

Introduction to MSK Radiology

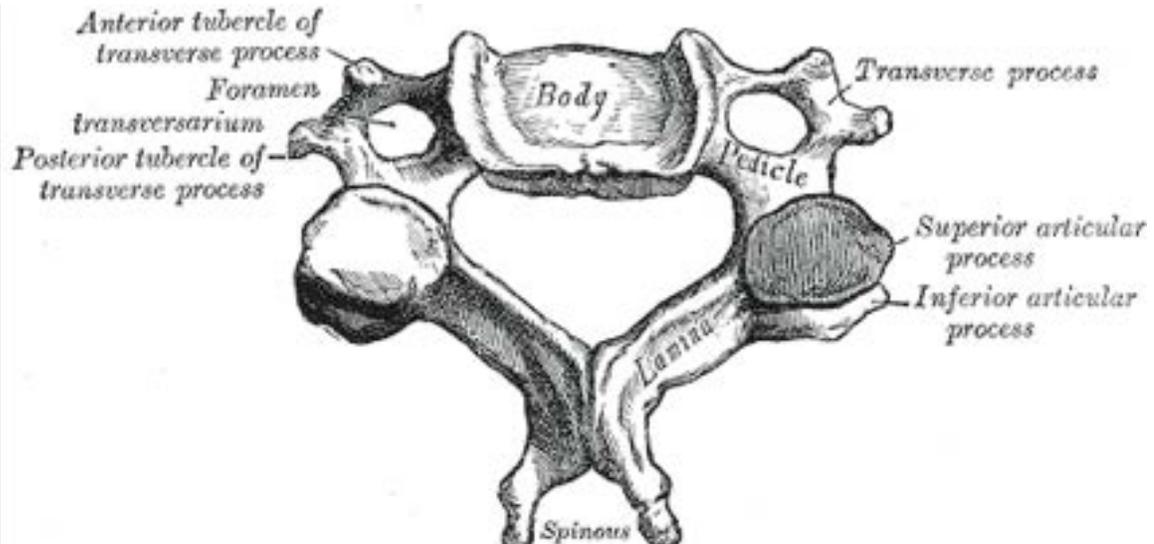
Please email any corrections or additions to ghchang@ucsd.edu

Recommended Reading: Skeletal Radiology by Helms

Cervical Spine

- As first years, you will most likely do two months of MSK radiology at both Hillcrest and the VA. At both locations, you will most likely be reading plain films and CTs.
- At UCSD, >90% of trauma are required to get a C-spine CT and thus, it will be a good idea to read as many as those as possible prior to taking call.
- This introduction is focused on trauma so it's not a complete introduction.

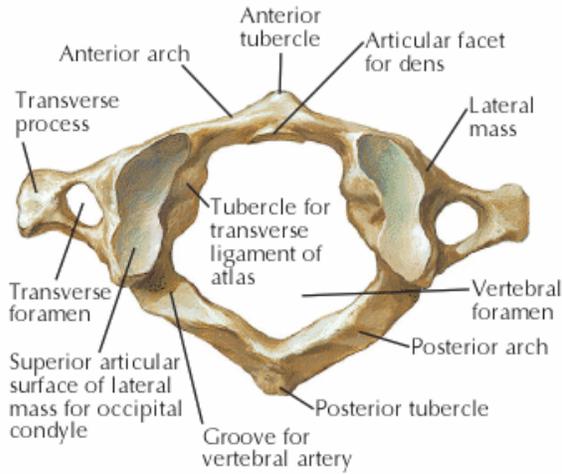
ANATOMY



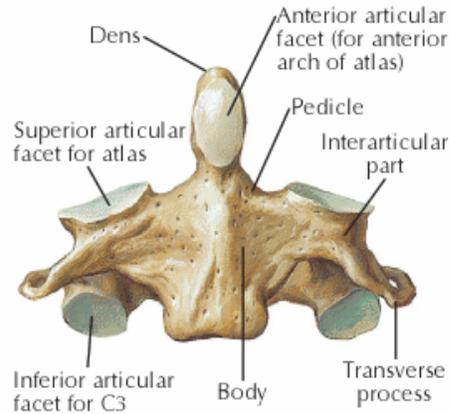
Wikipedia.com

- 7 cervical vertebrae (remember the cervical nerves exit above their corresponding vertebral body except C8)
- The top vertebra is called Atlas and its lies on Axis (C2), which has a protrusion called the odontoid process or dens.
- The lateral masses of the atlas rest on the edges of the Axis
- Typical cervical vertebra has a body, two transverse and one spinous process, two transverse and one vertebral foramen. Surrounding the vertebral foramen are two pedicles and two laminae.

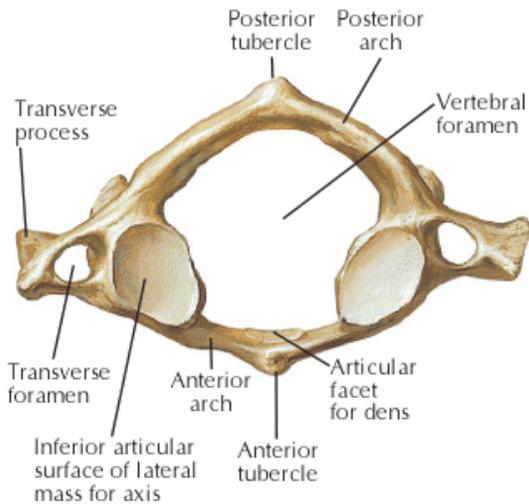
ATLAS AND AXIS



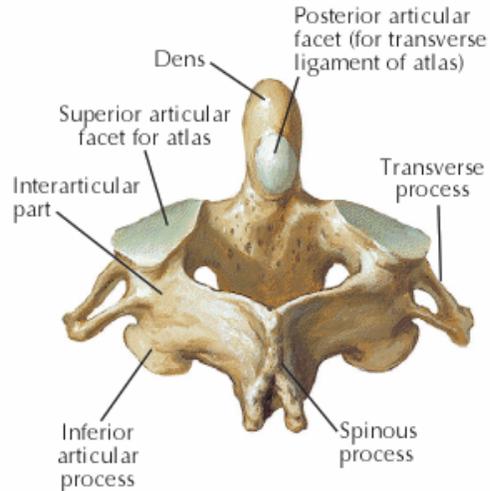
Atlas (C1): superior view



Axis (C2): anterior view



Atlas (C1): inferior view



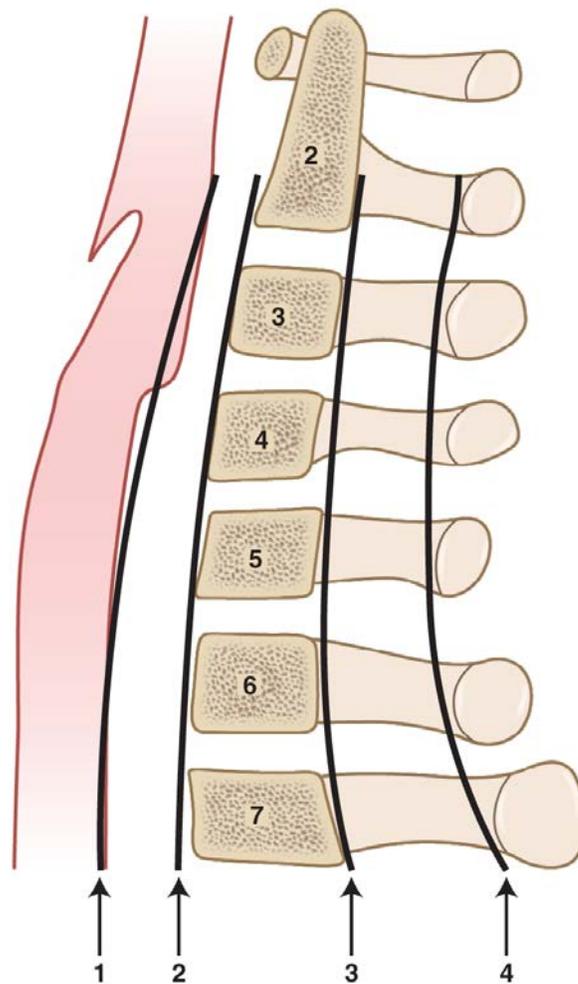
Axis (C2): posterosuperior view

The Netter collection of medical illustrations. Volume 6, Part 2. Spine and lower limb: Saunders, 2013

APPROACH—C spine Radiographs (usually bypassed unless CT is really not indicated); Lateral, Frontal & Odontoid views

- Lateral view:
 - Make sure all 7 cervical vertebra is completely visible; If not, recommend a swimmer's view, which is a lateral view with the patient's arm raised to display C7 more clearly
 - Alignment: ensure there are no step-off deformity; the most reliable line is the posterior vertebral line

- Look for any fractures; measure the distance between the odontoid process and the anterior portion of the atlas (C1). If this measurement is >3mm (in adults), a fracture/dislocation is suspected and patient will need CT
- Disc spaces: if decreased, likely degenerative changes
- Look at prevertebral soft tissue; no greater than >7mm at C3 and no greater than 21 mm at C7.



1= soft tissue line
 2= anterior vertebral line
 3 = posterior vertebral line
 4= posterior spinous line

Brant. Fundamentals of Diagnostic Radiology. 2012.

- Frontal view/ Odontoid Views
 - Frontal view: highest vertebrae often difficult to see; mostly used to confirm that there are no fractures; look for alignment of the spinous processes
 - Odontoid view: ensure that the lateral masses of the atlas are perfectly aligned with the edge of the Axis; slippage of lateral masses sideways is suggestive of a fracture



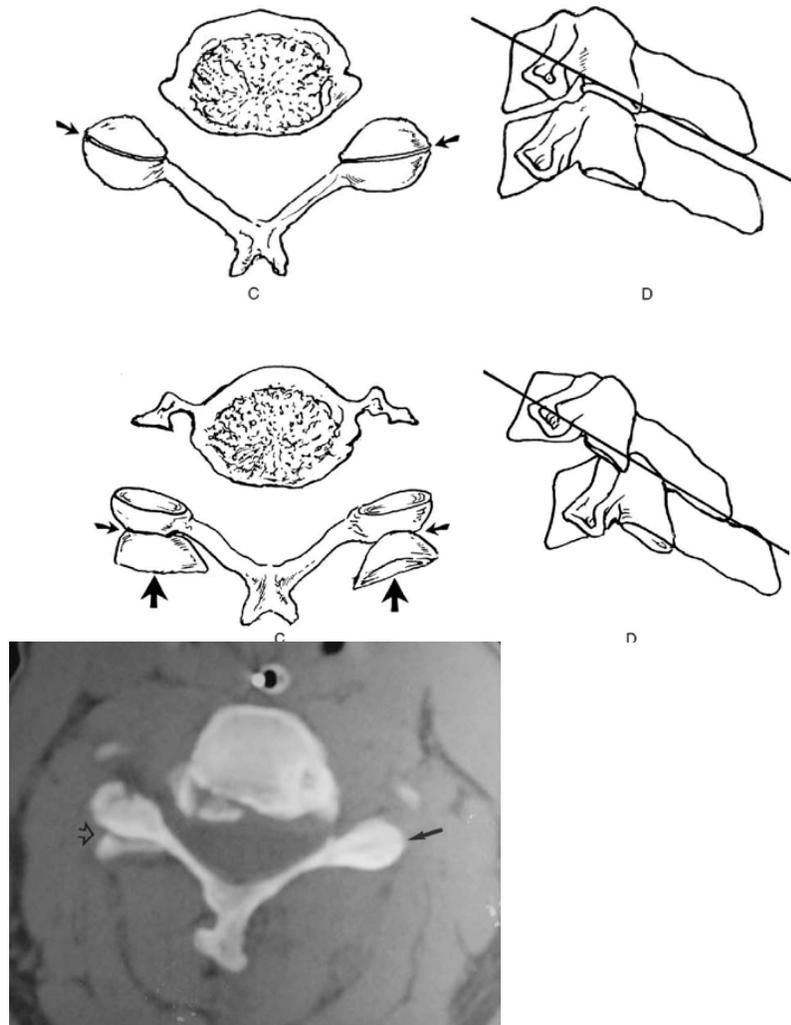
○



○ Bonepit.com

APPROACH—CT C spine

- Axial images
 - “Bone window”
 - Begin at the cephalad end of the series
 - Inspect each vertebral body for cortical defects representing fractures
 - Note any fracture fragments within the spinal canal or other impingement on the canal
 - Note fracture through the transverse foramen
 - Inspect facet joints for normal “hamburger bun” appearance; reverse hamburger bun may suggest a dislocated facet (open arrow: dislocated facet; skinny arrow: normal facet)



Daffner. Computed Tomography diagnosis of facet dislocations: the “hamburger bun” and “reverse hamburger bun” signs. *Journal of Emergency Medicine* 2002

- Sagittal images
 - Resemble lateral radiograph
 - Allow assessment of subluxation as well as fracture
 - Note any fracture fragments within the spinal canal
 - Inspect facet joints for normal overlap
- Coronal Images
 - Helpful for assessment of odontoid fractures/burst fractures of C1
 - Similar to open mouth/AP radiographs

PATHOLOGY

1. Atlantooccipital dislocation—dislocation at the junction between the atlas vertebra and the skull; often results in death (I have never seen one)



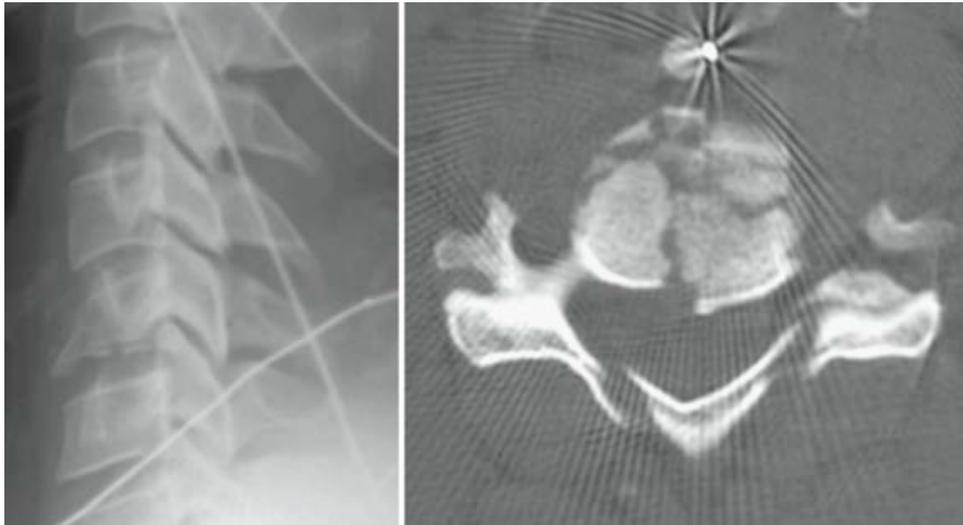
Deliganis. Radiologic Spectrum of Craniocervical Distraction Injuries. Radiographics. Oct. 2000

2. Facet joint dislocations—best seen on lateral view as a step deformity within the vertebral alignment; step deformity of >3 mm is abnormal and indicates that the spine is unstable; often due to hyperflexion of the cervical spine, causing disruption of the anterior longitudinal ligament, intervertebral disc and posterior ligaments; 3 types including subluxed, perched and locked.



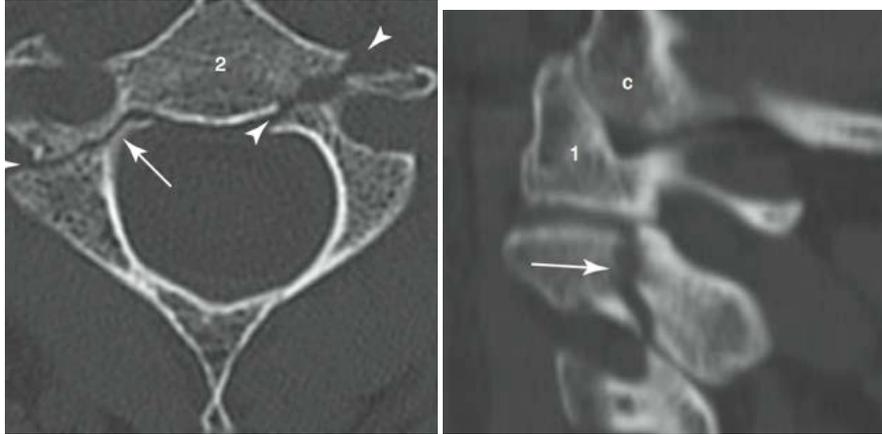
Manaster. Musculoskeletal Imaging: The Requisites. 2013

3. Flexion Teardrop Fractures: secondary to flexion injury; very unstable and severe; results in disruption of all ligaments as well as the intervertebral disc at the level of the injury; small fragment of the anteroinferior portion is broken off of a vertebral body with posterior displacement of the vertebral body itself; often results in anterior spinal cord compression.



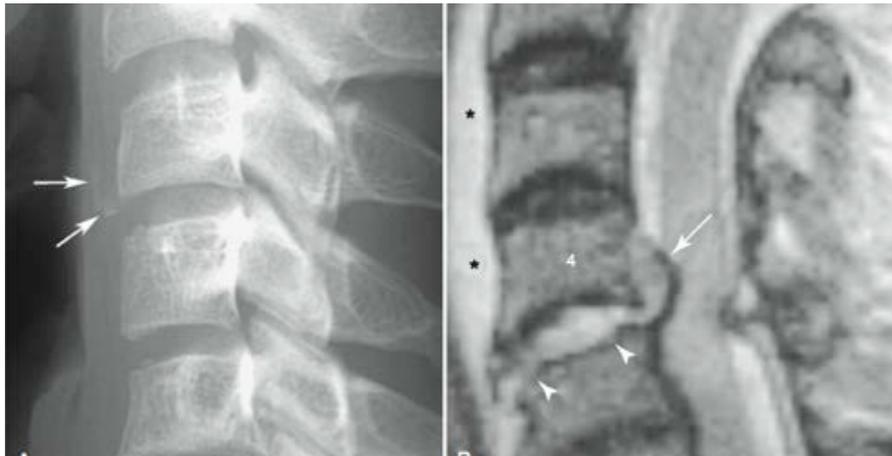
Manaster. Musculoskeletal Imaging: The Requisites. 2013

4. Hangman's fracture: secondary to extension injury; bilateral C2 pedicle fractures with anterior displacement of anterior part of C2



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5. Hyperextension injury: avulsion fracture at inferior endplate



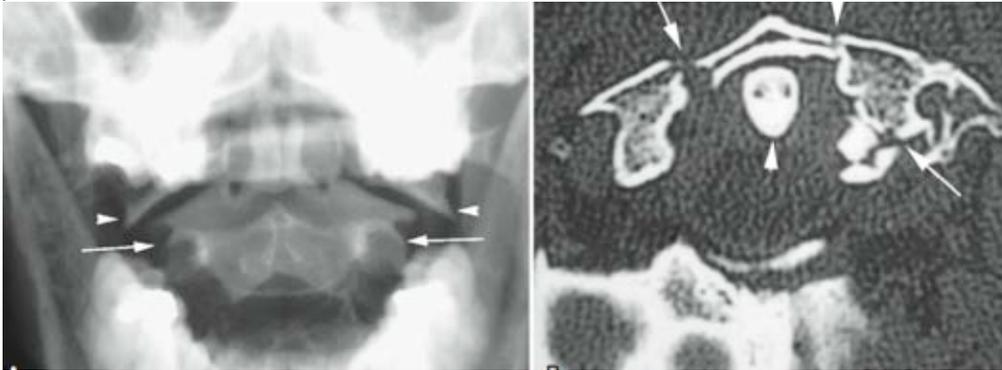
Manaster. Musculoskeletal Imaging: The Requisites. 2013

6. Burst Fracture: results from axial injury; compression of the vertebral body and results in both anterior and posterior vertebral body height loss; most common in mid-cervical spine



Munera. Imaging Evaluation of Adult Spinal Injuries: Emphasis on Multidetector CT in Cervical Spine Trauma. Radiology, 263: 3. June 2012.

7. Jefferson's Fracture: at least 2 fractures of C1



Manaster. Musculoskeletal Imaging: The Requisites. 2013

8. Odontoid: secondary to multidirectional injury; 3 types of odontoid fractures
- a. Type 1: Oblique avulsion fx of tip of odontoid due to avulsion of alar ligament
 - b. Type 2: Fx through waist; high nonunion rate
 - c. Type 3: Fx extends into cancellous body of C2 and involves a portion of the C1-C2 joint



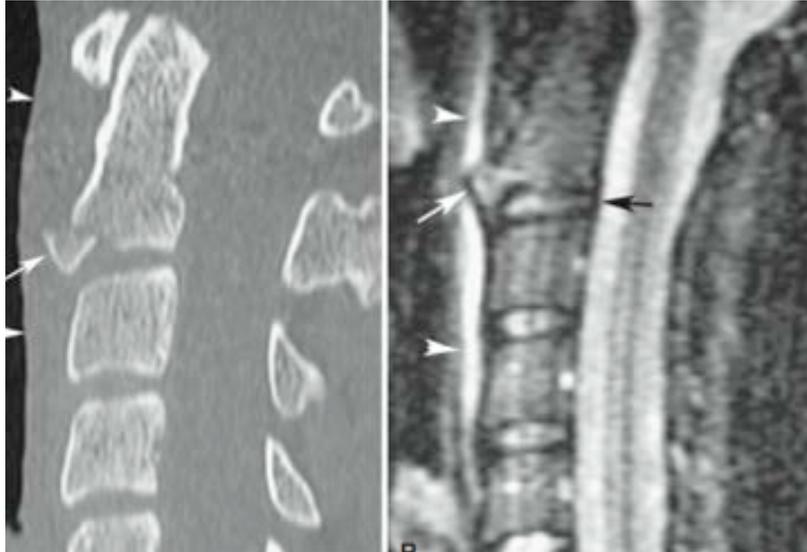
Munera. Imaging Evaluation of Adult Spinal Injuries: Emphasis on Multidetector CT in Cervical Spine Trauma. Radiology, 263: 3. June 2012.

9. Clay-Shoveler's: secondary to flexion injury; avulsion of a piece of the spinous process and most likely occurs on the lower C-spine



Brant. Fundamentals of Diagnostic Radiology 2012

10. Extension Teardrop: avulsion of a piece of the anteroinferior portion of a vertebrae



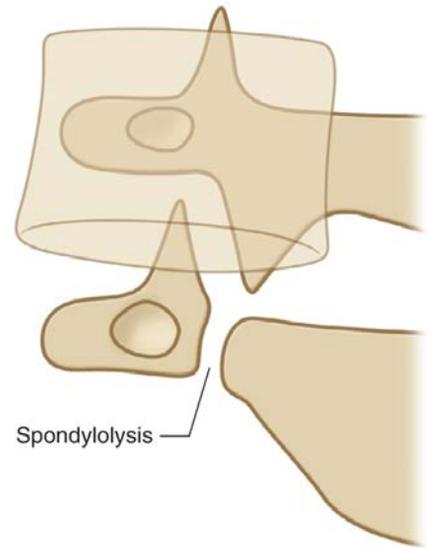
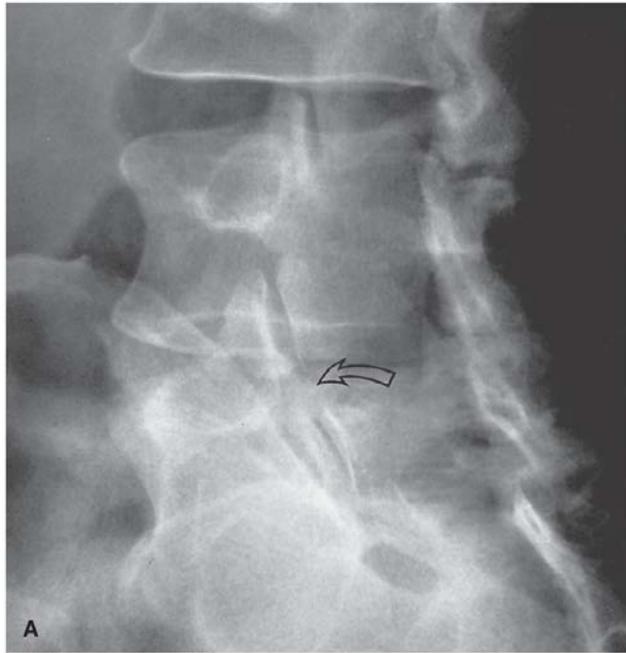
Manaster. Musculoskeletal Imaging: The Requisites. 2013

THORACOLUMBAR SPINE

- CT spines of the T and L spines are routinely acquired unless there is an abnormality on the plain film so I don't be going into as much detail

ANATOMY/APPROACH

- Thoracic spine has 12 vertebrae and concave anteriorly (kyphosis); the lumbar spine has 5 vertebrae and is concave posteriorly (lordosis)
- Typical vertebrae contains: vertebral body, vertebral foramen, 2 transverse processes, 1 spinous process, 2 pedicles, 2 pars interarticularis and 2 laminae.
- Frontal radiograph
 - Ensure that the distance between each intervertebral disk space is equal
 - Look for any step-deformities
 - Look for two pedicles at each levels
 - Fractures
- Lateral radiograph
 - Look for alignment
 - Ensure that the intervertebral disk spaces are even throughout
 - Compare the anterior and posterior cortex of each vertebral body
 - Look for black fracture lines in the spinous processes
- Oblique radiograph:
 - Front legs and hind legs: inferior intervertebral articular processes
 - Ears and tail: superior intervertebral articular processes
 - Body: laminae
 - Eye: Pedicle
 - Nose: transverse processes
 - Neck: Pars interarticularis



Brant. Fundamentals of Diagnostic Radiology 2012

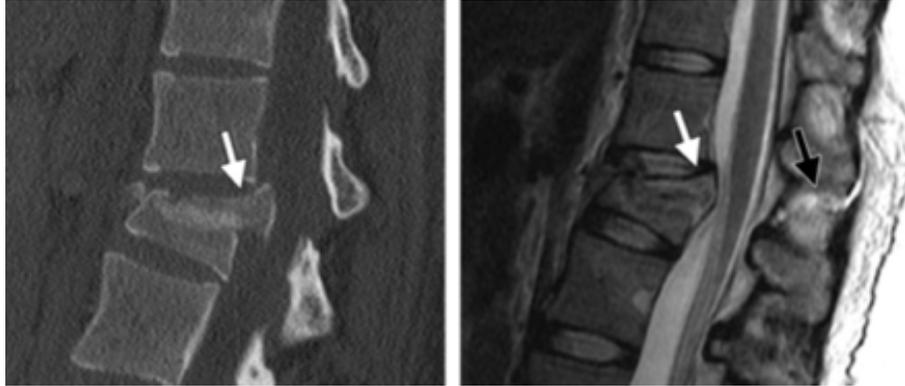
PATHOLOGY

1. Chance fracture: horizontal severing of a vertebra; fracture can extend through the spinous process; mechanism -> MVA, lap belt injury



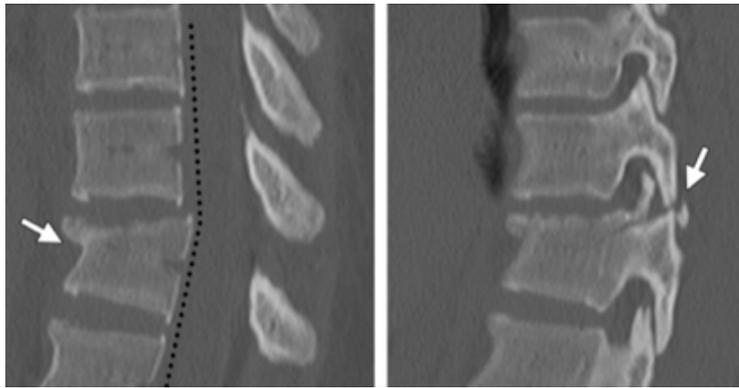
Manaster. Musculoskeletal Imaging: The Requisites. 2013

2. Burst fracture: collapse of an entire vertebral body; fragments can extend into the spinal canal and cause neurological damage; mechanism-> fall from height (example: boarder jumpers)



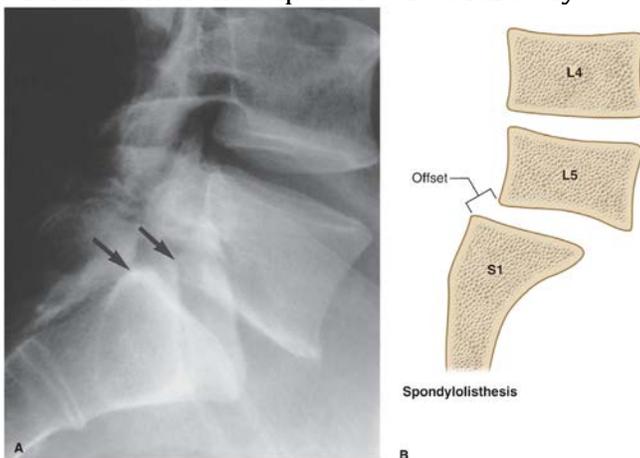
Khurana. Traumatic Thoracolumbar Spine Injuries: What the Spine Surgeon Wants to Know.

3. Compression fracture: compression of the anterior part of the vertebral body; stable fracture



Khurana. Traumatic Thoracolumbar Spine Injuries: What the Spine Surgeon Wants to Know.

4. Spinous process fracture: black fracture line in the spinous process; spinal canal/stability of spine are unaffected
5. Spondylolysis: defect in the pars interarticularis
6. Spondylolisthesis: bilateral pars interarticularis defects, causing anterior subluxation of the superior vertebral body



Brant. Fundamentals of Diagnostic Radiology 2012

PELVIS

APPROACH

- An AP view of the pelvis is always obtained on a trauma board.
- Pelvis fractures: if you see one, always look for the second one; ring never breaks at only one place
- Compare one side with the other
- Look for widening of the SI joints and pubic symphysis
- Look for black fracture lines in the iliac wings/sacrum

PATHOLOGY

1. Malgaigne fracture: fractures through the ischiopubic rami or pubic symphysis and the SI joint on the same side



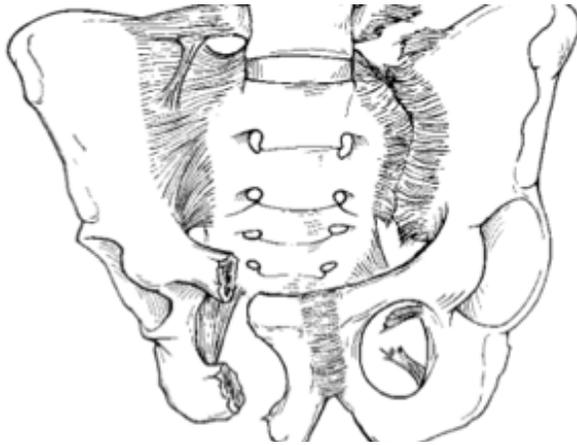
Manaster. Musculoskeletal Imaging: The Requisites. 2013

2. Open book fracture: fractures through the ischiopubic rami or pubic symphysis and SI joints on both sides



Haq, e t al. Classification of pelvic fractures and its clinical relevance. Symposium on pelvi trauma. 7:1, 8-13. 2014.

3. Bucket handle fracture: fractures through the ischiopubic rami on one side and SI joint fracture on the opposite side



Tile. Acute Pelvic Fractures: Causation and Classification. J Am Acad Orthop Surg 1996;4:143-151

4. Straddle fracture: fractures through both ischial rami and pubic rami



Gentilli.net

5. Rami fractures: located at both the ischial ramus and pubic ramus and stable
6. Avulsion fracture: avulsion fractures occurs when a small chip of bone is pulled off at the origin or insertion site of a tendon (Refer to my paper, Lower extremity overuse injuries in pediatric athletes: clinical presentation, imaging findings, and treatment in Clinical Imaging. Shameless advertising. However, there really is a good section on avulsion fractures about the pelvis)

UPPER & LOWER EXTREMITIES
COMMON PATHOLOGY & CLASSIFICATIONS

1. Proximal humerus fracture: classification based on the number and amount of displacement of bony fragments (Neer classification)

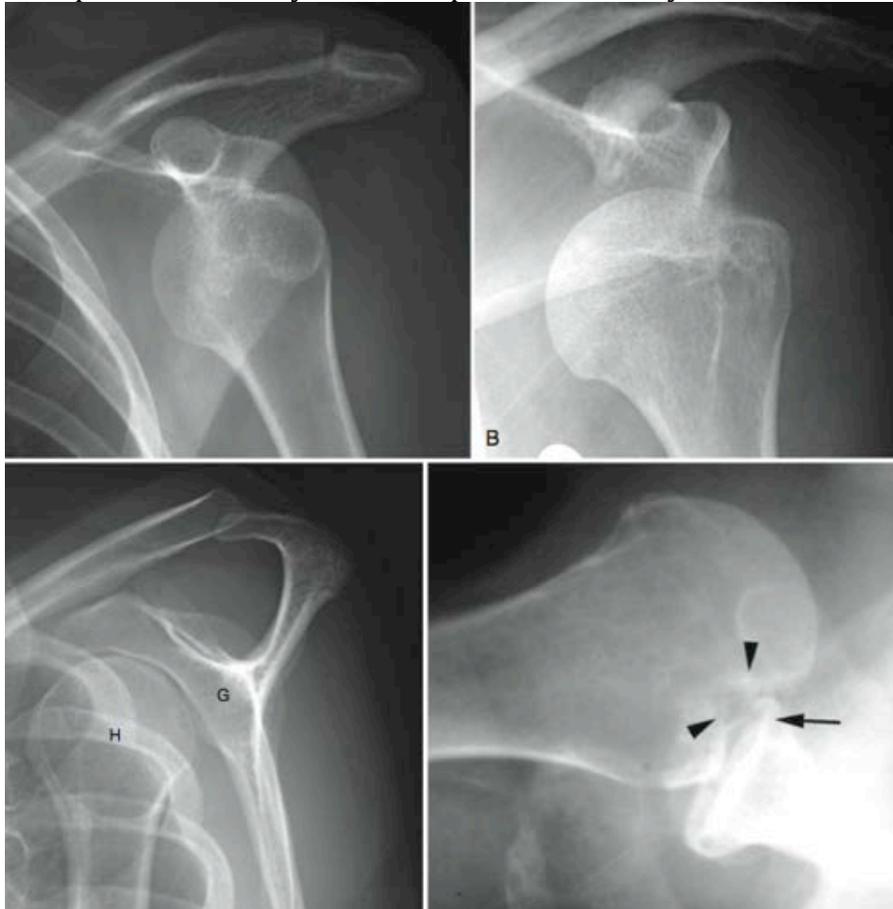
1 part fracture	
Surgical Neck fx	• Most common type
Anatomic Neck fx	
2 part fracture	
Surgical Neck	• Most common fx pattern (85%) pectoralis pulls shaft anterior and medial 2) head and attached tuberosities stay neutral than anterior and varus angulation
Greater tuberosity	• Often missed • Deforming forces: GT pulled superior and posterior by SS, IS, and TM displacement or else it will block ER and ABD
Lesser tuberosity	• Assume posterior dislocation until proven otherwise
Anatomic neck	• Rare
3 part fracture	
Surgical neck and GT	• Subscap will internally rotate articular segment associated with longitudinal RCT
Surgical neck and LT	• Unopposed pull of external rotators lead to articular surface to point anterior
4 part fracture	
Valgus impacted 3- and 4-part fracture	• Radiographically will see alignment between medial shaft and head segments
4-part with articular surface and head-splitting fracture	Characterized by removal of soft tissue from fracture fragment leading to high risk of AVN (21-75%) Deforming forces: 1) shaft pulled medially by pectoralis



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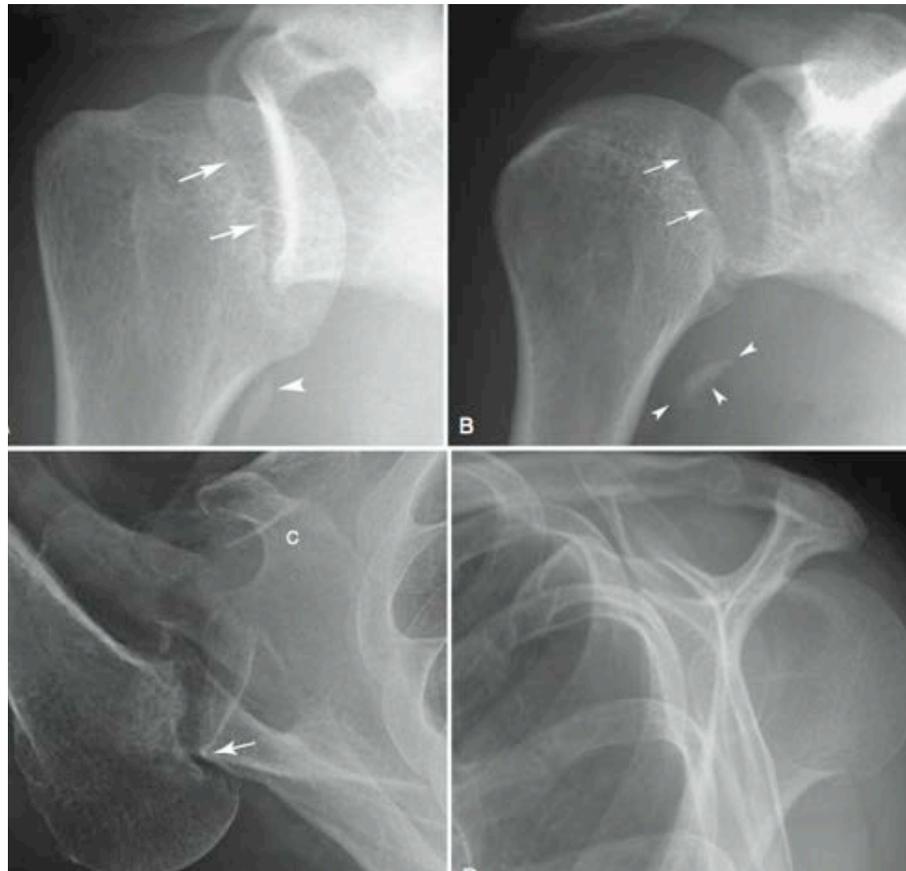
2. Glenohumeral joint dislocation

- a. Anterior: 90% are anterior dislocations; humeral head appears medial and inferior to the glenoid fossa on the frontal film and humeral head is displaced anteriorly on the scapula-Y or axillary view.



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- b. Posterior: Humeral head is superimposed on the glenoid and there is loss of the glenohumeral space on the frontal view and humeral head is displaced posteriorly on the scapula-Y or axillary view

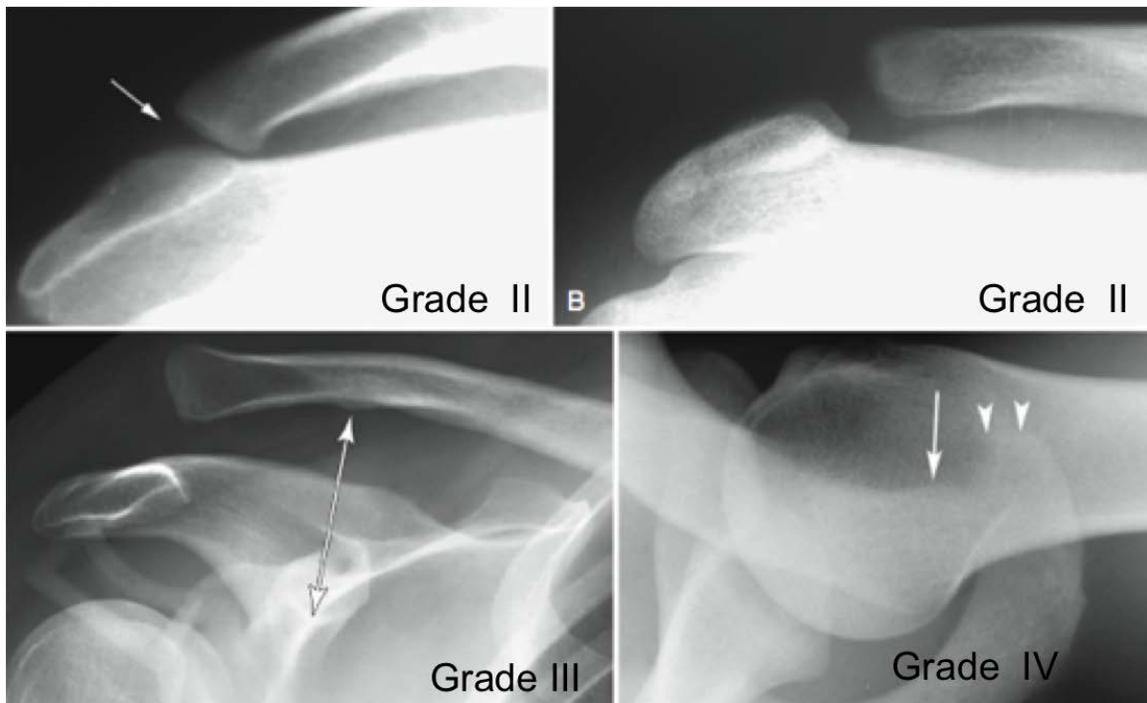


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3. Acromioclavicular joint separation:

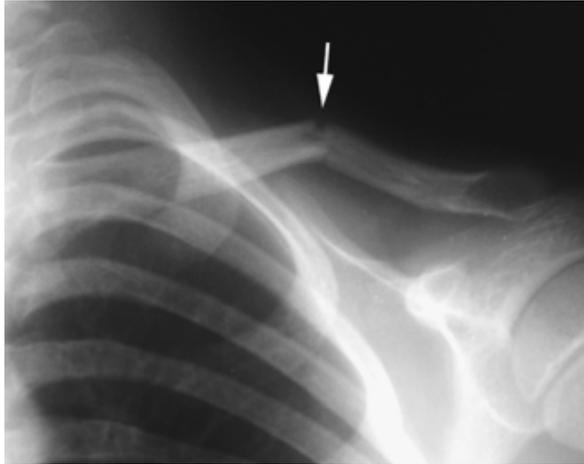
Type	Anatomy	Radiographic findings
I Sprain	Stretching of AC ligament AC joint is stable CC ligament intact	Only seen on stress views of injured and uninjured shoulders=widening of AC joint
II Subluxation	Partial or complete rupture of AC ligament Partial, but not complete, disruption of CC ligament	Widening of AC joint but a normal coracoclavicular distance Stress films may still be required to demonstrate widening of both AC joint and CC space

III	Disruption of both AC and CC ligaments	Widening of both the AC and CC spaces on routine erect film
IV	Posterior AC and CC ligaments disrupted but coracoacromial ligament remains intact	Distal end of clavicle lies inferior and posterior to acromion seen best on axillary view
V Inferior	AC and CC ligaments disrupted 1 ligament remains intact Sternoclavicular separation occurs as well	Marked widening of both the AC and CC space Sternoclavicular dislocation
VI	Distal end of clavicle displaced inferiorly and lodges in biceps and coracobrachialis muscles	Distal end of clavicle comes to lie inferior to acromion



Manaster. Musculoskeletal Imaging: The Requisites. 2013

4. Clavicle fracture: most occur in the middle third of this bone



Manaster. Musculoskeletal Imaging: The Requisites. 2013

5. Humeral shaft fracture: commonly associated with radial nerve injury



Manaster. Musculoskeletal Imaging: The Requisites. 2013

6. Distal humerus fractures

Can be classified as

- supracondylar fractures (extraarticular)
- transcondylar fracture (separation of either the lateral or medial condyle)
- intracondylar (separates the 2 condyles)



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7. Olecranon fracture: usually intraarticular and best seen on lateral view



Manaster. Musculoskeletal Imaging: The Requisites. 2013

8. Elbow dislocation: classified by the relation to the ulna to the humerus
- Simple: no associated fracture (left image)
 - Complex: associated fracture (right image)



Sheehan. Traumatic elbow injuries: what the orthopedic surgeon wants to know. Radiographics 2013;33:869-888.

11. Galeazzi fracture-dislocation: fracture of the distal radius with associated dislocation of the distal radio-ulnar joint at the wrist; secondary to fall on outstretched hand.



Garcia. Rad Cases: Musculoskeletal Imaging. Thieme. 2010

12. Colles' fracture: extraarticular fracture of the distal radius with dorsal displacement of the distal fragment with the apex palmar angulation.



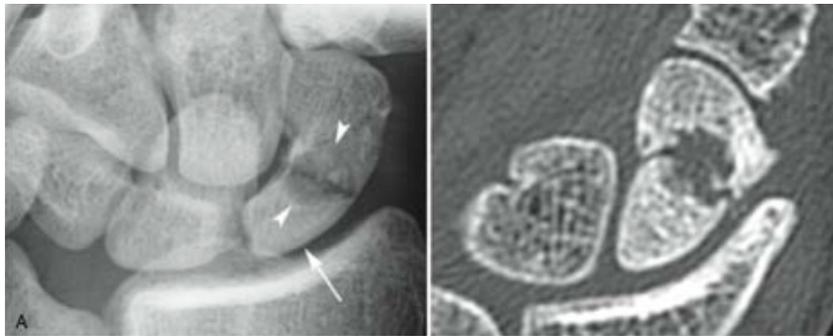
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13. Smith's fracture: either extra or intraarticular; inverted Colle's fracture since there is apex dorsal angulation.



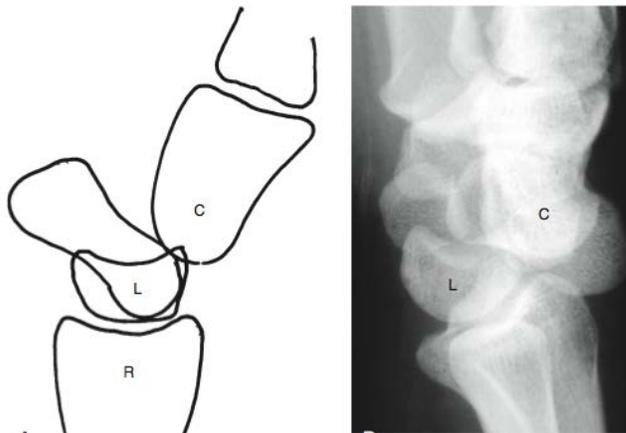
Goldfarb et al. Wrist fractures: what the clinician wants to know. Radiology 2001; 219:11-28

14. Scaphoid fracture: most commonly fractured carpal bone; usually breaks at the waist; if there is concern for occult fracture, usually treat and re-image in 10-14 days. High risk of avascular necrosis if untreated as the blood supply is distal to proximal.



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15. Perilunate dislocation: dorsal dislocation of the capitate bone; the lunate bone is still aligned to the radius



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16. Lunate dislocation: palmar dislocation of the lunate bone; capitate remains aligned with radius



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17. First metacarpal base fracture: Bennett's fracture is a single intraarticular fracture of the base of the first metacarpal bone with the distal fragment dislocated radially and dorsally by the abductor pollicis longus muscle; Rolando's fracture (comminuted Bennet's fracture); typically both need ORIF



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18. Gamekeeper's thumb: fracture of the base of the proximal phalanx of the thumb with disruption of the ulnar collateral ligament.



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19. Boxer's fracture: fracture of the fifth metacarpal neck with dorsal angulation and external rotation of the distal fragment.



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20. Mallet finger: due to hyperflexion injury at the DIP joint with avulsion of the extensor tendon with or without associated avulsion fracture of the proximal dorsal aspect of the distal phalanx.



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21. Femoral neck fractures: refer to Garden classification

Type 1	Incomplete, valgus impacted	 <p>Manaster. Musculoskeletal Imaging: The Requisites. 2013</p>
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<p>Type 2</p>	<p>Complete, non displaced</p>	 <p>Gentili.net</p>
<p>Type 3</p>	<p>Complete, displaced <50%</p>	 <p>Manaster. Musculoskeletal Imaging: The Requisites. 2013</p>
<p>Type 4</p>	<p>Complete, displaced</p>	 <p>Manaster. Musculoskeletal Imaging: The Requisites. 2013</p>

22. Hip dislocation: 90% are posterior (left image), the femoral head displaced superiolaterally in relation to the acetabulum vs. anterior (right image), the femoral head is displaced inferomedially to the acetabulum.

Anterior:



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Posterior:

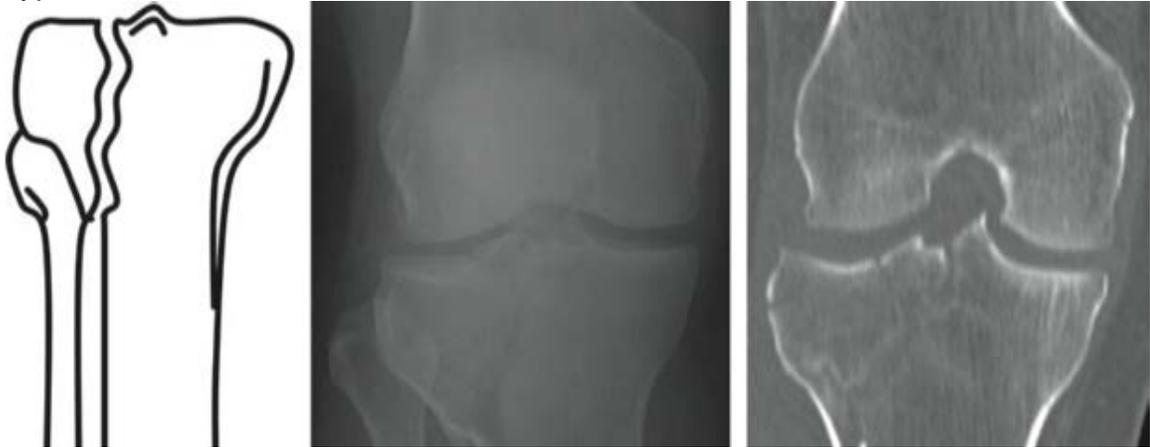


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23. Tibial plateau fracture:

- Type I: lateral split fracture
- Type II: split-depressed fracture
- Type III: purely depressed fracture
- Type IV: medial plateau fracture
- Type V: bicondylar fracture
- Type VI: metaphyseal-diaphyseal disassociation

Type I:



Markhardt. Schatzker Classification of Tibial Plateau Fractures: Use of CT and MR Imaging Improves Assessment

24. Patellar fracture: most frequently fracture transversely



25. Ankle fractures:

Lauge-Hansen Class	Image	Sequence
Supination-Adduction (SA)	 <p data-bbox="581 821 967 1033">Okanobo, et al. Simplified Diagnostic Algorithm for Lauge-Hansen Classification of Ankle Injuries. Radiographics 2012; 32:E71-E84</p>	<ol data-bbox="1049 310 1382 600" style="list-style-type: none"> 1. Talofibular sprain or distal fibular avulsion 2. Vertical medial malleolus and impaction of anteromedial distal tibia
Supination-External Rotation (SER)	 <p data-bbox="553 1667 972 1839">Okanobo, et al. Simplified Diagnostic Algorithm for Lauge-Hansen Classification of Ankle Injuries. Radiographics 2012; 32:E71-E84</p>	<ol data-bbox="1049 1045 1382 1598" style="list-style-type: none"> 1. Anterior tibiofibular ligament sprain 2. Lateral short oblique fibula fracture (anteroinferior to posterosuperior) 3. Posterior tibiofibular ligament rupture or avulsion of posterior malleolus 4. Medial malleolus transverse fracture or disruption of deltoid ligament

<p>Pronation-Rotation (PR)</p>	 <p>Okanobo, et al. Simplified Diagnostic Algorithm for Lauge-Hansen Classification of Ankle Injuries. Radiographics 2012; 32:E71-E84</p>	<ol style="list-style-type: none"> 1. Medial malleolus transverse fracture or disruption of deltoid ligament 2. Anterior tibiofibular ligament sprain 3. Transverse comminuted fracture of the fibula above the level of the syndesmosis
<p>Pronation-External Rotation (PER)</p>	 <p>Okanobo, et al. Simplified Diagnostic Algorithm for Lauge-Hansen Classification of Ankle Injuries. Radiographics 2012; 32:E71-E84</p>	<ol style="list-style-type: none"> 1. Medial malleolus transverse fracture or disruption of deltoid ligament 2. Anterior tibiofibular ligament disruption 3. Lateral short oblique or spiral fx of fibula (anterosuperior to posteroinferior) above the level of the joint 4. Posterior tibiofibular ligament rupture or avulsion of posterior malleolus

27. Calcaneal fracture: secondary to fall from height (once again, boarder jumpers); often associated with thoracolumbar burst fractures

Sander's Classification

Type I	Nondisplaced posterior facet (regardless of fracture lines)
Type II	One fracture line in the posterior facet
Type III	Two fracture lines in the posterior facet
Type IV	Three or more fracture lines in the posterior facet; comminuted



Badillo. Multidetector CT Evaluation of Calcaneal Fractures. Radiographics 2011; 31:81-92.