Anatomy and Osteology of the Acetabulum

- Judet and Letournel
  - JBJS 1964: "Fractures of the Acetabulum: Classification and Surgical Approaches for Open Reduction"

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Bone and Joint Surgery

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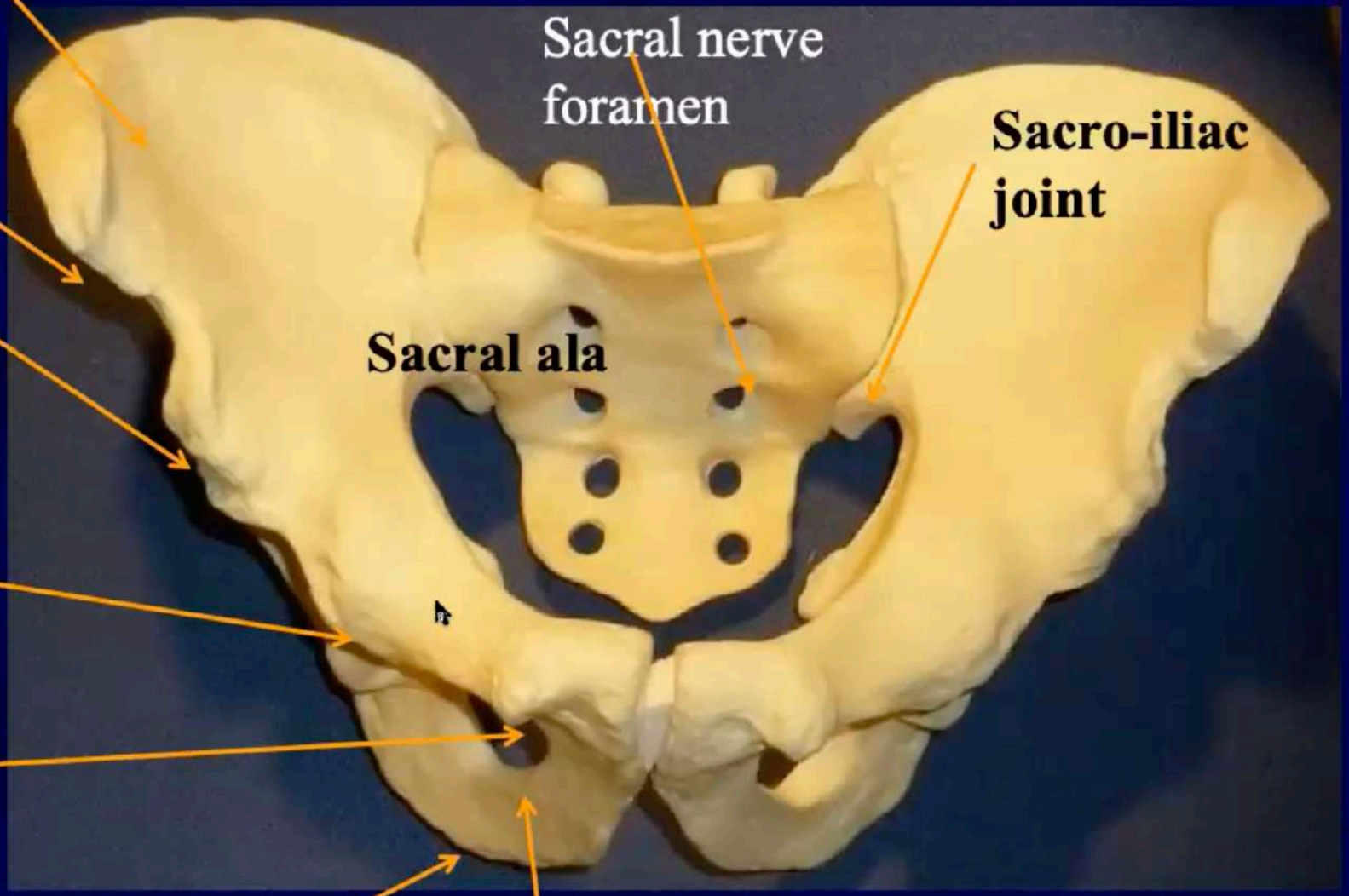
Fractures of the Acetabulum: Classification and Surgical Approaches for Open Reduction

PRELIMINARY REPORT

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

Anatomy and Osteology



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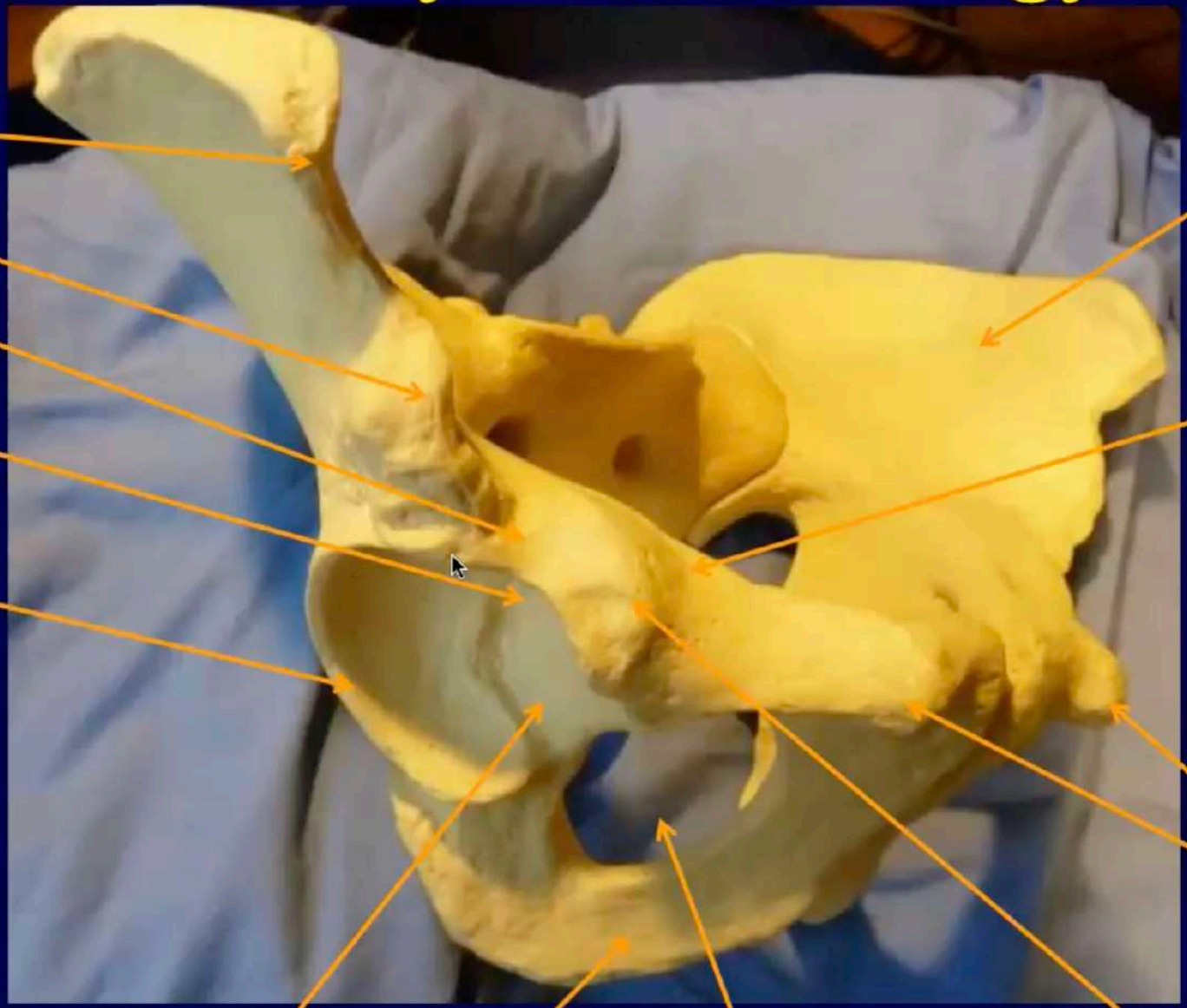

ASIS

AIIS

Psoas gutter

Anterior rim

Posterior rim

Iliac wing

Anterior column / iliopectineal line

Pubic tubercles

Iliopectineal eminence

Obturator foramen

Ischiopubic ramus

Cotyloid fossa

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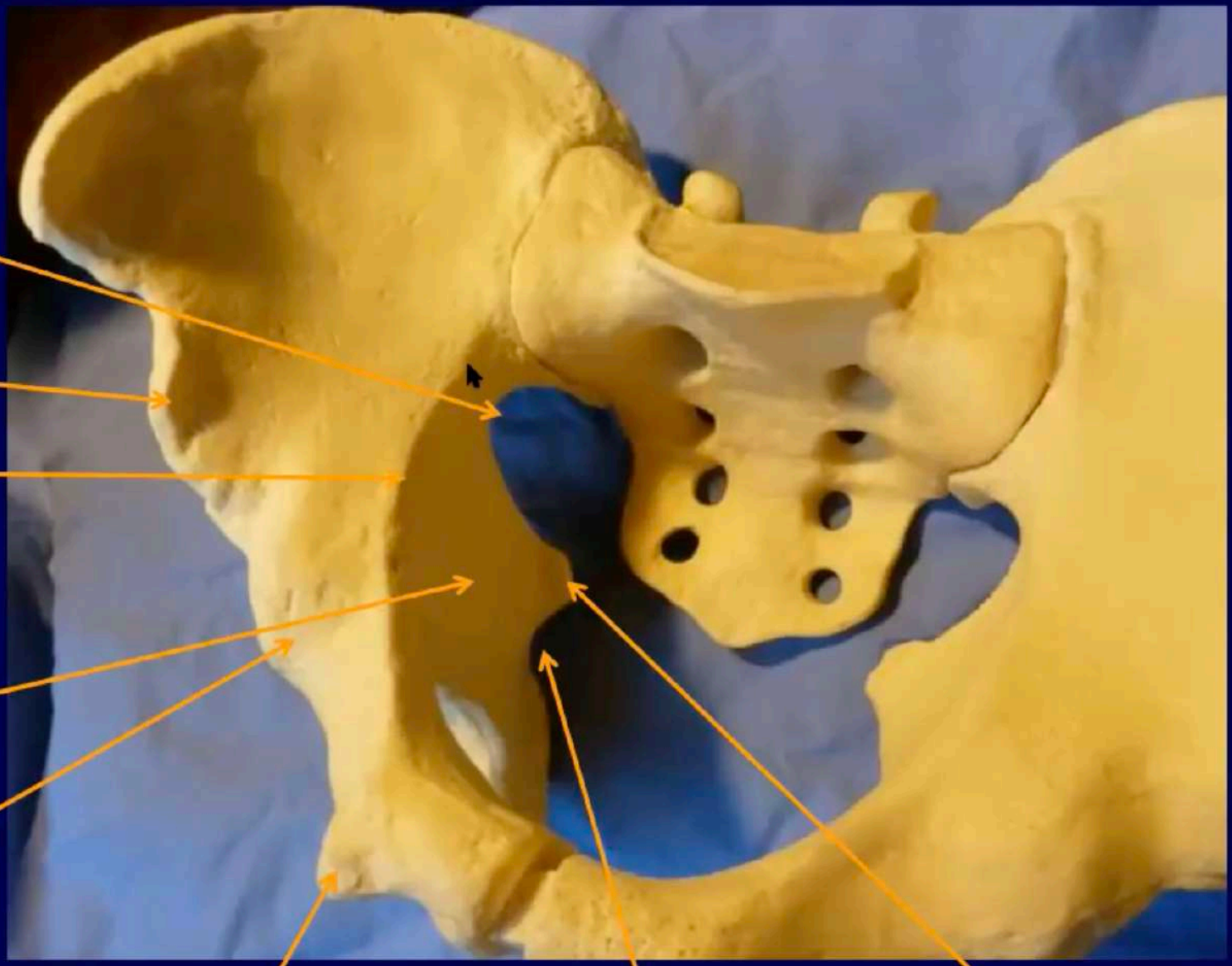

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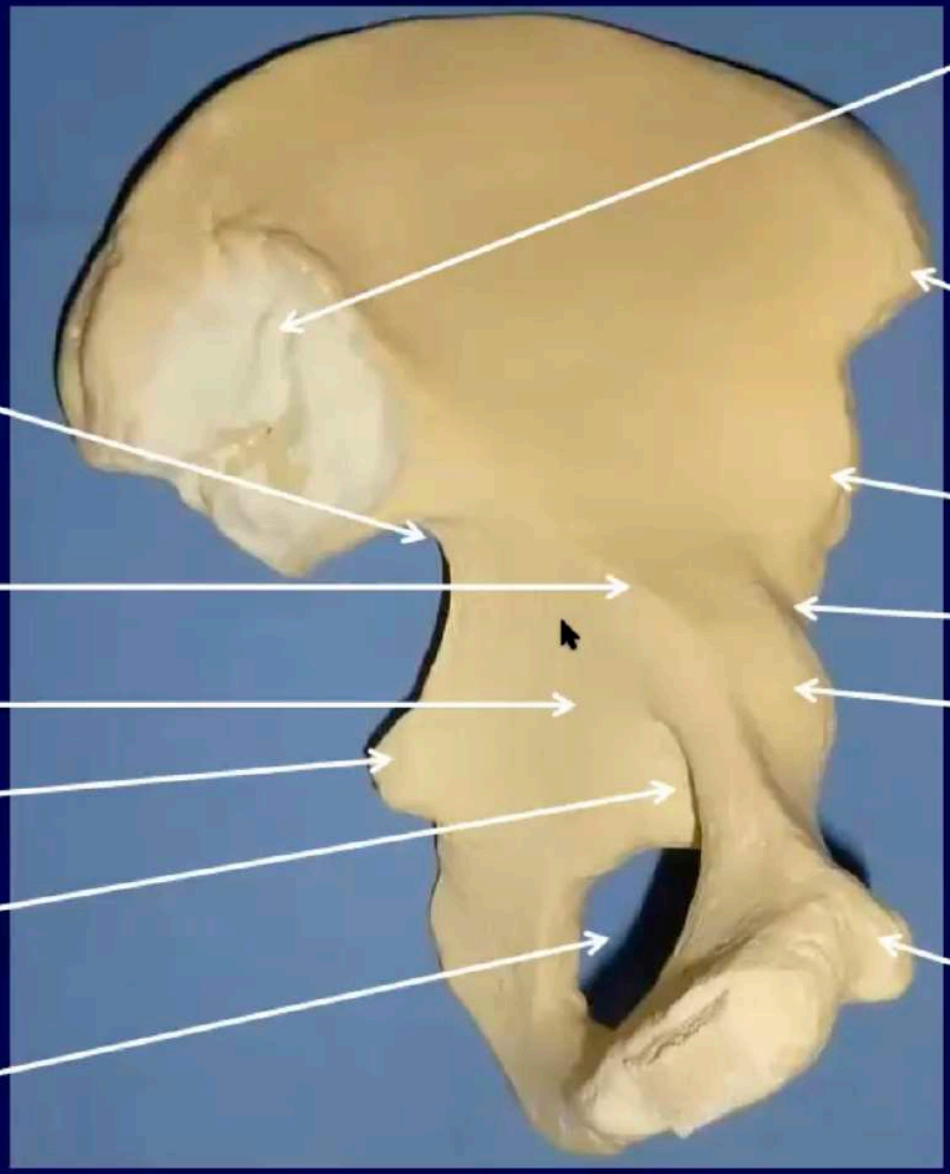

Sacro-iliac articulation

ASIS

AIIS

Psoas gutter

Iliopectinea l eminence

Pubic tubercle

Greater sciatic notch

Pelvic brim

Quadrilateral surface

Ischial spine

Obturator canal

Obturator foramen

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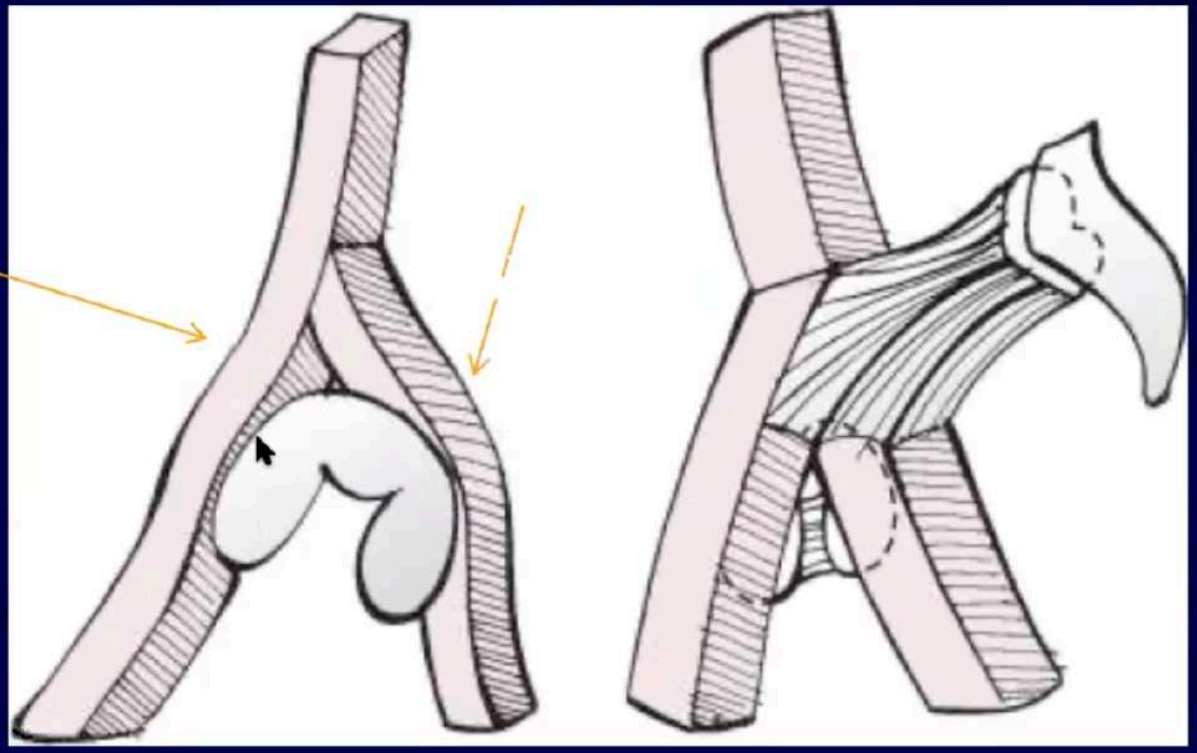
Anatomy and Osteology

- Judet and Letournel
  - Inverted "Y" 2 column concept



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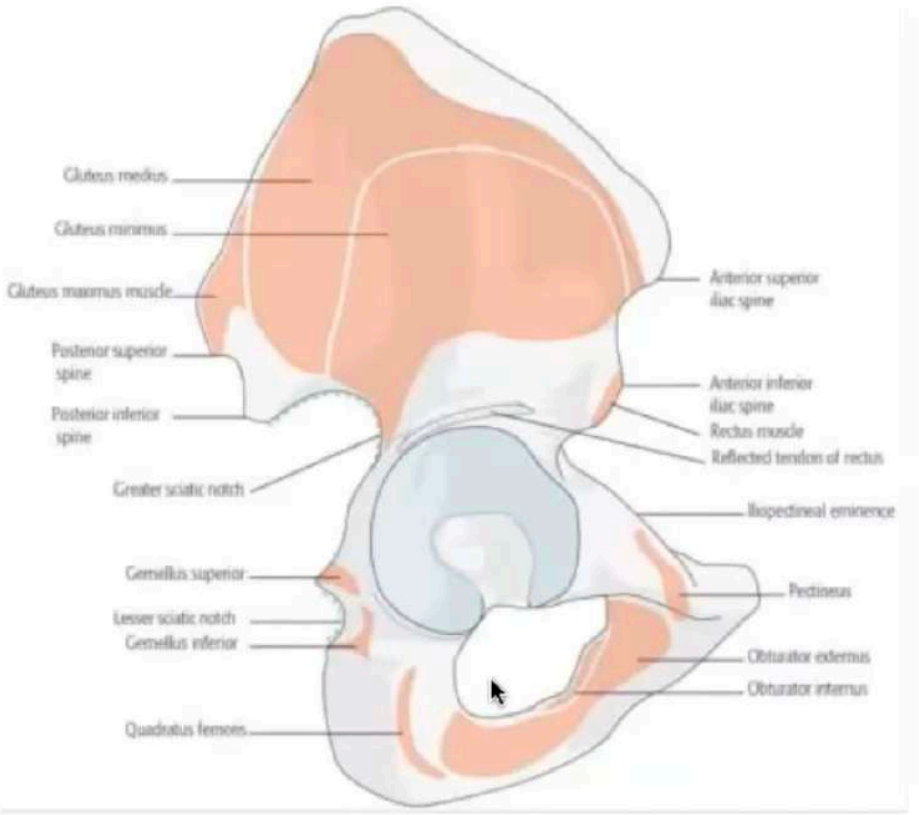
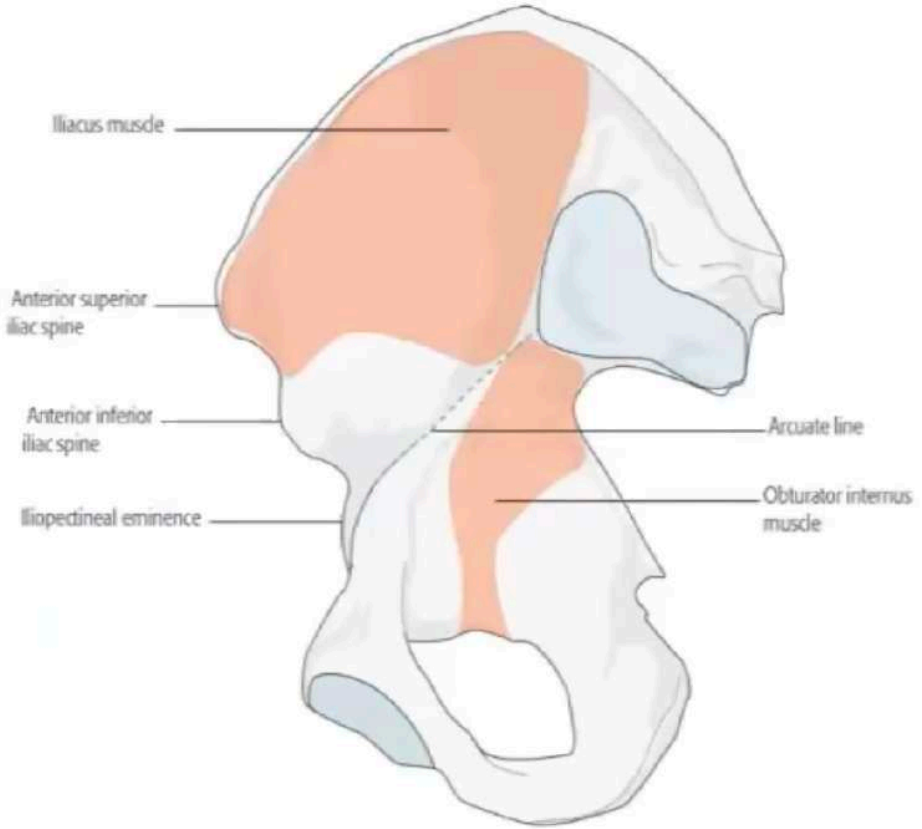
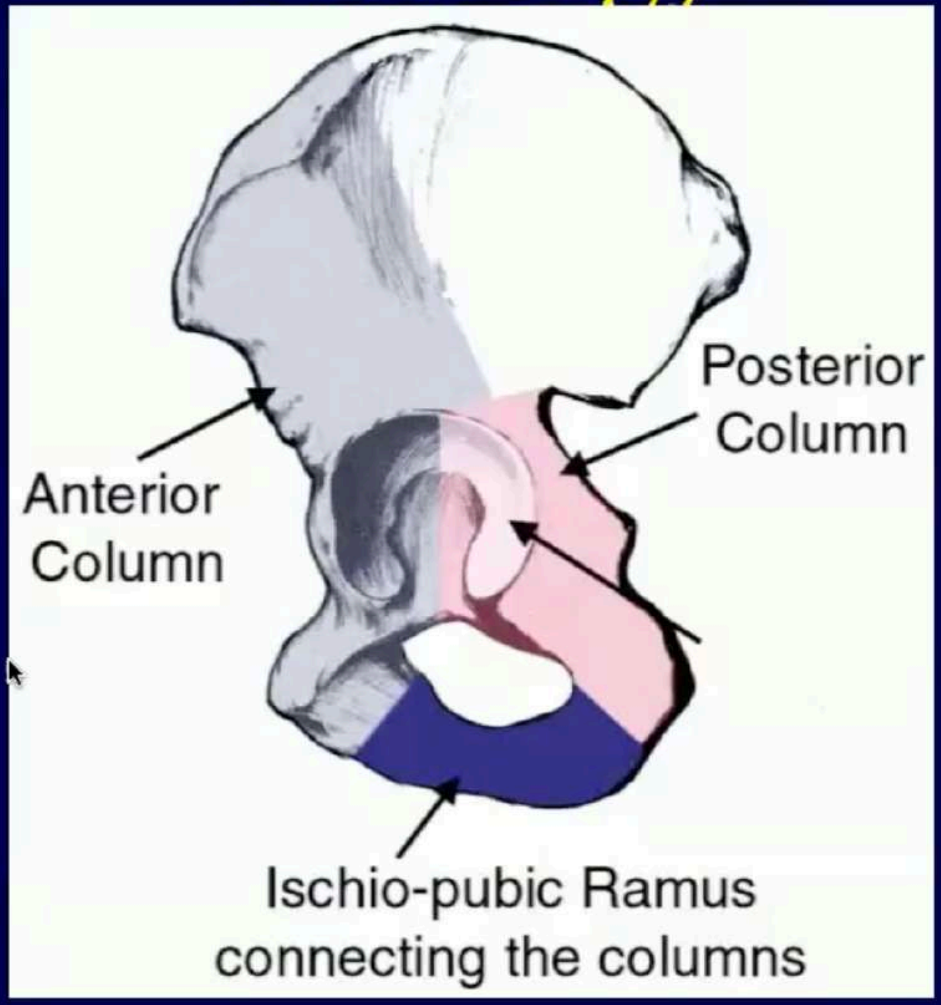
Osteology and Muscle Origins





Osteology



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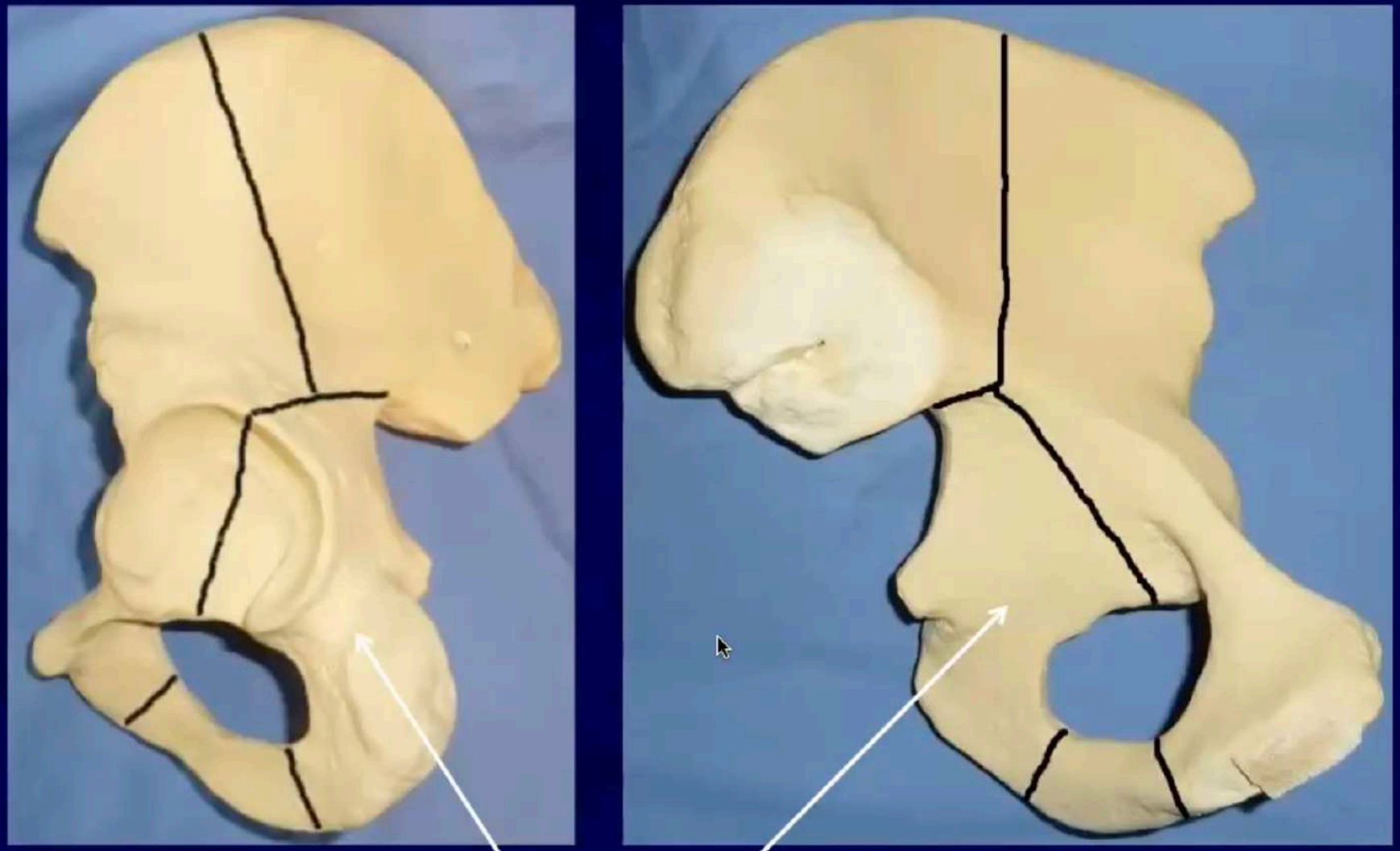
Posterior Column (Ilio-ischial column)

- Internal surface: quadrilateral plate continuous with inner surface of ischial spine
- Posterior surface: convex area comprising retro-cotyloid surface (part of posterior wall); sub-cotyloid groove (obturator externus tendon) and ischial tuberosity
- Antero-lateral surface: posterior part of acetabular articular surface superiorly; body of ischium inferiorly
- Posterior border formed by posterior edge of innominate bone with greater and lesser sciatic notches separated by ischial spine

Posterior Column



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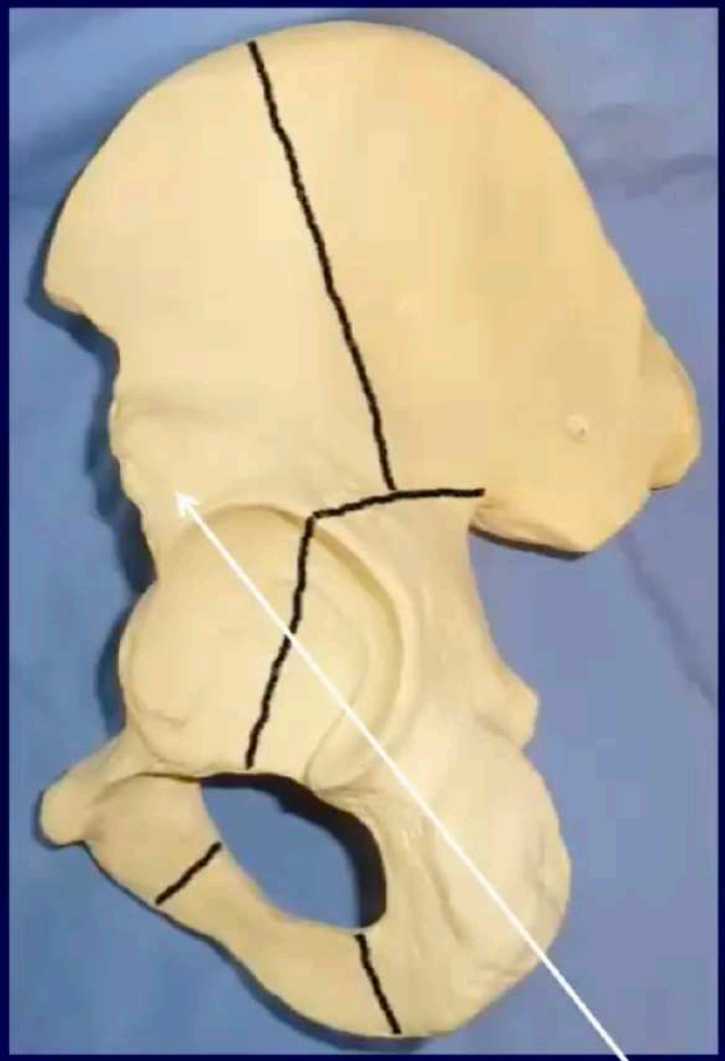
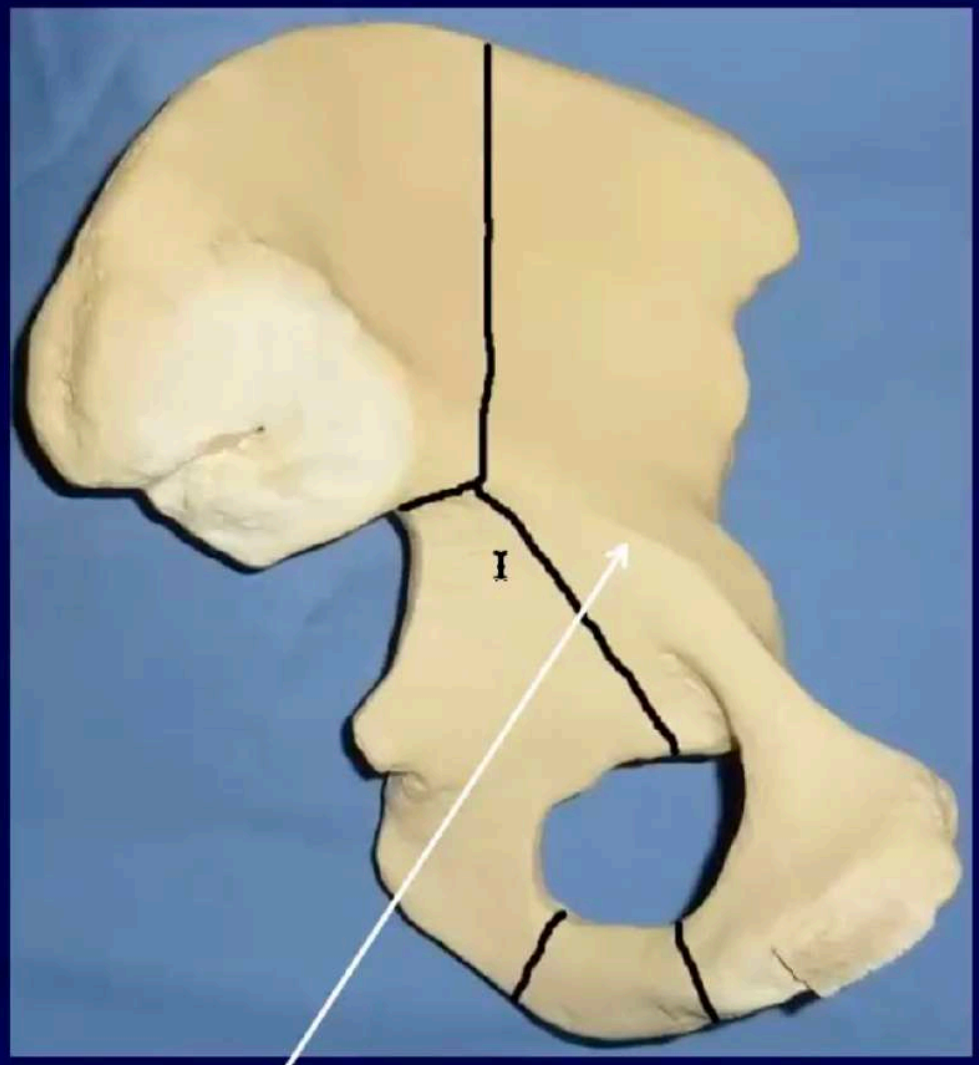
Anterior Column
(Ilio-pubic column)

- Extends from anterior iliac crest to pubic symphysis
- 3 segments:
  - Iliac
  - Acetabular
  - Pubic

Anterior Column





Anterior Column

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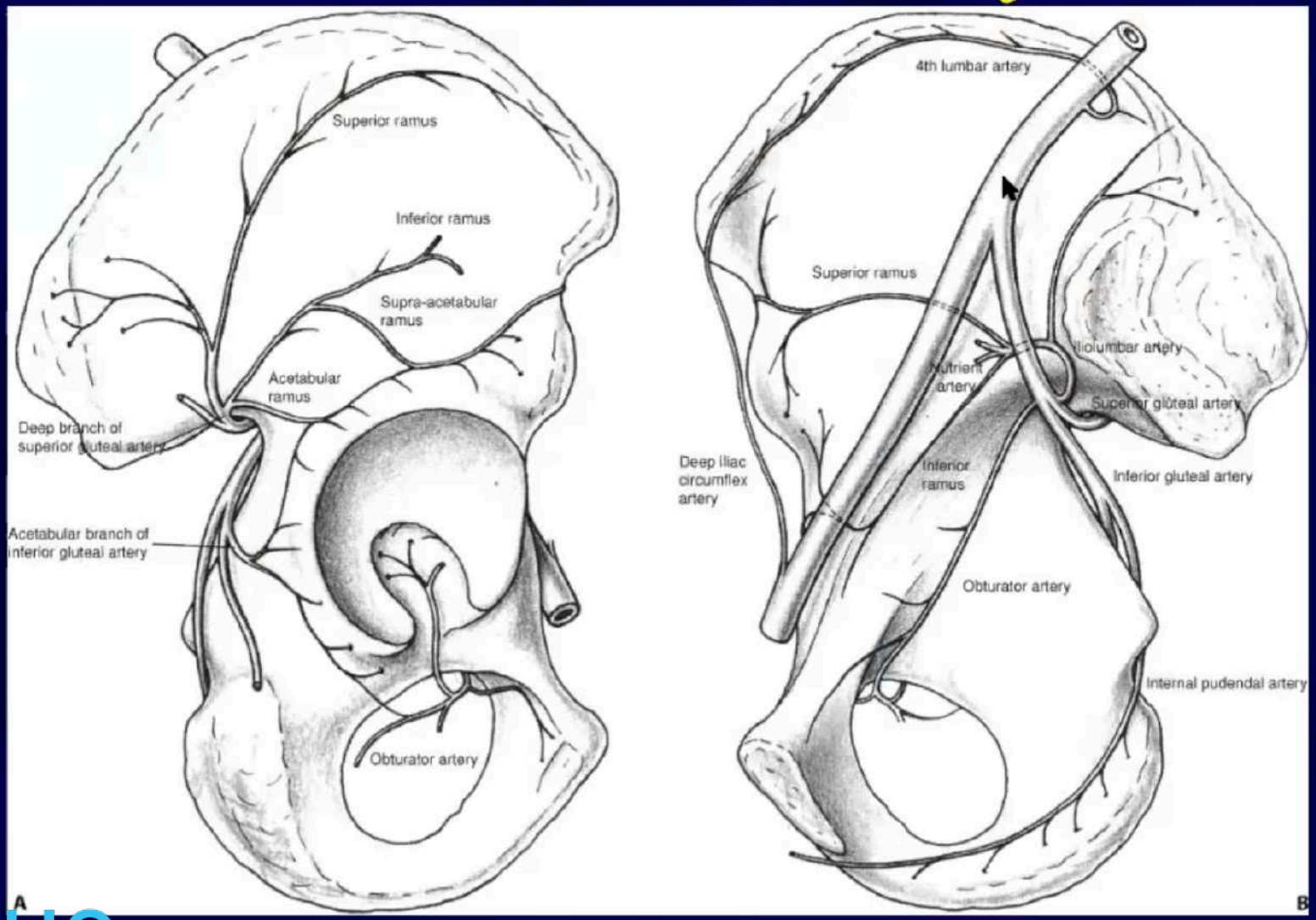
Vascular Anatomy



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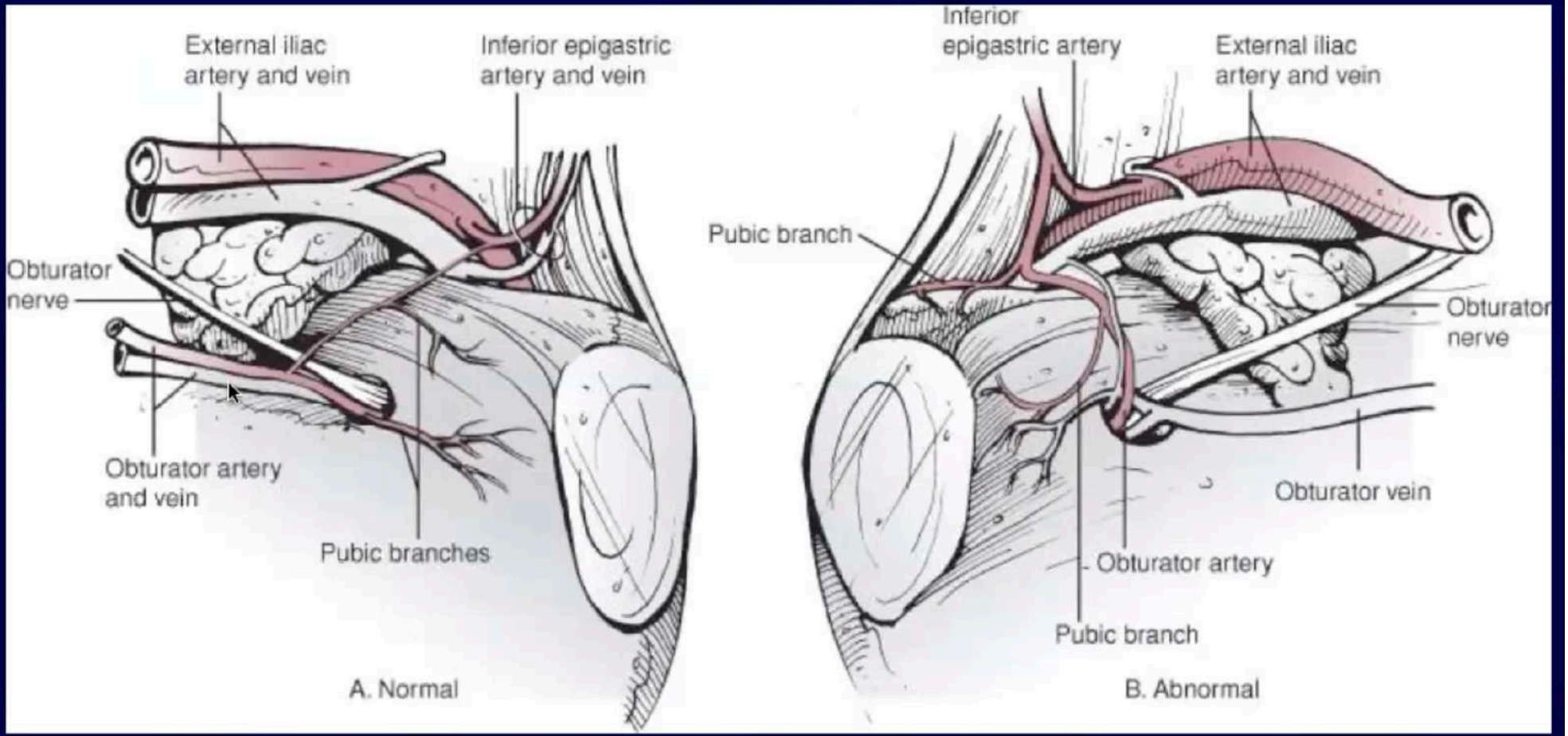
Obturator Artery Variation



CORONA MORTIS

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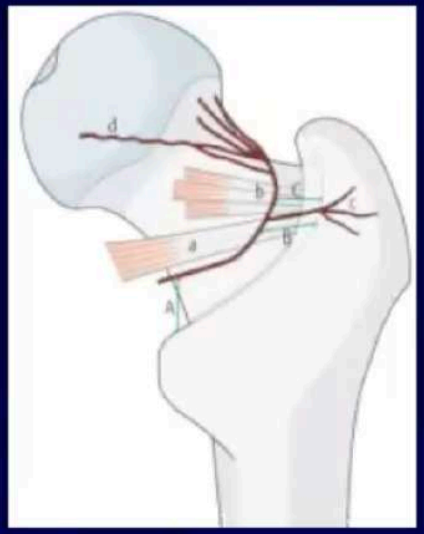
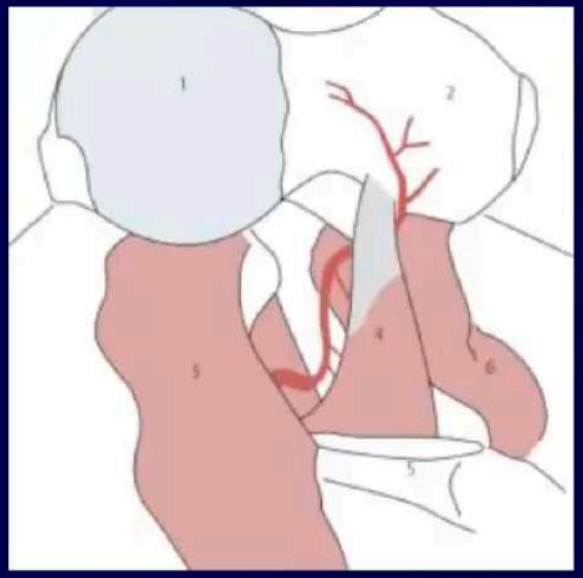
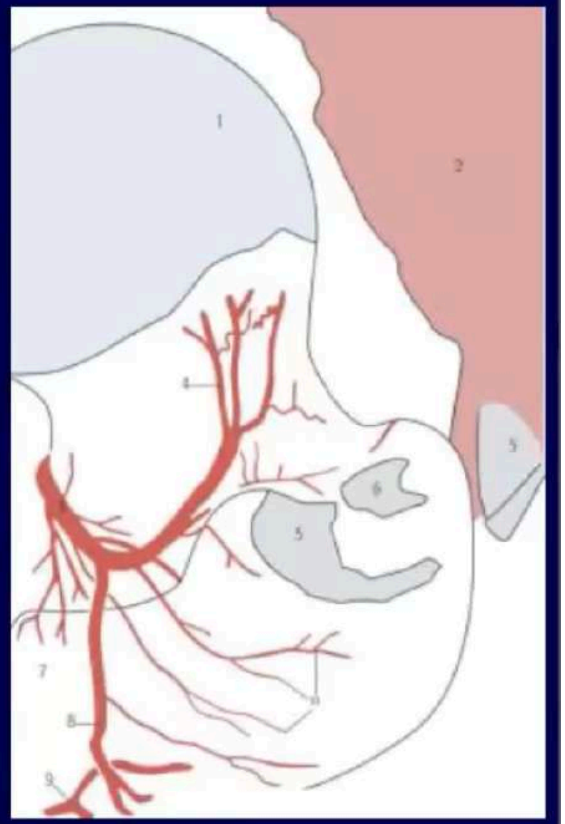
Vascular Anatomy

- Ascending Branch of Medial femoral circumflex artery:
  - Main blood supply to femoral head
  - Deep to quadratus femoris, obturator internus, and piriformis
  - Superficial to obturator externus

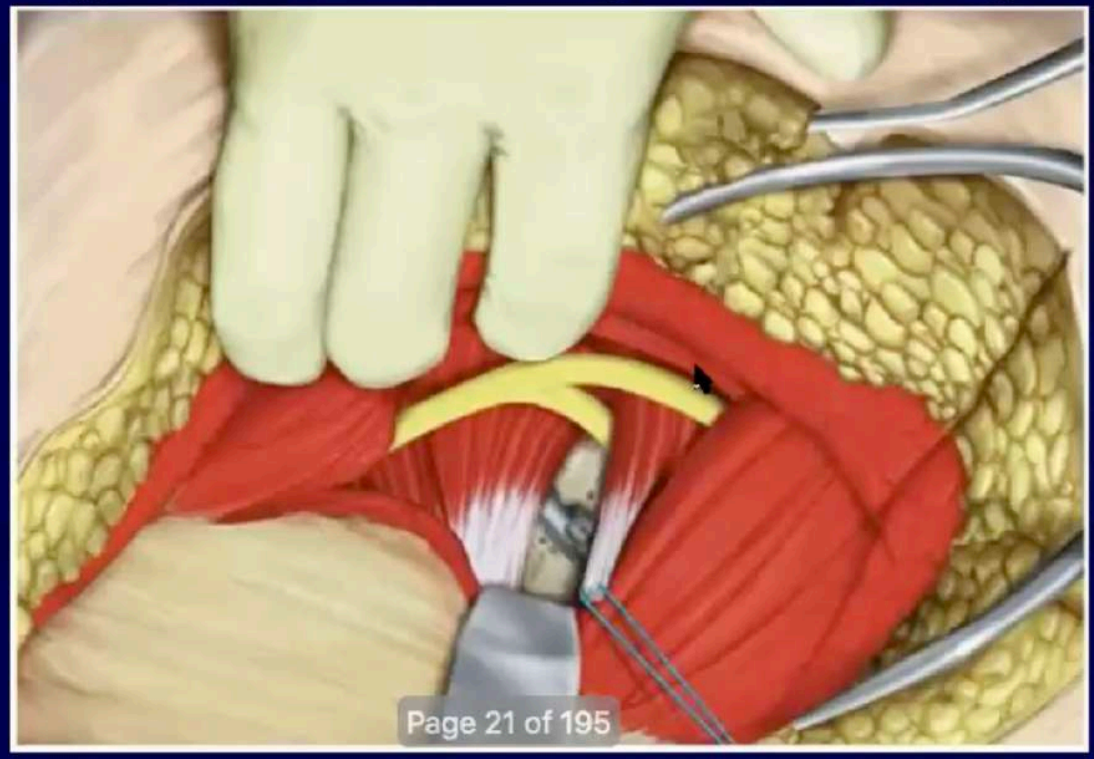






Neural Anatomy

- Sciatic nerve:
  - Most commonly injured (traumatic and iatrogenic)
  - Variable proximal anatomy at level of piriformis



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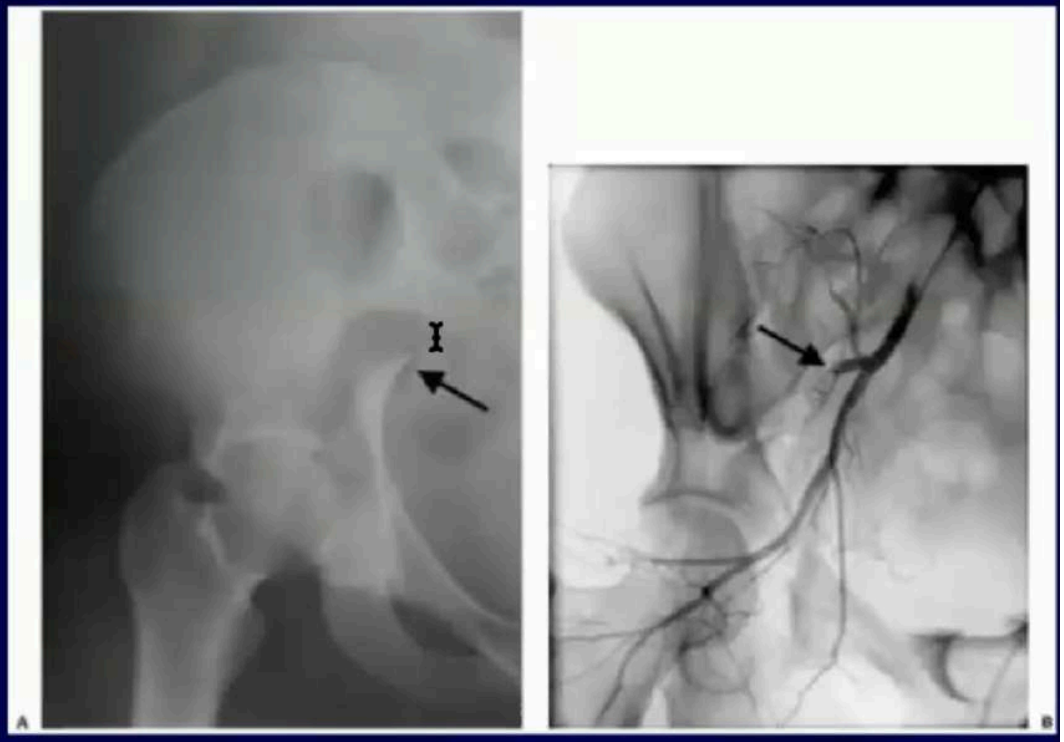
Vascular Anatomy

- Superior Gluteal artery:
  - Exits greater sciatic notch
  - May be lacerated secondary to injury or during superior/lateral retraction during Kocher-Langenbeck approach



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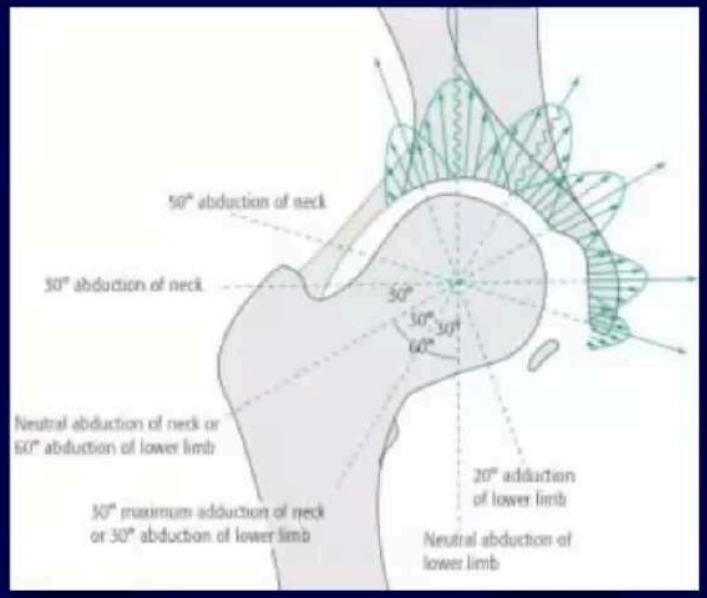
Neural anatomy

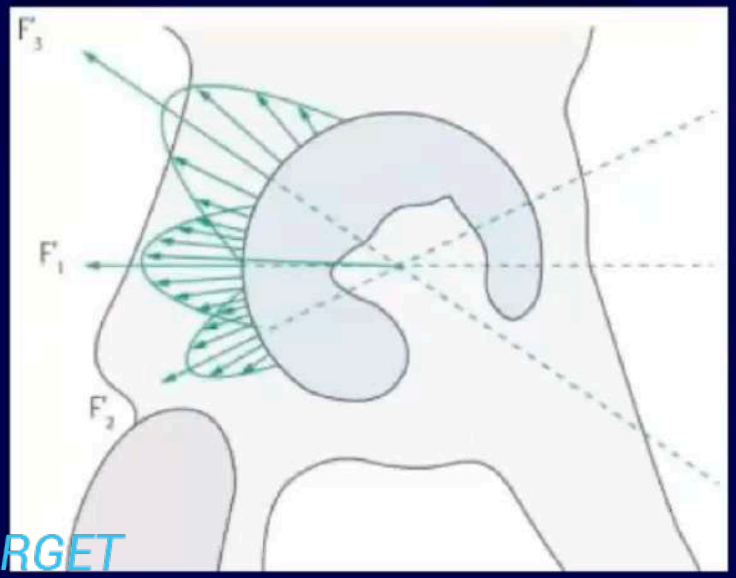
- Superior gluteal nerve:
  - Exits greater sciatic notch with superior gluteal artery
  - May be lacerated secondary to injury or aggressive retraction
- Inferior gluteal nerve:
  - Innervates gluteus maximus m.
  - Branches innervating superior 1/3 located halfway between PSIS and greater trochanter
  - Proximal and superior extension of KL approach may cause iatrogenic injury

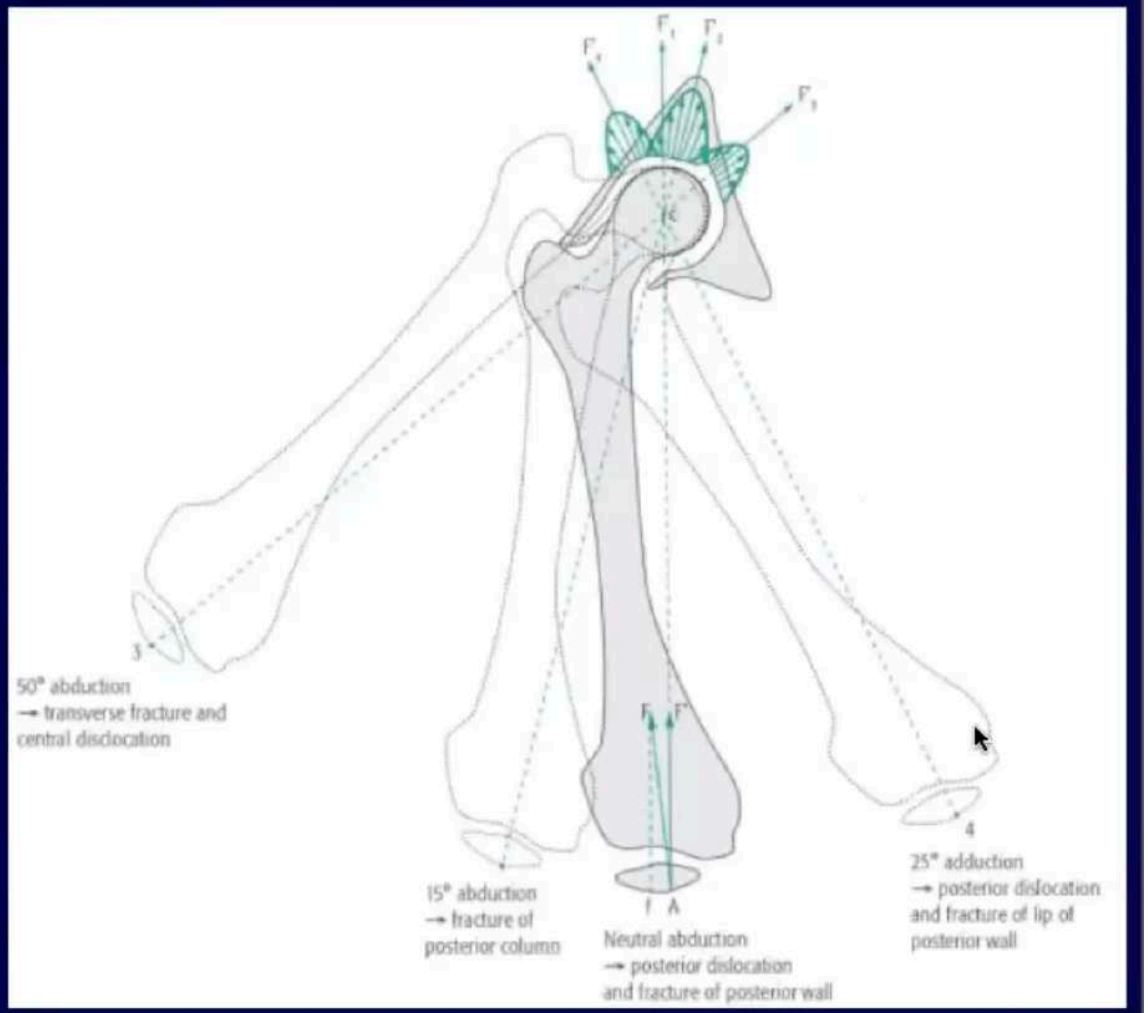
Mechanism of Injury

- Fractures caused by forces that drive femoral head into the acetabulum
  - Damage to articular surface of femoral head and acetabular surface
- Type of fracture depends on the position of the femoral head within acetabulum on impact AND the direction of the force
- Variables affecting type of fracture
  - Sitting position, impact, axis of loading, internal vs external rotation , abduction vs adduction, and flexion vs extension

Mechanism of Injury

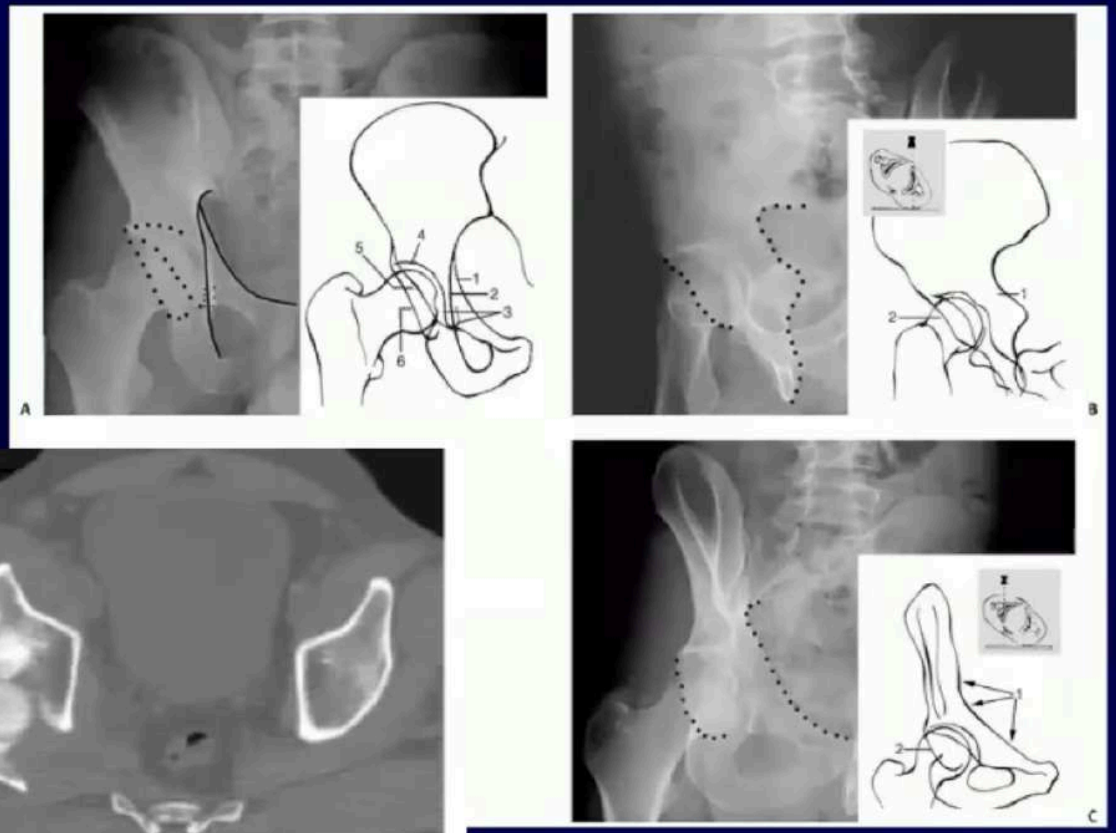






Radiographic Evaluation of the Acetabulum

- Radiological lines are produced by rays tangential to a bony surface or crossing a border



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Radiographic Evaluation

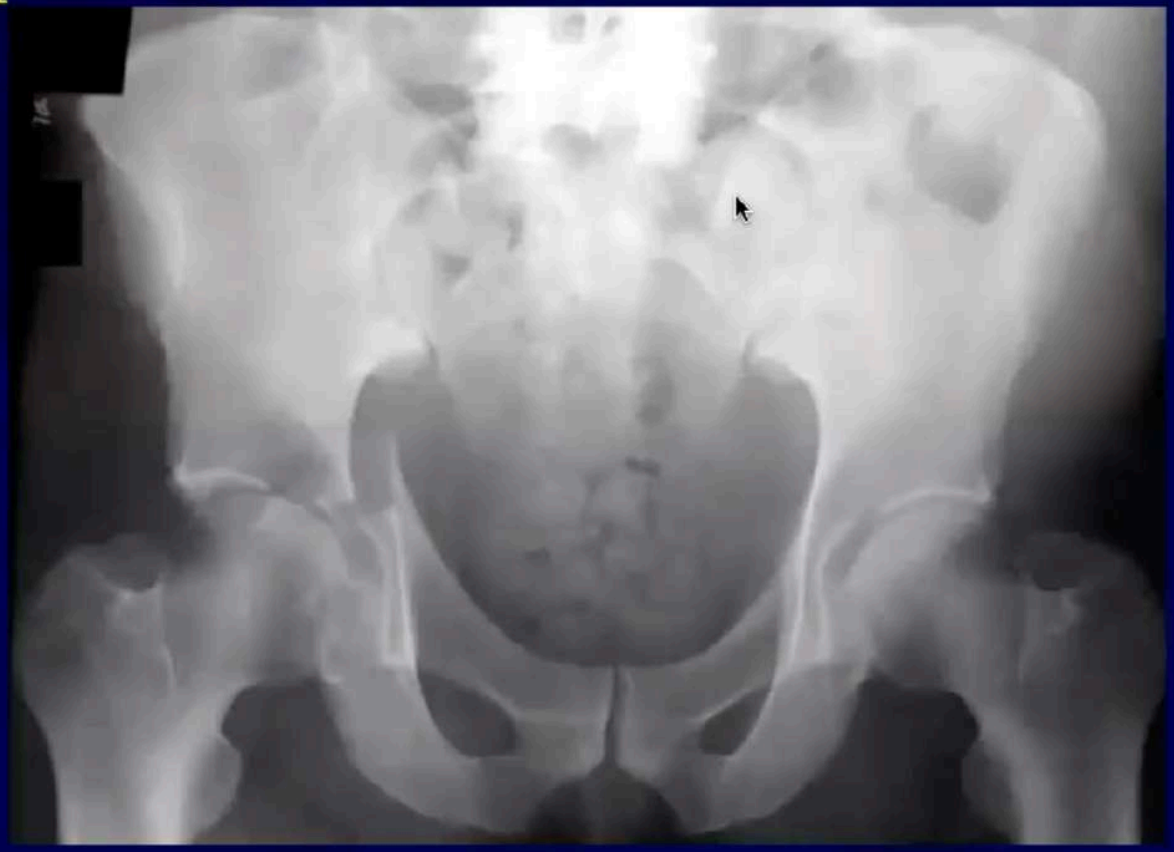
- Anteroposterior pelvis
- Judet views

OUT OF TRACTION

- CT scan +/- 3D reconstructions
- Fluoroscopic dynamic stress exam

Anteroposterior Pelvis

- Associated pelvic ring injuries
- Bilateral acetabular fx's
- Femoral head fx's
- Fx displacement
- Congruency of femoral head within acetabulum



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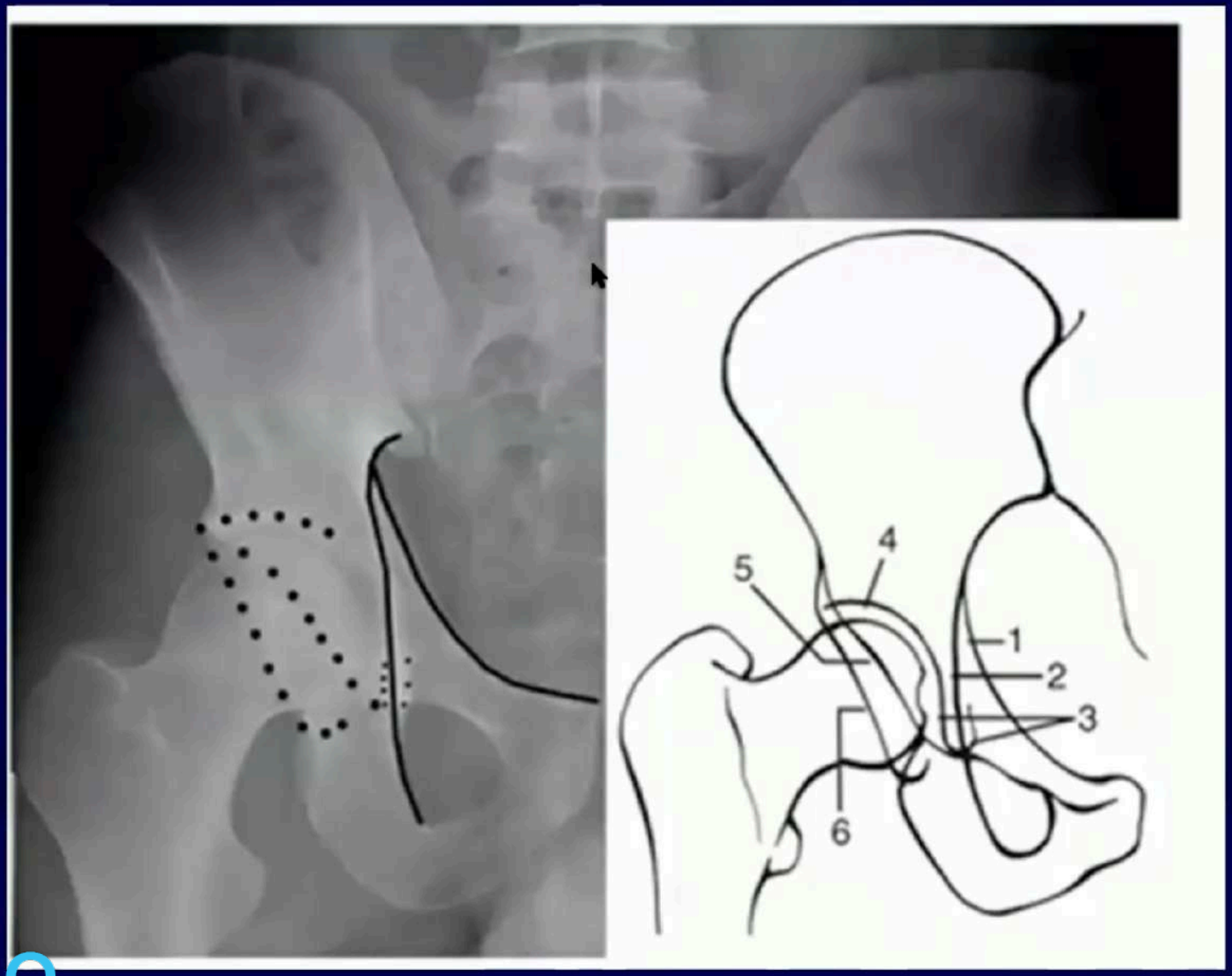
AP Pelvic Radiographic



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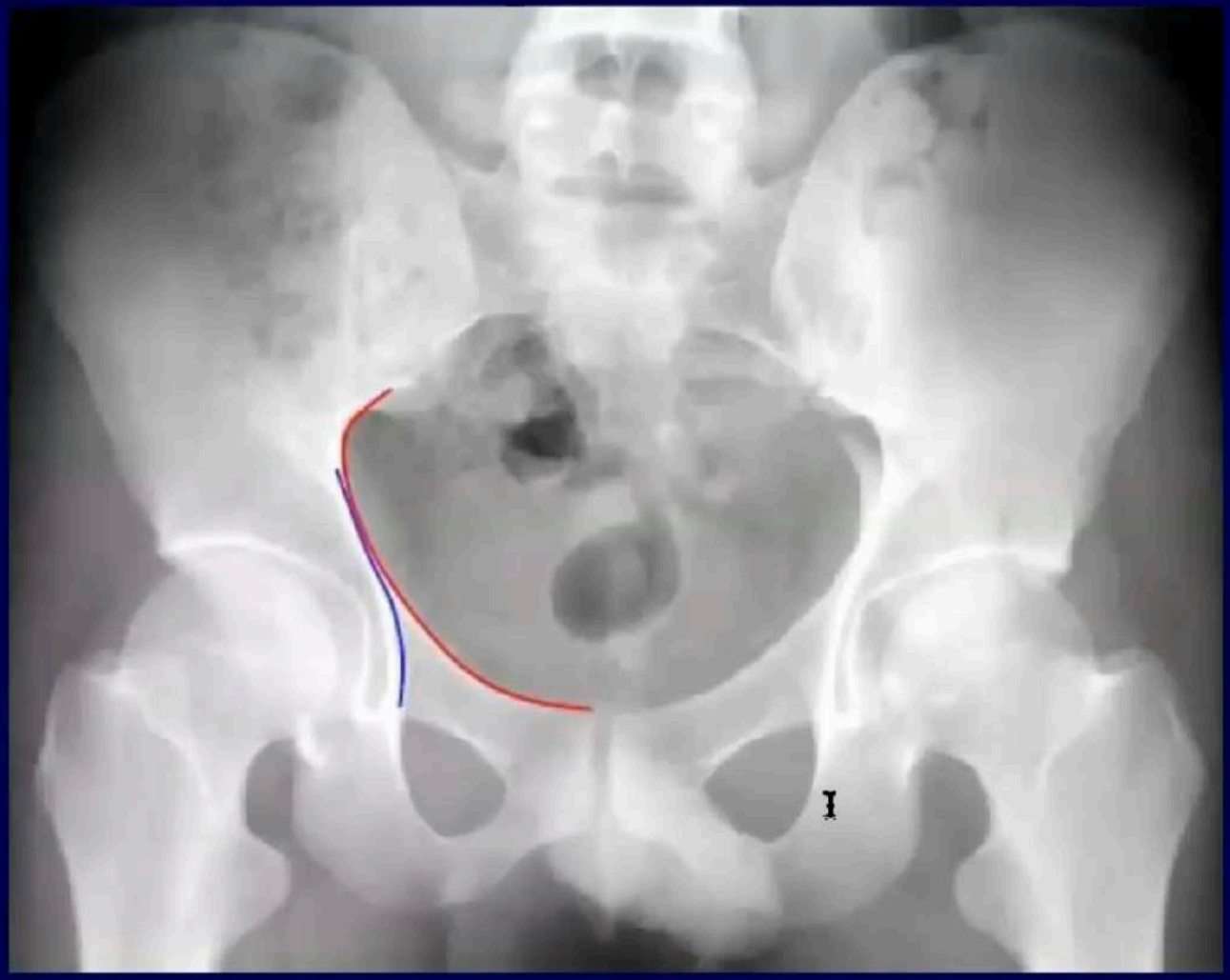
AP Pelvic Radiographic Landmarks

1) Iliopectineal line → anterior column
2) Ilioischial line → posterior column
3) Teardrop → cotyloid fossa and quadrilateral surface/obturator canal; column involvement
4) Sourcil → acetabular roof; anterior/posterior column
5) Anterior rim → anterior wall/column
6) Posterior rim → posterior wall/column

AP Pelvis

- Iliopectinal line:
  - Anterior ¾ (pubic symphysis to ilioischial line): radiological pelvic brim and anatomical brim correlate
  - Posterior ¼: lower half of sciatic buttress and roof of sciatic notch
- Ilioischial line:
  - Quadrilateral surface

Iliopectineal and Ilioischial Lines



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AP Pelvis

- Teardrop/Radiologic "U":
  - Lower border→ischipubic notch/superior obturator foramen
  - External limb→tangential to middle 1/3rd cotyloid fossa
  - Internal limb→confluence of outer wall obturator canal and quadrilateral surface
- Internal and external limbs are not in same coronal plane
  - Variation in shape among patients
  - Most case the limbs are parallel and form a "U"

Radiologic "U" or teardrop

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Radiologic "U" or teardrop

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AP Pelvis

- Sourcil/Acetabular roof:
  - Superior weight bearing portion of acetabulum
  - 45-60 degree arc
- Anterior/Posterior walls:
  - Extensions of the articular surface

Sourcil and Anterior/Posterior Walls

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Judet Oblique Radiographs

- Iliac oblique and obturator oblique
  - 45 degree oblique views
  - Plane of ilium roughly 90 degrees to plane of obturator foramen
  - Demonstrates column anatomy
  - Tip of coccyx should be above center of cotyloid fossa/femoral head

Obturator (Internal) Oblique

- Injured side bumped up 45 degrees
- Obturator foramen/ring visualized fully
- Visualization of:
  - Pelvic brim
  - Anterior column
  - Posterior wall
  - Demonstrates posterior fracture dislocations

Obturator Oblique

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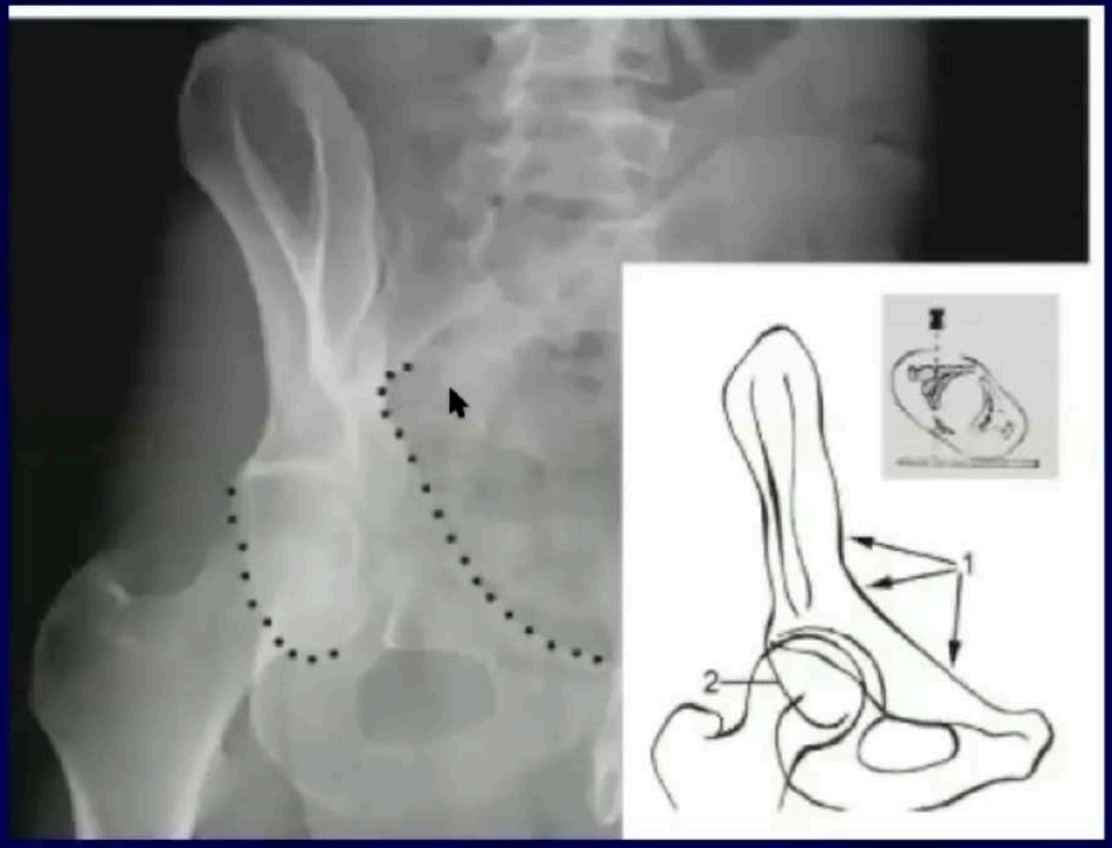

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Iliac (External) Oblique

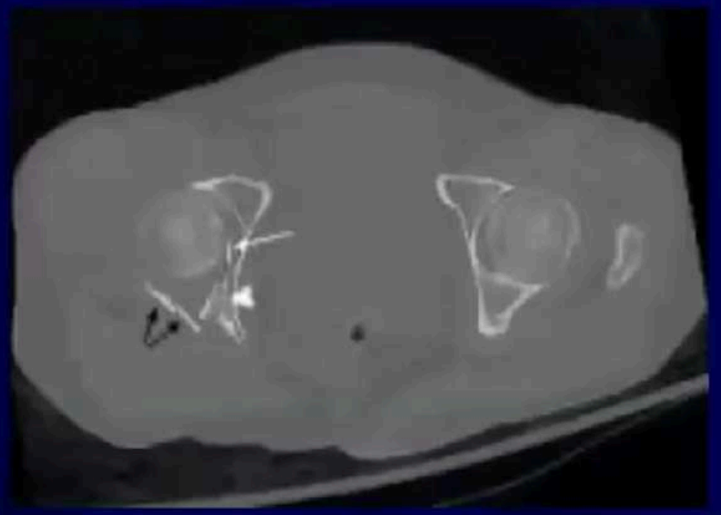
- Injured side down/good side bumped up 45 degrees
- Iliac wing visualized fully
- Visualization of:
  - Posterior column
  - Anterior wall
  - Posterior border of innominate bone
  - Quadrilateral plate

CT Imaging

- Useful adjunct to radiographic imaging
- Not a replacement for good quality AP/oblique radiographs
- 2-3mm cuts
- Utilize the CT to better interpret the plain radiographs and understand the fracture lines

CT Imaging

- Acetabular wall fractures
- Intra-articular fragments
- Marginal impaction
- Comminution
- Femoral head lesions
- Joint congruence
- Evaluation of posterior pelvic ring



"Rockwood and Green's Fractures in Adults-8th Edition"

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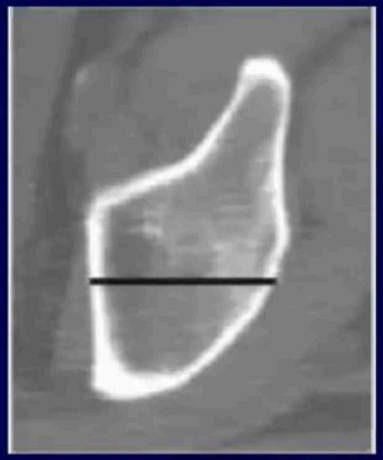
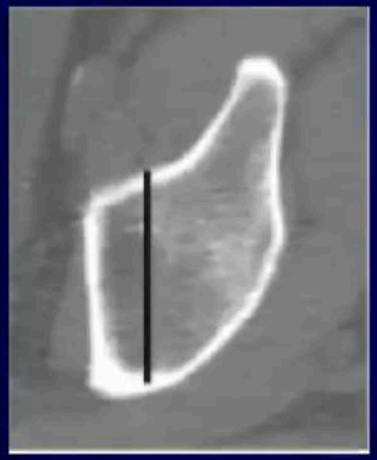
2-D CT Imaging



Column fracture



Transverse fracture

Anterior Wall

Posterior Wall

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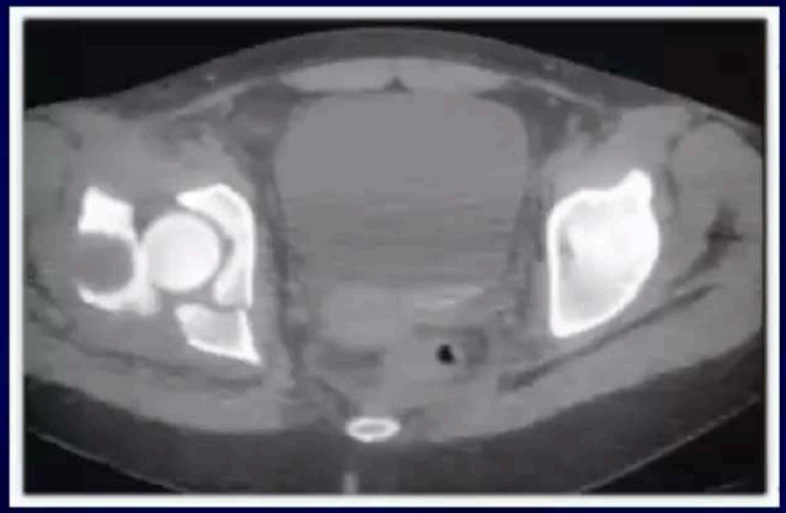
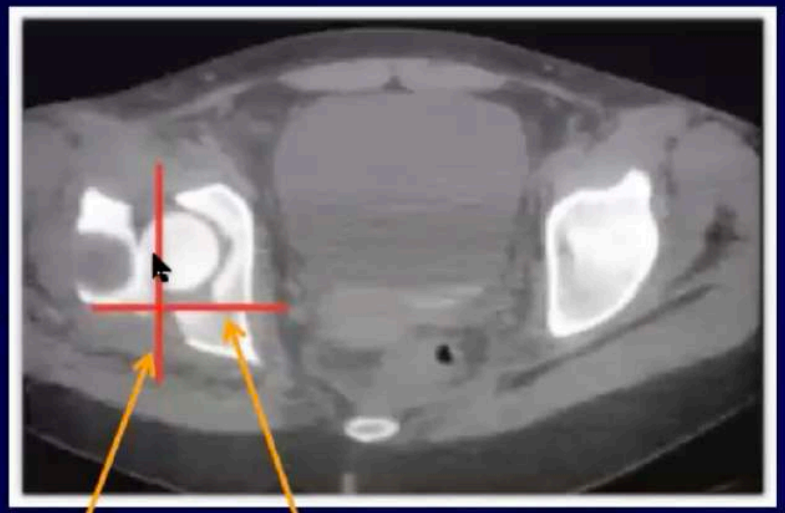
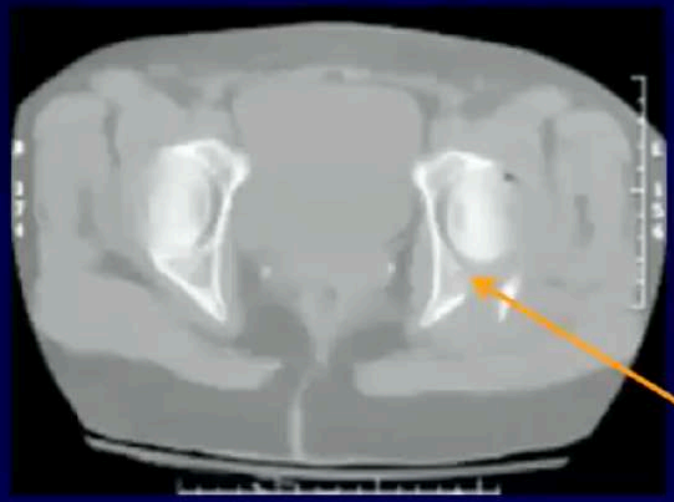
2-D CT





Transverse fx

Column fx line



Wall fx line

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3-D CT

- Creates a realistic 2-D image that conveys 3-D relationships
- 3-D images present findings of a study that are easier to interpret for less-experienced
- May help with pre-operative planning and as teaching tool
- Allows for rotation and osseous subtraction
- Limitations of detail based on averages used to construct 3-D images
- STILL NOT AS ACCURATE AS PLAIN 2-D CT FOR EXAMINING MARGINAL IMPACTION, SUBTLE FRACTURE LINES, OR SMALL OSSEOUS FRAGMENTS IN JOINT

3-D CT

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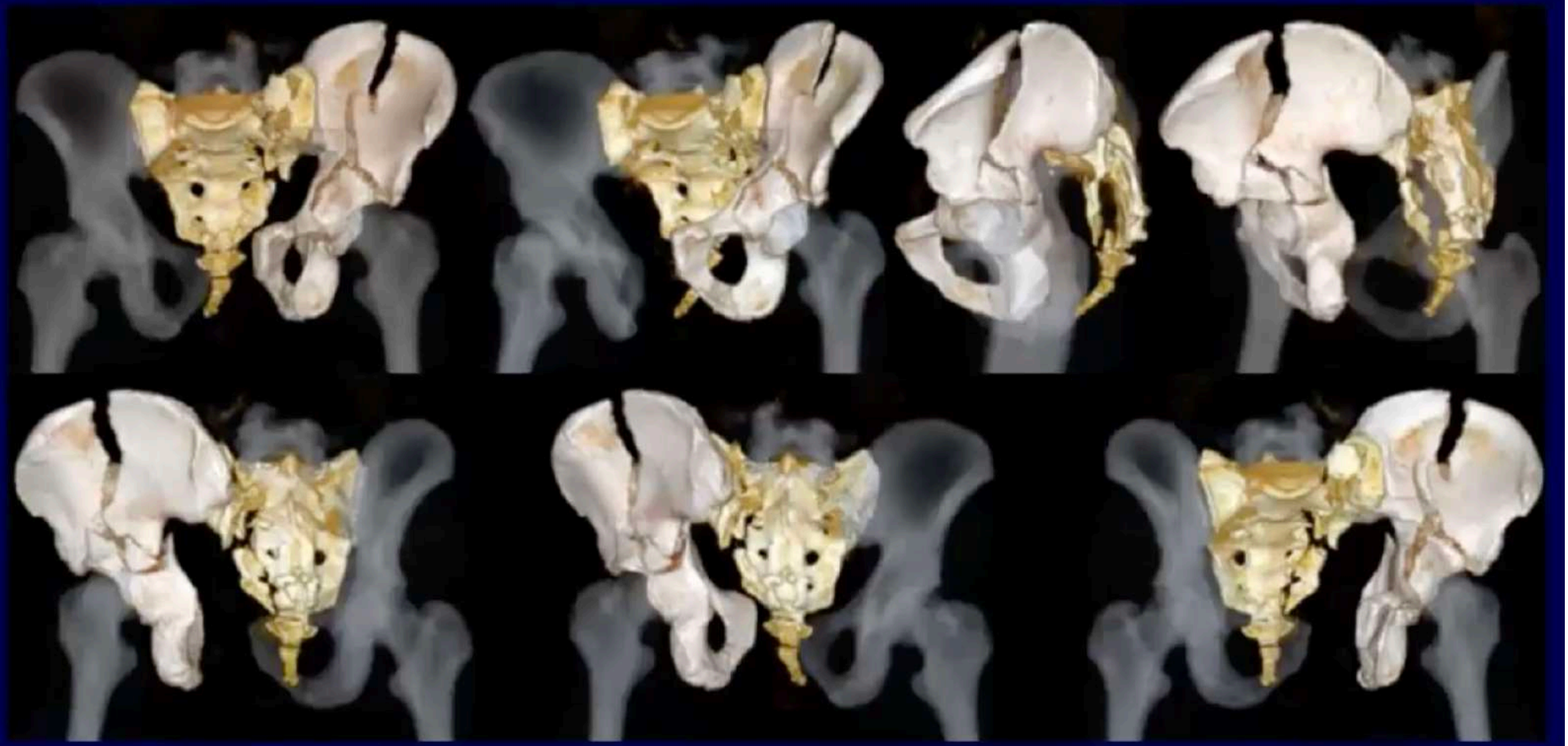
3-D CT



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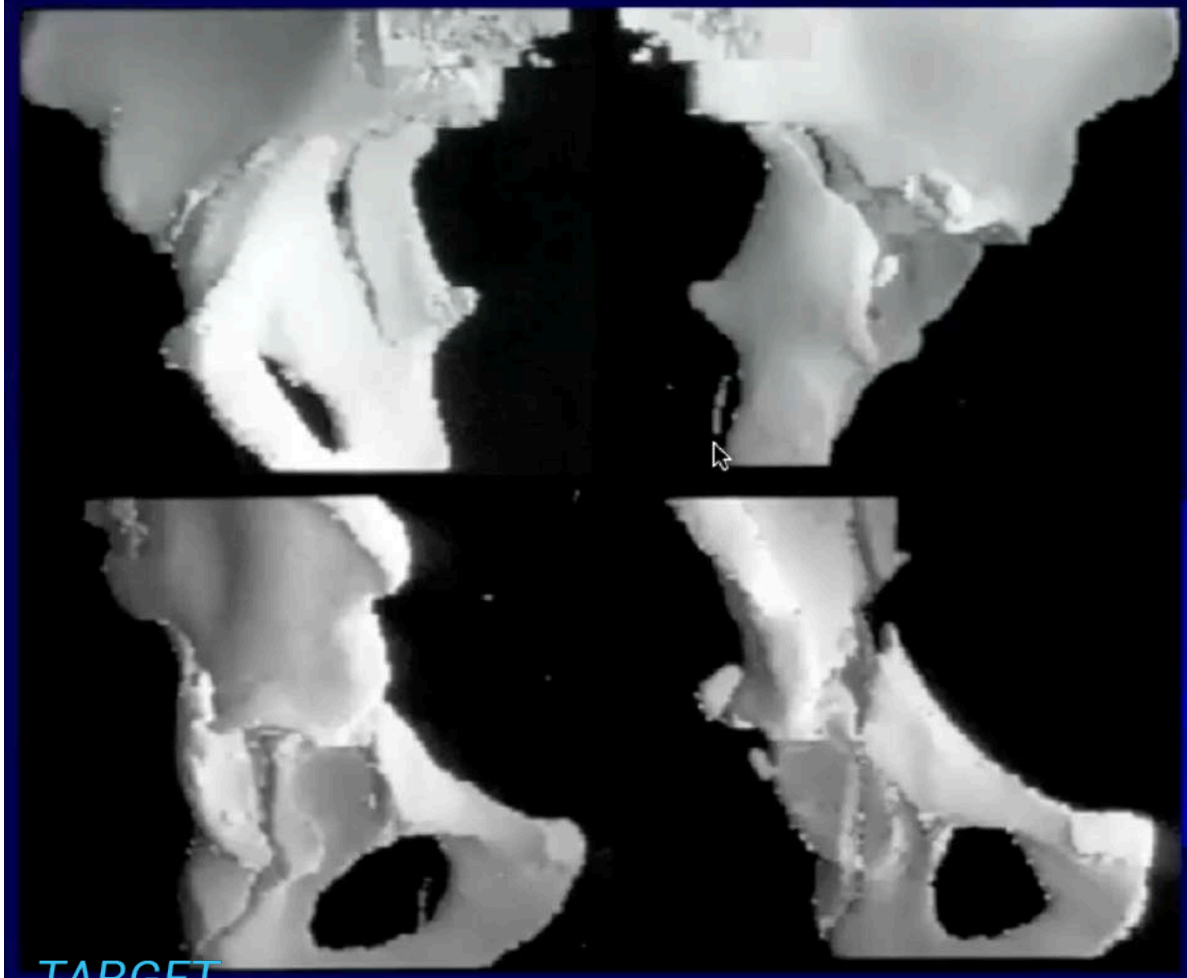
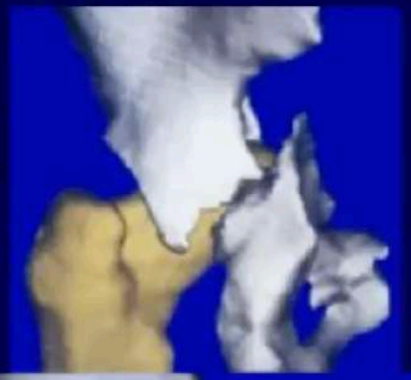
Surface versus Volume Rendered 3-D CT Imaging

- Surface rendered:
  - Demonstrates gross 3-D anatomy most effectively
  - MORE ARTIFACT; simplifies data to binary form
  - Does not demonstrate lesions/pathology hidden behind or underneath overlying bone cortex
- Volume rendered:
  - Little artifact; accurately depicts reality
  - Incorporates all of the data of the contained volume into the displayed image
  - Demonstrates sub-cortical lesions and minimally displaced fractures better than surface rendered
  - Ability to demonstrate 3-D relationship varies based on degree of surface shading/opacity
  - Increased cost

Surface Rendered 3-D CT





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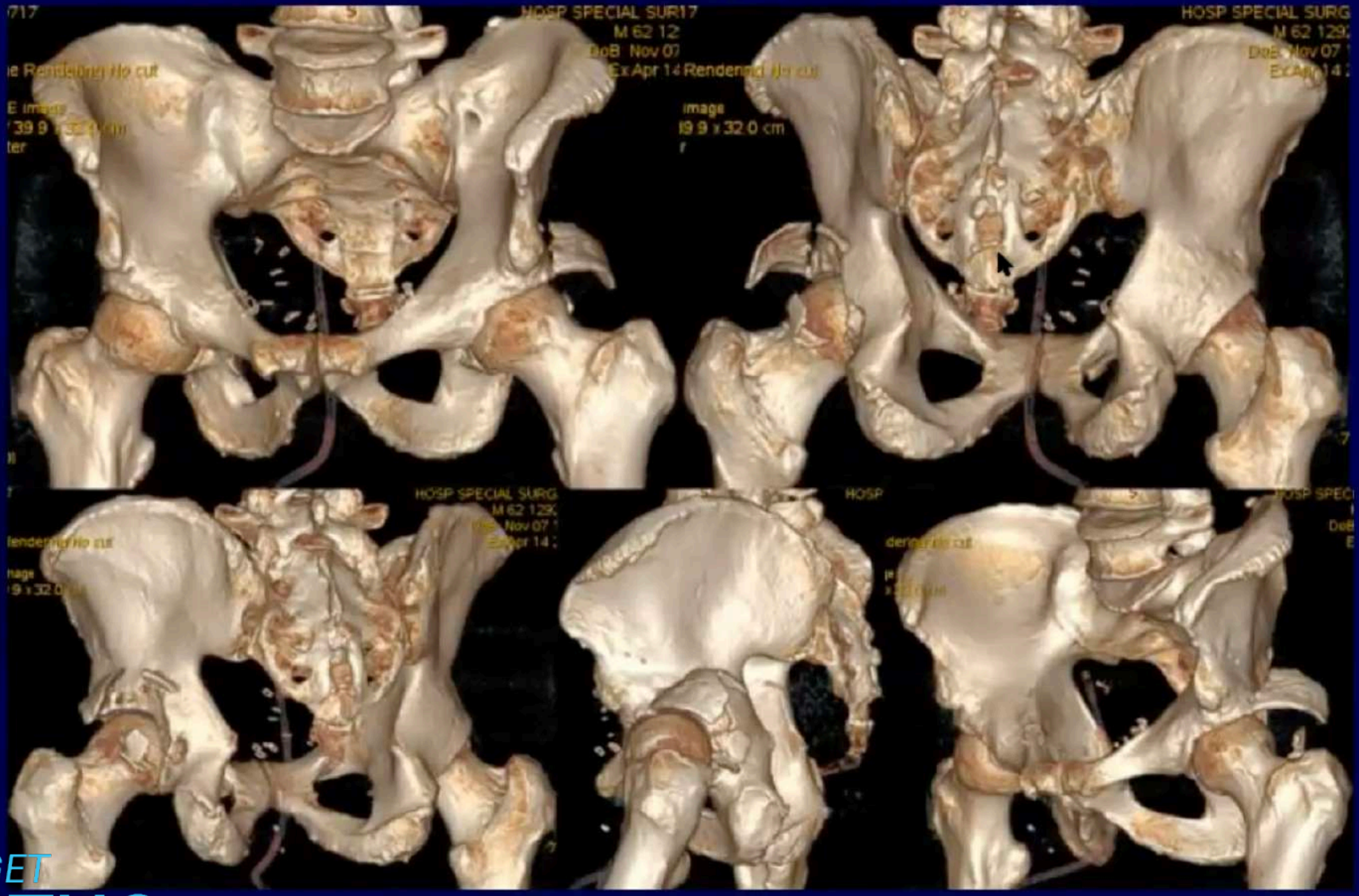
Volume Rendered 3-D CT



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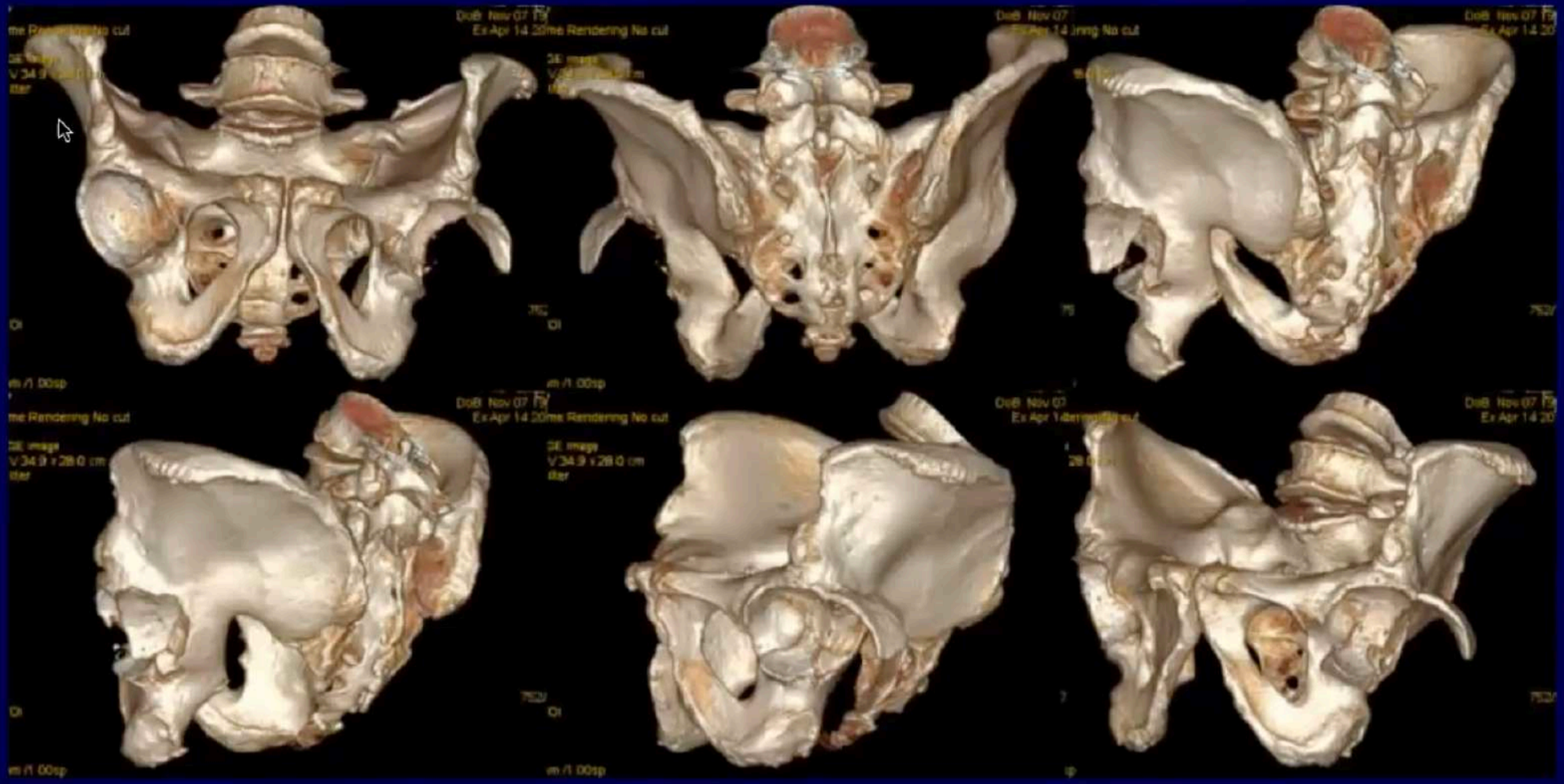
Volume Rendered 3-D CT



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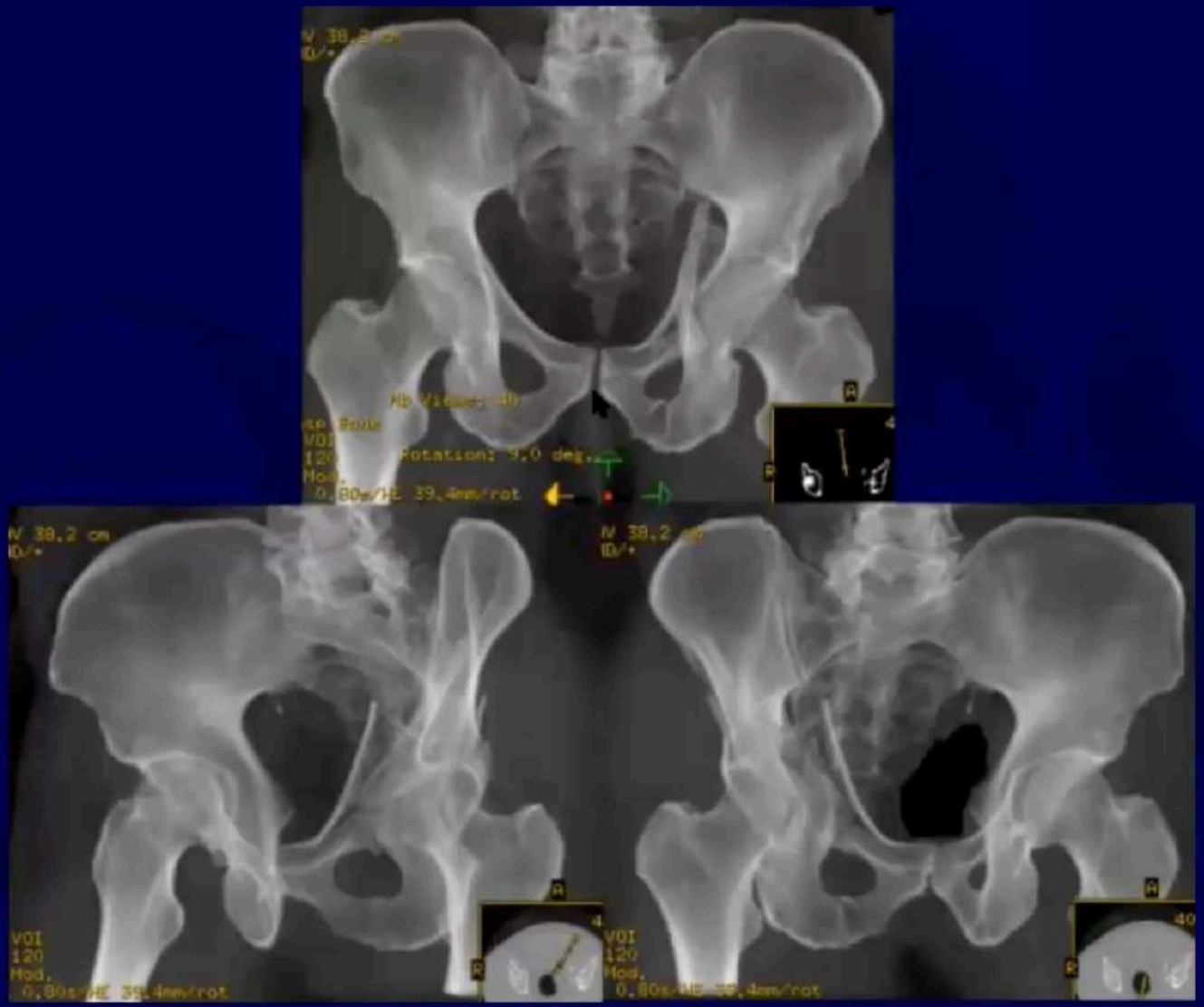
CT-simulated XR



Opaque volume rendered
Possible replacement for traditional plain radiographs

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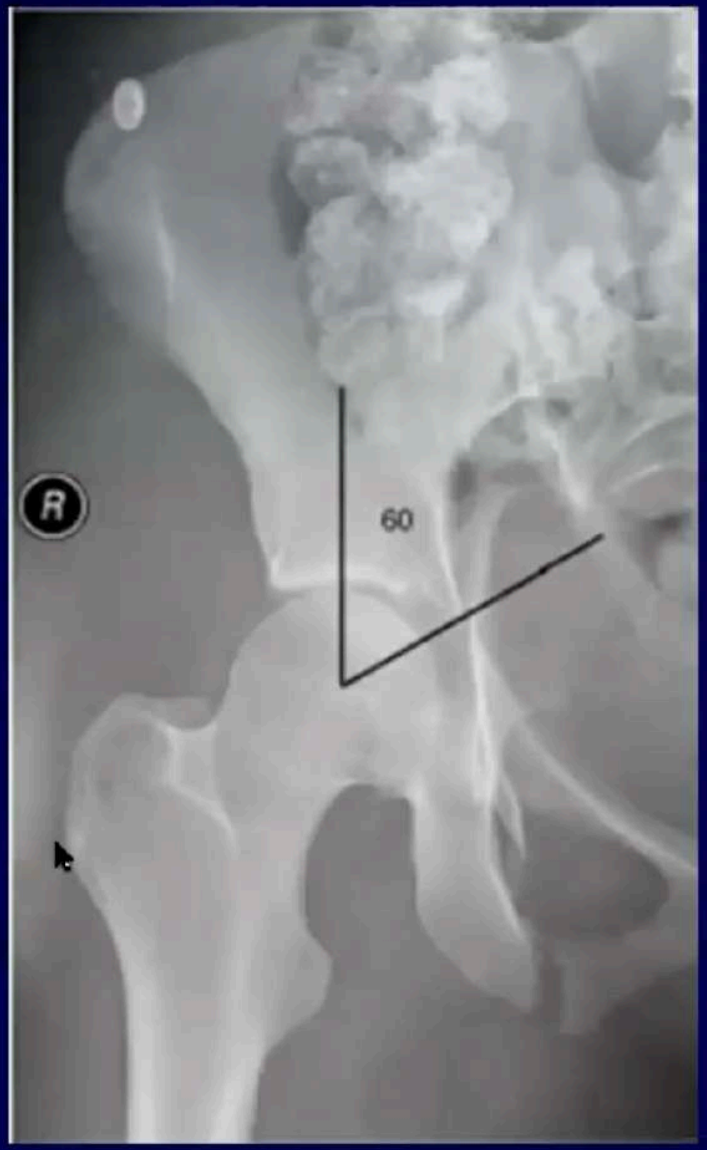
Roof Arc Measurements

- Matta (1986)
- Angle between vertical line through femoral head and line through fracture site on all 3 views
- Used to determine whether fracture line has violated weight bearing dome
- Determines if remaining intact acetabulum can maintain a stable and congruent joint
- Marker of non-operative vs operative treatment



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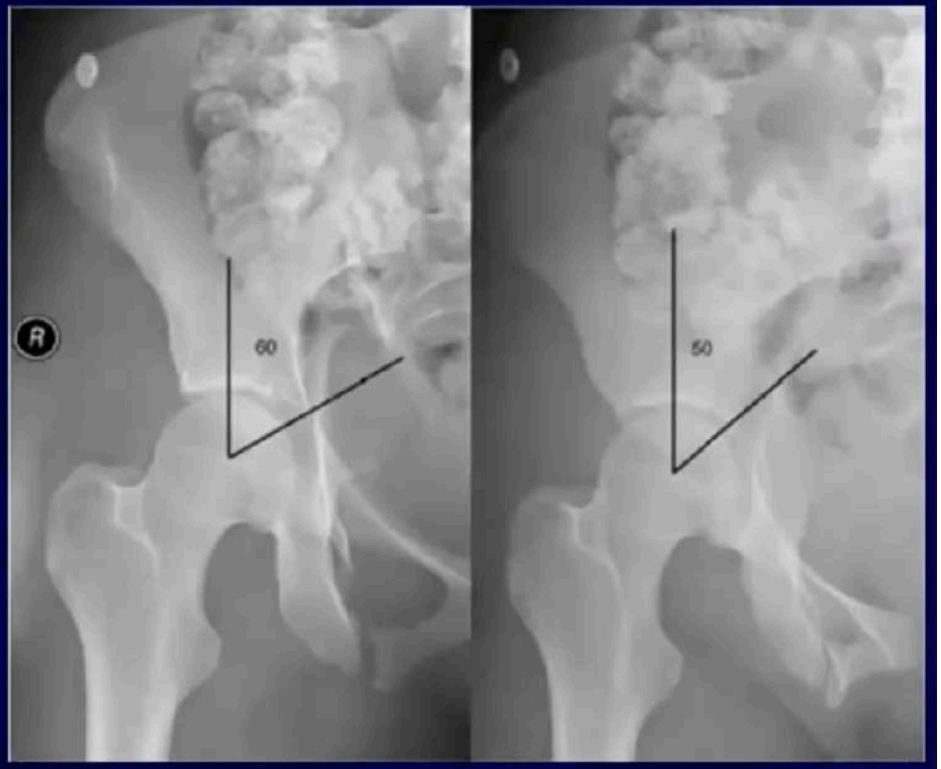
Roof Arc Measurement

- Roof arcs
  - Medial arc >30 degrees on AP
  - Anterior arc >40 degrees on obturator oblique
  - Posterior arc >50 degrees on iliac oblique
- Associated Both Column and Posterior wall➔DOES NOT APPLY



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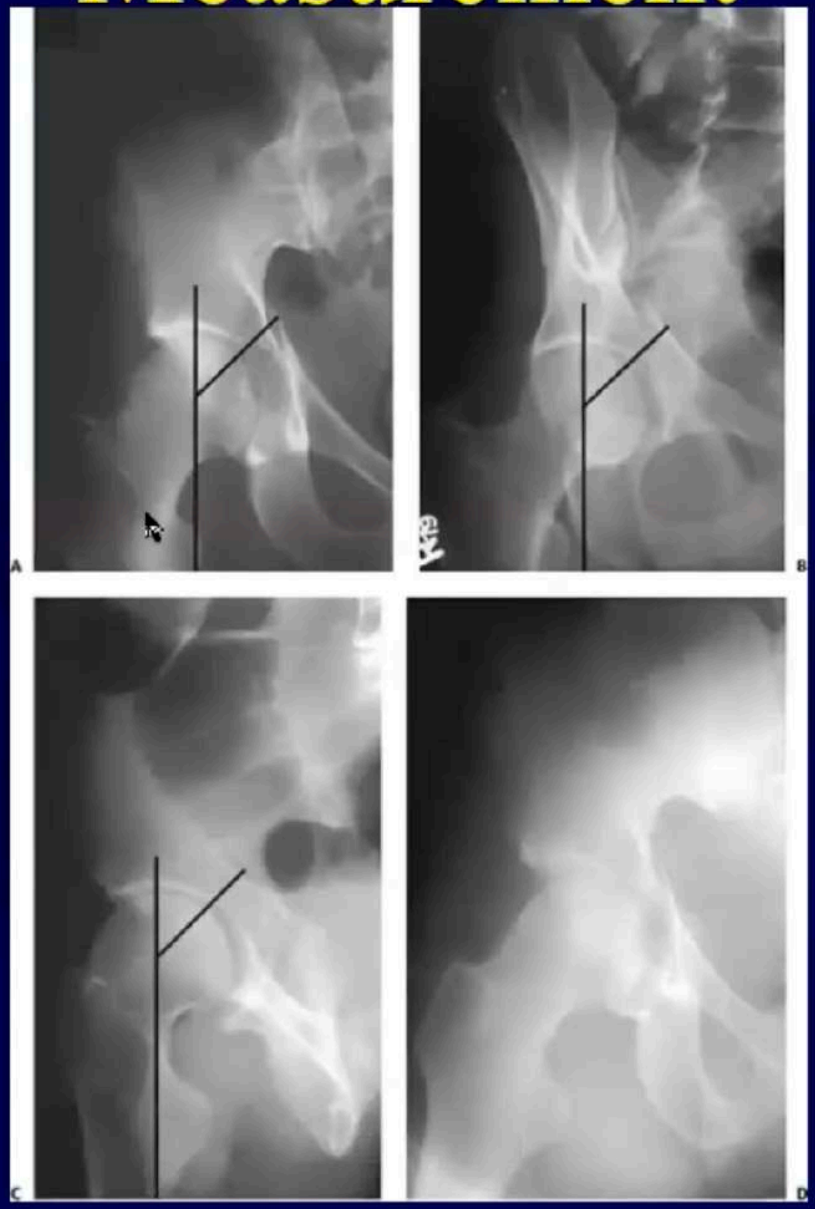
Revised Roof Arc Measurements

- Vrahas et al. JBJS 1999
  - Biomechanical study, sufficient acetabulum with:
    - Medial roof arc >45 degrees
    - Anterior roof arc >25 degrees
    - Posterior roof arc >70 degrees
- Matityahu et al. JOT 2012
  - Biomechanical study, sit to stand loads higher than single leg stance and require:
    - Medial roof arc >90.9 degrees
    - Anterior roof arc >67.3 degrees
    - Posterior roof arc >101.4 degrees

Failure of Roof Arc Measurement



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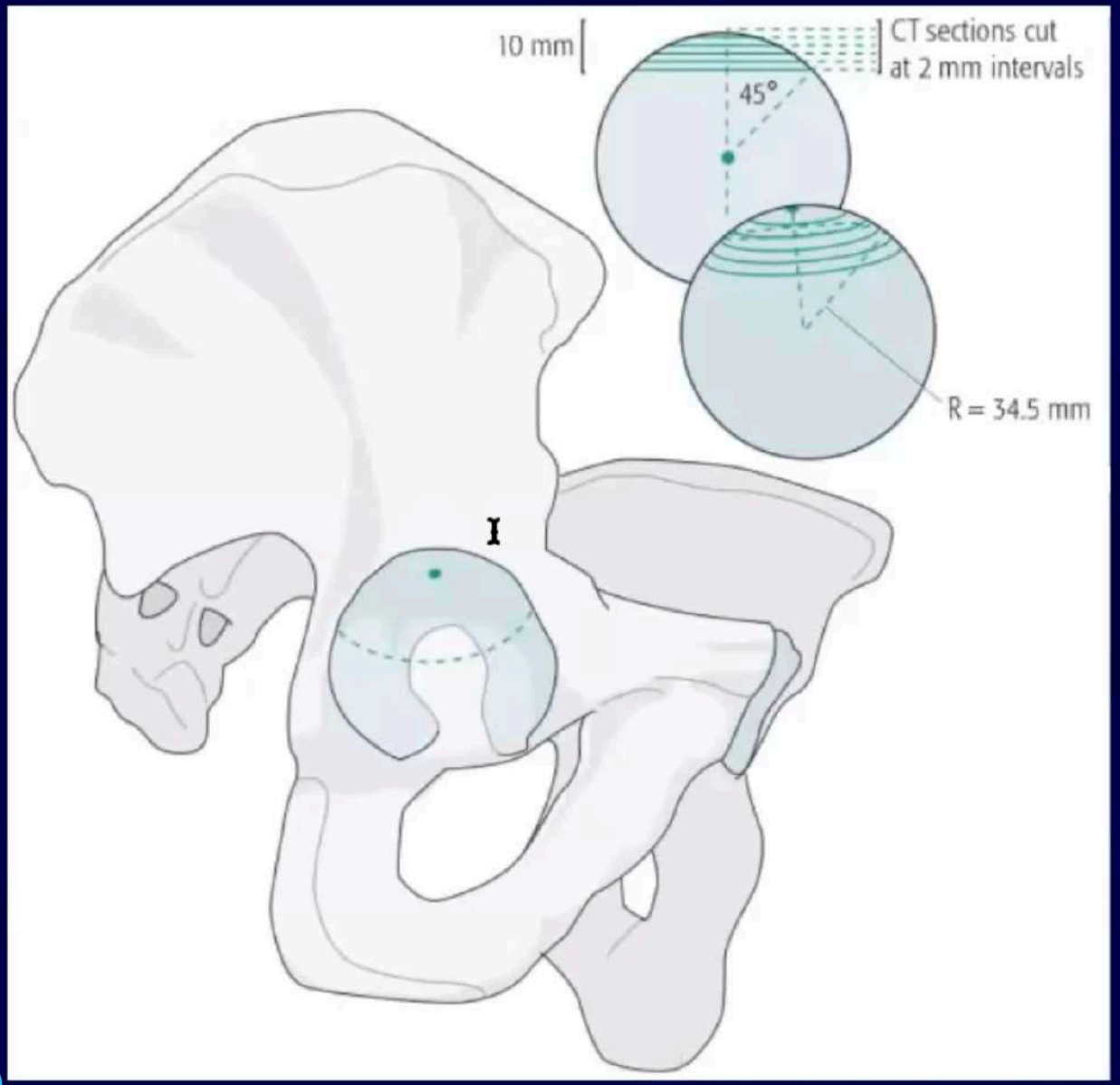
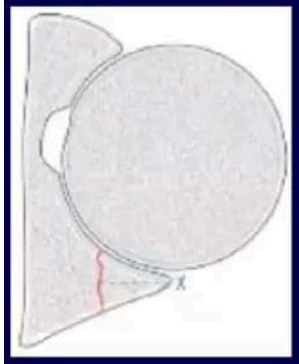
Subchondral Roof Arc on CT

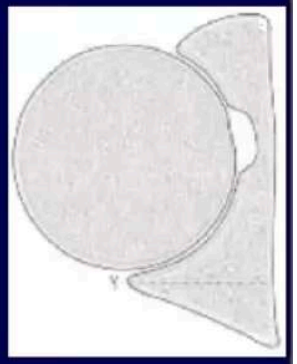
- Olson and Matta JOT 1993
  - Superior 10mm of the acetabular articular surface evaluates an area equivalent to the 45 degree roof arc measurements

Subchondral Roof Arc on CT





Dynamic Fluoroscopic Stress Examination



- Various methods to determine posterior wall stability:
  - Calkins
  - Keith
  - Moed
- Historically if fragment <20% (stable), 20-50% (indeterminate stability) and >50% (unstable)
- Recent literature has demonstrated that wall size <20% is not a reliable indicator of stability
- If stable per EUA a non-operatively treated PW acetabulum fx maintains congruity and leads to good to excellent early clinical and functional outcomes (McNamara et al. JOT 2015)

EUA Technique (Moed)

- Patient supine on a radiolucent table
- Hip in full extension and neutral rotation
- Hip slowly flexed past 90° with progressive manual force
- Examiner employs entire body weight to axially load the hip
- Hip is visualized using C-arm fluoroscopic imaging
- Performed twice - using AP and obturator oblique views
- If stable, repeat adding 20° adduction and 20° internal rotation
- Posterior subluxation of the femoral head or loss of joint parallelism on either view indicates dynamic hip instability; do not need frank dislocation to diagnose instability

Posterior Wall Instability during EUA

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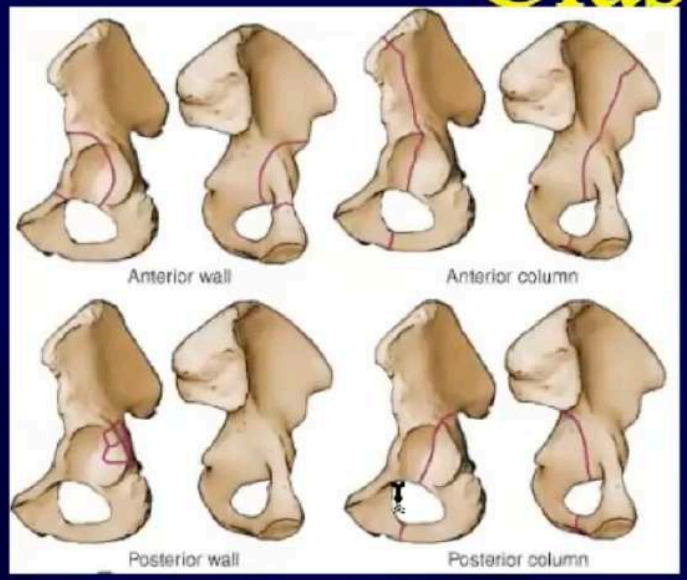
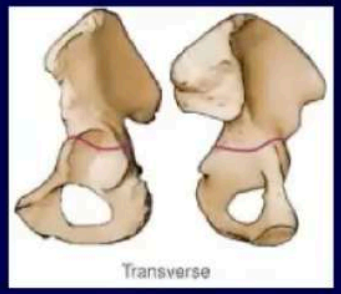
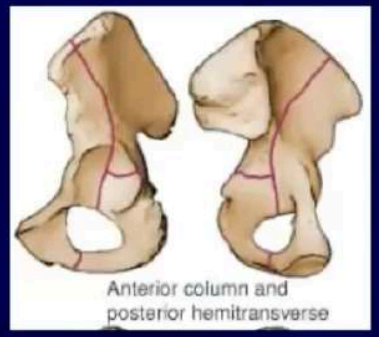
Intra-operative views with hip in full extension and 90 degrees of flexion with neutral rotation demonstrate congruent hip joint. Then the hip is axially loaded in 90 degrees of flexion demonstrating gross subluxation and loss of joint congruency

Acetabular Fracture Classification







Elementary

Associated

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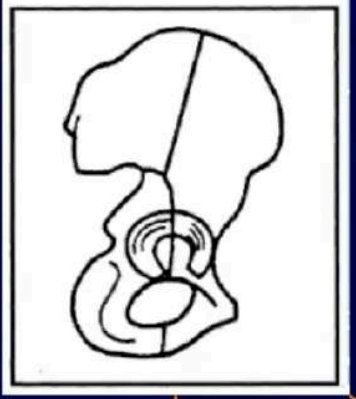
Acetabular Fracture Classification

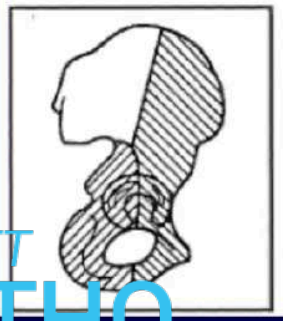
- Classification system developed by Judet and Letournel
- Elementary and associated patterns
  - Based on column and wall disruptions
- OTA/AO classification (62-A, -B, -C) based on this system
  - Allows for standardization for coding and research

OTA Classification

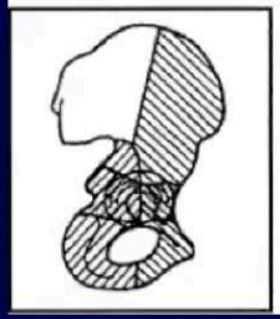
Location: Acetabulum (62)



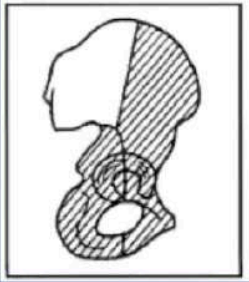
A. Partial articular, 1 column (62-A)



B. Partial articular, transverse (62-B)

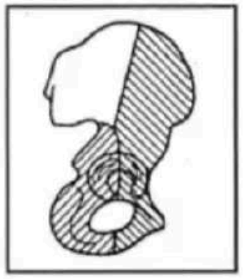


C. Complete articular, both columns (62-C)

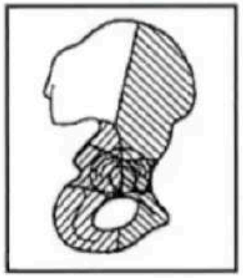


"OTA Fracture and Dislocation Compendium"

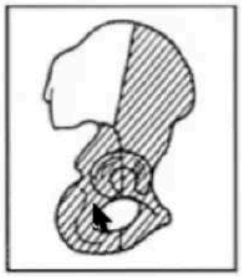
A. Partial articular, 1 column (62-A)

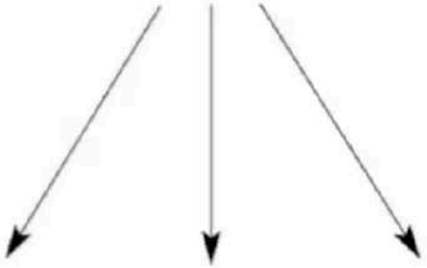


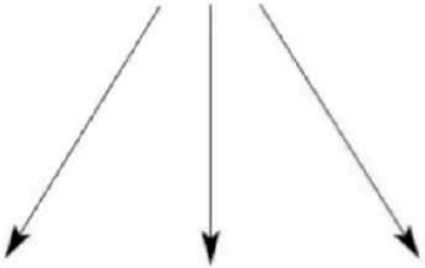
B. Partial articular, transverse (62-B)

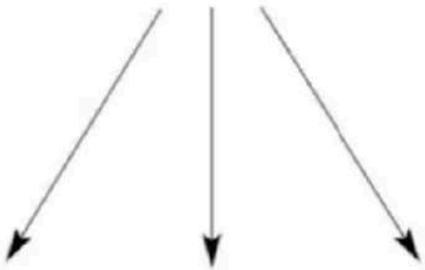


C. Complete articular, both columns (62-C)









Groups:

Pelvis, acetabulum, partial articular, one column (62-A)

1. Posterior wall (62-A1)
2. Posterior column (62-A2)
3. Anterior (62-A3)

Pelvis, acetabulum, partial articular, transverse (62-B)

1. Transverse (62-B1)
2. T-shaped (62-B2)
3. Anterior column, posterior hemitransverse (62-B3)

Pelvis, acetabulum, complete articular, both columns (62-C)

1. High (62-C1)
2. Low (62-C2)
3. Involving sacroiliac joint (62-C3)

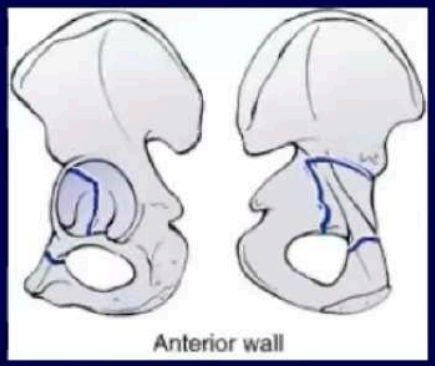
Acetabular Fracture Classification

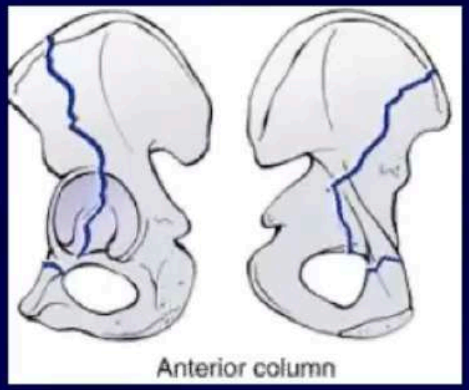
- Elementary Patterns
  - Anterior wall
  - Anterior column
  - Posterior wall
  - Posterior column
  - Transverse

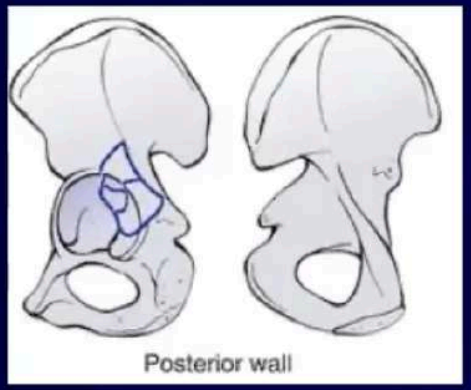
Part or all of ONE column fractured

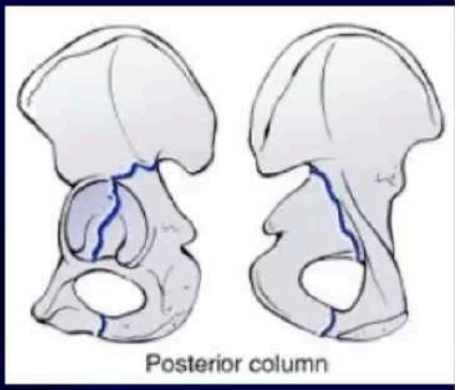
Transversely cuts BOTH columns into upper and lower segments
Elementary due to "simplicity" of the fracture line

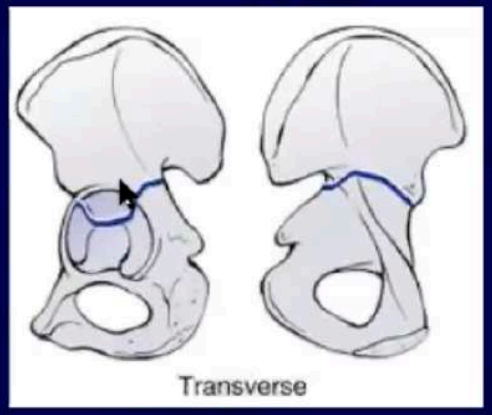
Elementary Fracture Patterns







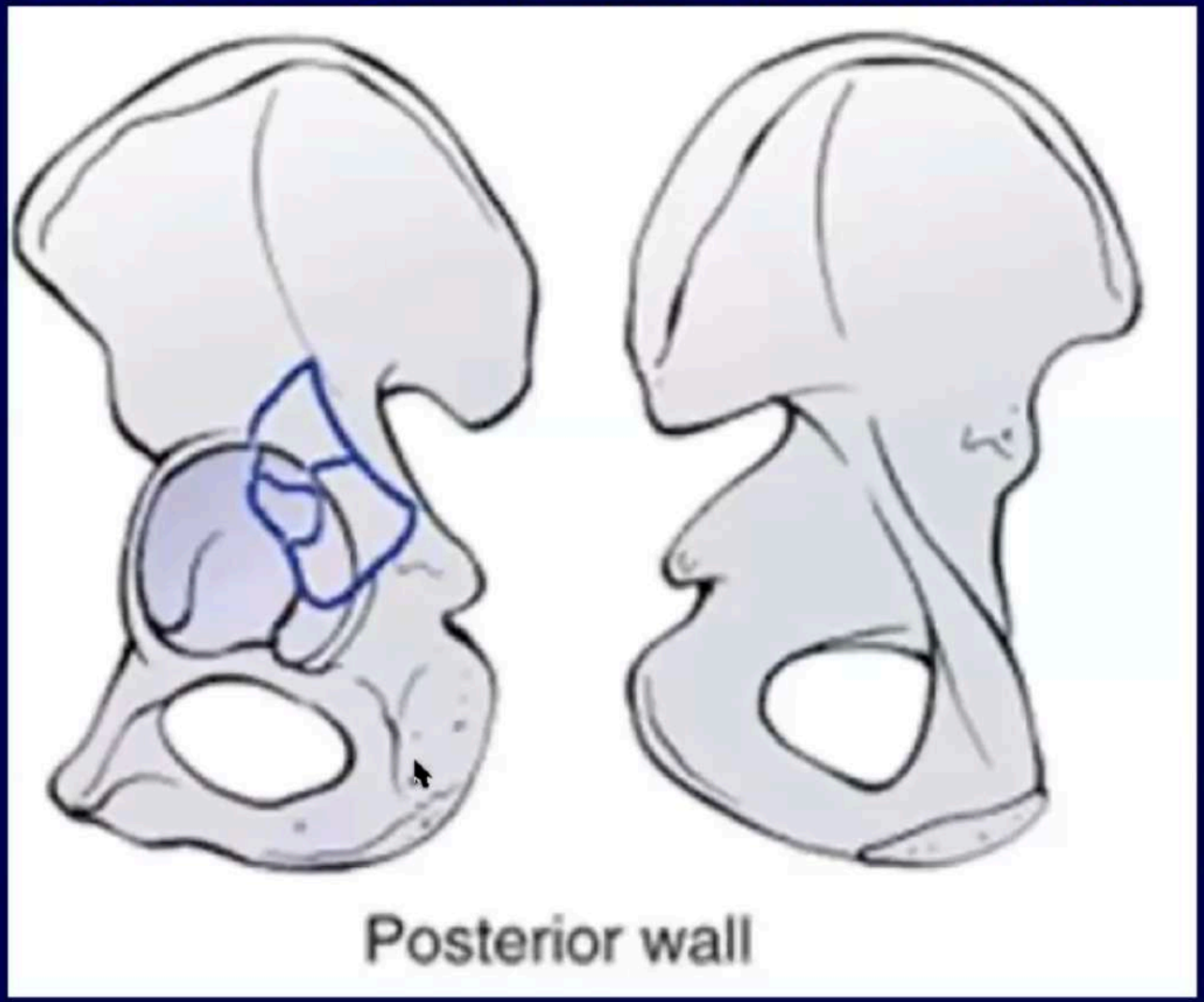




Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

ELEMENTARY FRACTURE PATTERN EXAMPLES

Posterior Wall Fractures



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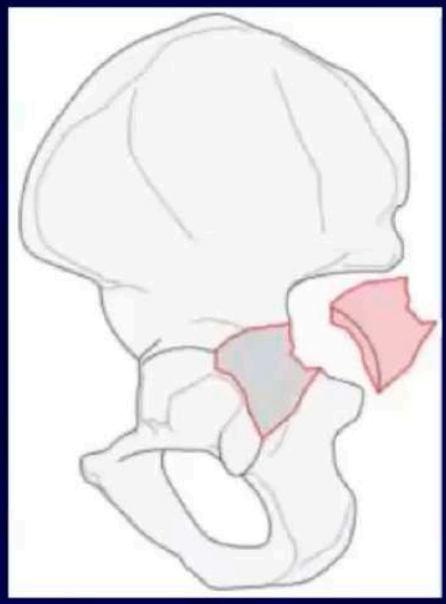
Posterior Wall Fractures

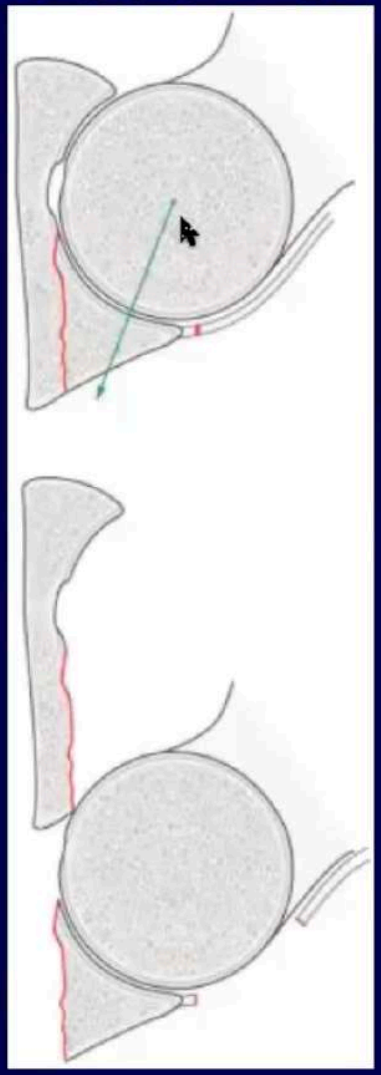
- Most common → 25% of acetabular fractures
- Separation of posterior articular surface
- Majority of posterior column undisturbed
- Commonly associated with posterior hip dislocation
- Simple appearance on plain XR underestimates complexity

Posterior Wall Fractures

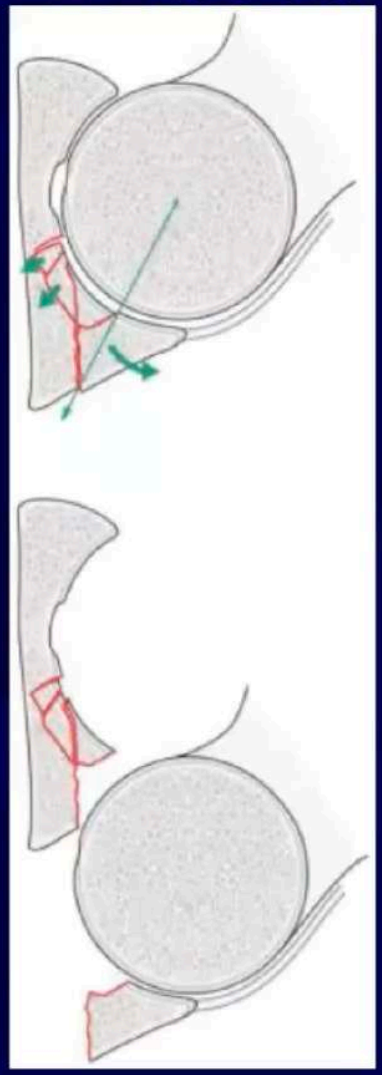


- Fracture subtypes
  - Confined below the roof
  - Postero-superior
    - Part of roof separated
  - Postero-inferior
    - Detached fragment inferior horn of articular surface, sub-cotyloid groove, and superior ischium

Posterior Wall Fractures

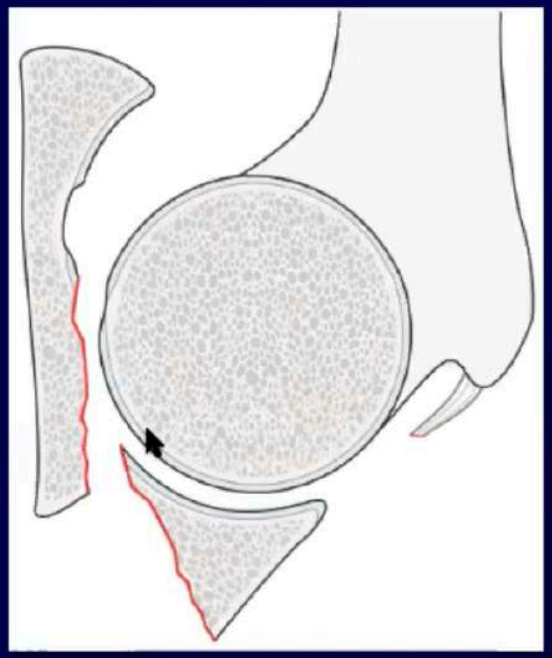


Pure posterior wall fracture

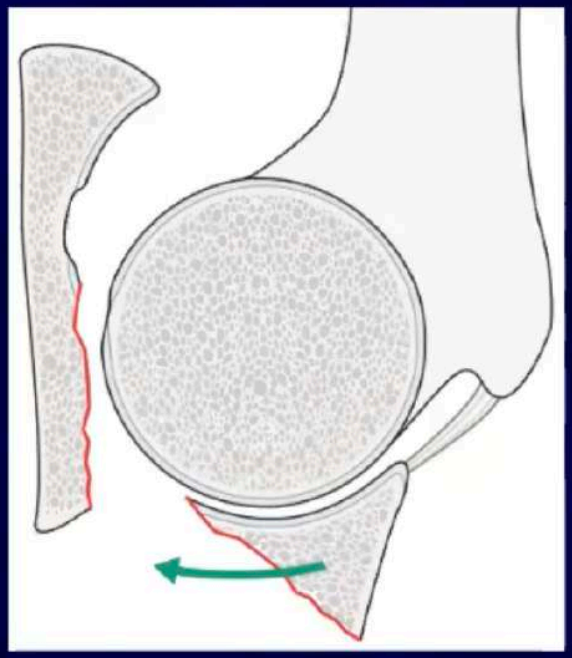


Posterior wall fracture with marginal impaction

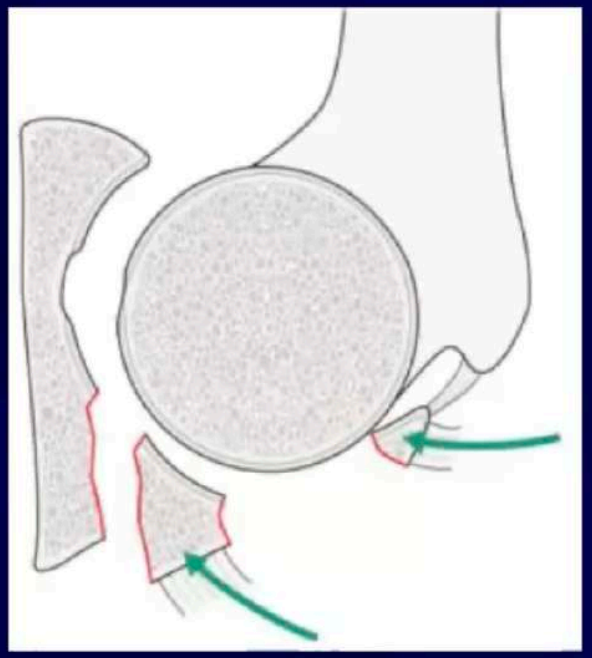
Posterior Wall Fractures



Capsule disrupted from wall fragment→avascular



Capsule attached to wall fragment→viable fragment



Capsule attached to peripheral fragment→peripheral fragment viable and intercalary fragment avascular

Posterior Wall Fractures

Disruption of posterior wall/rim
Femoral head dislocation

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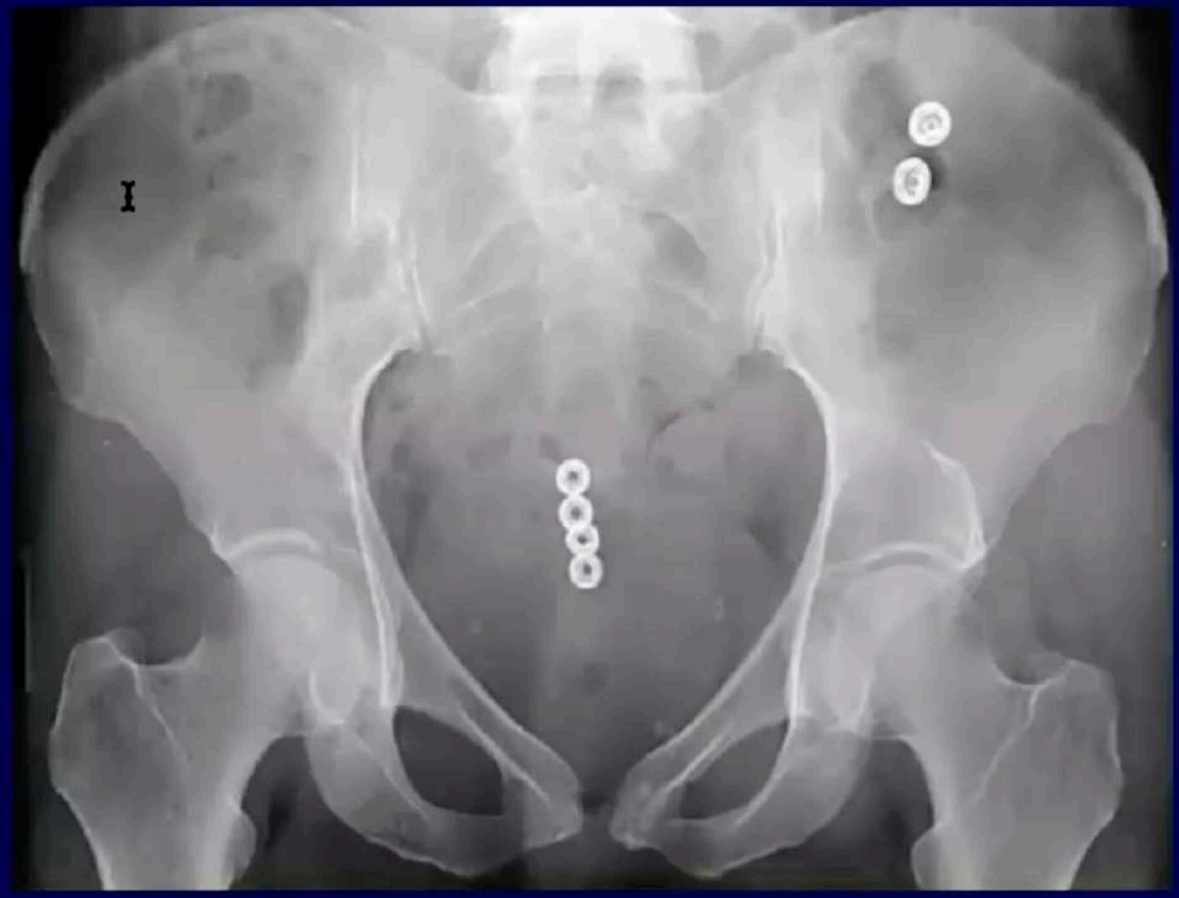
Posterior Wall Fractures

- Be aware that sometimes the femoral head will be or appear to be reduced on AP XR
- Scrutinize AP view for disruptions of 6 lines
- Consider that although femoral head may be reduced there still may be instability . . .



David Helfet, MD

Posterior Wall Fractures

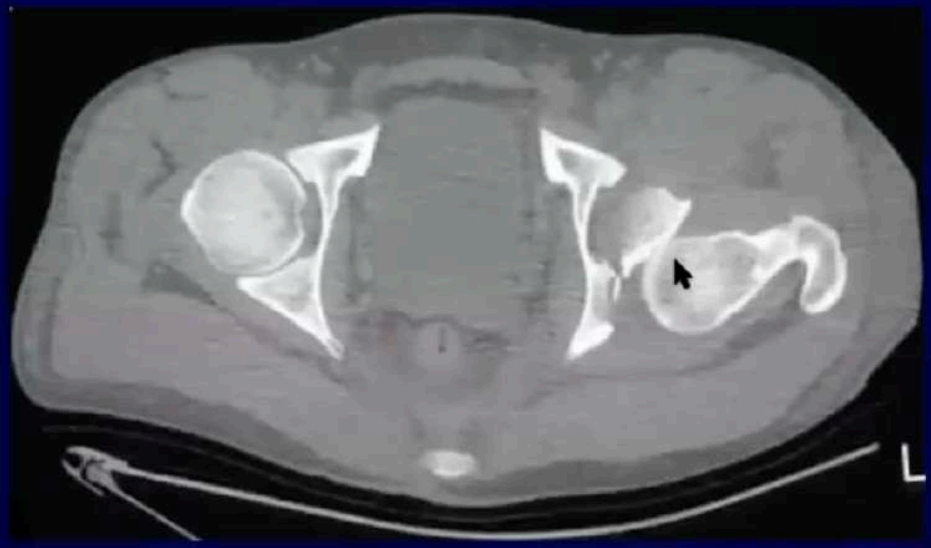
David Helfet, MD

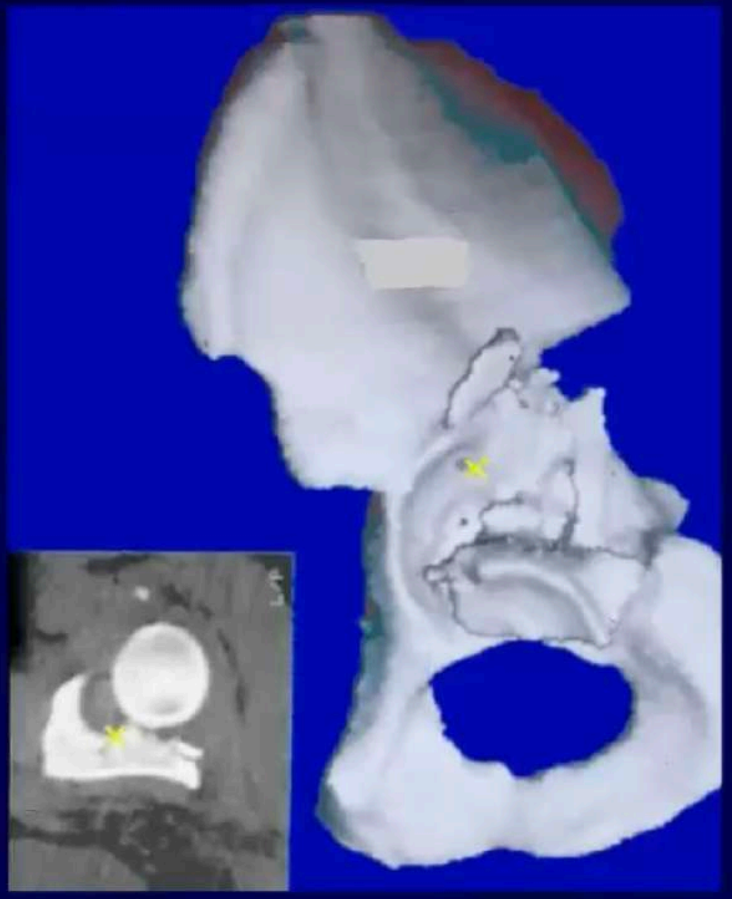
Posterior Wall Fractures
Judet Radiographs

- Obturator oblique
  - Posterior wall displacement
  - Demonstrates congruency of femoral head within acetabulum
  - obturator ring intact
- Iliac oblique
  - Posterior border of innominate bone and iliac wing intact
  - Anterior wall intact

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

CT scan





Marginal impaction

Incarcerated fragments

Comminution

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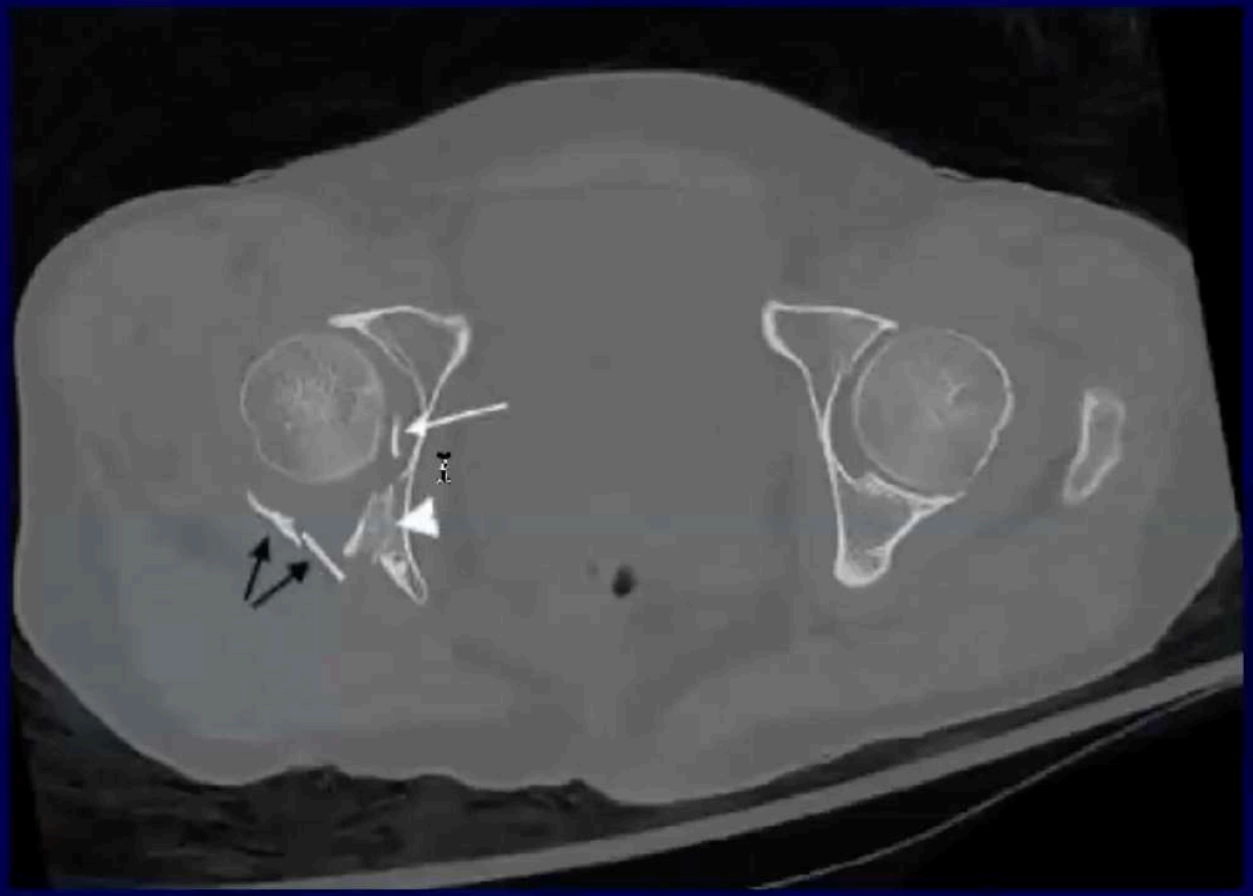
Marginal Impaction



Marginal Impaction: segment of articular surface and underlying cancellous bone is impacted away from joint surface causing incongruity
Also note intra-articular fragment

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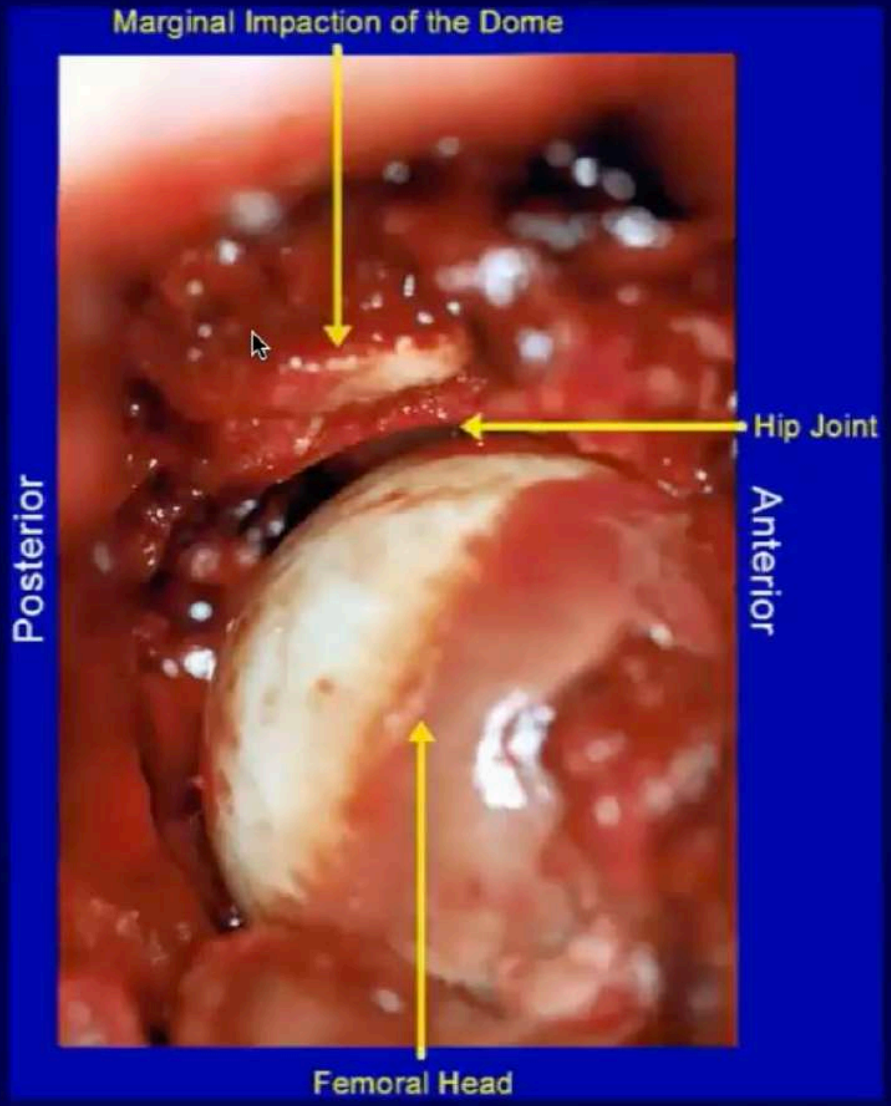
Marginal Impaction



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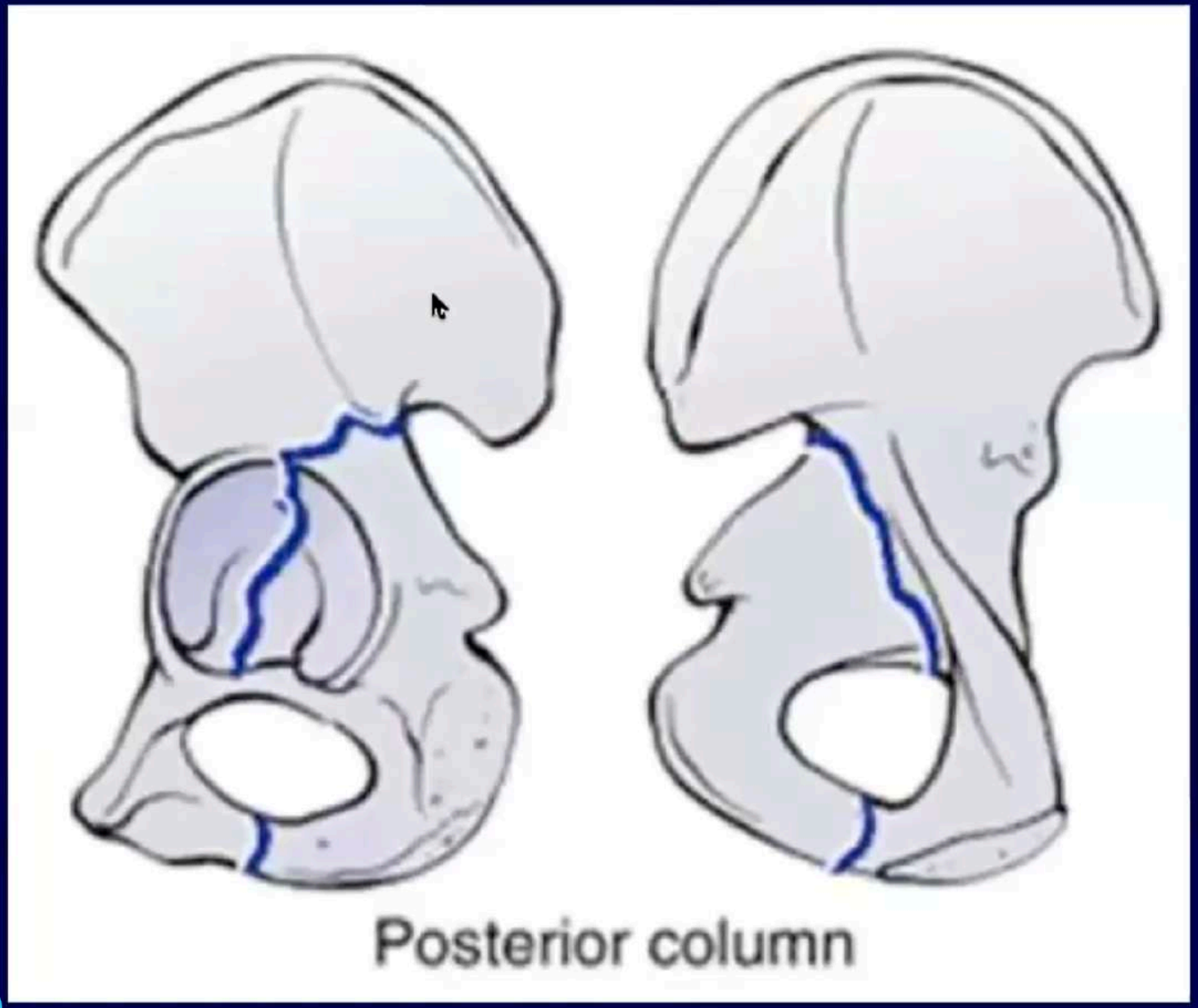
Posterior Column Fractures



Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Posterior Column Fractures

- 3-5% of all acetabulum fractures
- Detachment of entire ischioacetabular segment from innominate bone
- Fracture begins at posterior border of innominate bone near apex of greater sciatic notch
- Fracture continues inferior across articular surface, quadrilateral surface, ischiopubic notch, and inferior pubic ramus
- Femoral head follows column fragment medially and posteriorly
- Unstable injuries, commonly requires skeletal traction to maintain hip reduction
- Superior gluteal neurovascular bundle may become entrapped

** "Gull sign"➔ originally described by Letournel and Judet for variations of posterior column fractures where the posterior column displaces and takes the hind portion of acetabular roof; therefore the posterior segment loses its normal relationship with the segment still attached to anterior column and forms "an image like a gull in flight". This is not the same as the "gull sign" described for AC/PHT injuries representing impacted subchondral bone of the medial roof**

Posterior Column Fractures
AP Radiograph

Note:
Normally ilioischial line displaces relative to teardrop; if large portion of quadrilateral surface is part of column fragment, teardrop will displace WITH ilioischial line

Ilioischial, posterior rim, and inferior ramus disrupted
Ilioischial line displaced medially
Iliopectineal line intact

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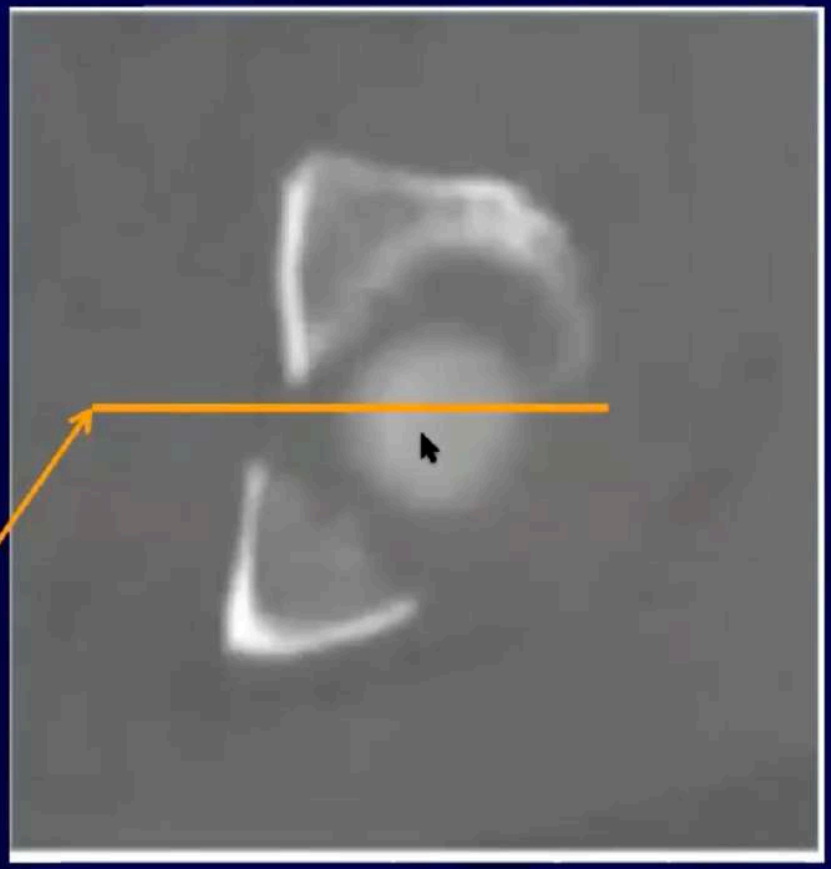
Posterior Column Fractures
Judet Radiographs

- Obturator oblique
  - Intact anterior column
  - Ischiopubic ramus fracture identified
- Iliac Oblique
  - Delineates posterior column fracture

Posterior Column Fractures
Judet Radiographs

Court-Brown, C. et al.
Rockwood & Greens
Fractures in Adults.
Philadelphia: Lippincott
Williams & Wilkins, 2014

CT scan



Column fracture line orientation

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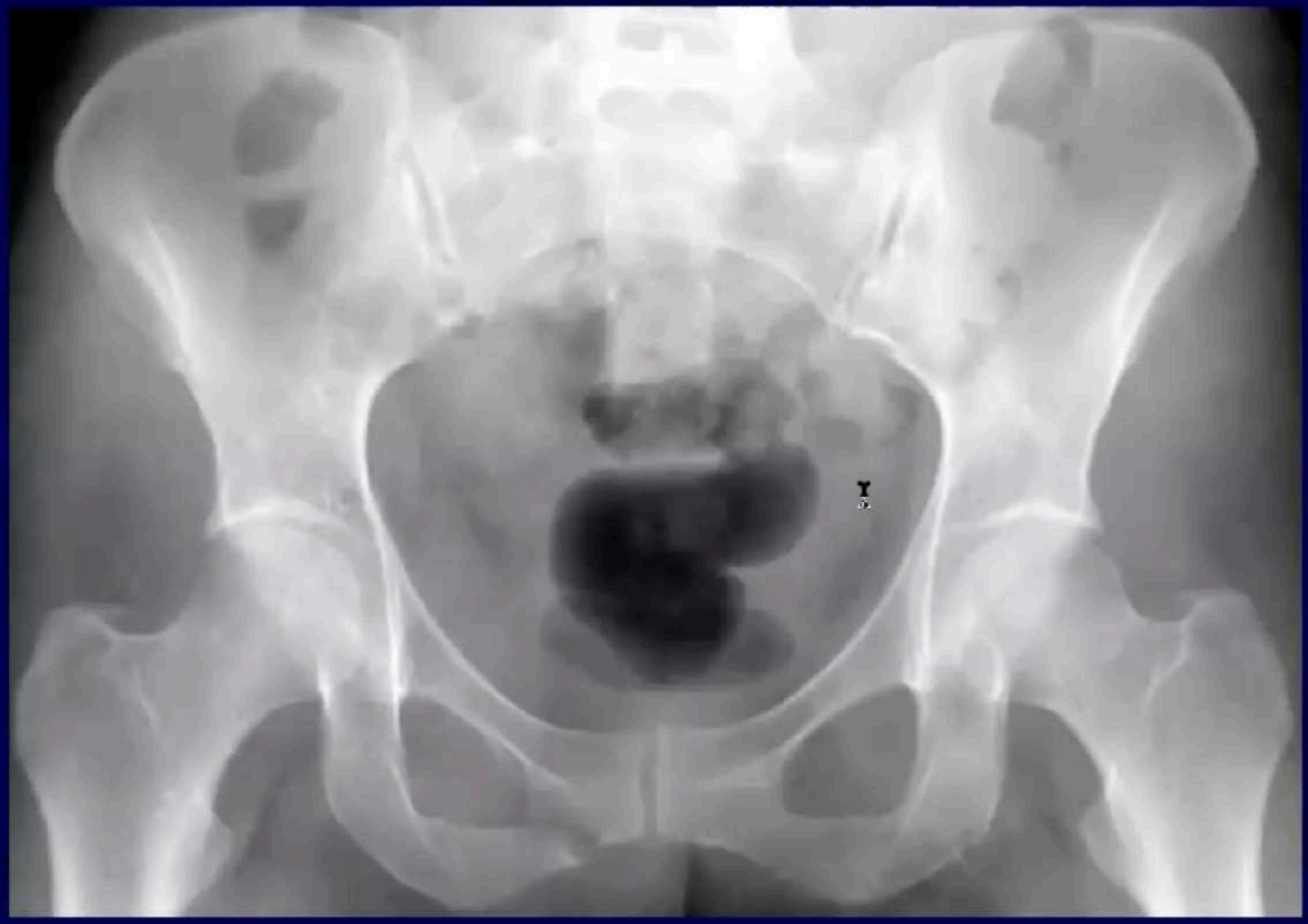
Posterior Column Fractures
Case #2 . . .



Note subtle disruption of ilioischial line and intact iliopectineal line; also note posterior rim disruption

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Posterior Column Fractures

Posterior column fx visualized

Intact anterior column, fx of inferior ramus visualized

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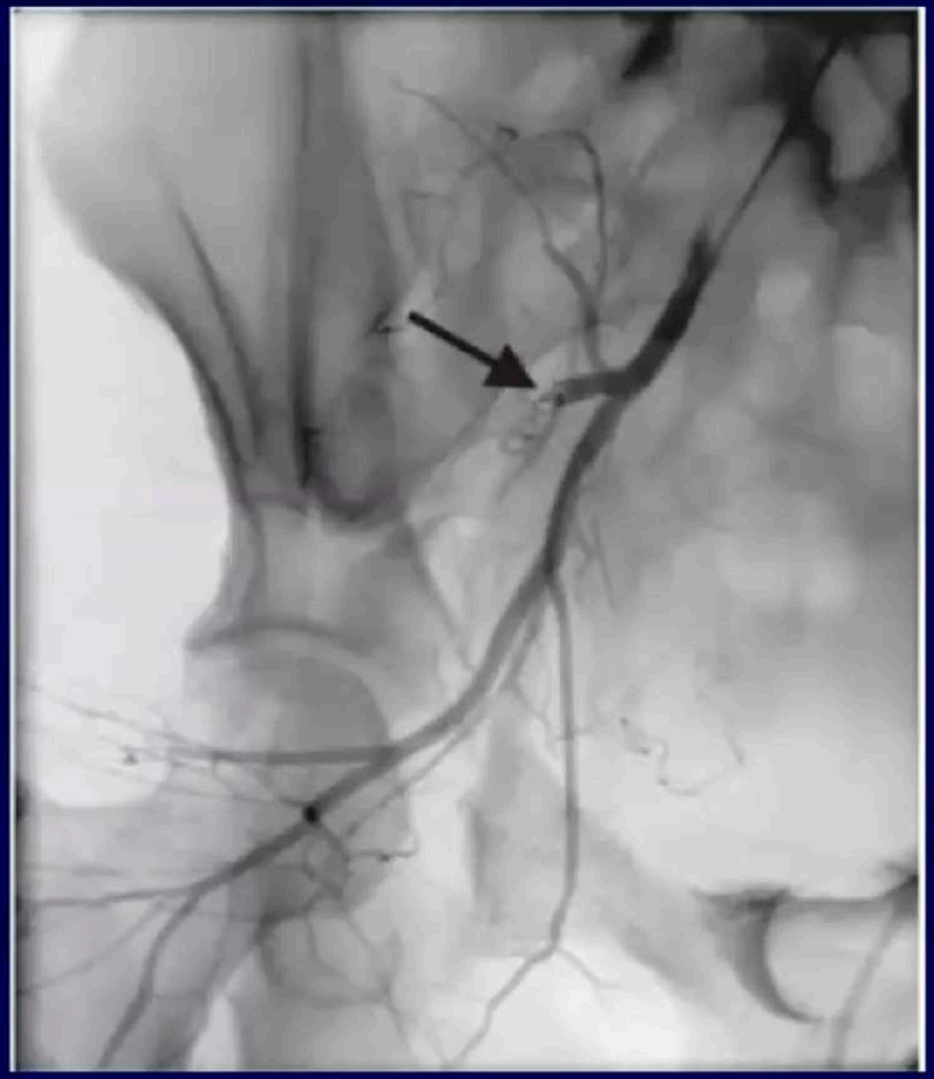
Posterior Column Fractures
Case #2 . . .

Note subtle disruption of ilioischial line and intact iliopectineal line; also note posterior rim disruption

David Helfet, MD

Remember . . .

- Superior gluteal NV bundle exits at greater sciatic notch and may become tethered at fx site



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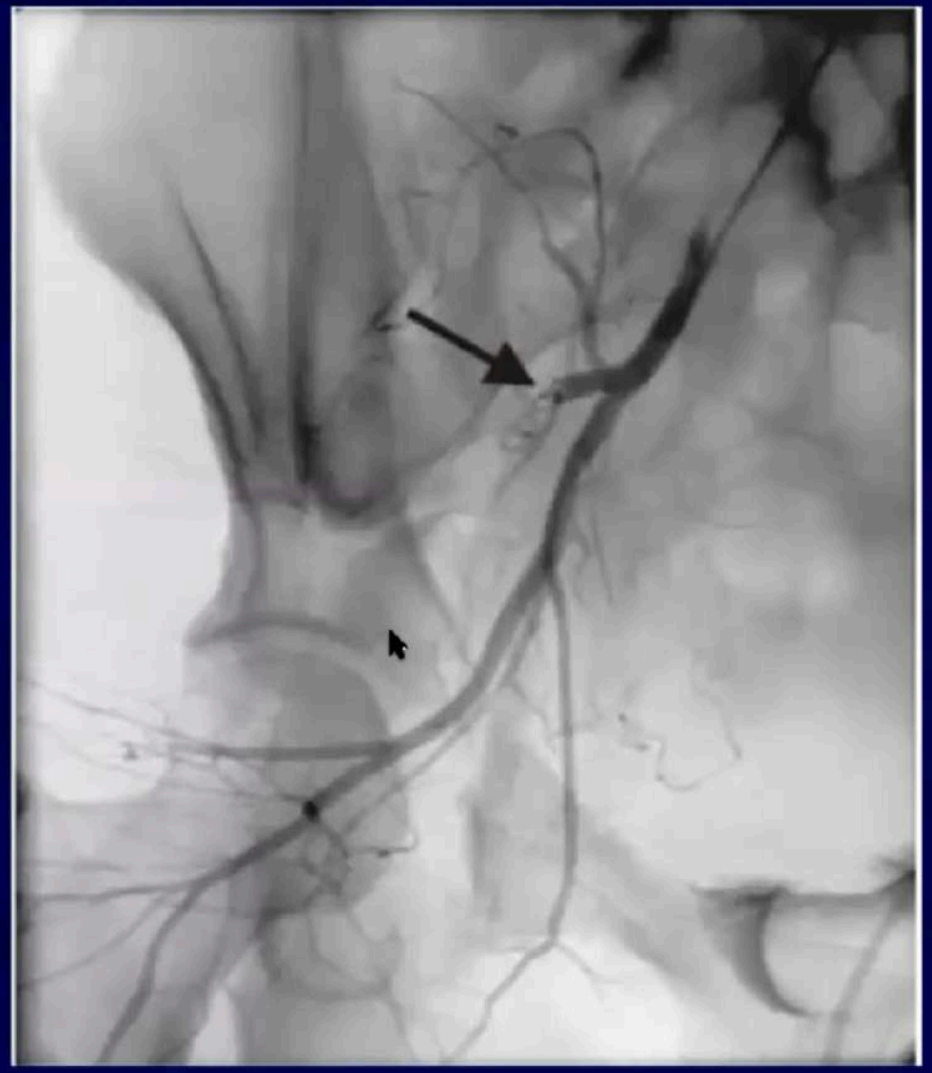
Posterior Column Fractures
Judet Radiographs

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

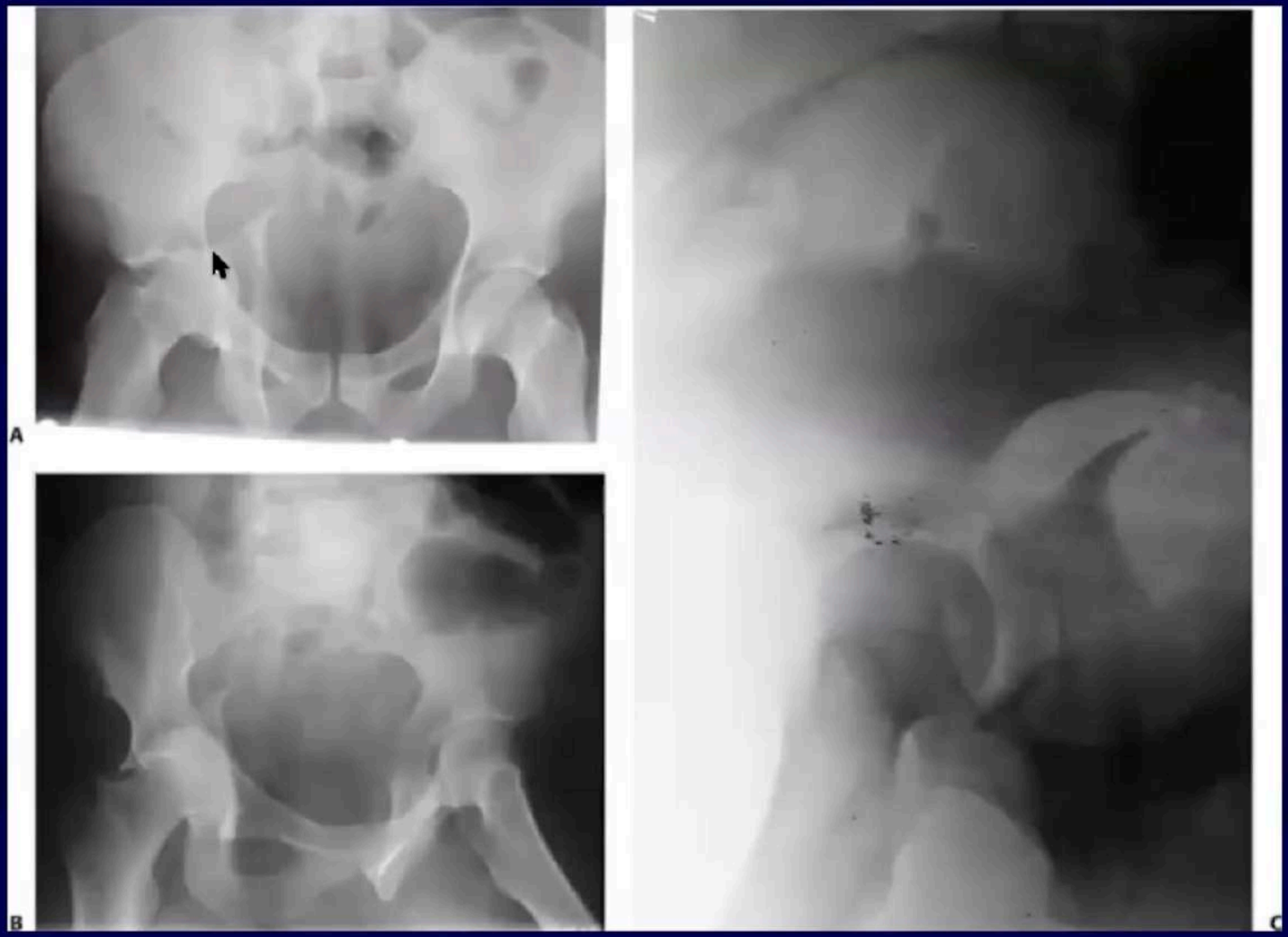
Remember . . .

- Superior gluteal NV bundle exits at greater sciatic notch and may become tethered at fx site



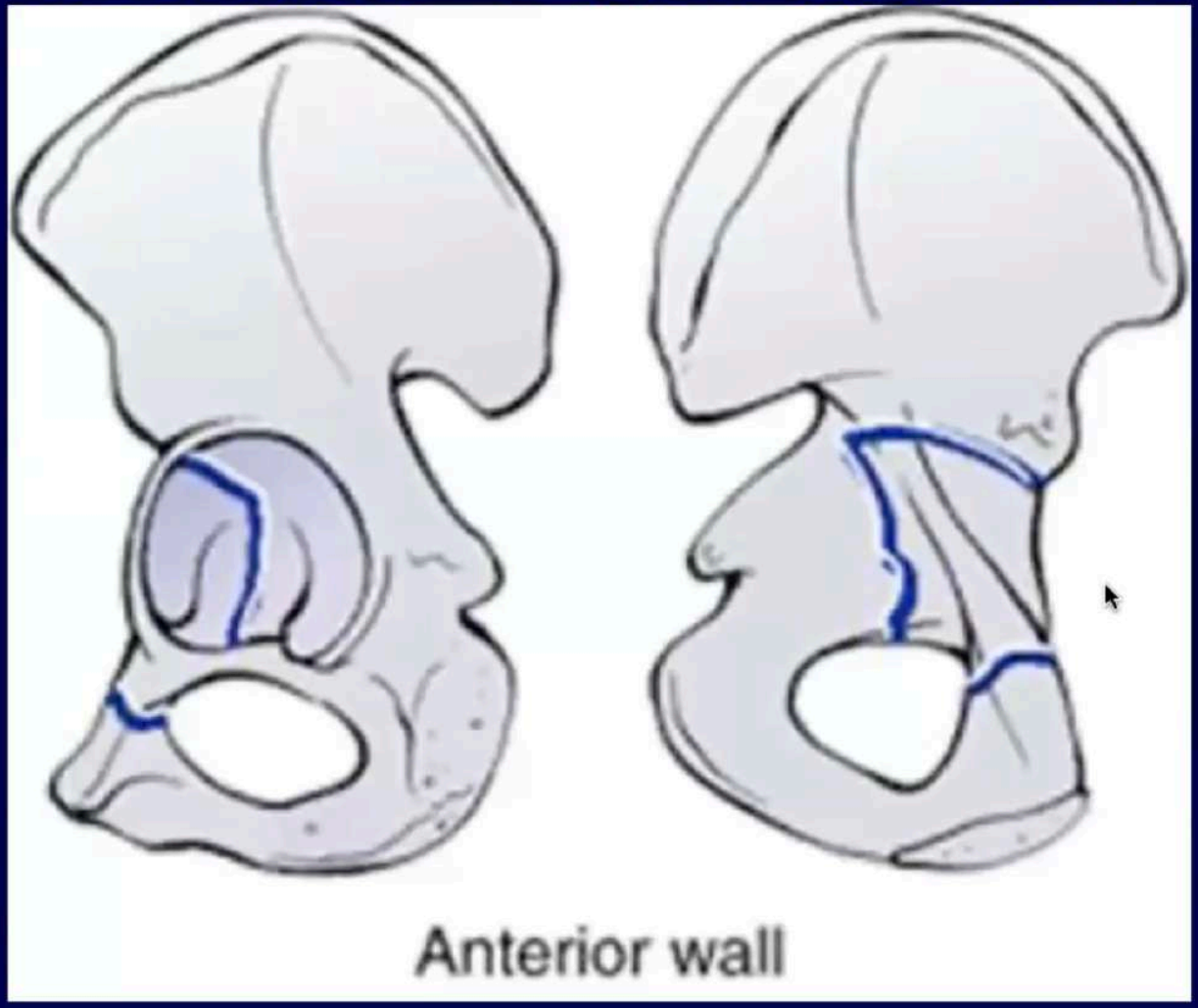
Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Posterior Column Fractures
Case #3 . . .



Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Anterior Wall Fractures

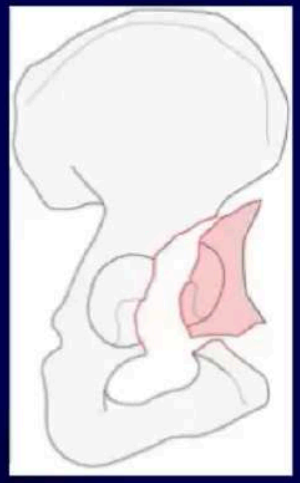


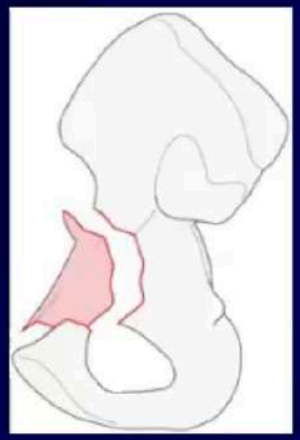
Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

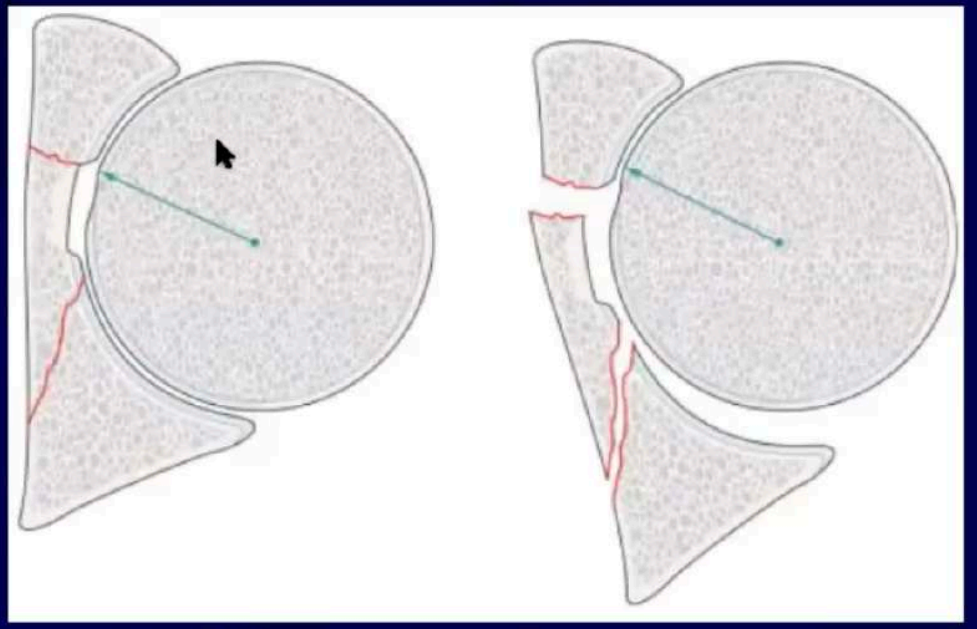
Anterior Wall Fractures

- 1-2% of acetabulum fractures
- Fracture begins below the AIIS, crosses the articular surface to the pelvic brim, and proceeds down the quadrilateral surface to the ischiopubic notch
- Secondary fracture line through superior ramus; ischiopubic ramus intact
- Most of anterior column intact

Anterior Wall Fractures







Anterior wall fracture associated with plate of bone from cotyloid fossa and quadrilateral surface and involving inner border or posterior wall

Anterior Wall Fractures
AP Radiograph

Disruption of iliopectineal line at 2 points
Anterior rim disrupted, upper 1/3rd
Femoral head may dislocate anteriorly and externally rotated
Ilioischial line intact

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Anterior Wall Fractures
Judet Radiographs

- Obturator oblique
  - Anterior wall/column fracture visualized
  - Confirms posterior border of acetabulum intact
  - Demonstrates obturator ring fracture to be at level of ischiopubic notch and roof of obturator canal
  - Displays trapezoidal shape of detached fragment driven medially by femoral head
- Iliac oblique
  - Posterior border of innominate bone intact
  - Establishes anterior wall point of rupture
  - Commonly demonstrates elevated quadrilateral bone plate on inner aspect of pelvis; appears as "thinning" or re-duplication of ilioischial line

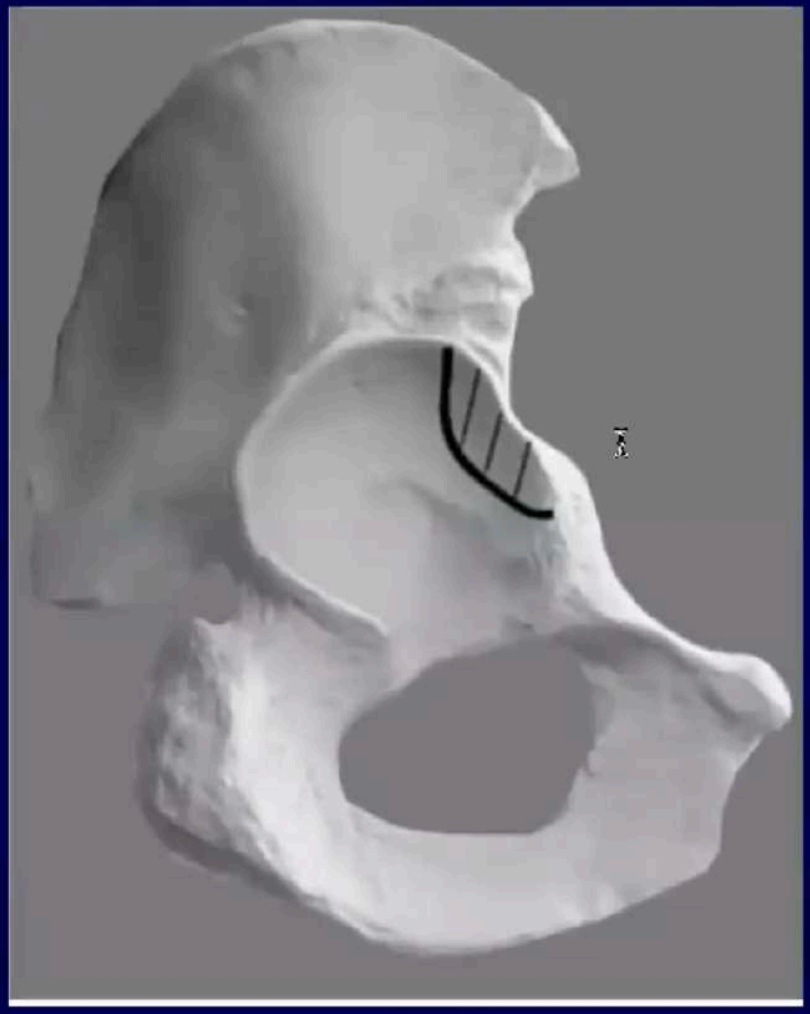
Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Anterior Wall Fracture Variant

- Very rare, 1.5% acetabular fractures
- Morphologic equivalent of posterior wall fracture
- Letournel and Judet did not have a morphologically similar fracture in their series

Anterior Wall Fracture Variant



No inner table (pelvic brim) involvement

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Anterior Wall Fractures
Case #2 . . .

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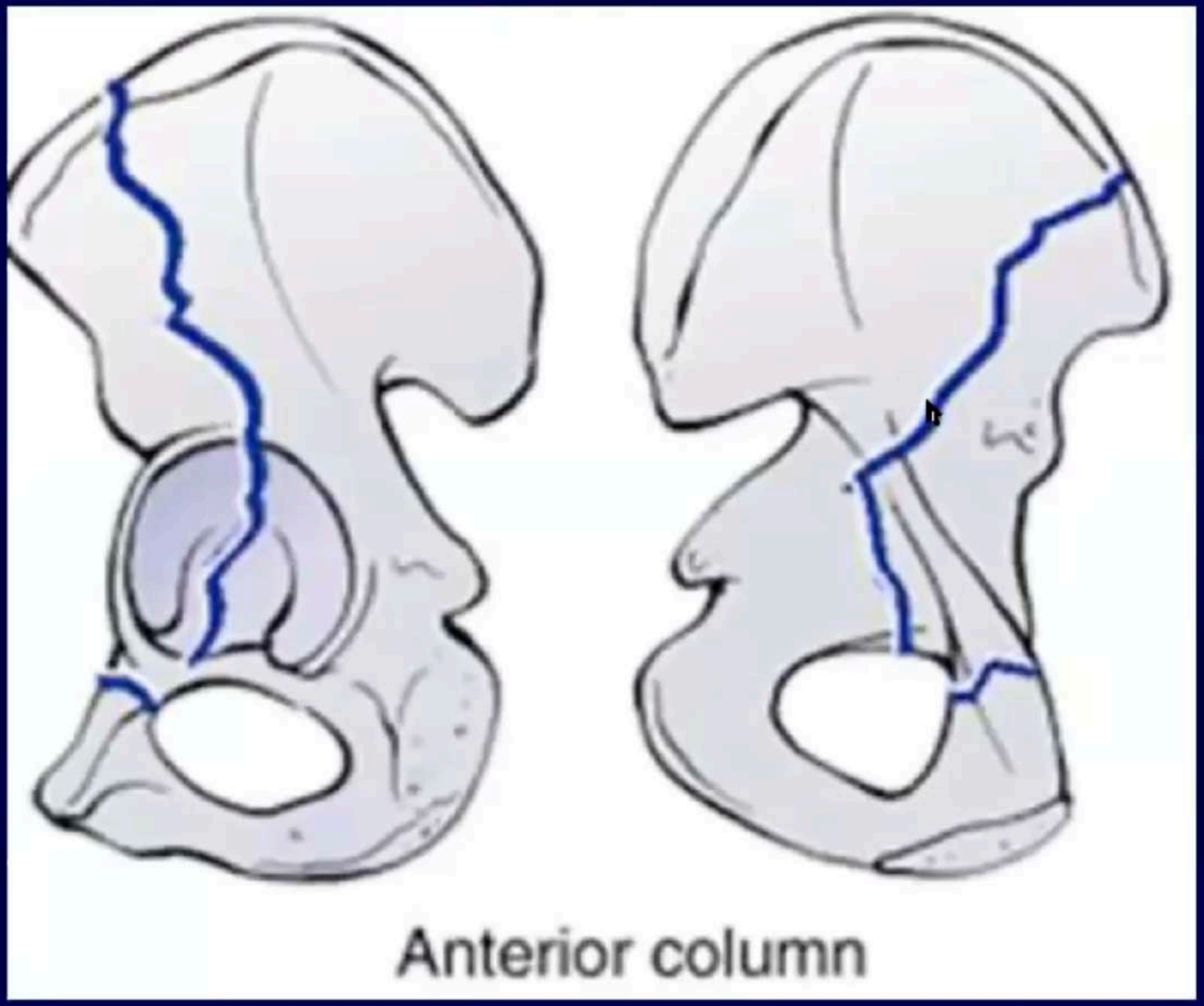
Anterior Column Fractures



Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

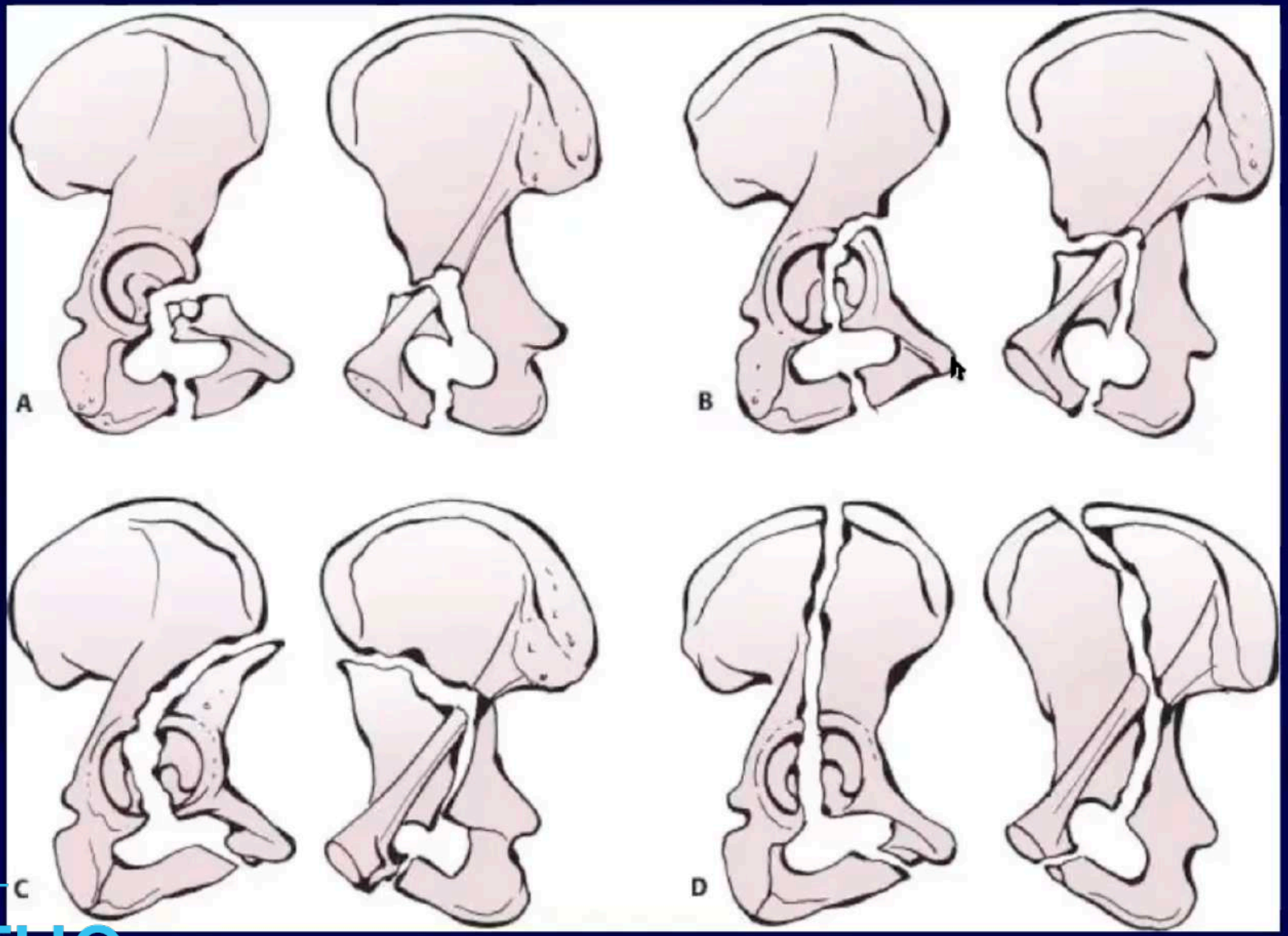
Anterior Column Fractures

- 3-5% of acetabulum fractures
- Separates anterior border of innominate bone from intact ilium
- Fractures cross the pelvic brim, propagate down quadrilateral surface, enter ischiopubic notch and end in an inferior ramus fracture
- Quadrilateral surface may be detached as separate fragment but posterior border of innominate bone remains intact

Anterior Column Fractures

- 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
AP Radiograph

High subtype

Disruption of iliopectineal line
Fracture of ischiopubic ramus
+/- fracture line in superior ilium
Ilioischial line intact

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Anterior Column Fractures
Judet Radiographs

- Obturator oblique
  - Anterior column disruption
  - Illustrates anterior column displacement by femoral head
  - Ischiopubic ramus fracture
- Iliac oblique
  - Iliac wing fx extension
  - Posterior border innominate bone intact
  - May demonstrate quadrilateral plate fracture

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Anterior Column Fractures
Case #2. . . Low subtype

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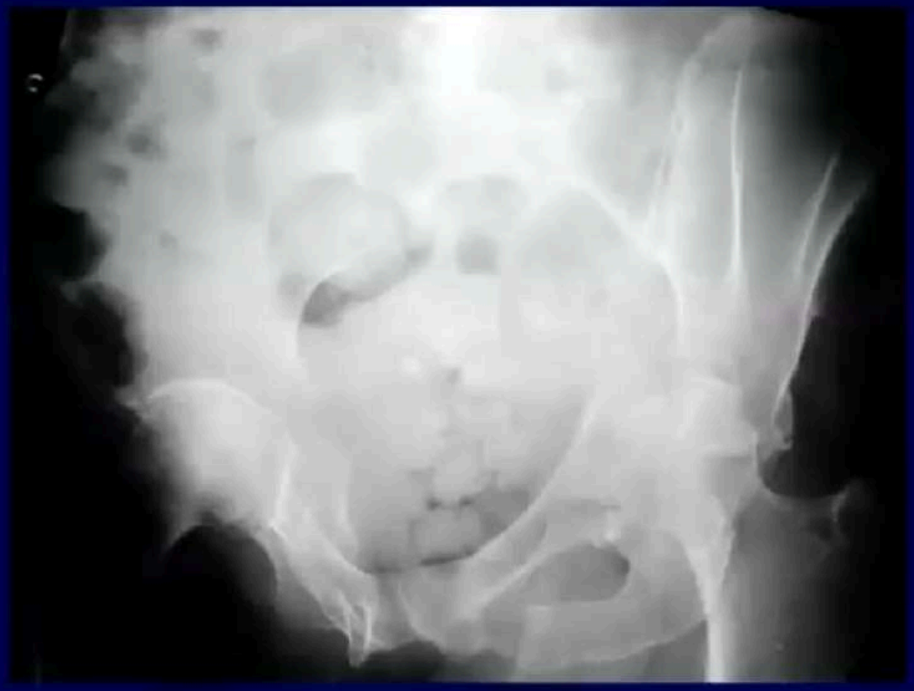
Anterior Column Fractures
Low Subtype



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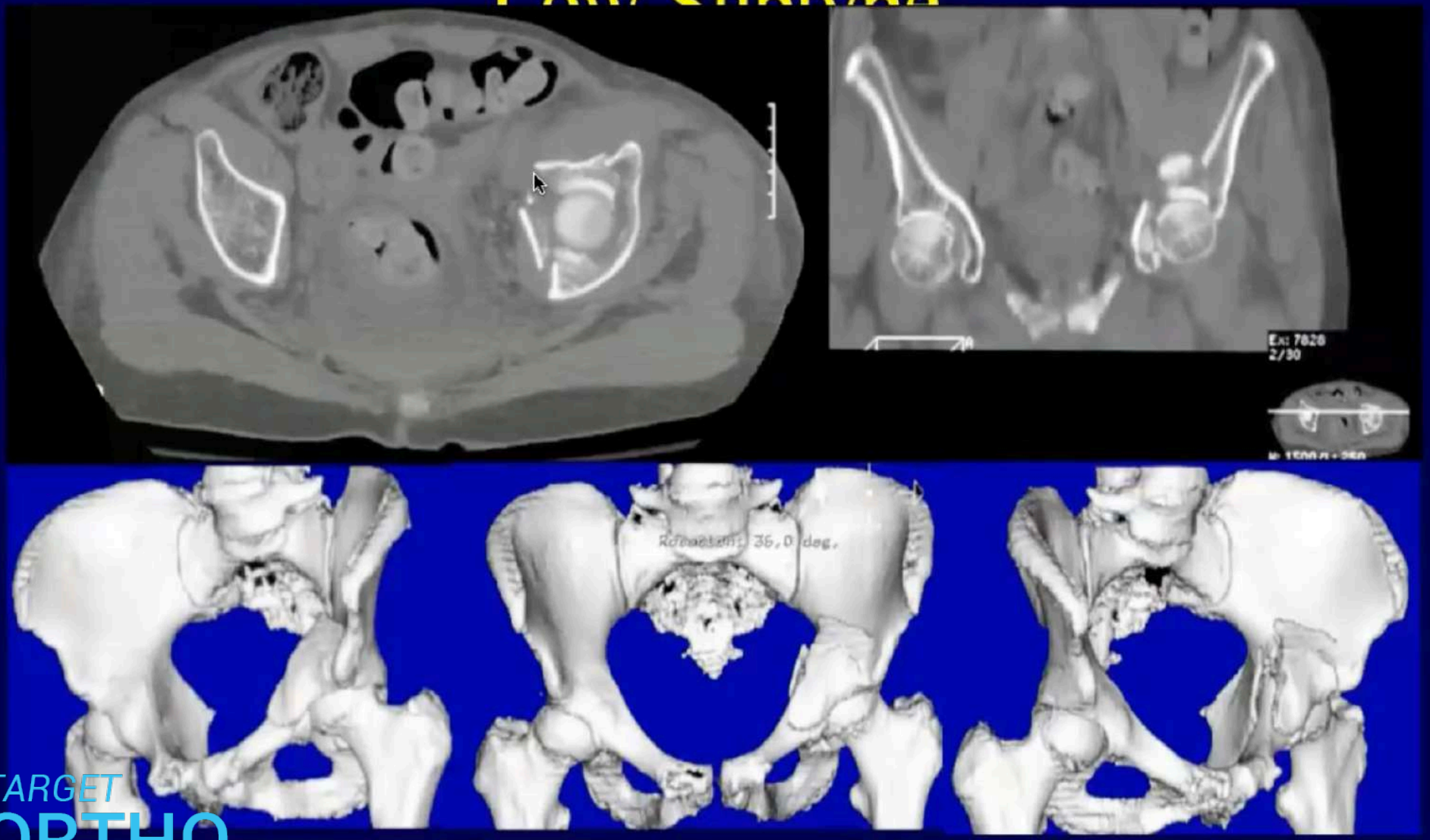
Anterior Column Fractures

Low Subtype



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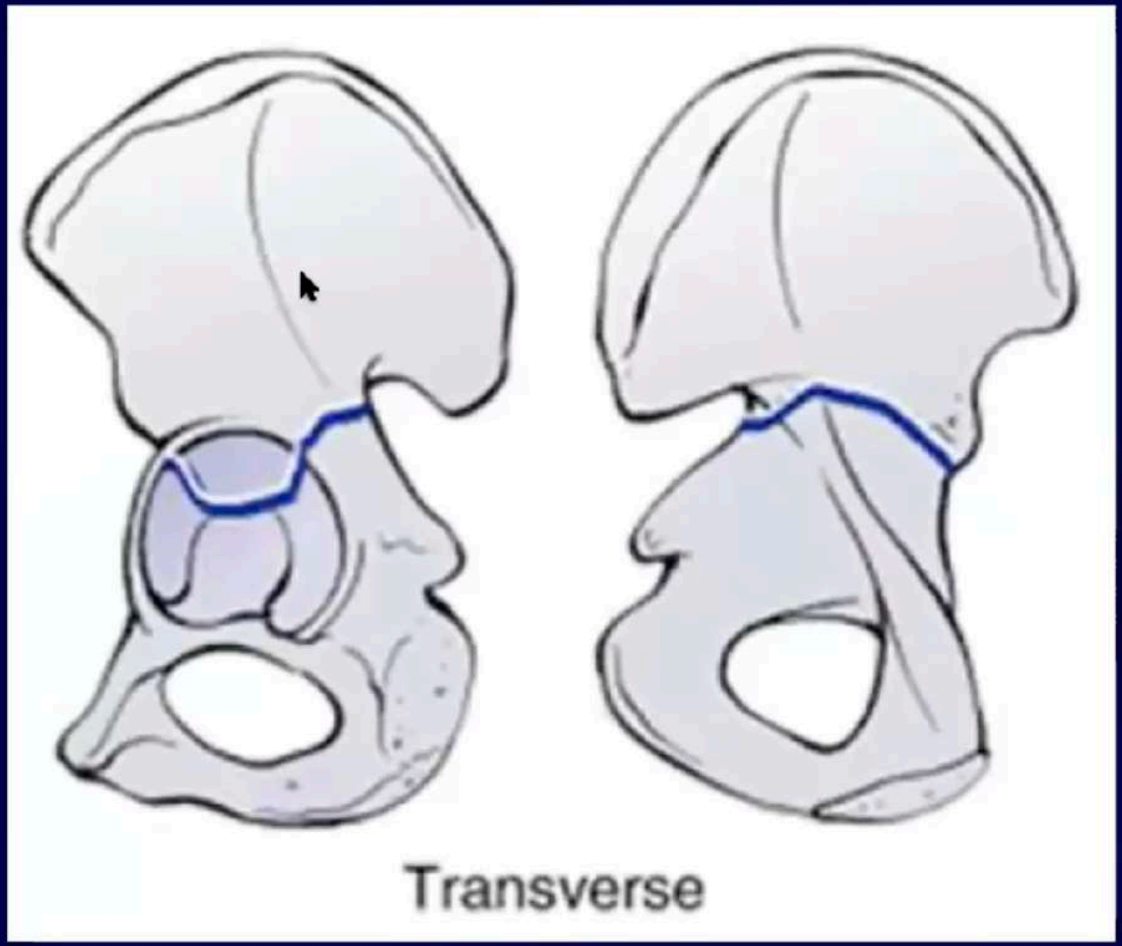
Transverse Fractures



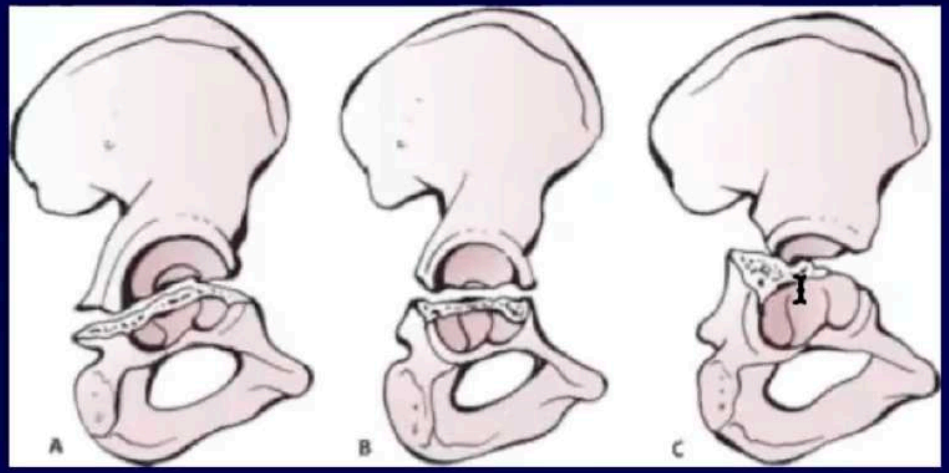
Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Transverse Fractures

- 5-19% acetabular fractures
- Fracture line traverses anterior and posterior border (columns) of innominate bone
  - Upper iliac segment→intact to ilium
  - Lower ischiopubic segment→rotates about pubic symphysis
    - Medial and superior displacement of femoral head as it follows ischiopubic segment
    - Femoral head may also remain under intact portion of remaining roof
- Rotation causes greater posterior translational displacement than anterior
- As location of fracture moves superior on articular surface
  - Orientation of fracture becomes more vertical
  - Size of intact remaining articular surface decreases

Transverse Fractures

- Subtypes based on where fracture crosses articular surface
  - Transtectal➔crosses weight bearing dome
  - Juxtatectal➔crosses articular surface at level of the top of cotyloid fossa
  - Infratectal➔crosses at level of cotyloid fossa



Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Transverse Fractures
AP Radiograph

Iliopectineal and ilioischial lines disrupted
Anterior and posterior rims disrupted
+/- disruption of sourcil/roof depending on level of fracture

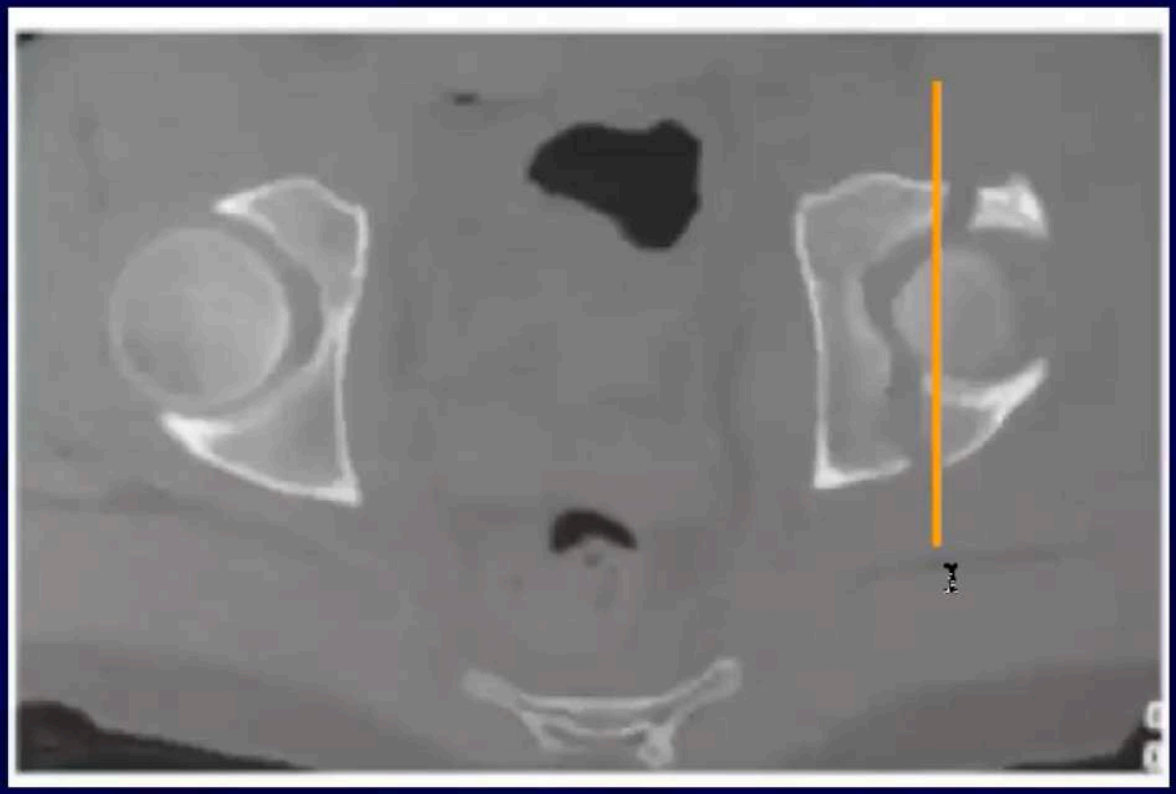
Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Transverse Fractures
Judet Radiographs

- Obturator oblique
  - Disruption of anterior column/pelvic brim
  - Demonstrates displacement of ischiopubic segment
  - Confirms uninjured obturator ring
- Iliac oblique
  - Demonstrates where the fracture exits greater sciatic notch and fracture of quadrilateral surface
  - Demonstrates posterior displacement

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

CT Scan



Antero-posterior fracture orientation

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Transverse Fractures
Case #2 . . .

Roof involvement; displacement of femoral head with ischiopubic segment

Iliopectineal and ilioischial lines disrupted
Anterior and posterior rims disrupted
Sourcil/roof disrupted

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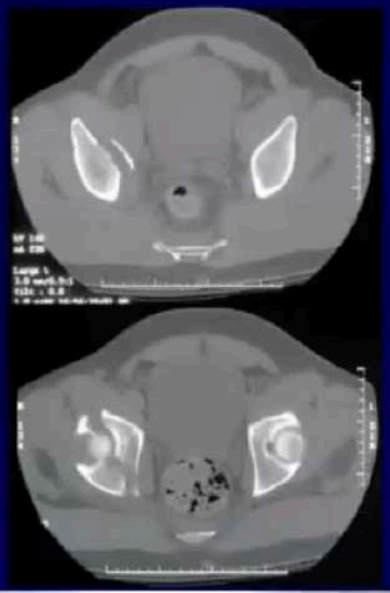
Transverse Fractures
Judet Radiographs

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Transverse Fractures
Case #3 . . .



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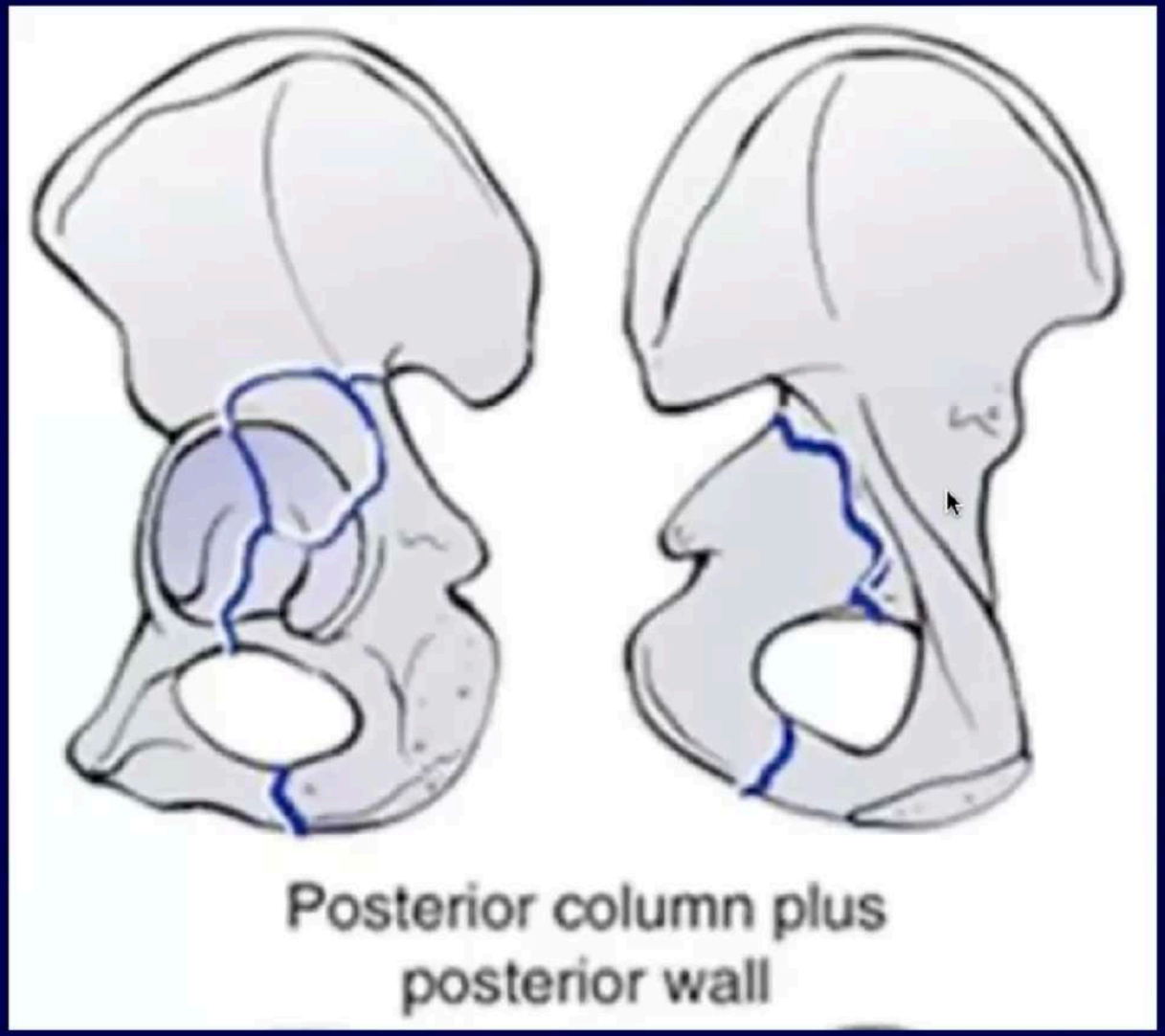
Associated Fracture Pattern Examples

Posterior Column plus Posterior Wall Fractures



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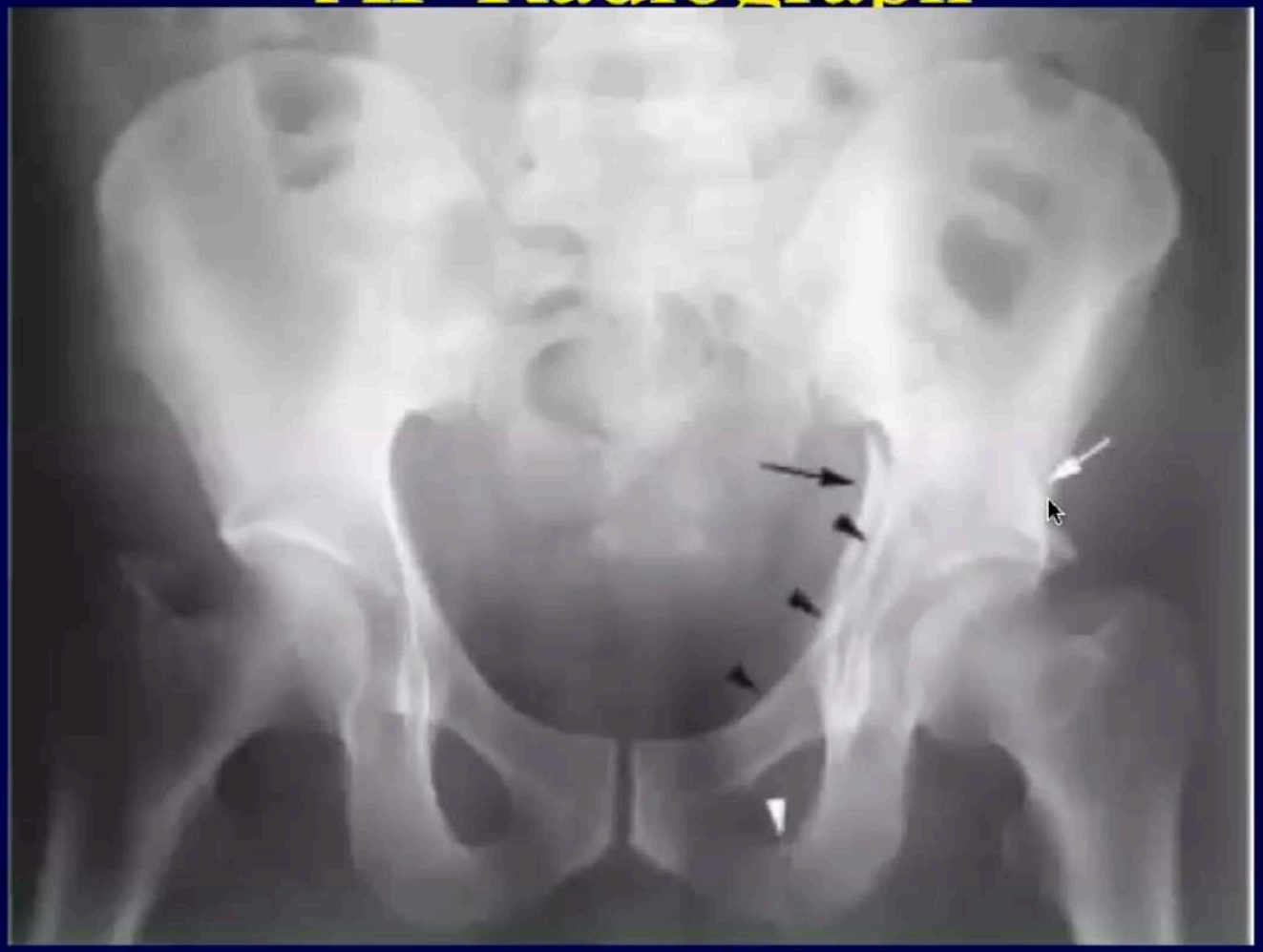
Posterior Column + Posterior Wall Fractures

- 3-4% of fractures; combination PC + PW
- Posterior wall fragment
  - articular comminution of acetabular rim with traversing posterior column fracture line
  - Travels with femoral head during dislocation and remains displaced after femoral head reduction
  - May block reduction of femoral head
- Posterior column fragment
  - Divides posterior border of innominate bone and ischium → free ischioacetabular fragment
  - Femoral head component follows ischioacetabular fragment and dislocates cranially/posteriorly

Posterior Column + Posterior Wall
AP Radiograph



Disrupted Ilioischial line
Disrupted posterior rim
Ischiopubuc ramus disruption (variable)
Intact Iliopectineal line
Femoral head dislocation/subluxation

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Posterior Column + Posterior Wall
Judet Radiographs

- Obturator oblique
  - Anterior column intact
  - Demonstrates posterior wall fragment
  - Inferior fracture line delineated as either splitting ischiopubic ramus or splitting ischium and leaving obturator foramen intact
- Iliac oblique
  - Anterior wall intact
  - Demonstrates displacement of posterior column and level of rupture of greater sciatic notch

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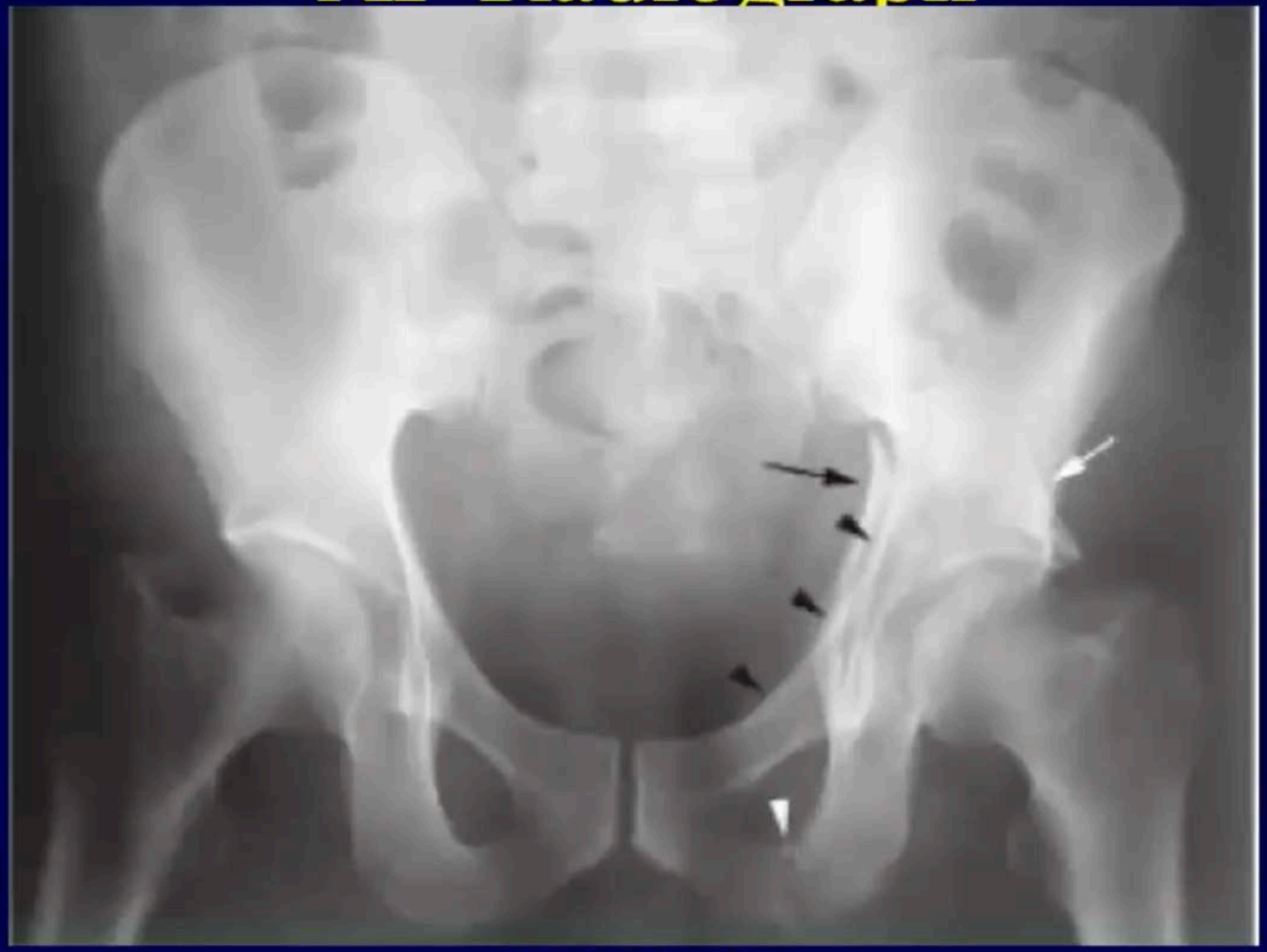
Posterior Column + Posterior Wall
AP Radiograph



Disrupted Ilioischial line

Disrupted posterior rim

Ischiopubuc ramus disruption (variable)

Intact Iliopectineal line

Femoral head dislocation/subluxation

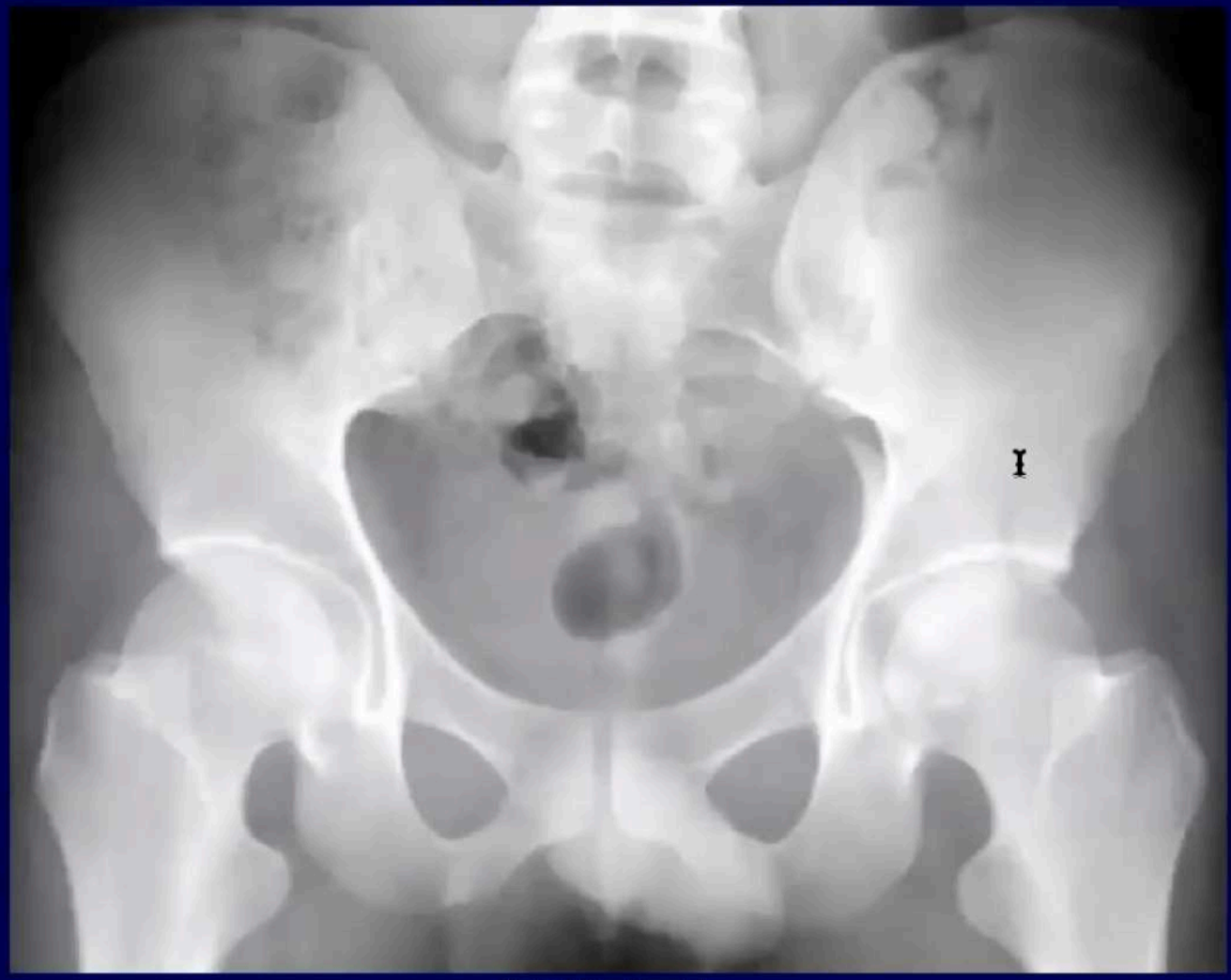
Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

CT scan

Black arrow: posterior column fx line
White arrow: posterior wall fragment

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Posterior Column + Posterior Wall
Case #2 . . .



Ilioischial line disrupted
Posterior rim disruption
No obvious ischiopubic ramus/obturator foramen disruption
Iliopectineal line intact

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Posterior Column + Posterior

Posterior Wall fragment

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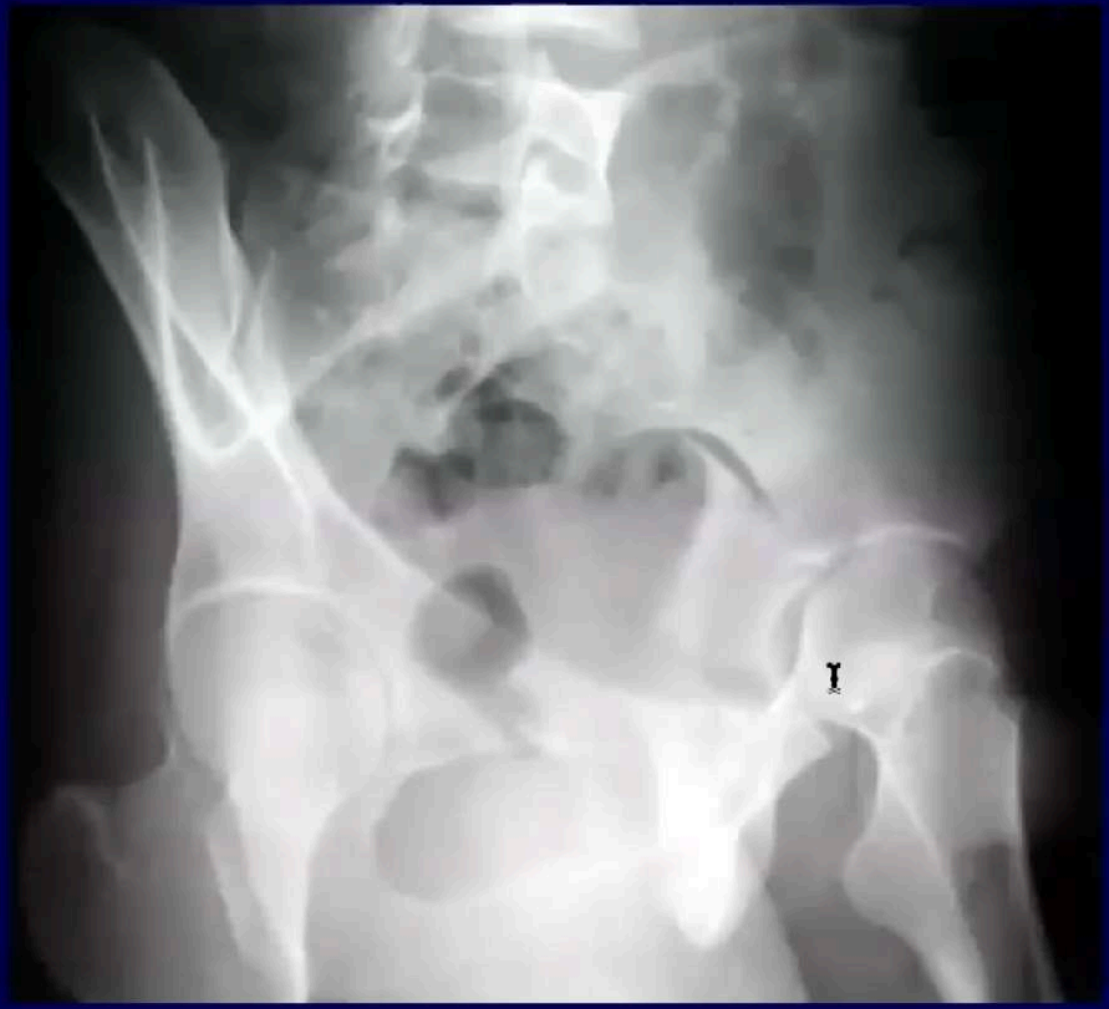
Posterior Column + Posterior



Posterior column exit and greater sciatic notch

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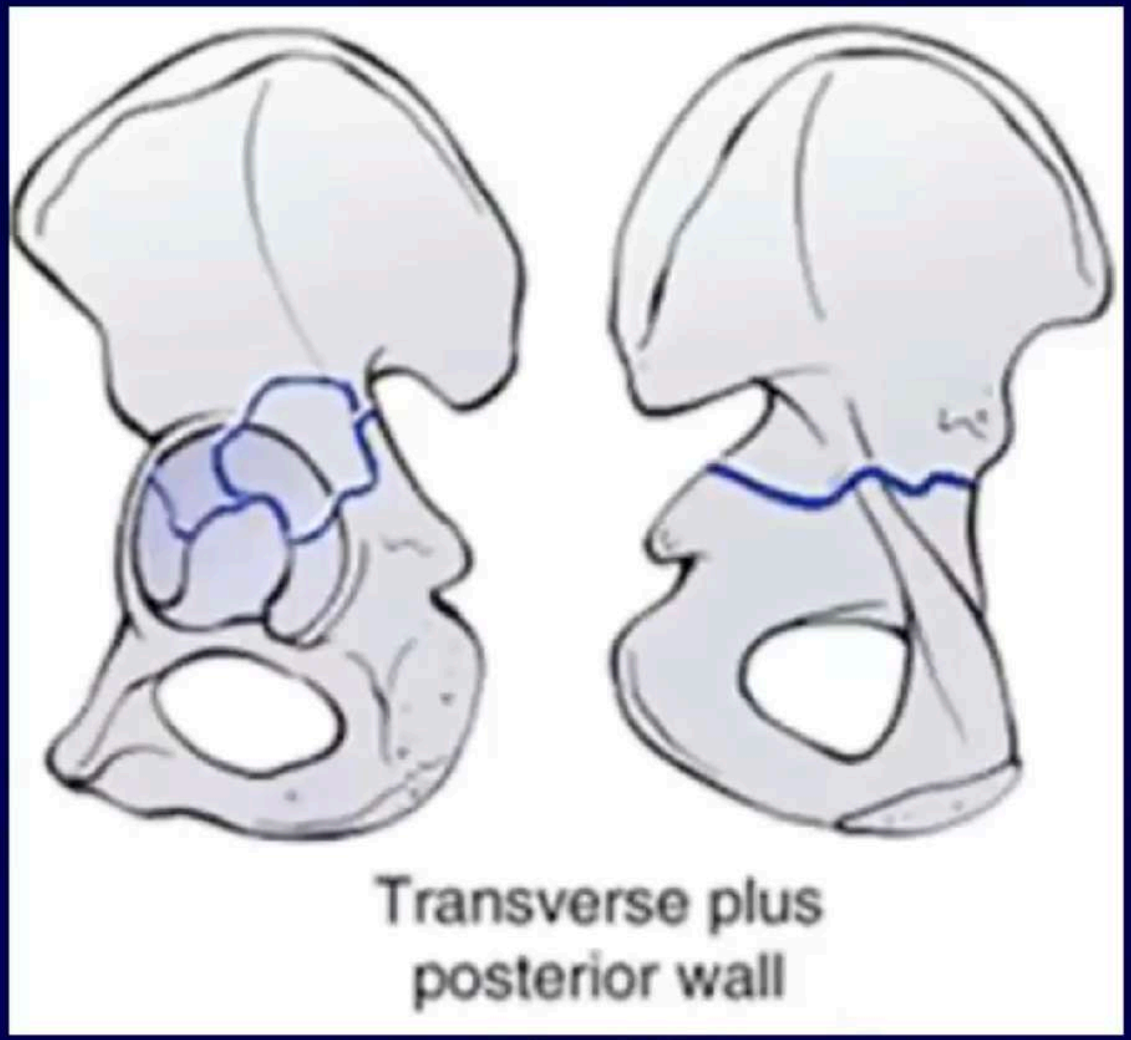
Transverse + Posterior Wall Fractures



Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Transverse + Posterior Wall Fractures

- 20% of acetabulum fractures
- Combines elementary transverse and posterior wall patterns
- Posterior wall component:
  - Single or multi-fragmentary
  - +/- marginal impaction
- Transverse component
  - Infra-, juxta-, or trans-tectal
  - Fracture line travels from posterior wall segment towards posterior border of innominate bone and greater sciatic notch

Transverse + Posterior Wall Fractures

- Rotation similar to pure transverse fractures
  - Rotation around vertical axis passing through pubic symphysis
  - Rotation around horizontal axis passing from pubic symphysis to point of disruption on posterior border of innominate bone
  - Posterior displacement/translation more common
- Obturator foramen intact
- Dislocation common
  - Central
    - Commonly obvious and severe
    - Few cases femoral head spontaneously reduced for first XR
  - Posterior
    - Large posterior capsular ruptures common
    - Rarely, with cases of marginal impaction, separated fragment remains attached to capsular remnant

Transverse + Posterior Wall
AP Radiograph

All vertical and oblique landmarks disrupted

Anterior/Posterior rim disruption

Obturator ring intact

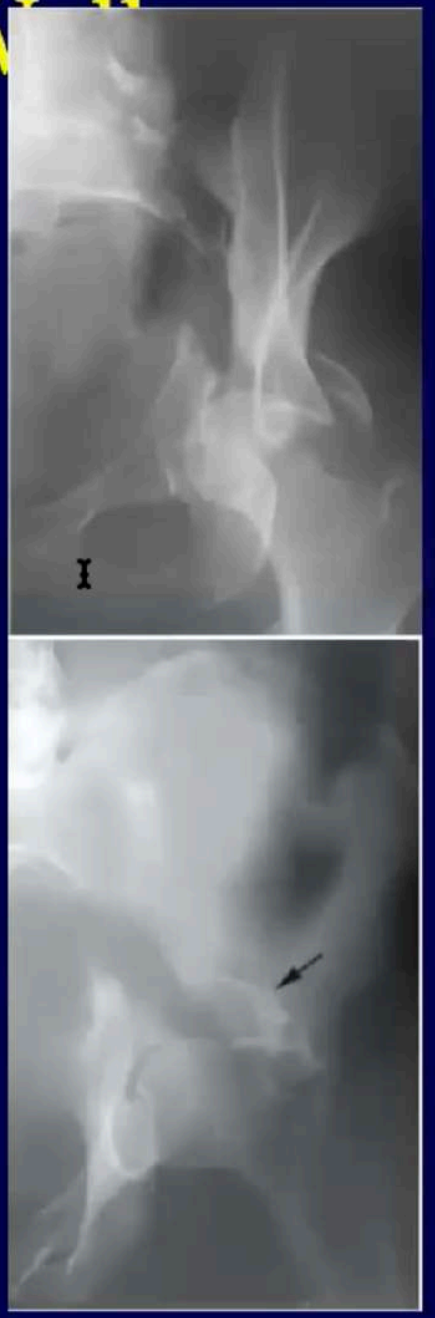
Central vs. posterior dislocation

Wide displacement of inferior ischiopubic segment

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

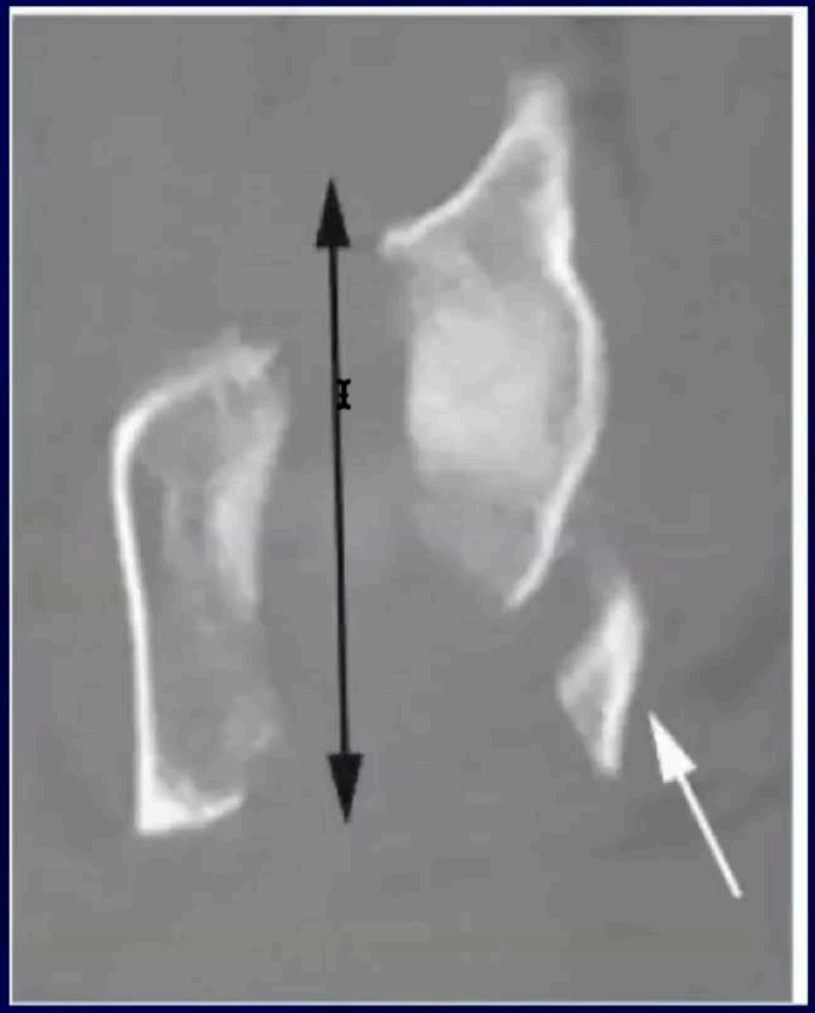
Transverse + Posterior W
Judet Radiographs

- Obturator oblique
  - Posterior wall size visualized
  - Posterior vs. central dislocation
  - Obturator ring intact
  - Degree of obliquity of transverse fracture line
- Iliac oblique
  - Iliac wing intact
  - Confirms posterior column disruption
  - May demonstrate superimposed posterior wall fragment with roof



Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

CT scan



Typical anterior to posterior transverse fracture line (black arrow)
Posterior wall fragment (white arrow)

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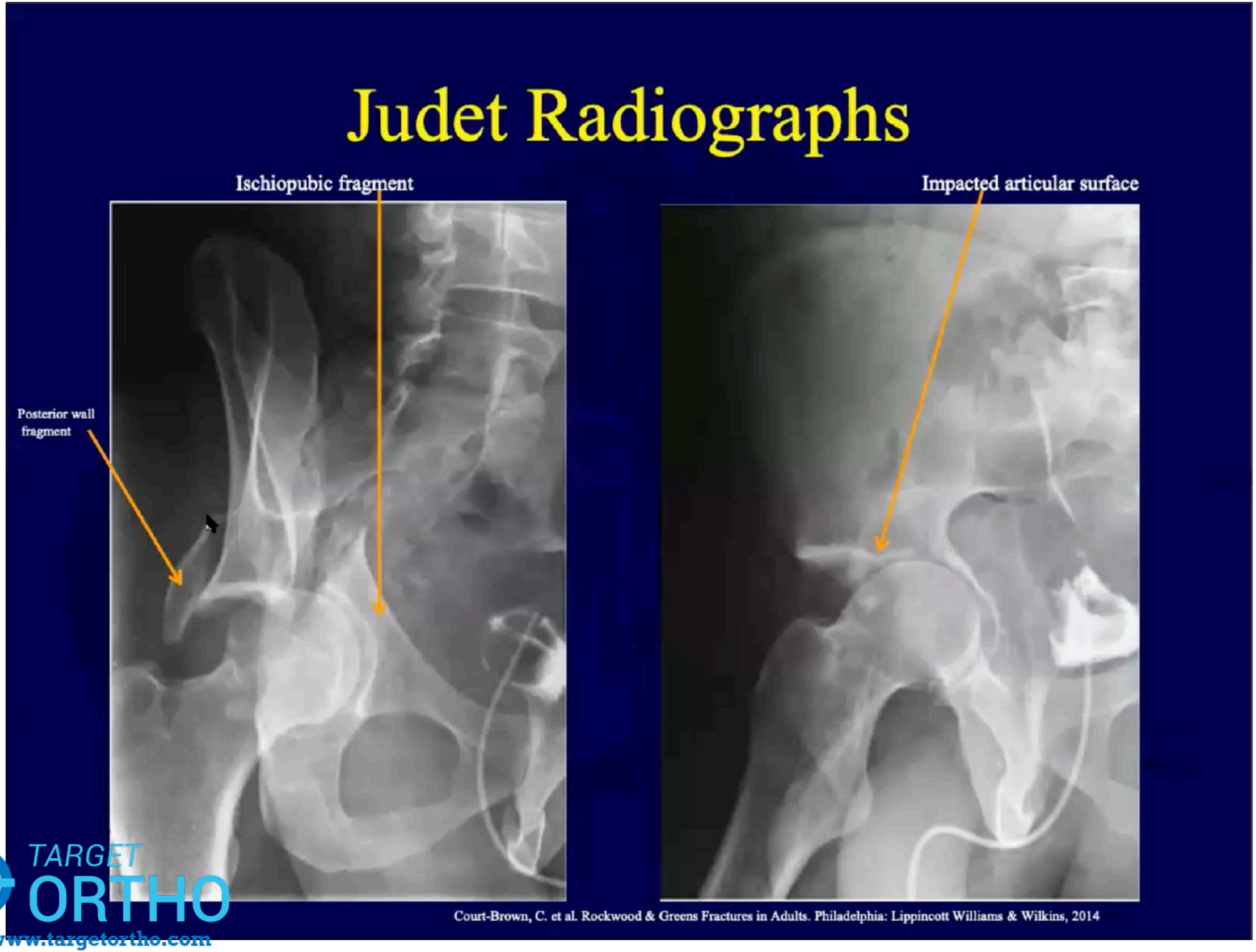
Transverse + Posterior Wall Fracture
Case #2 . . .

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Judet Radiographs



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Transverse + Posterior Wall Fractures - Case #3 . . .

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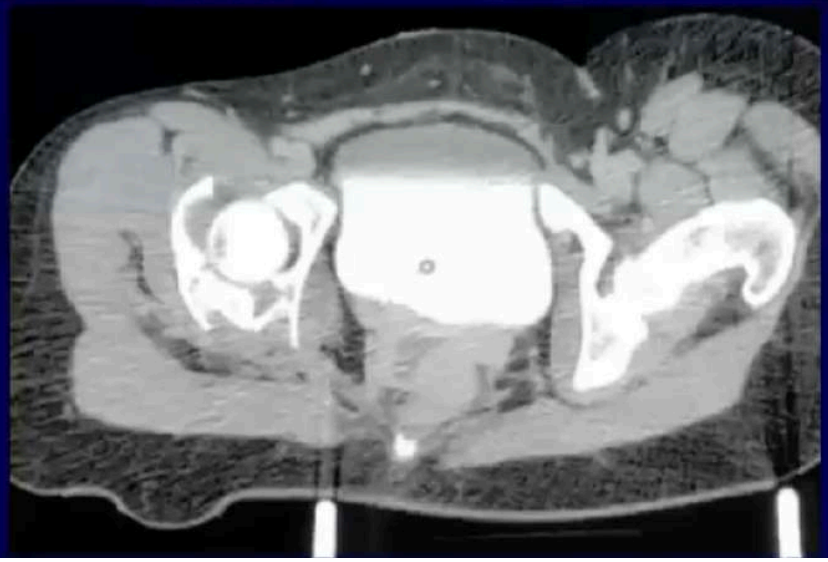
Judet Radiographs/CT



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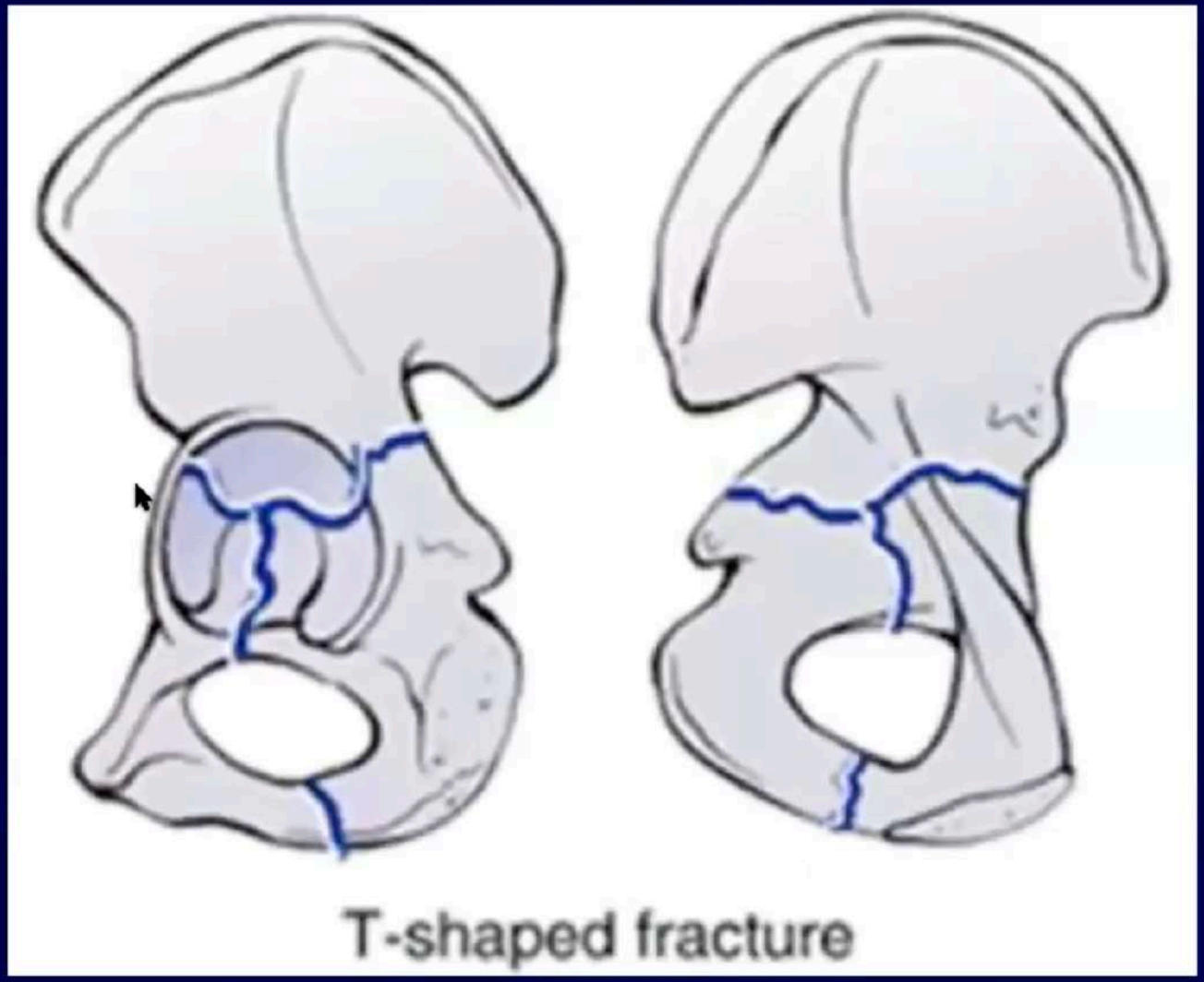
T-Type Fractures

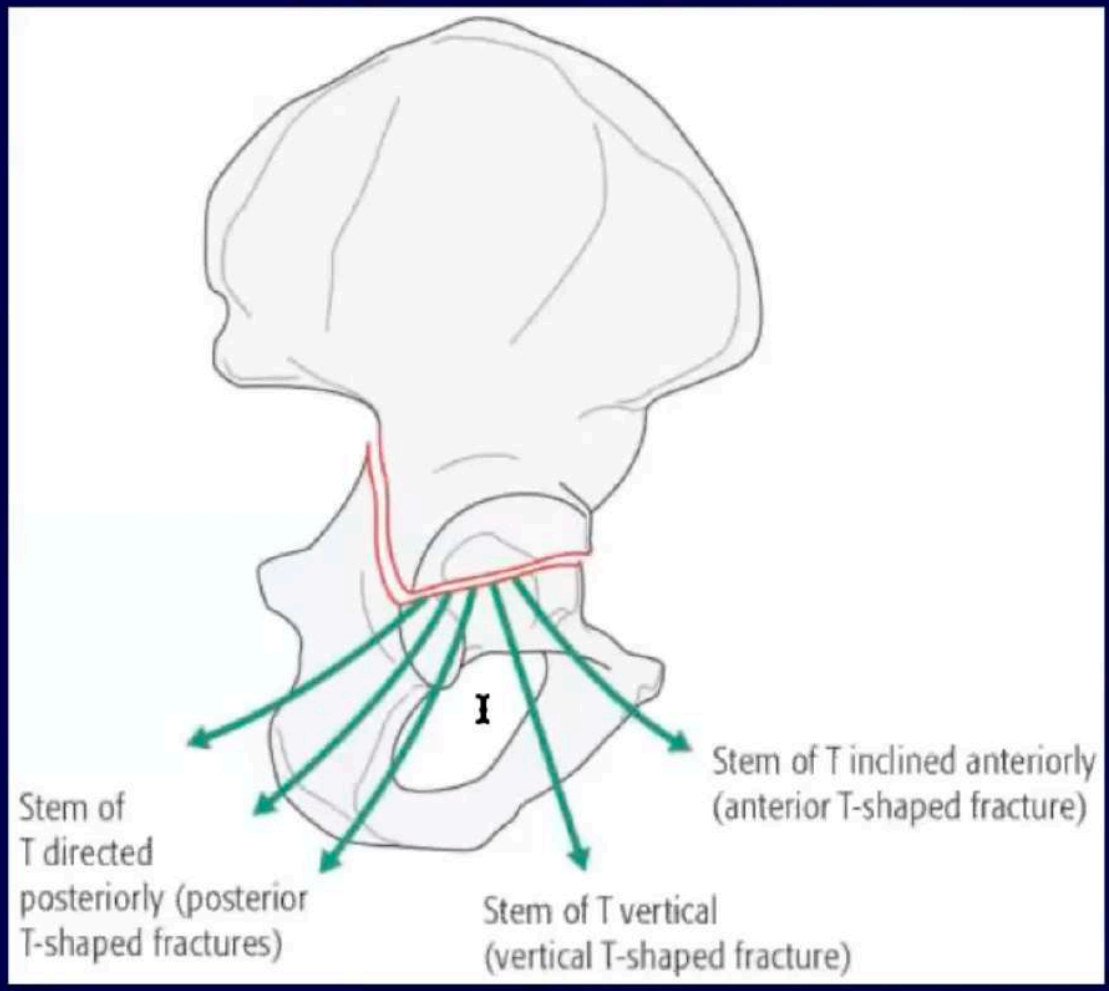


Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

T-Type Fractures

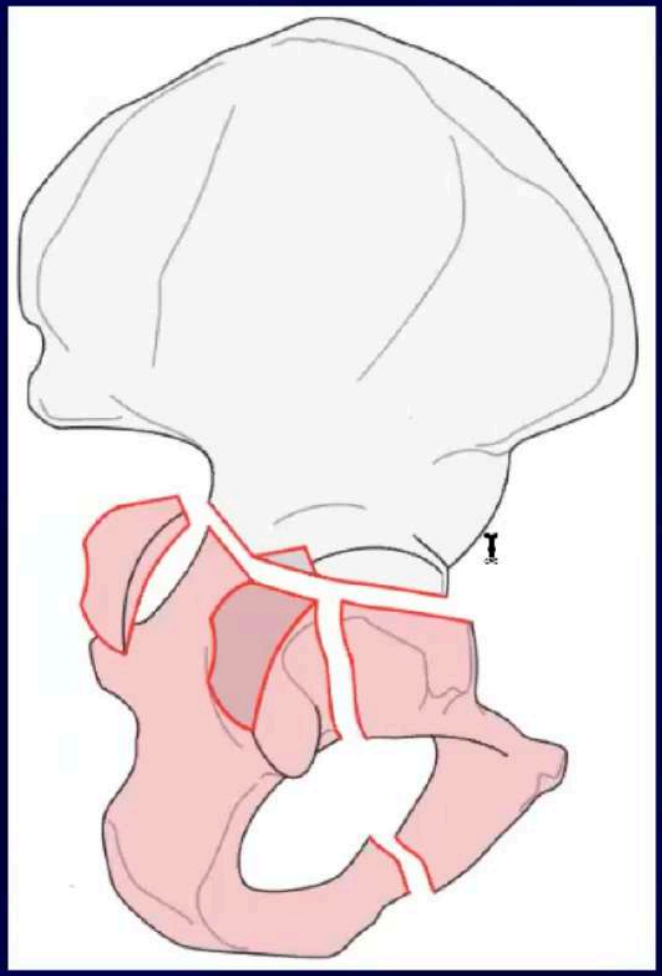
- Cranial iliac segment
  - Superior to transverse fracture
- Caudal ischiopubic segment
  - Anterior articular segment (pubic)
  - Posterior articular segment (ischial)
- Femoral head displaces medially with caudal anterior and posterior column segments rotating around head
- PORTION OF ARTICULAR SURFACE MAINTAINS ATTACHMENT TO ILIAC WING; DIFFERENTIATING FROM ASSOCIATED BOTH COLUMN FRACTURE
- RADIOGRAPHICALLY → TRANSVERSE FRACTURE LINE IN PRESENCE OF ISCHIAL RAMUS FRACTURE → T-TYPE

T-Type Fractures



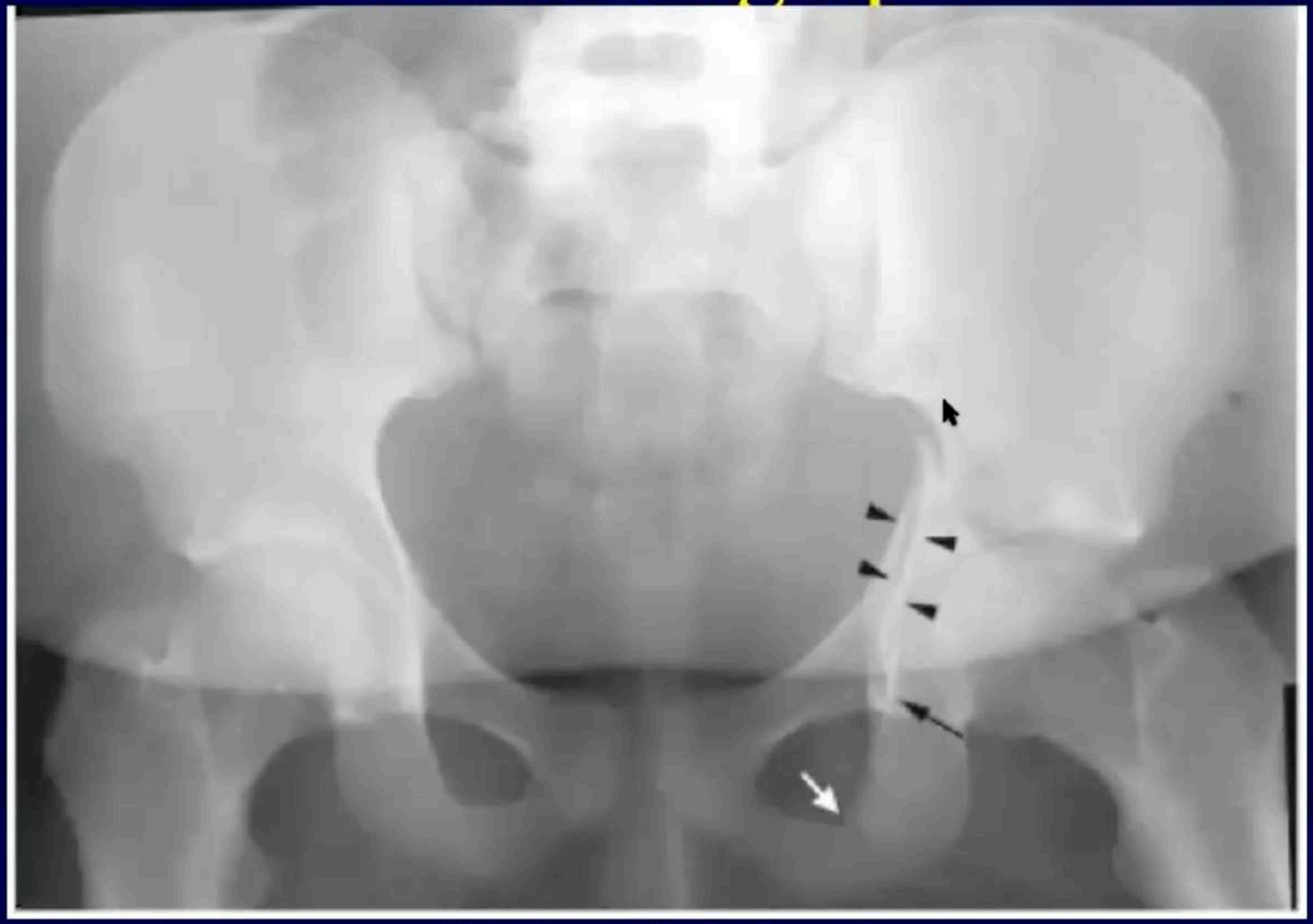
Possible directions of "stem" in T-type fractures

T-Type Fractures



"T-shaped" may also be associated with posterior wall fragment; these types often placed into transverse plus posterior wall category

T-Type Fractures
AP Radiograph



All vertical landmarks disrupted

+/- roof involvement based on level of transverse fracture

Ischiopubic ramus fracture

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

T-Type Fractures
Judet Radiographs

- Obturator oblique
  - Anterior column disruption
  - Ischiopubic notch disruption
  - Ischiopubic/obturator ring disruption
  - Visualization of vertical stem of fracture as it enters obturator foramen
- Iliac oblique
  - Fracture through posterior column/greater sciatic notch
  - Quadrilateral plate disruption
  - Femoral head dislocation/subluxation

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

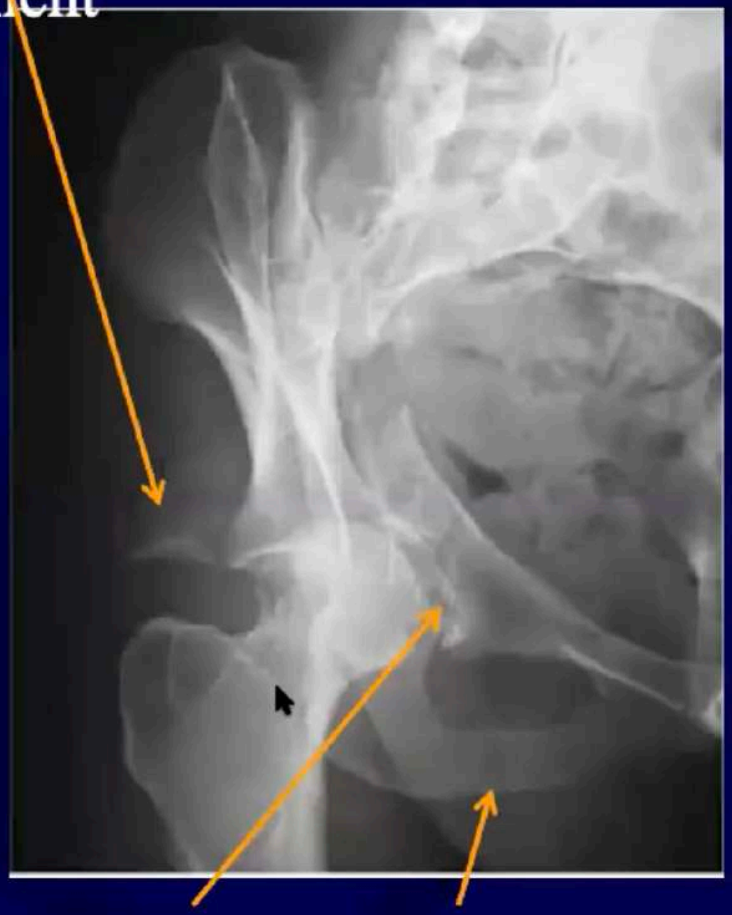
T-Type Fractures
Case #2 . . .

Vertical landmarks disrupted
Posterior wall fracture
Ischiopubic ramus fracture
Transtectal roof involvement
Dislocation of femoral head and SI joint

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Judet Radiographs

Posterior wall fragment



Stem of "T" entering obturator foramen and ischiopubic ramus disruption

Disruption of greater sciatic notch and femoral head dislocation

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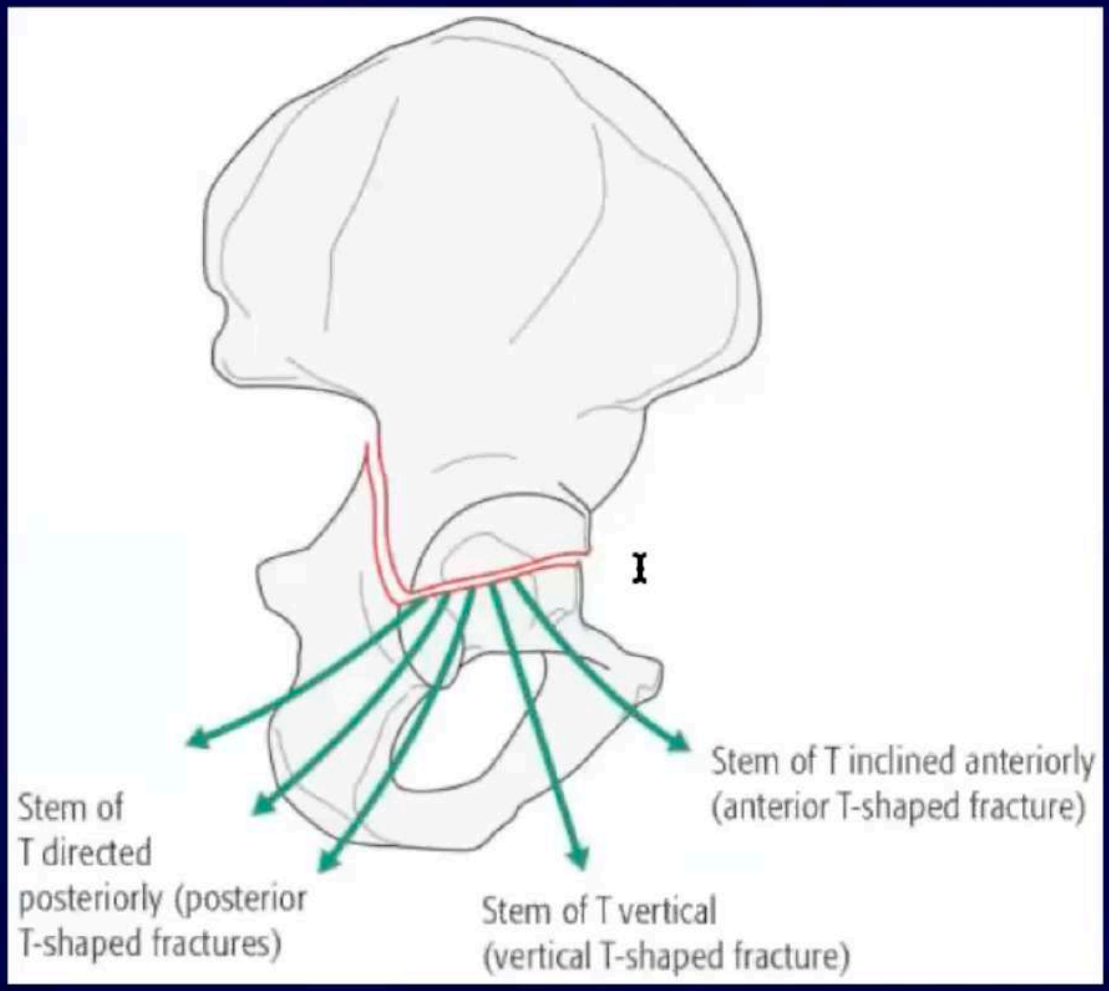
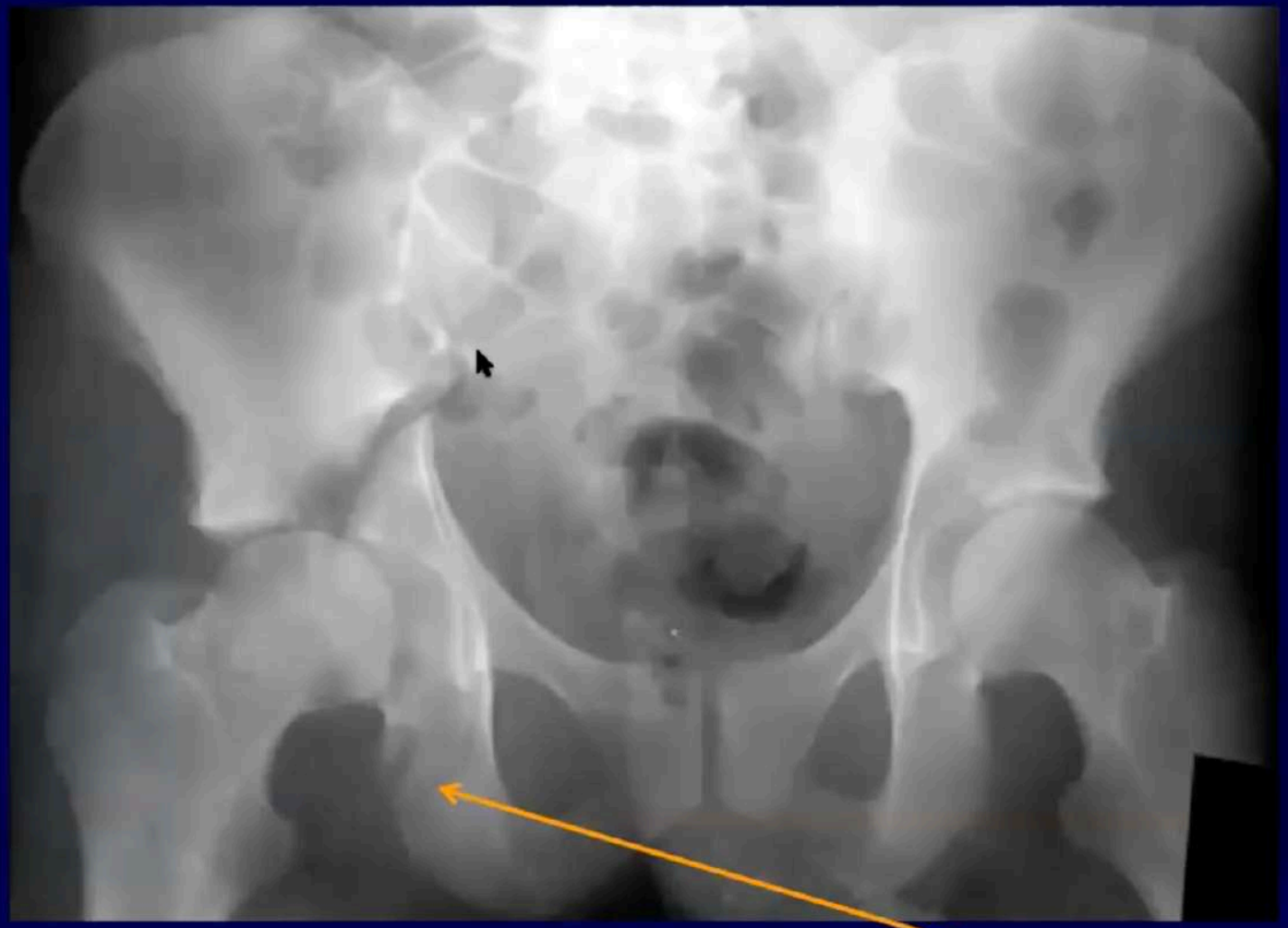
T-Type Fractures



Possible directions of "stem" in T-type fractures

T-Type Fractures
Case #3. . .



T-Type with intact obturator ring and ischial posterior exit

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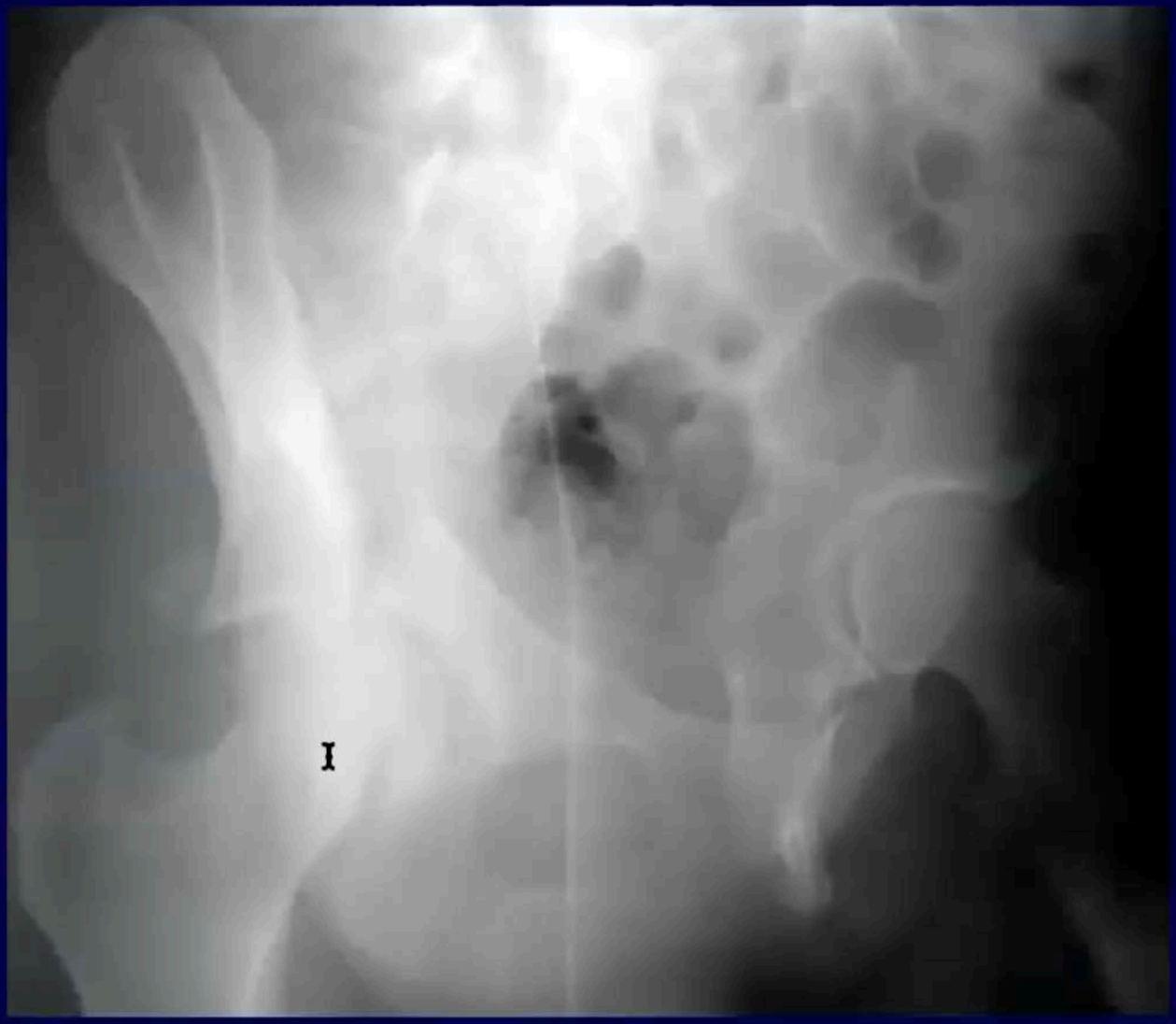
Obturator Oblique



Note intact obturator ring

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Iliac Oblique

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T-Type
Case #4 . . .

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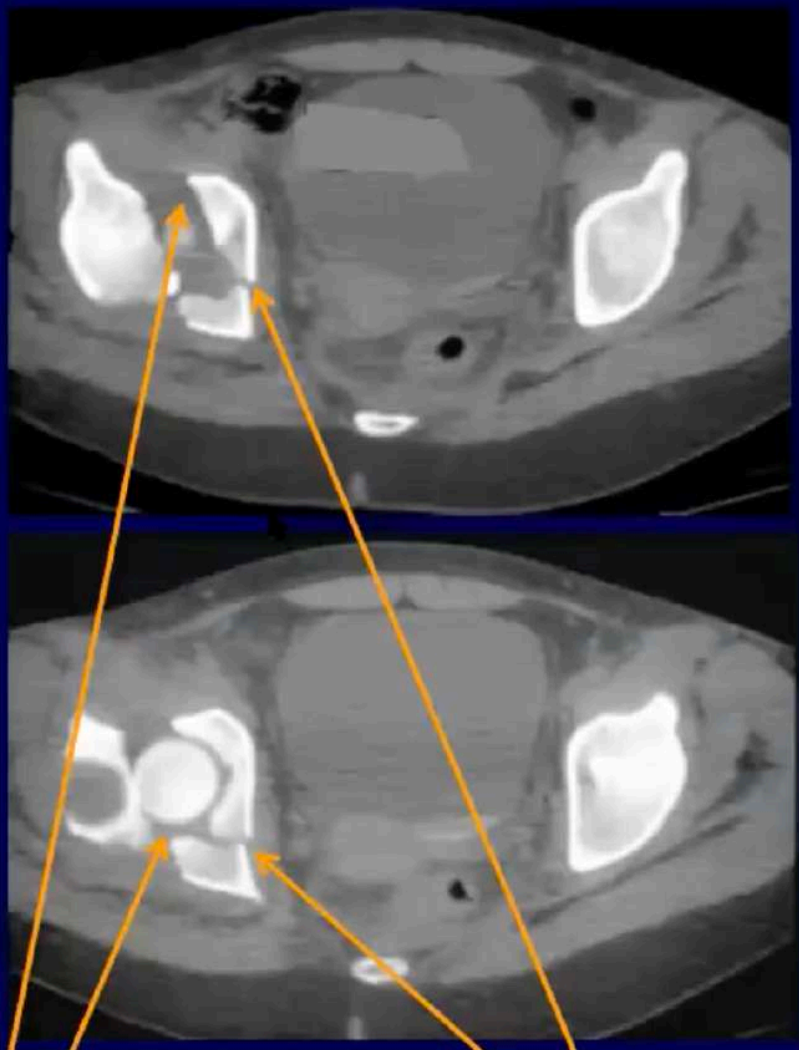
Obturator Oblique

David Helfet, MD

Iliac Oblique

David Helfet, MD

CT scan



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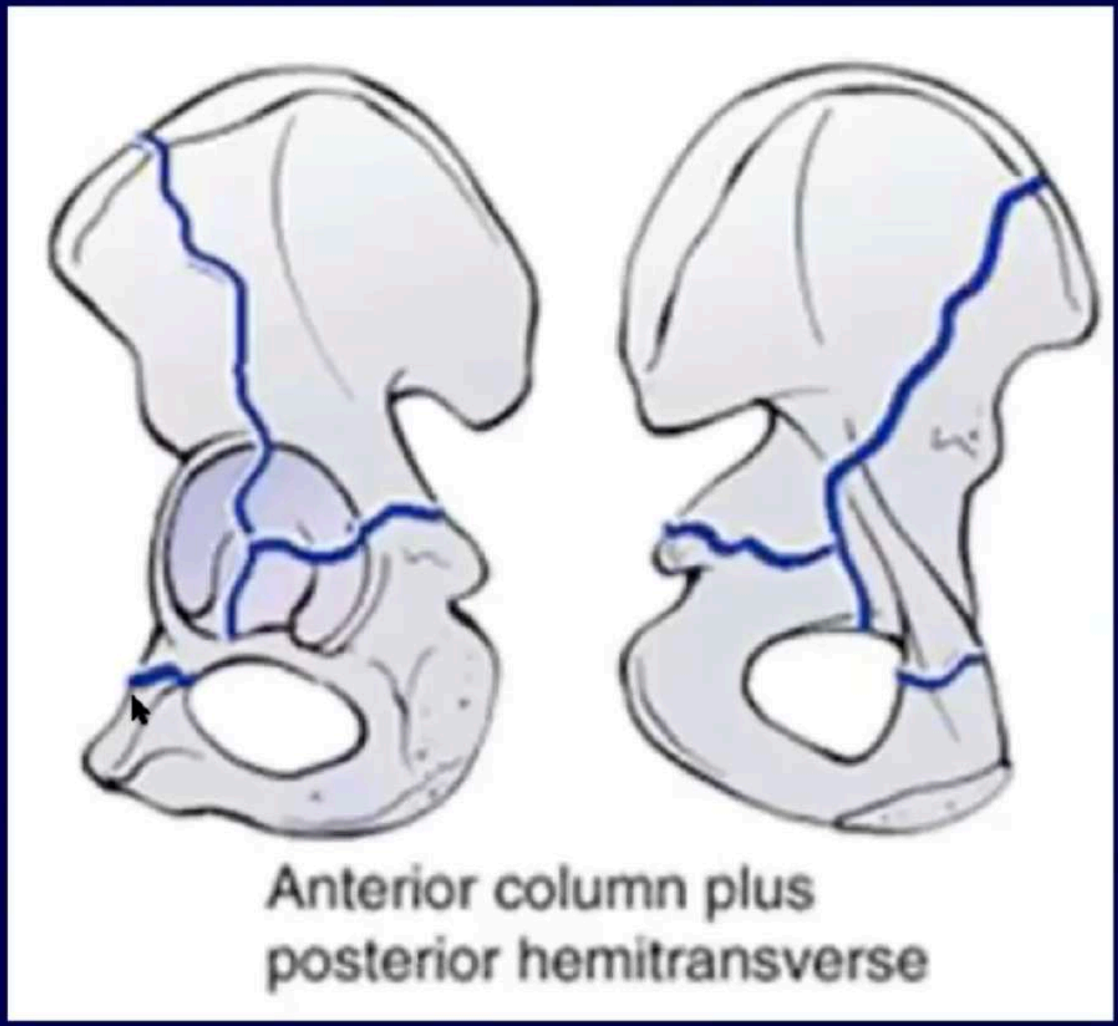
Transverse fracture line

Vertical stem of "T" separating anterior pubic segment and posterior ischial segment

Anterior Column or Wall Fracture + Posterior Hemitransverse Fracture



Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Anterior Column or Wall Fracture + Posterior Hemitransverse Fracture

- 7% of acetabulum fractures
- Primary fracture line: anterior wall or column
  - ¾ involve anterior column
- Associated transverse fracture propagates from anterior fracture→articular surface to posterior innominate bone
- Posterior hemitransverse fracture is identical to posterior half of transverse fracture and may be infra-, juxta, or trans-tectal

"Gull" Sign

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

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

* **original "gull" sign described by Letournel and Judet in Posterior Column fractures; represented posterior and superior fragment displacement ***

Anterior Column or Wall Fracture + Posterior Hemitransverse Fracture

- Anterior displacement>posterior displacement
- Femoral head dislocated anteriorly
- Ischiopubic ramus fracture variable
- A PORTION OF ARTICULAR SURFACE OF THE ROOF AND POSTERIOR WALL ALWAYS MAINTAIN ATTACHMENT TO ILIAC WING; DIFFERENTIATES FROM ASSOCIATED BOTH COLUMN FRACTURE

Anterior Column or Wall Fracture + Posterior Hemitransverse Fracture AP Radiograph

Iliopectineal (segmental) and ilioischial disruption
Anterior and posterior rim disruption
Anterior lesion is same as its elementary component
Femoral head follows anterior lesion

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Anterior Column or Wall Fracture + Posterior Hemitransverse Fracture Judet Radiographs

- Obturator oblique
  - Anterior column/wall lesion illustrated
  - Posterior rim disruption
  - Femoral head dislocation/subluxation follows anterior fragment
- Iliac oblique
  - Posterior fracture line illustrated through posterior column
  - May visualize quadrilateral surface connected to displaced posterior column fragment
  - Iliac wing fracture in high anterior column fragments

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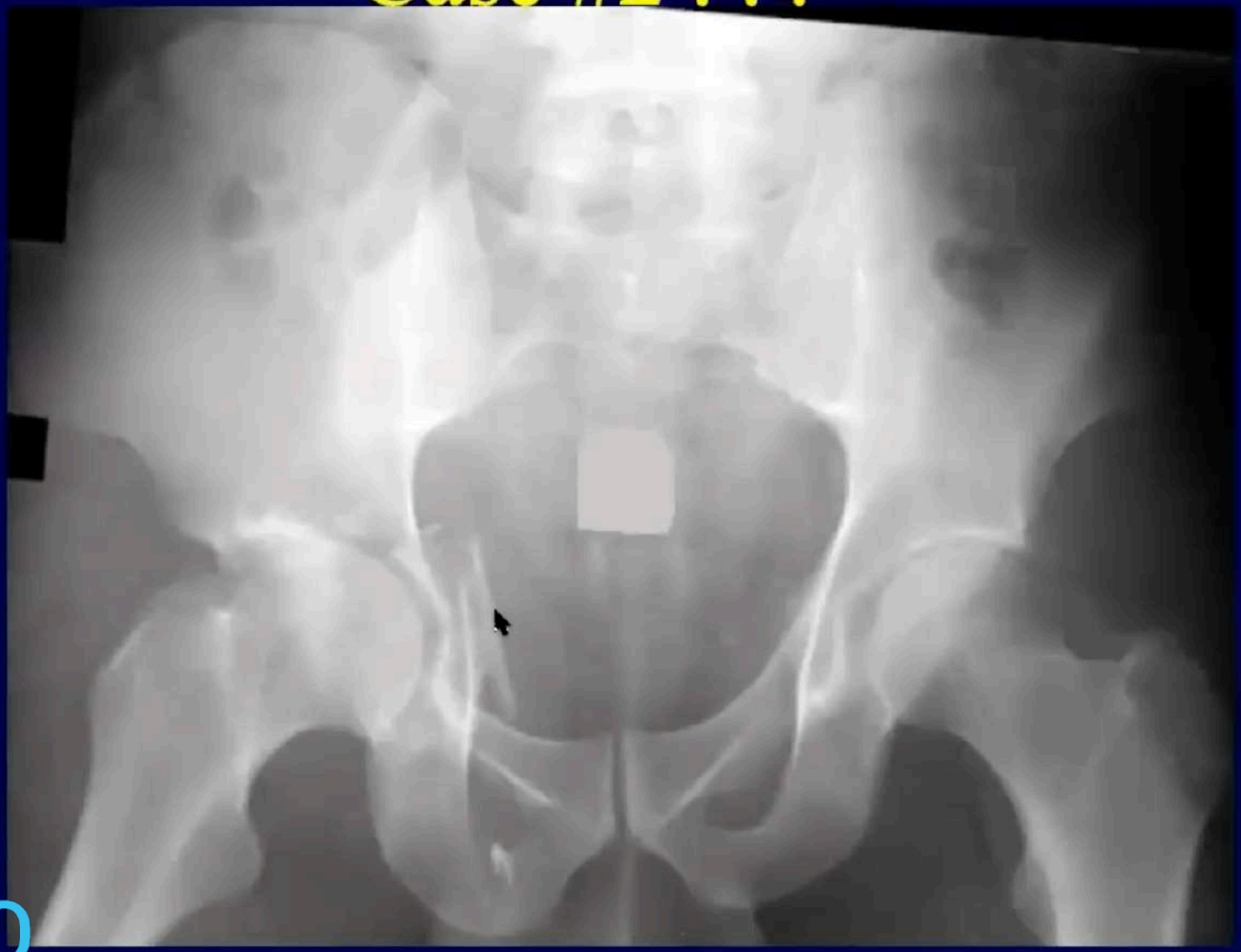
Anterior Column or Wall Fracture + Posterior Hemitransverse Fracture Case #2 . . .



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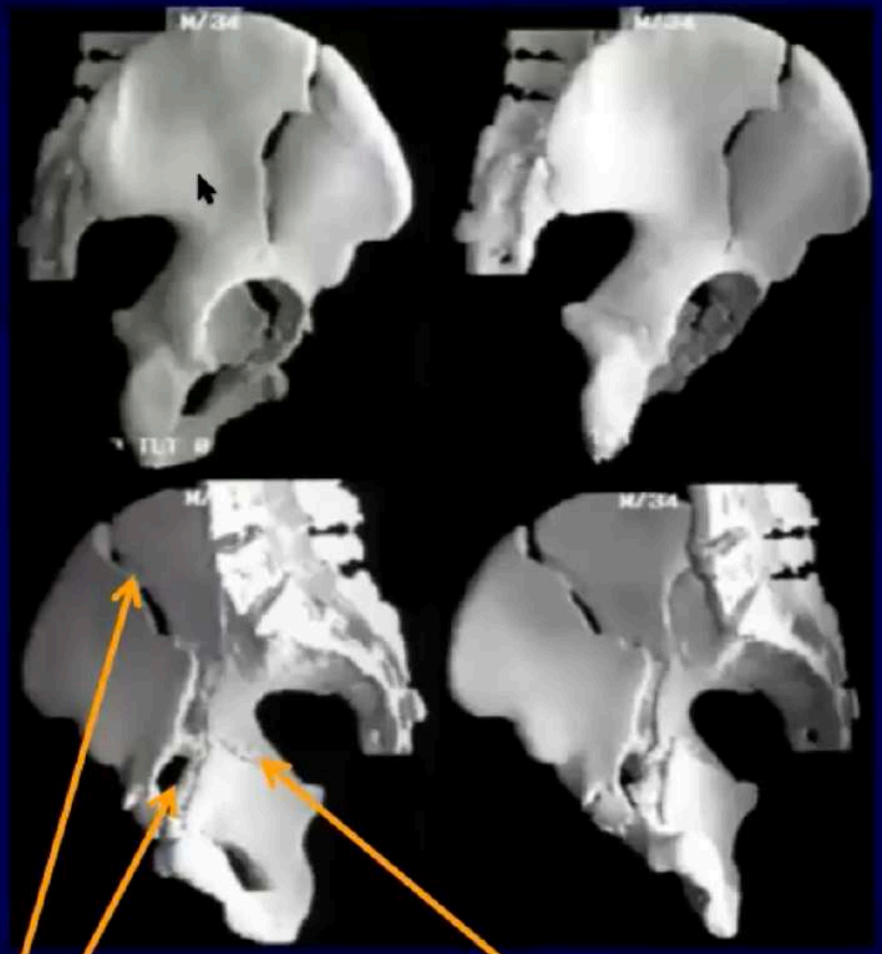
CT scan



High anterior column

Posterior hemitransverse

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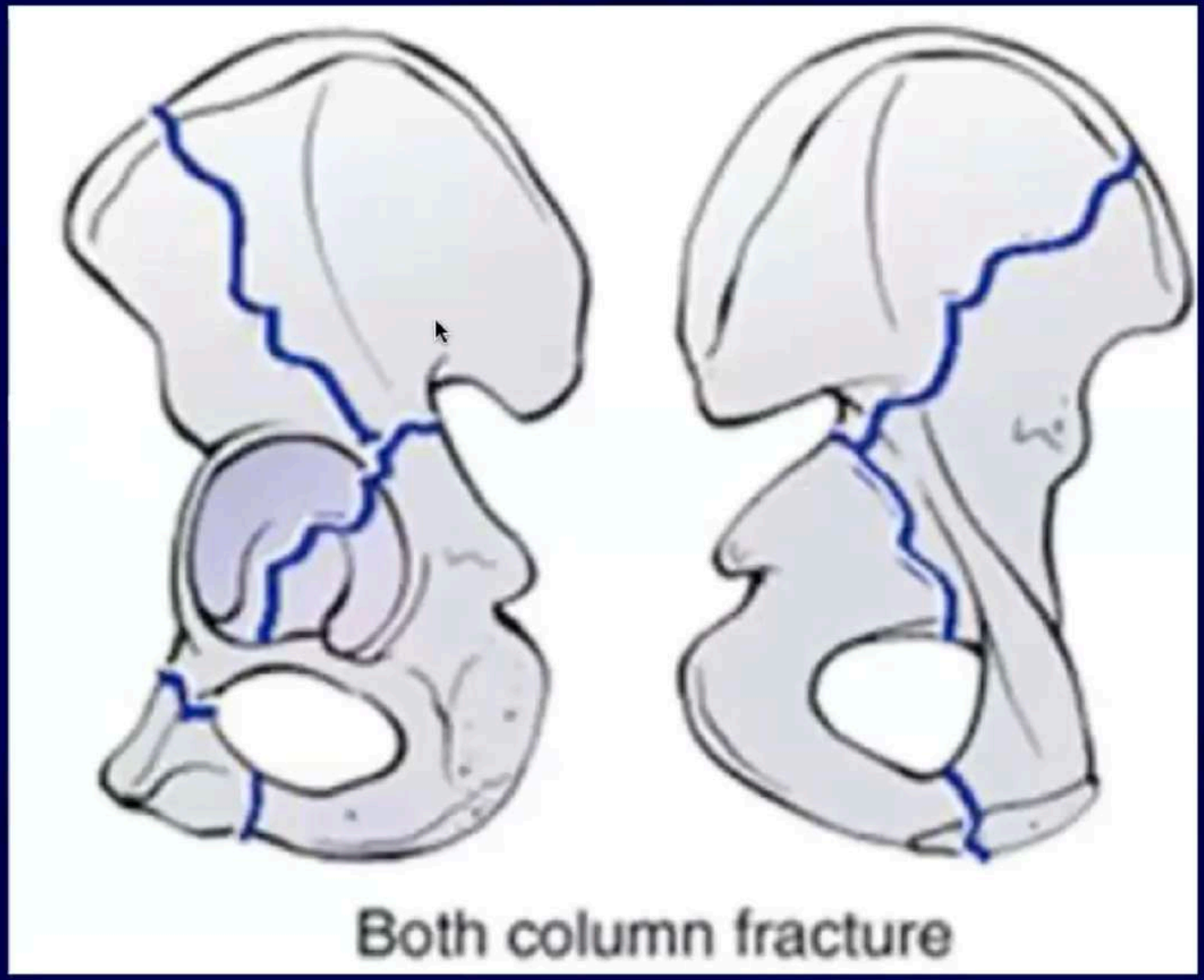
Both Column Fractures



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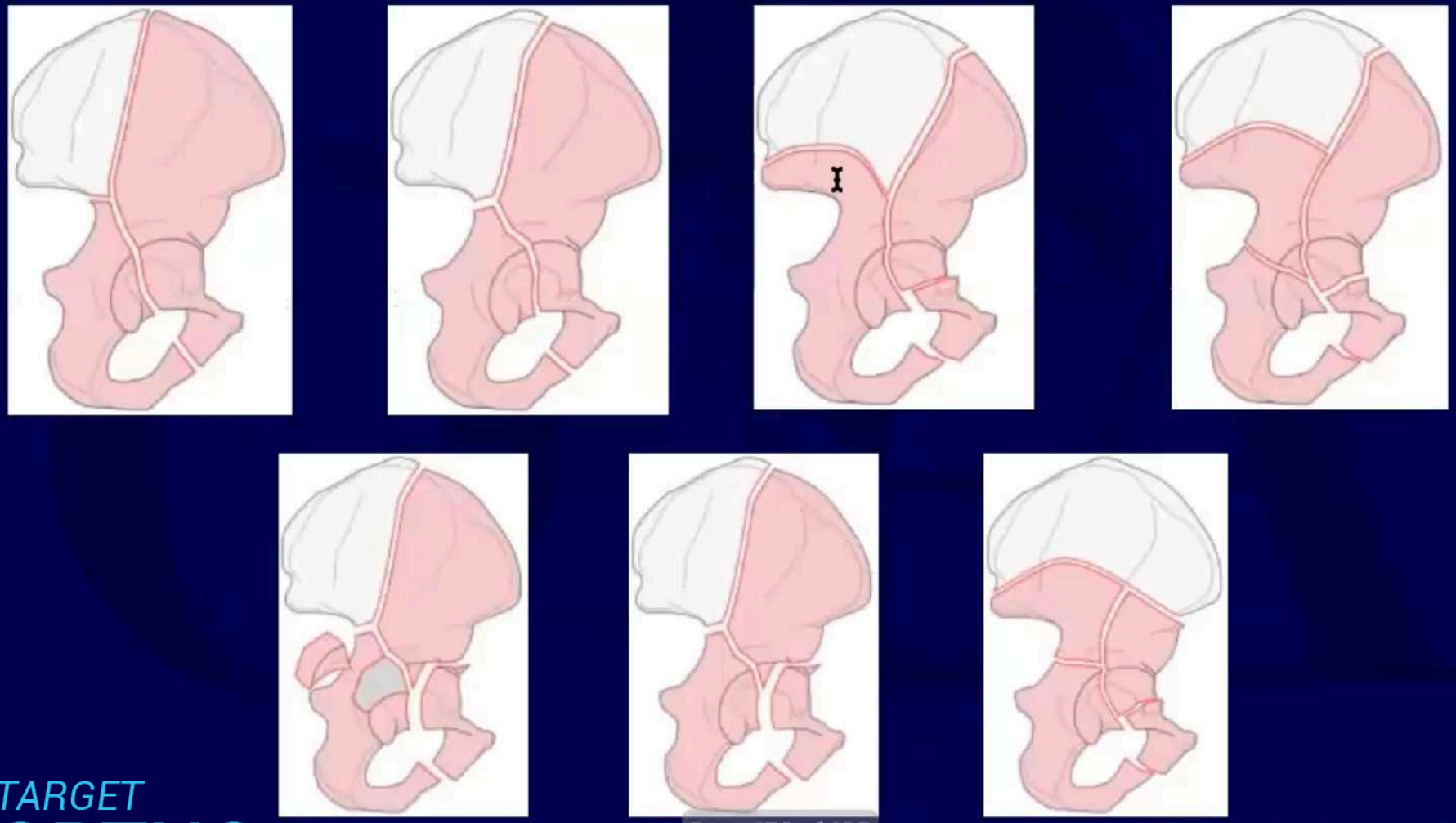
Both Column Fractures

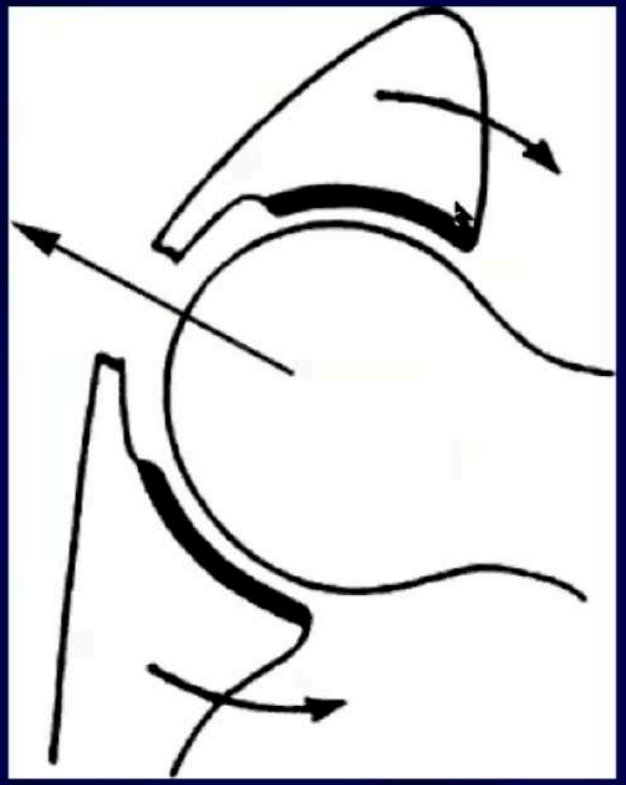
- Most common associated pattern → 23% of all acetabulum fractures
- COMPLETE SEPARATION OF ACETABULUM FROM AXIAL SKELETON
- No portion of the articular surface remains attached to innominate bone
- Split between anterior and posterior columns
  - Common to have numerous secondary fractures and comminution involving columns

Variations of Associated Both Column Fractures



Both Column Fracture

- "Secondary congruence"
  - Central dislocation/medialization of femoral head secondary to muscular pull; labrum intact
  - With medialization the articular fragments rotate around each other and maintain congruency to femoral head



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Secondary Congruence

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Both Column Fracture

- "Spur Sign"
  - Obturator oblique
  - Represents most caudal portion of intact ilium
  - Due to medialization of all articular components with femoral head
  - Pathognomonic for associated both column fracture

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Both Column Fracture
AP Radiograph

All 6 radiographic lines disrupted
Central dislocation/medialization of femoral head
Iliac wing fracture
Ischiopubic ramus fracture
Inward displacement of posterior column
Roof tilted and displaced to look downwards and inwards

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Both Column Fracture
Judet Radiographs

- Obturator oblique
  - Anterior column/iliopectineal line disruption
  - Anterior rim disrupted
  - Roof/sourcil tilted
  - Posterior rim disrupted
  - Ischiopubic ramus disrupted
  - "spur" sign

Obturator Oblique

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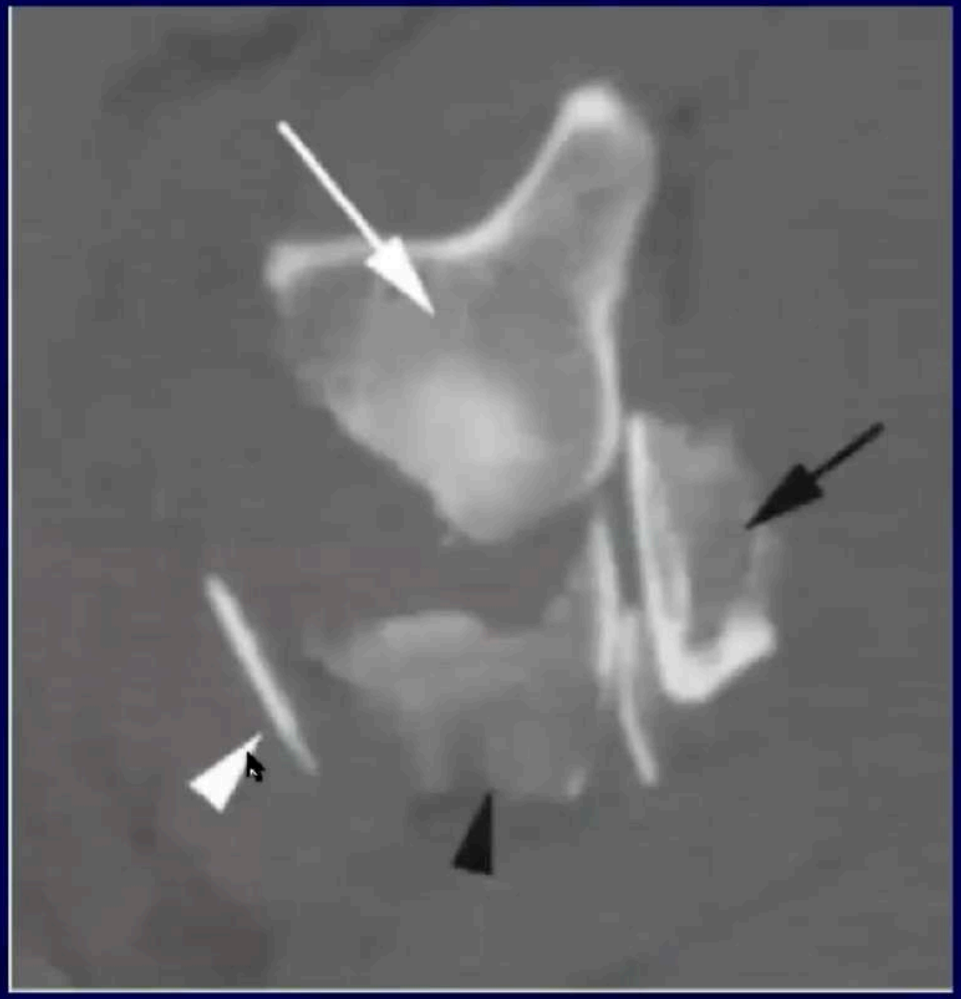
Iliac Oblique

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

CT Scan



Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

White arrow: anterior column
White arrow head: superior extent of posterior column
Black arrow: "spur" sign
Black arrow head: posterior wall fragment

Both Column Fracture
Case #2 . . .

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Both Column Fracture
Case #2

Court-Brown, C. et al. Rockwood & Greens Fractures in Adults. Philadelphia: Lippincott Williams & Wilkins, 2014

Both Column Fracture
Case #3 . . .

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Both Column Fracture
Case #3

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Summary Slide

- Inverted "Y" 2 column concept; know borders/anatomy of anterior and posterior columns
- Know osseous anatomy of acetabulum and how to correlate to radiographs/CT
- Beware corona mortis and sciatic nerve anatomy variations
- Know how to obtain judet/oblique radiographs
- Good quality AP/obturator oblique/iliac oblique radiographs for EVERY ACETABULUM FRACTURE; classify pattern based on radiographs
- CT +/- 3D reconstructions to further understand fracture lines, evaluate marginal impaction, and confirm classification pattern
- Consider MRI for pediatric posterior wall fractures to evaluate fragment size
- Understand roof arc/subchondral CT measurements and how applied to treatment of acetabulum fractures
- Know elementary and associated classification patterns
  - Understand primary components/fracture lines of each pattern
  - Be able to identify the 6 radiographic lines on AP radiograph
  - Understand what lines/landmarks disrupted or intact on AP and judet radiographs for each elementary and associated pattern
  - Understand that there are many variations/sub-types for each classification pattern
  - ASSOCIATED BOTH COLUMN FRACTURES HAVE COMPLETE SEPARATION OF THE ARTICULAR SURFACE FROM THE INNOMINATE BONE
- WHEN EVALUATING AN ACETABULUM FRACTURE ALWAYS START WITH PLAIN RADIOGRAPHS
  - IDENTIFY THE INTACT AND DISRUPTED LINES AND LANDMARKS ON EACH VIEW AND DETERMINE A PRELIMINARY CLASSIFICATION
  - DRAW THE FRACTURE LINES ON A SAW BONE PELVIS
  - USE THE CT IMAGING TO CONFIRM CLASSIFICATION

T-Type Fractures

- 7% of acetabulum fractures
- Transverse fracture line with associated inferior vertical fracture line → stem of "T"
- Vertical stem propagates from transverse fracture line → across quadrilateral surface and cotyloid fossa → enters obturator foramen → fracture of ramus/ischiopubic ramus
- Fracture may also propagate posteriorly to ischium or anteriorly to pubis