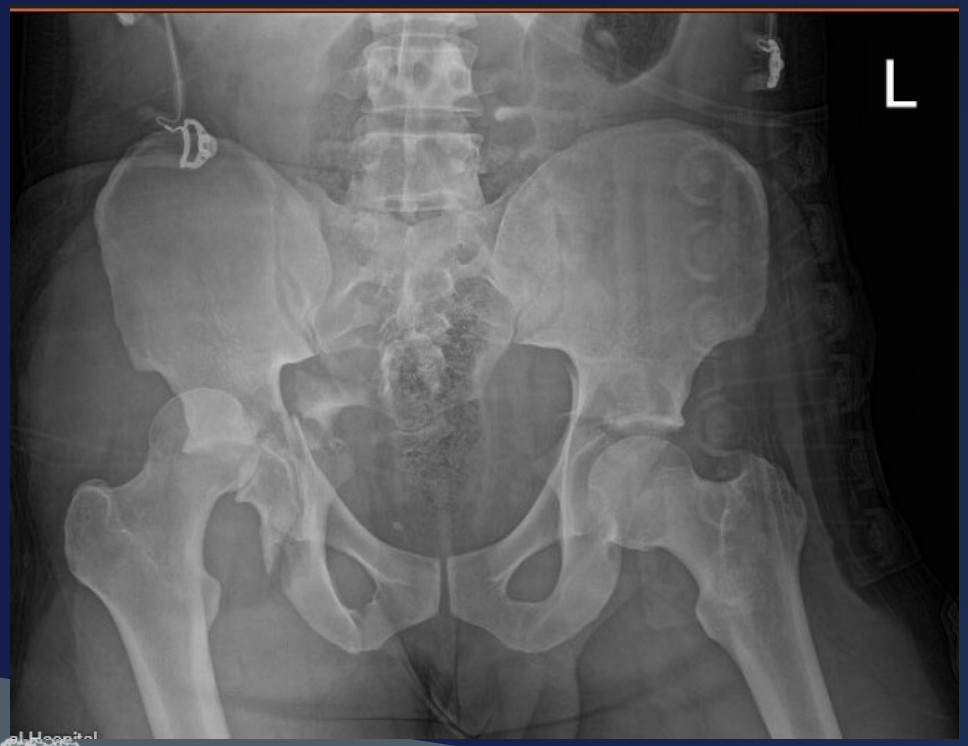
Radiographic Understanding, Evaluation, and Classification of Acetabular Fractures

Objectives

- Appreciate radiographic findings in acetabulum fractures.
- Understand how to classify acetabulum fractures.

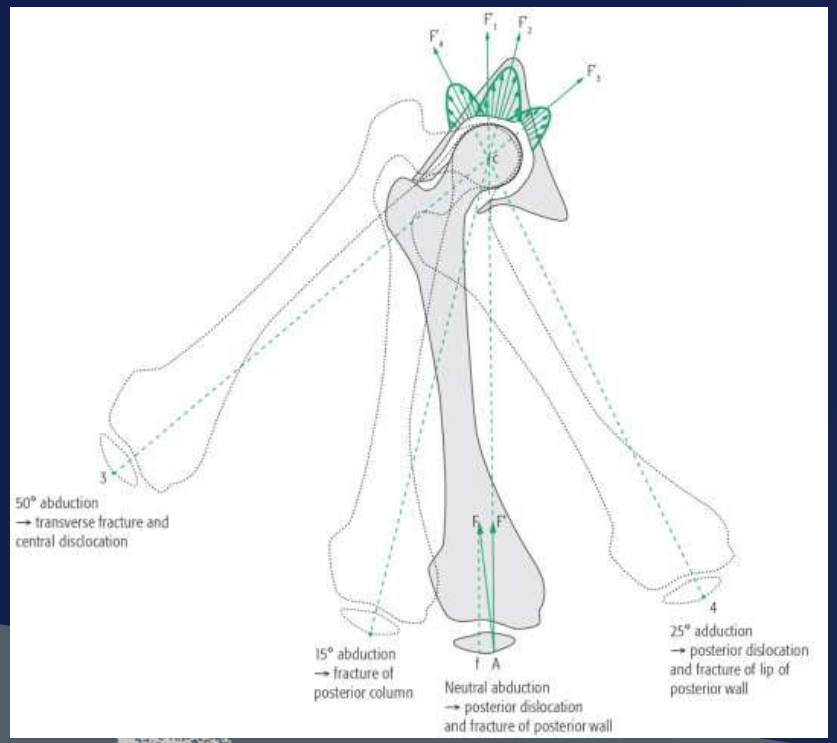
Initial Management

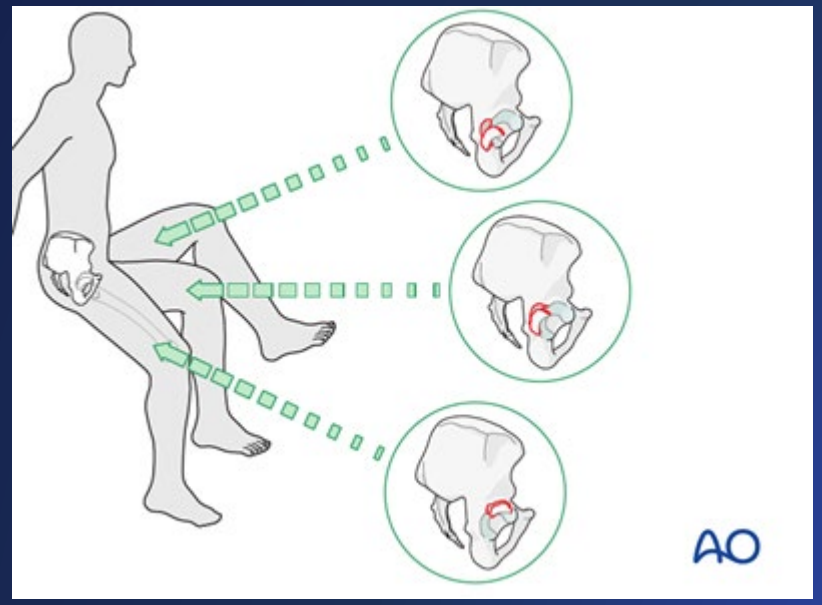


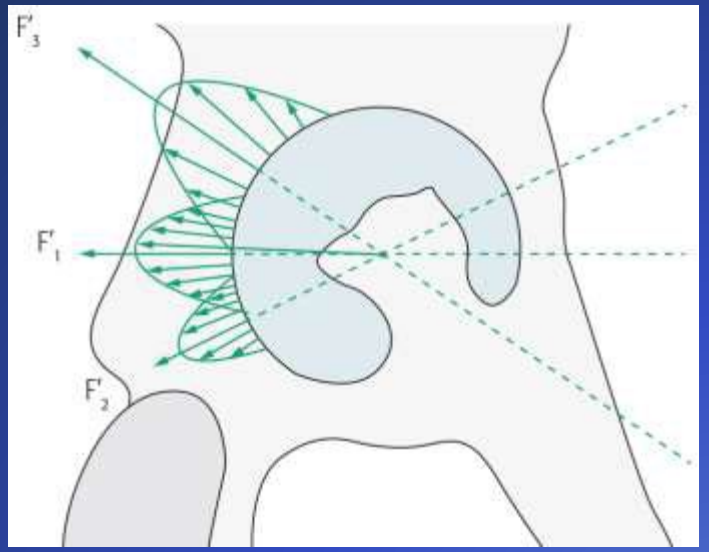
- Initial trauma evaluation
- AP pelvis
- Reduction before CT
- Traction if needed
- Neurovascular exam
- Look for sciatic nerve injury
  - Peroneal division most at risk

Mechanism of Injury

Fracture pattern determined by leg position at time of injury.





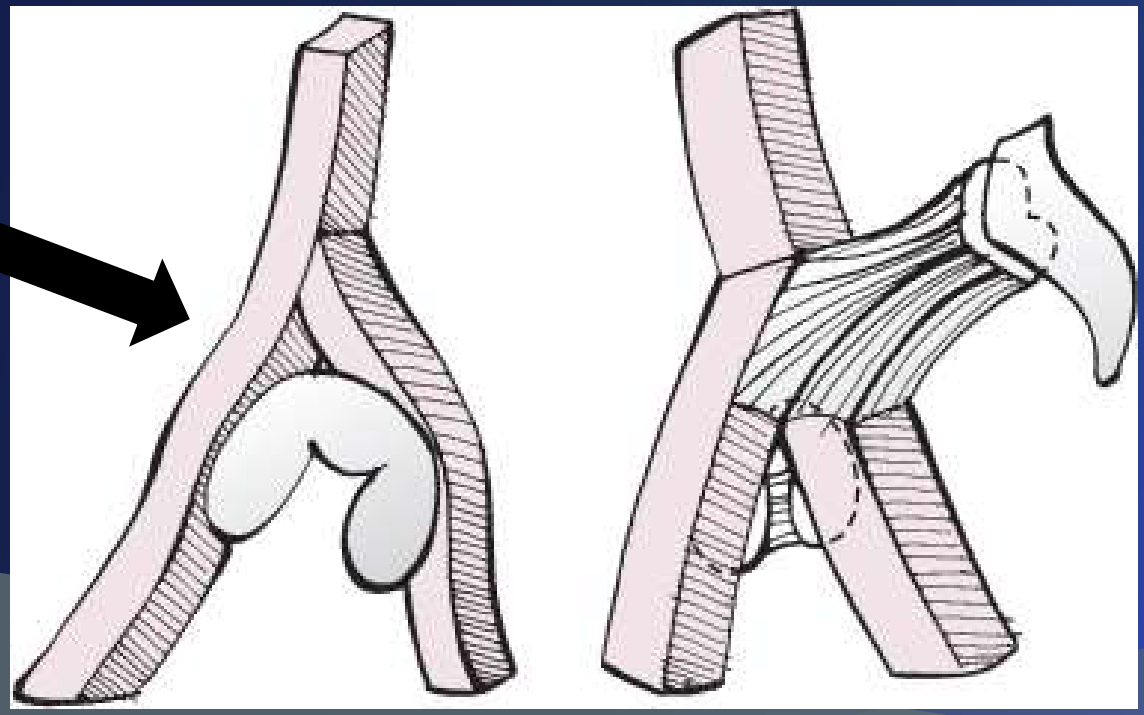


ORTHOPAEDIC TRAUMA ASSOCIATION

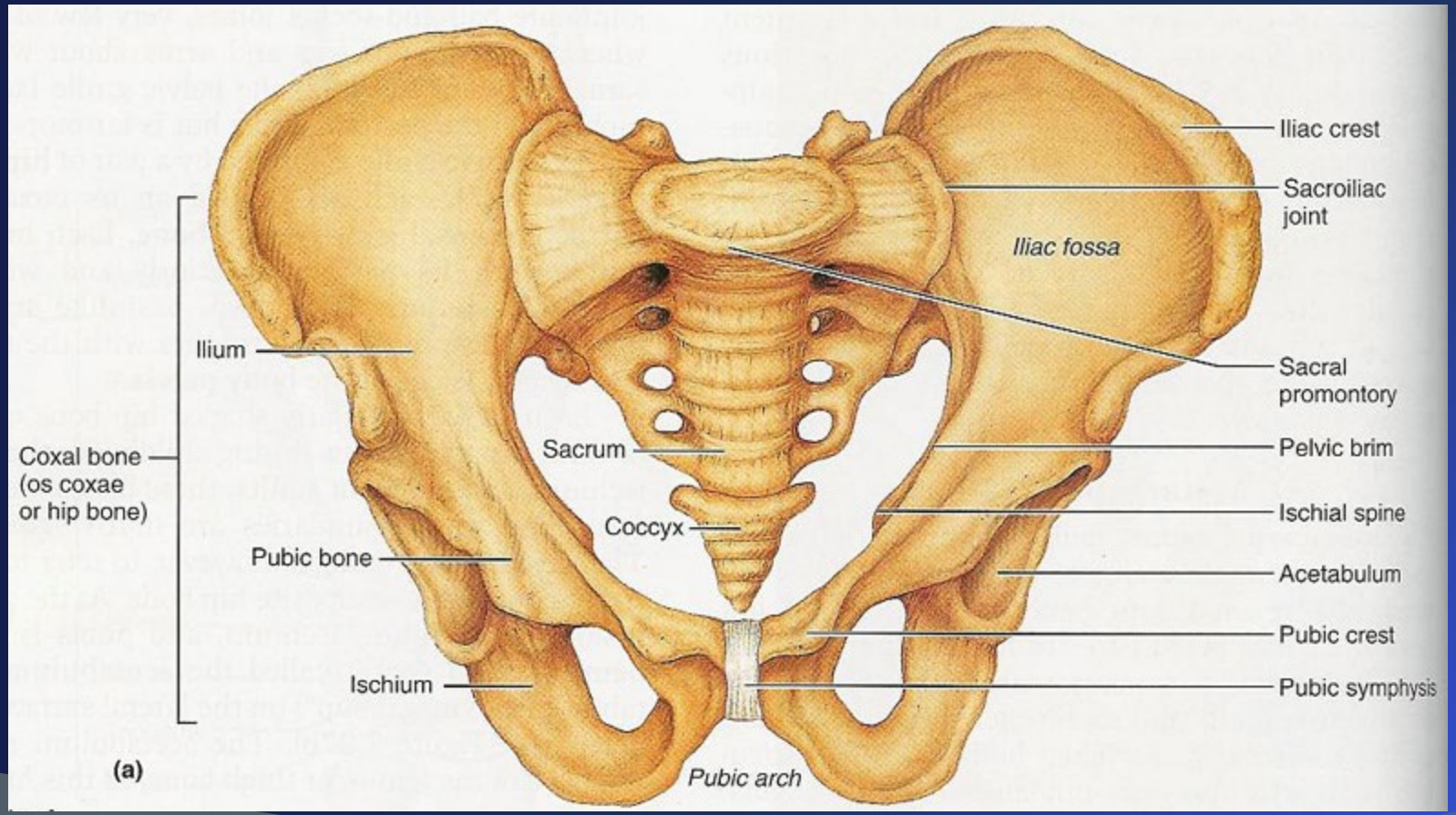
Anatomy

- Judet and Letournel
- Inverted “Y” Two Column Concept

Anterior column



Anatomy



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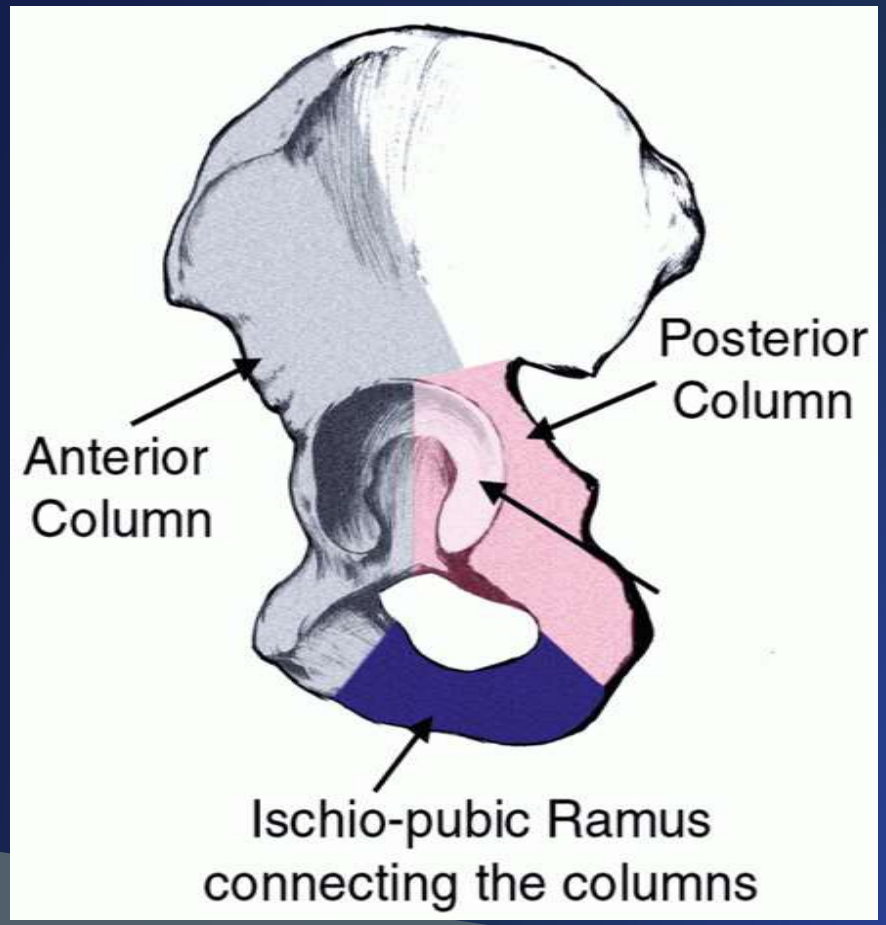
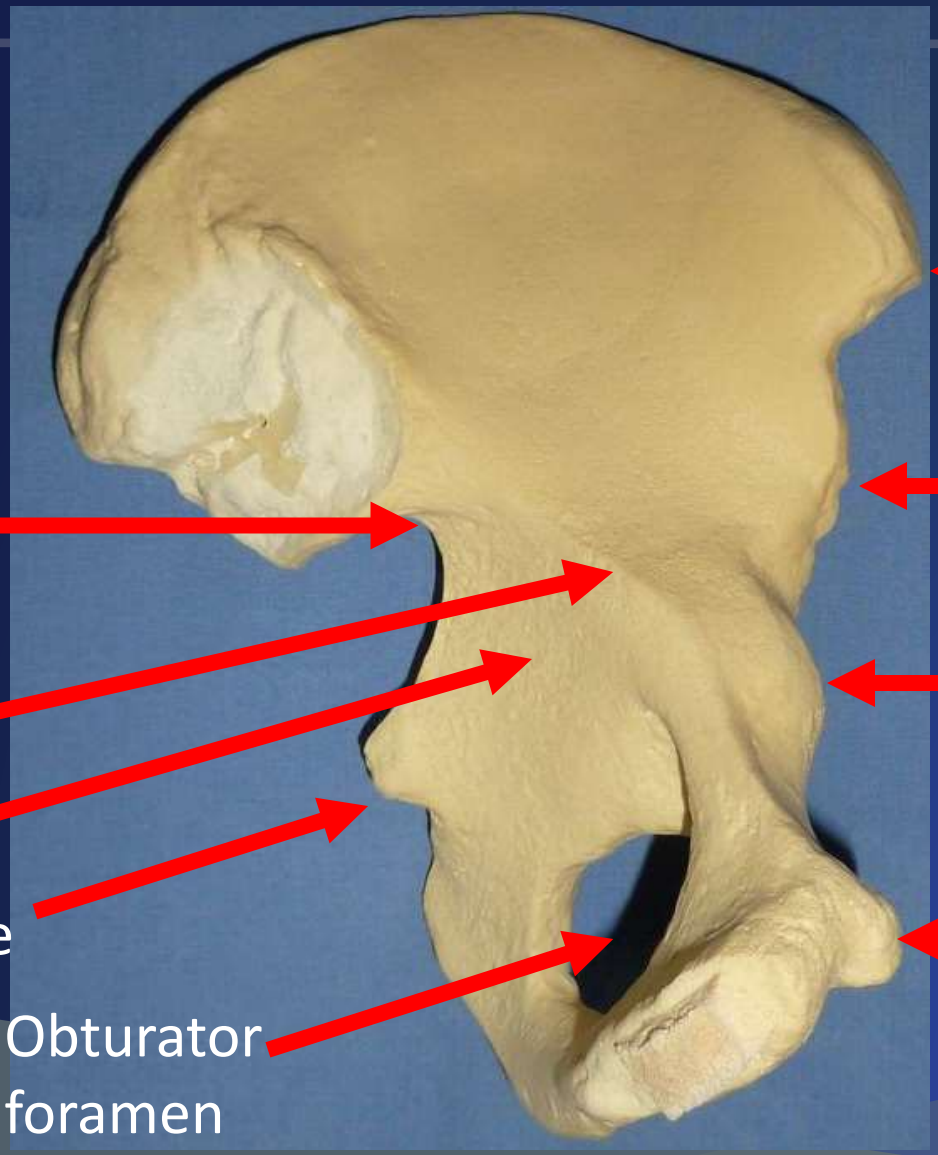
Anatomy



Anatomy



ASIS

AIIS

Iliopectineal eminence

Pubic tubercle

Greater sciatic notch

Pelvic brim

Quadrilateral surface

Ischial spine

Obturator foramen

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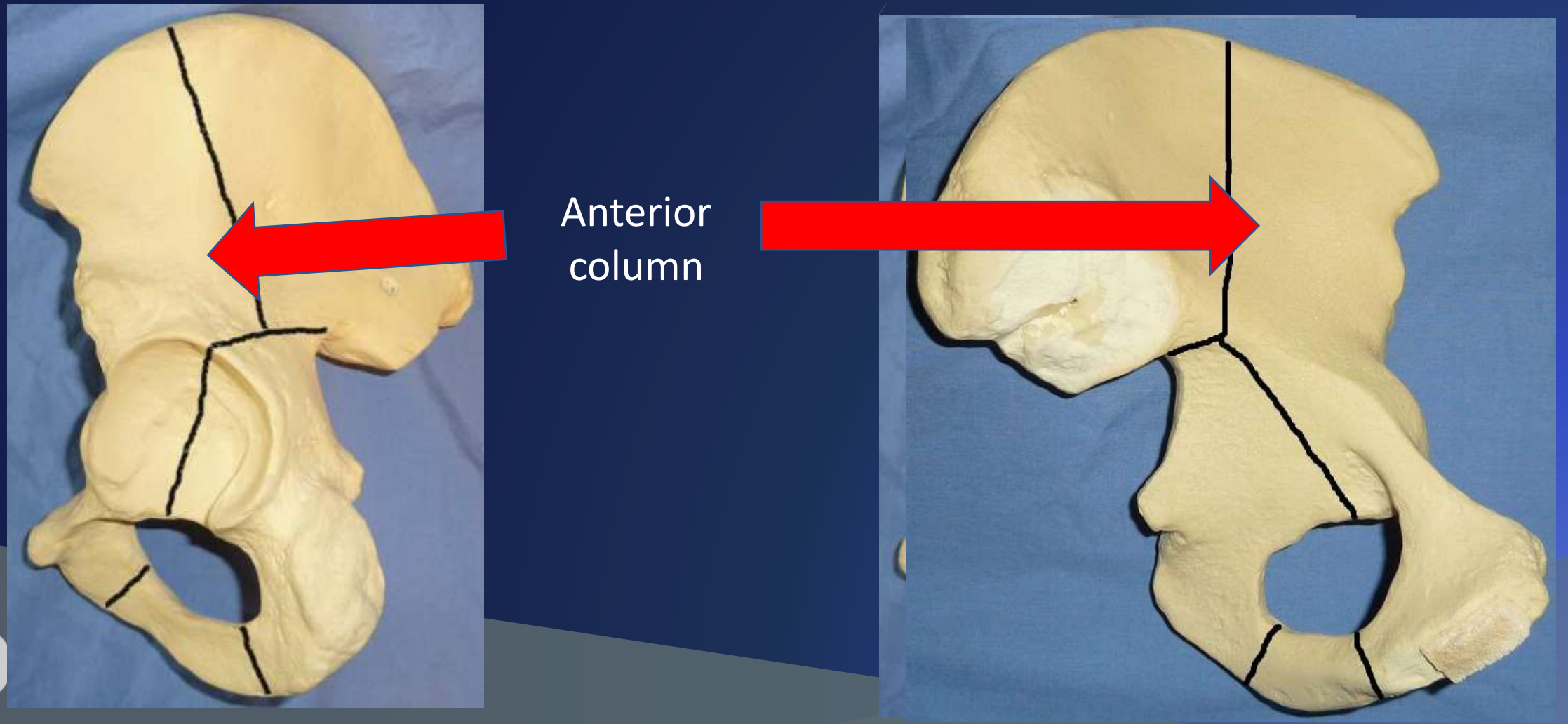
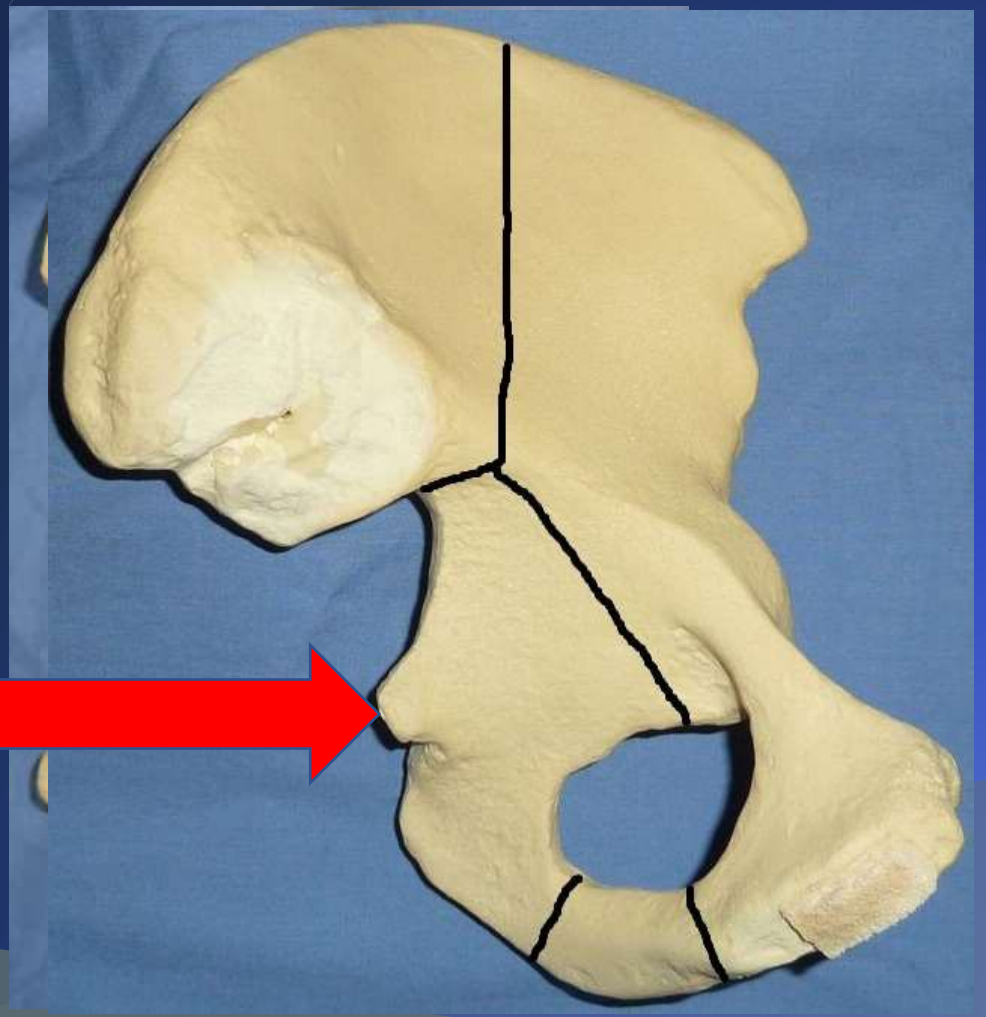
Anterior Column



Posterior Column

Posterior column



Imaging

- **Xrays**
  - AP and Judets
    - Iliac oblique
    - Obturator oblique
- **CT scan**

The 6 Radiographic Lines of Judet

- Iliopectineal line
- Ilioischial line
- Anterior rim
- Posterior rim
- Roof
- Teardrop

Radiographic Lines

- **Iliopectineal line**
- Anterior column

Radiographic Lines

- **Ilioischial line**
- Posterior column
- Quadrilateral surface

Radiographic Lines

- **Anterior rim**
- Anterior wall
- Anterior column

Radiographic Lines

- **Posterior rim**
- Posterior wall
- Posterior column

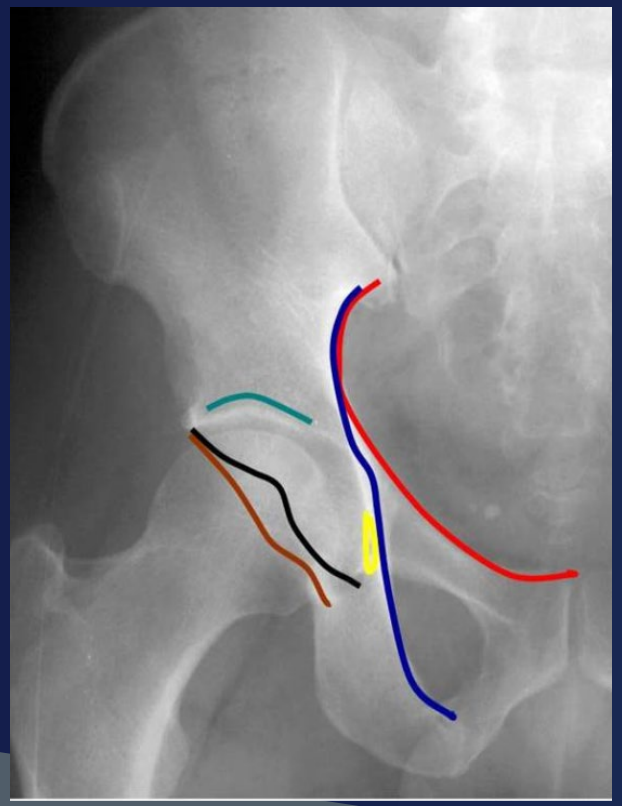
Radiographic Lines

- **Roof**
- Sourcil
- Superior weightbearing portion of acetabulum
- 45-60 degree arc

Radiographic Lines

- **Teardrop**
- Lower border
  - Obturator foramen, ischiopubic notch
- External limb
  - Middle 1/3 cotyloid fossa
- Internal limb
  - Confluence of obturator canal and quadrilateral surface

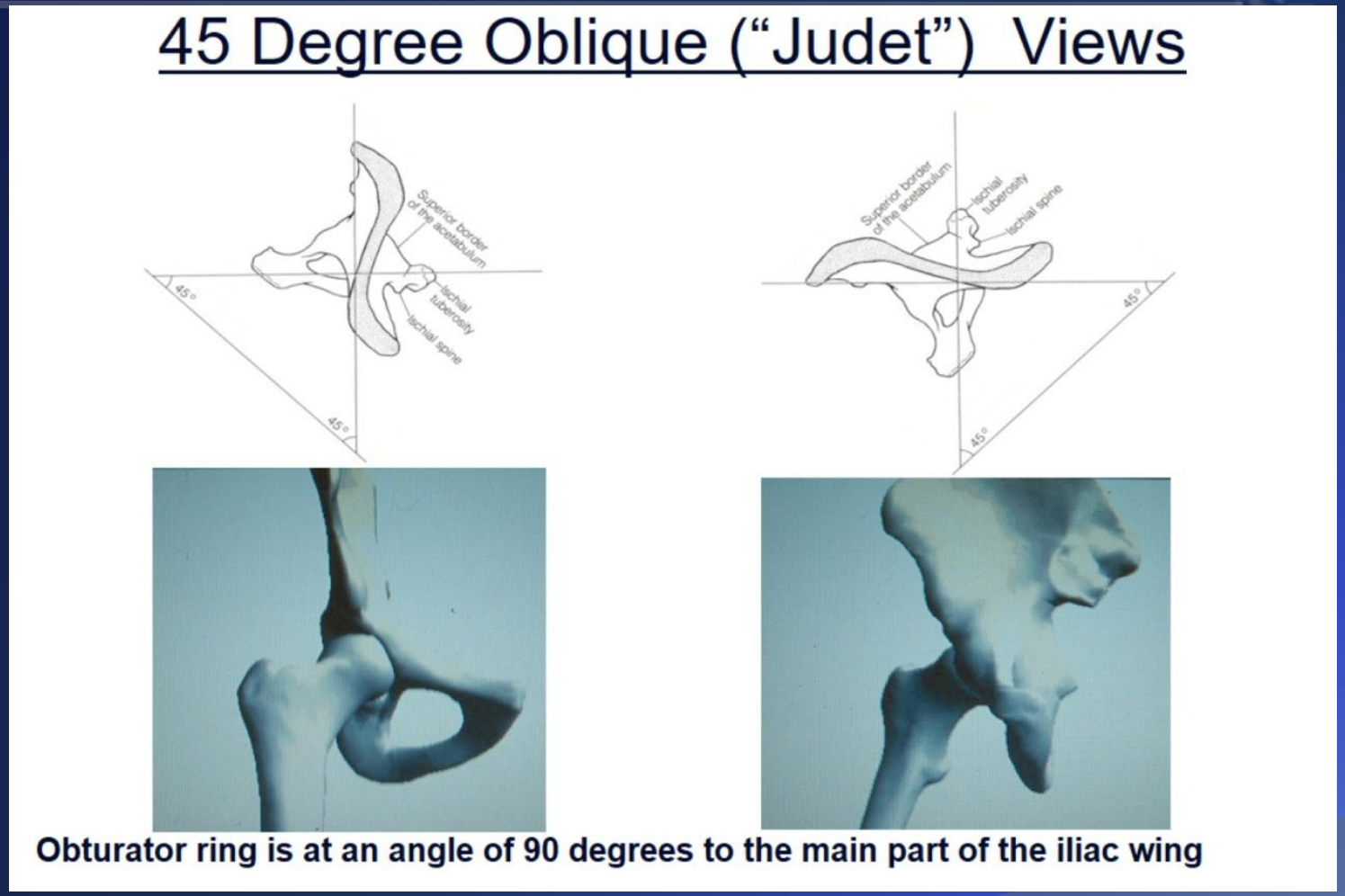
Radiographic Lines



- Iliopectineal line
- Ilioischial line
- Anterior rim
- Posterior rim
- Roof
- Teardrop

Judet Xrays

- 45 degree oblique views
- Obturator ring is 90 degrees to main part of iliac wing



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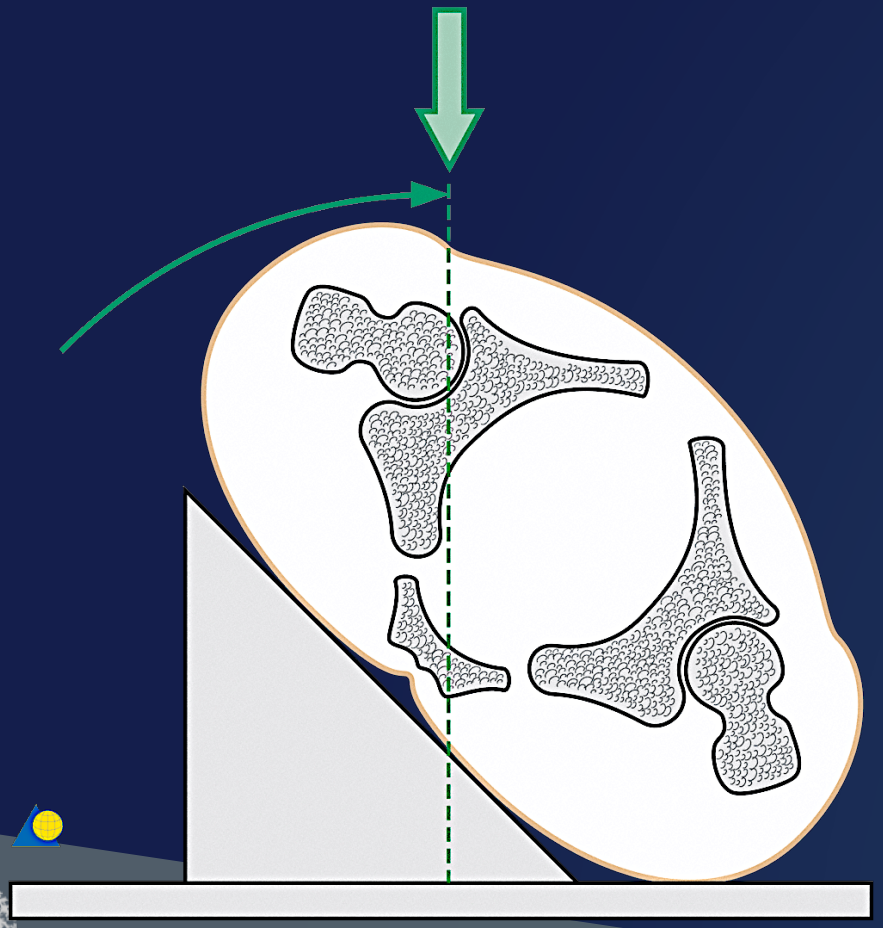
Obturator Oblique



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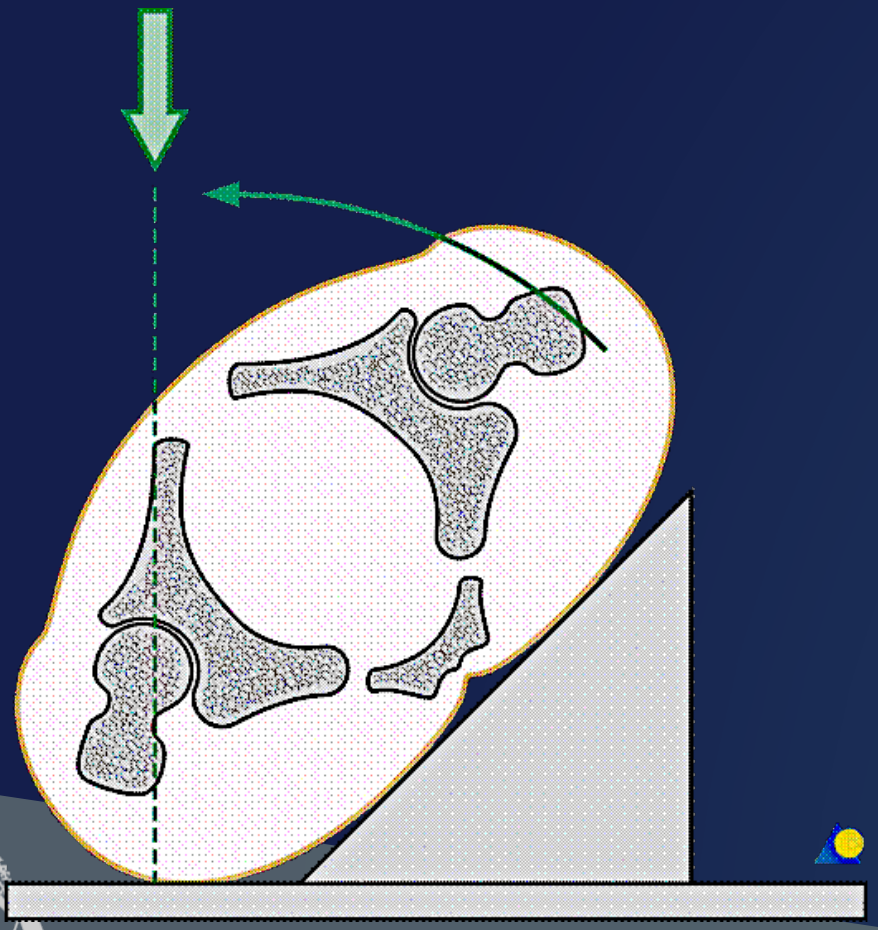
Obturator Oblique

- Anterior column
- Posterior wall
- Obturator foramen
- Radiographic roof
- Ilium seen in section

Obturator Oblique

- Pelvic brim
- Posterior fracture/dislocations
- Tip of coccyx above the center of cotyloid fossa/femoral head
- Inferior ramus fractures

Iliac Oblique



Iliac Oblique

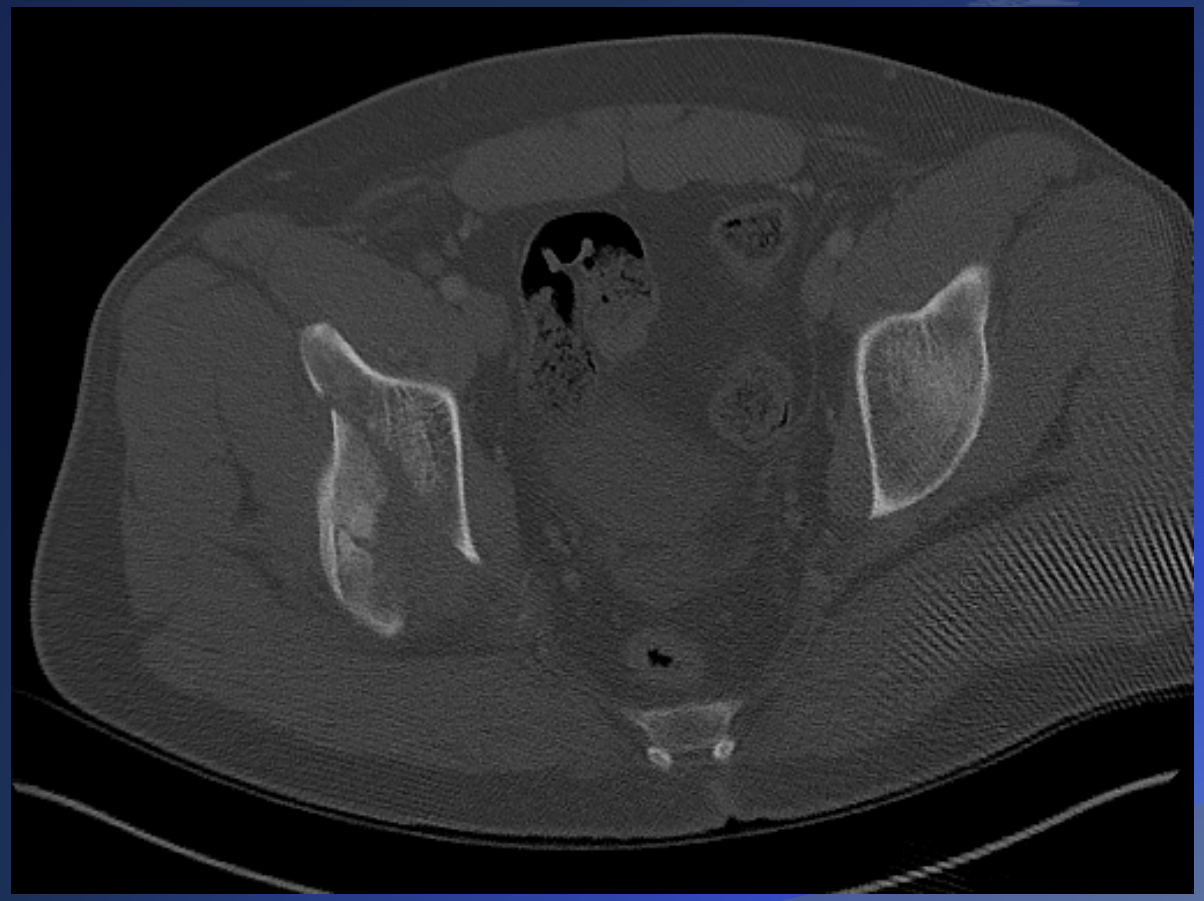
- Posterior column
- Anterior wall
- Iliac wing in profile

Iliac Oblique

- Injured side down
- Posterior border of innominate bone
- Quadrilateral plate

CT Scan

- Defines anatomic structures
- Defines fracture lines
- Intra-articular fragments
- Marginal impaction
- Joint congruence
- Injuries to the pelvic ring and femoral head

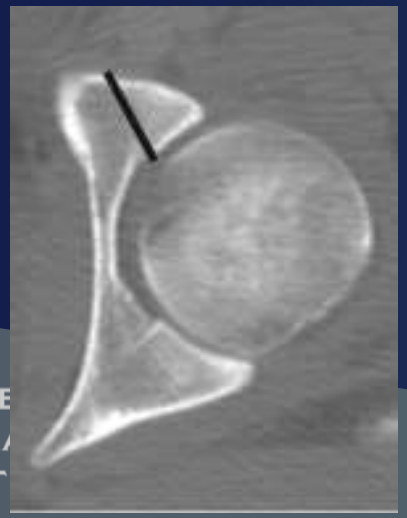


CT Scan

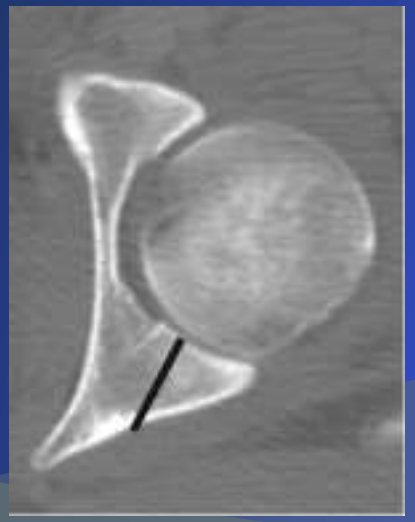
Column fracture

Transverse fracture

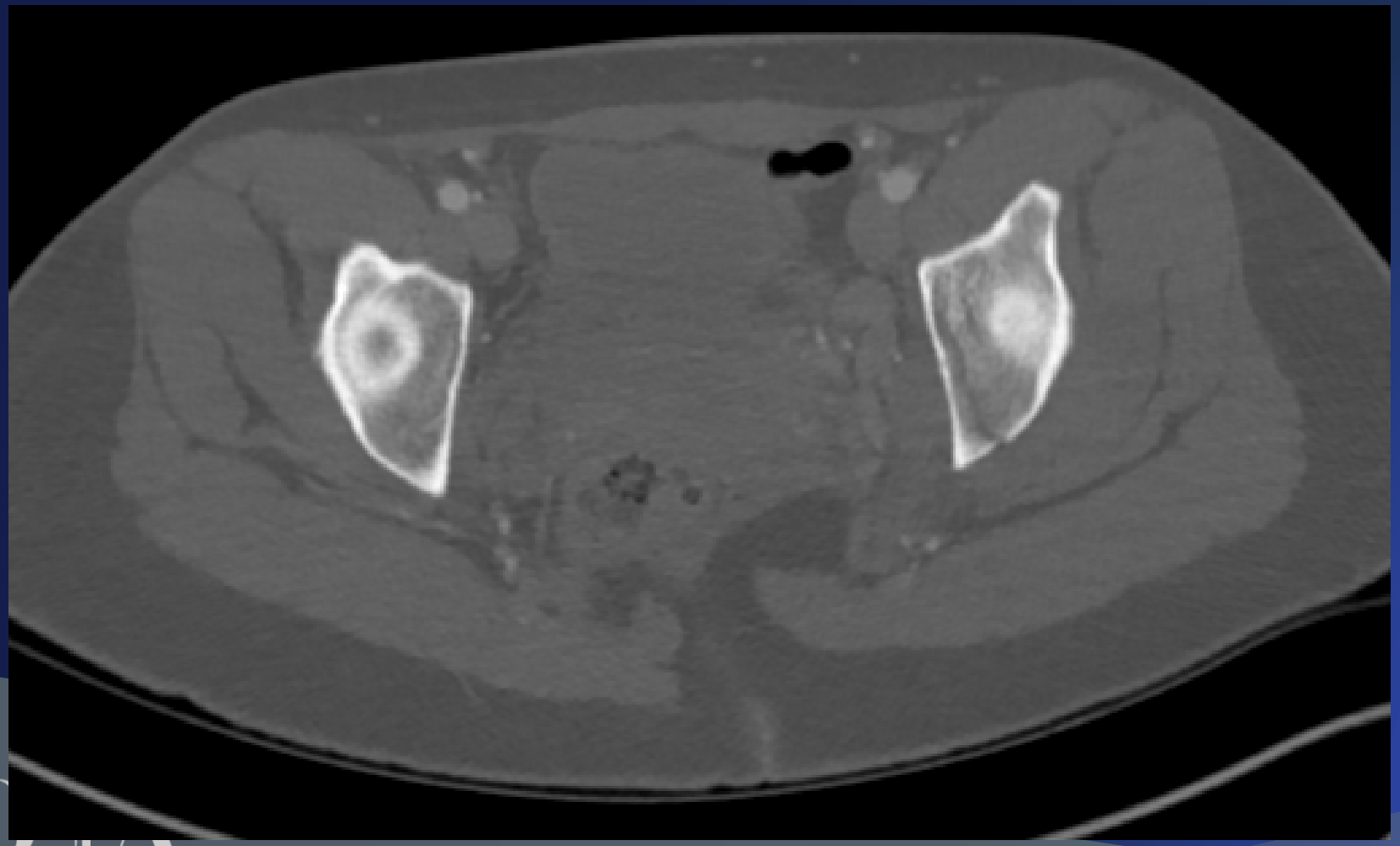
Anterior wall fracture



Posterior wall fracture

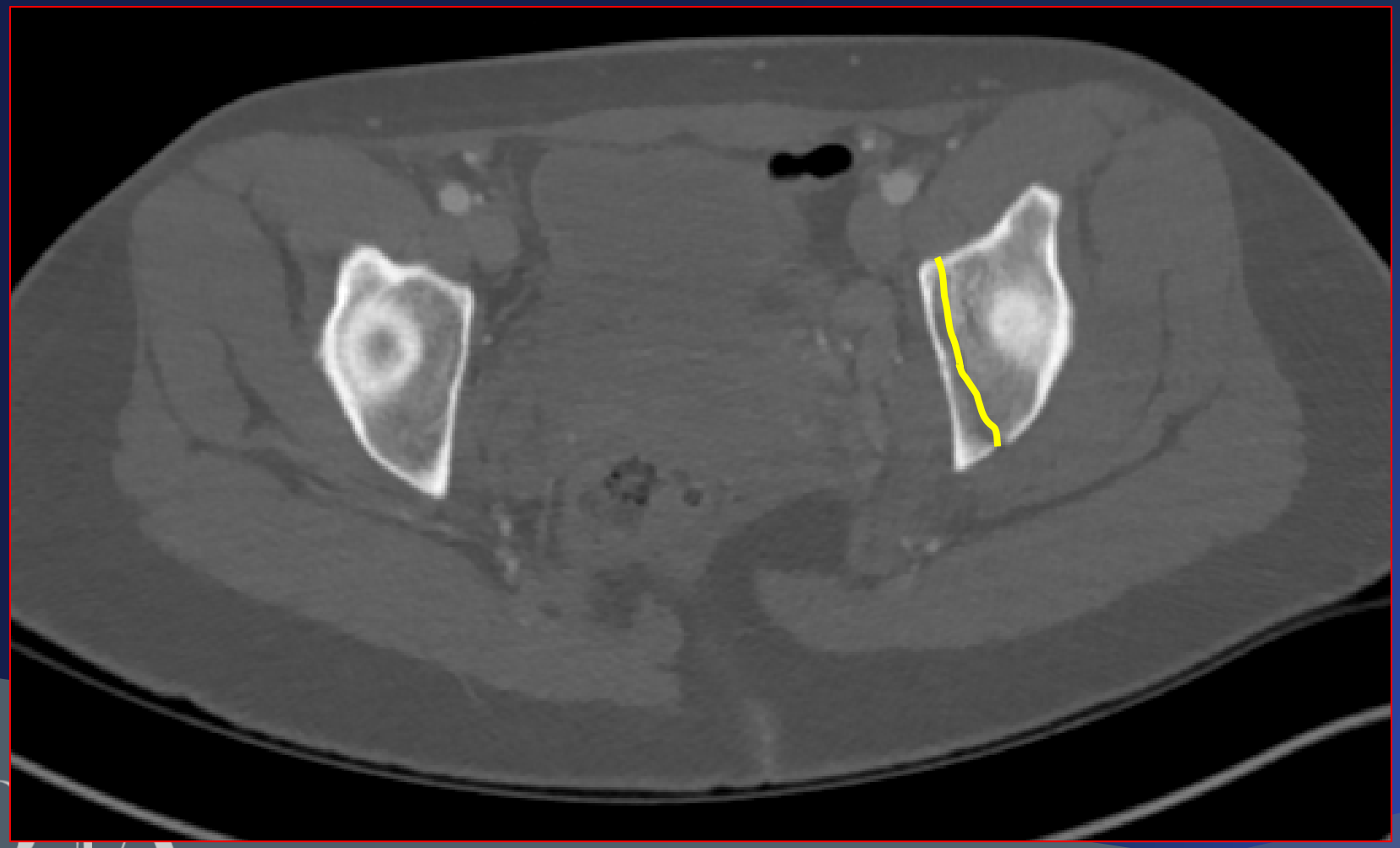


CT Scan



Transverse fracture

CT Scan



Transverse fracture

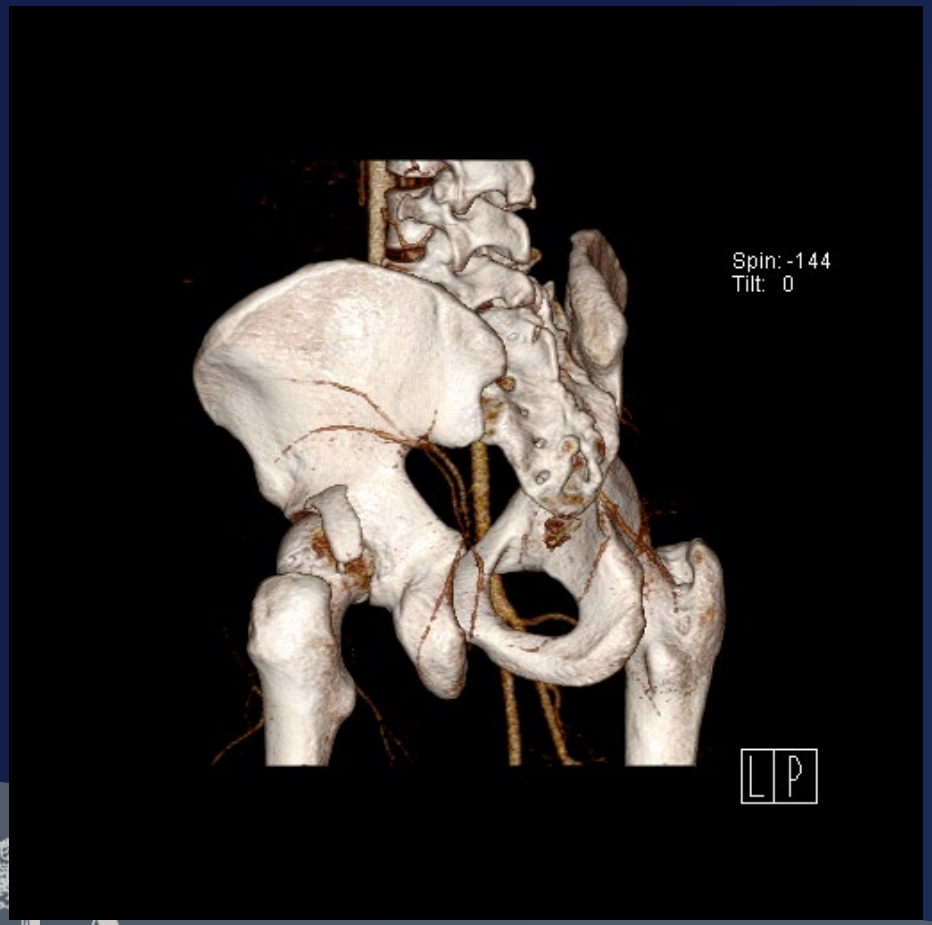
CT Scans

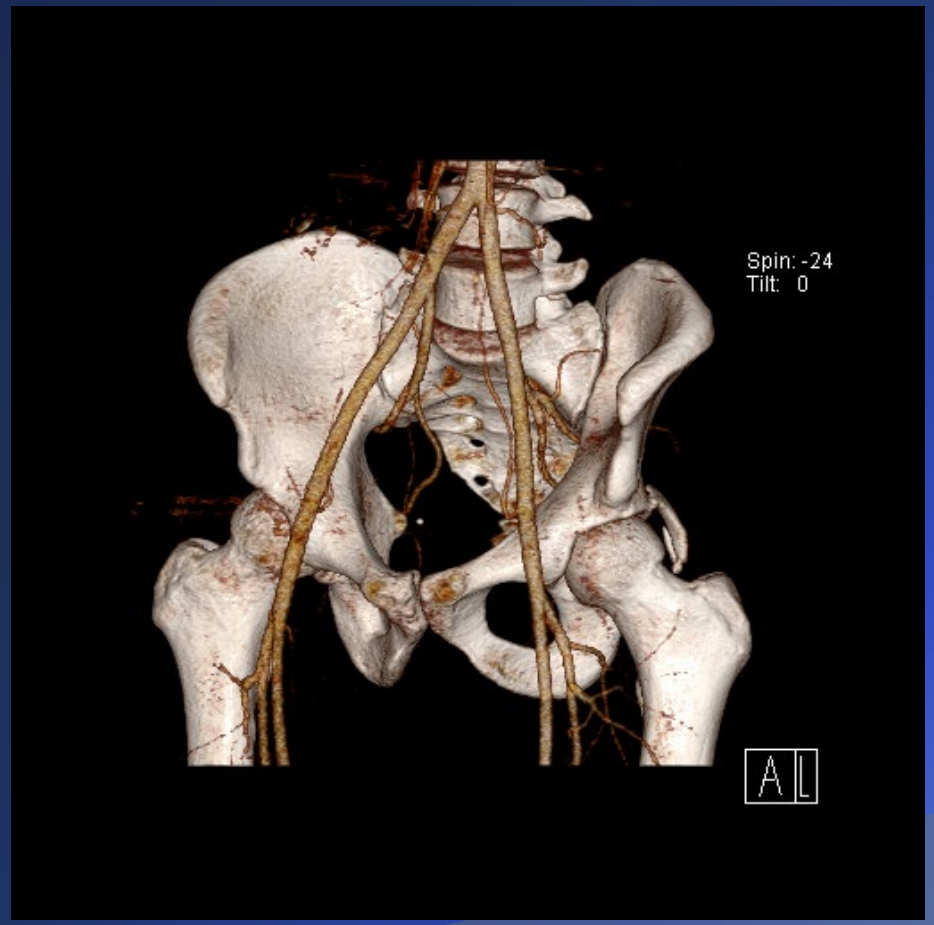
Posterior wall fracture

CT Scans

Posterior wall fracture

3-D CT Scans





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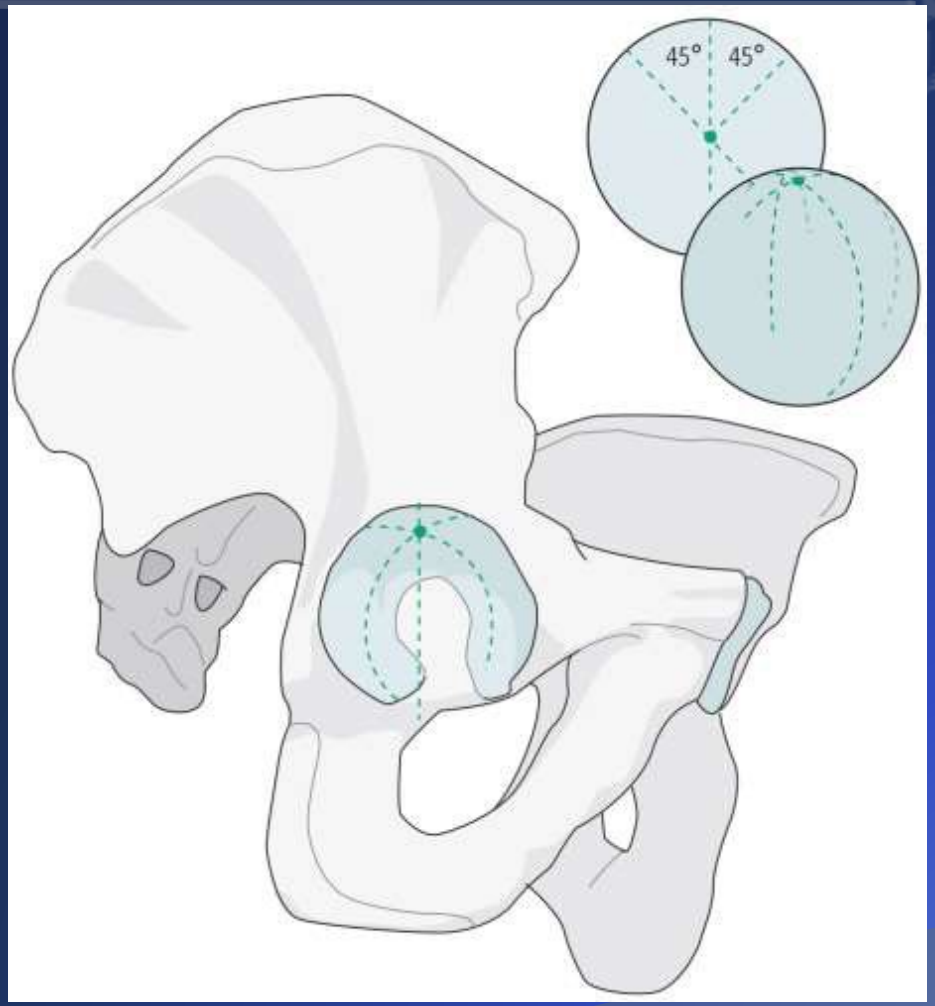
Treatment Principles – Operative Indications

- **Instability**
- Hip dislocation with wall or column displacement
- **Incongruity**
- Fractures through roof or dome
- Retained intra-articular fragments
- Displaced femoral head fractures
- Step or gap wider than width of cartilage
- Fracture involving 20% or more of weight-bearing surface
- >2mm incongruity of articular surface

Roof Arc Measurements

- Vertical line from roof of acetabulum to center of femoral head
- Second line from femoral head through the fracture
- Measured on 3 views
- Indicates amount of intact acetabular dome and if weight-bearing surface is involved
- Aids in determining if joint can remain stable and congruent with non-operative treatment



Matta JM et al. Fractures of the Acetabulum. A Retrospective Analysis. Clin Orthop Relat Res. 1986.

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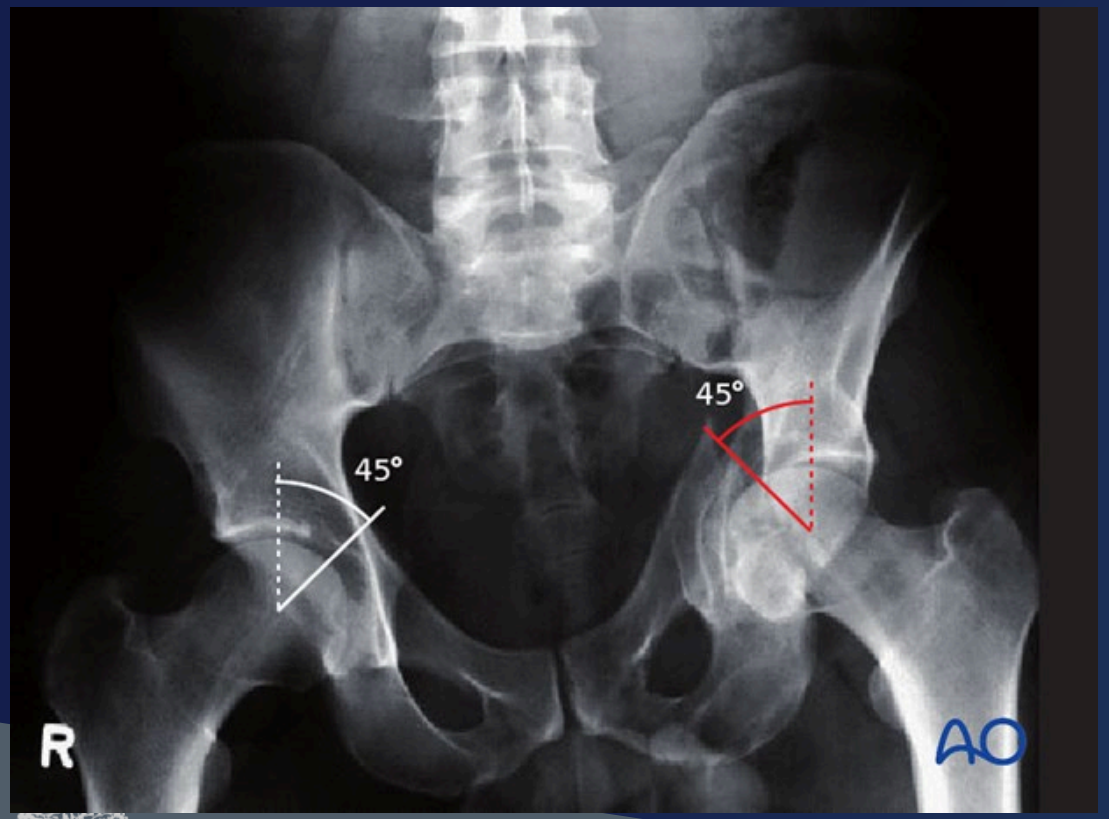
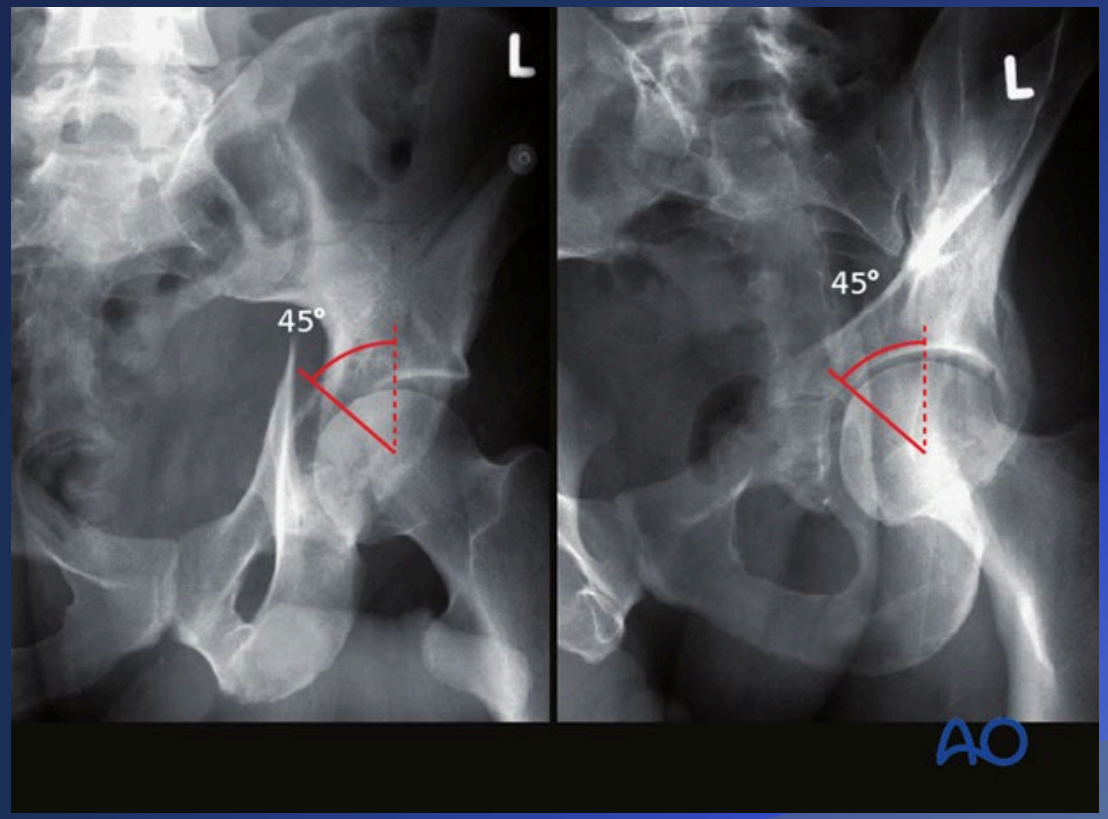
Roof Arc Measurements





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Does not apply to posterior wall or both column fractures

Roof Arc Measurements

- Indicates fracture crosses weight-bearing portion - operative
- Medial roof arc – AP view
  - < 45 degrees - unstable
- Anterior roof arc – obturator oblique
  - < 25 degrees - unstable
- Posterior roof arc – iliac oblique
  - < 70 degrees - unstable

Vrahas MS et al. The Effects of Simulated Transverse, Anterior Column, and Posterior Column Fractures of the Acetabulum on Stability of the Hip Joint. JBJS. 1999.

- Sit –to –stand loading higher than single-leg stance
- Medial roof arc – AP view
  - <90.9 degrees – unstable
- Anterior roof arc – obturator oblique
  - <67.3 degrees – unstable
- Posterior roof arc – iliac oblique
  - <101.4 degrees - unstable

Matityahu A et al. Propensity for Hip Dislocation in Gait Loading Versus Sit-to-Stand Maneuvers: Implications for Redefining the Dome of the Acetabulum Needed for Stability of the Hip During Activities of Daily Living. JOT. 2012.

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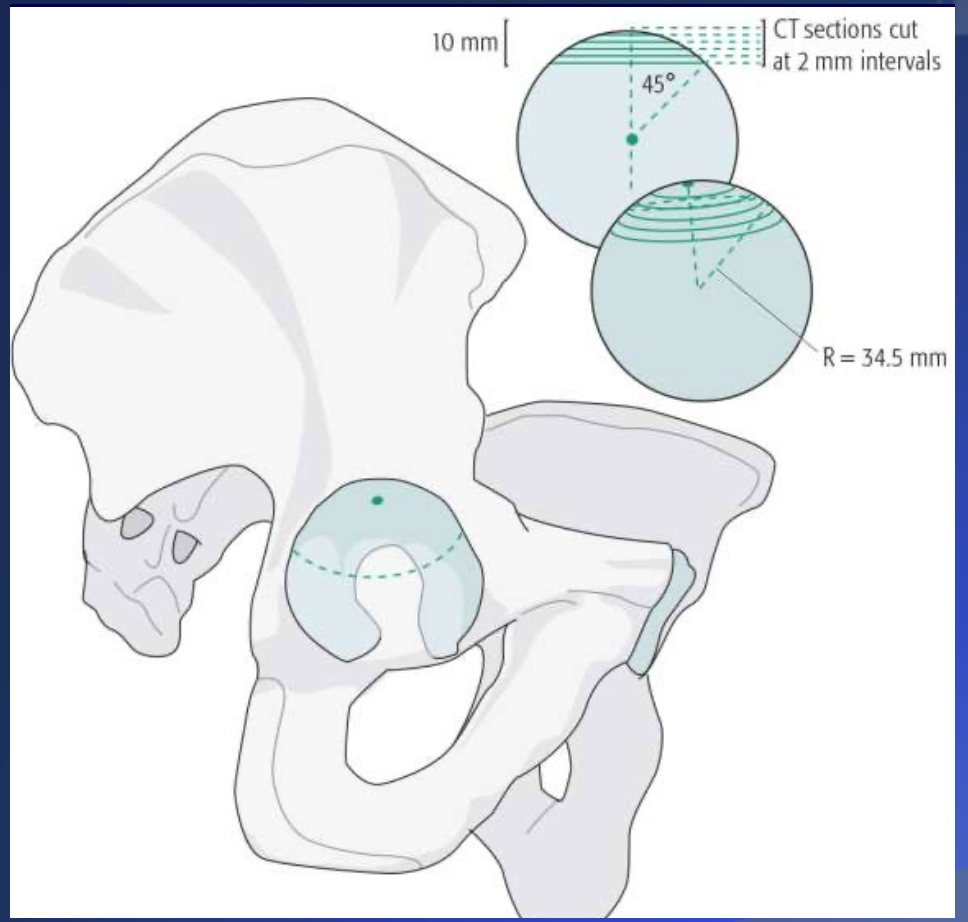
Subchondral Roof Arc on CT

- CT of the superior 10mm of acetabular articular surface
  - Equivalent to roof arch measurement of 45 degrees
- Non-operative therapy
  - Acetabulum intact in superior 10mm on CT
  - Minimum of 50% of posterior wall articular surface intact



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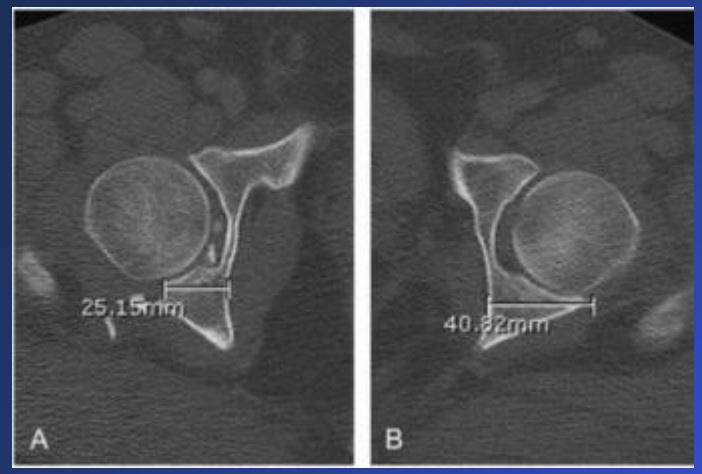
Olson SA and Matta JM. The Computerized Tomography Subchondral Arc: A New Method of Assessing Acetabular Articular Continuity After Fracture (A Preliminary Report). JOT. 1993

Dynamic Fluoroscopic Stress Examination

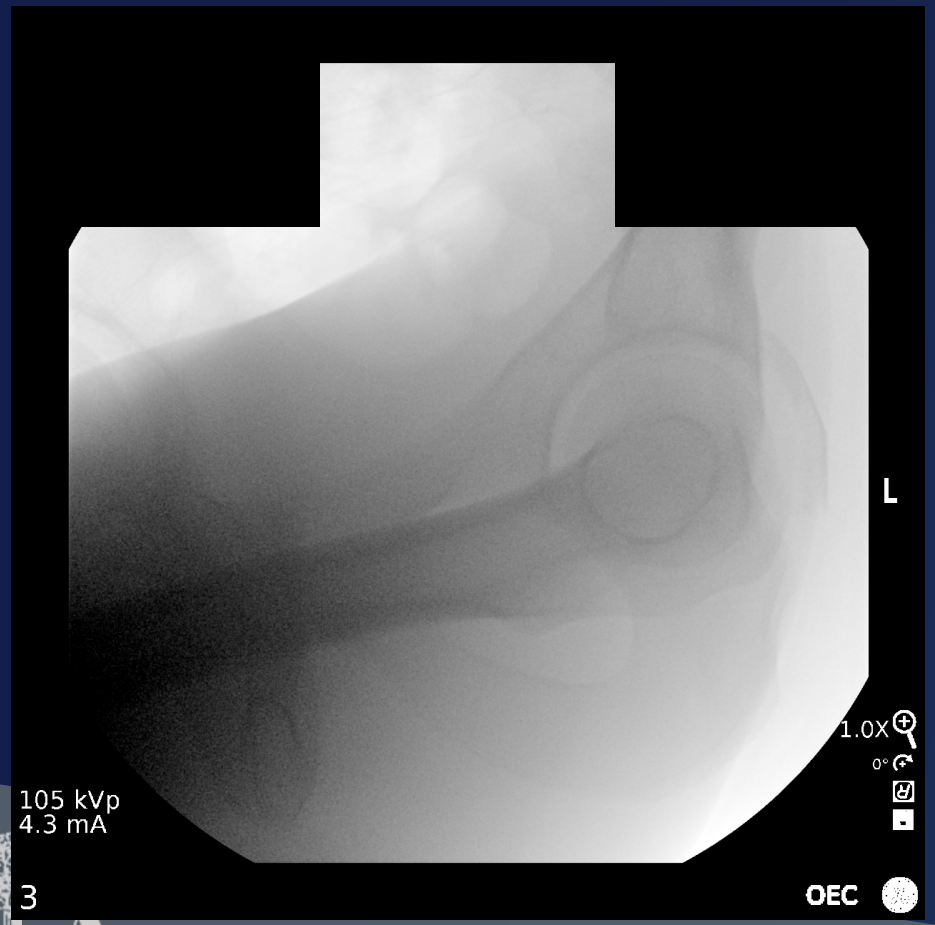
- Historically, <20% stable, 20-50% indeterminate, >50% unstable
- Most reliable of multiple methods using largest posterior wall deficit
- Exam under anesthesia is gold standard with little risk



Moed BR et al. Computed Tomography as a Predictor of Hip stability Status in Posterior Wall Fractures of the Acetabulum. JOT. 2009.

ORTHOPAEDIC TRAUMA ASSOCIATION

EUA



- Stable EUA predicts good-to-excellent radiographic and clinical results
- Supine on OR table
- Flex hip slowly past 90 degrees
- Hip is axially loaded
- AP and obturator oblique images
- Repeat with 20 degrees of adduction and internal rotation
- Subluxation or loss of joint congruity indicates instability

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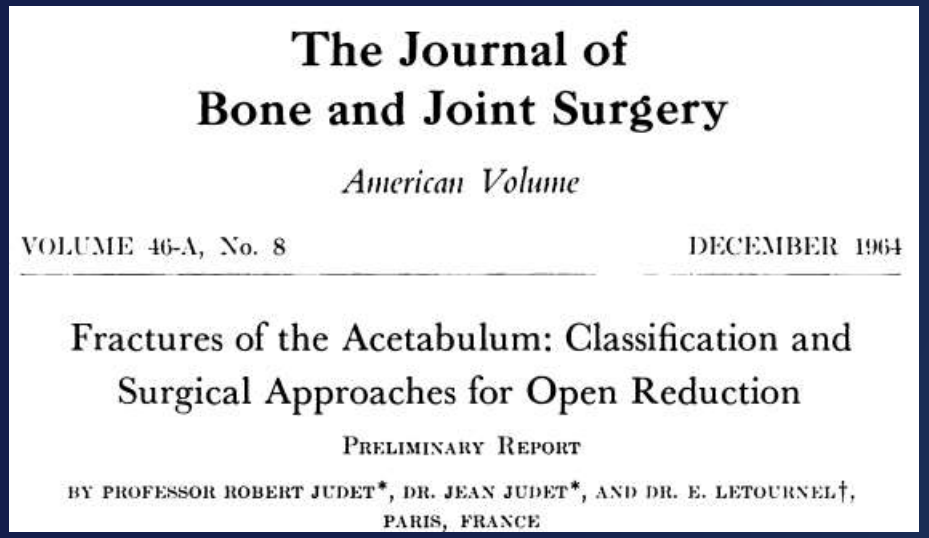
McNamara AR et al. Nonoperative Treatment of Posterior Wall Acetabular Fractures After Dynamic Stress Examination Under Anesthesia. JOT. 2015.

Classification



The Journal of
Bone and Joint Surgery

American Volume

VOLUME 46-A, No. 8 DECEMBER 1964

Fractures of the Acetabulum: Classification and Surgical Approaches for Open Reduction

PRELIMINARY REPORT

BY PROFESSOR ROBERT JUDET*, DR. JEAN JUDET*, AND DR. E. LETOURNEL†, PARIS, FRANCE

- Classification by Judet and Letournel
- Elementary and associated patterns
- Determined by wall and column involvement

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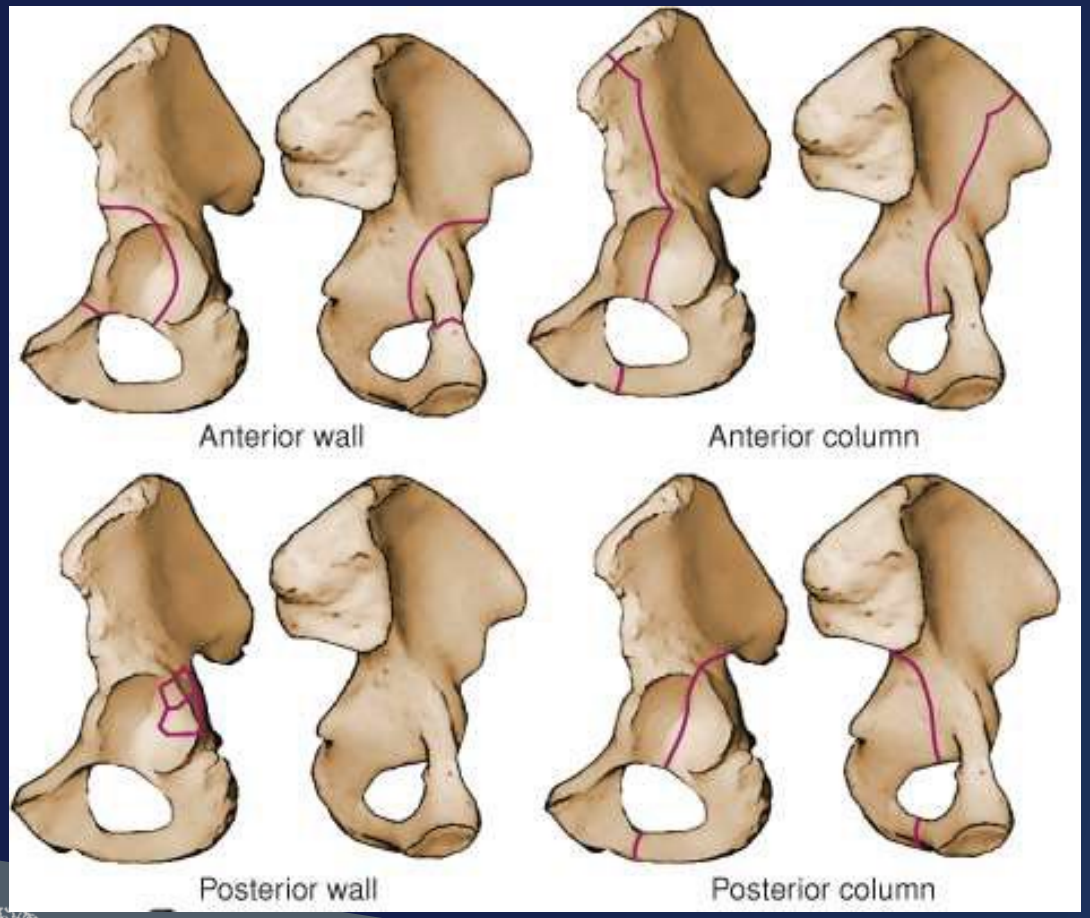
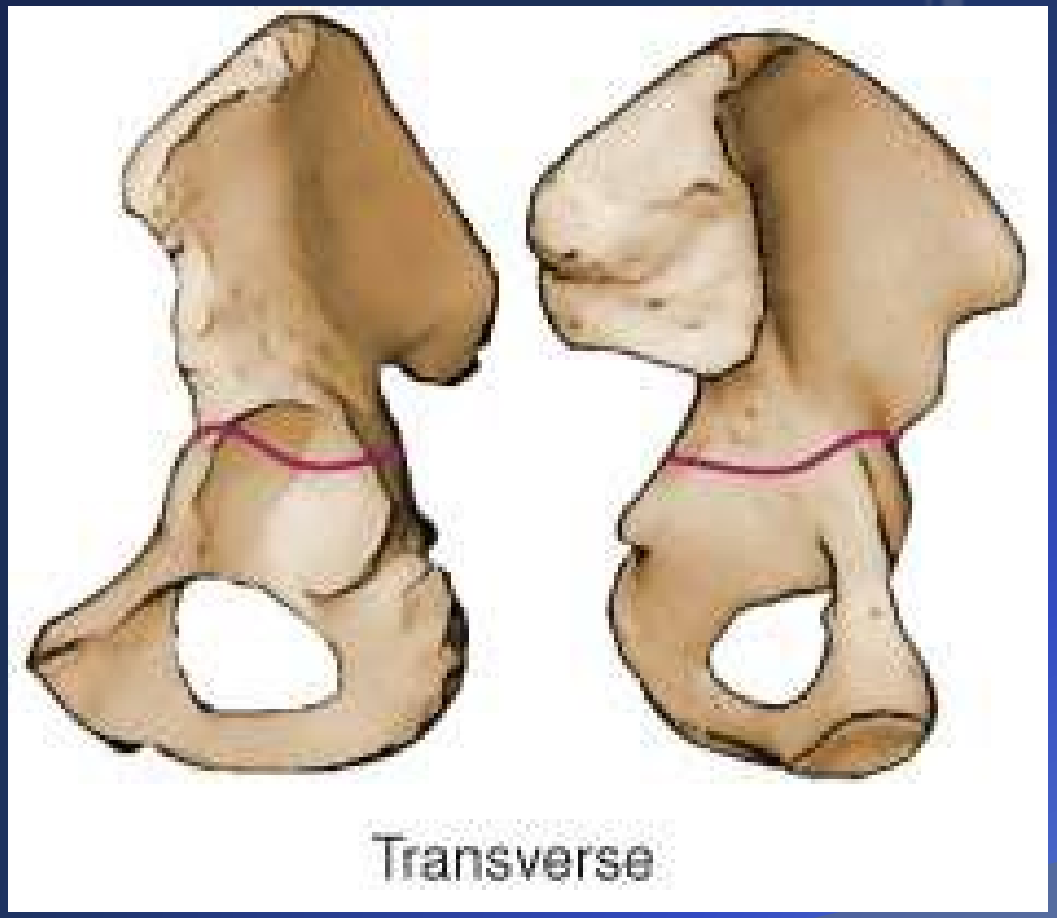
Elementary Fracture Patterns





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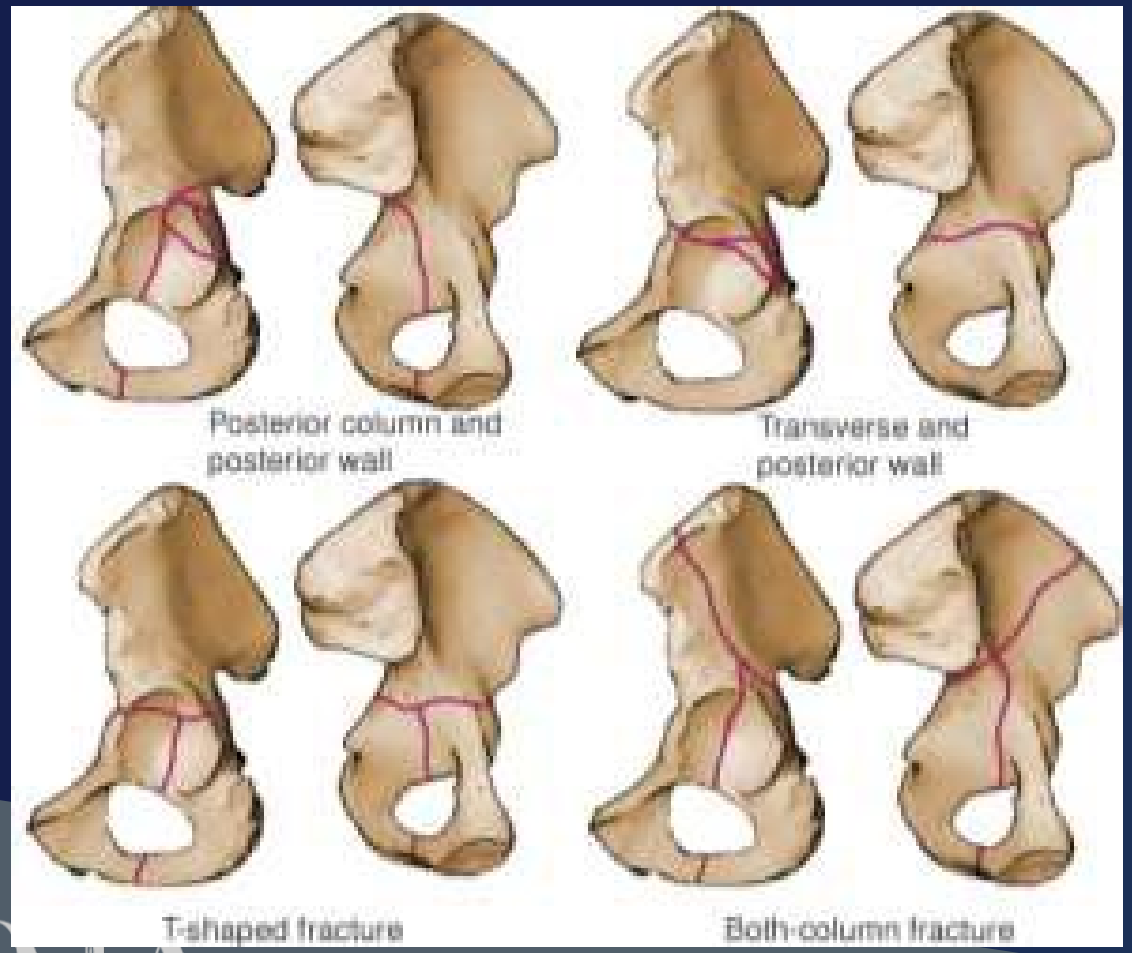
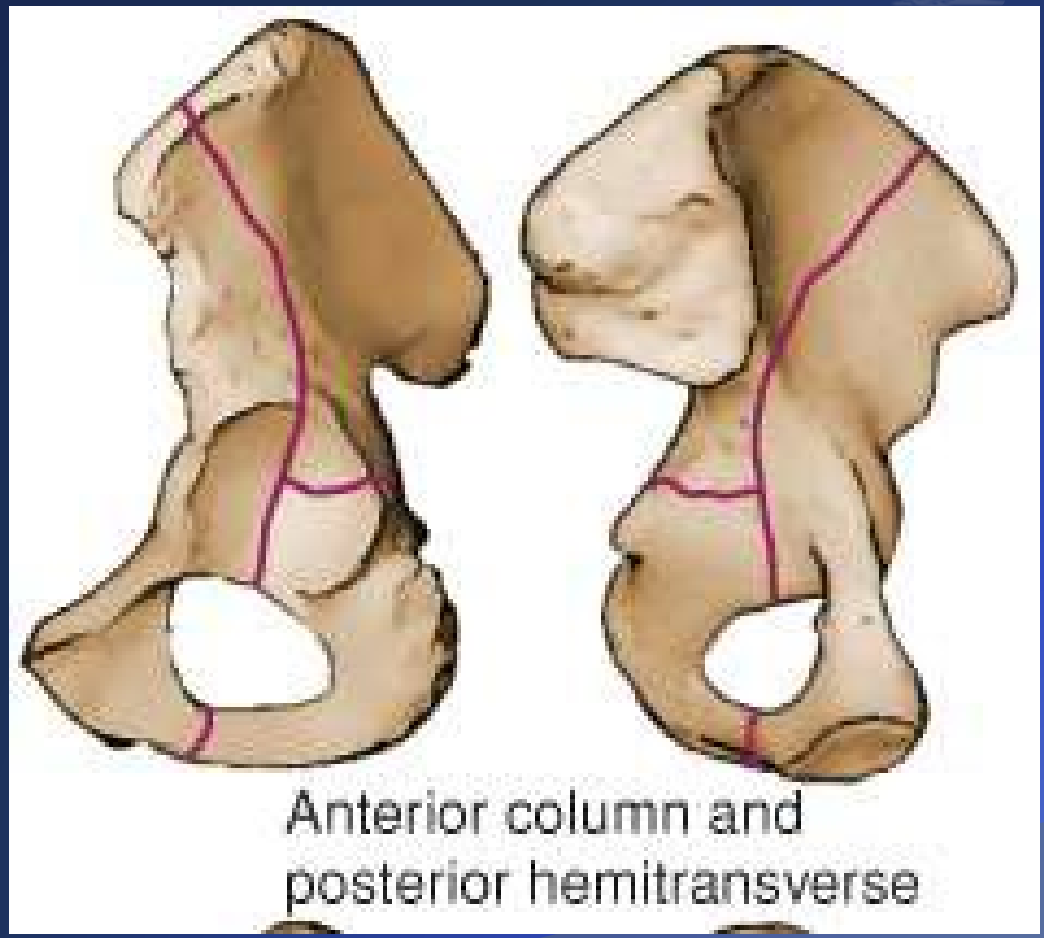
Associated Fracture Patterns





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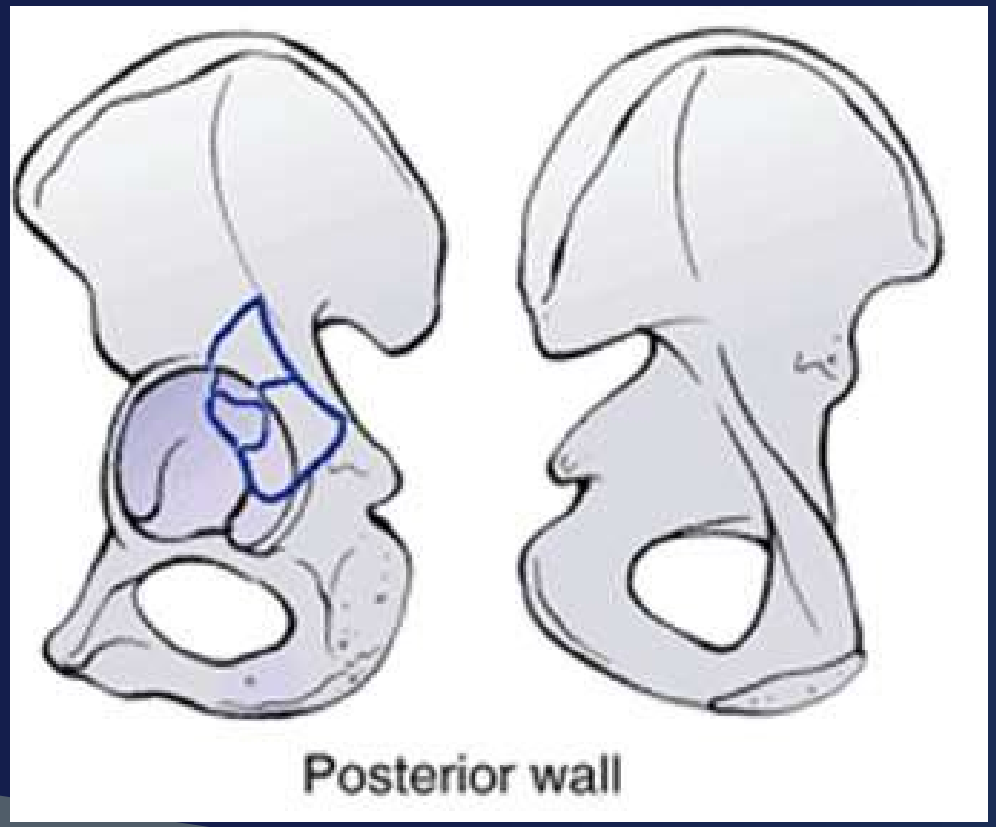
Elementary Fracture Patterns

Posterior Wall Fractures

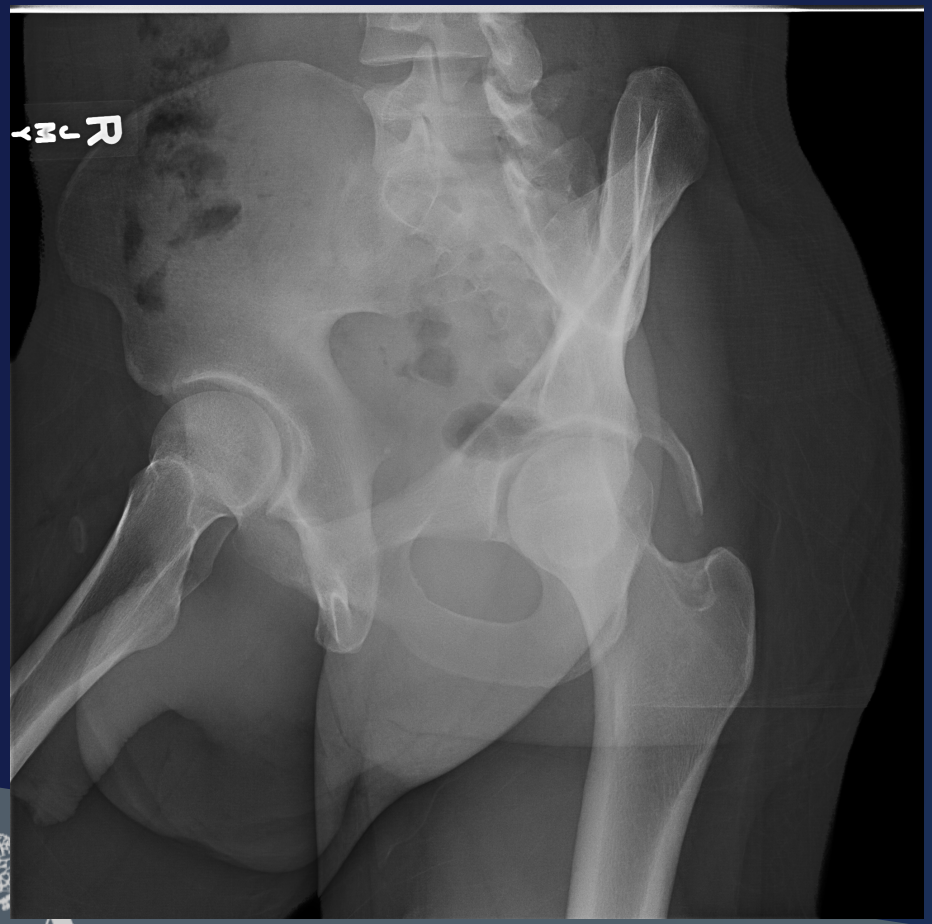


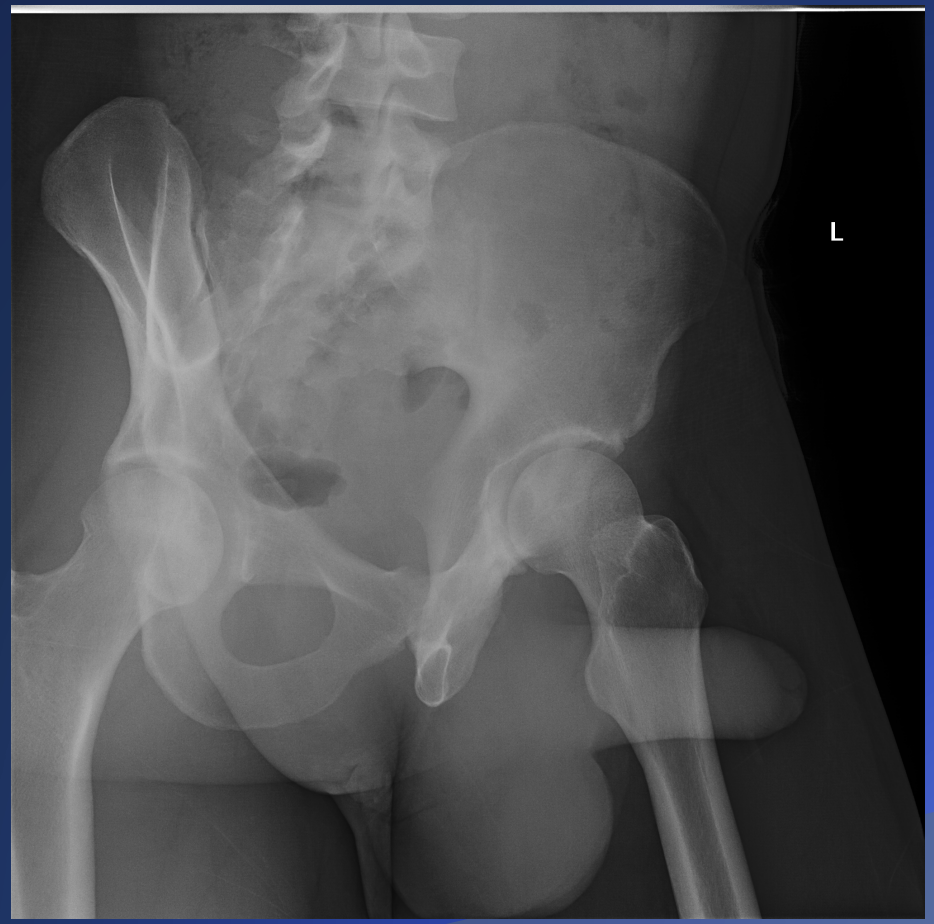
- Most common type of acetabular fracture
- Fracture through the posterior articular surface
- May be associated with **marginal impaction**
  - Articular surface with subchondral surface is impacted into the metaphyseal bone by the femoral head
- Often associated with posterior hip dislocations (35%)
- May be irreducible
  - Incarcerated fragment
  - Large area of the roof
  - Soft tissue incarceration

Posterior Wall Fractures

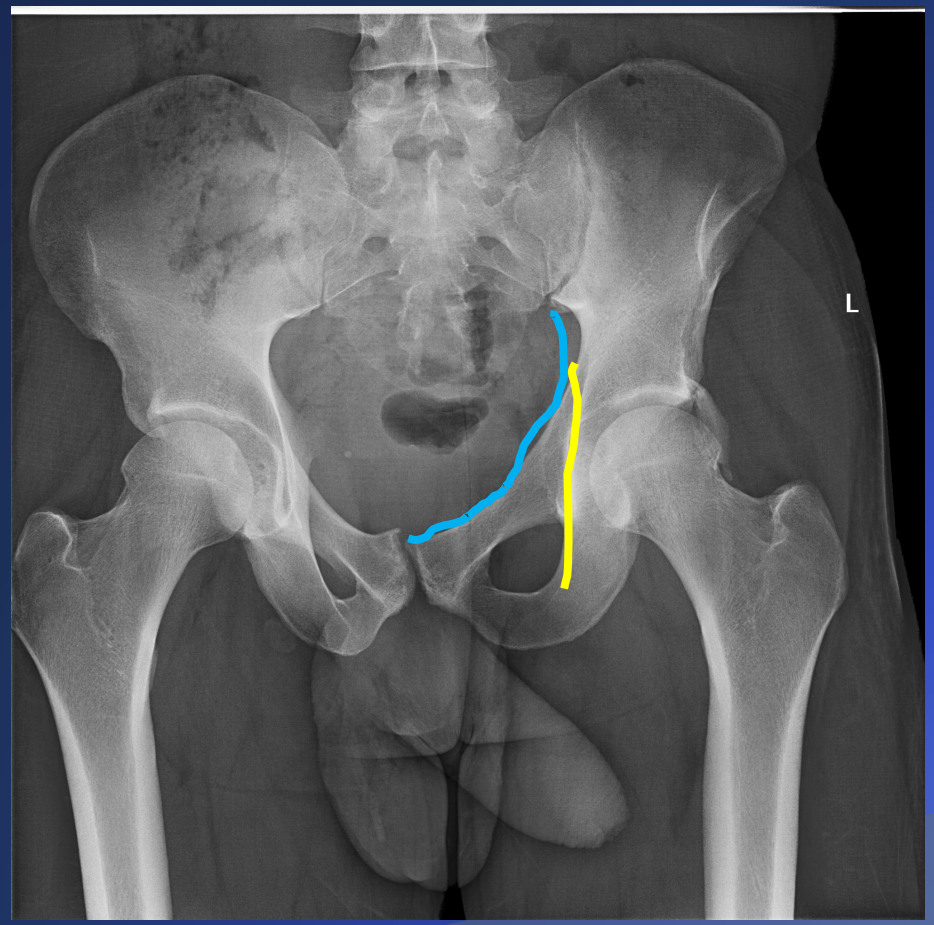
ORTHOPAEDIC TRAUMA ASSOCIATION

Posterior Wall Fractures





Posterior Wall Fractures



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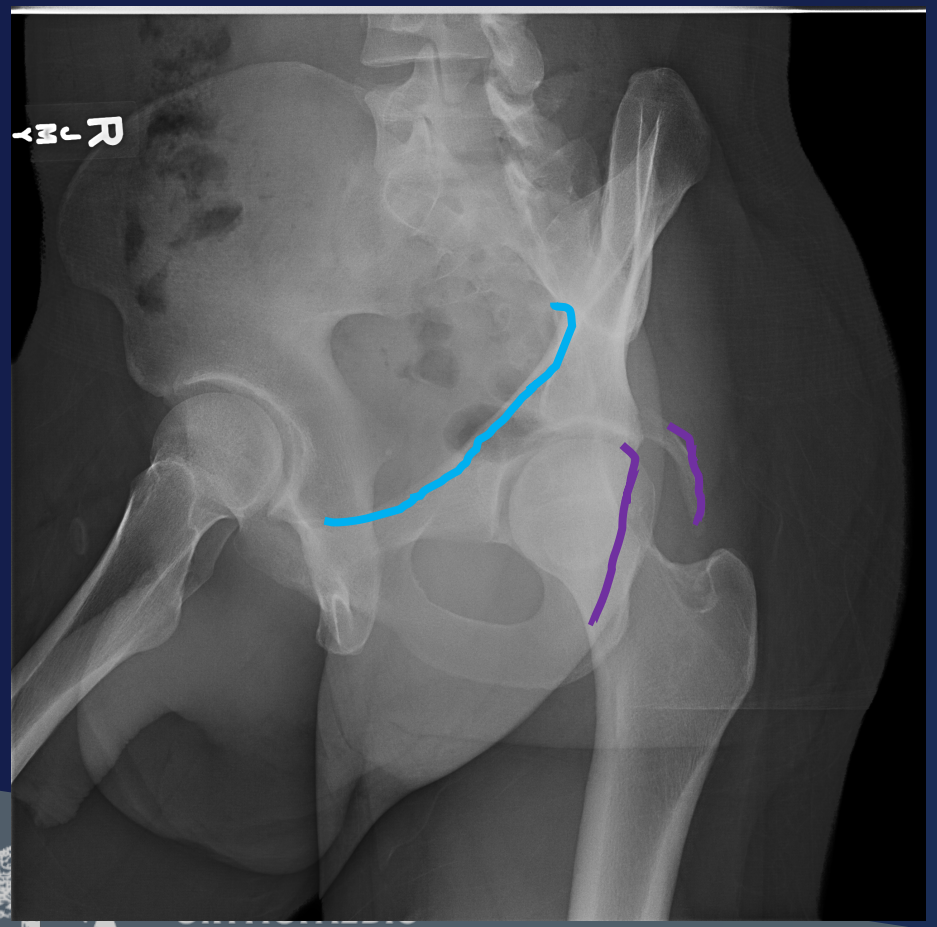
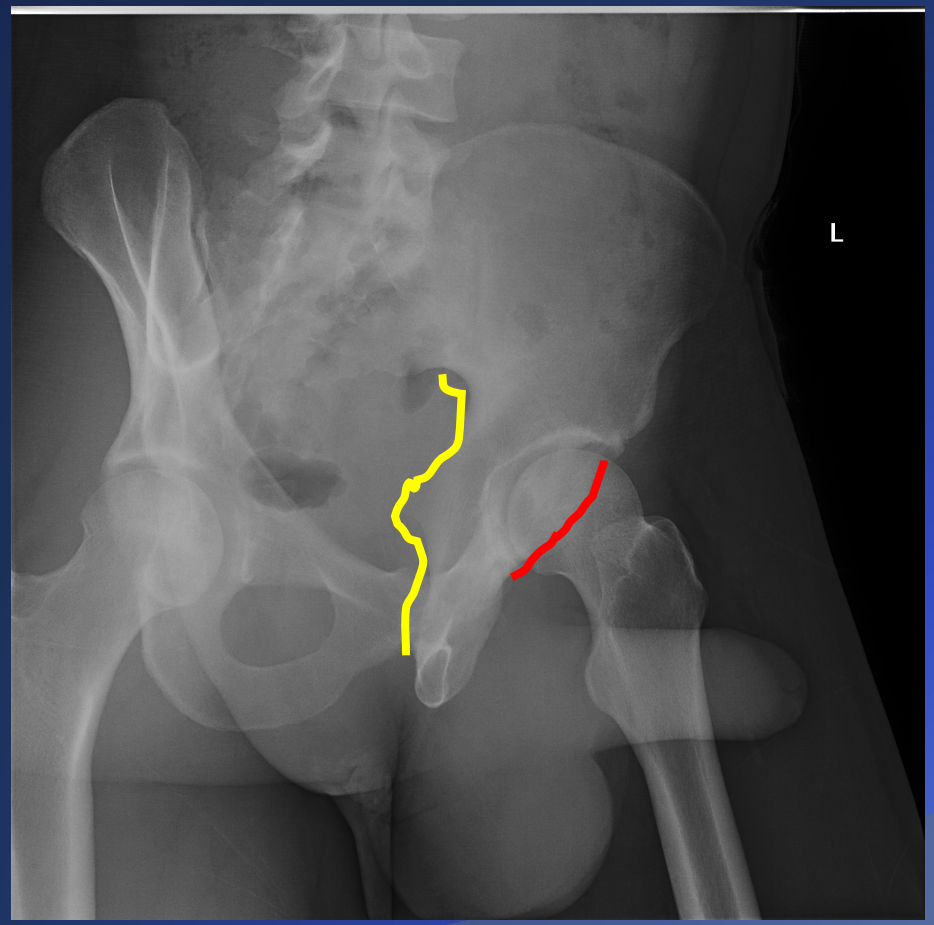
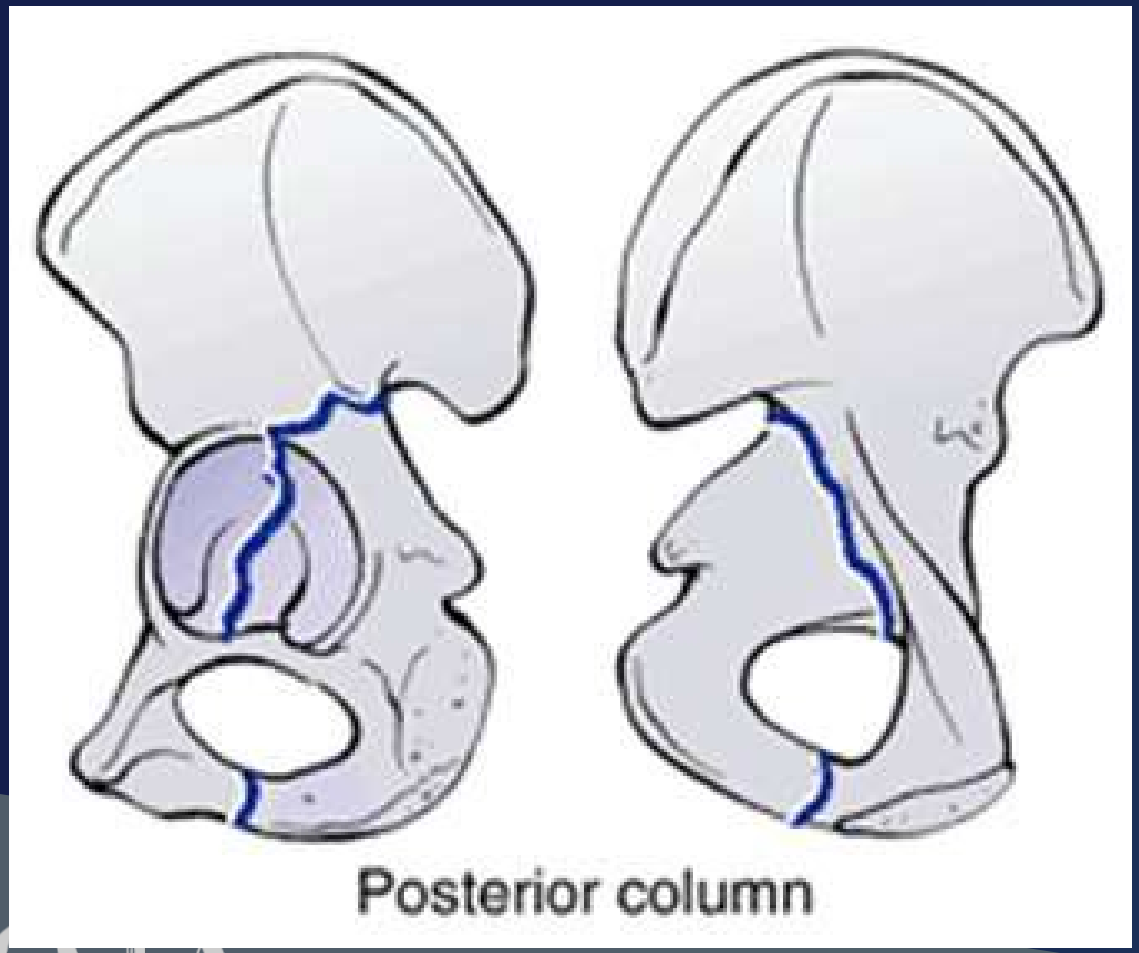
Posterior Wall Fractures





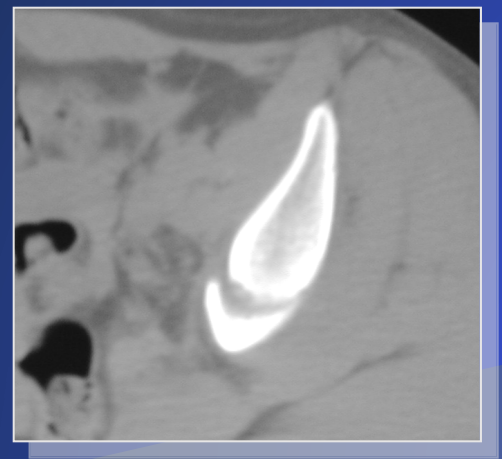
Posterior Column Fractures



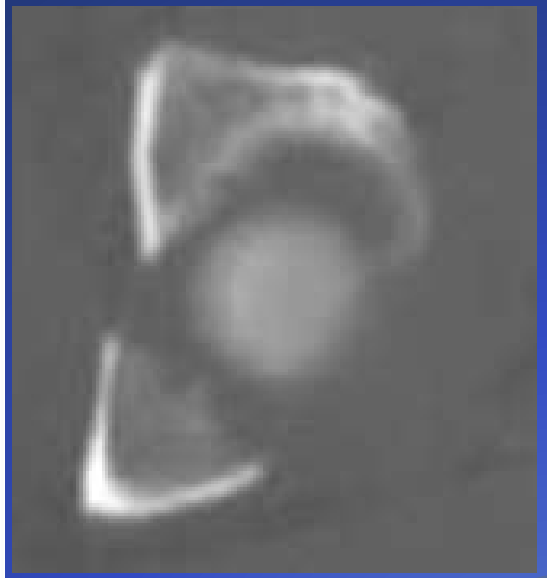
- Isolated fractures are rare
- Usually associated with dislocation
- Begin at the greater sciatic notch
- Continues through the weight bearing dome
- Exit through the obturator ring
- Complete detachment of posterior column
- Posterior and medial displacement with internal rotation

Posterior Column Fractures

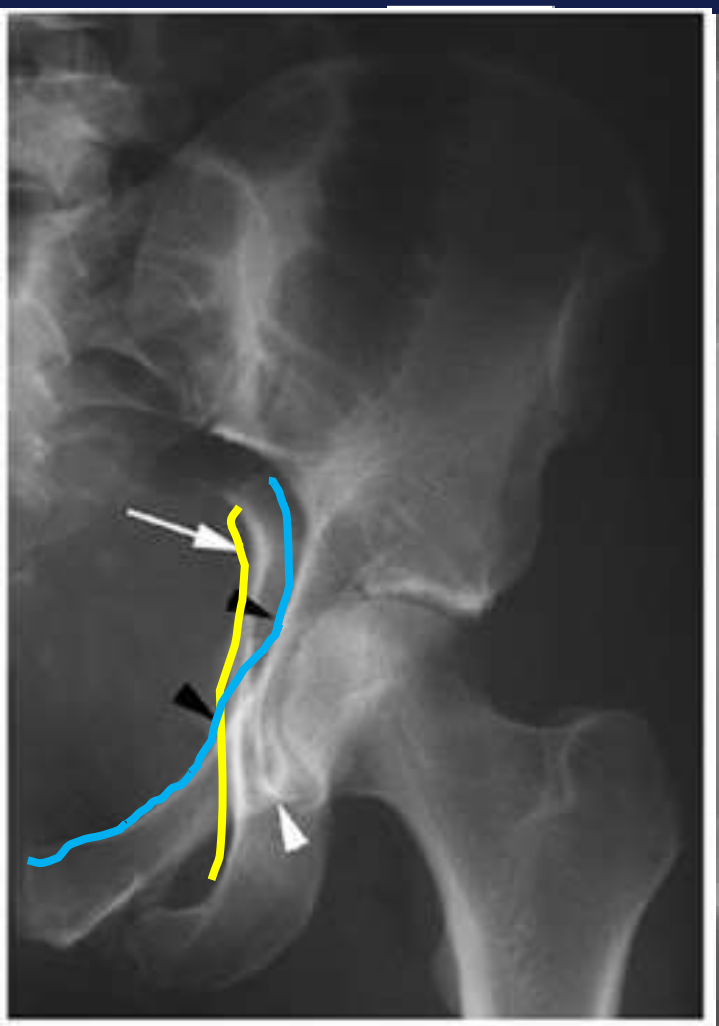
- Usually unstable injuries that require operative fixation
- Superior gluteal neurovascular bundle can be involved

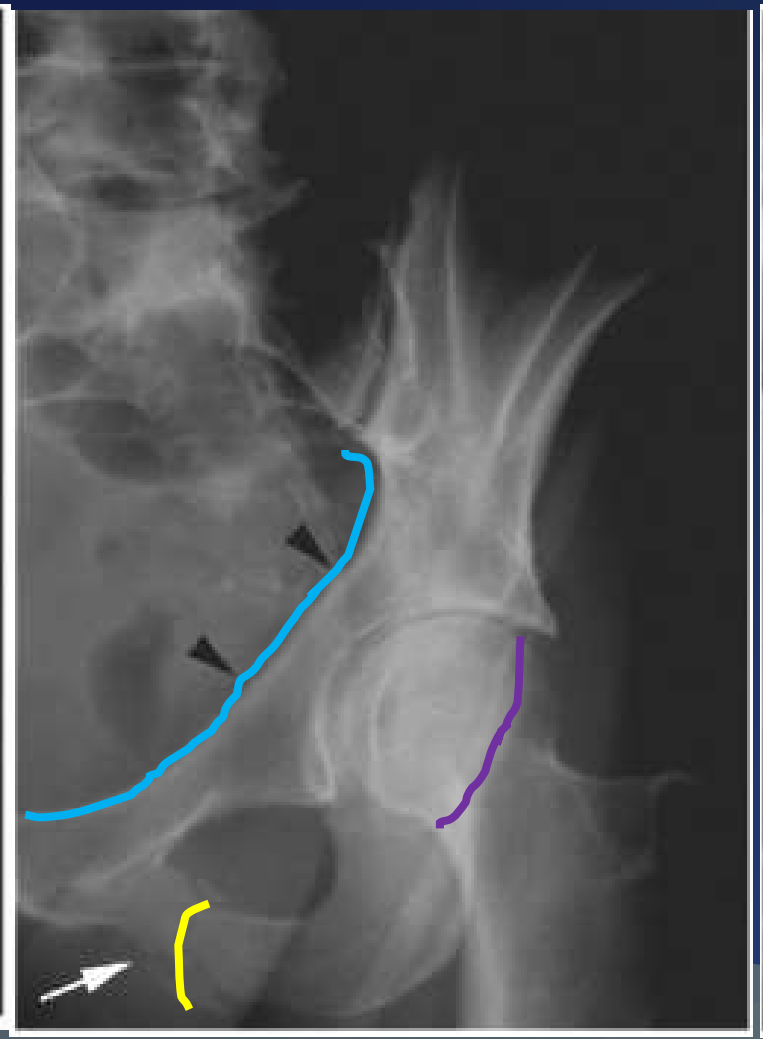


Posterior Column Fractures



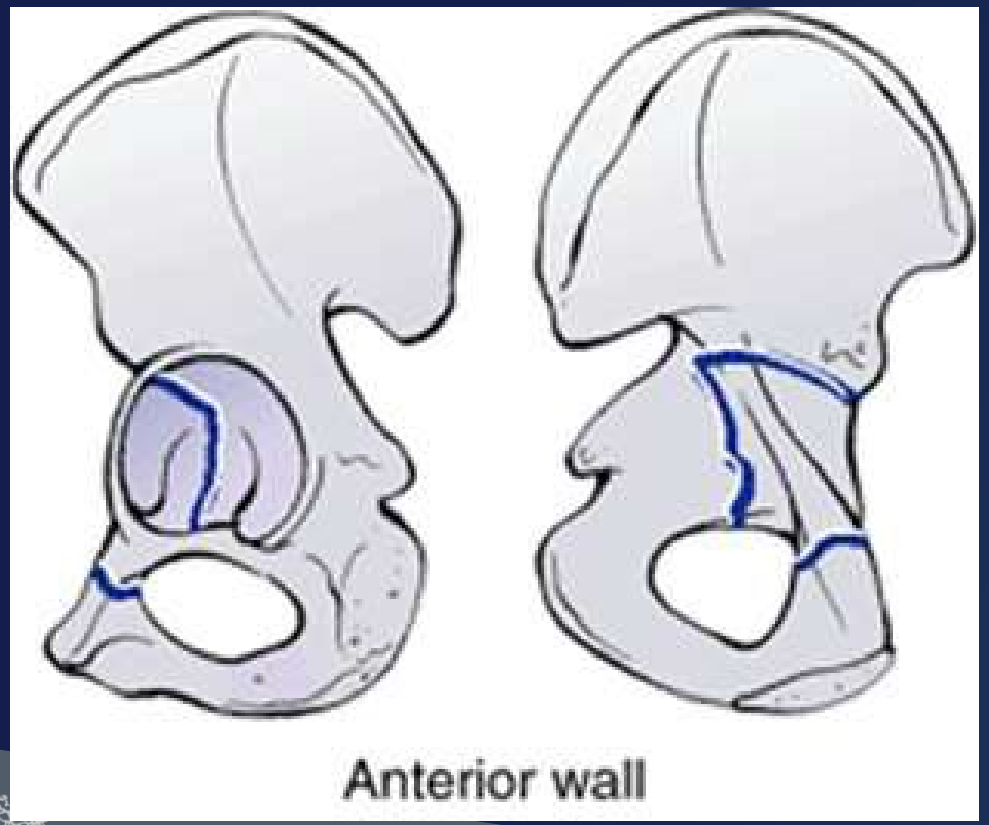
Posterior Column Fractures





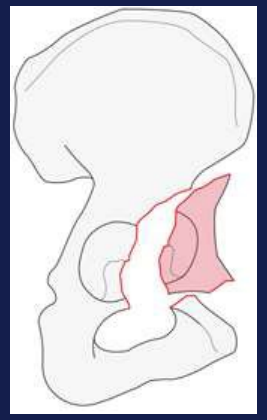
- Ilioischial line disrupted
- Iliopectineal intact

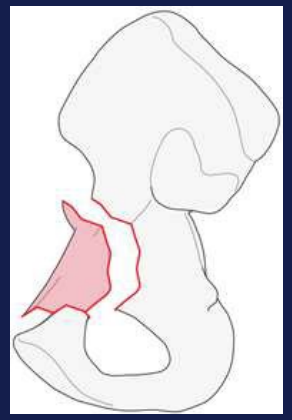
Anterior Wall

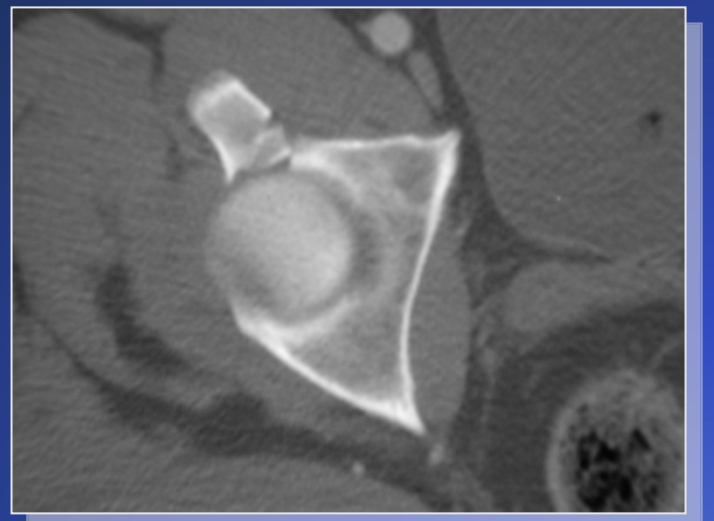


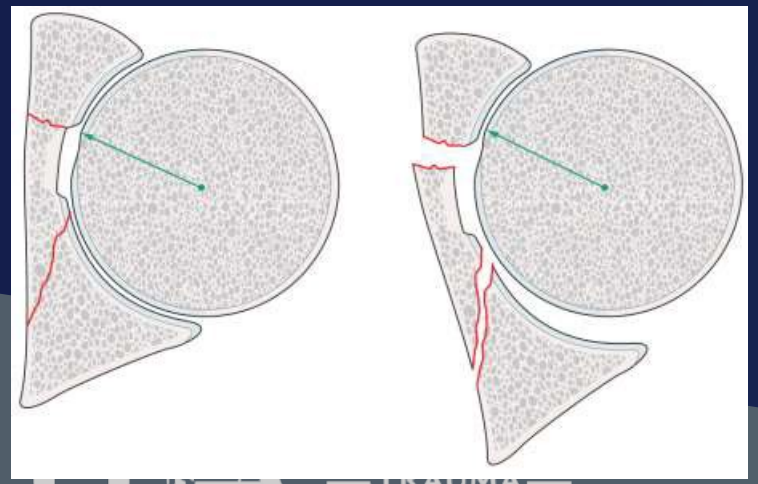
- Common in elderly patients from low-energy trauma
- Begins at the anterior border of the acetabulum below the AIIS
- Crosses the articular surface
- Descends along the quadrilateral surface to upper border of obturator foramen
- Transects the pubic ramus
- Femoral head displaces anterior and medially
- Marginal impaction possible

Anterior Wall Fractures









Anterior Wall Fractures

Anterior Wall Fracture

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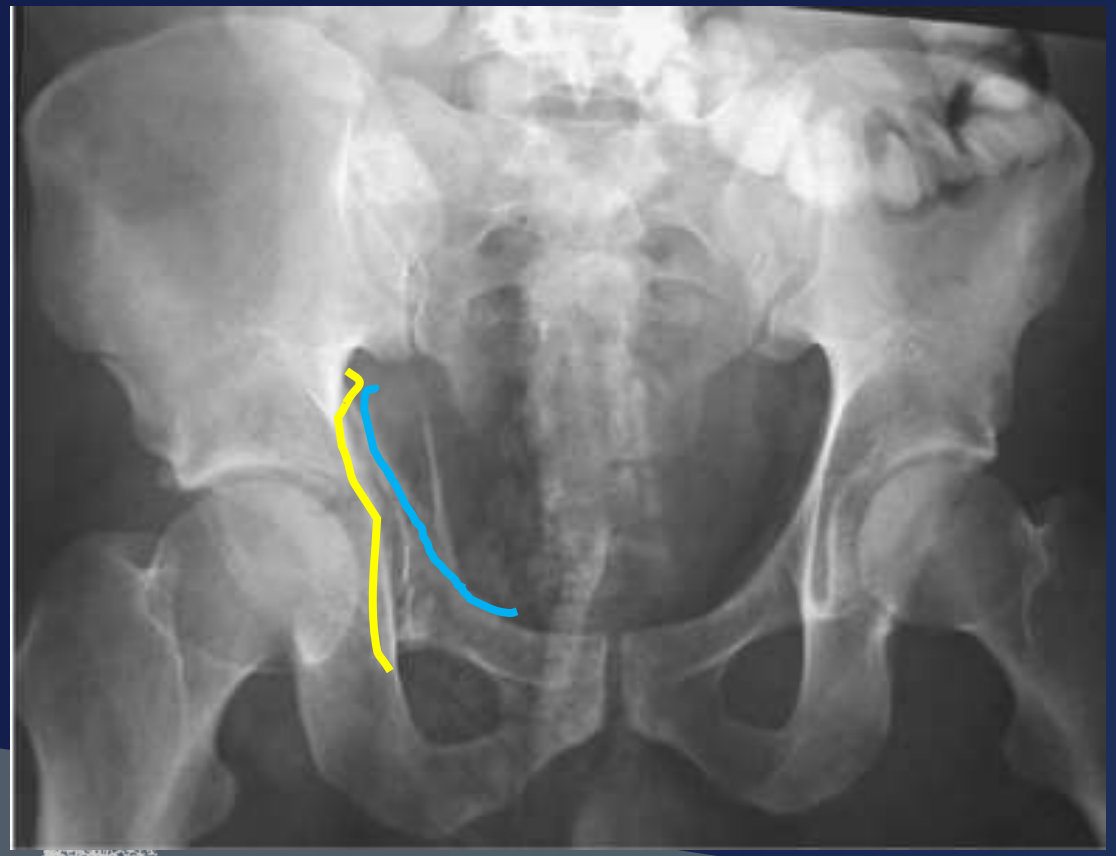
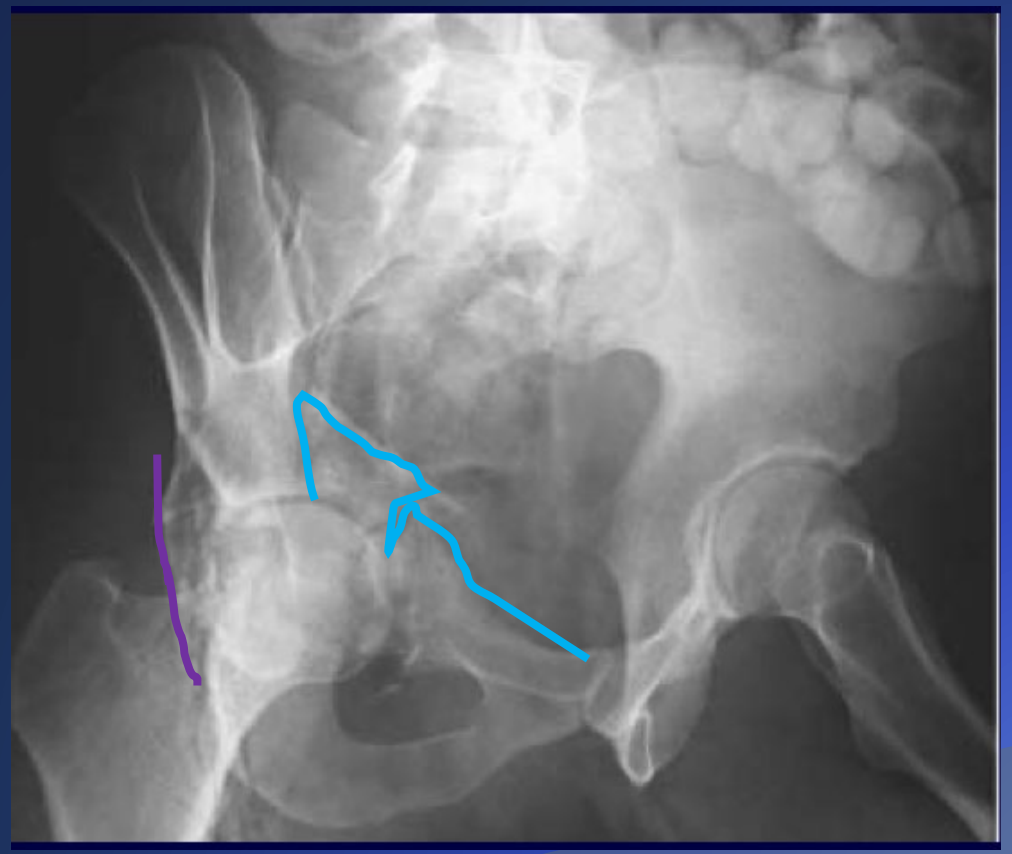
Anterior Wall Fracture

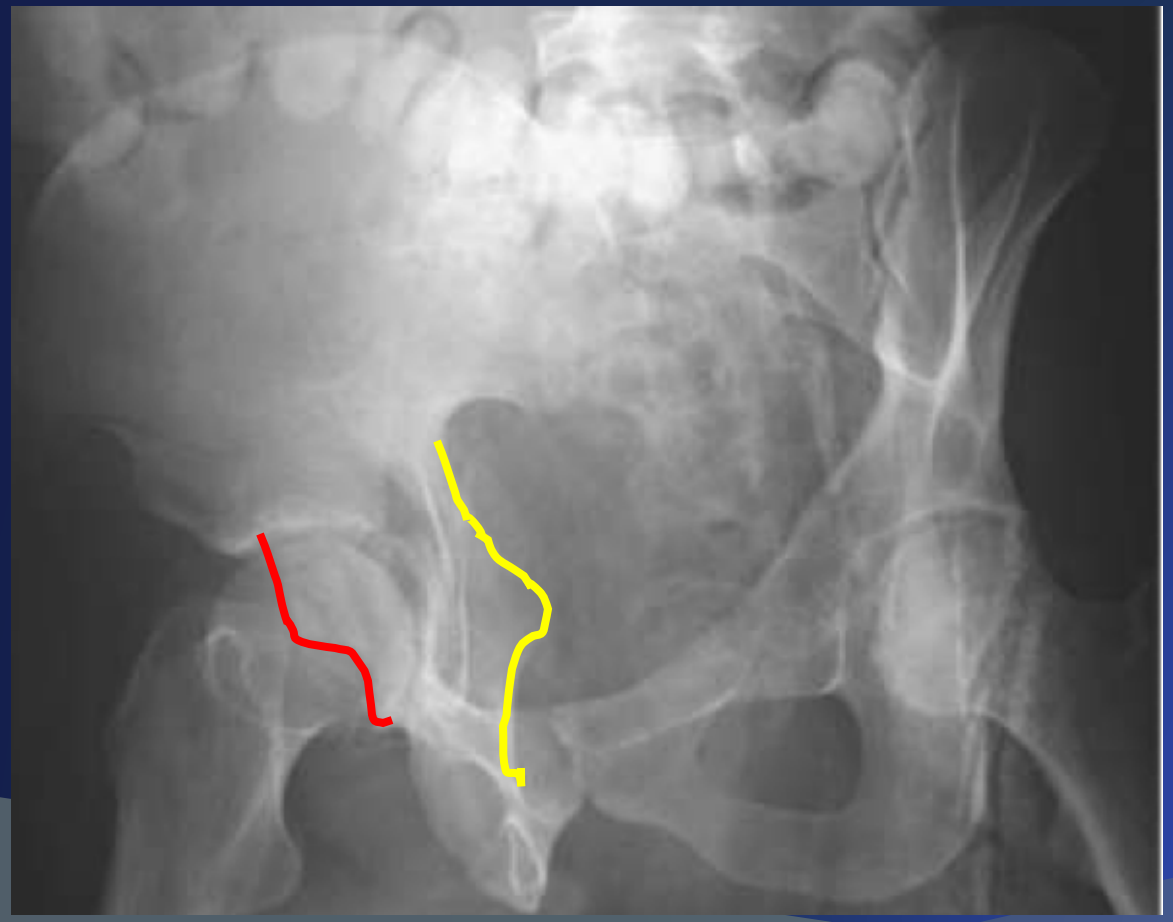
- **Letournel description of anterior wall characteristics**
- Ilioischial line intact
- Fracture involves only part of the anterior column
- AP view- radiographic landmarks broken
  - Anterior border of the acetabulum
  - Iliopectineal line in its middle part and always at two points
  - Posterior one divides the posterior half of the pelvic brim
  - Anterior one breaks the superior pubic ramus
- Moed describes an atypical anterior wall that extends into the ilium

Anterior Wall Fractures





Anterior Wall Fracture



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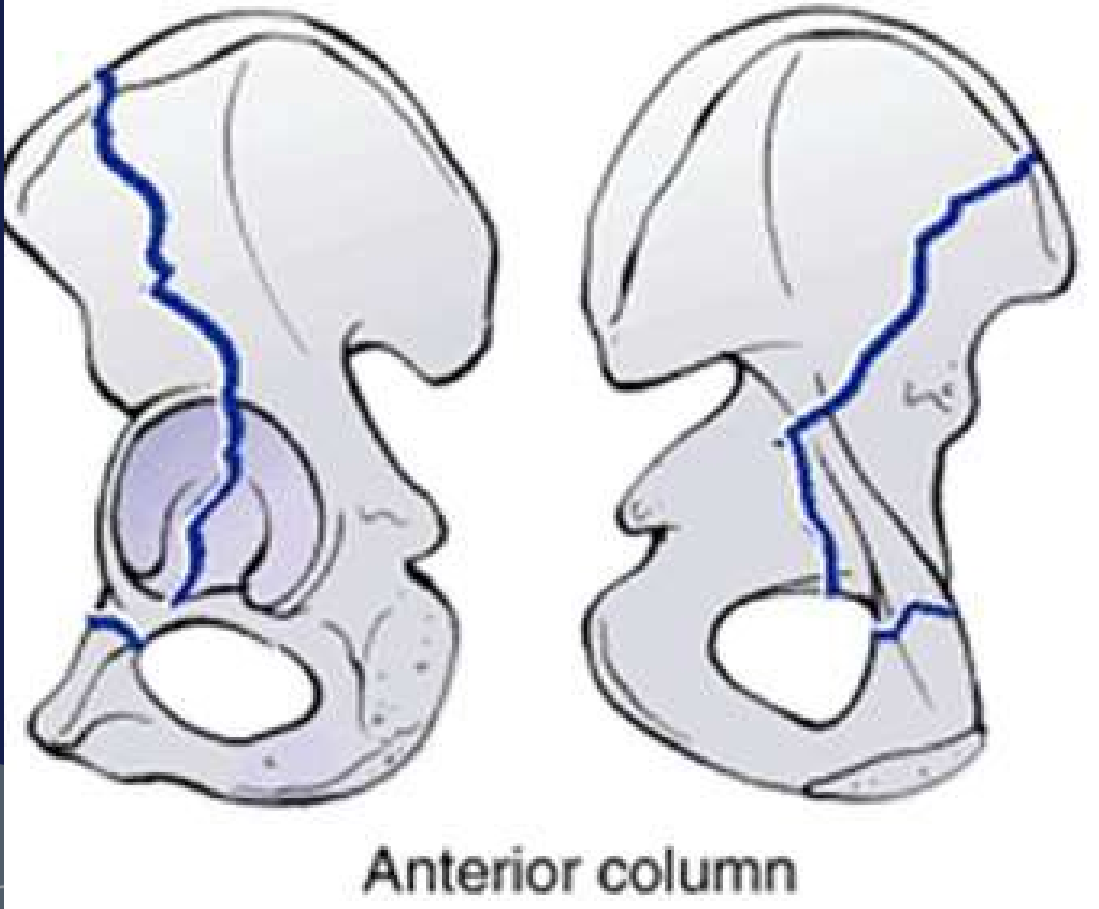
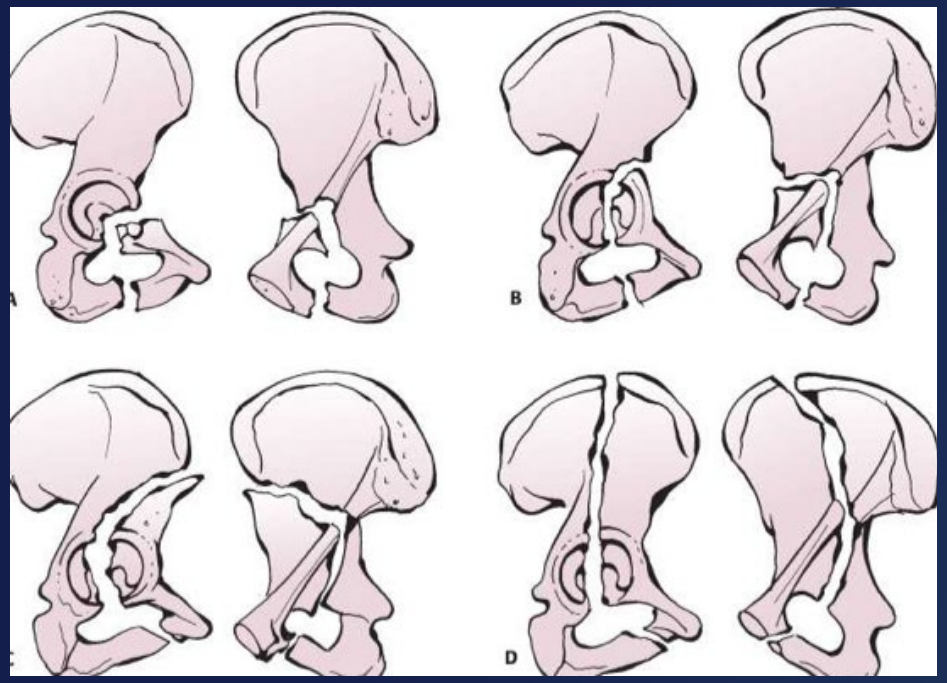
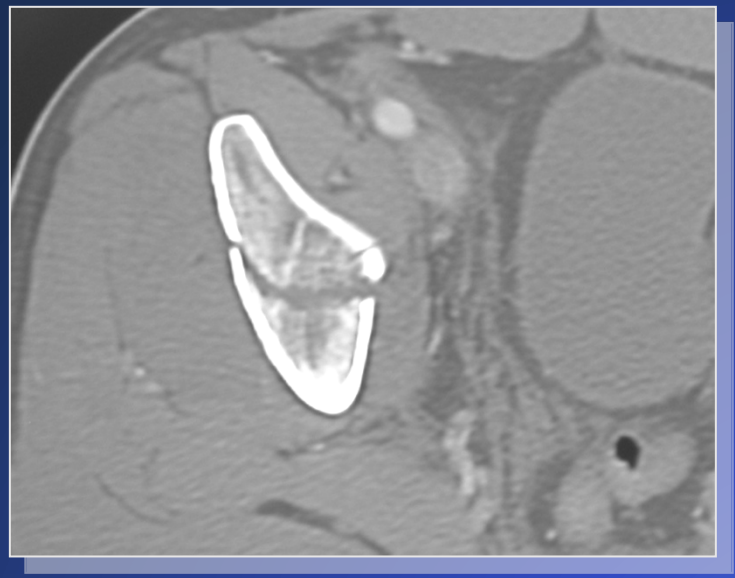
Anterior Column



- Starts from the middle of the ischiopubic ramus and passes through the anterior acetabulum
- Described by level of their proximal extent
- Fracture may extend to the pelvic brim
- May be associated with medialization of the quadrilateral surface
- Displaces anterior and medial

Anterior Column Fractures





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Anterior Column Fractures

Anterior Column Fractures

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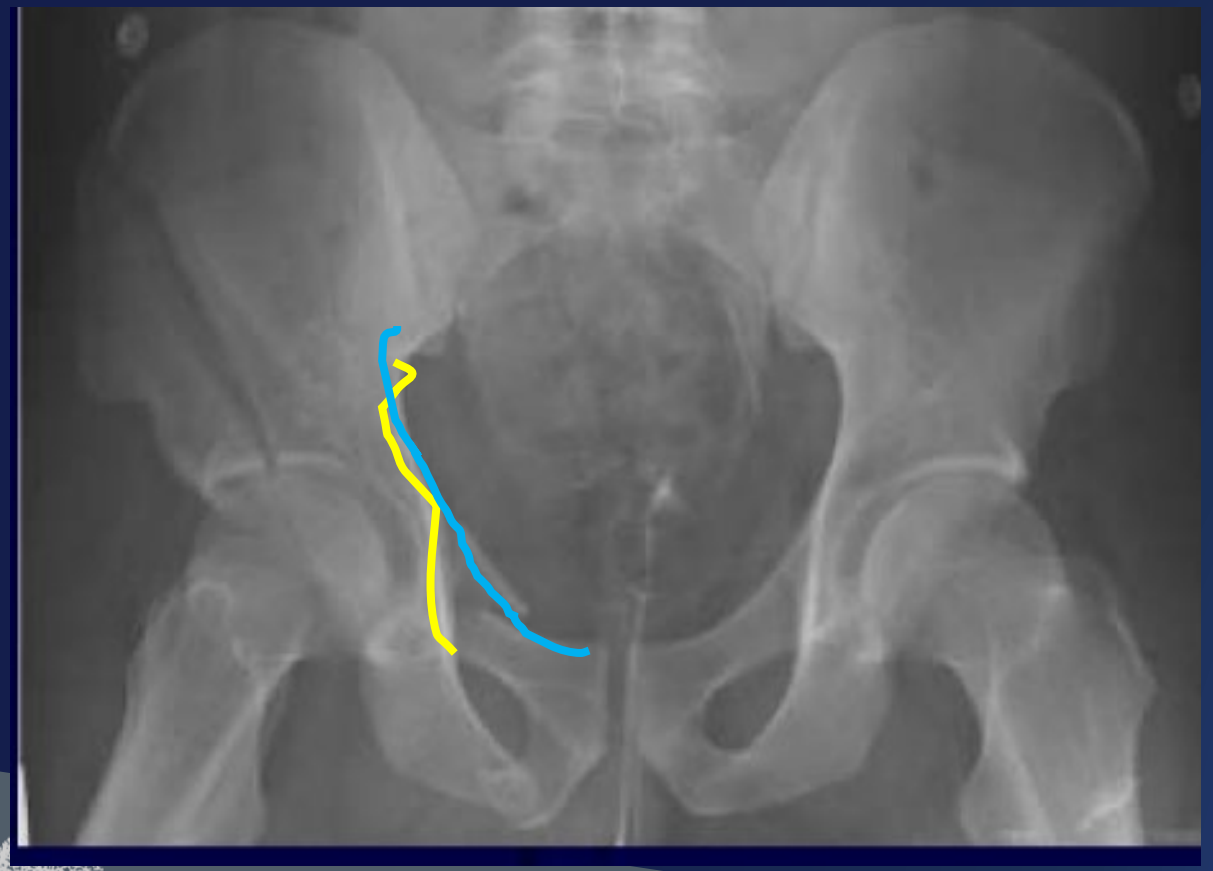
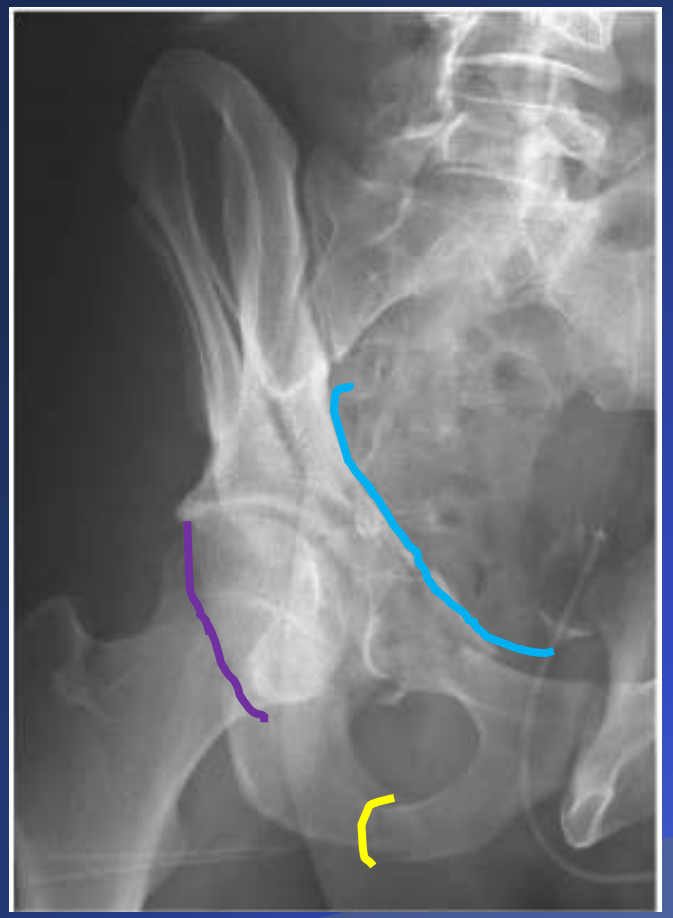
Anterior Column Fracture

- Subtypes based on location where fracture exits innominate bone anteriorly
- High
  - Iliac crest
- Intermediate
  - ASIS
- Low
  - Psoas gutter below AIIS
- Very low
  - Iliopectineal eminence

Anterior Column Fractures





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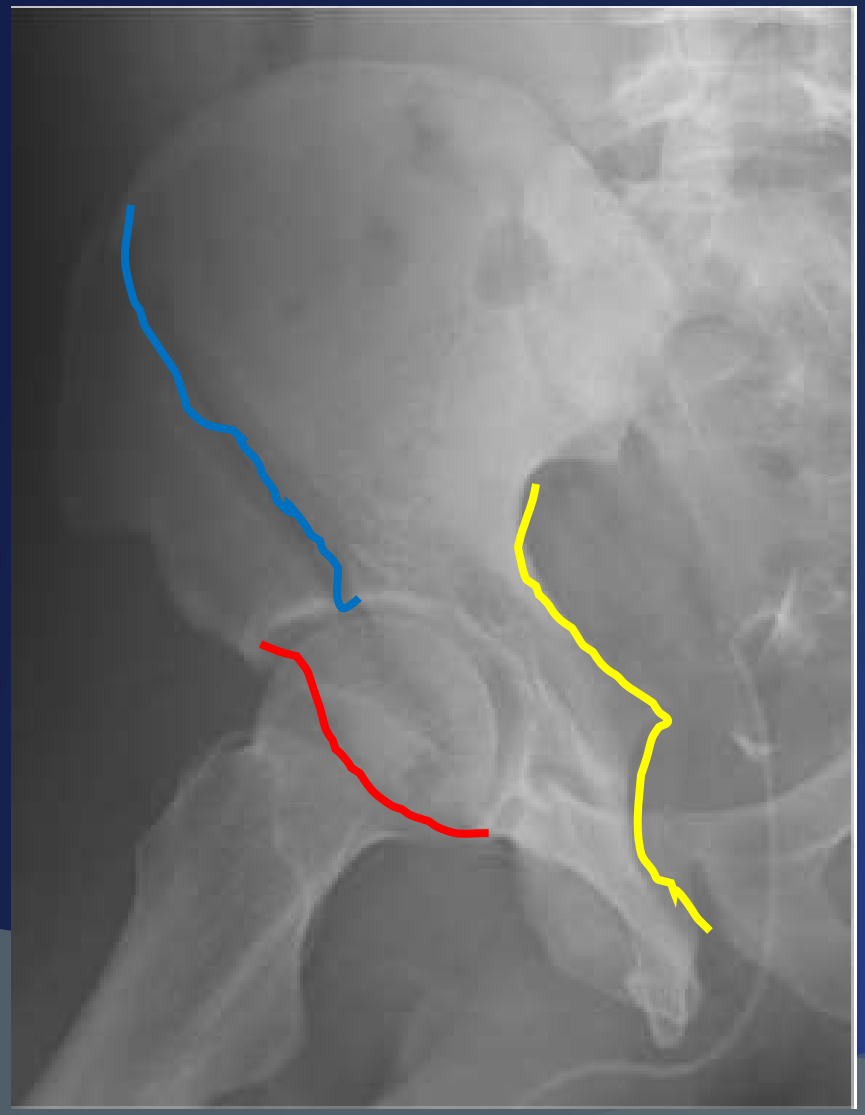
Anterior Column Fractures



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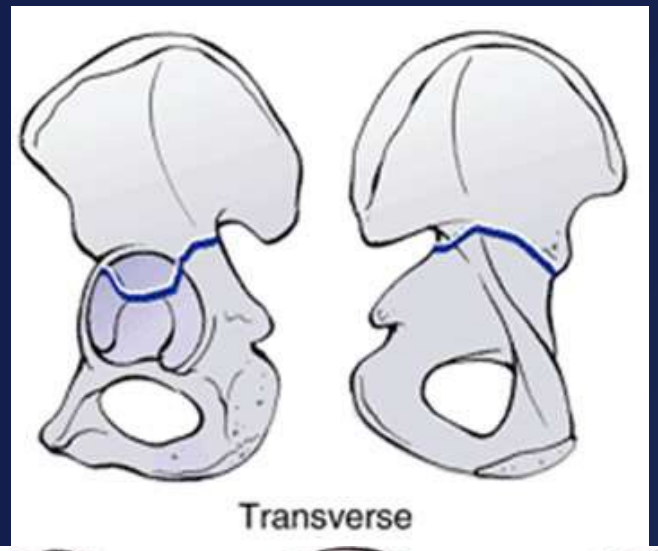
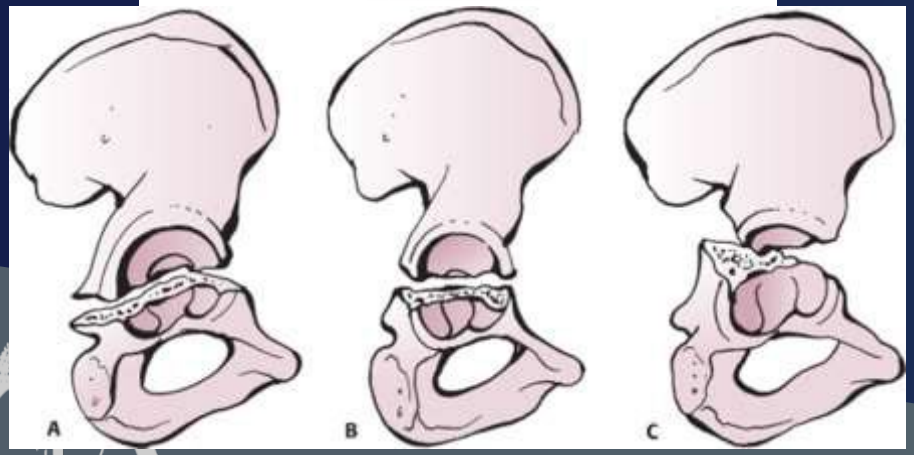
Transverse Fractures

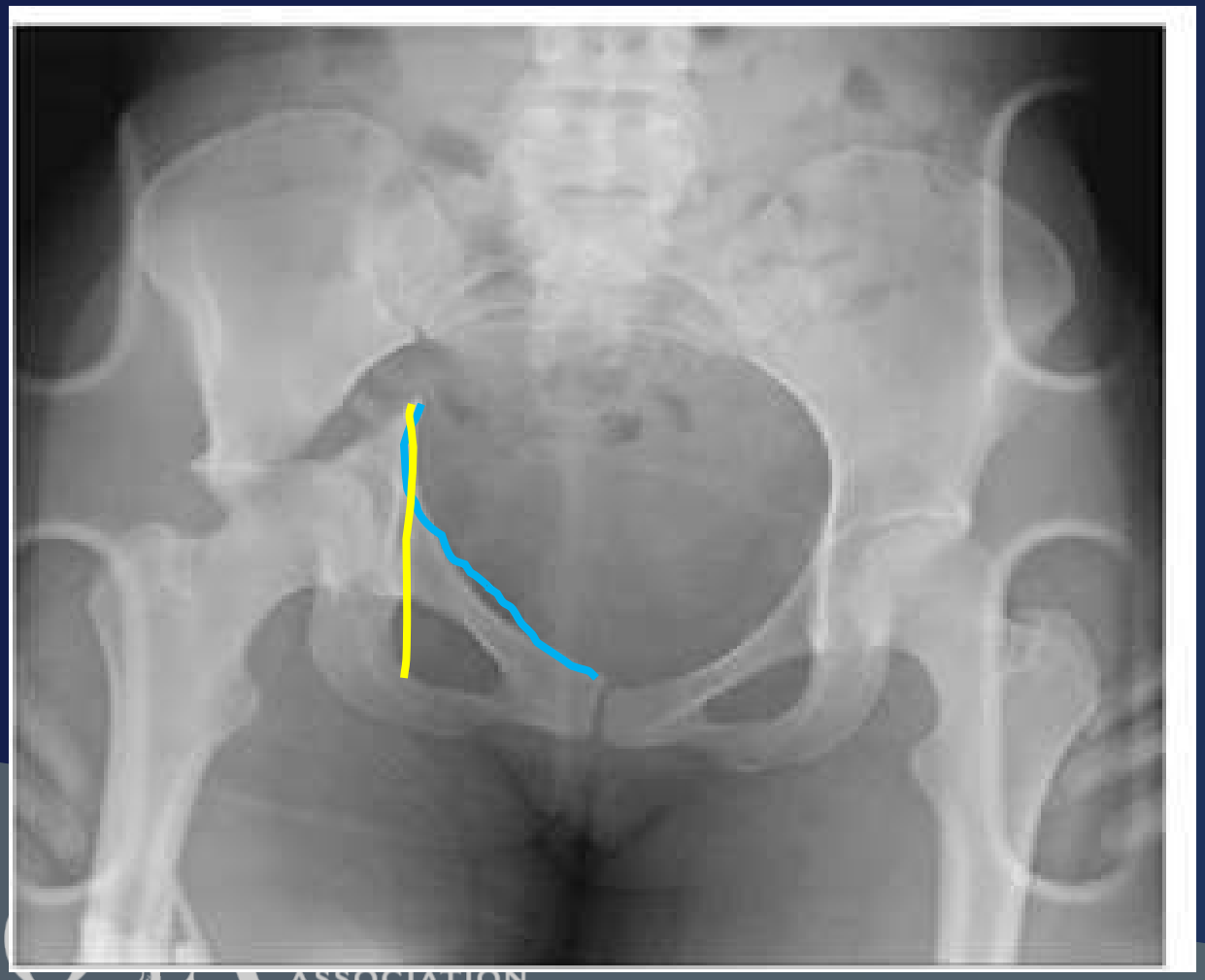




- Crosses through anterior and posterior columns
- Divides into upper portion (ilium/roof) and lower portion (ischium/pubis)
- Lower portion usually displaced medially
- Different levels
  - Infratectal
  - Juxtatectal
  - Transtectal – worse prognosis

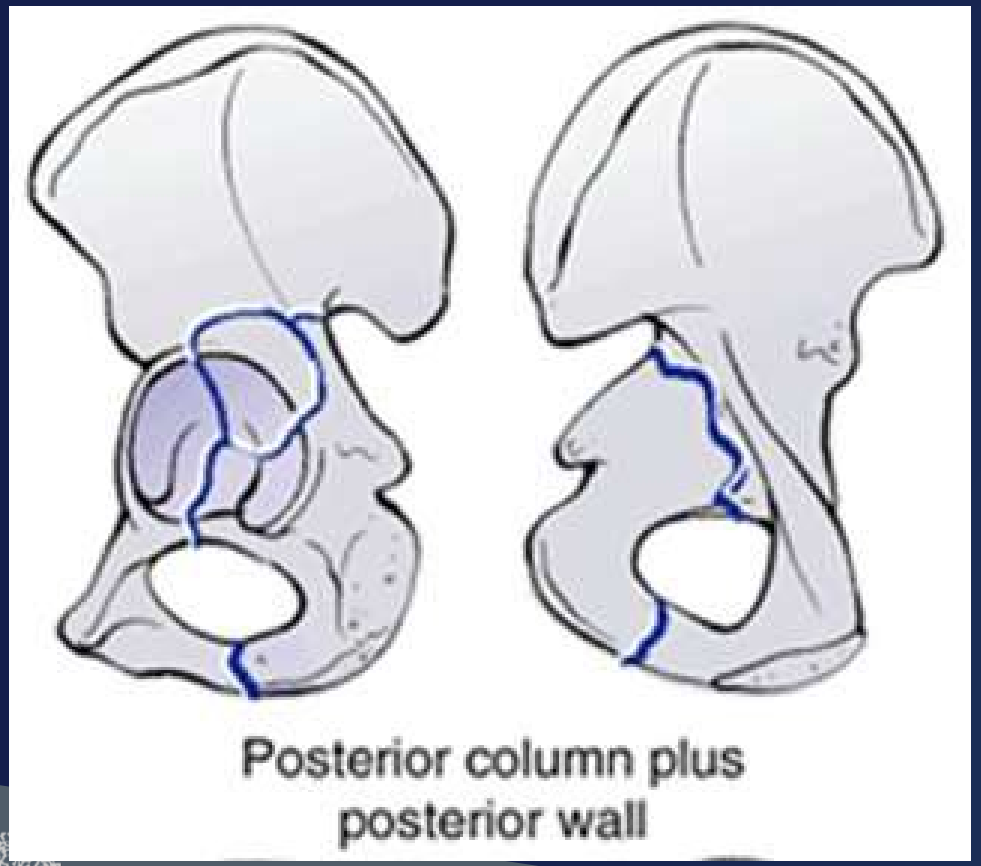
Transverse Fractures

Transverse Fractures

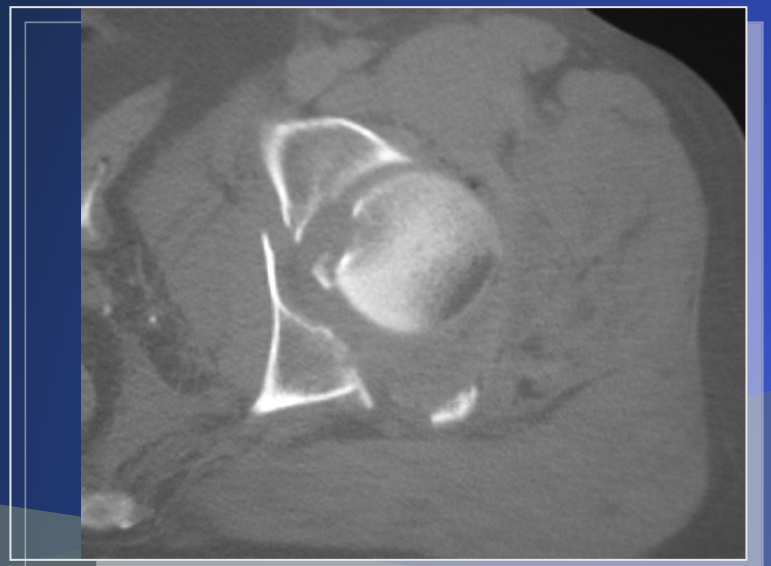


Associated Fracture Patterns

Posterior Column/Posterior Wall



- Column fracture may be non-displaced and wall fracture more obvious
- May be associated with femoral head fractures



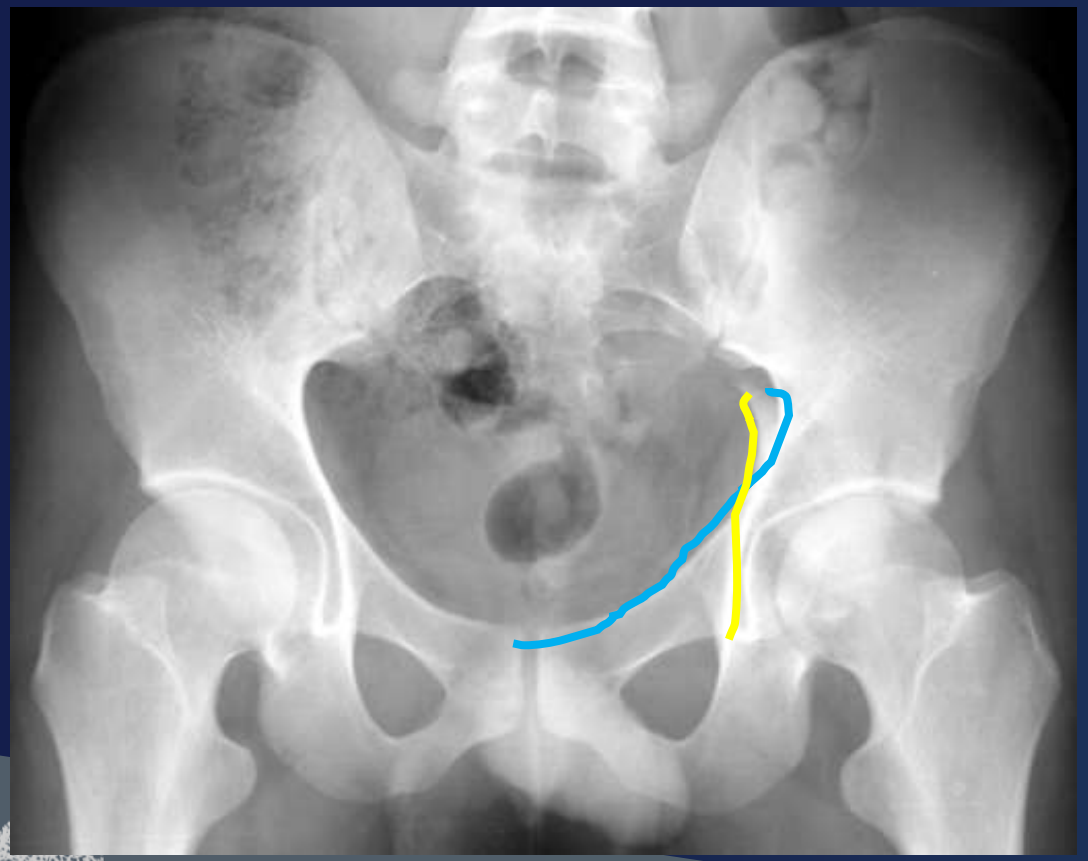
ORTHOPAEDIC TRAUMA ASSOCIATION

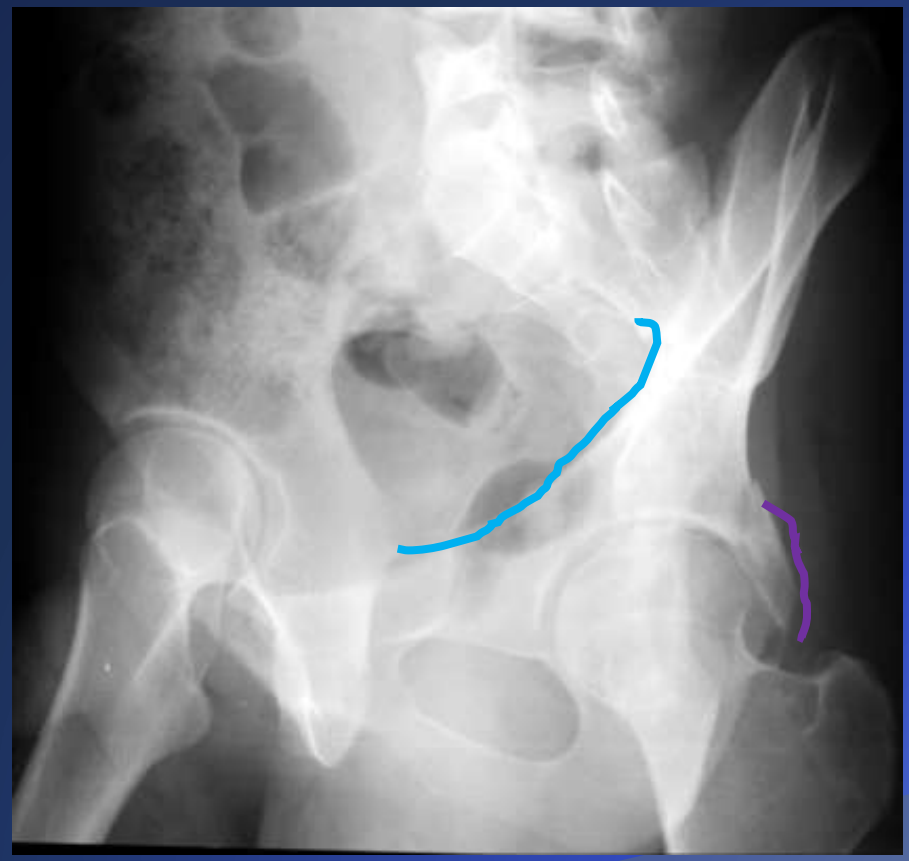
Posterior Column/Posterior Wall

Posterior Column/Posterior Wall

ORTHOPAEDIC TRAUMA ASSOCIATION

Posterior Column/Posterior Wall





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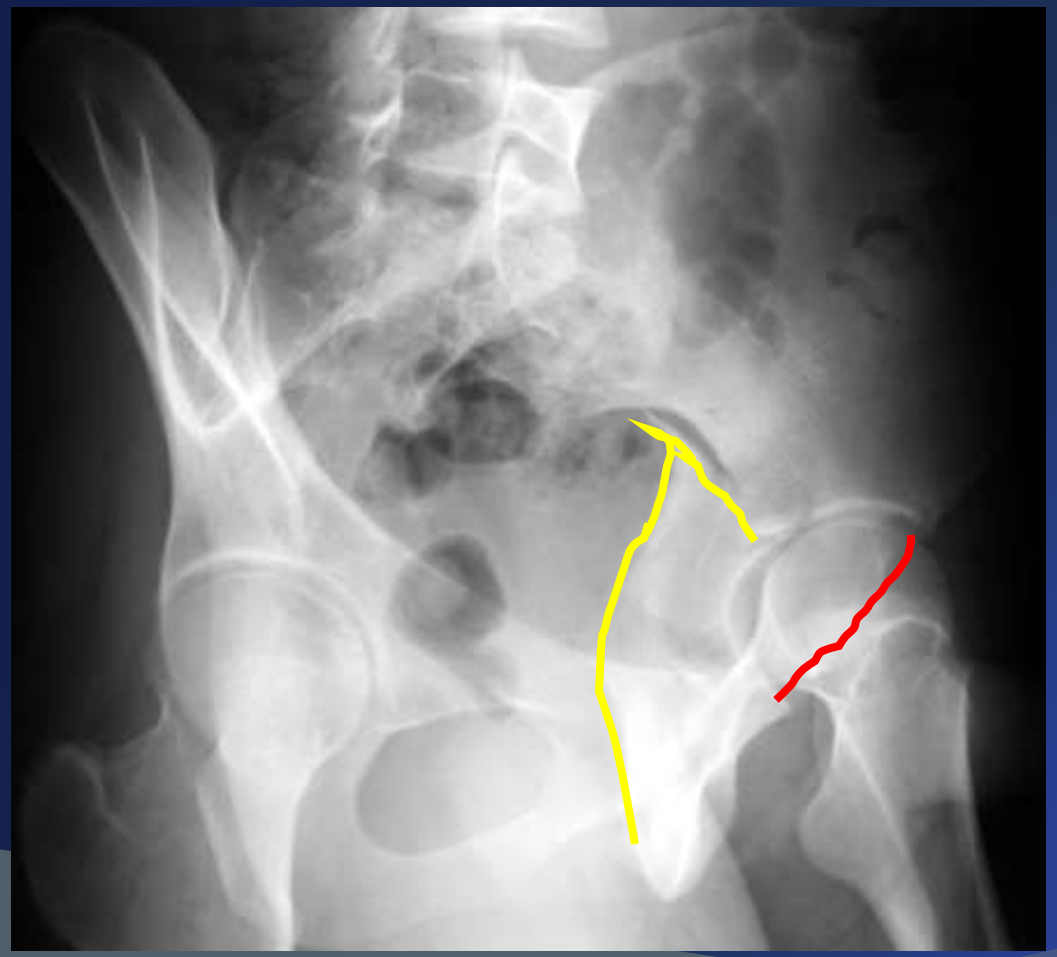
Posterior Column/Posterior Wall



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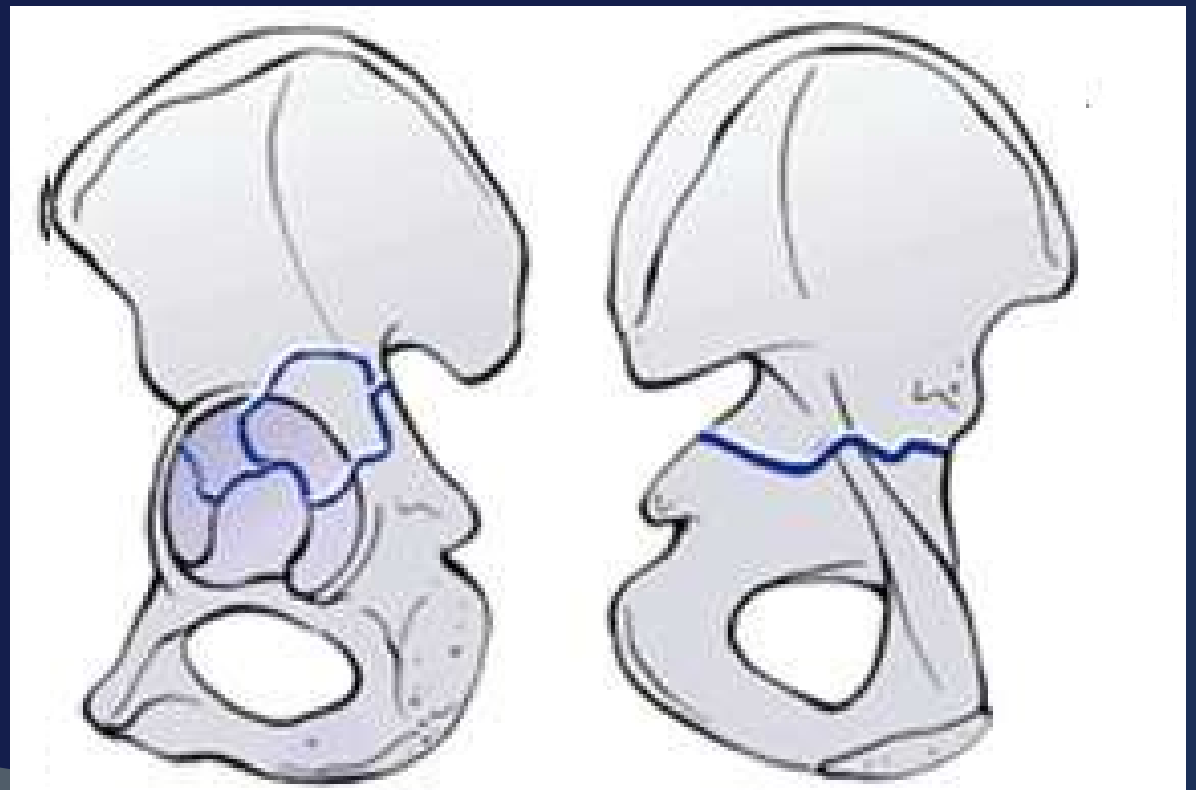
Transverse and Posterior Wall



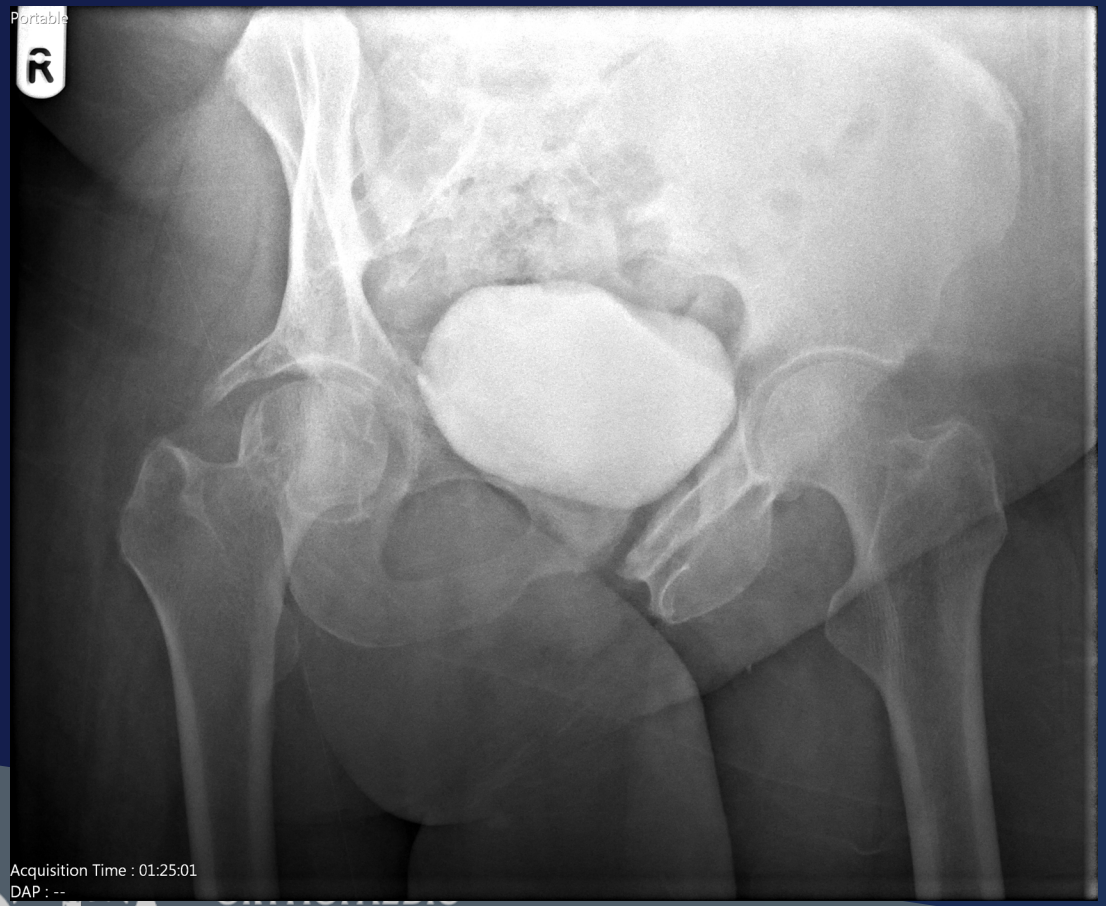
Transverse plus posterior wall

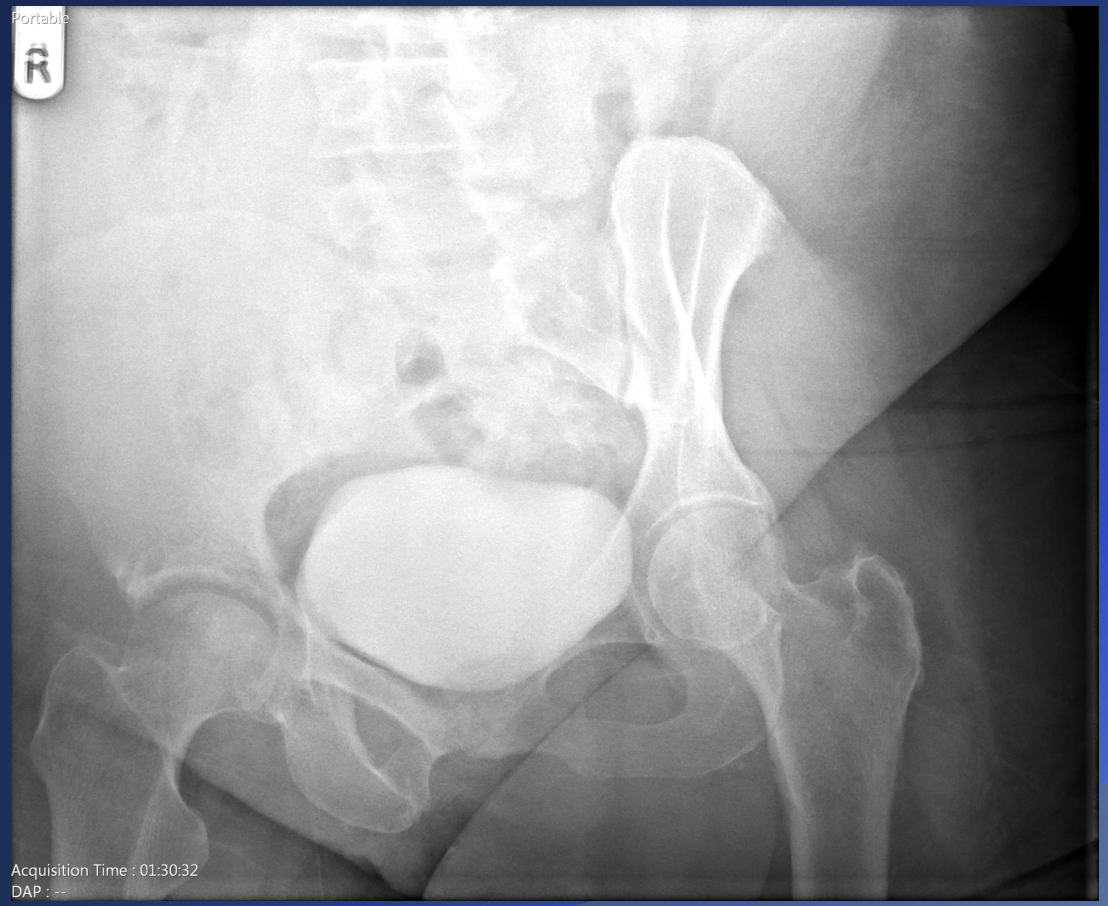
- Two different patterns of injury
- Posterior wall more displaced – posterior hip dislocation
- Transverse more displaced – central dislocation

Transverse and Posterior Wall

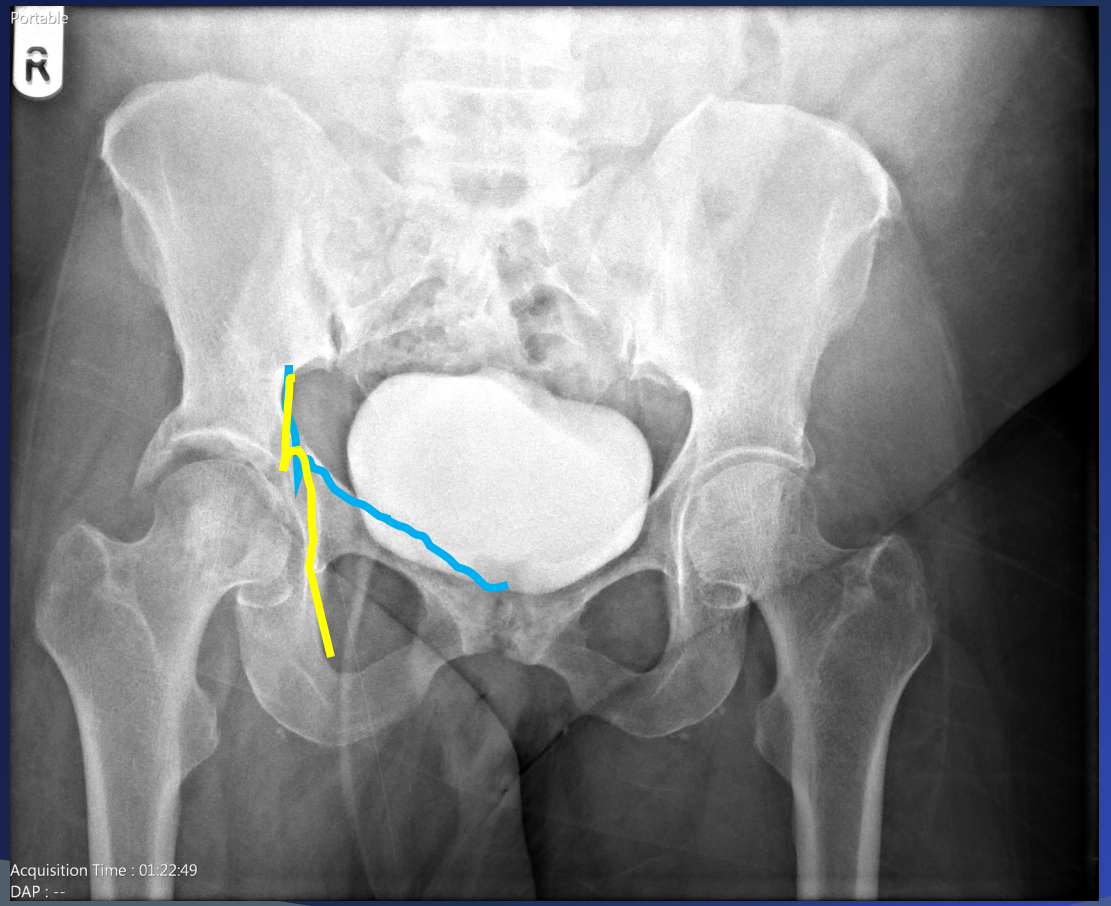
OTA ORTHOPAEDIC TRAUMA ASSOCIATION

Transverse and Posterior Wall



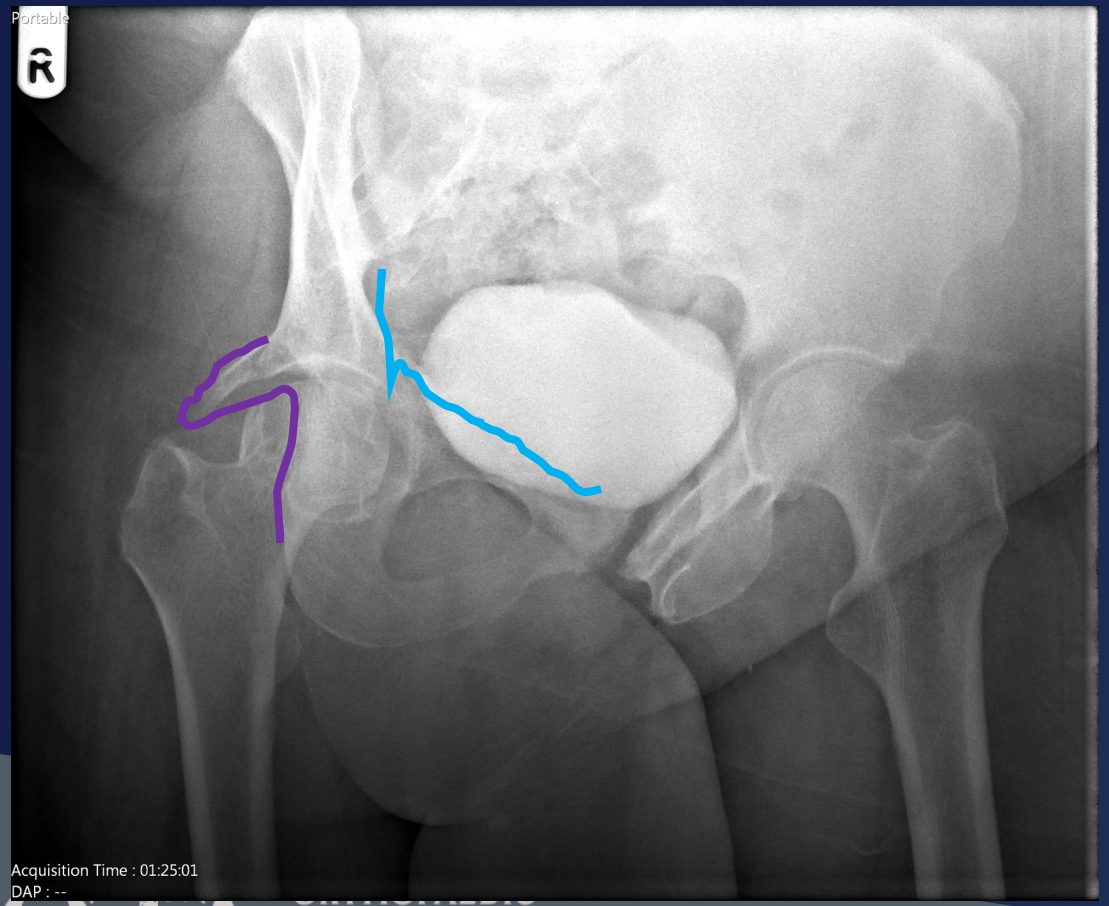


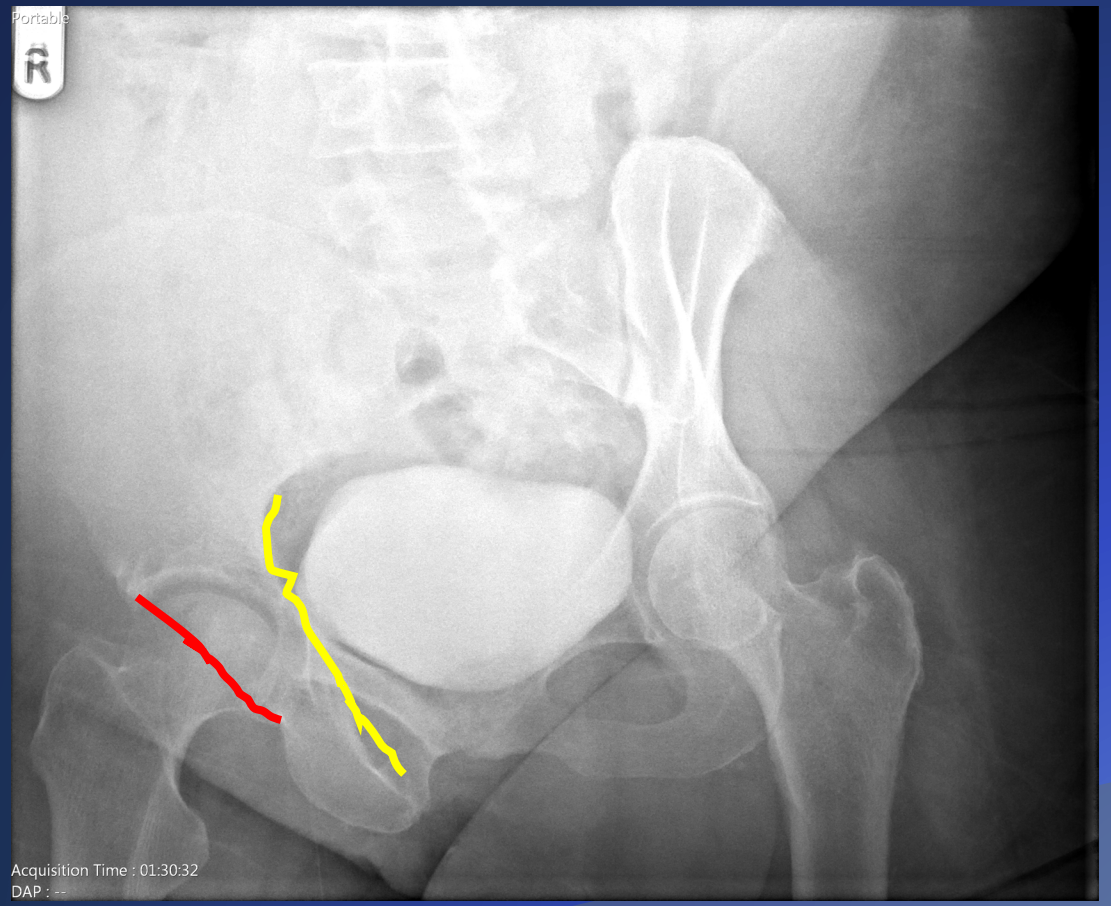
Transverse and Posterior Wall



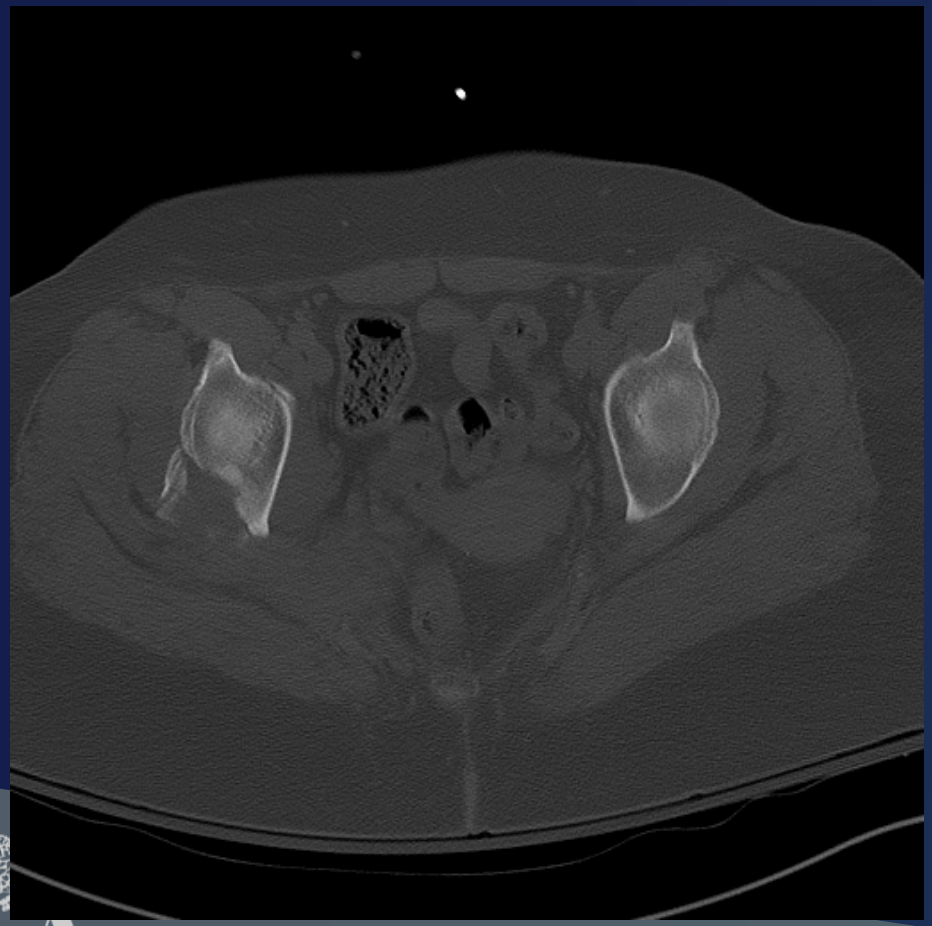
ORTHOPAEDIC TRAUMA ASSOCIATION

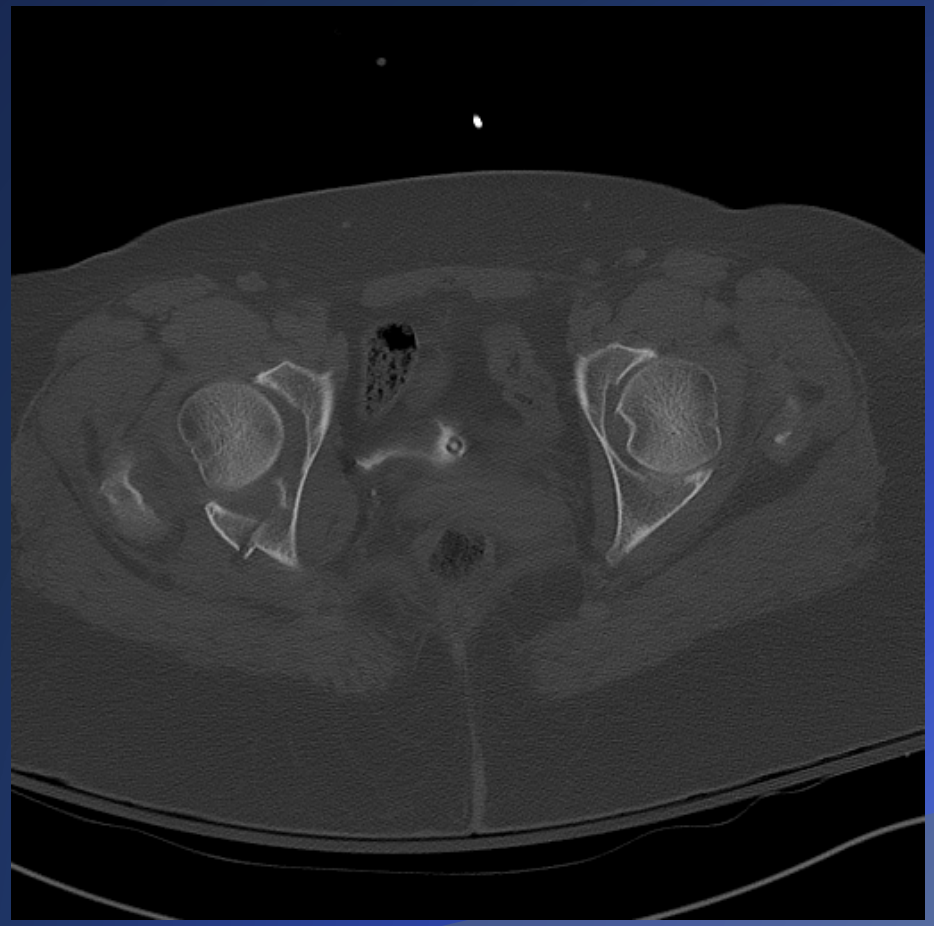
Transverse and Posterior Wall





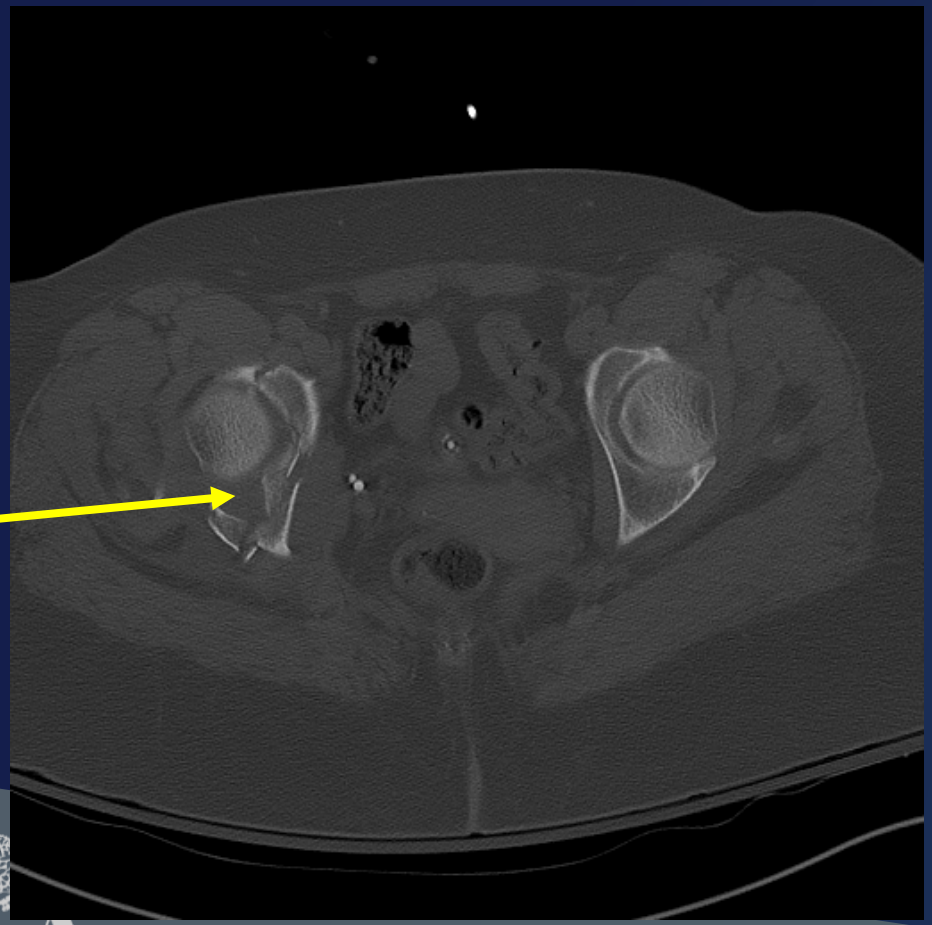
Transverse and Posterior Wall



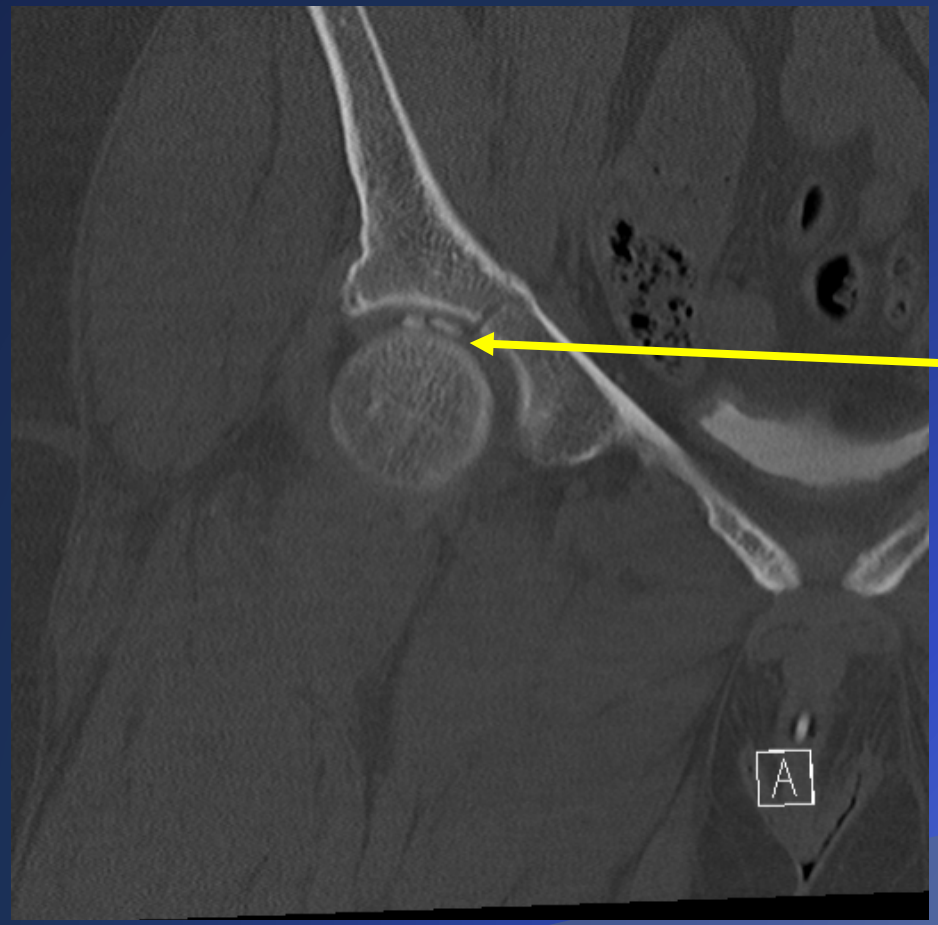


OTA TRAUMA ASSOCIATION

Transverse and Posterior Wall

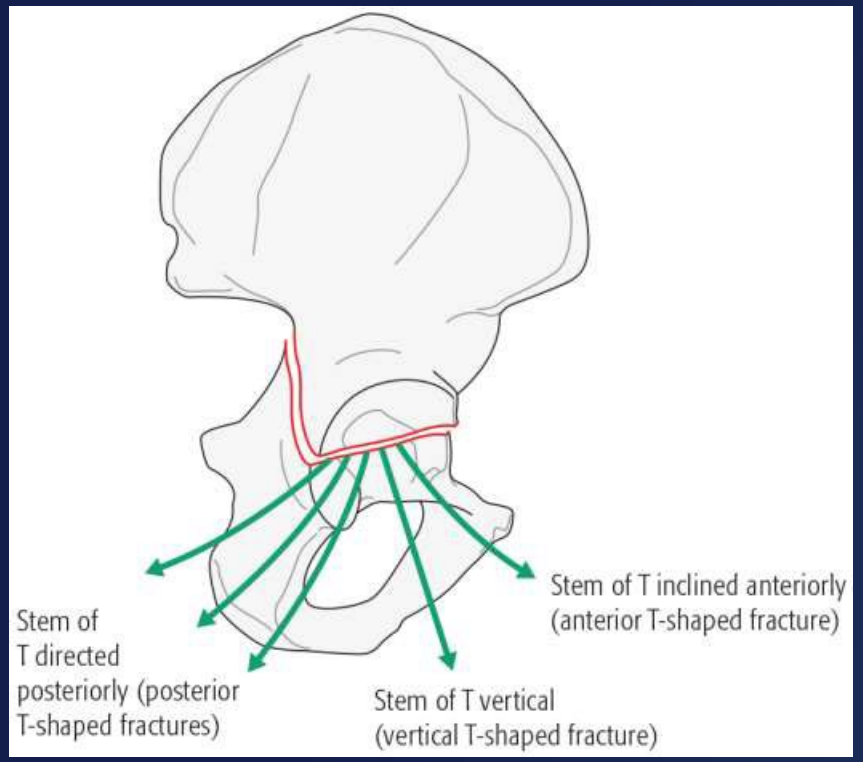


Marginal impaction



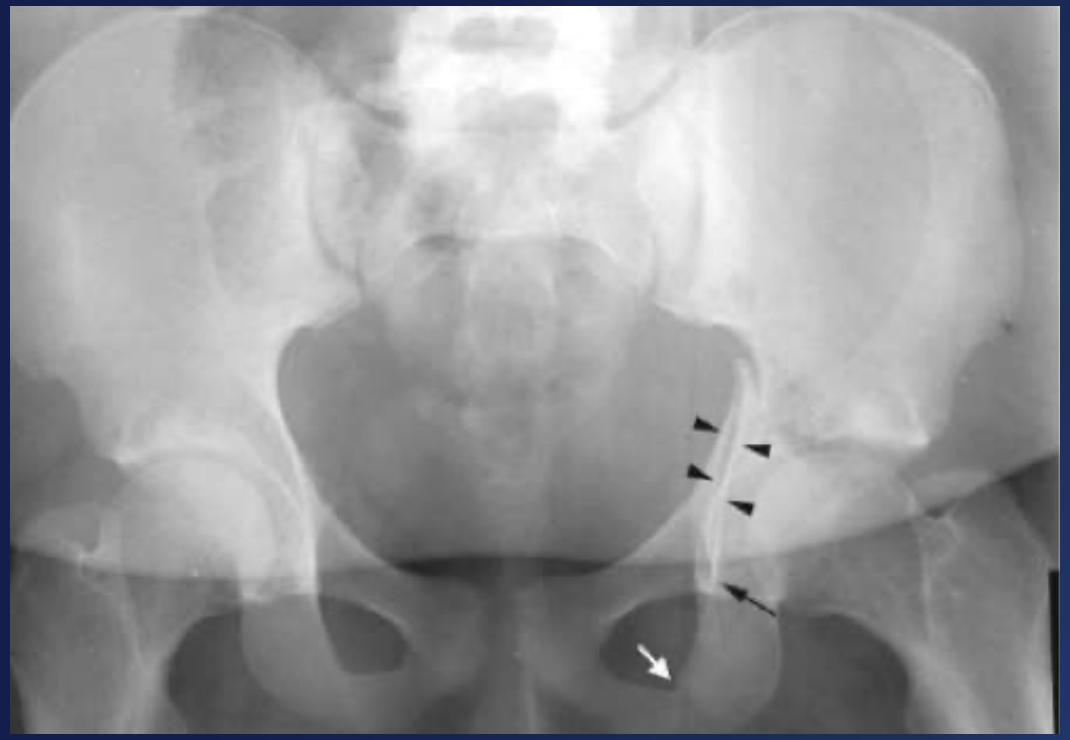
Retained articular fragment

T-type



- T-type with fracture line that extends through obturator ring or through the ischium
- Radiographically transverse type with ischial ramus fracture
- Portion of articular surface attached to iliac wing

T-type Fractures



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T-type Fractures

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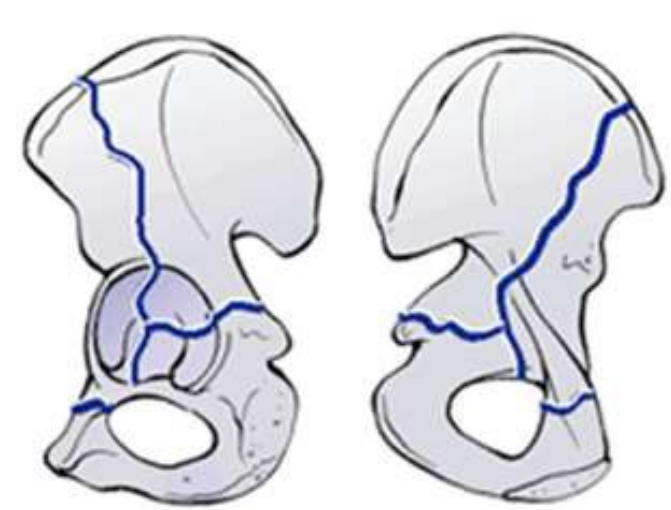
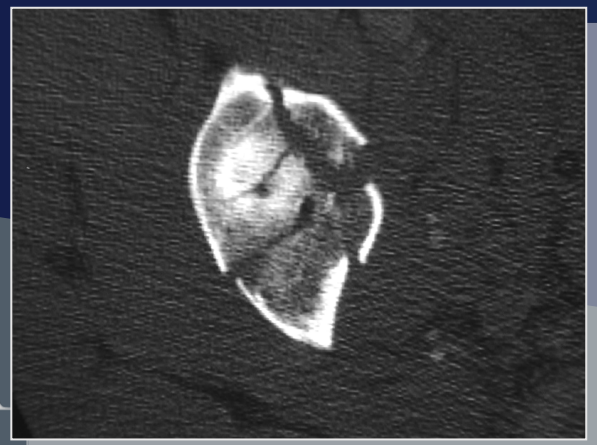
Anterior Column-Posterior Hemitransverse





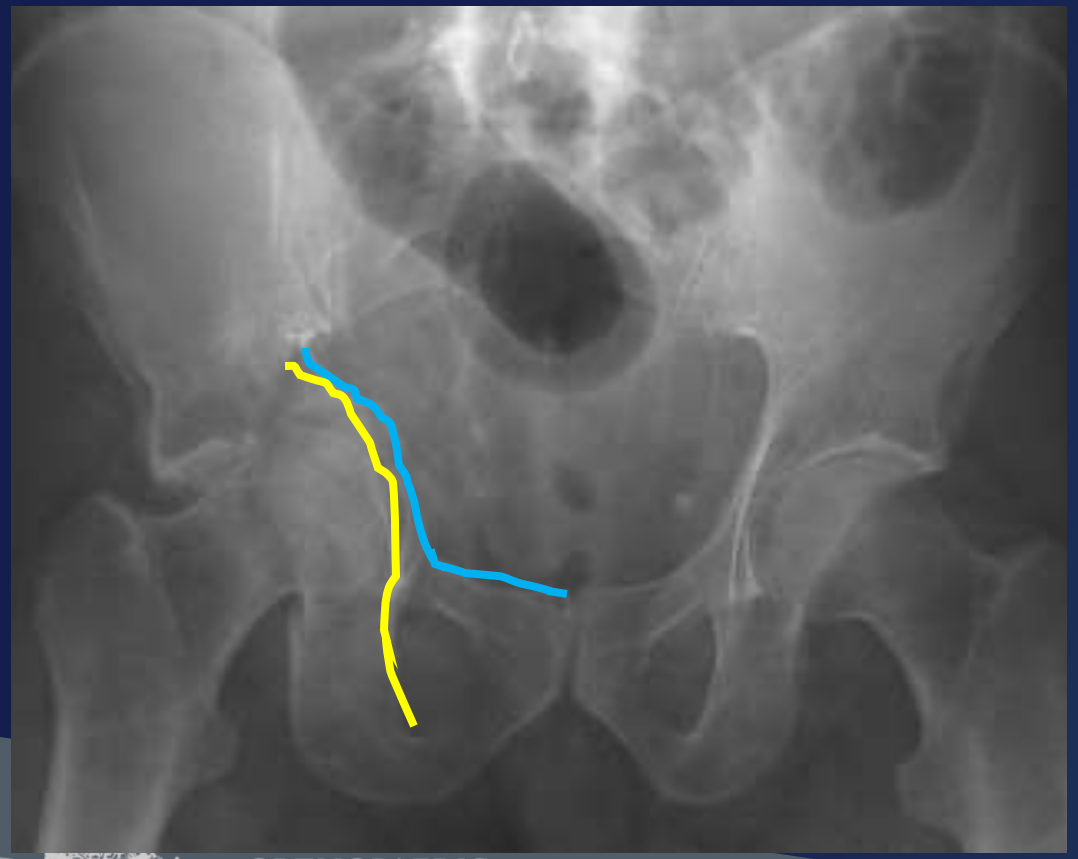
- Femoral head is usually medially subluxed
- Varies on anterior column exit in the ilium
- Posterior fracture line varies with its level of exit through the greater sciatic notch

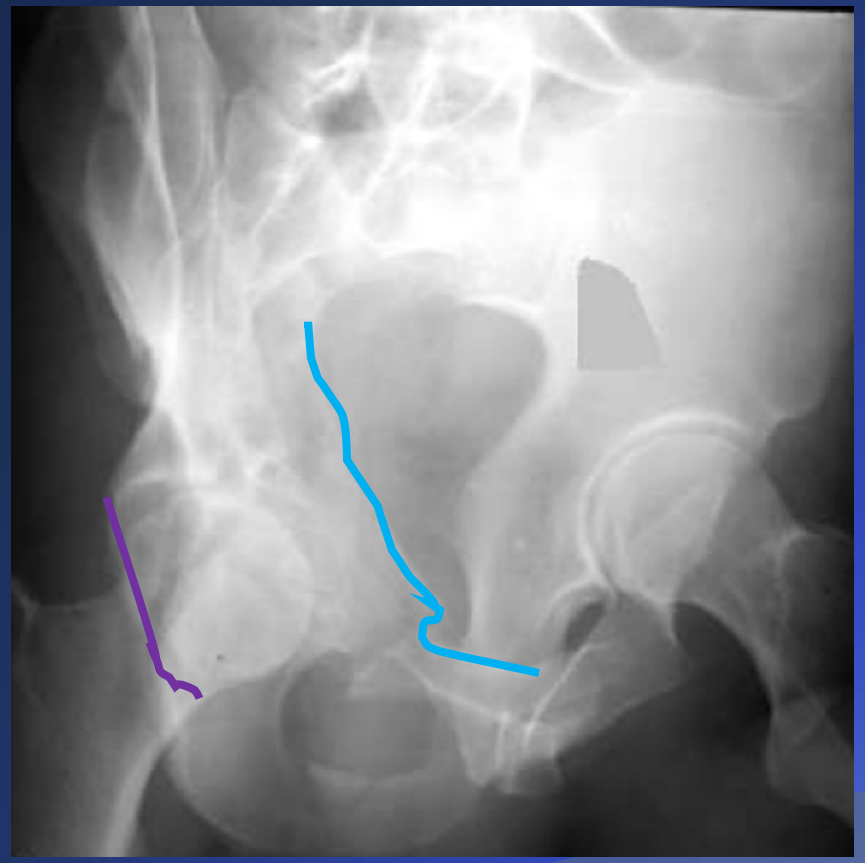
Anterior Column-Posterior Hemitransverse

Anterior Column-Posterior Hemitransverse

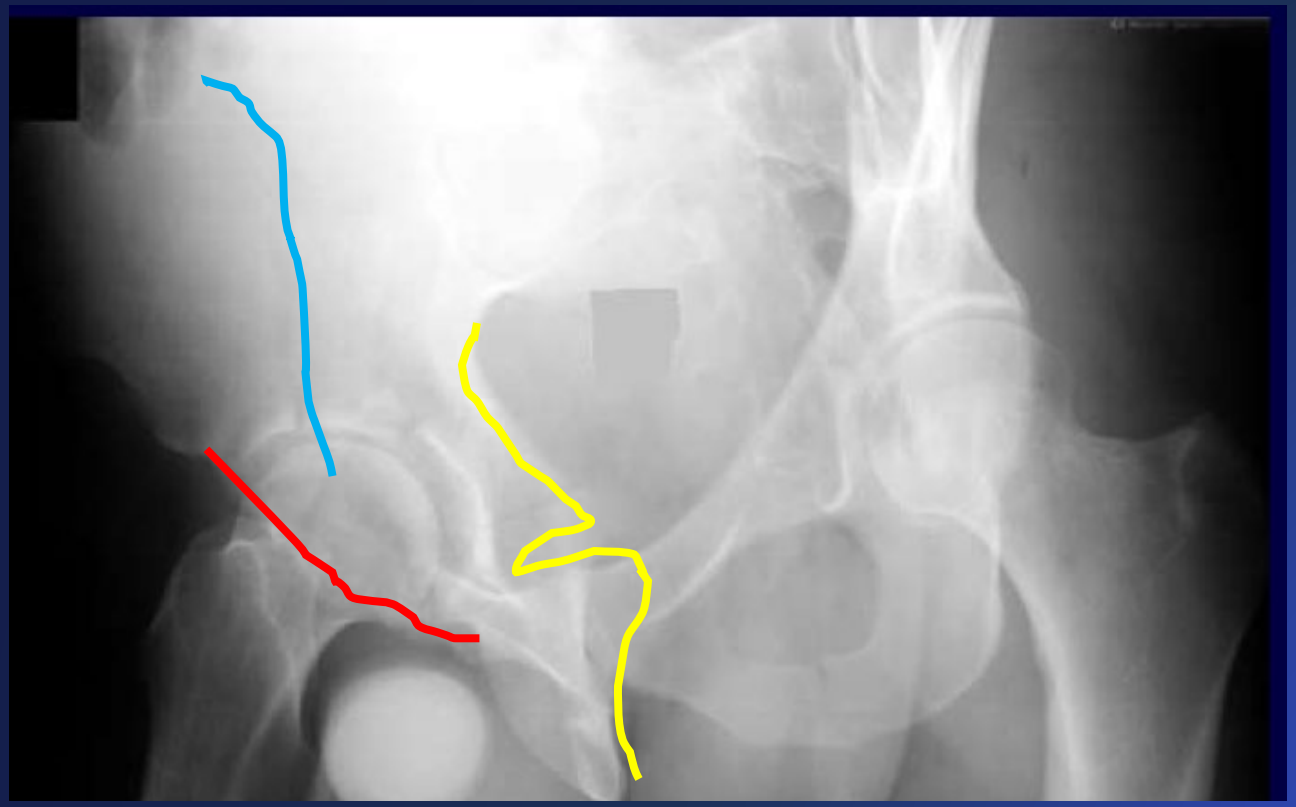
ORTHOPAEDIC TRAUMA ASSOCIATION

Anterior Column-Posterior Hemitransverse





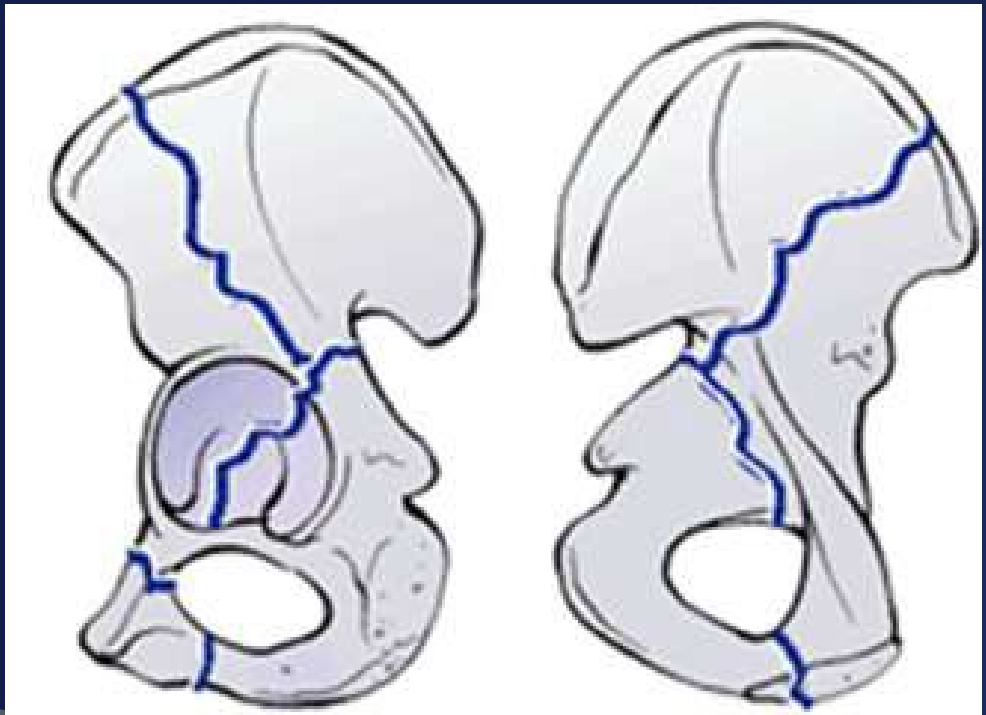
Anterior Column-Posterior Hemitransverse



Gull Sign

- Impaction of acetabular roof
- Poor prognostic sign
  - Anglen et al. JOT 2003

Both Column



- No part of the articular surface remains attached to the intact ilium
- Complete articular fracture
- Most common associated pattern
- Split between anterior and posterior column
- Common to have numerous secondary fractures

Both Column

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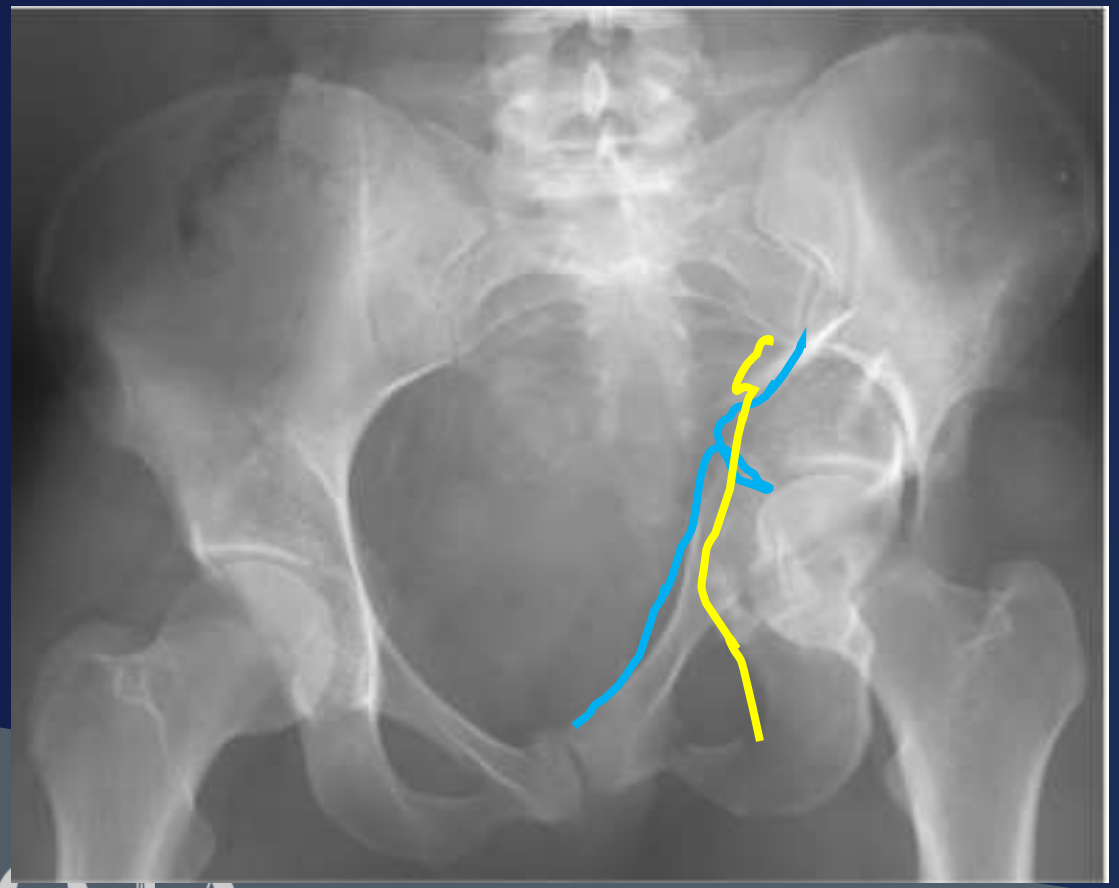
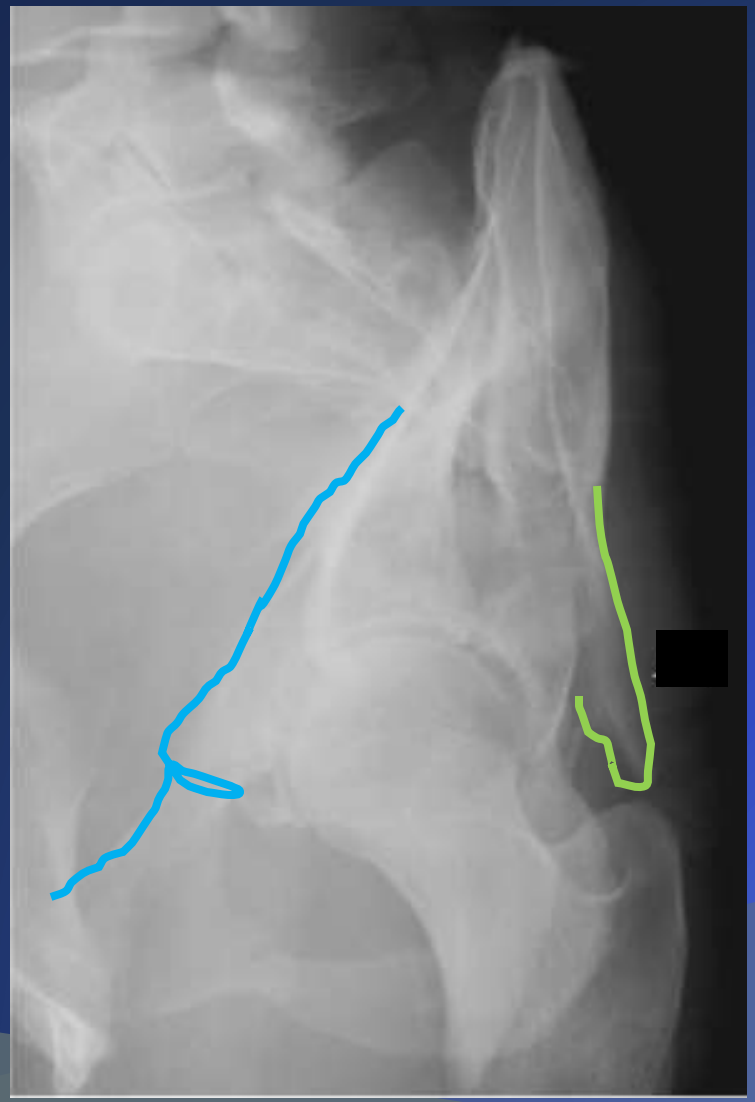
Both Column

“Spur Sign”

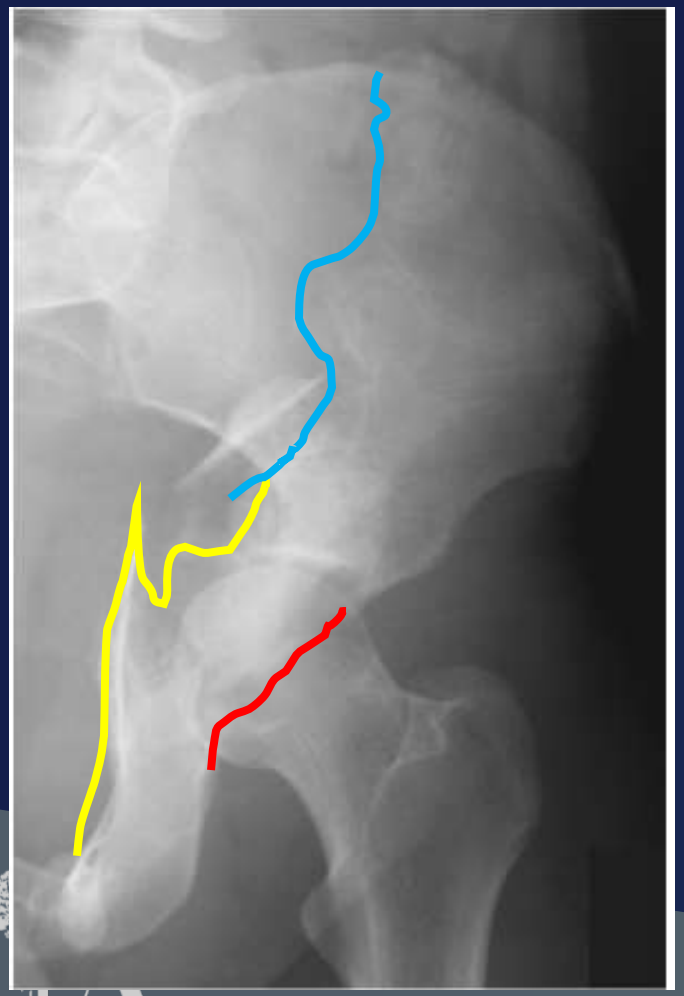
- Due to medialization of femoral head
- Pathognomonic for a both column fracture
- Most inferior portion of intact ilium
- Obturator oblique

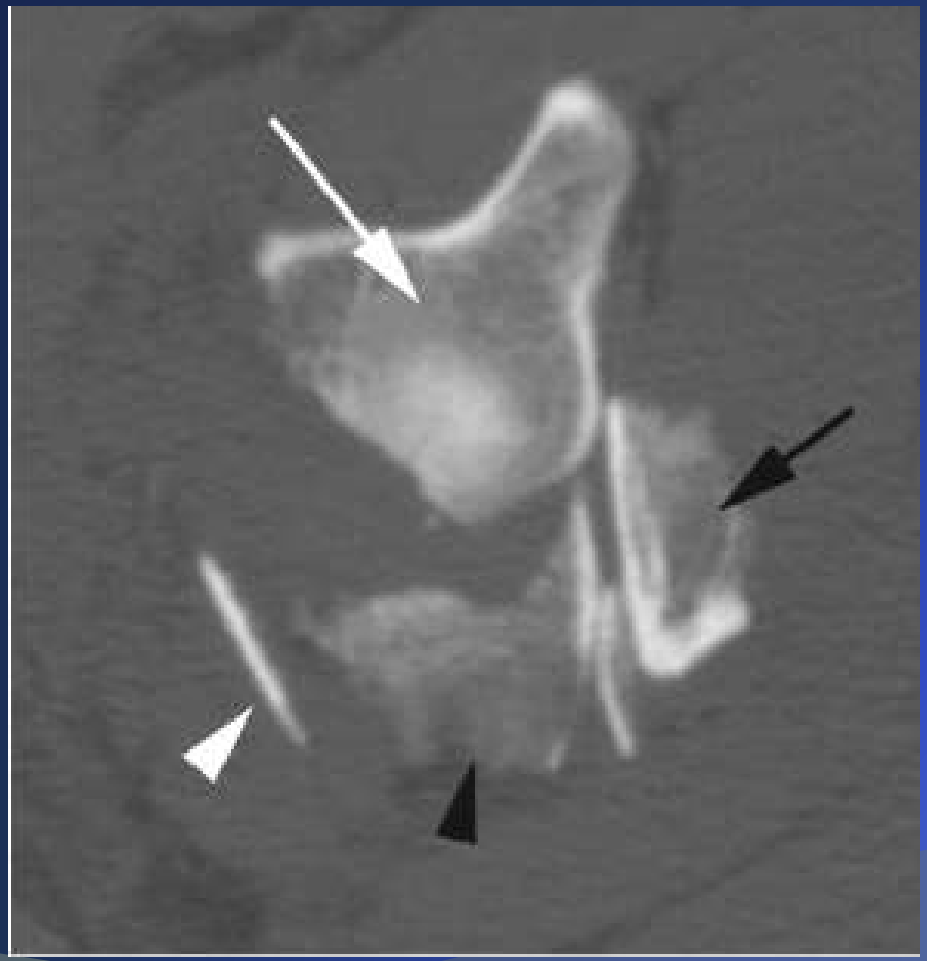
Both Column





Both Column





Secondary Congruence

- Medialization of femoral head
- Articular fragments rotate around each other
- Maintain congruency with femoral head

Summary

- Identify radiographic findings of acetabulum fractures
- Understand how to use these radiographic findings to classify the fractures