal Tunnel release)

Sensory: **Palmar Cutaneous Branch**

Dorsal distal phalanges of 3 1/2 digits: via proper palmar digital branches

Volar wrist capsule

Volar 3 1/2 digits and lateral palm: via palmar palmar digital branches (multiple variations of thumb sensory innervation)

Motor: **Motor Recurrent (Thenar motor) Branch**: Usually branches off median before carpal tunnel

THENAR

Abductor pollicis brevis [APB]

Opponens pollicis

Flexor pollicis brevis [FPB]

I (Joint innervation with ulnar nerve) /

INTRINSIC

Lumbricals [lateral two (1,2)]

### POSTERIOR CORD

3. **Radial**  
(C5-T1):

Sensory: Dorsal 3 1/2 digits and hand: via superficial branch (dorsal digit branches)

Dorsal wrist capsule

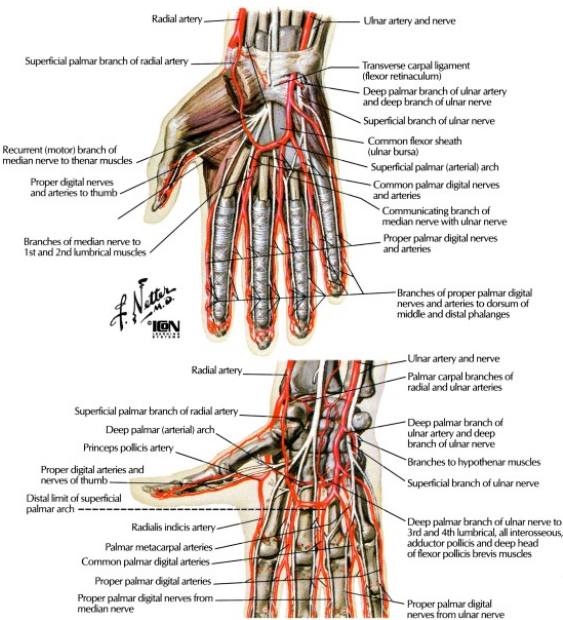


Motor:

NONE (in hand)

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ARTERIES



COURSE	BRANCHES	COMMENT
DEEP PALMAR ARCH		
Through heads of the adductor pollicis	Terminal branch of <i>radial</i> artery deep branch of the <i>ulnar</i> artery	
	Principes pollicis	
	Radialis indicis	Under FPL, along 1 <sup>st</sup> metacarpal
	Proper digital artery of thumb	
		May come from deep arch
	Palmar metacarpal (3)	Joins common digital artery
SUPERFICIALS PALMAR ARCH		
Just deep to aponeurosis.	Terminal branch of <i>ulnar</i> artery superficial branch of the <i>radial</i> artery	
	Common palmar digital (3)	Bifurcates
	<i>Proper palmar digital</i>	Along sides of fingers
	<i>Proper palmar digital</i>	Of small finger only



DISORDERS: ARTHRITIS

Osteoarthritis



Section through distal interphalangeal joint shows irregular, hyperplastic bony nodules (Heberden's nodes) at articular margins of distal phalanx. Cartilage eroded and joint space narrowed



Radiograph of distal interphalangeal joint reveals late-stage degenerative changes. Cartilage destruction and marginal osteophytes (Heberden's nodes)

Rheumatoid Arthritis



Radiograph shows cartilage thinning at proximal interphalangeal joints, erosion of carpus and wrist joint, osteoporosis, and finger deformities

Stenosing Tenosynovitis (Trigger Finger)



Inflammatory thickening of fibrous sheath (pulley) of flexor tendons with fusiform nodular enlargement of both tendons. Broken line indicates line for incision of lateral aspect of pulley



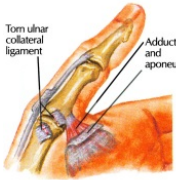
Late-stage degenerative changes in carpometacarpal articulation of thumb

DESCRIPTION	HISTORY/PHYSICAL EXAM	WORK-UP/FINDINGS	TREATMENT
ARTHRITIS: OSTEOARTHRITIS/DEGENERATIVE JOINT DISEASE (DJD)			
• Wear and tear arthritis	Hx: Older, women, pain worse with activity	XR: OA findings: osteophytes, joint spaceloss, sclerosis, subchondral cysts	1. NSAID, splint, steroid injection
• Loss of articular cartilage	PE: + IP (DIP and/or PIP) nodes, + CMC grind test		2. DIP: arthrodesis, CMC/PIP: arthroplasty
• DIP #1 [Heberden's nodes] CMC, IP #2 [Bouchard's nodes]			
ARTHRITIS: RHEUMATOID			
• Systemic inflammatory disease affecting synovium: destroys joints. MCP #1	Hx: Painful, stiff (worse in AM)	XR: Hand series: joint destruction	I. Medical management splinting
• Has 4 stages	PE: Multiple joint swelling. deformities: ulnar drift (MCP) swan neck, boutonniere	Labs: RF, ANA, WBC, ESR, uric acid	II. Synovectomy (single joint)
• Associated with tenosynovitis, Carpal Tunnel Syndrome			III/IV. Tendon transfer or repair, arthrodesis, arthroplasty
FLEXOR TENOSYNOVITIS: TRIGGER FINGER/THUMB			
• Nodule on tendon	Hx: Age: 40+, tender		1. Steroid injection +/-

catches on pulley (A1 most common)	1. Age 40+, tender nodule	XR: None needed	1. Steroid injection +/- splint)
• Also seen in Diabetes Mellitus	PE: Pain. Locking with flexion extension		2. A1 release [must spare A2]


DISORDERS: LIGAMENT INJURIES

### Gamekeeper's Thumb



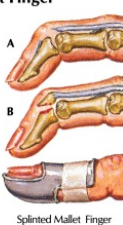
Ruptured ulnar collateral ligament of metacarpophalangeal joint of thumb

### Jersey Finger



Flexor digitorum profundus tendon may be torn directly from distal phalanx or may avulse small or large bone fragment.

### Mallet Finger



A. Tendon torn from its insertion. B. Bone fragment avulsed with tendon. In A and B there is a 40°-45° flexion deformity and loss of active extension.

Splinted Mallet Finger

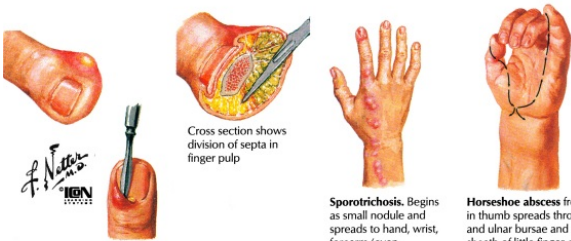
DESCRIPTION	HISTORY/PHYSICAL EXAM	WORK-UP/FINDINGS	TREATMENT
CENTRAL SLIP INJURY: BOUTONNIERE DEFORMITY			
• Extensor tendon (central slip) at PIP ruptures, lateral bands slip volar and flex PIP.	Hx: Hand trauma	XR: Hand series: normal	1. Splint PIP in extension, DIP free
	PE: PIP flexed, no active extension, DIP extended		2. Reconstruct central slip and bands
• Associated with RA			3. Severe: fusion or arthroplasty
FLEXOR TENDON INJURY: JERSEY FINGER			
• Flexor tendon avulses from forceful extension	Hx: Extension injury, 1/2 pain.	XR: Rule out fracture (1/2 avulsion fracture)	1. Primary repair
• In football; RF#1; FDPFDS	PE: FDS: 1 sublimus test FDP: 1 profundus test		2. Older patient: DIP fusion
MALLET FINGER			
• Extensor tendon rupture at distal phalanx	Hx: Minor trauma	XR: 1/2 avulsion fracture	1. CONSTANT splint (DIP only) for 8 weeks
	PE: Cannot extend DIP, minimal pain swelling		
• FDP unopposed so DIP flexes			2. Repair if large bony avulsion fracture
SWAN NECK DEFORMITY			
• FDS rupture/volar plate injury	Hx: Trauma, RA, spastic	XR: Hand series	1. Early: splint
• Lateral bands subluxes dorsally, PIP hyperextends DIP flexes	PE: PIP hyperextended, DIP flexed		2. Late: surgical repair (individualize)

ULNAR COLLATERAL OF THUMB: GAMEKEEPER'S THUMB			
---	--	--	--

• Ulnar collateral ligament torn	Hx: Trauma. Pain swelling.	XR: 1/2 avulsion fracture.	1. Incomplete: splint 2-4 weeks
• Mechanism: forceful radial deviation	PE: Ulnar thumb unstable with radial extension/abduction	Stress view shows injury	2. Complete: surgical repair (treat Stener lesion)
• Often in ski pole injury			

DISORDERS: INFECTIONS

**Felon**



Cross section shows division of septa in finger pulp

Eponychium elevated from nail surface

**Sporotrichosis.** Begins as small nodule and spreads to hand, wrist, forearm (even systemically).

**Horseshoe abscess** from focus in thumb spreads through radial and ulnar bursae and tendon sheath of little finger, with rupture into Parona subcutaneous space

DESCRIPTION	HISTORY/PHYSICAL EXAM	WORK-UP/FINDINGS	TREATMENT
BITES: HUMAN/ANIMAL			
• Usually dominant hand	Hx: Laceration or puncture, dorsal MCP most common location	XR: Rule out fracture	1. Thorough ID, Td if necessary
• Classic mechanism: fist fight		Labs: Aerobic anaerobic cultures, WBC	2. IV antibiotics Animal: Unasyn Human: Augmentin
• Human: poly bacterial including Eikenella corrodens	PE: Red, swollen, 1/2 drainage, streaking. Decreased extension if tendon torn	[Contact health officials if animal possibly rabid]	
			3. Do not close wound, dress appropriately
• Animal: Pasteurella multocida			
DEEP SPACE INFECTION			
• From palm puncture or spread from finger (+/- Horseshoe)	Hx/PE: Erythema, fluctuance, and tenderness	XR: Usually normal	Dorsal volar ID and IV antibiotics
FELON			
• Deep infection or abscess in pulp	Hx/PE: Erythematous, swollen, and painful.	XR: Usually normal	1. ID, release septae
			2. IV antibiotics
• Staph Aureus #1 organism			
PARONYCHIA/EPONYCHIA			
• Nail bed infection (most common finger infection)	Hx/PE: Red, painful, swollen, often purulent drainage	XR: Usually normal	1. Soaks and oral antibiotics
			2. ID with nail removal if necessary
• Staph Aureus #1			



organism			
<b>PURULENT TENOSYNOVITIS</b>			
• Infection of flexor tendon sheath	Hx: Puncture wound	XR: Possible foreign body or subcutaneous air	1. Mild (early): IV antibiotics, re-evaluate within 24 hours
• Usually from puncture wound	PE: KANAVEL SIGNS: 1. Flexed position, 2. Pain on passive extension, 3. Fusiform swelling, 4. Tender flexor sheath		2. Most: ID (1/2 drain) and IV antibiotics
• May extend into palm and develop "horseshoe" infection			No treatment results in adhesions necrosis
<b>SPOROTRICHOSIS</b>			
• Lymphatic infection (from roses)	Hx/PE: Discoloration or rash	XR: None	Potassium iodine solution
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DISORDERS: MASSES TUMORS

Deep Space Infections



DESCRIPTION	HISTORY/PHYSICAL EXAM	WORK-UP/FINDINGS	TREATMENT
DUPUYTREN'S DISEASE			
• Proliferation of fascia (long bands)	Hx: Male, 401 years old	XR: None needed	1. No proven conservative treatment
• Northern European descent	PE: nodule, non-tender, flexed digit (RF#1, SF#2)		
• Associated with DM, epilepsy			2. Fasciotomy
ENCHONDROMA			
• #1 Primary bone tumor	Hx: Pain after pathologic fracture	XR: Lytic lesion	Curettage and bone graft
• Usually proximal phalanx			
EPIDERMAL INCLUSION CYST			
• Epidermal cells embedded deep into tissue	Hx: Trauma or puncture	XR: Normal	Excision (get all epidermal cells or it will recur)
	PE: Painless mass, usually on digits, no transillumination		
GANGLION RETINACULAR CYST			
• Cyst (arises from joint or tendon) with mucinous joint fluid	Hx: Young patient	XR: No osteophyte in corresponding area	Aspiration of cyst if symptomatic. (may recur)
	PE: Visible, firm mass (volar MCP flexor tendon #1 site).		
• Most common mass in hand			
GIANT CELL TUMOR (FIBROXANTHOMA)			
• Originates from tendon sheath	Hx/PE: Firm, painless mass, usually volar finger (IF,MF)	XR: Normal	Excise, they do recur
• 2nd most common hand mass			

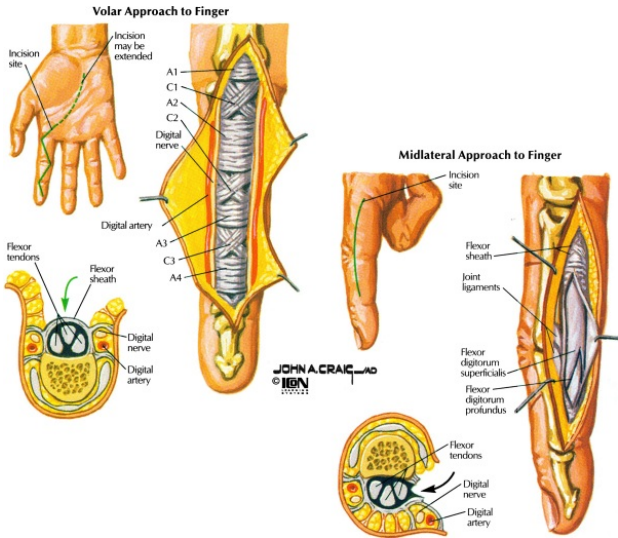
**MALIGNANT TUMORS**

• #1 Primary: squamous cell	Hx/PE: Mass, usually on dorsum of hand	XR: Normal	Excise
• #1 Metastatic: lung			

**MUCOUS CYST**

• A ganglion of dorsal DIP	Hx: Women, older patients	XR: OA and/or spur at DIP	Excision and osteophyte or joint debridement
• Associated with OA at DIP	PE: Dorsal DIP mass, 1/2 pain		

SURGICAL APPROACHES



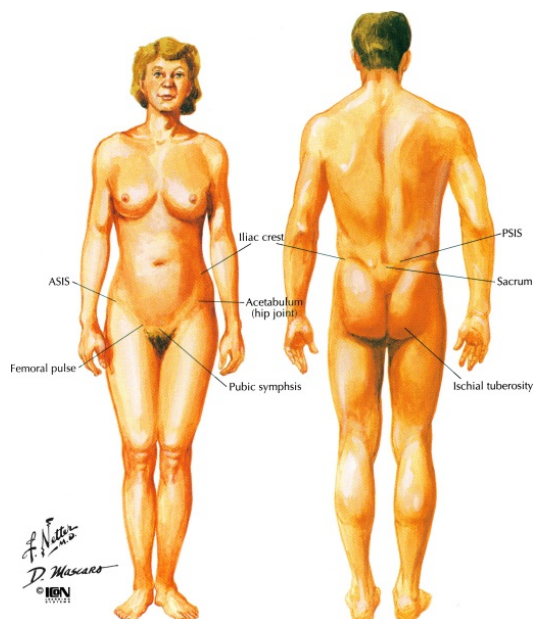
USES	INTERNEUROUSPLANE DANGERS	COMMENT
FINGER: VOLAR APPROACH		
1. Flexor tendons (repair/explore)	No planes	1. Digital artery 1. Make a "zig-zag" incision with angles of 90°
2. Digital nerve		2. Digital nerve
3. Soft tissue releases		2. Neurovascular bundle is lateral to the tendon sheath
4. Infection drainage		
FINGER: MID-LATERAL APPROACH		
Phalangeal fractures	No planes	1. Digital nerve Soft tissues are thin, capsule can be incised if care is not taken.
		2. Digital artery

## **CHAPTER 6 - PELVIS**

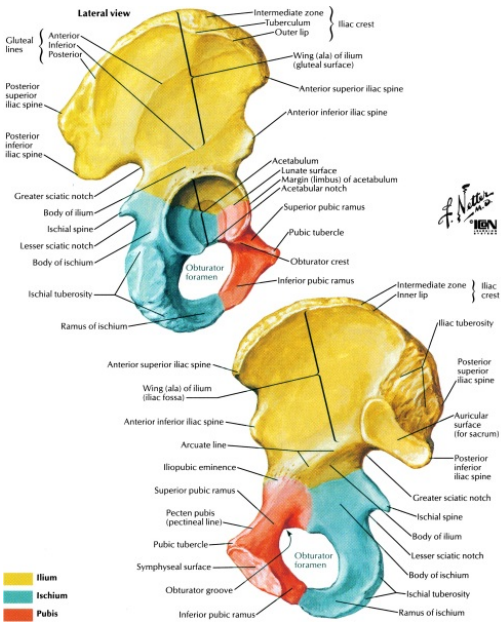
- [TOPOGRAPHIC ANATOMY](#)
- [OSTEOLOGY](#)
- [LANDMARKS AND OTHER STRUCTURES](#)
- [TRAUMA](#)
- [JOINTS](#)
- [HISTORY AND PHYSICAL EXAM](#)
- [PHYSICAL EXAM OF THE PELVIS](#)
- [PHYSICAL EXAM](#)
- [MUSCLES: ORIGINS AND INSERTIONS](#)
- [ANTERIOR MUSCLES \(also see muscles of the thigh/hip\)](#)
- [GLUTEAL MUSCLES \(also see muscles of the thigh/hip\)](#)
- [NERVES](#)
- [ARTERIES](#)

## CHAPTER 6 – PELVIS

### TOPOGRAPHIC ANATOMY



OSTEOLOGY



CHARACTERISTICS	OSSIFY	FUSE	COMMENT
INNOMINATE: COXAL BONE			
<ul style="list-style-type: none"> <li>One bone: started as 3, connected by tri-radiate cartilage at acetabulum Ilium: body ala Ischium: body ramus Pubis: body 2 rami</li> </ul>	Primary (one in each body)	2-6 mo to 15 yrs	<ul style="list-style-type: none"> <li>Iliac wing and superior pubic ramus are "weak spots"</li> </ul>
			<ul style="list-style-type: none"> <li>ASIS: avulsion fracture can result from sartorius</li> </ul>
	Secondary Iliac crest Acetabulum Ischial tuberosity A.I.S. Pubis	15 yrs All fuse 20 yrs	<ul style="list-style-type: none"> <li>A.I.S.: avulsion fracture can result from rectus femoris</li> </ul>
<ul style="list-style-type: none"> <li>Two innominate per pelvis (L R)</li> </ul>			<ul style="list-style-type: none"> <li>Iliac crest ossification used to determine skeletal maturity (Risser stage)</li> </ul>

• Acetabulum: anteverted and oblique orientation (approx. 45°)

• Iliac crest contusion referred to as “hip pointer”

SACRUM

See spine chapter



LANDMARKS AND OTHER STRUCTURES

STRUCTURE	ATTACHMENTS/ RELATED STRUCTURES	COMMENT
ASIS	Sartorius Inguinal ligament	• LFCN crosses the ASIS can be compressed there (Meralgia paresthetica)
	Transverse internal oblique abdominal muscles	• Sartorius can avulse from it (avulsion fracture)
AIS	Rectus femoris Tensor fascia lata Iliofemoral ligament (hip capsule)	• Rectus femoris can avulse from it (avulsion fracture)
PSIS	Posterior sacroiliac ligaments	• Excellent bone graft site
	Marked by skin dimple	
Arcuate line	Pectineus muscle	• Strong, weight bearing region
Gluteal lines	3 lines: anterior, inferior, posterior	• Separate origins of gluteal muscles
Greater trochanter	SEE ORIGINS/INSERTIONS	• Tender with trochanteric bursitis
Lesser trochanter	Iliacus Psoas muscles	
Ischial tuberosity	SEE ORIGINS/INSERTIONS Sacrotuberous ligaments	• Excessive friction can cause bursitis (Weaver's bottom)
Ischial spine	Coccygeus Levator ani attach Sacrospinous ligaments	
Anterior (iliopubic) column of acetabulum	Consists of: 1. Pubic ramus 2. Anterior acetabulum 3. Anterior iliac wing	• Involved in several different fracture patterns
Posterior (ilioischial) column of acetabulum	Consists of: 1. Ischial tuberosity 2. Posterior acetabulum 3. Sciatic notch	• Involved in several different fracture patterns
Lesser sciatic foramen	Short external rotators exit: Obturator externus Obturator internus	
Greater sciatic foramen	Structures that exit: 1. Superior gluteal nerve 2. Superior gluteal artery 3. Piriformis muscle 4. Pudendal nerve 5. Inferior pudendal artery 6. Nerve to the Obturator internus 7. Posterior	• Piriformis muscle is the reference point • Superior Gluteal nerve and artery exit superior to the piriformis • POP'S IQ is a mnemonic for the

Cutaneous nerve of thigh

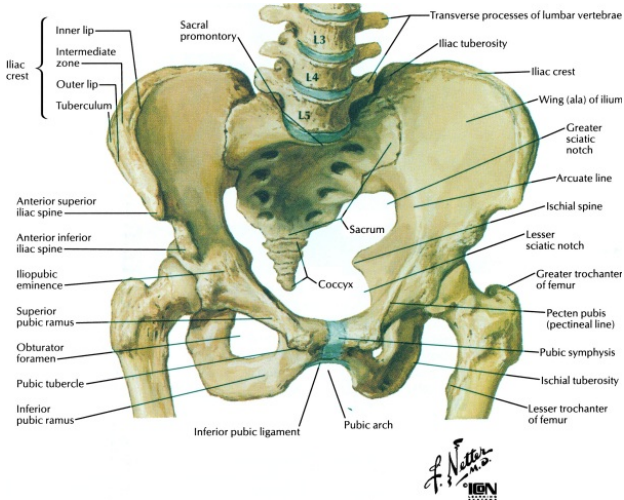
nerves (structures) that exit inferior to the piriformis (medial to lateral)

8. Sciatic nerve

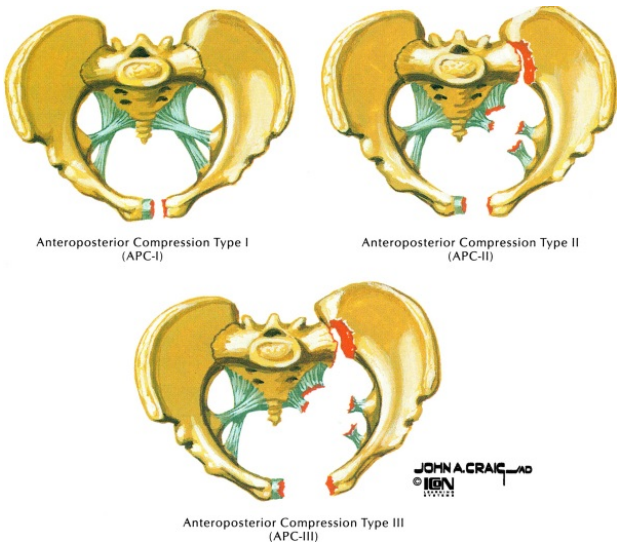
9. Inferior gluteal nerve

10. Inferior gluteal artery

11. Nerve to Quadratus femoris



TRAUMA



Classification of Pelvic Fractures (Young and Burgess)

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
PELVIC FRACTURE			
<ul style="list-style-type: none"><li>• Mechanism 1: High energy force (e.g. MVA). Lateral force more common than AP</li><li>• Usually associated with other injuries (often life threatening).</li><li>• Open pelvic fracture with associated GI and/or GU injury: 50% mortality</li><li>• Posterior SI ligament is key to pelvic stability</li><li>• Mechanism</li></ul>	<p>HX: Trauma. Swelling, pain, deformity.</p> <p>PE: ABC's. Affected LE shortened, +/-blood in rectum/vagina/urethra. Do good neurovascular exam: +/-pulses in groin</p> <p>LE with neurologic deficits including loss of rectal tone bulbocavernosus reflex.</p> <p>XR: AP, Inlet, Outlet Judet views of the pelvis.</p>	<p>Young and Burgess:</p> <ul style="list-style-type: none"><li>• AP compression (APC):<ul style="list-style-type: none"><li>I. 2.5cm pubic diastasis fracture of 1-2 rami</li><li>II. 2.5cm diastasis; SI disruption, but stable</li><li>III. Complete disruption pubis symphysis SI joint: unstable fracture</li></ul></li><li>• Lateral Compression (LC):<ul style="list-style-type: none"><li>I. Sacral compression with rami fractures</li></ul></li></ul>	<p>Treat life threatening injuries first (ABC's).</p> <p>Treat pelvic hemorrhage with external fixation (+/- 2embolization)</p> <p>Diverting colostomy for GI injury (avoid sepsis)</p> <p>Stable fractures: (single ramus, avulsion fx, APC or LC I): conservative treatment; bedrest, decreased</p>

<p>2: Minor trauma (e.g. fall on osteopenic bone); stable single ramus fracture</p> <ul style="list-style-type: none"> <li>• Mechanism</li> </ul> <p>3: Stable avulsion fracture - ASIS (Sartorius) - AIS (Rectus femoris) - Ischium (hamstring)</p>	<p>CT: Scan entire pelvis</p> <p>AGRAM: for hemorrhage</p>	<p>II. Rami fracture, posterior SI ligament disrupted, but stable</p> <p>III. LC II, with contralateral APC III ("windswept")</p> <ul style="list-style-type: none"> <li>• Vertical shear: anterior posterior pelvic injury (displacement): vertically unstable.</li> </ul>	<p>activity</p> <p>Unstable fractures: external fixation with ORIF as needed</p> <p>Early mobilization aids recovery</p>
--	--	---	--

COMPLICATIONS: Associated injuries (especially with APC III): 1. GI, 2. GU, 3. Vascular/hemorrhage, 4. Neurologic; Prolonged hospital stay with associated risks (infection, DVT, etc.); Residual deformity and/or pain (lower back or SI); Leg length discrepancy



Lateral Compression Type I (LC-I)

Lateral Compression Type II (LC-II)



Lateral Compression Type III (LC-III)

Vertical shear



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I. Fracture of posterior wall.  
Repair with plate and lag screws



II. Fracture of posterior column.  
Repair with plate and lag screw



III. Wedge fracture of anterior wall.  
Repair with lag screws



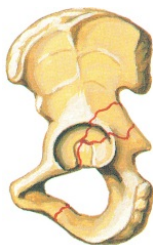
IV. Fracture of anterior column.  
Repair with plate and long screws



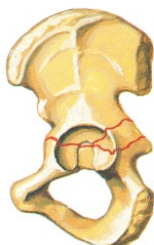
V. Transverse fracture.  
Repair with plate and lag screw

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
ACETABULAR FRACTURE			
<ul style="list-style-type: none"> <li>• Uncommon, younger</li> <li>• High energy or violent injury; femoral head is forced into acetabulum</li> <li>• <b>Dislocation of hip is often associated</b></li> <li>• Also GI, GU, vascular associated injuries.</li> </ul>	<p>HX: Trauma (e.g. dashboard injury). Pain, deformity.</p> <p>PE: LE shortened, rotated. Usually neurovascularly intact distally.</p> <p>XR: AP. Internal external obliques (Judet views): many possible fracture sites</p> <p>CT: shows fracture pattern and loose fragments</p>	<p>Judet/Letournel:</p> <ul style="list-style-type: none"> <li>I. Posterior wall</li> <li>II. Posterior column</li> <li>III. Anterior wall</li> <li>IV. Anterior column</li> <li>V. Transverse</li> <li>VI. Posterior column wall</li> <li>VII. Transverse post. wall</li> <li>VIII. T-type</li> <li>IX. Anterior column posterior emi-transverse</li> <li>X. Both columns</li> </ul>	<p>Traction on affected side</p> <p>Nondisplaced, congruent joint,</p> <p>Displaced, dislocation, unstable fx: ORIF</p> <p>XRT (600 rads) prophylaxis for heterotopic bone.</p>

COMPLICATIONS: Need for Total Hip Arthroplasty; Nerve injury (sciatic); Heterotopic bone formation; Osteonecrosis steoarthritis



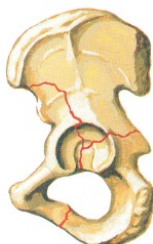
VI. Posterior column/posterior wall



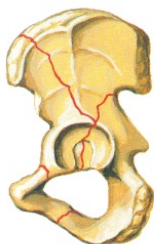
VII. Transverse/posterior wall



VIII. T-shaped fracture.  
Repair with plate and lag screws



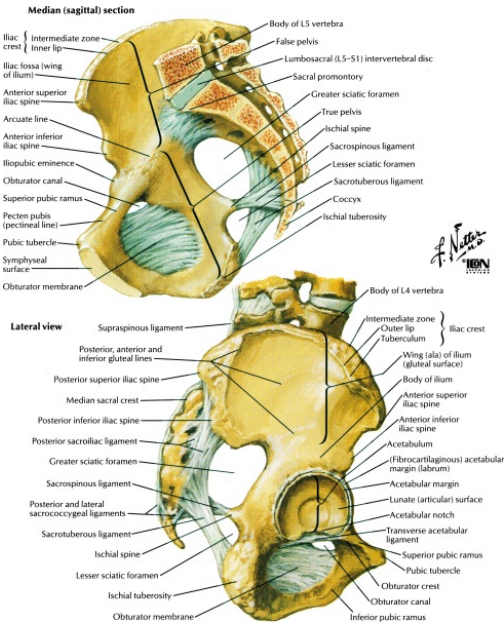
IX. Anterior column/posterior hemi transverse



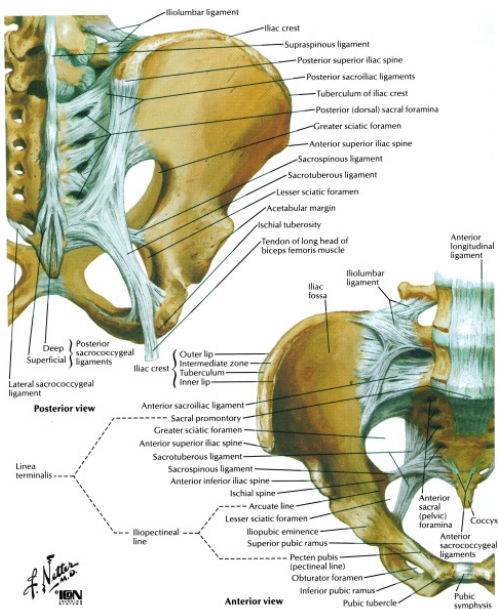
X. Both columns

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JOINTS



LIGAMENTS	ATTACHMENTS	COMMENTS
SACROILIAC (GLIDING)		
Posterior SI (short long)	Sacrum to ilium: Short are horizontal Long are vertical	Strongest SI ligaments: key to stability. Short: resist rotation Long: resist vertical shear
		Disruption: rotational vertical instability
Anterior SI	Sacrum to ilium (horizontal)	Rotational stability
Interosseous	Sacral to iliac tuberosities	Strong



## LIGAMENTS

## ATTACHMENTS

## COMMENTS

### SYMPHYSIS PUBIS

Superior pubic ligament

Both pubic bones superiorly

There is a fibrocartilage disc between the two hemipelvi

Arcuate pubic ligament

Both pubic bones inferiorly

### OTHER LIGAMENTS

Sacrospinous

Anterior sacrum to ischial spine

Divides greater lesser sciatic foramina; provides rotational stability

Sacrotuberous

Anterior sacrum to ischial tuberosity

Inferior border of lesser sciatic foramina; provides vertical stability

Iliolumbar

L5 transverse process to crest

Can result in avulsion fracture

Lumbosacral

L5 transverse process to ala

Vertical stability



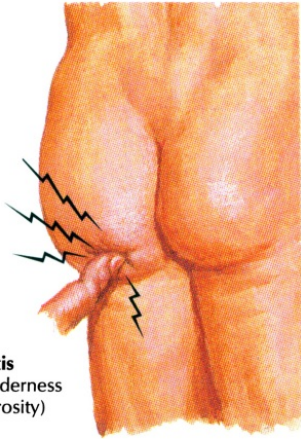
# HISTORY AND PHYSICAL EXAM

QUESTION	ANSWER	CLINICAL APPLICATION
1. AGE	Young Middle age, elderly	Ankylosing Spondylitis (1HLA-b27) Decreased mobility
2. PAIN a. Onset b. Character c. Occurrence	Acute Chronic Deep, non- specific Radiating In out of bed, on stairs Adducting legs	Trauma: fracture, sprain Systemic inflammatory disorder Sacroiliac etiology To thigh or buttock on ipsilateral side: SI joint injury Sacroiliac etiology Symphysis pubis etiology
3. PMHx	Pregnancy	Laxity of ligaments of SI joint causes pain
4. TRAUMA	Fall on buttock, twist injury	Sacroiliac joint injury
	High velocity: MVA, fall	Fracture
5. ACTIVITY/WORK	Twisting, stand on one leg	Sacroiliac etiology
6. NEUROLOGIC SYMPTOMS	Pain, numbness, tingling	Spine etiology, sacroiliac etiology
7. HISTORY of ARTHRITIDES	Multiple joints involved	SI involvement of RA, Reiter's syndrome, Ankylosing Spondylitis, etc.
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PHYSICAL EXAM OF THE PELVIS

With palpation

**Ischial bursitis**  
(deep pain and tenderness  
over ischial tuberosity)



EXAM/OBSERVATION	TECHNIQUE	CLINICAL APPLICATION
INSPECTION		
Skin	Discoloration, wounds	
ASIS's, Iliac crests	Both level (same plane)	If on different plane: Leg length discrepancy, sacral torsion
Lumbar curvature	Increased lordosis	Flexion contracture
	Decreased lordosis	Paraspinal muscle spasm
PALPATION		
Bony structures	Standing: ASIS, Pubic Iliac tubercles, PSIS	Unequal side to side 5pelvic obliquity: leg length discrepancy
	Lying: Iliac crest, Ishial tuberosity	Mass: cluneal neuroma
Soft tissues	Inguinal ligament	Protruding mass: hernia
	Femoral pulse nodes	Diminished pulse: vascular injury; palpable nodes: infection
	Muscle groups	Each group should be symmetric bilaterally
RANGE OF MOTION		
Forward flexion	Standing: bend forward	PSIS's should elevate slightly (equally)
Extension	Standing: lean backward	PSIS's should depress (equally)
Hip flexion	Standing: knee to chest	PSIS should drop but will elevate in hypomobile SI joint
		Ischial tuberosity should move laterally, will elevate in hypomobile SI joint



PHYSICAL EXAM

Straight Leg Test



Extend knee, hip relaxed



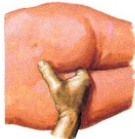
Passively flex hip

F. Netter M.D.  
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Trendelenburg test

Left: patient demonstrates negative Trendelenburg's test of normal right hip. Right: positive test of involved left hip. When weight is on affected side, normal hip drops, indicating weakness of left gluteus medius muscle. Trunk shifts left as patient attempts to decrease biochemical stresses across involved hip and thereby maintain balance

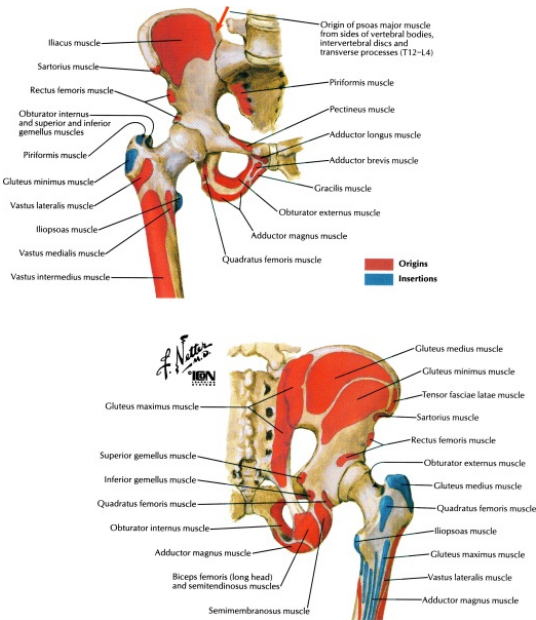


**Rectal examination** for sphincter function and perianal sensation important in all patients with spinal injury. Gloved finger in rectum feels contraction when patient instructed to contract anal sphincter. Cross blood indicates pelvic fracture communicating with colon.

EXAM/ OBSERVATION	TECHNIQUE	CLINICAL APPLICATION
NEUROVASCULAR		
Sensory		
Iliohypogastric nerve (L1)	Suprapubic, lateral buttocks thigh	Deficit indicates corresponding nerve/root lesion
Ilioinguinal nerve (L1)	Inguinal region	Deficit indicates corresponding nerve/root lesion (e.g. abdominal muscle compression)
Genitofemoral nerve (L1-2)	Scrotum or mons	Deficit indicates corresponding nerve/root lesion
Lateral femoral cutaneous nerve (L2-3)	Lateral hip thigh	Deficit indicates corresponding nerve/root lesion (e.g. Meralgia paresthetica)
Pudental nerve (S2-4)	Perineum	Deficit indicates corresponding nerve/root lesion
Motor		
Femoral (L2-4)	Hip flexion	Weakness 5Iliopsoas or corresponding nerve/root lesion
Inferior Gluteal nerve	External rotation	Weakness 5Gluteus maximus or nerve/root lesion
Nerve to Quadratus femoris	External rotation	Weakness 5Short rotators or corresponding nerve/root lesion
Nerve to Obturator internus		
Nerve to Piriformis		
Superior Gluteal nerve	Abduction	Weakness 5Gluteus medius/minimus, TFL or corresponding nerve/root lesion
Reflex	Bulbocavernosus	Finger in rectum, squeeze or pull penis (Foley), anal sphincter should contract
Pulses	Femoral pulse	
SPECIAL TESTS		
Straight leg	Supine: extend	Pain radiating to L5-S1MB with radiculopathy

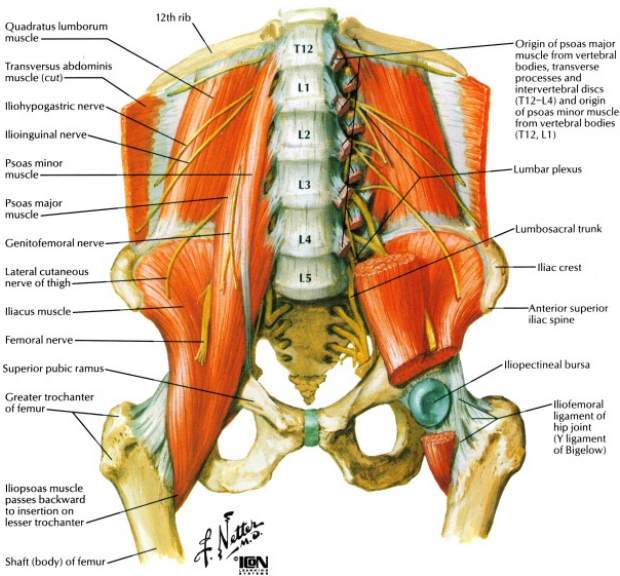
Straight leg	knee, flex hip	Pain radiating to LE, thigh with radiculopathy
SI stress	Press ASIS, iliac crest, sacrum	Pain in SI could be SI ligament injury
Trendelenburg sign	Standing: lift one leg (flex hip)	Flexed side: pelvis should elevate; if pelvis falls: Abductor or gluteus medius dysfunction
Patrick (FABER)	<b>Flex</b> , <b>AB</b> duct, <b>ER</b> hip, then abduct more	Positive if pain or LE will not continue to abduct below other leg: SI joint pathology
Meralgia	Pressure medial to ASIS	Reproduction to pain, burning, numbness: LFCN entrapment
Rectal Vaginal exam	Especially after trauma	Gross blood indicates trauma communicating with those organ systems

MUSCLES: ORIGINS AND INSERTIONS



PUBIC RAMI (ASPECT)	GREATER TROCHANTER	ISCHIAL TUBEROSITY	LINEAASPERA/ POSTERIOR FEMUR
Pectineus (pectineal line/superior)	Piriformis (anterior)	Inferior gemellus	Adductor magnus
Adductor magnus (inferior)	Obturator internus (anterior)	Quadratus femoris	Adductor longus
Adductor longus (anterior)	Superior gemellus	Semimembranosus	Adductor brevis
Adductor brevis (inferior)	Gluteus medius (posterior)	Semitendinosus	Biceps femoris
Gracilis (inferior)	Gluteus minimus (anterior)	Biceps femoris (LH)	Pectineus
Psoas minor (superior)		Adductor magnus	Gluteus maximus
			Vastus lateralis
			Vastus medialis

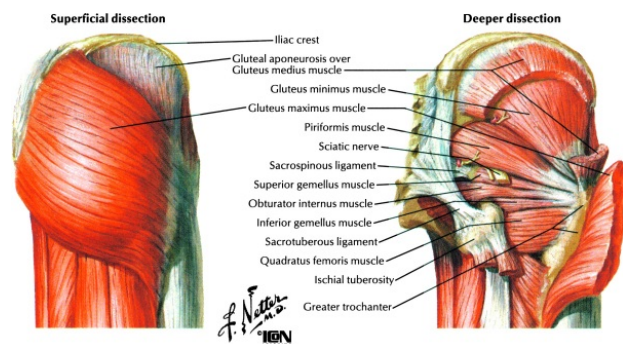
ANTERIOR MUSCLES (also see muscles of the thigh/hip)



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
HIP FLEXORS					
ANTERIOR					
Psoas	T12-L5 vertebrae	Lesser trochanter	Femoral	Flex hip	Covers lumbar plexus
Iliacus	Iliac fossa	Lesser trochanter	Femoral	Flex hip	Covers anterior ilium

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# GLUTEAL MUSCLES (also see muscles of the thigh/hip)

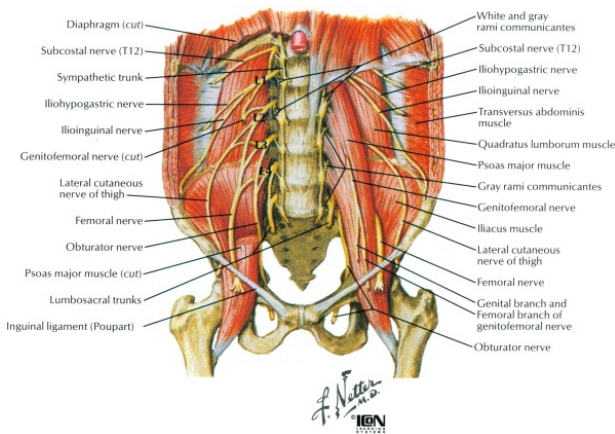


MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
HIP ABDUCTORS					
Tensor fascia latae	Iliac crest, ASIS	Iliotibial band	Superior Gluteal	Abducts, flex, IR thigh	A plane in anterior approach to hip
HIP ABDUCTORS					
Gluteus medius	Ilium between anterior posterior gluteal lines	Greater trochanter	Superior Gluteal	Abduct (IR) thigh	Trendelenburg gait if muscle is out.
Gluteus minimus	Ilium between anterior inferior gluteal lines	Anterior greater trochanter	Superior Gluteal	Abduct (IR) thigh	Works in conjunction with medius
HIP EXTERNAL ROTATORS					
Gluteus maximus	Ilium, dorsal sacrum	Gluteal tuberosity (femur), ITB	Inferior Gluteal	Extend, ER thigh	Must detach in post. approach to hip
Piriformis	Anterior sacrum	Superior greater trochanter	Piriformis	ER thigh	Used as landmark
Obturator externus	Ischiopubic rami, obturator membrane	Trochanteric fossa	Obturator	ER thigh	Muscle actually in medial thigh
<b>Short Rotators</b>					
Obturator internus	Ischiopubic rami, obturator membrane	Medial greater trochanter	N. to Obturator internus	ER, abduct thigh	Muscle makes a right turn
Superior gemellus	Ischial spine	Medial greater trochanter	N. to Obturator internus	ER thigh	Assists obturator internus
Inferior gemellus	Ischial tuberosity	Medial greater trochanter	N. to Quadratus femoris	ER thigh	Assists obturator internus
Quadratus femoris	Ischial tuberosity	Intertrochanteric crest	N. to Quadratus femoris	ER thigh	Runs with ascending branch of medial circumflex artery





NERVES



LUMBAR PLEXUS

ANTERIOR DIVISION

1. Subcostal (T12):

Sensory:	Subxyphoid region
Motor:	NONE

2. Iliohypogastric (L1)

Sensory:	Above pubis
	Posterolateral buttocks
Motor:	Transversus abdominus
	Internal Oblique

3. Ilioinguinal (L1)

Sensory:	Inguinal region
Motor:	NONE

4. Genitofemoral (L1-2): pierces Psoas, lies on anteromedial surface.

Sensory:	Scrotum or mons
Motor:	Cremaster

5. Obturator (L2-4): exits via obturator canal, splits into ant. post. divisions. Can be injured by retractors placed behind the transverse acetabular ligament.

Sensory:	Inferomedial thigh via cutaneous branch of Obturator nerve
Motor:	External oblique
	Obturator externus (posterior division)

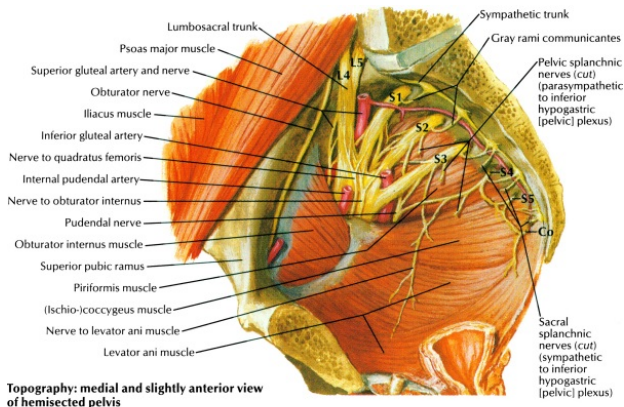
6. Accessory Obturator (L2-4): inconsistent

Sensory:	NONE
Motor:	Psoas

POSTERIOR DIVISION

7. Lateral Femoral Cutaneous [LFCN](L2-3): crosses, ASIS, can be compressed at ASIS

Sensory:	NONE (in pelvis)
Motor:	NONE
8. <b>Femoral</b> (L2-4): lies between psoas major and iliacus	
Sensory:	NONE (in pelvis)
Motor:	Psoas
	Iliacus
	Pectineus



*f. Netter*  
M.D.

## SACRAL PLEXUS

### ANTERIOR DIVISION

#### 9. Nerve to Quadratus femoris (L4-S1):

Sensory: NONE

Motor: Quadratus femoris

Inferior gemelli

#### 10. Nerve to Obturator internus (L5-S2): exits greater sciatic foramen

Sensory: NONE

Motor: Obturator internus

Superior gemelli

#### 11. Pudendal (S2-4): exits greater then re-enters lesser sciatic foramen

Sensory: Perineum: via Perineal (scrotal/labial branches) via Inferior rectal nerve via Dorsal nerve to penis/clitoris

Motor: Bulbospongiosus: Perineal nerve

Isiocavernosus: Perineal nerve

Urethral sphincter: Perineal nerve

Urogenital diaphragm: Perineal nerve

Sphincter ani externus: Inf. rectal nerve

#### 12. Nerve to coccygeus (S3-4)

Sensory: NONE

Motor: Coccygeus

Levator ani

## POSTERIOR DIVISION

### 13. **Superior Gluteal** (L4-S1):

Sensory: NONE

Motor: Gluteus medius

Gluteus minimus

Tensor fascia lata

### 14. **Inferior Gluteal** (L5-S2):

Sensory: NONE

Motor: Gluteus maximus

### 15. **Nerve to piriformis** (S2):

Sensory: NONE

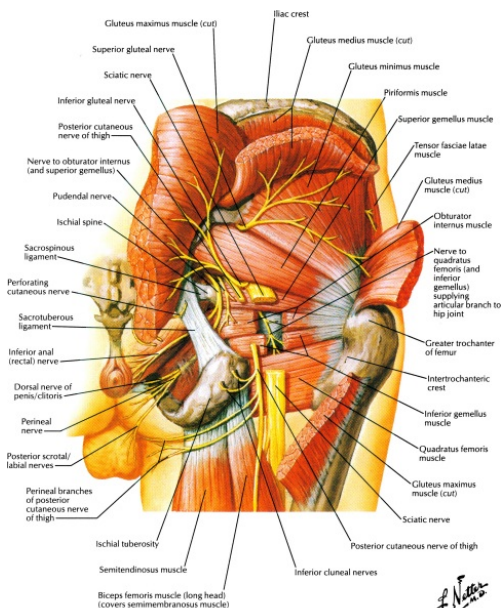
Motor: Piriformis

### OTHER NERVES (non-plexus)

16. **Cluneal nerves:** branches of lumbar and sacral dorsal rami. Can be injured during bone grafts.

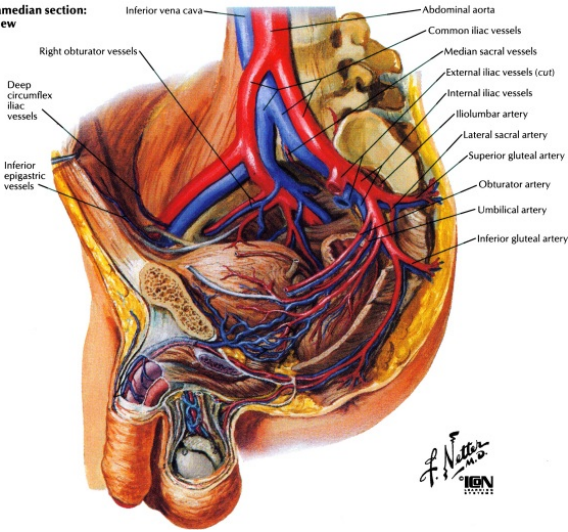
Sensory: Skin of gluteal region

Motor: NONE



ARTERIES

Left paramedian section:  
lateral view



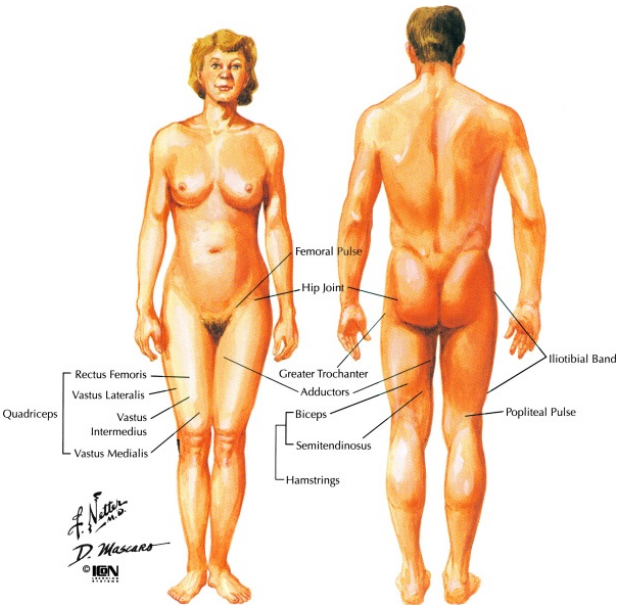
COURSE	BRANCHES	COMMENT
AORTA		
Along anterior vertebral bodies ALL	Common iliacs at L4 Lumbar arteries (4 sets)	
		Paired: posterior branch supplies cord, meninges paraspinous muscles
	Median sacral artery 5th Lumbar arteries (2)	Unpaired vessel
		Anastomoses with lat. sacral artery
COMMON ILIACS		
Still on anterior L-spine sacrum	Divide into internal external iliacs at S1	
INTERNAL ILIAC		
Under ureter near SI joint, divides into its divisions at edge of greater sciatic foramen	Supplies most of pelvis and the pelvic organs	
	ANTERIOR DIVISION	
	Obturator	Runs with nerve through foramen
	Fovea artery (artery of ligamentum teres in hip)	Minor contributions to the vascular supply of the femoral head
	Inferior gluteal	Supplies muscles of the

	Internal <i>gluteal</i>	buttocks
	Multiple visceral branches <sup>[*]</sup>	
	<u>POSTERIOR DIVISION</u>	
	Superior <i>gluteal</i>	Supplies muscles of the buttocks
	Iliolumbar	Supplies iliopsoas and ilium
	Lateral sacral	Supplies sacral roots, meninges, muscles covering sacrum
EXTERNAL ILIAC		
Under inguinal ligament over the pubic rami, on the psoas muscle	Does not supply much in the pelvis	
	Deep circumflex iliac artery	
	Inferior epigastric artery	
	Femoral artery (under inguinal ligament)	At risk Total Hip Arthroplasty (THA)
<ul style="list-style-type: none"> <li>Other branches of the Internal iliac include: Umbilical, Vaginal/Inferior vesical, Uterine, Middle rectal, Inferior pudendal</li> </ul>		

## CHAPTER 7 - THIGH/HIP

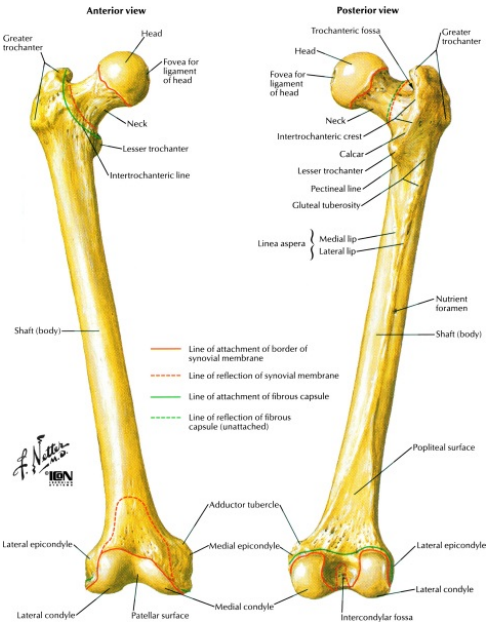
- [TOPOGRAPHIC ANATOMY](#)
- [OSTEOLOGY](#)
- [TRAUMA](#)
- [JOINTS](#)
- [MINOR PROCEDURES](#)
- [HISTORY](#)
- [PHYSICAL EXAM](#)
- [MUSCLES: ORIGINS AND INSERTIONS](#)
- [MUSCLES: ANTERIOR](#)
- [MUSCLES: MEDIAL](#)
- [MUSCLES: POSTERIOR \(HAMSTRINGS\)](#)
- [THIGH MUSCLES: CROSS SECTIONS](#)
- [NERVES](#)
- [ARTERIES](#)
- [ARTERIES OF THE FEMORAL NECK](#)
- [DISORDERS](#)
- [TOTAL HIP ARTHROPLASTY](#)
- [TIPS ON TOTAL HIPS](#)
- [PEDIATRIC DISORDERS](#)
- [SURGICAL APPROACHES](#)

CHAPTER 7 – THIGH/HIP  
TOPOGRAPHIC ANATOMY





OSTEOLOGY



CHARACTERISTICS	OSSIFY	FUSE	COMMENT
FEMUR			
<ul style="list-style-type: none"><li>Long bone characteristics</li><li>Proximally: head, neck, greater lesser trochanters</li><li>Neck: bone comprised of tensile compressive groups</li><li>Distally: 2 condyles</li><li>Lateral: more anterior proximal</li><li>Medial: larger, more posterior distal</li></ul>	<p>Primary (Shaft)</p> <p>Secondary</p> <ol style="list-style-type: none"><li>Distal physis</li><li>Head</li><li>Greater trochanter</li><li>Lesser trochanter</li></ol>	<p>7-8 wks (fetal)</p> <p>Birth</p> <p>1 yr</p> <p>4-5 yr</p> <p>10 yr</p> <p>16-18 years</p> <p>19 years</p> <p>18 years</p> <p>16 years</p> <p>16 years</p>	<p>Blood supply</p> <p>Head neck: branches of the Medial Lateral circumflex artery (from profunda)</p> <p>Shaft: nutrient (from profunda)</p> <p>Head neck vascularity tenuous:</p> <ul style="list-style-type: none"><li>increased risk of ischemia in fracture or dislocation.</li></ul> <p>Femoral neck weakens with age:</p> <ul style="list-style-type: none"><li>susceptible to</li></ul>

Femoral

- anteversion:  
12-14°
- Neck/shaft  
angle: 126°

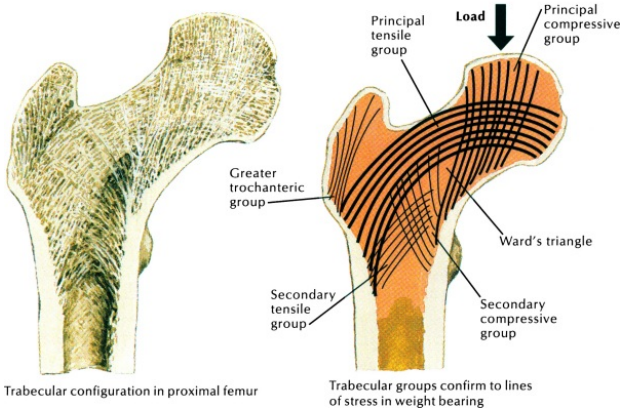
fracture

- Anatomic axis:  
along shaft of  
femur

Mechanical  
axis: femoral  
head to  
intercondylar  
notch

### Bone Architecture in Relation to Physical Stress

**Wolff's law.** Bony structures orient themselves in form and mass to best resist extrinsic forces (ie, form and mass follow function)



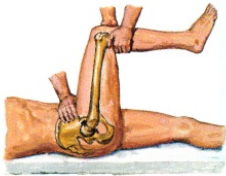
TRAUMA



**Anteroposterior view.**  
Dislocated femoral head lies posterior and superior to acetabulum. Femur adducted and internally rotated; hip flexed. Sciatic nerve may be stretched



**Anteroposterior radiograph**  
shows posterior dislocation



**Allis maneuver.** Patient supine on table, under anesthesia or sedation. Examiner applies firm distal traction at flexed knee to pull head into acetabulum; slight rotatory motion may also help. Assistant fixes pelvis by pressing on anterior superior iliac spines

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
HIP DISLOCATION			
<ul style="list-style-type: none"><li>High energy trauma (esp MVA-dash-board injury or significant fall.)</li><li>Orthopaedic emergency</li><li>Multiple associated injuries +/- fractures, (e.g. femoral head neck)</li><li>Posterior most common (85%)</li></ul>	<p>HX: Trauma. Severe pain, Cannot move thigh/hip.</p> <p>PE: Thigh position:</p> <p>Post: adducted, flexed, IR</p> <p>Ant: abducted, flexed, ER.</p> <p>Pain (esp. with motion), good neurovascular exam</p> <p>XR: AP pelvis, frog lateral (Femoral head is different size) Also femur knee series</p> <p>CT: Rule out fracture or bony fragments</p>	<p>Posterior. Thompson:</p> <p>I. Simple, no posterior fragment</p> <p>II. Simple, large posterior fragment</p> <p>III. Comminuted posterior fragment</p> <p>IV. Acetabular fracture</p> <p>V. Femoral head fracture</p> <p>Anterior. Epstein:</p> <p>I. (A, B, C): Superior</p> <p>(A, B, C): Inferior</p> <p>A: No associated fracture</p> <p>II. B: Femoral head fracture</p> <p>C: Acetabular fracture</p>	<p>Early reduction essential, then repeat XR neurologic exam</p> <p>Posterior:</p> <p>I: Closed reduction abduction pillow</p> <p>II-V: 1. Closed Reduction (open if irreducible)</p> <p>ORIF fracture</p> <p>2. or excise fragme</p> <p>Anterior: closed reduction, ORIF if necessary.</p>

COMPLICATIONS: Osteonecrosis (AVN) reduced risk with early reduction; Sciatic nerve injury (posterior dislocations); Femoral artery nerve injury (anterior dislocations); Instability recurrence; Osteoarthritis; Heterotopic ossification

## Femoral Neck Fracture



**Type I.** Impacted fracture



**Type II.** Nondisplaced fracture



**Type III.** Partially displaced



**Type IV.** Displaced fracture.  
Vertical fracture line generally suggests poorer prognosis

### DESCRIPTION

### EVALUATION

### CLASSIFICATION

### TREATMENT

#### FEMORAL NECK FRACTURE

##### Mechanism:

1. Fall by elderly woman most common;
2. High velocity injury in young adults

- Intracapsular fractures
- Associated with osteoporosis
- Often caused by medical condition (syncope, etc)
- High morbidity
- complication rate (25%)

HX: Fall. Pain, inability to bear weight or walk.

PE: LE shortened, abducted, externally rotated. Pain with "rolling" of leg.

XR: AP pelvis (+/-IR), groin lateral

MR: If symptomatic with negative XR

##### Garden (4 types):

- I. Incomplete fracture; valgus impaction
- II. Complete fracture; nondisplaced
- III. Complete fracture, Partial displacement (varus)
- IV. Complete fracture, total displacement

Early reduction essential

All fractures:

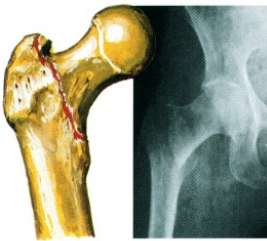
Closed (open) reduction then IF of fracture:

Young: 3 parallel screws  
Old: hemiarthroplasty

(Stable fracture, type I, may heal without surgery, ORIF because of displacement risk)

**COMPLICATIONS:** Osteonecrosis (AVN) incidence increases with fracture type (displacement) +/- late segmental collapse; Nonunion; Hardware failure

## Intertrochanteric Fracture of Femur

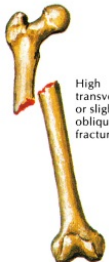


I. Nondisplaced fracture



II. Comminuted displaced fracture

## Fracture of Shaft Femur



High transverse or slightly oblique fracture



Spiral fracture



Comminuted fracture



Segmental fracture

*F. Netter M.D.*  
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DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
<b>SUBTROCHANTERIC FRACTURE</b>			
<ul style="list-style-type: none"> <li>Fall by a <u>more</u> elderly woman most common</li> <li>Associated with osteoporosis</li> <li>Occurs along or below the intertrochanteric line</li> <li>Extracapsular fractures</li> <li>Stable vascularity</li> <li>Most heal well with proper fixation</li> </ul>	<p>HX: Fall. Pain, inability to bear weight or walk</p> <p>PE: LE shortened, ER. Pain with "log rolling" of leg</p> <p>XR: AP pelvis (+/- IR), groin lateral</p> <p>MR: If symptomatic with negative XR</p>	<p>Evans (based on post-reduction stability)</p> <p>Type I. Stable</p> <p>Type II. Unstable</p>	<p>Nonoperative is very rarely indicated.</p> <p>Operative treatment with sliding compression hip screw and side plate.</p> <p>Early mobilization with partial weight-bearing</p>

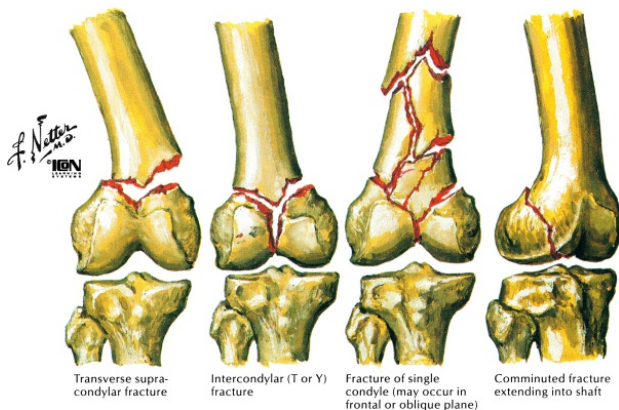
COMPLICATIONS: Nonunion/Malunion; Hardware failure or loss of reduction; Infection. Mortality rate, first 6 months after fracture, is 15-25%

<b>SUBTROCHANTERIC FRACTURE</b>			
<p>Mechanism:</p> <ul style="list-style-type: none"> <li>1. Fall in elderly</li> <li>2. Trauma in young</li> </ul> <p>Occurs below</p>	<p>HX: Trauma or fall. Pain, swelling</p> <p>PE: ...</p>	<p>Seinsheimer (5 types):</p> <p>I. Non or minimally displaced</p> <p>II. Displaced: 2 parts</p>	<p>Nonoperative treatment: traction hip spica cast for 6-8 wks (not commonly used)</p>

<ul style="list-style-type: none"> <li>the lesser trochanter (up to 5cm below it).</li> <li>Pathologic fractures seen here.</li> <li>Decreased vascularity = tenuous healing</li> </ul>	Swelling, tenderness +/- shortening of LE XR: AP lateral	III. Displaced: 3 parts IV. Comminuted (41 parts) V. Subtrochanteric/intertrochanteric fracture.	Operative treatment: Locked IM nail, compression screw, or Zickel nail, +/- bone graft
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COMPLICATIONS: Nonunion/Malunion; Hardware failure or loss of reduction; Refracture with hardware removal

### Fracture of Distal Femur



DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
FEMORAL SHAFT FRACTURE			
<ul style="list-style-type: none"> <li>Orthopaedic emergency</li> <li>High energy injury</li> <li>Multiple associated injuries (many serious)</li> <li>Potential source of significant blood loss</li> <li>Patient should be transported with leg in traction</li> </ul>	HX: Trauma. Pain, swelling deformity PE: Deformity, +/- open wound soft tissue injury; Check distal pulses XR: AP lateral thigh, knee trauma series.	Winquist/Hansen (4 types): Stable <ul style="list-style-type: none"> <li>I. No/minimal comminution</li> </ul> Comminuted: 50% of cortices intact <ul style="list-style-type: none"> <li>II.</li> </ul> Unstable <ul style="list-style-type: none"> <li>III. Comminuted: 50% of cortices intact</li> <li>IV. Complete comminution, no intact cortex</li> </ul>	Extensive irrigation of any open fractures Operative: Interlocking intramedullary rods (closed) Early mobilization with crutch ambulation
COMPLICATIONS: Neurovascular injury and/or hemorrhagic shock; Nonunion/Malunion; Hardware failure or loss of reduction; Knee injury (5%)			
DISTAL FEMUR FRACTURE			

- Mechanism: direct blow
- Metaphysis or epiphysis
- Quadriceps or gastrocnemius often displace fragments
- Restoration of articular surface is essential to regain normal knee mobility function

HX: Trauma. Cannot bear weight, pain, swelling.

PE: Effusion, tenderness, do good neurovascular exam

XR: Knee trauma series

CT: Better defines fracture

AGRAM: if pulseless

Extraarticular  
Supracondylar

Intraarticular  
Intercondylar: T or Y  
Condylar

+/- aspirate hemarthroses

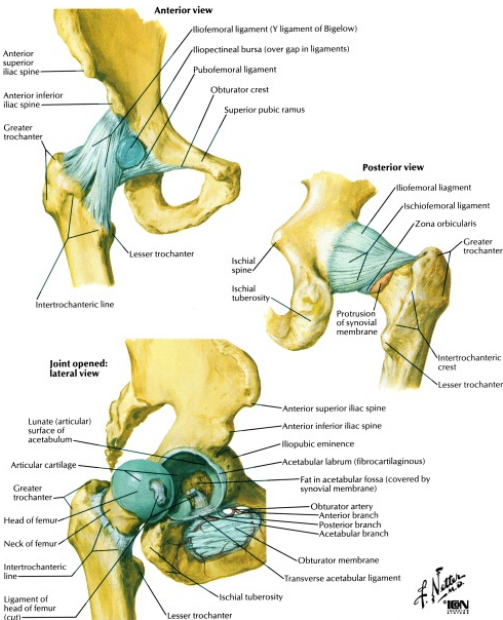
Undisplaced/extraarticular: reduce, immobilize (less commonly used method)

Displaced/intraarticular: ORIF: plates and screws or intramedullary nails

Early mobilization

COMPLICATIONS: Osteoarthritis and/or pain; Decreased range of motion; Malunion/nonunion; Instability

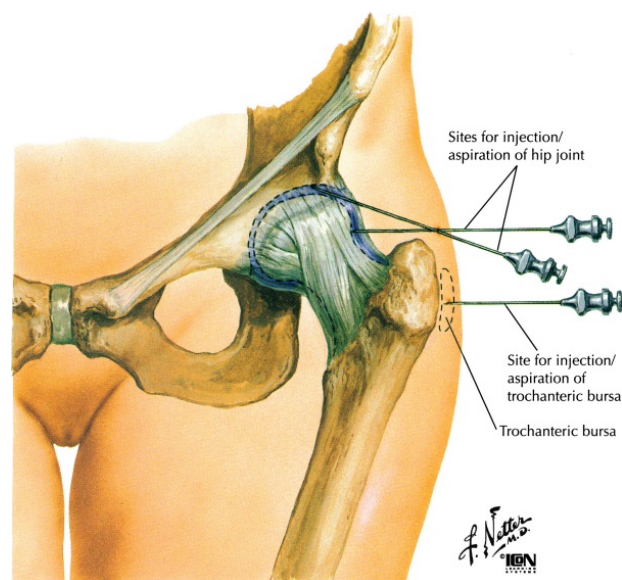
JOINTS



LIGAMENTS	ATTACHMENTS	COMMENTS
HIP JOINT (Spheroidal/Ball and Socket type)		
Transverse acetabular	Anteroinferior to posteroinferior acetabulum	Cups the acetabulum
Labrum	Acetabular rim	Deepens stabilizes acetabulum
<b>JOINT CAPSULE</b>	Acetabular rim to femoral neck	
Pubofemoral (anterior/inferior)	Femoral neck to superior pubic ramus	Covers femoral NECK
Iliofemoral (anterior) (Y ligament of Bigelow)	AIIS to intertrochanteric line	Strongest, most support
Ishiofemoral (posterior)	Posterior rim to intertrochanteric crest	Posterior femoral neck only partially covered (weak)
Zona orbicularis (posterior)		
Ligament of Teres	Fovea to cotyloid notch	Artery runs in ligament



## MINOR PROCEDURES



### STEPS

#### HIP INJECTION OR ASPIRATION

1. Ask patient about allergies
2. Place patient supine, palpate the greater trochanter.
3. Prepare skin over insertion site (iodine/antiseptic soap)
4. Anesthetize skin locally (quarter size spot)

**ANTERIOR:** Find the point of intersection between a vertical line below ASIS and horizontal line from Greater trochanter. Insert 20 gauge (3 inch/spinal needle) upward slightly medial direction at that point.

5. **LATERAL:** Insert a 20 gauge (3 inch/spinal needle) superior and medial to greater trochanter until it hits the bone (the needle should be within the capsule which extends down the femoral neck).

Inject (or aspirate) local or local/steroid preparation into joint. (The fluid should flow easily if needle is in joint)

6. Dress injection site

#### TROCHANTERIC BURSA INJECTION


1. Ask patient about allergies
2. Place patient in lateral decubitus position, palpate the greater trochanter.
3. Prepare skin over lateral thigh (iodine/antiseptic soap)

Insert 20 gauge needle (at least 1 1/2 inches) into thigh to the bone at the point of most tenderness. Withdraw needle (1—2mm) so it is just off the bone and in the bursa. Aspirate to ensure needle is not in a vessel.

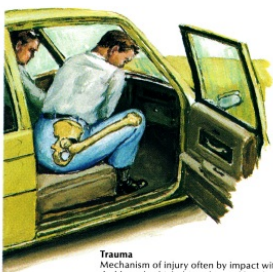
4. Inject 10ml of local or 4:1 local/corticosteroid preparation into bursa
5. Dress injection site




HISTORY



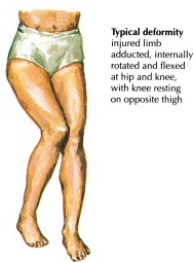
**Osteoarthritis**  
Characteristic habitus and gait



**Trauma**  
Mechanism of injury often by impact with dashboard, which drives femoral head backward, out of acetabulum



**LFCN entrapment**  
Numbness and dysesthesias in lateral thigh

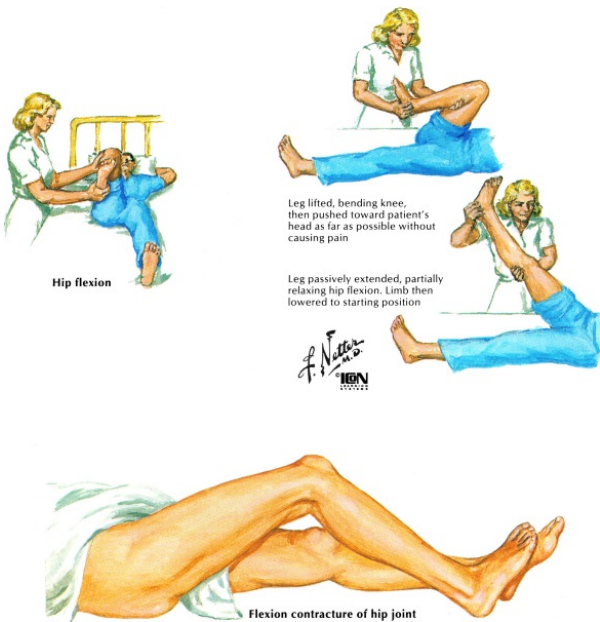


**Typical deformity**  
injured limb adducted, internally rotated and flexed at hip and knee, with knee resting on opposite thigh

QUESTION	ANSWER	CLINICAL APPLICATION
1. AGE	Young	Trauma, developmental disorders
	Middle age, elderly	Arthritis (inflammatory conditions), femoral neck fractures
2. PAIN	Acute	Trauma, infection
a. Onset	Chronic	Arthritis (inflammatory conditions)
b. Location	Lateral hip or thigh	Bursitis, LFCN entrapment, snapping hip
c. Occurrence	Buttocks/posterior thigh	Consider spine etiology
	Groin/medial thigh	Hip joint or acetabular etiology (less likely to be from pelvis or spine)
	Anterior thigh	Proximal femur
	Ambulation/motion	Hip joint etiology (i.e. not pelvis or spine)
	At night	Tumor, infection
3. SNAPPING	With ambulation	Snapping hip syndrome, loose bodies, arthritis, synovitis
4. ASSISTED AMBULATION	Cane, crutch, walker	Use (and frequency) indicates severity of pain condition
5. ACTIVITY TOLERANCE	Walk distance activity cessation	Less distance walked and fewer activities no longer performed = more severe
6. TRAUMA	Fall, MVA	Fracture, dislocation, bursitis
7. ACTIVITY/WORK	Repetitive use	Femoral stress fracture
8. NEUROLOGIC SYMPTOMS	Pain, numbness, tingling	LFCN entrapment, spine etiology
9. HISTORY OF ARTHRITIDES	Multiple joints involved	Systemic inflammatory disease

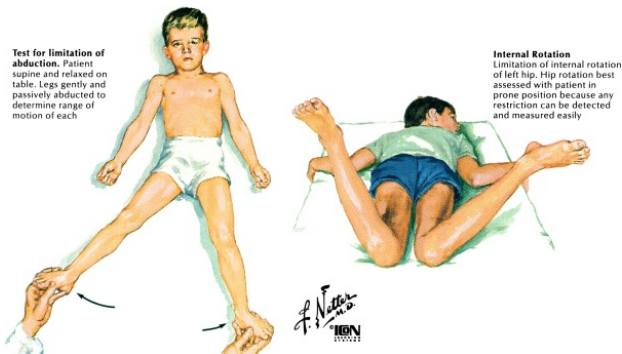


PHYSICAL EXAM



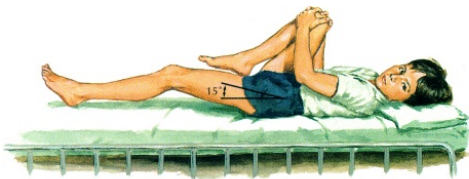
EXAM/OBSERVATION TECHNIQUE		CLINICAL APPLICATION
INSPECTION		
Skin	Discoloration, wounds	Trauma
	Gross deformity	Fracture, dislocation
Gait	60%stance, 40%swing	Normal gait: 20% double stance (both feet on ground)
Antalgic (painful)	Decreased stance phase	Knee, ankle, heel (spur), midfoot, toe pain
Lurch (Trendelenburg)	Laterally (on WB side)	Gluteus medius weakness, hip disease (OA, AVN)
Lurch	Posteriorly (hip extended)	Gluteus maximus weakness
Steppage	More hip knee flexion	Foot drop, weak anterior leg muscles
Flat foot	No push off	Hallux rigidus, gastrocnemius/soleus weakness
Wide	Feet 4 inches apart	Neurologic/cerebellar disease
Decreased step size	Less than previous normal	Pain, age, other pathology
PALPATION		
Bony structures	Greater trochanter/bursa	Pain/palpable bursa: infection/bursitis, gluteus medius tendinitis
Soft tissue	Sciatic nerve (hip)	Pain: disc herniation, piriformis spasm

Joint issues	flexed)	Pat. disc herniation, piriformis spasm
	Muscle groups	Each group should be symmetric bilaterally



EXAM/OBSERVATION	TECHNIQUE	CLINICAL APPLICATION
RANGE OF MOTION		
Flexion	Supine: knee to chest	Normal: 130 degrees
	Thomas test: see next page	Rule out flexion contracture
Extension	Prone: lift leg off table	Normal: 20 degrees
Abduction/adduction	Supine: leg lateral/medial	Normal: Abd: 40 degrees, Add: 30 degrees
Internal / External rotation	Seated: foot lateral/medial	Normal: IR: 30 degrees, ER: 50 degrees
	Prone: flex knee leg: in out	Normal: IR: 30 degrees, ER: 50 degrees
NEUROVASCULAR		
<b>Sensory</b>		
Genitofemoral nerve (L1-2)	Proximal anteromedial thigh	Deficit indicates corresponding nerve/root lesion
Obturator nerve (L2-4)	Inferomedial thigh	Deficit indicates corresponding nerve/root lesion
Lateral Femoral Cutaneous nerve (L2-3)	Lateral thigh	Deficit indicates corresponding nerve/root lesion
Femoral nerve (L2-4)	Anteromedial thigh	Deficit indicates corresponding nerve/root lesion
Posterior Femoral Cutaneous nerve (S1-3)	Posterior thigh	Deficit indicates corresponding nerve/root lesion
<b>Motor</b>		
Obturator nerve (L2-4)	Thigh adduction	Weakness =Adductor muscle group or nerve/root lesion.
Superior Gluteal nerve (L5)	Thigh abduction	Weakness =Gluteus medius or nerve/root lesion.
Femoral nerve (L2-4)	Hip flexion	Weakness =Iliopsoas or corresponding nerve/root lesion.
		Weakness =Quadriceps or

	Knee extension	Weakness = Quadriceps or corresponding nerve/root lesion.
Inferior Gluteal nerve (L5-S2)	Hip extension	Weakness = Gluteus maximus or nerve/root lesion.
Sciatic:		
Tibial portion (L4-S3)	Knee flexion	Weakness = Biceps Long Head or nerve/root lesion.
Peroneal portion (L4-S2)	Knee flexion	Weakness = Biceps Short Head or nerve/root lesion
Reflex	None	
Pulses	Femoral	



#### Thomas' sign

Hip flexion contracture determined with patient supine. Unaffected hip flexed only until lumbar spine is flat against examining table. Affected hip cannot be fully extended, and angle of flexion is recorded. 15° flexion contracture of hip is typical of Legg-Calvé-Perthes disease

*F. Netter M.D.*  
1909-2002

"Roll" test for muscle spasm. Patient relaxed and supine on table. Examiner places hands on limb, gently rolls hip into internal and external rotation, noting resistance



EXAM/OBSERVATION TECHNIQUE		CLINICAL APPLICATION
SPECIAL TESTS		
Thomas sign	Supine: one knee to chest	If opposite thigh elevates off table: flexion contracture of that side
Ober	On side: flex abduct hip	Leg should then adduct, if stays in abduction: ITB contracture
Piriformis	On side: adduct hip	Pain in hip/pelvis indicates tight piriformis (compressing sciatic nerve)
Leg length discrepancy	ASIS to medial malleolus	A measured difference of 1cm is positive
90-90 straight leg	Flex hip knee 90°, extend knee	20 degrees of flexion after full knee extension = tight hamstrings
Ely's	Prone: passively flex knee	If hip flexes as knee is flexed: tight rectus femoris muscle
Log roll	Supine, hip extended: IR/ER	Pain in hip is consistent with arthritis

Patrick (FABER)	Flex, <b>AB</b> duct, <b>ER</b> hip, then abduct more (figure of 4)	Positive if pain or LE will not continue to abduct below other leg: Hip or SI joint pathology
Meralgia	Pressure medial to ASIS	Reproduction to pain, burning, numbness: LFCN entrapment
Ortolani (Peds)	Hips at 90°, abduct hips	A clunk indicates the hip(s) was dislocated and now reduced
Barlow (Peds)	Hips at 90°, posterior force	A clunk indicates the hip(s) is now dislocated, should reduce with Ortolani
Galeazzi (Peds)	Supine: Flex hips knees	Any discrepancy in knee height : 1. Dislocated hip, 2. Short femur

#### Ortolani's (reduction) test

With baby relaxed and content on firm surface, hips and knees fixed to 90°. Hips examined one at a time. Examiner grasps baby's thigh with middle finger over greater trochanter and lifts thigh to bring femoral head from its dislocated posterior position to appose the acetabulum. Simultaneously, thigh gently abducted, reducing femoral head into acetabulum. In positive finding, examiner senses reduction by palpable, nearly audible "clunk".



#### Barlow's (dislocation) test

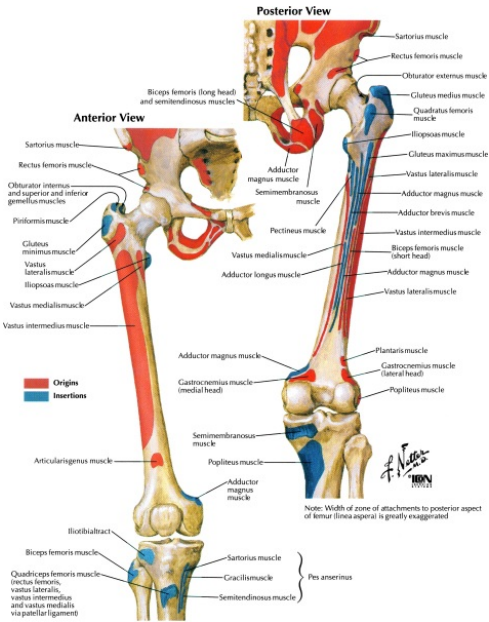
Reverse of Ortolani's test. If femoral head is in acetabulum at time of examination, Barlow's test is performed to discover any hip instability. Baby's thigh is grasped as above and adducted with gentle downward pressure. Dislocation is palpable as femoral head slips out of acetabulum. Diagnosis confirmed with Ortolani's test.



**Allis' or Galeazzi's sign**  
With knees and hips flexed, knee on affected side lower because femoral head lies posterior to acetabulum in this position

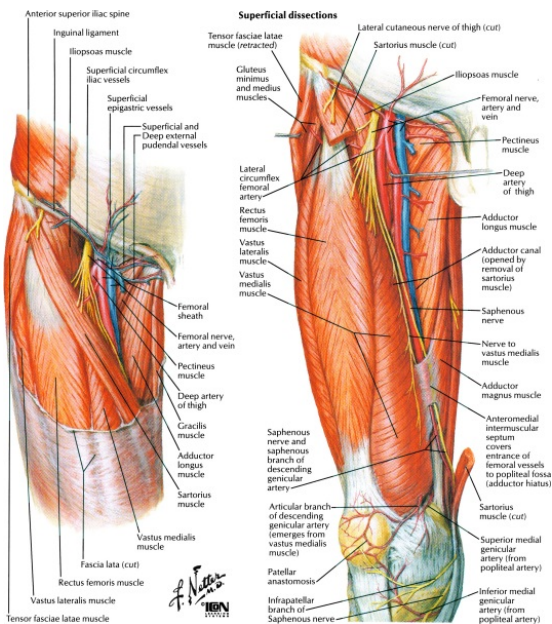


MUSCLES: ORIGINS AND INSERTIONS



PUBIC RAMI (ASPECT)	GREATER TROCHANTER	ISCHIAL TUBEROSITY	LINEA ASPERA/ POSTERIOR FEMUR
Pectineus (pectineal line/sup)	Piriformis (anterior)	Inferior gemellus	Adductor magnus
Adductor magnus (inferior)	Obturator internus (anterior)	Quadratus femoris	Adductor longus
Adductor longus (anterior)	Superior gemellus	Semimembranosus	Adductor brevis
Adductor brevis (inferior)	Gluteus medius (posterior)	Semitendinosus	Biceps femoris
Gracilis (inferior)	Gluteus minimus (anterior)	Biceps femoris (LH)	Pectineus
Psoas minor (superior)		Adductor magnus	Gluteus maximus
			Vastus lateralis
			Vastus medialis

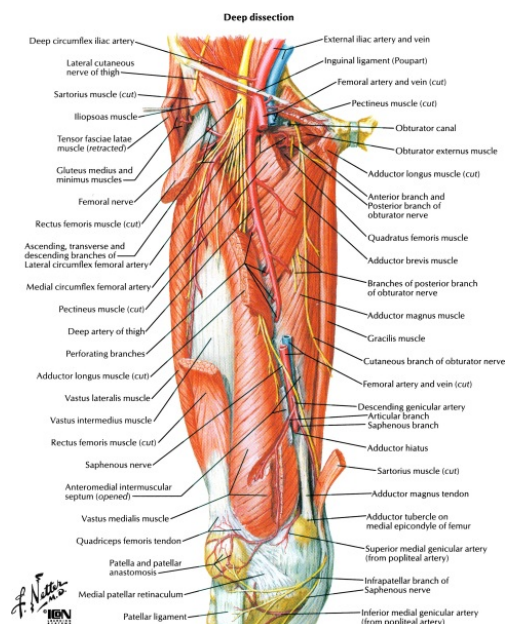
MUSCLES: ANTERIOR



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Articularis genu	Distal anterior femoral shaft	Synovial capsule	Femoral	Pulls capsule superiorly in extension	May join with vastus intermedius
Sartorius	ASIS	Proximal medial tibia (Pes anserinus)	Femoral	Flex, ER hip	Can avulse from ASIS (fracture)
QUADRICEPS					
Rectus femoris	AIS, superior rim of acetabulum	Patella/tibial tubercle	Femoral	Flex thigh, extend leg	Can avulse from AIS (fracture)
LEG EXTENSORS					
Vastus lateralis	Greater trochanter, lateral linea aspera	Lateral patella, tibial tubercle	Femoral	Extend leg	Oblique fibers can affect Q angle
Vastus intermedius	Proximal femoral shaft	Patella; tibial tubercle	Femoral	Extend leg	Covers articularis genu
Vastus medialis	Intertrochanteric line, medial linea aspera	Medial patella, tibial tubercle	Femoral	Extend leg	Weak in many patello-femoral disorders.



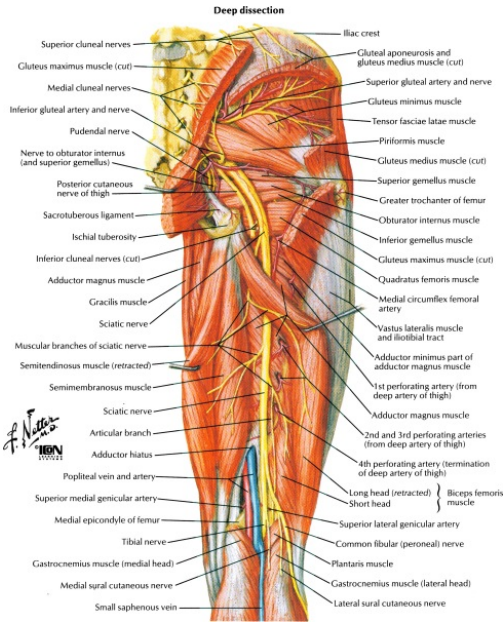
# MUSCLES: MEDIAL



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Obturator externus	Ischiopubic rami, obturator membrane	Trochanteric fossa	Obturator	ER thigh	Tendon posterior to femoral neck
HIP ADDUCTORS					
Adductor longus	Body of pubis (inferior)	Linea aspera (mid 1/3)	Obturator	Adducts thigh	Tendon can ossify
Adductor brevis	Body and inferior pubic ramus	Pectineal line, upper linea aspera	Obturator	Adducts thigh	Deep to pectineus
Adductor magnus	Ischiopubic ramus ischial tuberosity	Linea aspera/adductor tubercle	Obturator/Sciatic	Adducts thigh	2 portions: separate insertions innervation
Gracilis	Body and inferior pubic ramus	Proximal medial tibia (Pes anserinus)	Obturator	Adducts (flex) thigh flex, IR leg	Used in ligament reconstruction (ACL)
HIP FLEXORS (also iliopsoas)					
Pectineus	Pectineal line of pubis	Pectineal line of femur	Femoral	Flex and adduct thigh	Part of femoral triangle floor

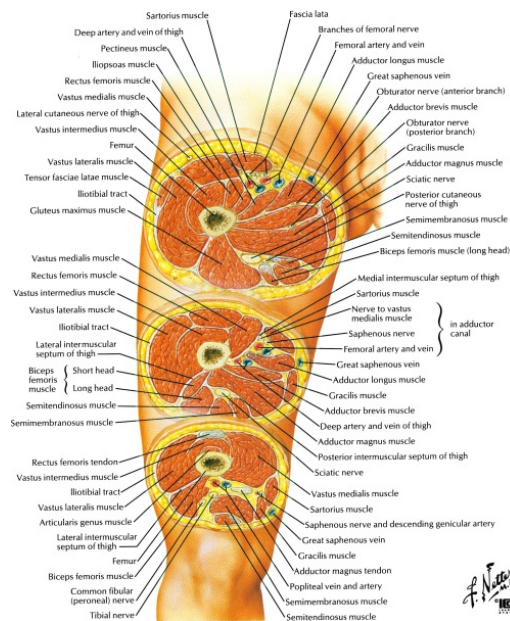


MUSCLES: POSTERIOR (HAMSTRINGS)

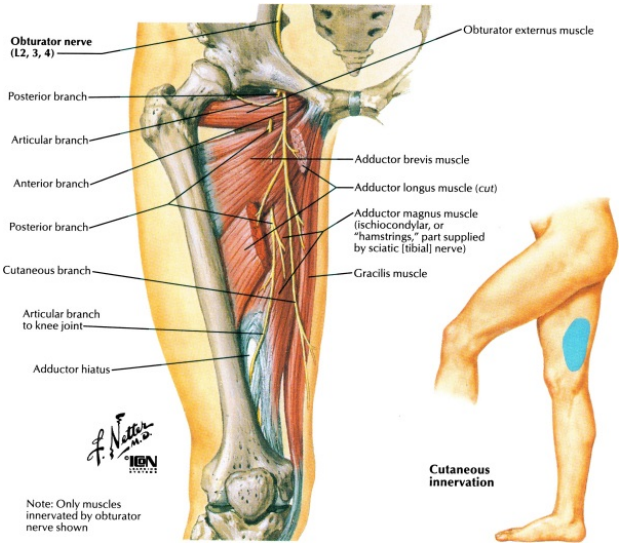


MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Semitendinosus	Ischial tuberosity	Proximal medial tibia (Pes anserinus)	Sciatic (tibial)	Extend thigh, flex leg	Used in ligament reconstructions (ACL)
Semimembranosus	Ischial tuberosity	Posterior medial tibial condyle	Sciatic (tibial)	Extend thigh, flex leg	A border in medial approach
Biceps femoris: Long Head	Ischial tuberosity	Head of fibula	Sciatic (tibial)	Extend thigh, flex leg	Covers sciatic nerve
Biceps femoris: Short Head	Linea aspera, supra condylar line	Fibula, lateral tibia	Sciatic (peroneal)	Extend thigh, flex leg	Shares insertion tendon with Long Head

## THIGH MUSCLES: CROSS SECTIONS



NERVES



LUMBAR PLEXUS

ANTERIOR DIVISION

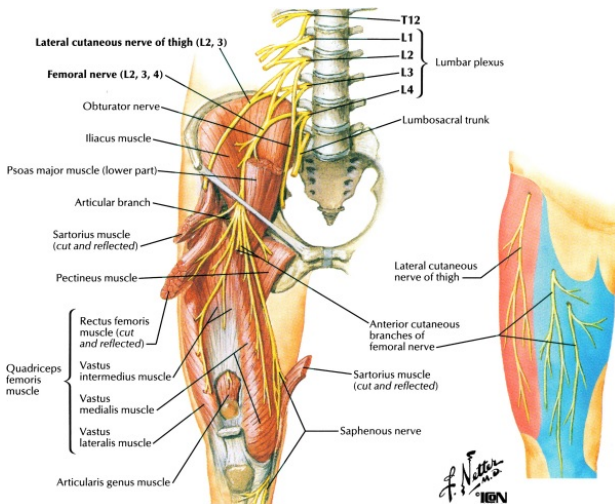
**Genitofemoral** (L1-2): pierces Psoas, lies on anteromedial surface

Sensory:	Proximal anteromedial thigh
Motor:	NONE (in thigh)

**Obturator** (L2-4): exits via obturator canal, splits into anterior posterior divisions. Can be injured by retractors placed behind the transverse acetabular ligament.

Sensory:	Inferomedial thigh: via cutaneous branch of obturator nerve
2.	Gracilis (anterior division)
Motor:	Adductor longus (anterior division)
	Adductor brevis (ant/post divisions)
	Adductor magnus (posterior division)





## LUMBAR PLEXUS

### POSTERIOR DIVISION

**Lateral Femoral Cutaneous [LFCN](L2-3):** crosses ASIS, can be compressed at ASIS.

Sensory: Lateral thigh

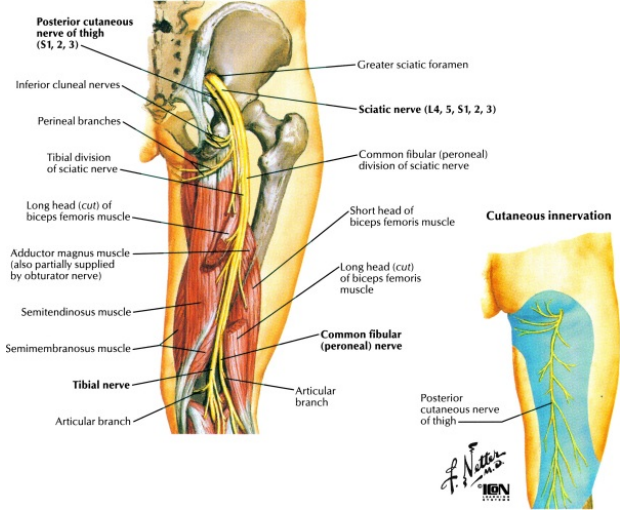
Motor: NONE

**Femoral (L2-4):** lies between psoas major and iliacus; Saphenous nerve branches in Femoral Triangle runs under sartorius.

Sensory: Anteromedial thigh: via anterior/intermediate cutaneous nerves

4.

Motor: Psoas  
Sartorius  
Articularis genu  
**QUADRICEPS**  
Rectus femoris  
Vastus lateralis  
Vastus intermedius  
Vastus medialis



3.

## SACRAL PLEXUS

### ANTERIOR DIVISION

**Tibial (L4-S3):** descends (as sciatic) in posterior thigh

Sensory:	NONE (in thigh)
Motor:	POSTERIOR THIGH Biceps femoris [long head] Semitendinosus Semimembranosus

### POSTERIOR DIVISION

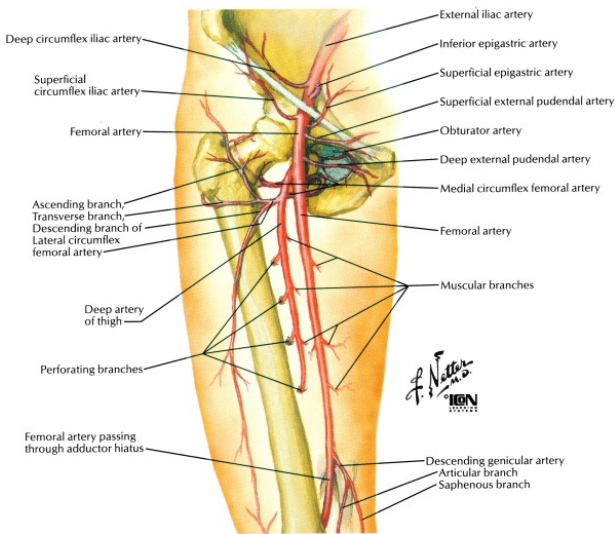
**Common peroneal (L4-S2):** descends(as sciatic) in posterior thigh

5.	Sensory:	NONE (in thigh)
	Motor:	Biceps femoris [short head]

**Posterior Femoral Cutaneous Nerve [PFCN] (S1-3)**

6.	7.	Sensory:	Posterior thigh
		Motor:	NONE

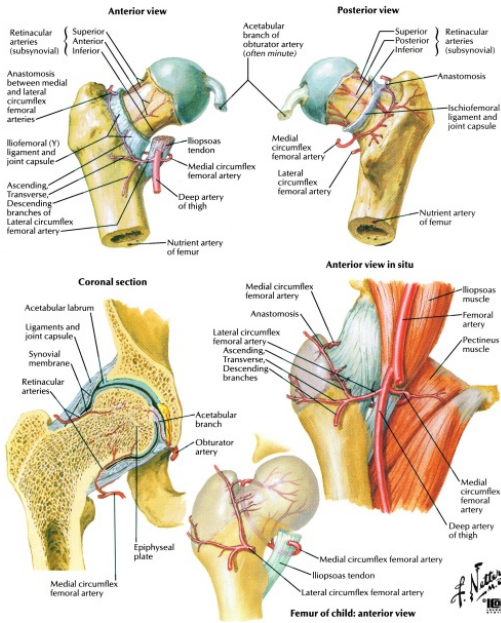
ARTERIES



ARTERY	BRANCHES	COMMENT
Obturator	Anterior posterior branches	Runs through obturator foramen
Femoral (Superficial Femoral) [SFA]	In femoral triangle, runs in medial thigh between vastus medialis and adductor longus, to obturator canal, through adductor hiatus, then becomes Popliteal Artery behind knee.	
	Superficial circumflex iliac	
	Superficial epigastric	
	Superficial external pudendal	
	Deep external pudendal	
	Deep artery of thigh (Profunda)	See below
	Descending genicular artery	Anastomosis at knee to supply knee
	Articular branch	
	Saphenous branch	
Deep Artery of the thigh (Profunda)	Medial circumflex	Supplies femoral neck
	Lateral circumflex	Supplies femoral neck
	Ascending branch	Forms anastomosis at femoral neck
	Transverse branch	Contributes to anastomosis at femoral neck
	Descending branch	Contributes to anastomosis at femoral neck
	Perforators/muscular branches	Supplies femoral shaft and thigh muscles



ARTERIES OF THE FEMORAL NECK



ARTERY	COURSE	COMMENT
Obturator: Fovea artery (A. of Ligament Teres)	Runs through the ligament of femur head	Relatively minor contribution to femoral head
Deep Artery of thigh	Branches from Femoral in Femoral triangle.	Supplies anterior medial thigh
Medial circumflex	Between pectineus iliopsoas to posterior femoral neck	Anastomosis: posterior supply
Ascending branch	Runs on Quadratus femoris	Can be injured in posterior approach
Lateral circumflex	Deep to sartorius and rectus femoris	Extracapsular anastomosis at neck
Ascending branch	To greater trochanter anteriorly	Anastomosis: anterior supply
Cervical branches	Extracapsular branches of anastomosis	Pierce the capsule
Retinacular arteries	Intracapsular branches: run along neck, enter bone at base of femoral head.	Most of femoral head supply is posterior (at risk in injury: AVN)
Transverse branch	Extends laterally	Minor contribution to anastomosis
Descending branch	Under rectus femoris	Minor contribution to anastomosis
Inferior Superior Gluteal arteries	Branches make small contributions to femoral neck anastomosis	



DISORDERS

DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
INFLAMMATORY ARTHRITIS			
<ul style="list-style-type: none"><li>Host immunologic response results in synovitis.</li><li>RA, Lupus, SeroNegative arthropathies, gout, etc.</li></ul>	Hx: Pain, stiffness, +/- other joints involved. PE: Antalgic gait, decreased ROM (especially IR)	XR: AP, frog leg lateral Labs: RF, ESR, CRP ANA, CBC, uric acid, crystals, culture	<ol style="list-style-type: none"><li>Physical therapy, NSAIDs</li><li>Cane or crutch</li><li>Synovectomy (early)</li><li>Total hip Arthroplasty (late)</li></ol>
OSTEOARTHRITIS			
<ul style="list-style-type: none"><li>Loss or damage to articular cartilage</li><li>Etiology: developmental, trauma, infection, metabolic, idiopathic</li></ul>	Hx: Chronic hip or groin pain, increasing over time with activity PE: Decrease ROM (first IR), + log roll, +/- flexion contracture antalgic gait	XR: AP/lateral hip <ol style="list-style-type: none"><li>Joint space narrowing</li><li>Osteophytes</li><li>Subchondral sclerosis</li><li>Bony cysts</li></ol>	<ol style="list-style-type: none"><li>NSAIDs, Physical Therapy</li><li>Injection, activity modification, cane</li><li>Osteotomy (young)</li><li>Arthrodesis (young)</li><li>Total Hip Arthroplasty (elderly)</li></ol>
LATERAL FEMORAL CUTANEOUS NERVE ENTRAPMENT (Meralgia Paresthetica)			
<ul style="list-style-type: none"><li>Nerve trapped near ASIS.</li><li>Due to activity (hip extension), or clothing (e.g. belt)</li></ul>	Hx: Pain/burning in lateral thigh PE: Decreased sensation on lateral thigh, + Meralgia	XR: AP/lateral of hip: rule out other pathology	<ol style="list-style-type: none"><li>Remove compressive entity</li><li>Surgical release: rare</li></ol>
OSTEONECROSIS (Avascular necrosis: AVN)			
<ul style="list-style-type: none"><li>Necrosis of femoral head (trabecular bone)</li><li>Due to vascular disruption</li><li>Associated with trauma, Etoh, steroid use, RA</li><li>Ficat classification: 4 stages based on sx, XR, bone scan</li></ul>	Hx: Insidious onset dull hip ache PE: With collapse: pain with IR ER Without collapse: discomfort with IR ER	XR: AP, frog leg lateral: femoral head sclerosis MR: Double line sign (T2)	Early: core decompression or vascularized fibular graft Late or collapse: Total hip arthroplasty
SNAPPING HIP (Iliotibial band)			
<ul style="list-style-type: none"><li>ITB snapping over greater trochanter of iliopsoas tendon over pectineal eminence</li></ul>	Hx: Snapping in hip with walking (as hip extends). Pain rare. PE: Adduct flex	XR: AP pelvis, AP/latearl of hip: usually normal, rule	<ol style="list-style-type: none"><li>Reassurance</li><li>Avoid activity, Physical therapy</li></ol>

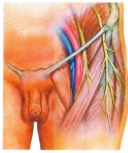
<p>• Women (wide pelvis) most common</p>	<p>PE: Adduct flex hip, then extend: + snap</p>	<p>out other pathology</p>	<p>3. Injection for acute bursitis</p> <p>4. Surgery rare</p>
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### TROCHANTERIC BURSITIS

<p>• Inflammation of bursa over greater trochanter or gluteal tendons</p>	<p>Hx: Lateral hip pain. Cannot sleep on affected side. PE: Point tenderness at greater trochanter</p>	<p>XR: AP pelvis, AP/lateral of hip: rule out spur, OA, calcified tendons</p>	<p>1. NSAIDs</p> <p>Physical therapy (IT Band stretching)</p> <p>3. Steroid injection</p>
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### Inflammatory Arthritis

Lateral femoral cutaneous nerve  
Entrapment of nerve under inguinal ligament



Hip joint involvement. Thinning of articular cartilages and flattening and medial migration of femoral head

### Osteoarthritis

Advanced degenerative changes in acetabulum



Radiograph of hip shows typical degeneration of cartilage and secondary bone changes with spur at margins of acetabulum



Erosion of cartilage and deformity of femoral head



## TOTAL HIP ARTHROPLASTY

### TIPS ON TOTAL HIP

#### GENERAL INFORMATION

Types of implants: cemented, noncemented (press fit porous ingrowth), hybrid

- "Supermetals": cobalt chrome titanium (shaft/head)
- - Acetabular cup: Ultra high-molecular weight polyethylene
- Porous ingrowth: best pore size 200-400 microns
- Cemented usually used in elderly patients, noncemented for younger patients
- Cement: Polymethylmethacrylate
- Head size: 26-28mm is optimal

#### INDICATIONS

Arthritis of hip: common etiologies: OA, RA, AVN

Most patients complain of pain, worsening over time (wakes them from sleep), and decreased ability to ambulate.

Patient should have appropriate radiographic evidence of arthritis

It is preferable when the patient is elderly (needs only one replacement)

#### OSTEOARTHRITIS

1. Joint space narrowing
2. Sclerosis
3. Subchondral cysts
4. Osteophyte formation

#### RHEUMATOID ARTHRITIS

1. Joint space narrowing
2. Periarticular osteoporosis
3. Joint erosions
4. Ankylosis

2. Failed conservative treatment: activity modification, weight loss, physical therapy/strengthening, NSAIDs, ambulation assistance (cane used on unaffected side, walker, etc.), injections.
3. Other: Fractures, tumors, developmental disorders (DDH, etc.)

#### CONTRAINDICATIONS

- Young, active patient (will wear out replacement many times)
- Medically unstable (e.g. severe cardiopulmonary disease)
- Neuropathic joint
- Any infection

#### ALTERNATIVES

1.
  - Considerations: Age, activity level, overall health
  - Osteotomy: Femoral or pelvic; not common in U.S.
  - Arthrodesis/Fusion: good for young patients/laborers, unilateral disease, no other joint disease (e.g. spine, knee). Fuse with hip in slight flexion

#### PROCEDURE

- Posterior or lateral approach usually used
- Femoral component should be in valgus ("Thou shalt not Varus")
- Acetabular cup at 45°

#### COMPLICATIONS

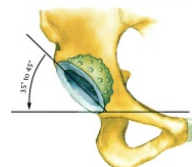
Failure of Implant

1. Loosening (#1 complication in cemented joints)
- 2. Varus alignment
3. Implant breakage (patients: active, heavy, young, will wear out prosthetic)
- Hip thigh pain post-operatively (#1 complication in noncemented joints)
- Deep Venous Thrombosis (DVT)/Pulmonary emboli: patients should be anticoagulated (Heparin/warfarin) postoperatively

- Infection: often leads to removal of prosthesis (Staph #1 cause)
- Dislocation: posterior are most common (abduction pillow can help prevent)
- External iliac/Femoral artery and vein injury with anterior/superior quadrant screw
- Obturator nerve, artery, vein injury with anterior/inferior quadrant screw. Posterior screw placement is preferable
- Nerve injury (sciatic: peroneal portion) by retractors: Foot drop
- Heterotopic ossification: one dose prophylactic XRT can help prevent it.
- Osteolysis: Macrophage response; due to polyethylene wear debris

## TIPS ON TOTAL HIP

### Total Hip Replacement



Final position of cup 35° to 45° lateral inclination and 15° anteversion

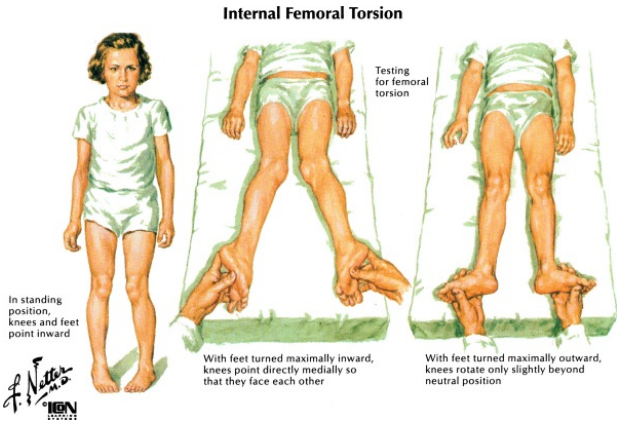


Trial prosthesis inserted into femoral canal to ensure fit (its collar flush with cut surface of femoral neck)



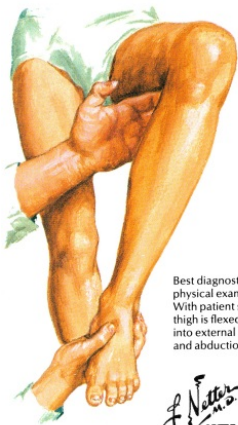
Reduction of hip with prosthesis in place.

PEDIATRIC DISORDERS



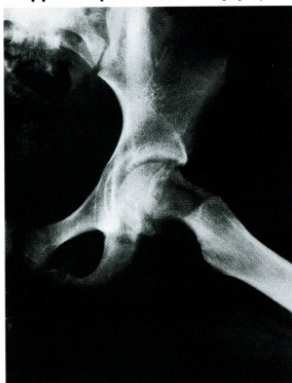
DESCRIPTION	EVALUATION	TREATMENT/COMPLICATIONS
DEVELOPMENTAL DYSPLASIA		
<ul style="list-style-type: none"><li>• Capsule/ligament laxity, or</li><li>1. Acetabular roof abnormal: hip does not develop correctly</li><li>Associated with: First female, breech delivery, + family health, decreased intrauterine space conditions</li><li>• Early diagnosis and treatment essential (3mo)</li><li>• Poor outcomes if diagnosis delayed</li></ul>	<p>Hx: Twins, other risk factors. Often unnoticed by parents.</p> <p>PE: + Barlow (dislocation), + Ortolani (relocation), + Galeazzi tests. Decreased abduction</p> <p>XR: In older patients</p> <p>US: if PE not conclusive</p>	<p>Goal: maintain femoral head in the acetabulum (concentric reduction):</p> <ul style="list-style-type: none"><li>•<ol style="list-style-type: none"><li>1. Pavlik harness (3mo)</li><li>2. Closed reduction cast (6-18mo)</li><li>3. Osteotomy (18mo)</li></ol></li></ul> <p>Post reduction films essential</p> <ul style="list-style-type: none"><li>• COMPLICATIONS: Osteonecrosis (femoral head)</li></ul>
FEMORAL ANTEVERSION		
<ul style="list-style-type: none"><li>• Internal rotation of femur, femoral anteversion does not decrease properly</li><li>• #1 cause of intoeing</li></ul>	<p>Hx: Usually presents 3-6 yrs</p> <p>PE: Femur IR (IR 65°), patella is medial, intoeing gait</p>	<ol style="list-style-type: none"><li>1. Most spontaneously resolve</li><li>2. Derotational osteotomy if it persists past age 10 (mostly cosmetic)</li></ol>

## Slipped Capital Femoral Epiphysis



Best diagnostic sign in physical examination. With patient supine, as thigh is flexed it rolls into external rotation and abduction

*F. Netter M.D.*  
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Frog-leg radiograph, which demonstrates slipped epiphysis more clearly, always indicated when disorder is suspected

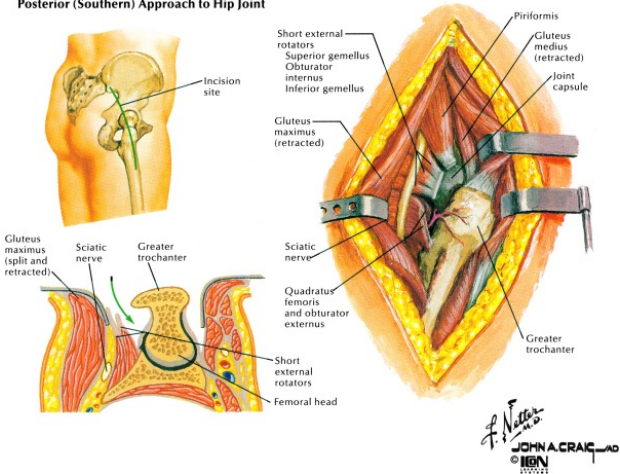
DESCRIPTION	EVALUATION	TREATMENT/COMPLICATIONS
<b>LEGG-CALVE-PERTHES DISEASE</b>		
<ul style="list-style-type: none"> <li>Osteonecrosis of femoral head</li> <li>Idiopathic, vascular etiology (hypercoagulable/sludging)</li> <li>Associated with: + family history, breech birth</li> <li>Catteral classification: 4 stages</li> <li>Poor prognosis: after age 9 or with large femoral head involvement</li> </ul>	<p>Hx: Boys(4:1) usually 4-8 yo, unilateral thigh or knee pain limp</p> <p>PE: Decreased abduction, no point tenderness on exam</p> <p>XR: AP pelvis, frog lateral (density of the femoral head is indicative; crescent sign: subchondral fx)</p>	<p>The femoral head must revascularize</p> <p>Based on age:</p> <p>5 yrs: observation NSAIDs</p> <p>5-8 yrs: concentric containment: abduction brace or osteotomy</p> <p>9+ yrs: operative treatment often fails (many need THA as adult)</p>
<b>SLIPPED CAPITAL FEMORAL EPIPHYSIS (SCFE)</b>		
<ul style="list-style-type: none"> <li>Proximal femoral epiphysis falls off femur (posterior) head in acetabulum</li> <li>Obese adolescents</li> <li>Early diagnosis and treatment essential</li> </ul>	<p>Hx: 11-14 yo, often obese, slow onset hip, thigh, knee pain, +/- limp</p> <p>PE: Decreased ROM (especially IR,</p>	<p>Do not attempt reduction</p> <p>1. Non weight-bearing</p> <p>2. Percutaneous pinning</p> <p>COMPLICATIONS: Osteonecrosis, chondrolysis, osteoarthritis, decreased ROM</p>

abduction)

XR: AP  
pelvis, frog  
lateral

SURGICAL APPROACHES

Posterior (Southern) Approach to Hip Joint



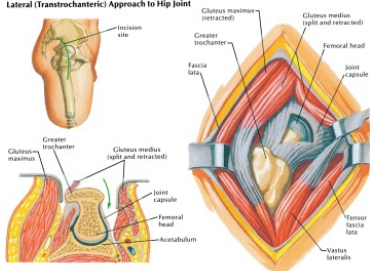
USES	INTERNEUVOUS PLANE	DANGERS	COMMENT
POSTERIOR (Moore/Southern) APPROACH TO HIP			
1. Total Hip Arthroplasty 2. Arthroplasty ORIF 3. posterior acetabulum 3. hip dislocations	Split gluteus maximus [Inferior gluteal n]	1. Sciatic nerve 2. Inferior gluteal artery	1. Superior and inferior gluteal arteries need to be controlled. 2. The short external rotators must be detached to access the joint.
LATERAL (Hardinge) APPROACH TO HIP			
Total Hip Arthroplasty (not used for revisions)	Split gluteus medius [Superior gluteal n]	1. Superior gluteal artery 2. Femoral nerve 3. Femoral Artery vein	1. No osteotomy of greater trochanter required. Leads to earlier mobilization. 2. Less exposure than posterior approach, thus not used for revision THA.
LATERAL APPROACH TO THIGH			
1. Fractures 2. Tumors	Split vastus lateralis (and intermedius)	1. Branch of Lateral femoral circumflex artery	1. Incision can be large or small; it is made along the line between greater trochanter and lateral condyle.

[Femoral  
nerve]

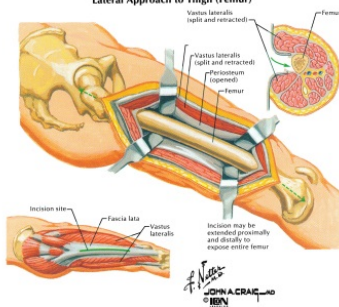
2. Superior  
lateral  
geniculate  
artery

2. Arteries (#1 2 at  
left) encountered if  
incision extended  
proximally or  
distally; ligate  
them.

#### Lateral (Trochanteric) Approach to Hip Joint



#### Lateral Approach to Thigh (Femur)



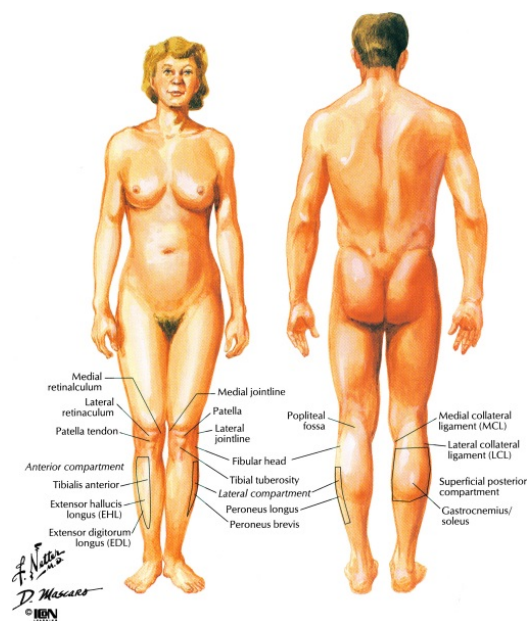


## CHAPTER 8 - LEG/KNEE

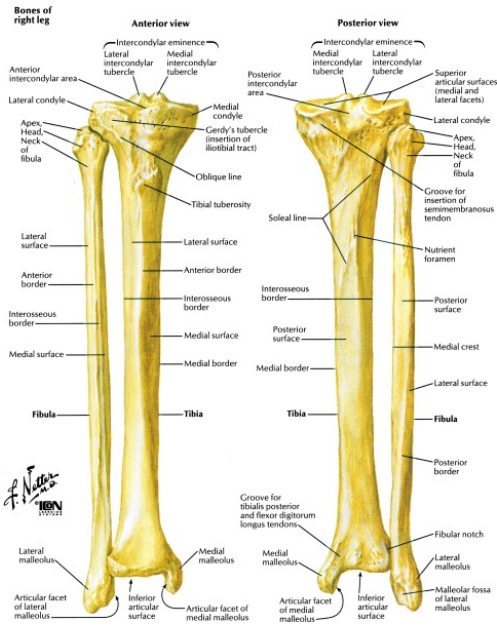
- [TOPOGRAPHIC ANATOMY](#)
- [OSTEOLOGY](#)
- [TRAUMA](#)
- [KNEE JOINTS](#)
- [MINOR PROCEDURES: KNEE](#)
- [HISTORY](#)
- [PHYSICAL EXAM](#)
- [MUSCLES: ORIGINS AND INSERTIONS](#)
- [MUSCLES: ANTERIOR COMPARTMENT](#)
- [MUSCLES: LATERAL COMPARTMENT](#)
- [MUSCLES: SUPERFICIAL POSTERIOR COMPARTMENT](#)
- [MUSCLES: DEEP POSTERIOR COMPARTMENT](#)
- [MUSCLES: CROSS SECTIONS](#)
- [NERVES](#)
- [ARTERIES](#)
- [DISORDERS](#)
- [DISORDERS: LIGAMENT INJURIES](#)
- [DISORDERS](#)
- [TOTAL KNEE ARTHROPLASTY](#)
- [TOTAL KNEE ARTHROPLASTY](#)
- [PEDIATRIC DISORDERS](#)
- [SURGICAL APPROACHES](#)

## CHAPTER 8 – LEG/KNEE

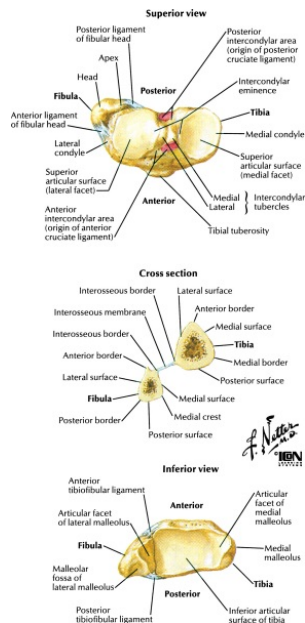
### TOPOGRAPHIC ANATOMY



OSTEOLOGY



CHARACTERISTICS	OSSIFY	FUSE	COMMENT
TIBIA			
• Long bone characteristics	Primary: Body	7 wks (fetal) 18 years	• Ossification site at the tibial tuberosity can be confused with a fracture.
• Wide proximal end (plateau) articulates with the femoral condyles	Secondary	18-20 years	• Traction (quadriceps) apophysitis at the tibial tuberosity: Osgood Schlatter disease
• Distal end (plafond) cups the talus	1. Proximal epiphysis	9 mo	• Primary weight-bearing bone in leg
• Medial malleolus is distal end	2. Distal epiphysis	1 yr	
• IT Band inserts on Gerdy's tubercle	3. Tibial tuberosity		
FIBULA			
• Long bone characteristics	Primary: Body	8 wks (fetal) 20 years	• Common peroneal nerve runs across the neck, injured in fractures (foot drop)
• Distal end (lateral malleolus) is lateral wall of ankle mortise.	Secondary	18-22 years	• Used to determine "lateral" on radiographs
	1. Proximal epiphysis	1-3 yr	
	2. Distal		



## CHARACTERISTICS

## OSSIFY FUSE

## COMMENT

## PATELLA

- Largest sesamoid bone in the body

Primary  
(single  
center)

3 years

11-13  
years

- Failure to fuse: Bipartite patella (can be confused with patella fracture).

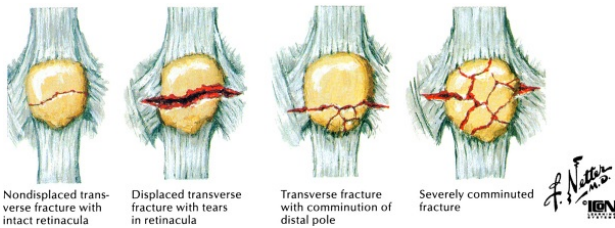
- Two facets (lateral is larger)

- Functions:
  1. Enhances quadriceps pull
  2. Protects knee

- Triangular in cross-section

- Very thick articular cartilage (bearing heavy loads)

TRAUMA



DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
PATELLA FRACTURE			
<p>Mechanism: direct indirect:</p> <ul style="list-style-type: none"> <li>• (e.g. fall, dashboard or kicking injury)</li> <li>• Pull of quadriceps and patella tendons displace most fractures</li> <li>• If intact, retinaculum resists displacement</li> <li>• Do not confuse with bipartite patella</li> </ul>	<p>HX: Trauma. Pain, cannot extend knee, swelling.</p> <p>PE: "Dome" effusion. Tenderness, +/- palpable defect. Inability to extend knee.</p> <p>XR: Knee trauma series</p> <p>CT: Not usually needed</p>	<p>Descriptive location:</p> <p>Nondisplaced</p> <p>Transverse</p> <p>Vertical</p> <p>Stellate</p> <p>Inferior/superior pole</p> <p>Comminuted</p>	<p>Nondisplaced or comminuted: cylinder cast for 6 wks</p> <p>Displaced (2-3mm): ORIF (e.g. tension bands) to restore articular surface</p> <p>Severely comminuted: may require patellectomy</p>
COMPLICATIONS: Osteoarthritis and/or pain, Decreased motion and/or strength; Osteonecrosis; Refracture			
TIBIAL PLATEAU FRACTURE			
<p>Mechanism:</p> <ul style="list-style-type: none"> <li>• Direct blow (e.g. MVA)</li> <li>• Intraarticular fracture</li> <li>• Restoration of articular surface is important</li> <li>• Most often lateral</li> <li>• Metaphyseal injury: bone compresses, leads to functional bone loss.</li> <li>• Associated with ligament injuries</li> </ul>	<p>HX: Trauma. Cannot bear weight. Pain, swelling.</p> <p>/PE: Effusion, tenderness, do good neurovascular PE</p> <p>XR: Knee trauma series</p> <p>CT: Better defines fracture.</p> <p>AGRAM: if pulseless</p>	<p>Schatzker (6 types):</p> <p>I. Lateral plateau split fx</p> <p>II. Lateral split/depression fx</p> <p>III. Lateral plateau depression</p> <p>IV. Medial plateau split fx</p> <p>V. Bicondylar plateau fx</p> <p>VI. Fx with metaphyseal-diaphyseal separation</p>	<p>+/- Aspirate hemarthroses</p> <p>Undisplaced (6 mm): cast, ROM at 6 wks, WB 3mos.</p> <p>Displaced/unstable: ORIF: plates and screws +/- bone graft</p> <p>Mobilize early, weight- bear at 2 months</p>

COMPLICATIONS: Compartment syndrome; Hardware failure or loss of reduction; OA; Popliteal artery or nerve injury

## KNEE DISLOCATION

- Rare: Ortho emergency
- Usually high energy injury
- Ligaments other soft tissue are disrupted
- High incidence of associated fracture neurovascular injury
- Close follow up is important for good result

HX: Trauma. Pain, inability to bear weight.

PE: Effusion, deformity, pain, +/- distal pulses  
peroneal nerve function

XR: AP/lateral

AGRAM: ID arterial injury

MR: Ligament injury

By position:

Anterior

Posterior

Lateral

Medial

Rotatory:

Anteromedial or anterolateral.

Early reduction essential Post reduction neurologic exam and x-rays.

Immobilize (cast): 6-8 wks (not if ligaments torn)

Open: If irreducible, vascular injury (+/- pro-phylactic fasciotomy), early repair of ligaments if needed.

COMPLICATIONS: Neurovascular: Popliteal artery, peroneal nerve injury; Decreased motion; Instability



I. Split fracture of lateral tibial plateau



II. Split fracture of lateral condyle plus depression of tibial plateau



III. Depression of lateral tibial plateau without split fracture



IV. Comminuted split fracture of medial tibial plateau and tibial spine



V. Bicondylar fracture involving both tibial plateaus with widening



VI. Fracture of lateral tibial plateau with separation of metaphyseal-diaphyseal junction

### Dislocation of Knee Joint

Types of dislocation

*A. Neri*  
BHN



Anterior



Posterior



Lateral



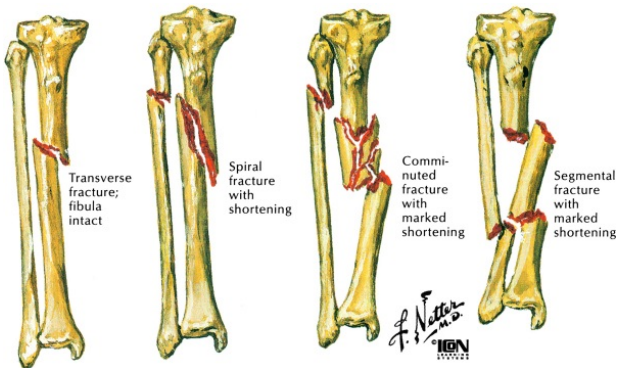
Medial



Rotational

Prompt reduction important and can usually be readily accomplished using manual traction, with or without pressure over prominence of dislocated bone





DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
<b>TIBIA SHAFT FRACTURE</b>			
<ul style="list-style-type: none"> <li>Common long bone fracture</li> <li>Young adults</li> <li>Often tibia/fibula fracture or tibia fracture/dislocation combination injuries</li> <li>Tenuous blood supply; union is a problem.</li> <li>Up to 5% residual angulation is acceptable</li> </ul>	<p>HX: Trauma. Cannot bear weight, pain, swelling.</p> <p>PE: Swelling, deformity, +/- tense compartments open wound. Palpate pulse</p> <p>XR: AP/lateral leg, + knee and ankle series</p> <p>AGRAM: if pulseless</p>	<p>Descriptive:</p> <p>Location</p> <p>Displaced/comminuted</p> <p>Type: transverse, spiral oblique</p> <p>Rotation/angulation</p>	<p>Stable, non or minimally displaced, closed injury: Long leg cast 4-6 wks then shorter cast</p> <p>Unstable, displaced, comminuted injury: ORIF Intramedullary nails (external fixation for severe open fractures)</p>

COMPLICATIONS: Malunion/nonunion: especially mid-distal 1/3; Compartment syndrome; Decreased motion; Hardware failure; Neurovascular injury; Reflex Sympathetic Dystrophy (RSD)

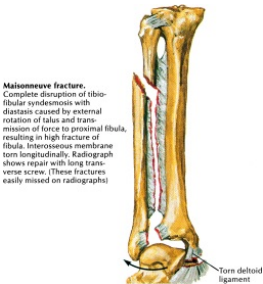
<b>MAISONNEUVE FRACTURE</b>			
<ul style="list-style-type: none"> <li>Complete syndesmosis disruption with diastasis proximal fibula fracture</li> <li>Variant of ankle fracture deltoid ligament rupture</li> <li>Unstable fracture</li> </ul>	<p>HX: Trauma. Ankle pain, +/- knee pain.</p> <p>PE: Ankle pain, swelling, +/- knee signs.</p> <p>XR: Knee series with each ankle fracture</p>		<p>Reduce and stabilize syndesmosis with a screw</p>

COMPLICATIONS: Ankle instability; Ankle arthritis

<b>PILON (DISTAL TIBIA) FRACTURE</b>			
<ul style="list-style-type: none"> <li>Intraarticular: through distal articular/WB surface.</li> <li>Comminution common</li> <li>Associated soft</li> </ul>	<p>HX: Trauma. Cannot bear weight, pain, swelling</p> <p>PE: Effusion, tenderness, do good neurovascular</p>	<p>Ruedi-Allgower (3 types):</p> <p>I. Non or minimally displaced.</p> <p>II. Displaced: articular</p>	<p>Nondisplaced: Long leg cast NWB for 6 wks</p> <p>Displaced/Comminuted: ORIF: plates screws +/-</p>

<ul style="list-style-type: none"> <li>tissue injuries</li> <li>Articular surface</li> <li>repair is difficult essential</li> <li>Healing is often slow</li> </ul>	PE XR: AP/lateral (obliques) CT: Needed: better image of articular surface	surface incongruous. III. Comminuted articular surface.	bone grafting Severely comminuted: external fixation
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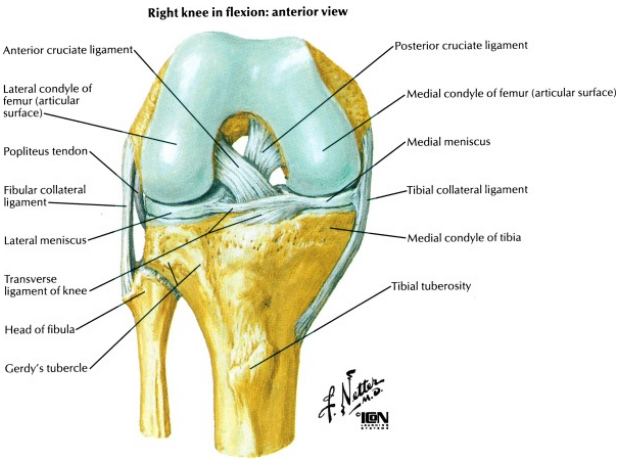
COMPLICATIONS: Post-traumatic Osteoarthritis (almost 100% in comminuted fractures); Decreased motion; Malunion/nonunion



**Pilon fracture**  
 Usual cause is vertical loading of ankle joint, eg, falling from height and landing on heel (usually with ankle dorsiflexed). Fracture and compression of articular surface of tibia plus separation of malleoli and fracture of fibula



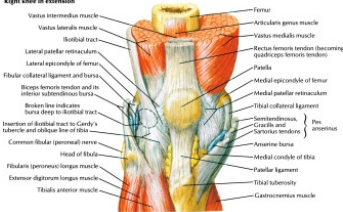
KNEE JOINTS



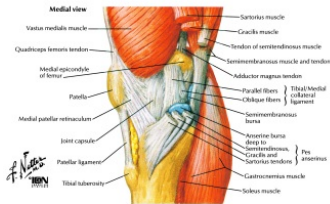
SUPPORT	ATTACHMENTS	COMMENTS
FEMORAL/TIBIAL: CONDYLOID		
ANTERIOR		
Patellofemoral joint	See page 212	
Anterior cruciate (ACL)	Tibial eminence to medial aspect of lateral femoral condyle	Prevents anterior translation, tight in flexion, must reconstruct if injured
Transverse meniscal ligament	Anterior menisci	Meniscus support stability
MEDIAL		
Meniscus	Between femoral condyle tibial plateau	More crescentic than lateral
Capsule (III)	Surrounds joint	Minimal support
Medial collateral (MCL)	Medial epicondyle to tibia (II) meniscus (III)	Superficial (II) and Deep (III) portion
Coronary ligament (III)	Meniscus to medial tibia	Stabilizes meniscus
Semimembranous membrane (II)	Attach to posterior tibial condyle	
Pes anserinus tendons (I)	Medial tibial condyle	Tendinitis can occur at insertion
LATERAL		
Meniscus	Between femoral condyle tibial plateau	More circular than medial
Popliteus muscle tendon	Proximal tibia	Intraarticular tendon
Capsule (III)	Surrounds joint	Minimal support
Arcuate ligament (III)	Posterolateral femoral condyle to fibular head	Covers popliteus tendon
Fabellofibular ligament (III)	Fabella to fibula	Variable
Lateral collateral (LCL)	Lateral femoral condyle to	Prevents varus angulation

(III)	fibular head	Prevents varus angulation
Biceps muscle tendon (I)	Gerty's tubercle fibular head	
Iliotibial band (I)	Lateral tibial condyle	If tight, ITB syndrome can occur
<b>POSTERIOR</b>		
Capsule (III)	Surrounds joint	Minimal support
Ligament of Humphrey	Posterior lateral meniscus to medial femoral condyle	In front of PCL
Posterior cruciate (PCL)	Tibial sulcus to anterior medial femoral condyle	Prevents posterior translation
Ligament of Wrisberg	Posterior lateral meniscus to medial femoral	Behind the PCL
	condyle	
Oblique popliteal ligament	Semimembranosus to lateral femoral condyle	Derived from semimembranosus
Gastrocnemius/plantaris muscle	Origin: posterior medial lateral femoral condyles	Two heads originate above knee

**Right knee in extension**



**Intercondylar notch**



#### Anteromedial compartment



Medial meniscus visualized before femoral condyle. Meniscus rises with valgus stress, permitting inspection beneath it.

#### Lateral view



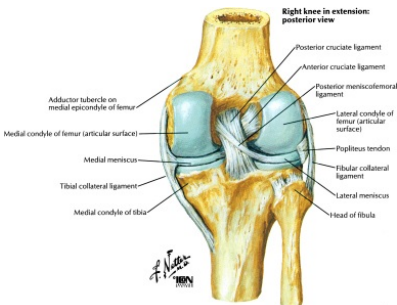
#### Anterolateral compartment



Lateral meniscus visualized. Tibio stress raises meniscus from tibial condyle.

Posteromedial compartment

#### Right knee in extension: posterior view



#### Posteromedial compartment



Posterior cruciate ligament seen beyond medial meniscus



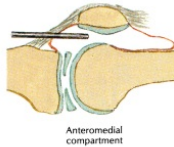
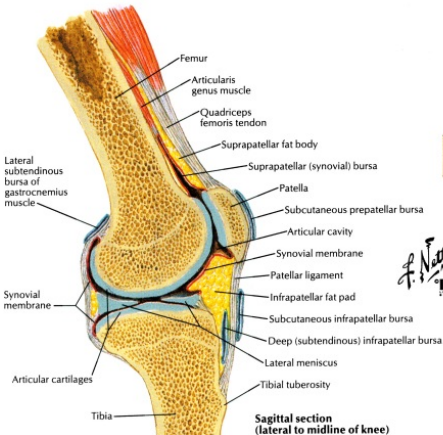
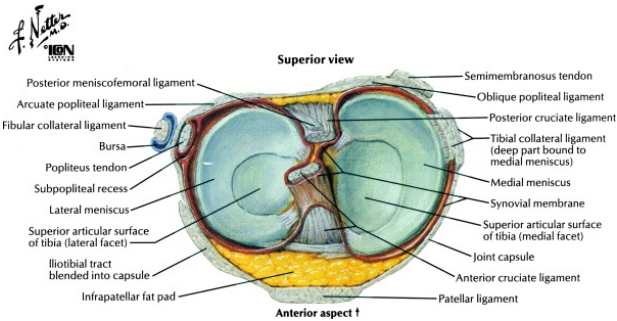
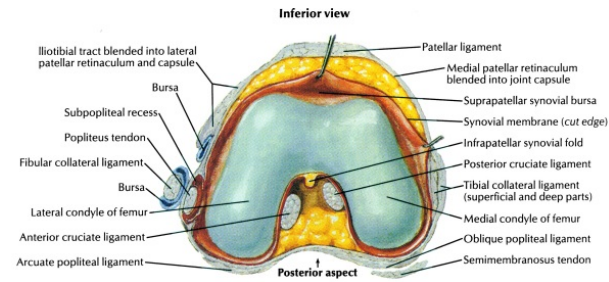
Broken lines indicate tibial collateral ligament

#### Posterolateral compartment



Popliteus tendon passing obliquely downward





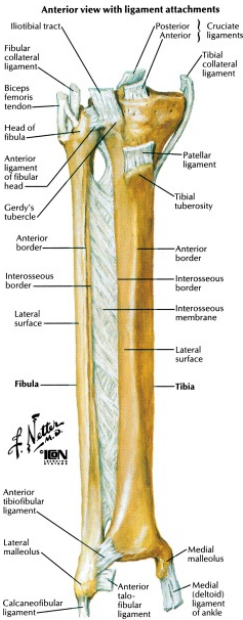
Quadriceps tendon	Attach on superior patellar pole	Superior extensor mechanism
Patellar ligament (tendon)	Inferior patella pole to tibial tuberosity	Inferior extensor mechanism
Medial lateral retinaculum (quadriceps oblique fibers) (II)	Quadriceps extensions to patella, then to tibial condyles	Stabilizes patella in motion. Can affect Q angle if tight
Medial lateral patellofemoral ligaments (II)	Patella to femoral condyles	Stabilizes patella
Medial lateral patellotibial ligaments	Patella to tibial condyles	Stabilizes patella

### PROXIMAL TIBIOFIBULAR : Plane

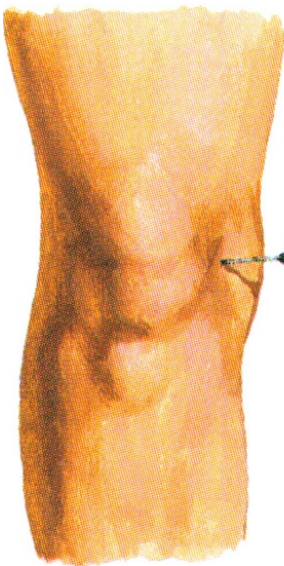
Anterior ligament of head of fibula	Fibula head to lateral tibia	Broader than posterior
Posterior ligament of head of fibula	Fibula head to lateral tibia	Weaker than anterior

### OTHER STRUCTURES

Interosseous membrane	Lateral tibia to medial fibula	Strong; runs length of leg
<ul style="list-style-type: none"> <li>• Three compartments in the knee: Medial, Lateral, Patellofemoral</li> <li>• Meniscus: Made of fibrocartilage. Function: 1) Protects articular cartilage (increases weight bearing surface area, 2) Stabilizes by deepening facet, 3) Load transmission</li> <li>Peripheral 1/3 vascular (geniculate arteries): can be repaired; Inner 2/3 supplied by synovial fluid: must debride in injured</li> <li>• There are three layers of support in the knee: I, II, III (noted in parentheses next to structure)</li> <li>• Posterolateral corner complex: Arcuate ligament, popliteus, posterolateral capsule</li> <li>• Muscles attaching at the pes anserinus: sartorius, gracilis, semitendinosus</li> </ul>		



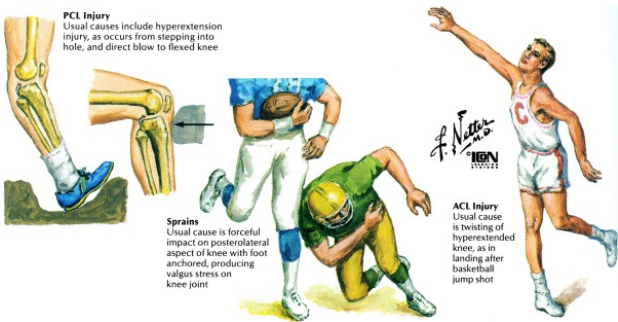
MINOR PROCEDURES: KNEE



**Knee.** Needle inserted horizontally at medial or lateral margin of patella to pass beneath patella. 20-gauge needle used for most joints.

STEPS
ARTHOCENTESIS/INJECTION
1. Ask patient about allergies
2. Place patient supine, knee extended, palpate the lateral patella and lateral distal femur.
3. Prepare skin over the knee (iodine/antiseptic soap)
4. Anesthetize skin locally (quarter size spot)
5. Insert an 18 gauge needle laterally into the suprapatella pouch (between the patella and femur) proximal to the joint. Aspirate fluid from joint (or inject 3-5cc of local/steroid preparation). Fluid should flow easily if needle is in joint.
6. If suspicious of infection, send fluid for GS culture.
7. Dress injection site

HISTORY



QUESTION	ANSWER	CLINICAL APPLICATION
1. AGE	Young	Trauma: fractures, ligamentous or meniscal injury
	Middle age, elderly	Arthritis
2. PAIN		
a. Onset	Acute	Trauma: fracture, dislocation, soft tissue (ligament/meniscus) injury, septic bursitis
	Chronic	Arthritis, infection, tendinitis/bursitis, tumor
b. Location	Anterior	Quadriceps or patellar tear or tendinitis, prepatellar bursitis, patellofemoral arthritis
	Posterior	Meniscus tear (posterior horn), Baker's cyst, popliteal aneurysm
	Lateral	Meniscus tear (jointline), collateral ligament injury, arthritis, ITB friction syndrome
	Medial	Meniscus tear (jointline), collateral ligament injury, arthritis, pes bursitis
c. Occurrence	Night pain	Tumor, infection
	With activity	Etiology of pain likely from joint
3. STIFFNESS	Without locking	Arthritis, effusion (trauma, infection)
	With locking or catching	Loose body, meniscal tear (especially bucket handle), arthritis, synovial plica
4. SWELLING	Within joint	Infection, trauma
	Acute (post injury)	Acute (hours): ACL injury; Subacute (day): meniscus injury
	Acute (without injury)	Infection: prepatellar bursitis, septic joint
5. INSTABILITY	Giving away/collapse	Cruciate ligament injury, extensor mechanism injury
	Giving away,+/- pain	Patellar subluxation/dislocation, pathologic plica, osteochondritis dissecans
6. TRAUMA	Mechanism: valgus force	MCL injury (+/- terrible triad: MCL, ACL, medial meniscus injuries)
	Varus force	LCL injury
	Flexion/posterior force	PCL injury (e.g. dashboard injury)
	Contact injury	Non-contact: ACL injury, Contact: multiple ligaments

	Popping noise	Cruciate ligament injury (especially ACL), osteochondral fracture
	NONE	Degenerative and overuse etiology
7. ACTIVITY	Agility sports	Cruciate and/or collateral ligament injury
	Running, cycling, climbing	Patellofemoral etiology
	Squatting	Mensicus tear
	Walking	Distance able to ambulate equates with severity of arthritic disease
8. NEUROLOGIC SYMPTOMS	Pain, numbness, tingling	Neurologic disease, trauma
9. SYSTEMIC COMPLAINTS	Fevers, chills	Infection, septic joint
10. HISTORY OF ARTHRITIDES	Multiple joints involved	Rheumatoid Arthritis, gout, etc.



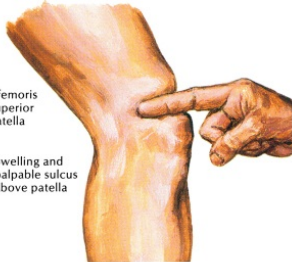
PHYSICAL EXAM



EXAM	TECHNIQUE/FINDINGS	CLINICAL APPLICATION
INSPECTION		
Gait	Observe patella tracking	Abnormal patella tracking can lead to patellofemoral problems
	Flexed knee gait	Tight Achilles tendon or hamstrings: patellofemoral problems
Anterior	Genu valgum (knock knee) Genu varum (bow leg)	Normal: 7 degrees valgus; varus or valgus deformity with ligamentous or osseous deficiency
	Swelling	Effusion (arthritis, trauma, infection/inflammation), bursitis (prepatellar, infrapatellar)
Posterior	Swelling, mass	Effusion (arthritis), Baker's cyst
Lateral	Back knee, high/low riding patella	Genu recurvatum (PCL injury), patella alta (patellar instability)
Musculature	Atrophy	Vastus medialis atrophy: can lead to patellofemoral problems
PALPATION		
Bony structures	Patella: medial lateral aspects	Tenderness at distal pole: tendinitis (Jumpers knee)
	Tibial tubercle	Tenderness with Osgood Schlatter disease
Soft tissues	Compress suprapatellar pouch ("milk" knee)	Ballotable patella (effusion): arthritis, trauma, infection
	Prepatellar/infrapatellar bursae	Edematous or tender bursae indicate correlating bursitis
	Pes anserine bursa	Tenderness indicates bursitis
	Plica (medial to patella)	Thickened, tender plica is pathologic
	Medial jointline MCL	Tenderness: medial meniscus tear or MCL injury
	Lateral jointline LCL	Tenderness: lateral meniscus tear or LCL injury
	Iliotibial band (anterolateral knee)	Pain or tightness is pathologic
	Popliteal fossa	Mass consistent with Baker's cyst, popliteal aneurysm
	Compartments of leg (anterior, posterior, lateral)	Firm or tense compartment: Compartment syndrome

Rupture of quadriceps femoris tendon at superior margin of patella

Swelling and palpable sulcus above patella



### Acute Anterior Compartment Syndrome

Paresthesia

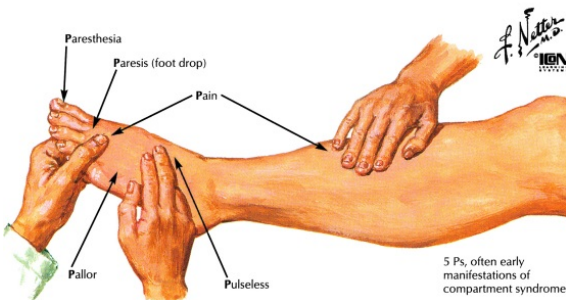
Paresis (foot drop)

Pain

Pallor

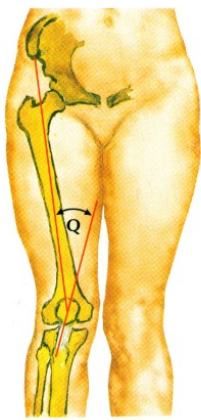
Pulseless

5 Ps, often early manifestations of compartment syndrome




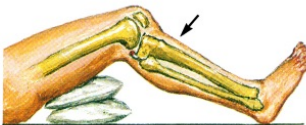
EXAM	TECHNIQUE/FINDINGS	CLINICAL APPLICATION
<b>RANGE OF MOTION</b>		
Flexion extension	Supine: knee to chest, then straight	Normal: Flex 0 to 125-135°, Extend 0 to 5-15°;
		Extensor lag (final 20° difficult): weak quadriceps; Decreased extension with effusion
	Note patellar tracking, pain, crepitus	Abnormal tracking leads to anterior knee pain; pain crepitus: arthritis
Tibial IR ER	Stabilize femur, rotate tibia	Normal: 10-15° IR ER
<b>NEUROVASCULAR</b>		
<b>Sensory</b>		
Femoral nerve (L4)	Medial leg (Medial cutaneous nerves)	Deficit indicates corresponding nerve/root lesion
Peroneal nerve (L5)	Lateral leg (common superficial)	Deficit indicates corresponding nerve/root lesion
Tibial nerve (S1)	Posterior leg (Sural nerves)	Deficit indicates corresponding nerve/root lesion
<b>Motor</b>		
Femoral nerve (L2-4)	Knee extension	Weakness = Quadriceps or nerve/root lesion
Sciatic: Tibial (L4-S3)	Knee flexion	Weakness = Biceps (LH) or nerve/root lesion
Peroneal (L4-S2)	Knee flexion	Weakness = Biceps (SH) or nerve/root lesion
Tibial nerve (L4-S3)	Foot plantarflexion	Weakness = TP, FHL, FDL or nerve/root lesion
Peroneal (deep) n. (L4-S2)	Foot dorsiflexion	Weakness = TA, EHL, EDL or nerve/root lesion

<b>Reflex</b>		
<b>L4</b>	Patellar	Hypoactive/absence indicates L4 radiculopathy
<b>Pulse</b>	Popliteal	



**Q angle** formed by intersection of lines from anterior superior iliac spine and from tibial tuberosity through midpoint of patella. Large Q angle predisposes to patellar subluxation

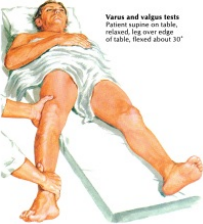
**Apprehension (Fairbank) test**  
As examiner displaces patella laterally, patient feels pain and forcefully contracts quadriceps femoris muscle

**Posterior sag sign.** Leg drops backward


EXAM	TECHNIQUE/FINDINGS	CLINICAL APPLICATION
SPECIAL TESTS		
Q (quadriceps) angle	ASIS to mid-patella to tibia tubercle	Normal: 13° male, 18° female; Increased angle: PF Syndrome, subluxation
Patella grind	Extend knee: fire quads, compress patella	Pain: patellofemoral joint pathology, patella chondromalacia
Patella apprehension	Relax knee: push patella lateral	Pain/apprehension: subluxation; Medial retinaculum injury
McMurray	Flex/ER leg/vargus force, then extend knee	Pop/click on extension indicates medial meniscal tear
	Flex/IR leg/varus force, then extend knee	Pop/click on extension indicates lateral meniscal tear
Apley compression	Prone: knee 90°, compress rotate tibia	Pain/popping: meniscal injury, arthritis
Ligament Stability Tests		
Valgus stress	Lateral force: knee at: 1) 30°, 2) 0°	Laxity at: 1) 30°: MCL, at 2) 0°: MCL/PCL/posterior capsule injury
Varus stress	Medial force: knee at 1) 30° 2) 0°	Laxity at: 1) 30°: LCL, at 2) 0° LCL/PCL/posterior capsule injury
Lachman	Flex knee 30°: anterior force on tibia	Laxity/displacement: ACL injury (most sensitive exam for ACL)
Anterior drawer	Flex knee 90°: anterior force on tibia	Laxity/displacement: ACL injury
Posterior drawer	Flex knee 90°: posterior force on tibia	Posterior translation: PCL injury

Posterior sag	Supine: hip 45°/knee 90°: lateral view	Posterior translation of tibia on femur: PCL injury
Quadriceps active	Supine: flex knee 90°, fire quadriceps	Posterior translated tibia will translate anterior when quadriceps fire: PCL injury
Pivot shift	Supine: extend knee, IR, valgus force on proximal tibia, then flex	Clunk with flexion: AnteroLateral Rotary Instability (ALRI): ACL and/or posterior capsule injury
Reverse pivot shift	Supine: knee at 45°, ER, valgus force on proximal tibia, extend	Clunk with extension: PosteroLateral Rotary Instability (PLRI): PCL and/or Posterolateral corner injury
Slocum	Knee 90°, ER foot 15°, anterior force	Displacement: AnteroMedial Rotary Instability
	Knee 90°, IR foot 30°, anterior force	Displacement: AnteroLateral Rotary Instability (ALRI): ACL injury
Posterior lateral drawer	Knee 90°, ER foot 15°, posterior force	Displacement: PosteroLateral Rotary Instability (PLRI): PCL/corner
Posterior medial drawer	Knee 90°, IR foot 30°, posterior force	Displacement: PosteroMedial Rotary Instability (PMRI): PCL
Prone ER at 30° 90°	Prone: ER both knees at: 1)30°, 2)90°	Increased ER at: 1) 30: PL corner, 2) 90: PCL PL corner injury

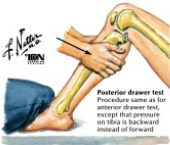


**Varus and valgus tests**  
Patient supine on table, relaxed, leg over edge of table, flexed about 30°

With one hand fixing thigh, examiner places other hand just above ankle and applies valgus stress. Degree of mobility compared with that of unoperated side, which is tested first. For varus stress test, direction of pressure reversed



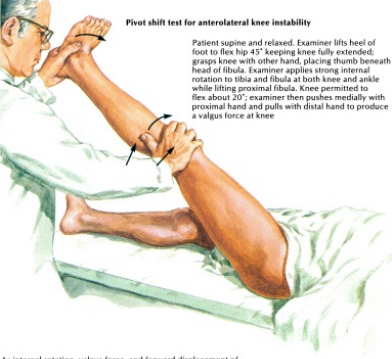
**Lachman test**  
With patient's knee bent 20° - 30°, examiner's hands grasp tibia over distal femur and proximal tibia. Tibia alternately pulled forward and pushed backward. Movement of 5 mm or more than that in normal limb indicates rupture of anterior cruciate ligament



**Posterior drawer test**  
Procedure same as for anterior drawer test, except that pressure on tibia is backward instead of forward

#### Pivot shift test for anterolateral knee instability

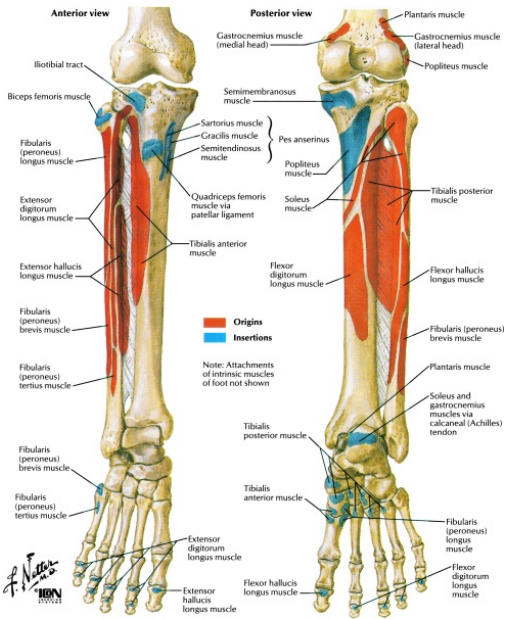
Patient supine and relaxed. Examiner lifts heel of foot to flex hip 45° keeping knee fully extended; grasps knee with other hand, placing thumb beneath head of fibula. Examiner applies strong internal rotation to tibia and fibula at both knee and ankle while lifting proximal fibula. Knee permitted to flex about 20°; examiner then pushes medially with proximal hand and pulls with distal hand to produce a valgus force at knee



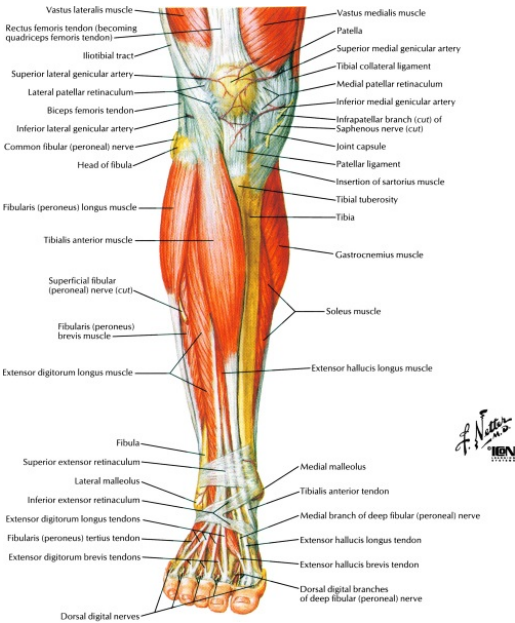
As internal rotation, valgus force, and forward displacement of lateral tibial condyle maintained, knee passively flexed. If anterior subluxation of tibia (anterolateral instability) present, sudden visible, audible, and palpable reduction occurs at about 20°-40° flexion. Test positive if anterior cruciate ligament ruptured, especially if lateral capsular ligament also torn



MUSCLES: ORIGINS AND INSERTIONS

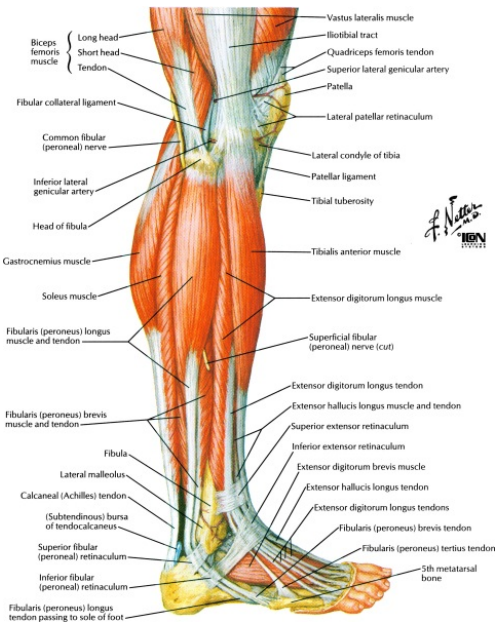


MUSCLES: ANTERIOR COMPARTMENT



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Tibialis anterior [TA]	Lateral tibia, interosseous membrane	Medial cuneiform, base of 1 <sup>st</sup> metatarsal	Deep peroneal	Dorsiflex invert foot	Test L4 motor function
Extensor hallucis longus [EHL]	Medial fibula, interosseous membrane	Base of distal phalanx of great toe	Deep peroneal	Dorsiflex extend great toe	Test L5 motor function
Extensor digitorum longus [EDL]	Lateral tibia condyle proximal fibula	Base of middle distal phalanges (4 toes)	Deep peroneal	Dorsiflex extend lateral 4 toes	Single tendon divides into four tendons
Peroneus tertius	Distal fibula, interosseous membrane	Base of 5 <sup>th</sup> metatarsal	Deep peroneal	Dorsiflex Evert foot	Often adjoined to the EDL

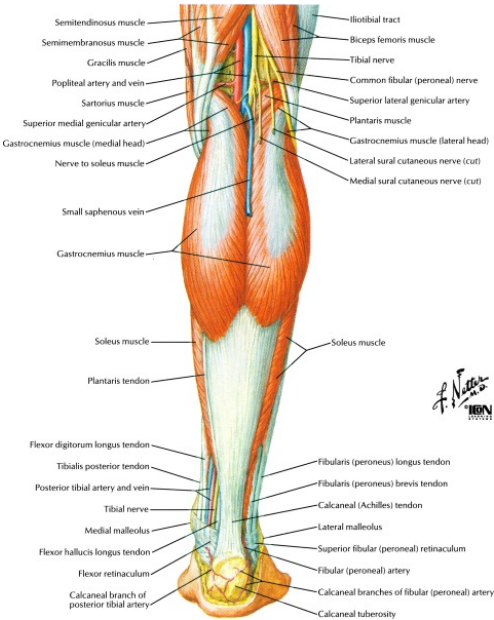
MUSCLES: LATERAL COMPARTMENT



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Peroneus longus	Proximal lateral fibula	Medial cuneiform, base of 1 <sup>st</sup> MT (plantarly)	Superficial peroneal	Evert, plantar flex foot	Test S1 motor function. Runs under the foot
Peroneus brevis	Distal lateral fibula	Base of 5 <sup>th</sup> metatarsal	Superficial peroneal	Evert foot	Can cause avulsion fx at base of 5 <sup>th</sup> MT

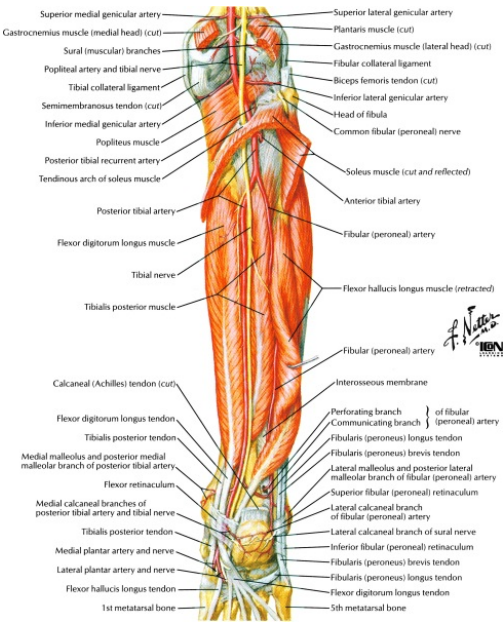


MUSCLES: SUPERFICIAL POSTERIOR COMPARTMENT



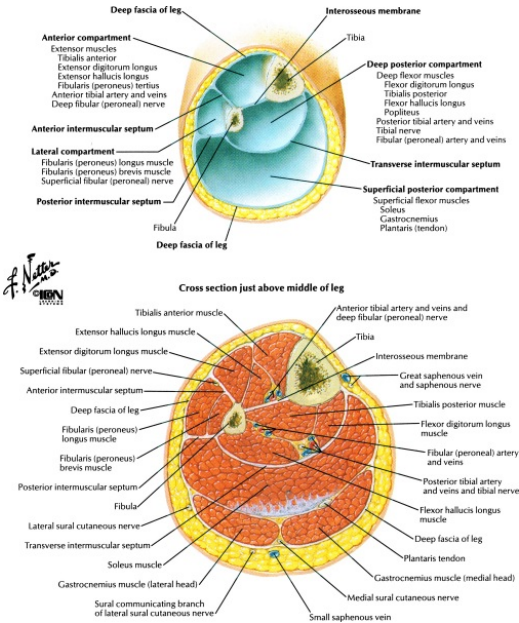
MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Gastrocnemius	Lateral and medial femoral condyles	Calcaneus (via Achilles tendon)	Tibial	Plantarflex foot	Test S1 motor function Has two heads
Soleus	Posterior fibular head/soleal line of tibia	Calcaneus (via Achilles tendon)	Tibial	Plantarflex foot	Fuses to gastrocnemius at Achilles tendon
Plantaris	Lateral femoral supracondylar line	Calcaneus	Tibial	Plantarflex foot	Short muscle belly is proximal, has a long tendon.

MUSCLES: DEEP POSTERIOR COMPARTMENT



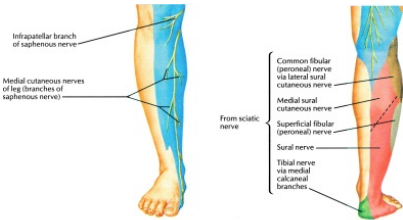
MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Popliteus	Lateral condyle	Proximal posterior tibia	Tibial	Flex ( IR) knee	Anterior distal to LCL on femur
Flexor hallucis longus [FHL]	Posterior fibula	Base of distal phalanx of great toe	Tibial	Plantarflex great toe	Test S1 motor function
Flexor digitorum longus [FDL]	Posterior tibia	Bases of distal phalanges of 4 toes	Tibial	Plantarflex lateral 4 toes	At ankle, tendon is just anterior to tibial artery.
Tibialis posterior [TP]	Posterior, interosseous membrane, tibia, fibula	Navicular tuberosity, cuneiform, MT's	Tibial	Plantarflex invert foot	Tendon can degenerate rupture: 2° pes planus

MUSCLES: CROSS SECTIONS



ANTERIOR	LATERAL	SUPERFICIAL POSTERIOR	DEEP POSTERIOR
MUSCLES			
Tibialis anterior [TA]	Peroneus longus	Gastrocnemius	Popliteus
Extensor hallucis longus [EHL]	Peroneus brevis	Soleus	Flexor hallucis longus [FHL]
Extensor digitorum longus [EDL]		Plantaris	Flexor digitorum longus [FDL]
Peroneus tertius			Tibialis posterior [TP]
NEUROVASCULAR			
Deep peroneal nerve	Superficial peroneal nerve	NONE	Tibial nerve
Anterior tibial artery and vein			Posterior tibial artery and vein
			Peroneal artery and vein

NERVES

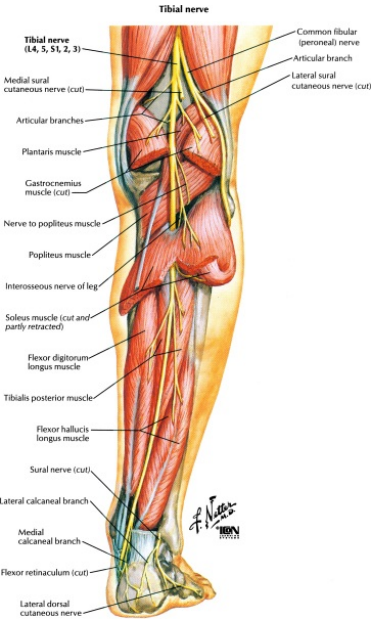


LUMBAR PLEXUS	
POSTERIOR DIVISION	
1. <b>Femoral</b> (L2-4):	
Sensory:	Medial leg: via medial cutaneous nerve ( <i>Saphenous N</i> )
Motor:	NONE (in leg)

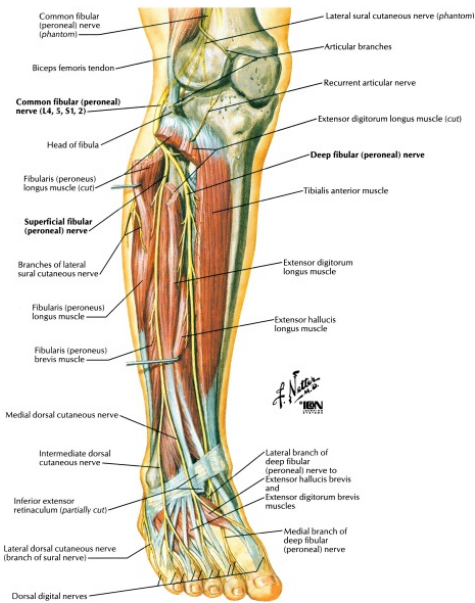
SACRAL PLEXUS	
ANTERIOR DIVISION	
2. <b>Tibial</b> (L4-S3):	descends between heads of gastrocnemius to medial malleolus
Sensory:	Posterolateral proximal calf: via Medial sural
	Posterolateral distal calf: via Sural
Motor:	<u>SUPERFICIAL POSTERIOR COMPARTMENT OF LEG</u>
	Soleus: via nerve to soleus
	Plantaris
	Gastrocnemius
	<u>DEEP POSTERIOR COMPARTMENT OF LEG</u>
	Popliteus: via nerve to popliteus
	Tibialis posterior [TP] (Tom)
	Flexor digitorum longus [FDL] (Dick)
	Flexor hallucis longus [FHL] (Harry)
POSTERIOR DIVISION	

3. **Common peroneal** (L4-S2): in groove between biceps lateral head of Gastrocnemius. Wraps around fibular head, deep to peroneus longus, then divides. Can be injured in lateral approach to the knee.

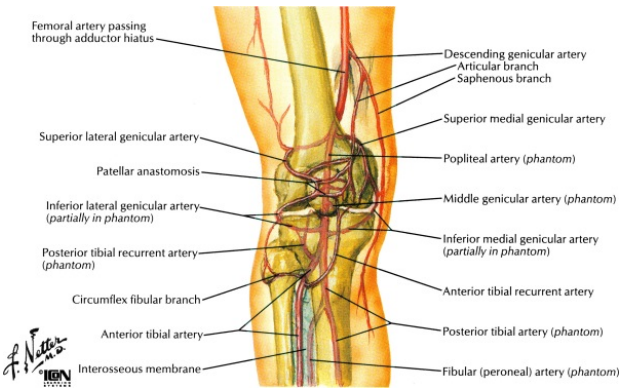
Sensory:	Proximal lateral leg: via Lateral sural
	Distal lateral leg: via superficial peroneal
Motor:	<u>ANTERIOR COMPARTMENT of LEG:</u>
	<b><u>Deep Peroneal Nerve</u></b>
	Tibialis anterior [TA]
	Extensor hallucis longus [EHL]
	Extensor digitorum longus [EDL]
	Peroneus tertius
	<u>LATERAL COMPARTMENT of LEG:</u>
	<b><u>Superficial Peroneal Nerve</u></b>
	Peroneus longus
	Peroneus brevis



# Common Peroneal Nerve



ARTERIES

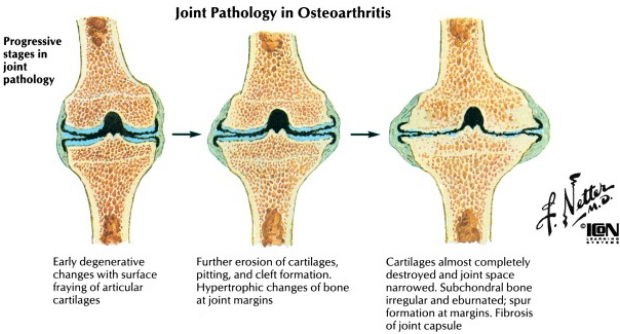


COURSE	BRANCHES	SUPPLY/COMMENT
POPLITEAL		
Through popliteal fossa. Terminates at the popliteus muscle.	Superior Inferior Medial Geniculate	All four arteries anastomose around knee patella (supply meniscus)
	Superior Inferior Lateral Geniculate	
	Middle Geniculate	Cruciate ligaments synovium
	Anterior Posterior Tibial	Terminal branches
	ANTERIOR TIBIAL	
Through 2 heads of Tibialis Posterior interosseous membrane. Then lies on anterior surface of the membrane with deep peroneal nerve, between TA and EHL.	Supplies muscles of the ANTERIOR COMPARTMENT	
	Anterior Tibial recurrent	Supplies knee
	Anterior Medial malleolar	Supplies ankle
	Anterior Lateral malleolar	Supplies ankle
	Dorsalis Pedis	Terminal branch in foot
From popliteal, through posterior compartment with tibial nerve to behind medial malleolus (between FDL FHL).	POSTERIOR TIBIAL	
	Supplies muscles of the POSTERIOR COMPARTMENT	
	Posterior Tibial recurrent	Supplies the knee
	Peroneal artery	LATERAL COMPARTMENT
	Posterior medial	

	malleolar	
	Perforating/muscular branches	
	<i>Medial calcaneal</i>	
	<i>Medial Lateral plantar</i>	Terminal branches in sole
	<b>PERONEAL</b>	
	Supplies muscles of the LATERAL COMPARTMENT	
From posterior tibial between tibialis posterior and FHL.	Posterior lateral malleolar	Terminal branch
	<i>Lateral calcaneal Artery</i>	



DISORDERS



DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
ANTERIOR FAT PAD SYNDROME (Hoffa disease)			
• Fat pad (under patellar tendon) is pinched (2° to trauma)	Hx: Intermittent anterior knee pain	XR: AP/Lateral: possible patella baja	1. RICE, activity modification
	PE: +/- click with motion		2. Surgical excision (rare)
ARTHRITIS: INFLAMMATORY			
• Synovitis (pannus formation) destroys articular cartilage and joint	Hx: Any age (disorder dependent), female male, multiple joints, AM pain.	XR: Arthritis series	1. Early: medical management
• RA, Gout, SeroNegative arthropathy	PE: +/- warm, effusion, crepitus	Labs: RF, ESR, CRP, ANA, CBC, crystals, culture	Late: a) Conservative: like OA 2. Operative: b) 1. Synovectomy 2. Total knee
ARTHRITIS: OSTEOARTHRITIS			
• Primary or posttraumatic	Hx: Elderly, pain (worse with activity or weight bearing), stiffness, sticking/grinding.	XR: Arthritis series	1. NSAIDs, Physical Therapy
• Loss or damage to articular cartilage	PE: Effusion, jointline tenderness, +/- angular deformity (varus #1) or contracture.	1. joint space narrowing	2. Injection, activity modification (cane)
• Knee (Medial compartment) #1 site		2. osteophytes	3. Fusion (young/worker)
• All 3 compartments are possible		3. subchondral sclerosis	4. High tibial osteotomy (young, 1 compartment disease)

sites			
		4. bony cysts	5. Total Knee Arthroplasty (old, 1 compartment)

**BAKER'S CYST**

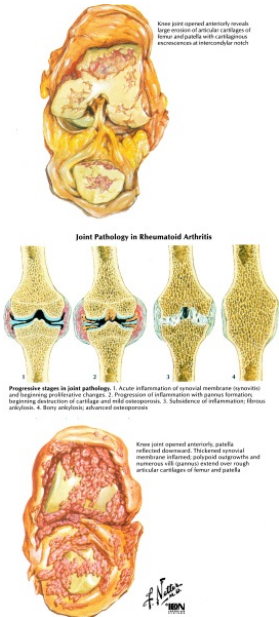
<ul style="list-style-type: none"> <li>Posterior knee (popliteal fossal)</li> </ul>	Hx: Stiffness, +/- knee tenderness	XR: AP/lateral: normal	1. Aspiration initially
<ul style="list-style-type: none"> <li>Arises from MM or hamstring tendon (may communicate)</li> </ul>	PE: Mass in popliteal fossa	MR or aspiration: confirm diagnosis	2. Surgical resection for recurrence or pain

**BURSITIS: PREPATELLAR (Housemaid's knee)**

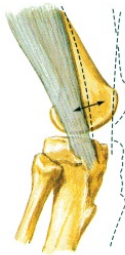
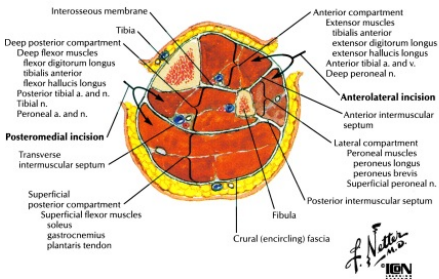
<ul style="list-style-type: none"> <li>Continuous irritation of bursa leads to inflammation</li> </ul>	Hx: Pain with activity	XR: AP/lateral: normal rule out infection (common problem)	1. NSAID, knee pads, injection
<ul style="list-style-type: none"> <li>Most common bursitis in knee</li> </ul>	PE: "egg" shaped swelling over patella		2. Bursal removal (rare)
			3. Treat infection if present

**BURSITIS: PES ANSERINE**

<ul style="list-style-type: none"> <li>Bursa under tendon insertion inflamed (overuse, runner, etc.)</li> </ul>	Hx: Pain in medial knee	XR: AP/lateral: normal+/- OA, rule out tumor	1. NSAID, activity modification, stretch
	PE: Pes anserine tenderness		2. Partial excision (rare)



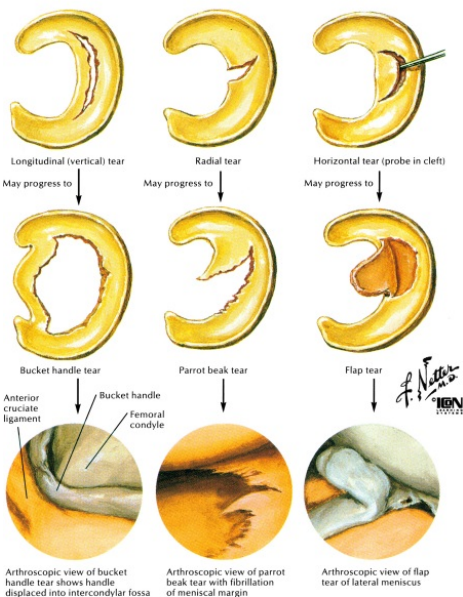
## Incisions for Compartment Syndrome of Leg



**Iliotibial Tract Friction Syndrome**  
As knee flexes and extends, iliotibial tract glides back and forth over lateral femoral epicondyle, causing friction

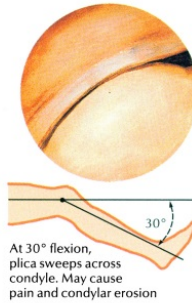
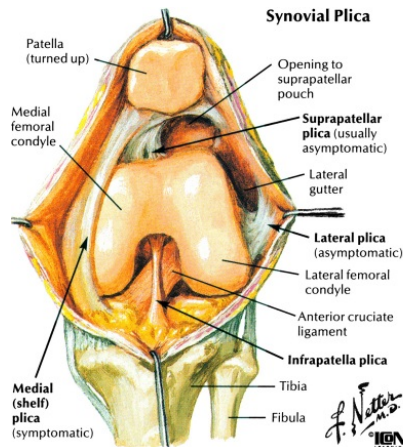
DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
<b>CHONDROMALACIA: PATELLOFEMORAL SYNDROME [PFS]</b>			
• Damage or softening of the patellar articular cartilage.	Hx: Anterior knee pain, worse with sitting (theater sign), and/or stairs	XR: AP/lateral/sunrise to evaluate alignment. Rule out patellofemoral OA	1. Physical therapy: quadricep strengthening stretching
• Multiple etiologies: trauma, dislocation, malalignment leads to patellofemoral OA	PE: +/- VMO atrophy, valgus deformity, high Q angle, patellar apprehension, + crepitus		2. Orthosis if patella subluxes
			3. Lateral release (early)
			4. Tibial tuberosity realignment
<b>COMPARTMENT SYNDROME</b>			
• Increased pressure in closed space	Hx: 5 P's: pain, paresthasias, pulseless, pallor, paralysis.	Compartment pressures: 40 mmHg (normal: 0-10 mmHg)	1. Fasciotomy within 4 hours (Usually two incisions)
• From: trauma, (e.g. fracture, burn, vascular injury, overexertion)	PE: Firm compartments (check all three)		2. Debride nonviable soft tissue.
• Results in nerve injuries soft tissue necrosis			
<b>ILIOTIBIAL BAND FRICTION SYNDROME</b>			
• ITB rubs on lateral femoral condyle	Hx: Pain with activity	XR: AP/lateral: normal Rule out tumor	1. NSAID, activity modification, stretching
• Common in runners, cyclists	PE: Lateral femoral condyle TTP (knee at 30° flexion)		2. Partial excision (rare)

# Tears of Meniscus



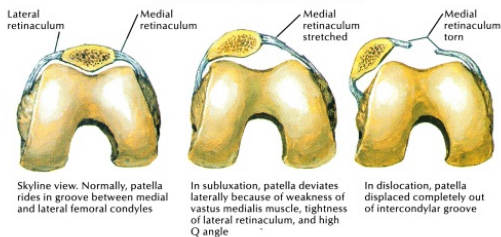
DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
<b>MENISCUS INJURY: TEAR</b>			
• Young: trauma/twisting injury	Hx: Pain, catching/locking (esp. bucket-handle tears)	XR: AP (extension 30° flexion)/lateral/sunrise, +/- arthrocentesis	1. Conservative for minor symptoms
• Old: Degeneration/squat injury	PE: Effusion, jointline tenderness, + McMurray test		2. Debride (inner 2/3 lesion)
• Seen with ACL injuries			3. Repair (outer 1/3 or longitudinal lesion)
• Medial lateral (cysts develop)			Improved results with ACL repair
<b>OSTEOCHONDritis DISSECANS</b>			
• Subchondral bone injury	Hx: Insidious onset knee pain	XR: AP/lateral: shows radiolucency, +/- fragment or loose body	1. Often spontaneously heals in children
• Unknown etiology: AVN, repetitive microtrauma	PE: Crepitus on flexion extension, femoral condyle tender to palpation		2. Adults: drill lesion vs. bone graft/chondroplasty
• Lateral aspect of medial femoral condyle #1			

## Synovial Plica



DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
<b>PLICA</b>			
• Synovial tissue (embryonic remnant) thickens rubs medial femoral condyle.	Hx: Anteromedial knee pain, catching/popping	XR: AP/lateral Arthrography	1. NSAIDs
• Medial patellar plica: #1	PE: Palpable plica, jointline tenderness		2. Activity modification
			3. Arthroscopic debridement
<b>PATELLAR COMPRESSION SYNDROME</b>			
• Compression of patella due to tight lateral retinaculum	Hx: Anterior knee pain	XR: AP/lateral: normal	1. Quadriceps strengthening
	PE: Lateral patella (facet) tender to palpation		2. Lateral release of retinaculum
<b>PATELLAR INSTABILITY</b>			
• Spectrum: malalignment-recurrent subluxation-instability-dislocation	Hx: Knee buckles, +/- pain	XR: AP/lateral/sunrise: Lateral displacement of the patella. +/- patella alta	1. PT: VMO strengthening
• Usually lateral, leads to OA	PE: +/- genu valgum, increased Q angle, VMO atrophy, + patellar apprehension		2. Orthosis for subluxation
			3. Lateral release, realignment procedures (especially for MMS)
Miserable Malalignment Syndrome (MMS): associated with femoral anteversion, increased Q angle, genu valgum			

### Subluxation and Dislocation of Patella



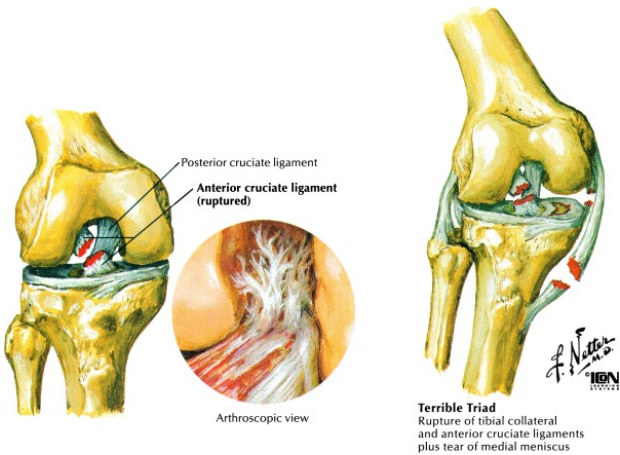
**Patellar tendon rupture**  
Rupture of patellar ligament at inferior margin of patella



**Quadriceps tendon rupture**  
Rupture of quadriceps femoris tendon at superior margin of patella

DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
<b>PATELLAR TENDINITIS: JUMPER'S KNEE</b>			
• Seen in jumpers (e.g. basketball volleyball players)	Hx: Sports, anterior knee pain	XR: AP/lateral: normal	1. NSAIDs, strengthen quadriceps [no steroid injection-tendon rupture]
	PE: Patella: inferior pole tender to palpation	MR: Increased signal in inferior pole	2. Debride tendon (rare)
<b>PATELLAR TENDON (LIGAMENT) RUPTURE</b>			
• Direct trauma (also systemic/metabolic disorders)	Hx: Young, history of trauma	XR: AP/lateral: relative patella alta	Primary surgical repair
• Quadriceps patella tendon rupture	PE: Decreased or no active extension, + palpable defect		
<b>QUADRICEPS TENDON RUPTURE</b>			
• Result of minor trauma	Hx: Older, cannot actively extend knee	XR: AP/lateral: relative patella baja	Primary surgical repair
• Metabolic disorders weaken tendon	PE: Palpable defect or sulcus		
<b>TUMORS</b>			
#1 in Adolescents: Osteosarcoma; #1 in Adults: Chondrosarcoma; #1 benign (young adult): Giant cell			

DISORDERS: LIGAMENT INJURIES



DESCRIPTION	H P	WORK-UP/FINDINGS	TREATMENT
ANTERIOR CRUCIATE (ACL)			
• Twisting injury, often no contact	Hx: "Popping," swelling	XR: AP/lateral/sunrise: +/- capsular avulsion	1. Closed chain exercises
• Associated with MCL meniscus tear (all 3 = Terrible Triad)	PE: Effusion. + Lachman, anterior drawer and pivot shifts tests (Lachman most sensitive)	Arthrocentesis (+/-): 70% have hemarthrosis	2. Reconstruction needed (usually after several weeks of rehabilitation)
• Second fracture: avulsion fx		MR: confirms diagnosis	
POSTERIOR CRUCIATE (PCL)			
• Anterior force on flexed knee (e.g. dashboard)	Hx: Pain, unable to ambulate	XR: AP/lat/sunrise: +/- avulsion fracture	1. Non-operative: crutches
• Also with other ligament njuries	PE: + posterior drawer, posterior sag, quad active tests	MR: confirms diagnosis	2. Quadriceps strengthening (Complication: OA)
MEDIAL COLLATERAL (MCL)			
• Valgus force (football clip)	Hx: Medial knee pain	XR: AP/lateral: possibly an avulsion.	1. Hinged knee brace
• Graded 1, 2 (partial), 3 (complete)	PE: Laxity and/or pain with valgus stress (at 30° flexion)		2. Physical therapy: early ROM strengthening
LATERAL COLLATERAL (LCL)			
• Varus force (isolated, rare)	Hx: Trauma. Pain swelling	XR: AP/lateral: possibly an avulsion.	1. Nonoperative: see MCL
• Associated with other ligament and peroneal nerve injuries	PE: Laxity pain with varus stress (at 30°). Test for foot drop		2. Surgical for grade III (usually combination injury)

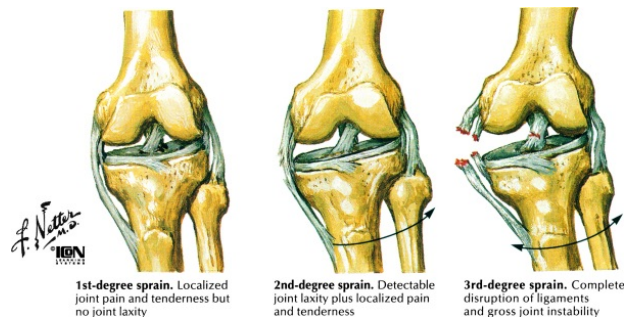
Isolated PCL, MCL, and LCL injuries are primarily treated non-operatively; operative repair is

used when these injuries occur in combination.

POSTEROLATERAL CORNER COMPLEX (PLC)			
• Often with PCL injury	Hx: Pain, instability	XR: AP/lateral	Early surgical repair
• LCL torn	PE: Increased ER at 30° flexion, + posterolateral drawer test		
• Popliteofibular ligament torn			



## DISORDERS



TOTAL KNEE ARTHROPLASTY

KEYS TO TOTAL KNEES

GENERAL INFORMATION

- Implants: unlike hip, all are cemented (to reduce complications with loosening)
- Cement: Polymethylmethacralate
- Femoral condylar and tibia components are metallic
  - Tibial component surface plate: Polyethylene

INDICATIONS

End stage DJD: results in disabling pain in knee secondary to arthritis in 2 + compartments (medial lateral patellofemoral).

- Common etiologies: OA, RA, AVN
- Most patients complain of PAIN, worsening over time (wakes them from sleep), and decreased ability to ambulate

Patient should have appropriate radiographic evidence of arthritis

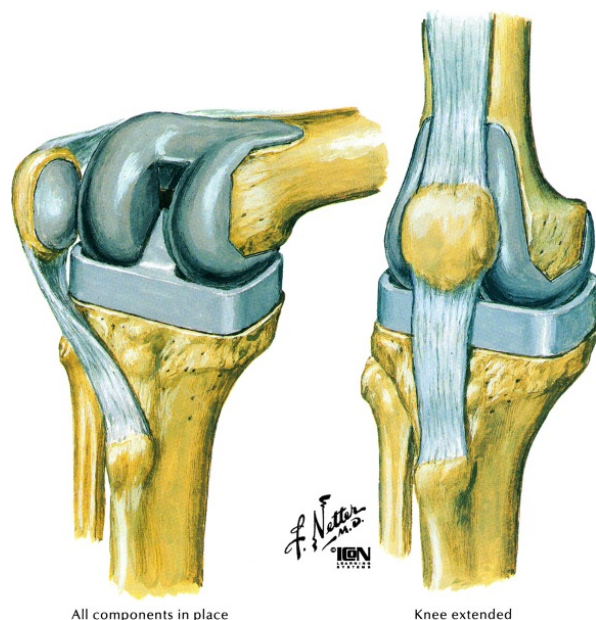
OSTEOARTHRITIS	RHEUMATOID ARTHRITIS
1. Joint space narrowing	1. Joint space narrowing
2. Sclerosis	2. Periarticular osteoporosis
3. Subchondral cysts	3. Joint erosions
4. Osteophyte formation	4. Ankylosis

- It is preferable that the patient is elderly (needs only one replacement)
- Failed conservative treatment: activity modification, weight loss, orthosis, physical therapy/strengthening, NSAIDs, ambulation assistance (cane, walker, etc.), injections.

CONTRAINDICATIONS

- Young, active patient (will wear out replacement many times)
- Knee extensor mechanism dysfunction
- Medically unstable (e.g. severe cardiopulmonary disease)
- Neuropathic joint
- Any infection

## TOTAL KNEE ARTHROPLASTY



### KEYS TO TOTAL KNEES

#### ALTERNATIVES

- Considerations: Age, activity level, overall health
- Osteotomy: for unicompartmental disease, young, active (not in elderly patients)
  - Medial compartment (varus deformity): high tibial osteotomy
  - Lateral compartment (valgus deformity): distal femoral osteotomy
- Arthrodesis/Fusion: totally destroyed, neuropathic, or septic joint
- Unicompartment arthroplasty: for unicompartment disease. Only in selected patients not eligible for osteotomy.

#### PROCEDURE

- Medial parapatellar approach used (lateral parapatellar for severe valgus deformity)
- ACL is sacrificed
- Using specialized guides, the distal femur and proximal tibia are removed and replaced with metallic/plastic components.
- Underside of patella also replaced.
- Flexion and extension gap should be equal

#### COMPLICATIONS

- Infection: often leads to removal of prosthesis (Staph #1)
- Loosening of components
- Patellofemoral joint pain

- Decreased ROM (usually from inadequate postoperative physical therapy)
- Patella fracture
- Superolateral geniculate artery is at risk
- Fat embolism
- Peroneal nerve palsy
- Deep Venous Thrombosis (DVT)/Pulmonary emboli: patients should be anticoagulated (Heparin/warfarin) postoperatively

PEDIATRIC DISORDERS

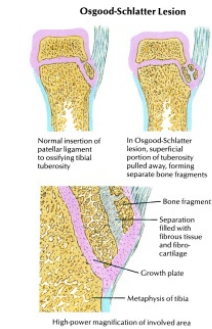
Bow Leg and Knock-knee



Two brothers, younger (left) with bowleg, older (right) with knock-knee. In both children, limbs eventually became normally aligned without corrective treatment

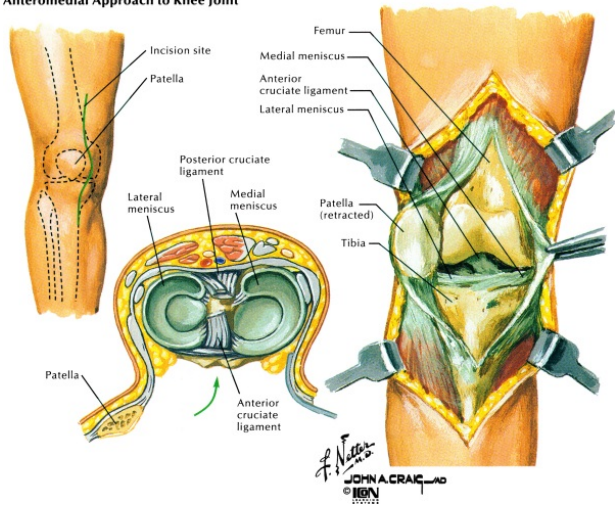
DESCRIPTION	EVALUATION	TREATMENT/COMPLICATIONS
GENU VARUM: BOW LEGS		
• Normal: neonate to 2 yrs old	Hx: Parents observe deformity	1. Most resolve spontaneously with normal development
• Etiology:	PE: Measure tibiofemoral angle	2. Night bracing rarely required
1. Blount's disease	XR: Only large deformity or if concerned about dysplasia.	3. Osteotomy if persistent (15°)
2. Rickets (nutritional)		
3. Skeletal dysplasia		
4. Trauma		
GENU VALGUM: KNOCK KNEES		
• Normal for 2 yrs to 4 yrs	Hx: Parents observe deformity	1. Most resolve spontaneously with normal development
• Adult: 5-10° valgus is normal	PE: Measure tibiofemoral angle	2. Surgery if persists past age 10
• Etiology:	XR: Only large deformity or if concerned about dysplasia.	
1. Rickets (renal)		
2. Skeletal dysplasia		
3. Trauma		
OSGOOD SCHLATTER DISEASE		
• Osteochondritis/traction apophysitis of tibial tubercle (at 2° ossification center)	Hx: Early adolescent. Knee pain worse after activity	1. Activity restriction/modification

<ul style="list-style-type: none"> <li>From repetitive extensor (quadriceps) pull on tubercle</li> </ul>	PE: Pain, swelling at tubercle	2. Most resolve with fusion of apophysis in midadolescence
	XR: Knee AP/lateral: may show heterotopic ossification	
	TIBIAL TORSION	
<ul style="list-style-type: none"> <li>Congenital IR of tibia (associated with intrauterine position)</li> </ul>	Hx: 1-2 yo, often tripping, no pain	Will resolve spontaneously (between 24-48 months)
<ul style="list-style-type: none"> <li>Often bilateral</li> </ul>	PE: Negative foot to thigh angle (normal 10-30°), with knee/patella pointed forward, intoeing gait observed	



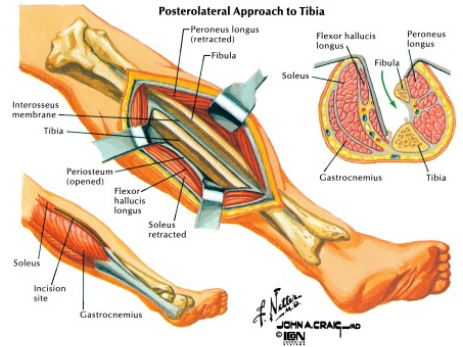
SURGICAL APPROACHES

Anteromedial Approach to Knee Joint



USES	INTERNEUROUS PLANE	DANGERS	COMMENT
KNEE: MEDIAL PARAPATELLAR APPROACH			
1. Ligament reconstruction	No planes: Capsule is under skin	1. Infrapatellar branch of Saphenous Nerve	1. Most commonly used approach
2. Total knee arthroplasty			2. Most/best exposure
3. Meniscectomy			3. Neuroma may develop from cutaneous nerves
LEG/TIBIA: POSTEROLATERAL APPROACH (Harmon)			
1. Fractures	1. Gastrocnemius/soleus/FHL [Tibial]	1. Lesser saphenous vein	1. A technically difficult approach
2. Nonunions	2. Peroneus longus/brevis [Superficial peroneal]	2. Posterior tibial artery	2. Bone grafting of nonunion
ARTHROSCOPY PORTALS			
1. Anteromedial	Just above joint line, 1 cm inferior to patella 1 cm medial to patellar ligament	Anterior horn of medial meniscus	Used to view lateral compartment
2. Anterolateral	Just above joint line, 1 cm inferior to patella 1 cm lateral to patellar ligament	Anterior horn of lateral meniscus	1. Used to view medial compartment, ACL, and menisci 2. PCL posterior structures hard to see
3. Posterolateral	2.5 cm above joint line, lateral to quadriceps tendon		Used to view patellofemoral articulation, patella tracking,

Superolateral	lateral to quadriceps tendon	etc.
4. Posteromedial	Flex knee to 90°, 1 cm posterior to femoral condyle	Used to view PCL, posterior horns of menisci



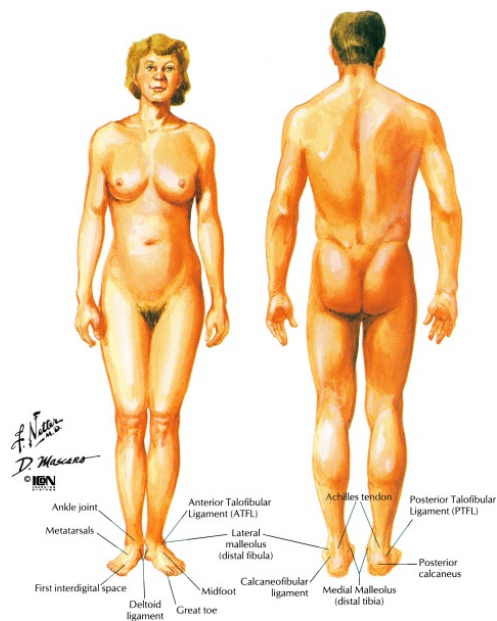


## CHAPTER 9 - FOOT/ANKLE

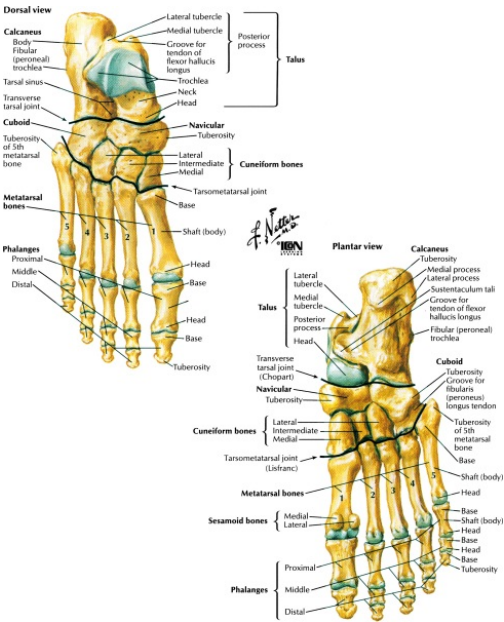
- [TOPOGRAPHIC ANATOMY](#)
- [OSTEOLOGY](#)
- [TRAUMA](#)
- [ANKLE JOINTS](#)
- [FOOT JOINTS](#)
- [OTHER STRUCTURES](#)
- [MINOR PROCEDURES](#)
- [HISTORY OF THE FOOT/ANKLE](#)
- [PHYSICAL EXAM](#)
- [MUSCLES: DORSUM](#)
- [MUSCLES: FIRST PLANTAR LAYER](#)
- [MUSCLES: SECOND PLANTAR LAYER](#)
- [MUSCLES: THIRD PLANTAR LAYER](#)
- [MUSCLES: FOURTH PLANTAR LAYER](#)
- [NERVES](#)
- [ARTERIES](#)
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## CHAPTER 9 – FOOT/ANKLE

### TOPOGRAPHIC ANATOMY

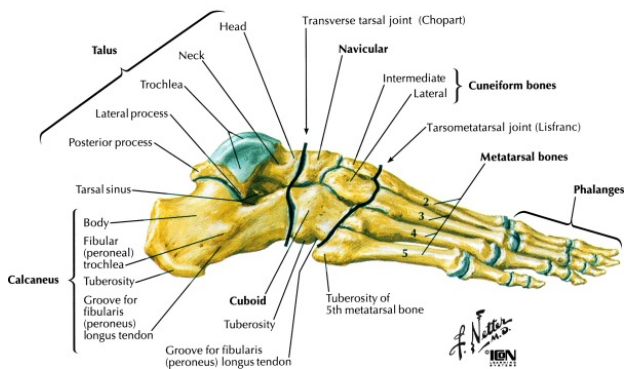


OSTEOLOGY

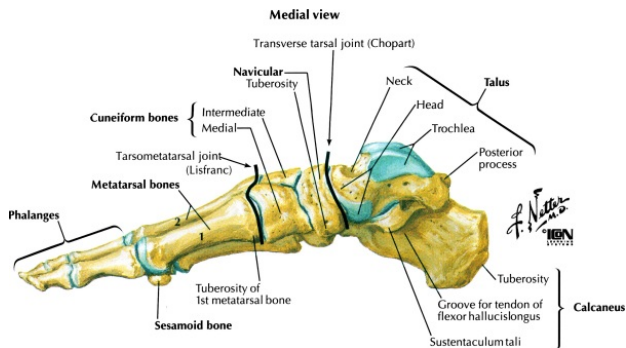


CHARACTERISTICS	OSSIFY	FUSE	COMMENT
See leg chapter for Tibia and Fibula			
TALUS			
<ul style="list-style-type: none"><li>• Head (anterior-navicular)</li><li>• Neck:</li><li>• Body/trochlea:</li><li>• in ankle mortise</li><li>• Lateral process</li><li>• Posterior process:</li><li>• medial lateral tubercles</li></ul>	Primary: Body	7mo. (fetal)  13-15 years	<ul style="list-style-type: none"><li>• Talus is only tarsal bone to articulate with tibia and fibula. No muscular attachments.</li><li>• AVN a concern due to retrograde blood supply from branches of posterior tibial dorsalis pedis arteries</li><li>• Weight from tibia is transmitted through the trochlea</li><li>• FHL runs between medial lateral tubercle of posterior process</li><li>• Unfused lateral tubercle: Os trigonum, not a fracture</li></ul>

Lateral view



CHARACTERISTICS	OSSIFY	FUSE	COMMENT
CALCANEUS			
<ul style="list-style-type: none"> <li>Multiple facets: posterior largest</li> <li>Sustentaculum tali: has the middle facet; supports talar neck</li> </ul>	Primary: Body Secondary: Tubercle	6 mo. (fetal) 13-15 years	<ul style="list-style-type: none"> <li>Largest tarsal bone; posterior support for longitudinal arch</li> <li>FHL runs under sustentaculum tali; spring ligament attaches to it</li> <li>Painful spurs can develop on tuberosity</li> </ul>
NAVICULAR			
<ul style="list-style-type: none"> <li>"Boat-shaped"</li> <li>Tuberosity (medial)</li> </ul>	Primary:	4 years	13-15 years <ul style="list-style-type: none"> <li>Tibialis posterior inserts on to the tuberosity</li> <li>Articulates with talus, cuneiforms, cuboid</li> <li>Shape of tarsals create transverse arch</li> </ul>
CUNEIFORMS			
<ul style="list-style-type: none"> <li>Three bones</li> <li>Medial: largest</li> <li>Intermediate: shorter than others</li> <li>Lateral</li> </ul>	Primary:	3 years 4 years 1 year	13-15 years <ul style="list-style-type: none"> <li>2nd MT is in "recess" of short intermediate bone; can lead to fracture of it's base, unstable TMT joint.</li> <li>Peroneus longus partially inserts on plantar aspect of med. cuneiform</li> </ul>



CHARACTERISTICS	OSSIFY	FUSE	COMMENT
<b>CUBOID</b>			
<ul style="list-style-type: none"> <li>Tuberosity inferiorly</li> <li>Cuboid groove inferiorly</li> </ul>	Primary:	Birth	13-15 yrs <ul style="list-style-type: none"> <li>Most lateral tarsal bone</li> <li>Peroneus longus tendon passes through groove on inferior surface</li> </ul>
<b>METATARSALS</b>			
<ul style="list-style-type: none"> <li>Long bone characteristics</li> <li>Base of 2nd MT in tarsal "recess"</li> <li>Anterior support of longitudinal arch of the foot</li> </ul>	Primary: Shaft Secondary: Epiphysis	9 wks (fetal) 5-8 yrs	Birth <ul style="list-style-type: none"> <li>Numbered medial to lateral: I to V.</li> <li>Only one epiphysis per bone: in the head except for the 1st MT [in the base]</li> <li>Peroneus brevis inserts on base of 5th MT (avulsion can occur)</li> </ul>
<b>PHALANGES</b>			
<ul style="list-style-type: none"> <li>Great toe has only two phalanges</li> </ul>	Primary: Body	10 wks (fetal)	14-18 <ul style="list-style-type: none"> <li>14 total phalanges in each foot</li> <li>Only one epiphysis per bone: in the</li> </ul>

- Great toe has two sesamoid bones

Secondary: Epiphysis

2-3 yrs

years

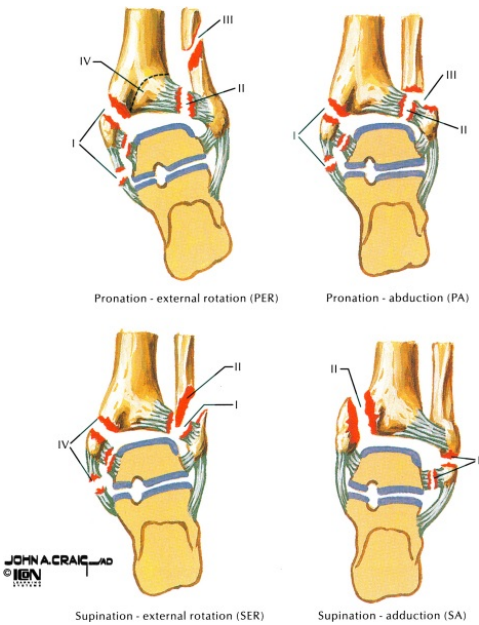
- base Sesamoid bones with other toes can occur as a normal variant

Ossification of each tarsal bone occurs from a single center

Borders of ankle mortise: Superior: tibia (plafond), medial: medial malleolus (tibia), lateral: lateral malleolus (fibula)

Tarsal Tunnel: A fibroosseous tunnel formed by the posterior medial malleolus, medial walls of calcaneus and talus, and flexor retinaculum. Contents: Tendons (TP, FDL, FHL), Posterior Tibial artery, Tibial nerve (can be compressed in tunnel)

TRAUMA



JOHN A. CRAIG, MD  
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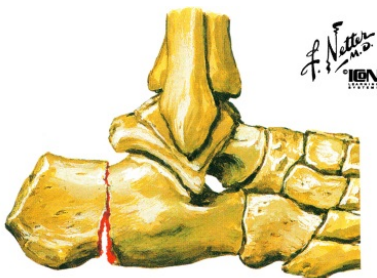
Lauge-Hansen Classification of Ankle Fractures

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
ANKLE FRACTURE			
(see Knee Trauma table for Maisonneuve fracture)			
<ul style="list-style-type: none"><li>Very common in all ages</li><li>Malleoli and/or talar dome are involved</li><li>1 malleolus fx: stable;</li><li>2 malleoli and/or ligaments injured: unstable</li><li>Perfect symmetrical mortise reduction required</li><li>Also must correct fibular length</li></ul>	<p>HX: Trauma. Pain, swelling</p> <p>PE: Effusion, intense tenderness at 1 or both malleoli +/- proximal fibula. Check posterior tibial pulse and tibial nerve function</p> <p>XR: Ankle trauma seriesCT: Good for intraarticularfractures needing repair</p>	<p>Lauge-Hansen – 4 types with subdivided stages</p> <p>SA:</p> <ul style="list-style-type: none"><li>supination/adduction stage I, II</li></ul> <p>SER:</p> <ul style="list-style-type: none"><li>supination/external rotation: stages I-IV</li></ul> <p>PA:</p> <ul style="list-style-type: none"><li>pronation/abduction stages I, II, III</li></ul> <p>PER:</p> <ul style="list-style-type: none"><li>pronation/external rotation: stages I-IV</li></ul>	<p>Dislocation: immediately reduce</p> <p>Stable/nondisplaced: short leg cast 4-6 weeks</p> <p>Unstable/displaced: ORIF, repair articular surface fibular length, +/- need for syndesmosis screw</p>

COMPLICATIONS: Post-traumatic osteoarthritis/pain; Decreased motion and/or strength; Instability; Nonunion/malunion; RSD

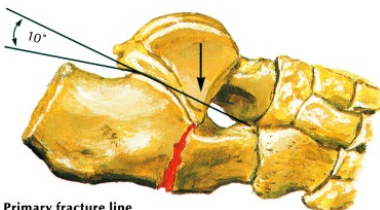


Fracture of sustentaculum tali



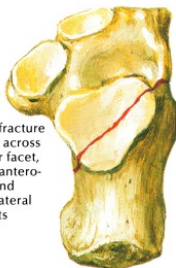
Fracture of body of calcaneus with no involvement of subtalar articulation

#### Extraarticular Fracture of Calcaneus



**Primary fracture line**  
Talus driven down into calcaneus, usually by fall and landing on heel. Böhler angle narrowed

Primary fracture line runs across posterior facet, forming antero-medial and posterolateral fragments



#### Intraarticular Fracture of Calcaneus

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
CALCANEUS FRACTURE			
<ul style="list-style-type: none"> <li>Most common tarsal fracture</li> <li>Mechanism: large axial load (e.g. high fall or jump)</li> <li>Must rule out spine injury</li> <li>Subtalar joint affected</li> <li>Most fractures are intraarticular (worse prognosis)</li> </ul>	<p>HX: Trauma. Cannot bear weight, pain, swelling. PE: Tender to palpation. Check Tibial nerve function, pulses arch swelling. XR: AP/lateral (+/- Harris) and spine films CT: Needed to better define fx</p>	<p>Extraarticular: Body Tuberosity Anterior/medial process Intraarticular: Nondisplaced Tongue-type Joint depression Comminuted</p>	<p>Extraarticular: Cast. ORIF if unstable Displaced/intraarticular: ORIF: plates and screws +/- bone graft Severely comminuted: Closed treatment.</p>

COMPLICATIONS: Osteoarthritis: subtalar; Decreased motion; Malunion/nonunion; Compartment syndrome; Sural nerve injury

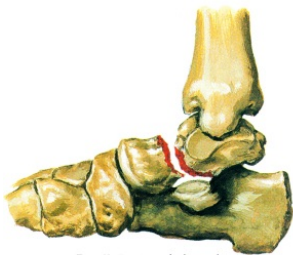


# Fracture of talar neck

Usual cause is impact on anterior margin of tibia due to forceful dorsiflexion



**Type I.** No displacement



**Type II.** Fracture of talar neck with subluxation or dislocation of subtalar joints

*F. Netter M.D.*  
NEW

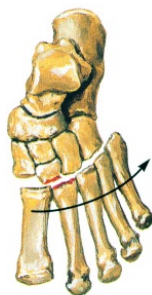


**Type III.** Fracture of talar neck with dislocation of subtalar and tibiotalar joints

## Fracture of Talar Neck

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
TALUS FRACTURE			
<ul style="list-style-type: none"> <li>MVA, fall from height</li> <li>Neck most common site, head body rare</li> <li>Tenuous blood supply adds complications</li> <li>Semi-emergent injury</li> <li>Hawkins sign (on XR)</li> <li>resorption of subchondral bone indicates healing (no AVN)</li> </ul>	<p>HX: Trauma. Cannot bear weight, pain, swelling.</p> <p>PE: Tender to palpation. Check Tibial nerve function, pulses, arch swelling</p> <p>XR: AP/lateral (+/- Canale)</p> <p>CT: usually not needed</p>	<p>Hawkins types [neck] predicts osteonecrosis:</p> <p>I. Nondisplaced</p> <p>II. Displaced; subtalar subluxation/dislocation</p> <p>III. Displaced; talar body dislocation</p> <p>IV. Talar head (+/- body) dislocation</p>	<p>Type I: Cast 2 months. Many prefer ORIF to reduce risk of displacement</p> <p>Type II, III, IV: ORIF emergently to avoid necrosis +/- bonegraft</p> <p>Early ROM</p>

COMPLICATIONS: Osteoarthritis: ankle and subtalar joints; Osteonecrosis of body (incidence decreased with ORIF); Delayed union/nonunion



*F. Netter M.D.*  
H&N



**Homolateral dislocation.**  
All five metatarsals displaced in same direction. Fracture of base of 2nd metatarsal

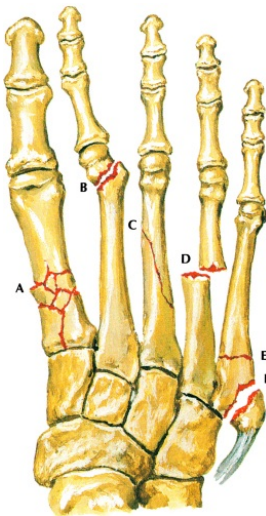
**Isolated dislocation.** One or two metatarsals displaced; others in normal position

**Divergent dislocation.** 1st metatarsal displaced medially, others superolaterally

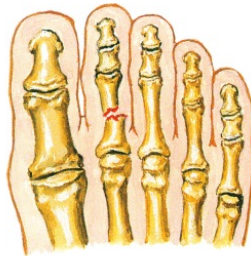
Injury to Tarsometatarsal (Lisfranc) Joint Complex

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
MIDFOOT FRACTURES			
<ul style="list-style-type: none"> <li>Involves tarsal bones</li> <li>Usually high energy</li> <li>Midtarsal joint injuries result from fractures of adjacent bones.</li> <li>Cuneiform cuboid fractures are rare</li> <li>2nd MT in tarsal recess: fracture of its base destabilizes TMT joint, dislocation may result.</li> </ul>	<p>HX: Trauma. Dorsal pain. PE: Swelling, severe pain at Midtarsal or TMT joint increases with midfoot motion. XR: AP/lateral/oblique, +/- foot stress film Med. 2nd MT and middle cuneiform should align CT/MR: if unsure of fracture</p>	<p>Midtarsal: Navicular fracture Avulsion Tuberosity Body Cuboid fracture Cuneiform fracture Tarsometatarsal - Lisfranc Fracture (2nd MT) dislocation Homolateral, Isolated, Divergent</p>	<p>Midtarsal: Nondisplaced: cast. Other: ORIF Navicular: Reduce, +/- PCP. Many require ORIF Lisfranc injury: Close reduce fracture and/or dislocation (+/- PCP). ORIF: if displaced or irreducible-most</p>

COMPLICATIONS: Neurovascular injury: Dorsalis pedis artery; Compartment syndrome; Decreased motion; Post-traumatic osteoarthritis or chronic pain.



**Types of fractures of metatarsal:** A. Comminuted fracture. B. Displaced neck fracture. C. Oblique fracture. D. Displaced transverse fracture. E. Fracture of base of 5th metatarsal. F. Avulsion of tuberosity of 5th metatarsal



Fracture of proximal phalanx



Fracture of phalanx splinted by taping to adjacent toe (buddy taping)

DESCRIPTION	EVALUATION	CLASSIFICATION	TREATMENT
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**METATARSAL AND PHALANGEAL FRACTURES**

- Common injuries: most are benign.
- Fracture at metaphyseal/diaphyseal junction of 5<sup>th</sup> MT (Jones fracture) is not benign
- Base of 5th MT avulsion fracture [PB]: benign
- Toe fx: usually stub injury 5th toe most common

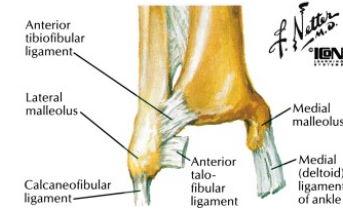
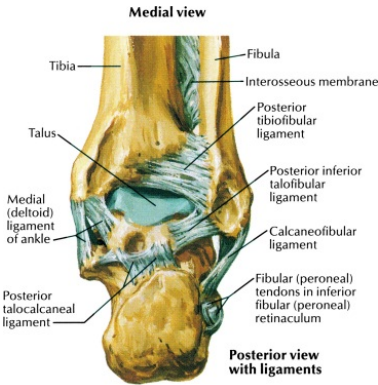
HX: Pain with weight bearing, swelling  
PE: Swelling, ecchymosis, bony pain (increases with motion)  
XR: MT: AP/lateral/oblique Toe: AP only

Metatarsal:  
Head neck fracture  
Shaft fracture  
Base (esp. of 5th)  
Phalanges:  
Shaft fracture  
Joint injuries

Metatarsal Fractures: Undisplaced: hard soled shoe or walking cast.  
Displaced/angulated: ORIF 5th MT Jones fx: Cast and NWB 6 weeks vs. ORIF  
Phalange Fractures: Great toe: Reduce. PCP joint injuries.  
Others: splint or buddy tape

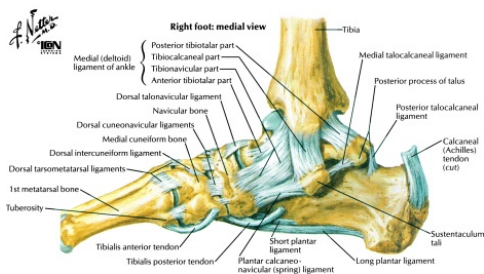
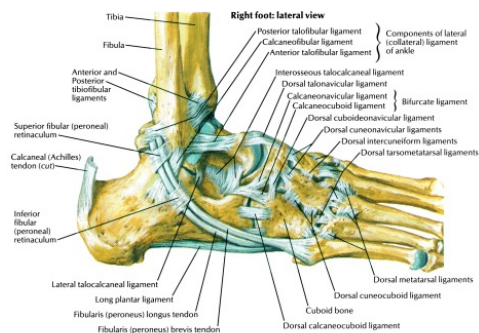
**COMPLICATIONS:** Neurovascular injury: Dorsalis pedis artery; Osteoarthritis/pain; Decreased motion; Nonunion, especially in 5th Metatarsal (Jones) fracture; Deformity

ANKLE JOINTS



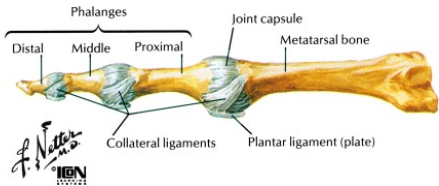
LIGAMENTS	ATTACHMENTS	COMMENTS
INFERIOR TIBIOFIBULAR		
<u>SYNDESMOSIS:</u>	Distal tibia/fibula support: must be stabilized if disrupted	
Anterior/inferior tibiofibular [AITFL]	Distal anterior tibia fibula	Oblique, connects bones anteriorly
Posterior/inferior tibiofibular [PITFL]	Distal posterior tibia fibula	Weaker, posterior support of mortise
Inferior transverse ligament	Inferior deep to PITFL	Strong posterior support of mortise
Interosseous ligament	Lateral tibia to med. fibula	A continuation of interosseous membrane, strong support; torn in Maisonneuve fracture
• Syndesmosis widening seen on radiographs if both the AITFL and PITFL are ruptured		
ANKLE (mortise/talus) (Ginglymus/hinge type)		
Capsule	Tibia to talus	Extends to interosseous ligament
<u>MEDIAL: Deltoid ligament (4 parts)</u>	Medial malleolus to:	Strong medial support: fewer sprains.
Tibionavicular	Navicular tuberosity	Overlaps the anterior tibiotalar ligament
Tibiocalcaneal	Sustentaculum tali	Oriented vertically
Posterior tibiotalar	Medial tubercle of talus	Thickest part of deltoid ligament
Anterior tibiotalar	Talus	Minimal support

<b>LATERAL:</b>	Lateral malleolus to:	Weaker lateral support: more sprains
Anterior talofibular [ATFL]	Neck of talus	Weak, most often sprained, positive anterior drawer test when ruptured
Calcaneofibular [CFL]	Calcaneus	Stabilizes subtalar joint
Posterior talofibular [PTFL]	Posterior process (talus)	Strong, seldom torn



FOOT JOINTS

Capsules and ligaments of metatarsophalangeal and interphalangeal joints: lateral view



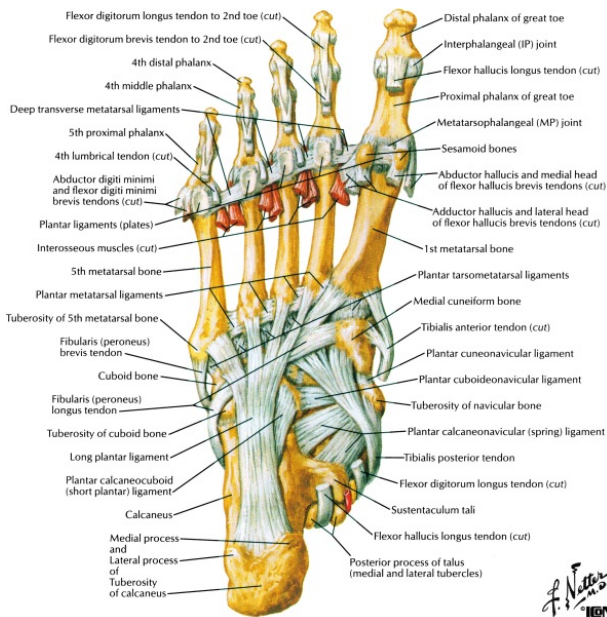
JOINT	LIGAMENTS	COMMENTS
INTERTARSAL		
<u>Subtalar</u> (talocalcaneal) Allows inversion/eversion of foot (e.g. walking on uneven surface)		
	Medial talocalcaneal	Medial tubercle to sustentaculum tali
	Lateral talocalcaneal	Deep to calcaneofibular ligament
	Posterior talocalcaneal	Short; Posterior process to calcaneus
	Interosseous talocalcaneal	Strong; in sinus tarsus
	Also supported by the ligaments of the ankle (see ankle joints)	
<u>Transverse/Midtarsal</u> (Chopart's Joint): assists subtalar joint with inversion eversion		
Talonavicular	Plantar calcaneonavicular (Spring)	Sustentaculum tali to navicular: plantar support for head of talus; Strong.
	Dorsal talonavicular	Dorsal support
	Calcaneonavicular (Bifurcate 1)	Lateral support
Calcaneocuboid	Calcaneocuboid (Bifurcate 2)	Stabilizes two rows of tarsus
	Dorsal calcaneocuboid	Dorsal support
	Plantar calcaneocuboid (short plantar)	Strong plantar support
	Calcaneocuboid MT (long plantar)	Additional plantar support
Cuboideonavicular Cuneonavicular Intercuneiform Cuneocuboid	Each of these four joints have dorsal, plantar, and interosseous ligaments, each bearing the name of the corresponding joint	These joints are small, have little motion or clinical significance. Share a common articular capsule.
Plantar ligaments are stronger than the dorsal ligaments		
TARSOMETATARSAL (Lisfranc) Gliding type		
	Dorsal, plantar, interosseous, tarsalmetatarsals (TMT) ligaments	Medial cuneiform to 2 <sup>nd</sup> metatarsal: Lisfranc's ligament
INTERMETATARSAL		
	Dorsal, plantar, interosseous MT	Strengthen transverse arch
	Deep transverse metatarsal	Connect the MT heads
METATARSOPHALANGEAL Ellipsoid/condyloid type		
	Plantar plate and Intersesamoid	Part of weight bearing surface
	Collateral	Strong
Deep transverse metatarsal ligaments add support to this joint		

# INTERPHALANGEAL Ginglymus/hinge type

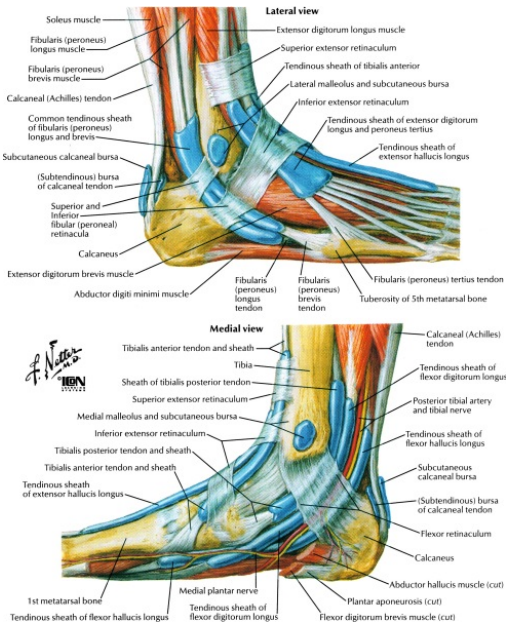
Plantar plate

Similar to the IP joints of the hand

Collateral



OTHER STRUCTURES



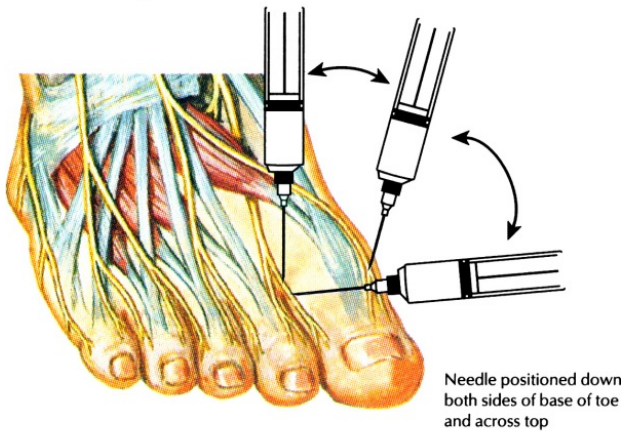
STRUCTURE	FUNCTION	COMMENT
Superior extensor retinaculum	Covers tendons, nerves vessels of anterior compartment at the ankle	Distal fibula to medial tibia
Inferior extensor retinaculum	Surrounds covers tendons, etc. of the anterior compartment in the foot	"Y" shaped; calcaneus to medial malleolus and navicular
Flexor retinaculum	Covers tendons of posterior compartment	Medial malleolus to calcaneus. Roof of tarsal tunnel.
Superior Inferior peroneal retinaculum	Covers tendons sheaths of the lateral compartment at the hindfoot	Superior: Lateral malleolus to calcaneus Inferior: Inferior extensor retinaculum to calcaneus
Plantar Aponeurosis (Plantar fascia)	Supports longitudinal arch	Inflamed: plantar fascitis. Can develop nodules



MINOR PROCEDURES

STEPS
ANKLE ARTHROCENTESIS
1. Ask patient about allergies
2. Plantarflex foot, palpate medial malleolus and sulcus between it and the tibialis anterior tendon. Use the visible EHL tendon if TA is not palpable.
3. Prepare skin over ankle joint (iodine/antiseptic soap)
4. Anesthetize skin locally (quarter size spot)
5. Insert 20 gauge needle perpendicularly into the sulcus/ankle joint (medial to the tendon, inferior to distal tibia articular surface, lateral to medial malleolus). Aspirate fluid. If suspicious for infection, send fluid for Gram Stain and culture. The fluid should flow easily if needle is in joint.
6. Dress injection site
DIGITAL BLOCK
1. Same as in hand. See Hand chapter.

Great toe digital block

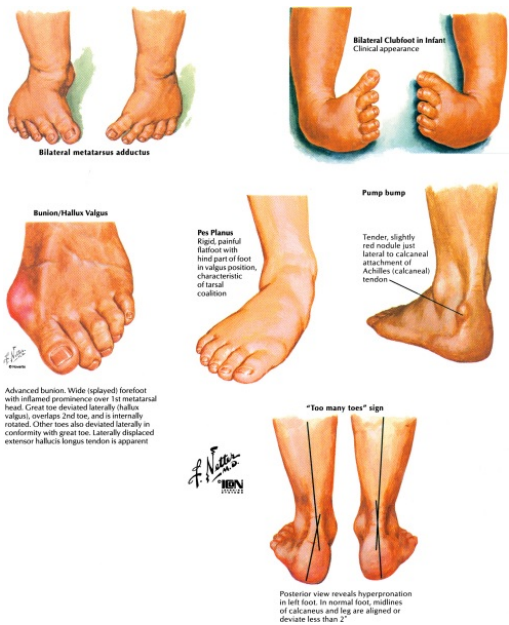




HISTORY OF THE FOOT/ANKLE

QUESTION	ANSWER	CLINICAL APPLICATION
1. AGE	Young	Sprain, fractures
	Middle age, elderly	Overuse injuries, arthritis, gout
2. PAIN		
a. Onset	Acute (less common)	Fracture, stress fracture
	Chronic	Most foot ankle disorders are chronic
b. Location	Ankle	Fracture, osteoarthritis, instability, posterior tibial tendinitis
	Hindfoot	Plantar fasciitis, fracture, retrocalcaneal bursitis, Achilles tendinitis
	Midfoot	Osteoarthritis of tarsal joints, fracture
	Forefoot	Hallux rigidus, fractures, metatarsalgia, Morton's neuroma, bunions, gout
	Bilateral	Consider systemic illness, RA
c. Occurrence	Morning pain	Plantar fasciitis (improves with stretching/walking)
	With activity	Overuse type injuries
3. STIFFNESS	Without locking	Ankle sprain, RA
	With locking	Loose body
4. SWELLING	Yes	Fracture, arthritis
5. TRAUMA	Mechanism/foot position	Inversion: ATFL injury/sprain
	Bear weight?	Yes: less severe injury;
		No: more severe (rule out fracture)
6. ACTIVITY/OCCUPATION	Sports, repetitive motion	Achilles tendinitis, overuse injuries
	Standing all day	Overuse injuries
7. SHOE TYPE	Tight/narrow toe box	Hallux valgus (bunion, overwhelmingly seen in women)
8. NEUROLOGIC SYMPTOMS	Pain, numbness, tingling	Tarsal tunnel syndrome
9. HISTORY OF SYSTEMIC DISEASE	Manifestations in foot	Diabetes mellitus, gout, peripheral vascular disease, RA, Reiter's syndrome
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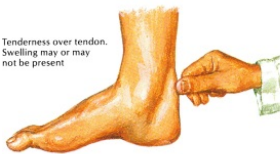
PHYSICAL EXAM



EXAM	TECHNIQUE	CLINICAL APPLICATION
INSPECTION		
Foot (standing/weight-bearing)	Anterior view	Alignment/rotational deformities, toe deformities, bunions
	Posterior view	Minimal valgus is normal, "pump bump" exostosis
	Superior view	Bunion, bunionette
	Medial view	Flat foot (pes planus); high arch foot (pes cavus)
Foot (supine/sitting/non-WB)	Inferior/plantar view	Callus, warts, ulcers (especially in diabetic foot)
Swelling	Foot and ankle	Swelling sign of infection, trauma (bilateral): cardiovascular etiology
Color	Change WB to non-WB	If foot changes color: pink to RED: arterial insufficiency
Shoes	All aspects of the shoe	Abnormal wear may indicate disease (e.g. scuffed toe, drop foot)

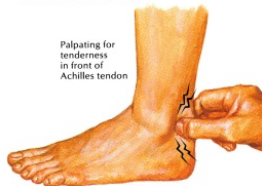
### Achilles Tendonitis

Tenderness over tendon.  
Swelling may or may not be present

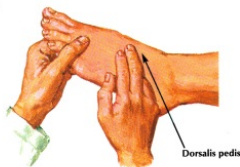


### Retrocalcaneal Bursitis

Palpating for tenderness in front of Achilles tendon



*f. Netter*  
M.D.  
1889-1971



EXAM	TECHNIQUE	CLINICAL APPLICATION
PALPATION		
Bony structures	1 <sup>st</sup> MTP joint (MT head)	Bunion, bursitis, callus; pain: gout, sesamoiditis, tendinitis
	Other MTP joint (MT head)	Pain: metatarsalgia, Freiberg's infraction, fracture, tailor's bunion (5 <sup>th</sup> MT head)
	Tarsal bones (Talus)	Tenderness suggests fracture, osteonecrosis, osteochondritis
	Calcaneus	Pain: fracture. Posterior: bursitis (pump bump); Plantar: spur, plantar fascitis; Medial pain: nerve entrapment
	Both malleoli	Pain indicates fracture, syndesmosis injury in leg
Soft tissue	Skin	Cool: peripheral vascular disease. Swelling: trauma or infection vs. venous insufficiency
	Between metatarsal heads	Mass pain: neuroma
	Medial ankle ligaments	Pain suggests ankle sprain (Deltoid ligament)
	Tendons at med. malleolus	Pain indicates tendinitis, rupture (sprain)
	Lateral ankle ligaments	Pain suggests ankle sprain ATFL, CFL, PTFL (rare)
	Peroneal tendons (lateral malleolus)	Pain indicates tendinitis, rupture/sprain, dislocation
	Achilles tendon	Pain: tendinitis. Defect suggests Achilles rupture
RANGE OF MOTION		
Ankle: dorsiflex/plantarflex	Stabilize subtalar joint	Normal: Plantarflex 50°, Dorsiflex (extend) 25°

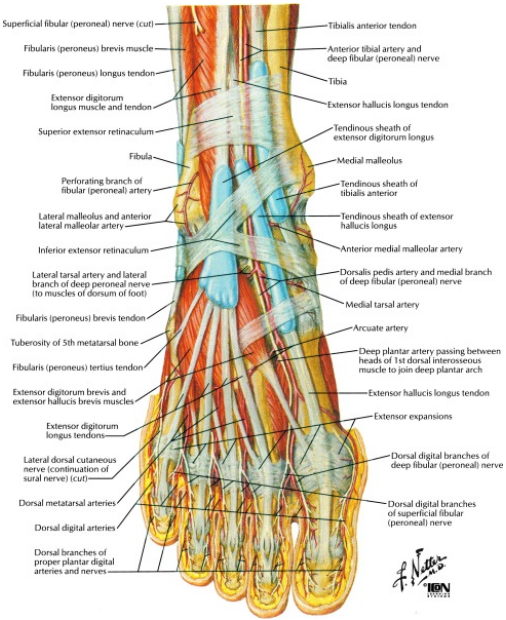
Subtalar: inversion/eversion	Stabilize tibia	Normal: Invert 5-10°, Evert 5°
Midtarsal: adduction/ abduction	Stabilize heel/hindfoot	Normal: Adduct 20°, abduct 10°
Great toe:		
MTP: flex/extend	Stabilize foot	Normal: Flex 75°, extend 75°. Decreased in hallux rigidus
IP: flex/extend	Stabilize foot	Normal: Flex 90, extend 0°

Pronation: dorsiflexion, eversion, abduction. Supination: plantarflexion, inversion, adduction

EXAM	TECHNIQUE	CLINICAL APPLICATION
NEUROVASCULAR		
<b>Sensory</b>		
Saphenous (L4)	Med. foot (med. cutaneous)	Deficit indicates corresponding nerve/root lesion
Tibial nerve (L4)	Plantar foot (calcaneal/plantar)	Deficit indicates corresponding nerve/root lesion
Superficial Peroneal (L5)	Dorsal foot	Deficit indicates corresponding nerve/root lesion
Deep Peroneal (L5)	1 <sup>st</sup> dorsal web space	Deficit indicates corresponding nerve/root lesion
Sural nerve (S1)	Lateral foot	Deficit indicates corresponding nerve/root lesion
<b>Motor</b>		
Deep Peroneal nerve (L4)	Foot inversion/dorsiflexion	Weakness = Tibialis Anterior or nerve/root lesion
Deep Peroneal nerve (L5)	Great toe extension (dorsiflex)	Weakness = EHL or corresponding nerve/root lesion
Tibial nerve (S1)	Great toe plantarflexion	Weakness = FHL or corresponding nerve/root lesion
Superficial Peroneal (S1)	Foot eversion	Weakness = Peroneus muscles or nerve/root lesion
<b>Reflex</b>		
S1	Achilles reflex	Hypoactive/absence indicates S1 radiculopathy
Upper Motor Neuron	Babinski reflex	Upgoing toes indicates an Upper Motor Neuron disorder
<b>Pulses</b>	Dorsalis pedis	Decreased pulses: trauma or vascular compromise, peripheral vascular disease
	Posterior tibial	
SPECIAL TESTS		
Anterior drawer	Hold tibia, anterior force to calcaneus	Anterior translation: AnteriorTaloFibular Ligament (ATFL) rupture (sprain)
Talar tilt	Hold tibia, invert ankle	Increased laxity compared to contralateral: CFL/ATFL sprain
Eversion/abduct stress	Hold tibia, evert/abduct Ankle	Increased laxity compared to contralateral: Deltoid ligament sprain
"Too many toes" sign	Standing, view foot posteriorly	"Too many toes" (more seen laterally than other side): acquired flat foot

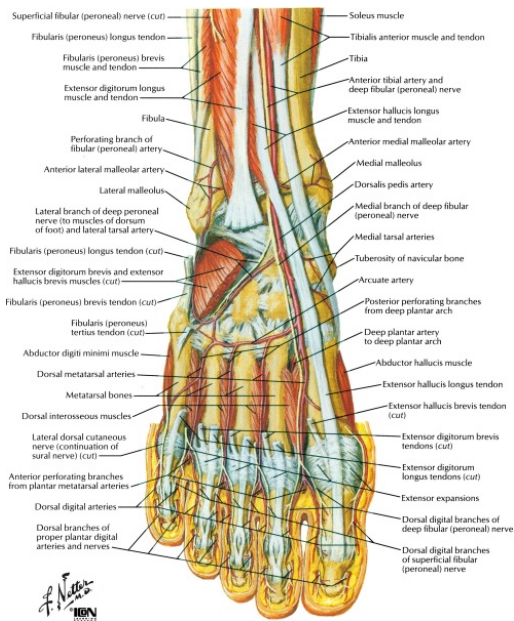
Squeeze	Compress distal tibia/fibula	Pain indicates a syndesmosis injury
Heel lift	Standing, raise onto toes	Heel into varus is normal. Decreased lift with posterior compartment pathology
Tinel's sign at the Ankle	Tap nerve posterior to medial malleolus	Tingling/parathesia is positive for posterior tibial nerve entrapment
Compression	Squeeze foot at MT heads	Pain, numbness, tingling: interdigital neuroma (Morton's)
Thompson	Prone: feet hang, squeeze calf	Absent plantar flexion indicates Achilles tendon rupture
Homans' sign	Knee extended: passively dorsiflex foot	Pain in calf suggestive of deep venous thrombophlebitis (DVT)

MUSCLES: DORSUM

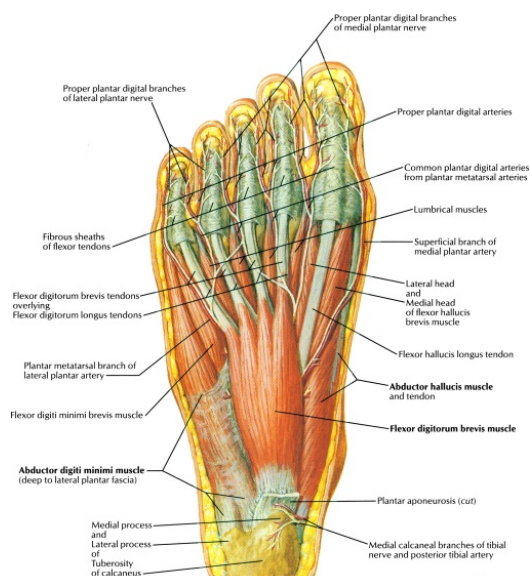
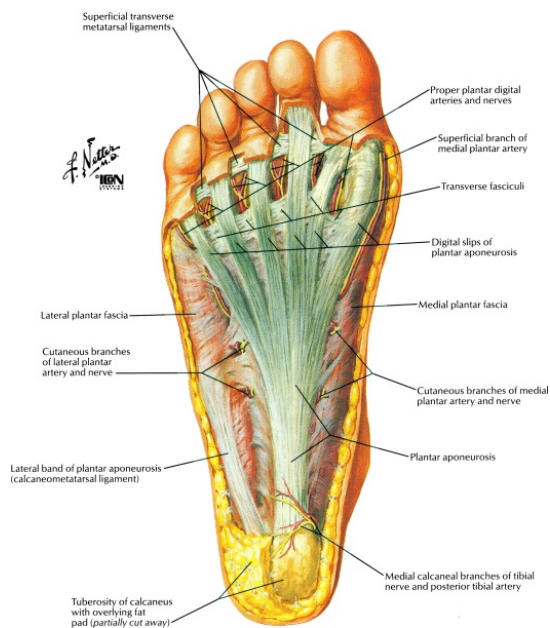


MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
Extensor hallucis brevis [EHB]	Dorsal calcaneus	Base of proximal phalanx of Great toe	Deep peroneal	Extends great toe	Assists EHL with its action
Extensor digitorum brevis [EDB]	Dorsal calcaneus	Base of proximal phalanx: 4 lateral toes	Deep peroneal	Extends toes	Injury can result in dorsal hematoma



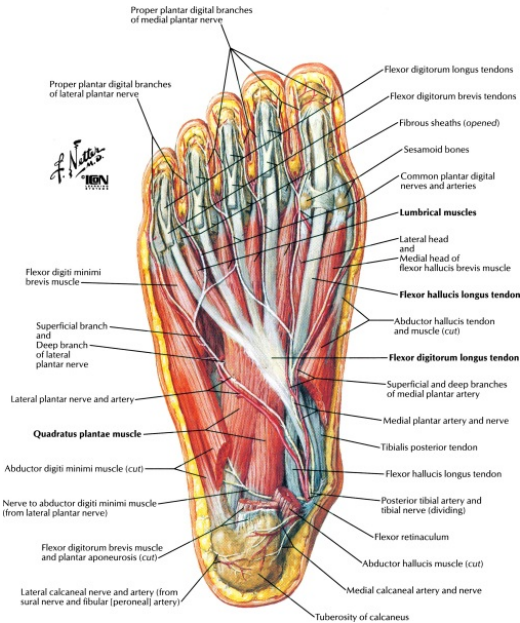


## MUSCLES: FIRST PLANTAR LAYER



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
FIRST LAYER					
Abductor hallucis	Calcaneal tuberosity medial process	Through med. sesamoid to proximal phalanx of great toe	Medial plantar	Abducts great toe	Supports longitudinal arch medially.
Flexor digitorum brevis [FDB]	Calcaneal tuberosity medial process	Sides of middle phalanges: lateral 4 toes	Medial plantar	Flex lateral 4 toes	Supports longitudinal arch
Abductor digiti minimi [ADM]	Calcaneal tuberosity medial lateral processes	Lateral base of proximal phalanx: 5th toe	Lateral plantar	Abducts small toe	Supports longitudinal arch laterally
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MUSCLES: SECOND PLANTAR LAYER

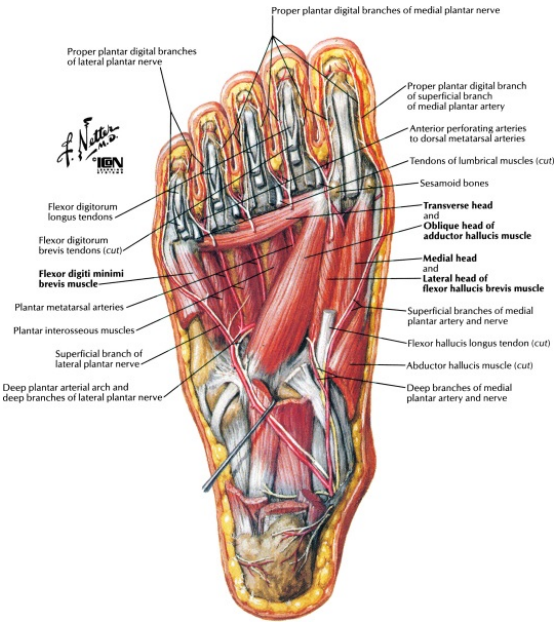


MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
SECOND LAYER					
Quadratus plantae	Medial and lateral plantar calcaneus	Lateral FDL tendon	Lateral plantar	Assists FDL with toe flexion	Two heads/bellies join on FDL tendon
Lumbricals	Separate FDL tendons	Proximal phalanges, extensor expansion	1. Medial plantar 2-4. Lateral plantar	Flex MTP joint, extend IP joint	1st lumbrical attaches to 1 FDL tendon

Tendons of FHL and FDL also pass through in the second layer

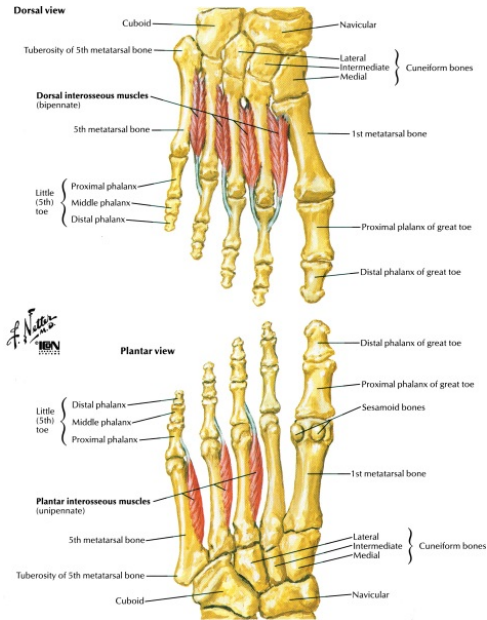
Medial and lateral plantar nerves are terminal branches of the Tibial nerve: they run in the 2nd layer.

MUSCLES: THIRD PLANTAR LAYER



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
THIRD LAYER					
Flexor hallucis brevis [FHB]	Cuboid, lateral cuneiform	Through sesamoids to proximal phalanx of great toe	Medial plantar	Assist great toe flexion	Sesamoid bones attach to each tendon
Adductor hallucis	Oblique: base 2-4 MT Transverse: Lateral 4 MTP	Through lateral sesamoid to proximal phalanx of great toe	Lateral plantar	Adducts great toe	Supports transverse arch. 2 heads have different orientations
Flexor digiti minimi brevis [FDMB]	Base of 5th metatarsal	Base of proximal phalanx small toe	Lateral plantar	Flex small toe	Small, relatively insignificant muscle

MUSCLES: FOURTH PLANTAR LAYER



MUSCLE	ORIGIN	INSERTION	NERVE	ACTION	COMMENT
FOURTH LAYER					
Plantar interossei (3)	Med. 3, 4, 5th MTs	Medial proximal phalanges: toes 3-5	Lateral plantar	Adduct toes (PAD)	Attachment to MT is medial for all 3
Dorsal interossei (4)	Adjacent MT shafts	Proximal phalanges toes 2-5	Lateral plantar	Abduct toes (DAB)	Larger than the plantar interossei muscles

Peroneus longus and Tibialis posterior tendons pass through the fourth layer

Medial and lateral plantar nerves are terminal branches of the Tibial nerve.

PAD = 5 Plantar ADDuct, DAB 5 = Dorsal ABduct; the second digit is used as the reference point for abduction/adduction in the foot

NERVES



LUMBAR PLEXUS

POSTERIOR DIVISION

1. **Femoral** (L2-4): Saphenous nerve branches in proximal thigh, descends in superficial medial leg, then anterior to medial malleolus in foot.

Sensory:	Medial foot: via medial cutaneous nerve ( <i>Saphenous</i> nerve)
Motor:	NONE (in foot or ankle)

SACRAL PLEXUS

ANTERIOR DIVISION

2. **Tibial** (L4-S3): behind medial malleolus, splits on plantar surface

Sensory:	Medial heel: via Medial calcaneal
	Medial plantar foot: via Medial plantar
	Lateral plantar foot: via Lateral plantar
Motor:	<u>FIRST PLANTAR LAYER of FOOT</u>
	Abductor hallucis: Medial plantar
	Flexor digitorum brevis[FDB]: Medial plantar
	Abductor digiti minimi: Lateral plantar
	<u>SECOND PLANTAR LAYER of FOOT</u>
	Quadratus plantae: Lateral plantar
	Lumbricals: Medial Lateral plantar
	<u>THIRD PLANTAR LAYER of FOOT</u>
	Flexor hallucis brevis [FHB]: Medial plantar
	Adductor hallucis: Lateral plantar
	Flexor digiti minimi brevis [FDMB]: Lateral plantar
	<u>FOURTH PLANTAR LAYER of FOOT</u>
	Dorsal interosseous: Lateral plantar
	Plantar interosseous: Lateral plantar

POSTERIOR DIVISION

3. **Common peroneal** (L4-S2): Superficial peroneal divides into intermediate and medial dorsal cutaneous branches in leg. Deep peroneal divides under extensor retinaculum into medial lateral branches.

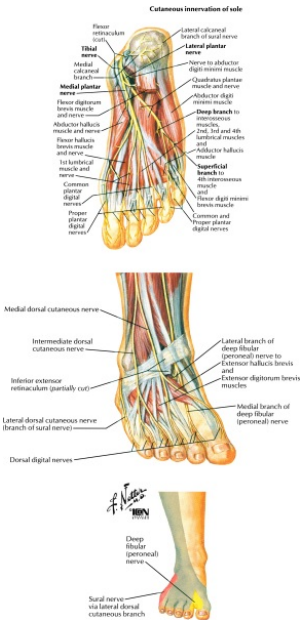
Sensory:	Lateral foot: via Sural (lateral calcaneal dorsal cutaneous).
	Dorsal foot: Superficial peroneal.
	Dorsal (med.) (Med. dorsal cutaneous branch).

1st/2nd interdigital space: Deep peroneal (med. branch)

Motor: **FOOT: Deep Peroneal (Lateral branch)**

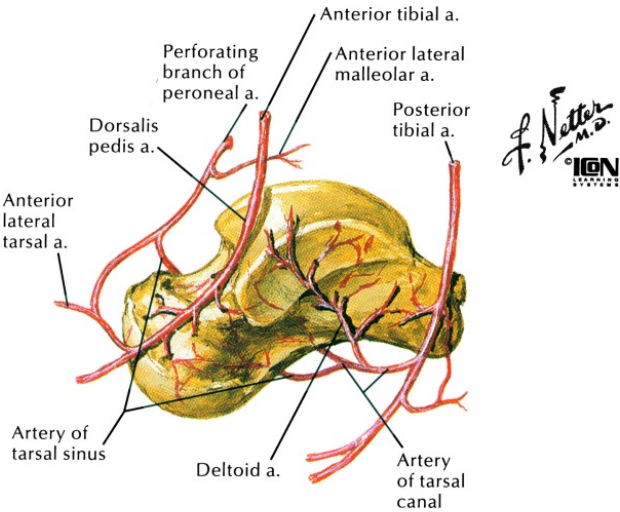
Extensor hallucis brevis [EHB]

Extensor digitorum brevis [EDB]





ARTERIES

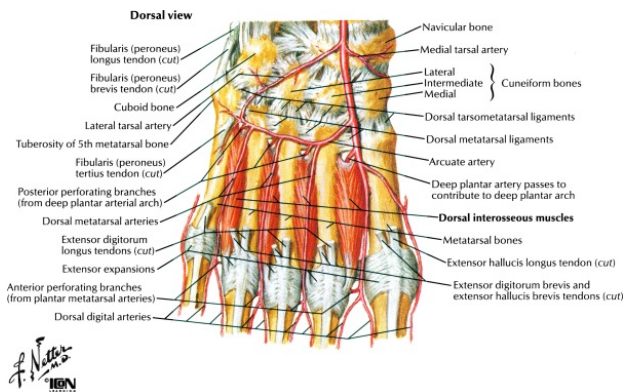


Blood supply of talus. Because of profuse intraosseous anastomoses, avascular necrosis commonly occurs only when surrounding soft tissue is damaged, as in types II and III fractures of talar neck

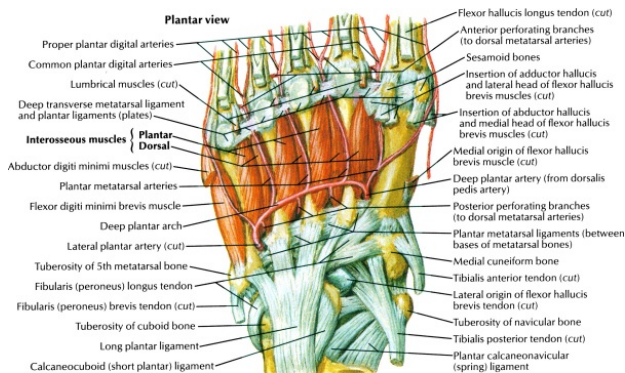
ARTERY	STEM ARTERY/ COMMENT
Artery to the Tarsal Sinus	Dorsalis pedis and Peroneal arteries
Artery to the Tarsal Canal	Posterior tibial artery
Deltoid artery	Posterior tibial artery; supplies medial body
Capsular ligamentous vessels	Multiple sources
Interosseous anastomosis	Extensive, protects against AVN

ARTERY	COURSE	COMMENT
(See Leg/Knee chapter for stem arteries)		
Anterior Medial Malleolar	Under TA EHL tendons to medial malleolus	From Anterior tibial artery, supplies medial malleolus
Anterior Lateral Malleolar	Under EDL tendon to lateral malleolus	From Anterior tibial artery, supplies lateral malleolus
Posterior Medial Malleolar	Under tendons of TP and FDL, not FHL, to medial malleolus	From Posterior tibial artery, supplies medial malleolus
Posterior Lateral Malleolar	Under Peroneus longus/brevis tendons to lateral malleolus	From Peroneal artery, supplies lateral malleolus
Perforating and communicating branches	Anastomosis with anterior lateral malleolar and posterior tibial arteries	From Peroneal artery, contributes supply to lateral malleolus

An anastomosis occurs at each malleolus between the above arteries



ARTERY	COURSE	BRANCHES	COMMENT/SUPPLY
(see Leg Knee chapter for stem arteries)			
<i>Lateral Calcaneal</i>	with <i>Lateral calcaneal</i> nerve (Sural nerve)	NONE	From Peroneal artery; supplies heel
<i>Medial Calcaneal</i>	with <i>Medial calcaneal</i> nerve (Tibial nerve)	NONE	From Posterior tibial artery; supplies heel
<i>Lateral plantar</i>	Between quadratus plantae FDB, runs w/ lateral plantar nerve	Deep plantar arch	Larger terminal branch of Posterior tibial artery
<i>Medial plantar</i>	Between Abductor hallucis FDB runs with medial plantar nerve	Superficial branch 1 <i>proper plantar digital</i> Deep branch	Smaller terminal branch of Posterior tibial artery; supplies medial Great toe Anastomose with plantar MT artery
Dorsalis Pedis	Dorsum of foot with medial branch of deep peroneal nerve	Supplies dorsum of foot via:	
		Medial Tarsal	No branches
		Lateral Tarsal	No branches
		Arcuate artery	3 Dorsal MT arteries branch off
		Deep Plantar	Descends to deep plantar arch
		1st dorsal metatarsal	Terminal branch of dorsalis pedis
		3 <i>dorsal digital</i> arteries	Supply dorsal great toe



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ARTERY	COURSE	BRANCHES	COMMENT/SUPPLY
(see Leg Knee chapter for stem arteries)			
Medial Tarsal	Across tarsals, under EHL tendon	NONE	Supplies dorsum of foot (can be 2 or 3 of these arteries).
Lateral Tarsal	Across tarsals with lateral branch of Deep peroneal nerve	NONE	Supplies EDB, lateral tarsal bones, anastomoses laterally
Arcuate	Across bases of metatarsals, under extensor tendons	2nd, 3rd, 4th dorsal MT artery 7 dorsal digital arteries	
Deep plantar	Descends between 1st 2nd MT's	Deep plantar arch	Anastomosis with Lateral calcaneal
Deep plantar arch	On plantar interosseous muscles in 4th layer of foot.	4 posterior perforating	Join dorsal metatarsal arteries
		1 Common/proper plantar digital	Most lateral artery in foot toes
		4 plantar metatarsal	
		4 anterior perforating	Join dorsal metatarsal arteries
		4 Common plantar digital	
		8 Proper plantar digital	Supplies the distal tip of phalanx

Total of 4 Dorsal Metatarsal arteries leading to 10 dorsal digital arteries. They do not reach the distal tip of the digit.

Total of 4 Plantar Metatarsal arteries leading to 10 proper plantar digital arteries via common plantar digital arteries.

Each digit has 2 dorsal digital and 2 proper plantar digital arteries. Dorsal branch of proper plantar digital artery supply distal tip.



DISORDERS

DESCRIPTION	HISTORY/PHYSICAL EXAM	WORK-UP/FINDINGS	TREATMENT
ACHILLES TENDINITIS			
<ul style="list-style-type: none"><li>Occurs at or above insertion of Achilles tendon</li></ul>	Hx/PE: Heel pain, worse with push off. Tender to palpation	XR: Standing lateral: spur at Achilles insertion	1. Rest, NSAID, heel lift 2. Excise bone or bursa (rare)
ACHILLES TENDON RUPTURE			
<ul style="list-style-type: none"><li>"Weekend warriors." Middle age men in athletics.</li></ul>	Hx: "hit with bat" sensation PE: Defect, + Thompson test	XR: Standing AP/lateral: usually normal	Casting (in equinus) vs. surgical repair
ACQUIRED FLAT FOOT (POSTERIOR TIBIALIS DYSFUNCTION)			
<ul style="list-style-type: none"><li>Tibialis posterior tendon dysfunction: tears or degeneration</li><li>No arch support results in valgus foot</li></ul>	Hx: Pain and swelling PE: + "too many toes" sign, no heel varus on toe rise	XR: Standing AP/lateral: middle foot sag	1. Orthosis 2. Activity modification 3. Calcaneal osteotomy and FDC transfer 4. Arthrodesis
ANKLE INSTABILITY			
<ul style="list-style-type: none"><li>Multiple/recurrent sprains</li><li>Also neurologic etiology decreased proprioception</li></ul>	Hx: Inversion instability esp. on uneven ground PE: + anterior drawer talar tilt test	XR: AP/lateral/stress view: gapping laterally	1. PT: strengthen peroneals 2. Surgical reconstruction if condition persists
ANKLE SPRAIN			
<ul style="list-style-type: none"><li>#1 musculoskeletal injury</li><li>Lateral 90% - ATFL alone 60%, with syndesmosis 5%</li><li>Inversion most common mechanism</li></ul>	Hx: "Pop," pain, swelling, +/- ability to bear weight PE: + Anterior drawer, +/- talar tilt test	XR: only if cannot bear weight or + bony point tenderness	1. RICE, NSAIDs 2. Immobilize grade III 3. PT ROM exercises 4. Surgery: athletes or severe injury
ARTHRITIS: OA/DJD			
<ul style="list-style-type: none"><li>Can occur in any joint</li><li>Associated with trauma, obesity, overuse activity</li></ul>	Hx/PE: Older, pain at affected joint.	XR: Standing AP/lateral: classic OA findings	1. NSAID, activity modification, orthosis 2. Fusion/arthroplasty (rare)
CHARCOT JOINT: NEUROPATHIC JOINT			
<ul style="list-style-type: none"><li>Neurologic disease results in decreased sensation</li><li>Joint destroyed/deformed by fx undetected by patient</li></ul>	Hx/PE: Patient is insensate-no pain. Red, warm, swollen joint	XR: Standing AP/lateral: fractures (callus or unhealed), joint destroyed	1. Immobilize (skin checks) 2. Bony excision or fusion
CLAW TOE			
<ul style="list-style-type: none"><li>Deformity: MTP extended, PIP flexed. Usually all toes</li><li>Etiology: Neurologic disease</li></ul>	Hx: Toe pain PE: Toe deformity, +/- callus corn, neurologic exam	XR: Standing AP/lateral/MR/EMG/lab: to rule out neurologic disease	1. Shoes with extra deep toe box 2. Surgical reconstruction: based on

(e.g. Charcot-Marie-Tooth)

deformity

### CORN

- Two types: 1. Hard 2. Soft
- 1. Hyperkeratosis: pressure on bones (5<sup>th</sup> toe #1)
- 2. Interdigital maceration

Hx/PE: Tight shoes.  
Pain at lesion site.

XR: AP/lateral: look for bone spurs

1. Wide toe box shoe, pads
2. Debride callus
3. Excise bony prominence

### DIABETIC FOOT: NEUROPATHIC FOOT

- Neuropathy leads to unperceived injury (ulcer, infection)
- Vascular insufficiency leads to decreased healing

Hx: Burning tingling, +/- pain  
PE: +/- skin changes, ulcers, deformity, swelling, warmth

XR: Standing AP/lateral: rule out osteomyelitis or Charcot joint  
Do Ankle Brachial Index

1. Skin care (prevention)
2. Protective shoe
3. Treat ulcers, infections
4. Amputation if necessary

### GOUT (Podagra)

- Purine metabolism defect
- Urate crystals create synovitis
- Great toe most common site

Hx: Men, acute  
exquisite pain  
PE: Red, swollen toe.

Labs:  
1. Elevated uric acid  
2. Negatively birefringent crystals

1. NSAIDs, colchicine
2. Rest
3. Allopurinol (prevention)

Achilles Tendinitis



Achilles tendon with inflammation at insertion into calcaneal tuberosity



Lateral view shows bone damage



Charcot foot



Anteroposterior radiograph of Charcot ankle joint

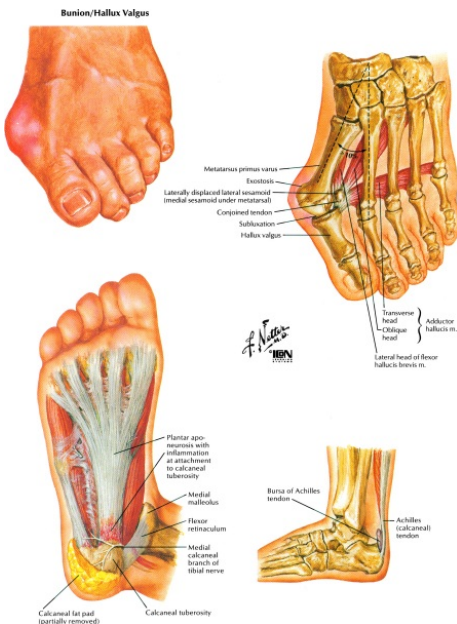
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DESCRIPTION	HISTORY/PHYSICAL EXAM	WORK-UP/FINDINGS	TREATMENT
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HALLUX RIGIDUS

<ul style="list-style-type: none"> <li>• DJD of MTP of Great toe</li> <li>• Often post traumatic</li> </ul>	Hx: Middle age. Painful, stiff PE: MTP Tender to palpation, decreased ROM	XR: Standing AP/lateral OA findings at 1 <sup>st</sup> MTP	1. NSAID, stiff sole shoe 2. Arthroplasty/fusion
HALLUX VALGUS (Bunion)			
<ul style="list-style-type: none"> <li>• Great toe valgus; MTP bursitis</li> <li>• Multiple etiologies: genetic, flat feet, narrow shoes, RA</li> <li>• 10:1 women (shoes)</li> </ul>	Hx: Pain, swelling (worse with shoe wear (narrow toe box) PE: Medial 1st MTP TTP, +/- decreased great toe ROM	XR: Standing AP: measure: 1. <b>Distal MT Articulation Angle</b> (normal 10°) 2. <b>Inter MT angle</b> (9°) 3. <b>Hallux Valgus angle</b> (15°)	1. Shoes: wide toe box 2. Refractory cases: multiple corrective surgical procedures based on deformity and severity
HAMMER TOE			
<ul style="list-style-type: none"> <li>• Toe PIP flexion deformity</li> <li>• Associated with trauma, Hallux Valgus (shoes)</li> </ul>	Hx: Toe pain, worse when wearing shoes PE: Toe deformity, +/- corn	XR: Standing AP/lateral: PIP deformity	1. Extra deep shoe toe box 2. Surgery: resect or fuse PIP
MALLET TOE			
<ul style="list-style-type: none"> <li>• Lesser toe DIP flexion deformity</li> <li>• 2nd toe most common</li> </ul>	Hx: Toe pain PE: Toe deformity, callus	XR: Standing AP/lateral: DIP deformity	1. Shoe modification 2. FDL release
METATARSALGIA			
<ul style="list-style-type: none"> <li>• Metatarsal head pain</li> <li>• Etiology: flexor tendinitis, ligament rupture, callus (#1)</li> </ul>	Hx/PE: Pain under MT head (2nd MT most common)	XR: Standing AP/lateral: look for short MT	1. Metatarsal pads 2. Modify shoes 3. Treat underlying cause
MORTON'S NEUROMA (Interdigital)			
<ul style="list-style-type: none"> <li>• Fibrosis of irritated nerve</li> <li>• Usually between 2nd 3<sup>rd</sup> metatarsals</li> <li>• 5:1 female(shoes)</li> </ul>	Hx: Plantar MT pain PE: MT TTP, +/- numbness, + compression test	XR: Standing AP/lateral: usually normal, not helpful	1. Wide toe shoes, steroid injections, MT pads 2. Nerve excision
PLANTAR FASCITIS			
<ul style="list-style-type: none"> <li>• Inflammation and/or degeneration of fascia. Female 2:1</li> <li>• Associated with obesity</li> </ul>	Hx: AM pain, improves with ambulation or stretching PE: Medial plantar calcaneus tender to palpation	XR: Standing lateral: +/- calcaneal bone spur	1. Stretching, NSAID 2. Heel cup 3. Splint (night), casting
PLANTAR WARTS			
<ul style="list-style-type: none"> <li>• Hyperkeratosis</li> <li>• Due to Papilloma virus</li> </ul>	Hx/PE: Painful plantar lesions	Histopathology if necessary	1. Pads vs. freeze or debride lesion
RETROCALCANEAL BURSITIS: HAGLUND'S DISEASE			
<ul style="list-style-type: none"> <li>• Bursitis at insertion of Achilles tendon on calcaneus</li> </ul>	Hx: Pain on posterior heel PE: Red, tender to palpation, "pump bump"	XR: Standing lateral: spur at Achilles insertion	1. NSAID, heel lift, casting 2. Excise bone/bursa (rare)
RHEUMATOID ARTHRITIS			
<ul style="list-style-type: none"> <li>• Synovitis destroys joints</li> <li>• More common in females</li> </ul>	Hx: Forefoot: pain, swelling PE: Red, tender, +/- deformity (e.g. Hallux valgus)	XR: AP/lateral: joint destroyed Lab: positive	1. Medical management 2. Custom molded shoes

• Associated with HLA-DR4	Genetic (e.g. HLA-B27)	RF, ANA	3. Fusion or resection
SERONEGATIVE SPONDYLOARTHRITIS: REITER'S, AS, PSORIASIS			
<ul style="list-style-type: none"> <li>Multiple manifestations</li> <li>Associated with HLA-B27</li> <li>Most common in males</li> </ul>	Hx/PE: Young, forefoot/toe/ heel: red, swollen, tender	XR: AP/lateral: +/- calcification Lab: negative RF, ANA	1. Conservative treatment 2. Rheumatology consult
TAILOR'S BUNION: BUNIONETTE			
<ul style="list-style-type: none"> <li>Prominent 5<sup>th</sup> MT head laterally</li> <li>Bony exostosis/bursitis</li> </ul>	Hx/PE: Difficulty fitting shoes, painful lateral 5 <sup>th</sup> metatarsal prominence	XR: Standing AP: 5 <sup>th</sup> toe medially deviated, MT head laterally deviated	1. Pads, stretch toe box 2. Metatarsal osteotomy

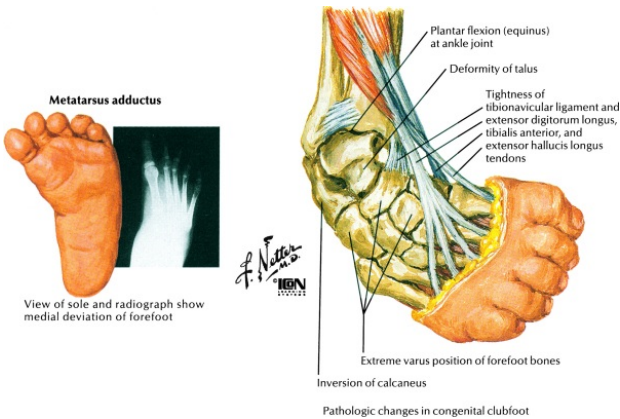


DESCRIPTION	HISTORY/PHYSICAL EXAM	WORK-UP/FINDINGS	TREATMENT
TARSAL TUNNEL SYNDROME			
<ul style="list-style-type: none"> <li>Tibial nerve trapped by flexor retinaculum and/or tendons</li> </ul>	Hx/PE: Pain, tingling, burning on sole (made worse with activity)	XR: AP/lateral: normal EMG: confirms diagnosis MR: to find mass lesion	1. NSAID, steroid injection 2. Surgical release (must follow plantar nerves also)





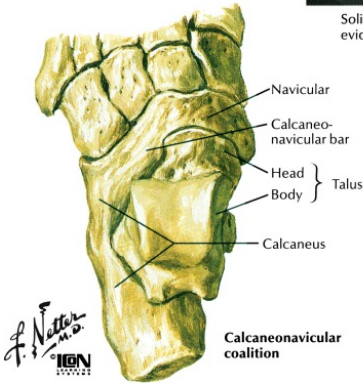
PEDIATRIC DISORDERS



DESCRIPTION	EVALUATION	TREATMENT/COMPLICATIONS
METATARSUS ADDUCTUS		
<ul style="list-style-type: none"><li>• Forefoot adduction (varus)</li><li>• #1 pediatric foot disorder</li><li>• Associated with intrauterine position or other disorders</li></ul>	<p>Hx: Parent notices deformity</p> <p>PE: "Kidney bean" deformity, negative thigh/foot angle, + intoeing gait</p>	<ol style="list-style-type: none"><li>1. Most spontaneously resolve with normal development</li><li>2. Serial casting</li><li>3. Rarely, midfoot osteotomies</li></ol>
TALIPES EQUINOVARUS: CLUBFOOT		
<ul style="list-style-type: none"><li>• Congenital, boys, 50% bilateral</li><li>• Genetic environment factors</li><li>• Idiopathic or associated with other disorders (neuromuscular, etc.)</li><li>• 4 deformities with soft tissue contractures</li></ul>	<p>Hx: Deformity at birth</p> <p>PE: Rigid foot with:</p> <ol style="list-style-type: none"><li>1. plantarflexed ankle (equinus)</li><li>2. inverted hindfoot (varus)</li><li>3. adducted forefoot</li><li>4. cavus midfoot</li></ol> <p>XR: if diagnosis is unclear</p>	<ol style="list-style-type: none"><li>1. Manipulation and casting 2-4 mo.</li><li>2. Surgical correction (release, lengthening, etc.) with post operative casting</li></ol>
COMPLICATION: recurrence of deformity		



Solid, bony calcaneonavicular coalition evident on oblique radiograph



*F. Netter M.D.*  
**ICON**  
 COLLECTION

DESCRIPTION	EVALUATION	TREATMENT/COMPLICATIONS
-------------	------------	-------------------------

**PES PLANUS: CONGENITAL FLATFOOT**

<ul style="list-style-type: none"> <li>• Normal in infants (up to 6 yo)</li> <li>• No longitudinal arch</li> <li>• Ankle everted (valgus)</li> <li>• Classified:               <ol style="list-style-type: none"> <li>1. Rigid (tarsal coalition/vertical talus)</li> <li>2. Flexible (variant of normal)</li> </ol> </li> </ul>	<p>Hx: Usually adolescent, 1/2 foot pain</p> <p>PE: Rigid: always flat</p> <p>Flexible: only flat when WB</p> <p>XR: AP/lateral: may see coalition/or vertical talus in rigid foot</p>	<p>Flexible:</p> <ol style="list-style-type: none"> <li>1. Asymptomatic: no treatment</li> <li>2. Symptomatic: arch supports, stretching</li> </ol> <p>Rigid: Treat underlying condition (see tarsal coalition)</p>
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**PES CAVUS: HIGH ARCH FOOT**

<ul style="list-style-type: none"> <li>• High arch due to muscle imbalance in immature foot (T.A. and peroneus longus)</li> <li>• Ankle flexed: causes pain</li> <li>• Must rule out neuromuscular disease (e.g. Charcot-Marie-Tooth)</li> </ul>	<p>Hx: 8-10 yrs, ankle pain</p> <p>PE: Toe walking, tight heel cord, decreased ankle dorsiflexion</p> <p>XR: AP/lateral foot and ankle</p> <p>EMG/NCS: test for weakness</p> <p>MR: spine: r/o neuromuscular disease</p>	<ol style="list-style-type: none"> <li>1. Braces/inserts/AFO as needed (used with mixed results)</li> <li>2. Various osteotomies</li> <li>3. Tendon transfer balance</li> </ol>
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**TARSAL COALITION**

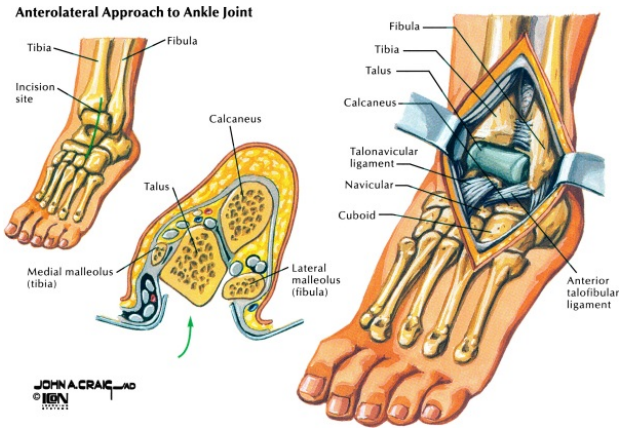
<ul style="list-style-type: none"> <li>• Connection (fibrous, cartilage then bony) of two tarsals</li> <li>• #1 Calcaneus/navicular (13-16yo)</li> <li>• #2 Talus/calcaneus (9-13yo)</li> </ul>	<p>Hx: Foot pain during adolescence</p> <p>PE: Stiff, decreased ROM (subtalar), flatfoot (peroneal spasm)</p> <p>XR: AP/lateral/oblique: coalitions can be</p>	<ol style="list-style-type: none"> <li>1. Mild: observe</li> <li>2. Casting</li> <li>3. Coalition resection</li> <li>4. Triple arthrodesis</li> </ol>
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• Flatfoot deformity  
results

seen  
CT: often necessary  
to confirm PE

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SURGICAL APPROACHES TO THE ANKLE



USES	INTERNEUROUS PLANE	DANGERS	COMMENT
ANKLE: ANTERIOR LATERAL APPROACH			
1. Fusions/triple arthrodesis	1. Peroneals [Superficial peroneal]	1. Deep peroneal nerve	1. Can access hindfoot
2. Talar procedures	EDL	Ant.	Preserving fat pad (sinus talus)
3. Intertarsal joint access	2. [Deep peroneal]	2. Tibial artery	2. helps wound healing.

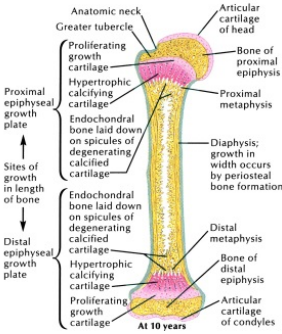
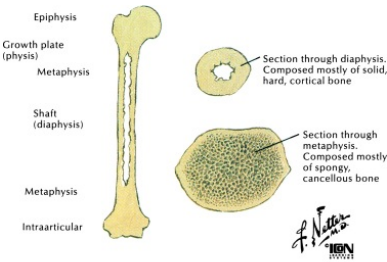
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## CHAPTER 10 - BASIC SCIENCE

- [BONES](#)
- [NERVES](#)
- [MUSCLES \(SKELETAL\)](#)
- [MICROBIOLOGY](#)
- [IMAGING](#)

CHAPTER 10 – BASIC SCIENCE

BONES



STRUCTURE	COMMENT
Bone function	Attachment of muscles Protection of organs Reservoir of minerals for body Hematopoiesis site
Bone Forms	
Long bones	Form by enchondral ossification, except clavicle Have a physis at each end (except in hand foot) 4 parts: epiphysis, physis, metaphysis, diaphysis Length is derived from the growing physis
Flat bones	Form by intramembranous ossification, (e.g., pelvis)
Physeal Anatomy	Divided into multiple zones
Reserve zone	Matrix production and storage
Proliferative zone	Cell proliferation, matrix production
Hypertrophic zone	Broken into 3 zones, calcification of matrix





## Structure of Cancellous Bone

### Trabecular bone (schematic)

On cut surfaces (as in sections), trabeculae may appear as discontinuous spicules

Osteoid (hypomineralized matrix)

Active osteoblasts produce osteoid

Inactive osteoblasts (lining cells)

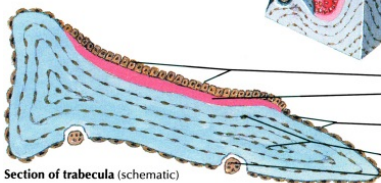
Marrow spaces contain hematopoietic cells and fat

Osteocytes

Osteoclasts (in Howship's lacunae)

Trabeculae

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Section of trabecula (schematic)

Active osteoblasts

Osteoid (hypomineralized matrix)

Inactive osteoblasts (lining cells)

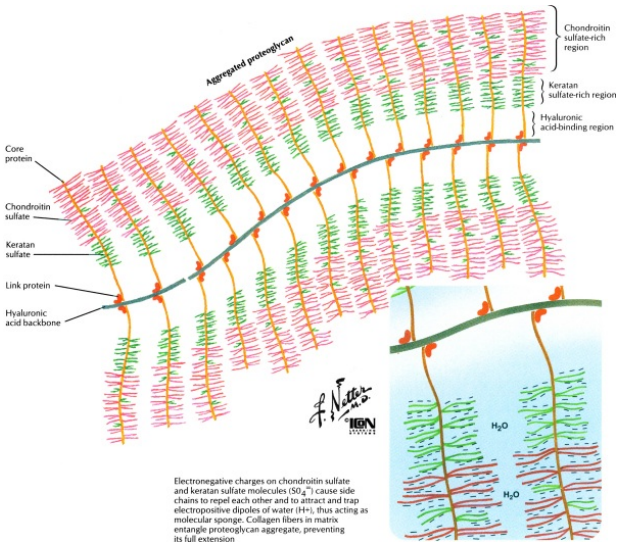
Osteocytes

Osteoclast (in Howship's lacuna)

### Four Mechanisms of Bone Regulation



STRUCTURE	COMMENT
<b>Cell Types</b>	
Osteoblasts	Make bone (secrete matrix, collagen, GAG, stimulated by PTH)
Osteoclasts	Resorb bone (giant cells, mineralized bone found only in Howship's lacunae)
Osteocytes	Maintain bone (90% of cells, inhibited by PTH)



STRUCTURE	COMMENT
<b>Bone Composition</b>	
Organic matrix (40%)	Produced by osteoblasts—becomes osteocytes when trapped in matrix
Collagen (Type I)	90% of matrix, gives strength. Mineralization occurs at gaps at the end of each collagen fiber
Proteoglycan	Glycosaminoglycans structure (GAGs)
Non-collagen protein	Osteonectin is most abundant
Inorganic (60%)	Mineralized portion
Calcium Hydroxyapatite	Adds strength to bone, found in the collagen gaps
<b>Types of Ossification</b>	
Enchondral	Bone replaces a cartilage template in long bones
Intramembranous	Mesenchymal template in flat bones and clavicle



**Type I.** Wound <1 cm long. No evidence of deep contamination

**Type II.** Wound >1 cm long. No extensive soft tissue damage

**Type IIIA.** Large wound. Good soft tissue coverage

**Type IIIB.** Large wound. Exposed bone fragments, extensive stripping of periosteum

**Type IIIC.** Large wound with major arterial injury

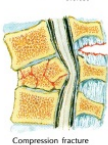


Transverse fracture

Oblique fracture

Spiral fracture

Comminuted fracture



Compression fracture



Pathologic fracture (tumor or bone disease)

Avulsion (greater tuberosity of humerus avulsed by supraspinatus muscle)

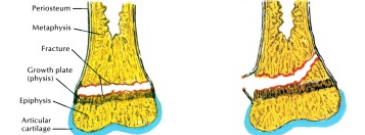


Greenstick fracture  
In children



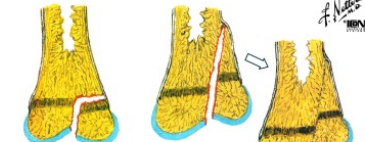
Torus (buckle) fracture  
In children

STRUCTURE	COMMENT
<b>Fracture Types</b>	Point tenderness and swelling are common findings
Open vs. closed	Break in skin is open. Gustilo classification (grade I, II, IIIA, B, C)
Direction	Transverse, spiral, oblique, comminuted
Displacement	Displaced or nondisplaced
Other	<ul style="list-style-type: none"> <li>Salter-Harris—fracture involving an open physis in adults, growth plate in children.</li> <li>Greenstick—only one cortex disrupted</li> <li>Torus—one cortex impacted, but intact</li> <li>Pathologic results—from bone tumor/disease</li> </ul>



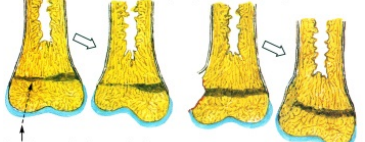
**Type I.** Complete separation of epiphysis from shaft through calcified cartilage (growth zone) of growth plate. No bone actually fractured; periosteum may remain intact. Most common in newborns and young children

**Type II.** Most common. Line of separation extends partially across deep layer of growth plate and extends through metaphysis, leaving triangular portion of metaphysis attached to epiphyseal fragment



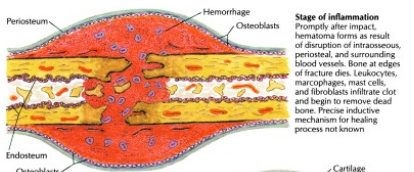
**Type III.** Uncommon. Intra-articular fracture through epiphysis, across deep zone of growth plate to periphery. Open reduction and fixation often necessary

**Type IV.** Fracture line extends from articular surface through epiphysis, growth plate, and metaphysis. If fractured segment not perfectly realigned with open reduction, osseous bridge across growth plate may occur, resulting in partial growth arrest and joint angulation



**Type V.** Severe crushing force transmitted across epiphysis to portion of growth plate by abduction or adduction stress or axial load. Minimal or no displacement makes radiographic diagnosis difficult; growth plate may nevertheless be damaged, resulting in partial growth arrest or shortening and angular deformity

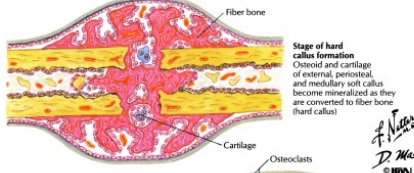
**Type VI.** Portion of growth plate sheared or cut off. Raw surface heals by forming bone bridge across growth plate, limiting growth on injured side and resulting in angular deformity



**Stage of inflammation**  
Promptly after impact, hematoma forms as result of disruption of intrasosseous, periosteal, and surrounding blood vessels. Bone at edges of fracture dies. Leukocytes, macrophages, mast cells, and fibroblasts infiltrate clot and begin to remove dead bone. Precise inductive mechanism for healing process not known



**Stage of soft callus formation**  
Clot organized by collagen fibers and vascular elements. New vessels grow in, but  $P_{O_2}$  low, pH acidic. Osteoprogenitor cells, preosteocytes, and osteoblasts of cambium layer of periosteum and endosteum proliferate. Osteoblasts and chondroblasts of mesenchymal origin also appear in clot. Soft callus forms, composed of osteoid, cartilage, and collagen



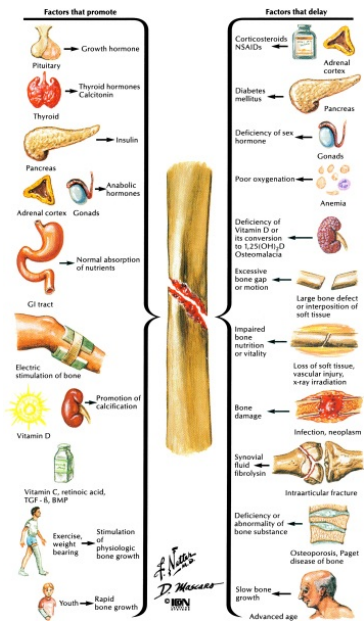
**Stage of hard callus formation**  
Osteoid and cartilage of external, periosteal, and medullary soft callus become mineralized as they are converted to fiber bone (hard callus)



**Stage of bone remodeling**  
Osteoclastic and osteoblastic activity converts fiber bone to lamellar bone with true Haversian systems. Normal bone contours restored; even angulation may be partially or completely corrected.  $P_{O_2}$  returns to normal

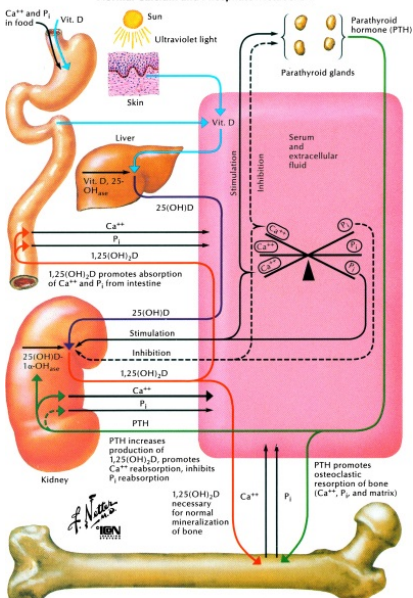
*F. Netter*  
*D. Mincato*  
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STRUCTURE	COMMENT
<b>Stages of Bone Healing</b>	
Inflammation	Hematopoietic cells, fibroblasts, osteoprogenitor cells
Repair	Callus formation (hard or soft), woven bone formation (enchondral)
Remodeling	Lamellar bone replaces woven, bone assumes normal shape, and repopulation of the marrow









STRUCTURE	COMMENT
<b>Bone Healing Factors</b>	
Minerals	Calcium, Phosphate

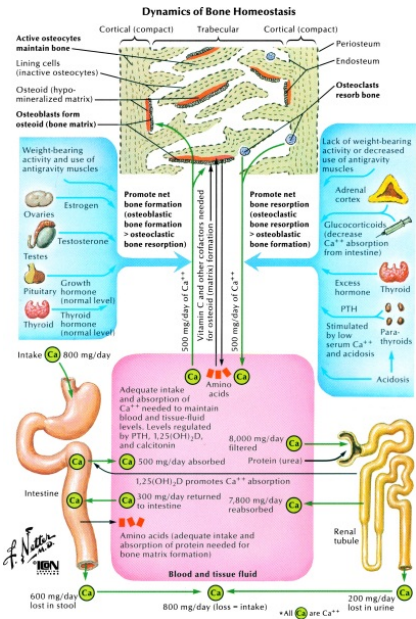
## Normal Calcium and Phosphate Metabolism



## Regulation of Calcium and Phosphate Metabolism

Hormone	Parathyroid hormone (PTH) (peptide)	1,25(OH) <sub>2</sub> D (steroid)	Calcitonin (peptide)
			
	From chief cells of parathyroid glands	From proximal tubule of kidney	From parafollicular cells of thyroid gland
Factors stimulating production	Decreased serum Ca <sup>++</sup>	Elevated PTH Decreased serum Ca <sup>++</sup> Decreased serum P <sub>i</sub>	Elevated serum Ca <sup>++</sup>
Factors inhibiting production	Elevated serum Ca <sup>++</sup> Elevated 1,25(OH) <sub>2</sub> D	Decreased PTH Elevated serum Ca <sup>++</sup> Elevated serum P <sub>i</sub>	Decreased serum Ca <sup>++</sup>
End organs for hormone actions	 No direct effect Acts indirectly on bowel by stimulating production of 1,25(OH) <sub>2</sub> D in kidney	Strongly stimulates intestinal absorption of Ca <sup>++</sup> and P <sub>i</sub>	?
	 Stimulates 25(OH)D-1α-OHase in mitochondria of proximal tubular cells to convert 25(OH)D to 1,25(OH) <sub>2</sub> D Increases fractional reabsorption of filtered Ca <sup>++</sup> Promotes urinary excretion of P <sub>i</sub>	?	?
	 Stimulates osteoclastic resorption of bone Stimulates recruitment of preosteoclasts	Strongly stimulates osteoclastic resorption of bone ? Role in normal human physiology	Inhibits osteoclastic resorption of bone ? Role in normal human physiology
Net effect on calcium and phosphate concentrations in extracellular fluid and serum	Increased serum calcium Decreased serum phosphate	Increased serum calcium Increased serum phosphate	Decreased serum calcium (transient)

STRUCTURE	COMMENT
<b>Main Hormones</b>	Parathyroid hormone (PTH), Vitamin D, Calcitonin (see fig.___)
<b>Other Hormones</b>	
Estrogen	Inhibits bone resorption
Corticosteroids	Increases bone loss
Thyroid hormone	Normal levels promote bone formation, increased levels enhance resorption
Growth hormone	Promotes bone formation



STRUCTURE	COMMENT
<b>Metabolic Disorders</b>	
<b>Hypercalcemia</b>	Symptoms: constipation, nausea, abdominal pain, confusion, stupor, coma
<b>1° hyperparathyroidism</b>	Increased urine calcium, decreased serum phosphate, "brown tumors" result
<b>2° hyperparathyroidism</b>	Malignancy #1, Multiple Endocrine Neoplasm (MEN) syndromes
<b>Hypocalcemia</b>	Symptoms: hyperreflexia, tetany + Chvostek's/Trousseau's sign, papilledema, prolonged QT interval
<b>1° hypoparathyroidism</b>	Hair loss, vitiligo
<b>Renal osteodystrophy</b>	Chronic renal failure, "Rugger jersey" spine
<b>Rickets/osteomalacia</b>	Decreased/failed mineralization, Vitamin D deficiency
<b>Osteoporosis</b>	Decreased bone mass, elderly
<b>Scurvy</b>	Vitamin C deficiency results in defective collagen
<b>Osteopetrosis</b>	Increased bone density due to reduced osteoclast activity
<b>Paget's Disease</b>	Simultaneous osteoblast osteoclast activity results in dense, but more brittle bones





**Grade I.** Stretching of ligament with minimal disruption of fibers



**Grade II.** Tearing of up to 50% of ligament fibers; small hematoma. Hemarthrosis may be present



**Grade III.** Complete tear of ligament and separation of ends, hematoma, and hemarthrosis

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STRUCTURE	COMMENT
<b>Cartilage</b>	Several types:
Hyaline	Articular surfaces, physal plates
Fibrocartilage	Annulus fibrosis, meniscus, pubic symphysis
Elastic	Nose, ears
<b>Articular Cartilage</b>	
Function	Distribute load over large surface, low friction motion surface
Components	Water, collagen <b>type II</b> , proteoglycans, chondrocytes
Water content	Decreases with age, increases in osteoarthritis
<b>Osteoarthritis</b>	<p><b>#1 form of arthritis</b>, articular cartilage defect/damage.                      Primary, "wear and tear"; or secondary, (e.g., posttraumatic.)                      Often found in hands and weight-bearing joints, <b>knees #1 site</b>  <b>Classic radiographic findings:</b></p> <ol style="list-style-type: none"> <li>1. Osteophytes</li> <li>2. Subchondral cysts</li> <li>3. Subchondral sclerosis</li> <li>4. Joint space narrowing</li> </ol>
<b>Inflammatory Arthritis</b>	<b>Rheumatoid, SLE, spondyloarthropathy, gout</b>
<b>Rheumatoid Arthritis</b>	<p>Immune disorder targeting the synovium. Chronic synovitis and pannus ormaton lead to articular surface and joint destruction.</p> <p><b>3: 1 women</b>, associated with <b>HLA-DR4</b>, +RF, increased ESR/CRP                      Multiple joints affected: <b>MCPs: ulnar deviation, feet: claw toe common</b>                      Findings: morning stiffness, nodules, radiographs:</p> <ol style="list-style-type: none"> <li>1. Bone erosions (periarticular)</li> <li>2. Osteopenia</li> <li>3. Swelling</li> </ol>
<b>Reiter's Syndrome</b>	Triad: Urethritis, conjunctivitis, asymmetric arthritis; + HLA-B27
<b>Gout</b>	<p>Mono-sodium urate crystals in the joint induce an inflammatory rxn                      Old men, great toe #1 site, elevated uric acid levels often seen                      Crystals: negatively birefringent</p>
<b>Ligaments</b>	Attach one bone to another
Ligament bone attachment	<ol style="list-style-type: none"> <li>1. Ligament to fibrocartilage</li> <li>2. Fibrocartilage to calcified fibrocartilage, (most injuries occur here)</li> <li>3. Calcified fibrocartilage to bone (Sharpey's fibers)</li> </ol>
<b>Sprain</b>	Tear of a ligament.
Grade I	Stretching of, or minor tear in, ligament; no laxity
Grade II	Incomplete tear, laxity is evident (usually swelling)



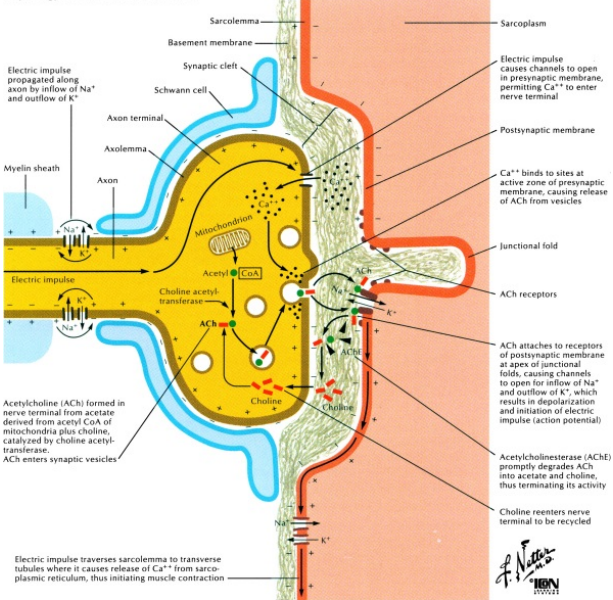
Grade III	Complete tear, increased laxity (swelling/hematoma)
<b>Ligament Strength</b>	Relative strength difference between ligament and one predict injury
Pediatrics	Stronger than physis. Injury will occur at physis first
Adult	Bone stronger than ligament. Ligament will rupture first
Geriatrics	Ligament stronger than bone. Bone will fracture first

Comparison of Osteoporosis and Osteomalacia		
Definition	<div> <div> <p>Unmineralized matrix</p> <p>Mineralized matrix</p> <p>Normal</p> </div> <div> <p>Unmineralized matrix</p> <p>Mineralized matrix</p> <p>Bone mass decreased, mineralization normal</p> </div> <div> <p>Unmineralized matrix</p> <p>Mineralized matrix</p> <p>Bone mass variable, mineralization decreased</p> </div> </div>	
Age at onset	<div> <p>Generally elderly, postmenopausal</p> </div> <div> <p>Any age</p> </div>	
Etiology	<div>Endocrine abnormality, age, idiopathic, inactivity, disuse, alcoholism, calcium deficiency</div> <div>Vitamin D deficiency, abnormality of vitamin D pathways, hypophosphatemic syndromes, renal tubular acidosis, hypophosphatosis</div>	
Symptomatology	<div> <p>Pain referable to fracture site</p> </div> <div> <p>Generalized bone pain</p> </div>	
Signs	Tenderness at fracture site	Tenderness at fracture site and generalized tenderness
Radiographic features	<div> <p>Axial predominance</p> </div> <div> <p>Often symmetric, pseudofractures, or completed fractures</p> <p>Appendicular predominance</p> </div>	
Laboratory findings	<div>Serum <math>Ca^{++}</math></div> <div>Serum <math>P_i</math></div> <div>Alkaline phosphatase</div> <div>Urinary <math>Ca^{++}</math></div> <div>Bone biopsy</div>	<div>Low (or normal) (high in hypophosphatosis)</div> <div>Low or normal</div> <div><math>Ca^{++} \times P_i &gt; 30</math> (if albumin normal) (high in renal osteodystrophy)</div> <div>Elevated, except in hypophosphatosis</div> <div>Normal or low (high in hypophosphatosis)</div> <div>Tetracycline labels normal</div> <div>Tetracycline labels abnormal</div>

NERVES

STRUCTURE	COMMENT
<b>Cellular Anatomy</b>	
Neuron	Cell body. Dendrites receive signal, axon conveys signal
Glial cells	Schwann cells produce myelin to cover the axon
<b>Microanatomy</b>	Peripheral nerve has both afferent and efferent fibers
Afferent fibers (axon)	Transmits sensory signals from peripheral nerve endings to the CNS Cell bodies are in the dorsal root ganglion (DRG)
Efferent fibers (axon)	Transmits motor signals from CNS via ventral horn/ventral root to peripheral muscles.
Endoneurium	Surrounds each individual fiber (axon)
Fascicles	Group of endoneurium coated fibers
Perineurium	Surrounds each fascicle
Peripheral nerve	Groups of fascicles, blood vessels, and connective tissue
Epineurium	Surrounds the groups of fascicles (nerves)
<b>Nerve Injuries</b>	Based on microanatomy
Neuropraxia	Conduction disruption, axon intact; resolves in days to weeks
Axontmesis	Axon disrupted, endoneurium intact allows axon regeneration; recovery is slow, growth 1mm/day, but usually full
Neurotmesis	Nerve transection, recovery requires surgical repair
<b>Poliomyelitis</b>	Viral destruction of ventral horn (motor) cells resulting in weakness/paralysis, but normal sensation. Vaccine for prevention.
<b>Nerve Conductions</b>	Facilitated by myelin coating on axon (larger/coated fibers are faster)
Resting potential	Maintained by a polar difference between intra/extracellular environments
Action potential	Change in permeability of Na+ ions depolarizes cell.
Nodes of Ranvier	Gaps between Schwann cells that facilitate conduction
<b>Nerve Conduction</b>	Evaluates motor and sensory peripheral nerves
<b>Studies (NCS)</b>	Stimuli is given and followed by surface electrodes. Latency (delay) and amplitude (strength of signal) are measured.
	Conduction velocities, 50m/s are abnormal
<b>Guillain-Barré Syndrome</b>	Ascending motor weakness/paralysis. Caused by demyelination of peripheral nerves following viral illness. Most self-limiting.
<b>Charcot-Marie-Tooth</b>	Autosomal dominant disorder. Demyelinating disorder affecting motorsensory nerves. Onset 5-15yrs, peroneal muscles first, then hand foot intrinsics. Can result in cavus foot, claw toe, intrinsic minus hand.
<b>Neuromuscular junction</b>	Axon of motor neuron synapses with the muscle (motor end plate)
Neurotransmitter	Acetylcholine stored in axon crosses synaptic cleft and binds to receptors on sarcoplasmic reticulum and depolarizes
Pharmacologic agents	Nondepolarizing agents (e.g., vecuronium) competitively bind Ach receptor
	Depolarizing agents (e.g. succinylcholine) bind short term to Ach receptor
	Toxins/nerve gas: also bind these receptors competitively; treat with anticholinesterase agents (increase Ach levels in cleft)
<b>Myasthenia gravis</b>	Relative shortage of acetylcholine receptors due to competitive binding by thymus derived antibodies. Treat with thymectomy or anti-acetylcholinesterase agents (increase acetylcholine levels in cleft)
<b>Motor Unit</b>	All the muscles innervated by a single motor neuron

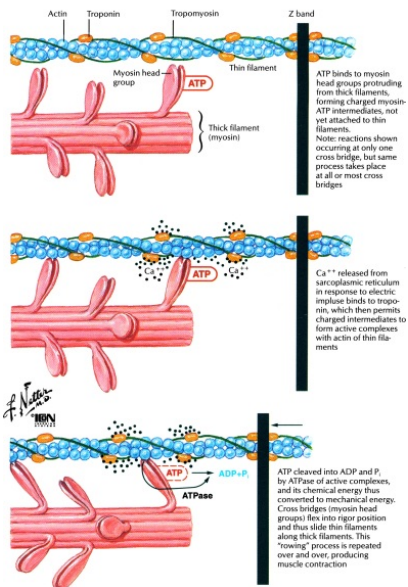
# Physiology of Neuromuscular Junction



MUSCLES (SKELETAL)

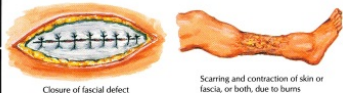
STRUCTURE	COMMENT
Types of Muscle	Smooth, cardiac, skeletal
Skeletal	Voluntary control, have an origin and insertion
Anatomy	Muscles cells have two types of contractile filaments: actin, myosin
Muscle	Comprised of multiple bundles or fascicles; surrounded by epimysium
Bundle/Fascicle	Comprised of multiple muscle fibers (cells); surrounded by perimysium
Fiber (cell)	Comprised of multiple myofibril; surrounded by endomysium
Myofibril	Comprised of multiple sarcomeres, end to end; no surrounding tissue
Sarcomere	Comprised of interdigitated thick and thin filaments; organized into bands. Z line to Z line defines the sarcomere A band: length of thick filaments, does not change with contraction I band, H zone, and sarcomere length all shorten with contraction
Myosin	Thick filament: have “heads” that bind ATP and attach to thin filaments
Actin	Thin filaments: fixed to Z bands; associated with troponin and tropomyosin
Troponin	Associated with actin and tropomyosin, binds Ca++ ions
Tropomyosin	Long molecule, lies in helical groove of actin and blocks myosin binding
Contraction	Initiated when Acetylcholine binds to receptors on sarcoplasmic reticulum and depolarizes them. Depolarization causes a release of Ca++ which then binds to troponin molecules. This binding causes the tropomyosin to move and the “charged” head (ATP bound) of myosin can bind to actin. Breakdown of ATP causes contraction of filaments, (shortening of sarcomere), and the release of the myosin from the actin filament.
Electromyography (EMG)	Intramuscular electrodes used to evaluate muscle function. Increased frequency, decreased duration, decreased amplitude indicate myopathy; opposite findings indicative of neuropathy.
Types of Contraction	
Isometric	Muscle fires against increasing resistance, muscle length is constant
Isotonic	Resistance is constant through contraction
Isokinetic	Muscle contracts at a constant speed
Eccentric	Muscle lengthens when it fires; can cause injury
Concentric	Muscle shortens when it fires
Strength	Related to cross sectional area of muscle
Duchene Muscular Dystrophy	X-linked recessive disorder affecting boys. Progressive, noninflammatory process affecting proximal muscles (increased CPK). Birth and development to age 3-5 usually normal, then weakness, clumsy walking, + Gower's sign (uses hands to rise from floor) and calf pseudohypertrophy. Most wheelchair bound by 15. Multiple associated deformities, contractures, scoliosis, etc.

# Biochemical Mechanics of Muscle Contraction

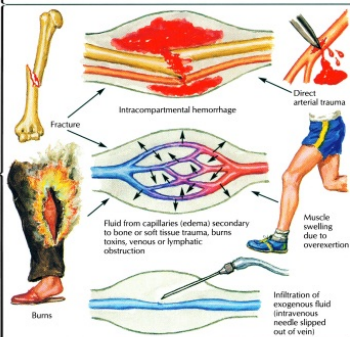


STRUCTURE	COMMENT
<b>Compartments</b>	Muscles are located within confined fibroosseous/fascial spaces
<b>Compartment Syndrome</b>	Multiple causes of increased compartment pressures. Increased pressures and decreased perfusion resulting in myonecrosis.
	5 P's: Pain, parathesias, paralysis, pallor, pulselessness (not all needed for diagnosis). Firm tense compartments on exam.
	Fasciotomy within 6 hours needed. Contracture can result.
<b>Musculotendinous</b>	Weakest portion of muscular attachment to bone (injuries occur here)
<b>Junction</b>	Muscle strain is a partial tear of this unit
<b>Tendon Anatomy</b>	Attaches muscles to bones
<b>Fibril</b>	Type I collagen grouped into microfibrils, then subfibrils, then fibrils, surrounded by endotenon
<b>Fascicle</b>	Fibroblasts and fibrils surrounded by peritenon
<b>Tendon</b>	Groups of fascicles surrounded by epitenon
<b>Vascular Tendon</b>	Vascular paratenon surrounds tendon to supply vascularity; no sheath
<b>Avascular Tendon</b>	These tendons are in a sheath, have a vincula to supply vascularity
<b>Tendon bone Junction</b>	<ol style="list-style-type: none"> <li>1. Tendon to fibrocartilage</li> <li>2. Fibrocartilage to calcified fibrocartilage (Sharpey's fibers)</li> <li>3. Sharpey's fibers to bone.</li> </ol>

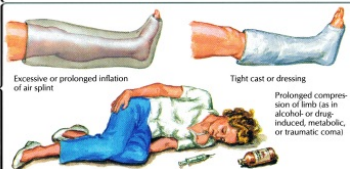
Constriction of compartment



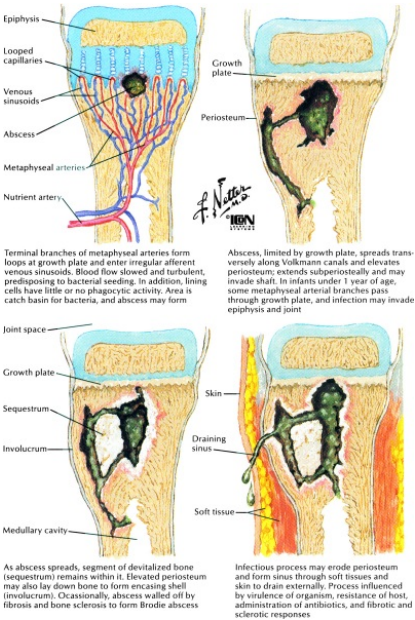
Increased fluid content in compartment



External compression



MICROBIOLOGY



INFECTION	COMMENT
Osteomyelitis	Bacterial infection of bone or bone marrow. <i>Staph. aureus</i> #1 organism.
	Hematogenous spread most common. Classified as acute, subacute, or chronic.
	Pain, swelling, increased WBC, ESR, positive blood cultures. XR shows radiolucencies, +/- sequestrum (dead cortical bone), involucrum (periosteal new bone). Bone scan helps diagnosis. ID abscess/sequestra, IV antibiotics followed by a course of oral antibiotics
Septic Joint	Infection of joint space (and synovium). <i>Staph. aureus</i> #1 organism.
	Hematogenous or extension of osteomyelitis common routes. Knee #1, hip #2 most common sites. Painful, warm swollen joint.
	Requires aspiration/surgical drainage IV antibiotics.
Tetanus	Neuromuscular disorder caused from exotoxin from <i>Clostridium tetani</i>
	Vaccine prophylaxis: Tetanus and diphtheria toxoid (Td); Tetanus immunoglobulin (TIG)
	Previously vaccinated (5yrs), clean wound: no treatment
	Previously vaccinated (5yrs), clean or dirty wound: 0.5mg Td
	Unknown vaccination status or "dirty" wound: Td and TIG

IMAGING

STUDY	COMMENT
X-ray (plain film)	Standard study, multiple views needed, shows bones well, but soft tissues poorly. The joint above and below a fracture should always receive plain films.
CT	Best study for bony anatomy. Soft tissue seen, but not as well as MRI. Often used for comminuted fractures and preoperative planning.
MRI	Best study for soft tissues including intervertebral discs, ligaments, tendons. Also highly sensitive for osteonecrosis; T1 images weighted for fat (good for normal anatomy), T2 images weighted for water (better for pathology). Also used for preoperative planning
Bone scan	Radioactive isotope injected into blood. Imaging of the whole body allows visualization of areas of increased uptake. Good for identifying tumor, fractures, infections, and heterotopic bone activity (HO).
Arthrography	Contrast injected into joint followed by plain films to evaluate capsular integrity (e.g. used for rotator cuff tears)
Myelography	Contrast injected into epidural space; evaluates disc herniation, cord tumors
Discography	Contrast injected into nucleus pulposus to evaluate disc degeneration. Not a common procedure.
Ultrasound	Good for evaluating rotator cuff pathology



**ABBREVIATIONS USED IN THIS BOOK**

**A**

<b>Abd</b>	<i>abduct</i>
<b>AC</b>	<i>acromioclavicular</i>
<b>ACL</b>	<i>anterior cruciate ligament</i>
<b>ADM</b>	<i>abductor digiti minimi</i>
<b>AGRAM</b>	<i>arthrogram</i>
<b>AIIS</b>	<i>anterior inferior iliac spine</i>
<b>AIN</b>	<i>anterior interosseus nerve</i>
<b>ALL</b>	<i>anterior longitudinal ligament</i>
<b>AMBRI</b>	<i>atraumatic, multidirectional, bilateral instability</i>
<b>ANA</b>	<i>antinuclear antibody</i>
<b>Ant.</b>	<i>anterior</i>
<b>AP</b>	<i>anteroposterior</i>
<b>APB</b>	<i>abductor pollicis brevis</i>
<b>APC</b>	<i>anterior-posterior compression</i>
<b>APL</b>	<i>abductor pollicis longus</i>
<b>ASIS</b>	<i>anterior superior iliac spine</i>
<b>AVN</b>	<i>avascular necrosis</i>

**B**

<b>BR</b>	<i>brachioradialis</i>
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**C**

<b>Ca<sup>++</sup></b>	<i>ion calcium</i>
<b>CBC</b>	<i>complete blood cell count</i>

<b>CL</b>	<i>capitate-lunate joint</i>
<b>CMC</b>	<i>carpal-metacarpal</i>
<b>CPK</b>	<i>creatine phosphokinase</i>
<b>CRP</b>	<i>C-reactive protein</i>
<b>C-spine</b>	<i>cervical spine</i>
<b>CT</b>	<i>computed tomography</i>
<b>CTL</b>	<i>capitotriquetral ligament</i>
<b>CTS</b>	<i>carpal tunnel syndrome</i>

## D

<b>DDD</b>	<i>degenerative disk disease</i>
<b>DIO</b>	<i>dorsal interossei</i>
<b>DIP</b>	<i>distal interphalangeal</i>
<b>DISI</b>	<i>dorsal intercalated segment instability</i>
<b>DJD</b>	<i>degenerative joint disease</i>
<b>DRC</b>	<i>dorsal radiocarpal ligament</i>
<b>DRUJ</b>	<i>distal radioulnar joint</i>
<b>DVT</b>	<i>deep vein thrombosis</i>

## E

<b>ECRB</b>	<i>extensor carpi radialis brevis</i>
<b>ECRL</b>	<i>extensor carpi radialis longus</i>
<b>ECU</b>	<i>extensor carpi ulnaris</i>
<b>EDC</b>	<i>extensor digitorum communis</i>
<b>EDL</b>	<i>extensor digitorum longus</i>
<b>EDM</b>	<i>extensor digiti minimi</i>

<b>EHL</b>	<i>extensor hallucis longus</i>
<b>EIP</b>	<i>extensor indicis proprius</i>
<b>EMG</b>	<i>electromyogram</i>
<b>EPB</b>	<i>extensor pollicis brevis</i>
<b>EPL</b>	<i>extensor pollicis longus</i>
<b>ER</b>	<i>external rotation</i>
<b>ESR</b>	<i>erythrocyte sedimentation rate</i>

## F

<b>FCR</b>	<i>flexor carpi radialis</i>
<b>FCU</b>	<i>flexor carpi ulnaris</i>
<b>FDB</b>	<i>flexor digitorum brevis</i>
<b>FDL</b>	<i>flexor digitorum longus</i>
<b>FDMB</b>	<i>flexor digiti minimi brevis</i>
<b>FDP</b>	<i>flexor digitorum profundus</i>
<b>FDS</b>	<i>flexor digitorum superficialis</i>
<b>FHB</b>	<i>flexor hallucis brevis</i>
<b>FHL</b>	<i>flexor hallucis longus</i>
<b>FPB</b>	<i>flexor pollicis brevis</i>
<b>FPL</b>	<i>flexor pollicis longus</i>
<b>Fx</b>	<i>fracture</i>

## G

<b>GAG</b>	<i>glycosaminoglycans</i>
<b>GI</b>	<i>gastrointestinal</i>
<b>GU</b>	<i>genitourinary</i>

## H

**HNP**    *hemiated nucleus pulposus*

**Hx**    *history*

## I

**ID**    *incision and drainage*

**IF**    *index finger*

**IJ**    *internal jugular*

**IM**    *intramedullary*

**Inf.**    *inferior*

**IP**    *interphalangeal*

**IR**    *internal rotation*

**ITB**    *iliotibial band*

**IV**    *intravenous*

## L

**Lat.**    *lateral*

**LBP**    *lowback pain*

**LC**    *lateral compression*

**LCL**    *lateral collateral ligament*

**LE**    *lower extremity*

**LFCN**    *lateral femoral cutaneous nerve*

**LH**    *long head*

**LT**    *lunotriquetral*

## M

**MC**    *metacarpal*

**MCL**    *medial collateral ligament*

**MCP**    *metacarpophalangeal*

**MDI**    *multidirectional instability*

**Med.**    *medial*

**MF**    *middle finger*

**MRI**    *magnetic resonance imaging*

**MT**    *metatarsal*

**MVA**    *motor vehicle accident*

**N**

**N.**    *nerve*

**NCS**    *nerve conduction study*

**NSAID**    *non-steroidal anti-inflammatory drug*

**O**

**OA**    *osteoarthritis*

**OP**    *opponens pollicis muscle*

**ORIF**    *open reduction, internal fixation*

**P**

**PAD**    *palmar adduct*

**PCL**    *posterior cruciate ligament*

**PCP**    *percutaneous pinning*

**PE**    *physical examination*

**PFCN**    *posterior femoral cutaneous nerve*

**PFS**    *patellofemoral syndrome*

**PIN**    *posterior interosseus nerve*

<b>PIP</b>	<i>proximal interphalangeal</i>
<b>PL</b>	<i>palmaris longus</i>
<b>PLC</b>	<i>posterolateral corner complex</i>
<b>PLL</b>	<i>posterior longitudinal ligament</i>
<b>PLRI</b>	<i>posterolateral rotary instability</i>
<b>PMHx</b>	<i>past medical history</i>
<b>PMRI</b>	<i>posterolateral rotary instability</i>
<b>PO</b>	<i>postoperatively</i>
<b>Post.</b>	<i>posterior</i>
<b>PQ</b>	<i>pronator quadratus</i>
<b>PSIS</b>	<i>posterosuperior iliac spine</i>
<b>PT</b>	<i>pronator teres</i>
<b>PTH</b>	<i>parathyroid hormone</i>
<b>PVNS</b>	<i>pigmented villonodular synovitis</i>

## Q

<b>Q</b>	<i>quadriceps</i>
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## R

<b>RA</b>	<i>rheumatoid arthritis</i>
<b>RAD</b>	<i>radiation absorbed dose</i>
<b>RC</b>	<i>rotator cuff</i>
<b>RCL</b>	<i>radioscaphocapitate ligament</i>
<b>RF</b>	<i>rheumatoid factor, ring finger</i>
<b>RICE</b>	<i>rest, ice, compression, and elevation</i>
<b>ROM</b>	<i>range of motion</i>

**RSD**     *reflex sympathetic dystrophy*

**RSL**     *radioscapholunate ligament*

**RTL**     *radiolunotriquetral ligament*

## S

**SC**       *sternoclavicular*

**SCM**     *sternocleidomastoid*

**SF**       *small finger*

**SFA**     *superficial femoral artery*

**SH**       *short head*

**SI**       *sacroiliac*

**SL**       *scapholunate*

**SLAC**   *scapholunate advanced collapse*

**SLAP**   *superior labrum anterior/posterior*

**STT**     *scaphotrapezoid-trapezial*

**Sup.**     *superior*

**Sx**       *symptom*

## T

**TA**       *tibialis anterior*

**TCL**     *transverse carpal ligament*

**Td**       *tetanus and diphtheria toxoid*

**TFCC**   *triangular fibrocartilage complex*

**TFL**     *tensor fascia lata*

**THA**     *total hip arthroplasty*

**TIG**     *tetanus immunoglobulin*

**TLSO**    *thoracolumbosacral orthosis*

**TP**        *tibialis posterior*

**TTP**        *tenderness to palpation*

**TUBS**    *traumatic, unilateral instability, and Bankart lesion*

## U

**UE**        *upper extremity*

**UMN**    *upper motor neuron*

## V

**VIO**    *volar interosseus*

**VISI**    *volar intercalated segment instability*

**VMO**    *vastus medialis obliquus*

## W

**WB**        *weight bearing*

**WBC**    *white blood cell count*

## X

**XR**        *x-ray*