Lumbopelvic Fractures and Fixation

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Objectives

- **Introduction to “spinopelvic dissociation”**
- **Anatomy**
- **Pathoanatomy**
- **Epidemiology**
- **Clinical evaluation**
- **Radiographic evaluation**
- **Fracture Classifications**
- **Importance of kyphosis reduction / sagittal balance**
- **Hardware placement and reduction techniques**
- **Common pitfalls**

Spinopelvic Dissociation

- Bilateral longitudinal sacral fractures, connected with a transverse component, resulting in separation of the axial skeleton from the appendicular skeleton

- Often times treated with Iliosacral or transiliac-transsacral screw fixation, however lumbopelvic fixation is utilized in specific instances due to anatomy of severity of injury
  - Sacral dysmorphism
  - Spinopelvic instability with displaced U-type variant

Anatomy

- Transmission of the torso’s weight is directed via axial loading through the spine at the lumbosacral junction

- Weight is transmitted from the lumbosacral junction, through the sacroiliac joints, and from the ilium to the lower extremities

- Skeletal support and muscular forces keep the head centered over the pelvis in the coronal and sagittal planes, preventing imbalance

Pathoanatomy

- Dissociation of the axial spine from the pelvis results in loss of osseous integrity
- May lead to kyphotic deformity
  - Initial deforming force at time of injury
  - Psoas muscle (T12-L4 transverse process to lesser trochanter of femur) can flex through sacral fracture
  - Gravity can cause progressive kyphotic deformity in undiagnosed insufficiency fractures
- Results in progressive positive sagittal balance, and/or neurologic deficits from nerve compression in the sacral canal

Epidemiology

- Bimodal distribution
  - Young patients typically with high energy mechanisms
    - Fall from height (suicide jumper)
    - Auto vs pedestrian
    - Motorcycle accident
    - Automobile collisions
  - Older patients with lower energy / insufficiency fractures
    - Ground level falls
    - Trauma in setting of osteoporosis
    - Failure of conservative treatment

Epidemiology

- Fractures of the pelvis represent less than 3% of skeletal injuries
  - Sacral fractures occur in 45% of pelvic fractures
- Only 3-5% of sacral fractures are spinopelvic dissociations
- 4.5% of sacral fractures have transverse component
- 25% of sacral fractures have a neurologic component

- No good data on the incidence of geriatric sacral insufficiency fractures requiring surgery

Clinical Evaluation

- Always evaluate for lacerations, bruising, tenderness, swelling, crepitus, sacral prominence, or subcutaneous fluid collection/degloving (Morel-Lavelle lesion)
- Any report of pain with AP or lateral compression of the pelvis should prompt imaging
- Neurologic evaluation
  - Predisposed to bowel, bladder, and sexual dysfunction given the location of sacral fractures
  - If sacral injury is more caudal to S1, motor exam my appear normal
    - Rectal exam is needed to assess motor function more distal to S1
- Urogenital examination to assess for urethral, bladder, rectal and/or vaginal injuries as well as open fractures

Radiography

- AP x-ray obtained as part of standard trauma workup
  - Inlet and outlet views if concern for pelvic ring injury
    - Inlet – shows sacral canal and superior view of S1
    - Outlet – true AP of the sacrum
    - Either performed with standard radiography, or with CT reformats

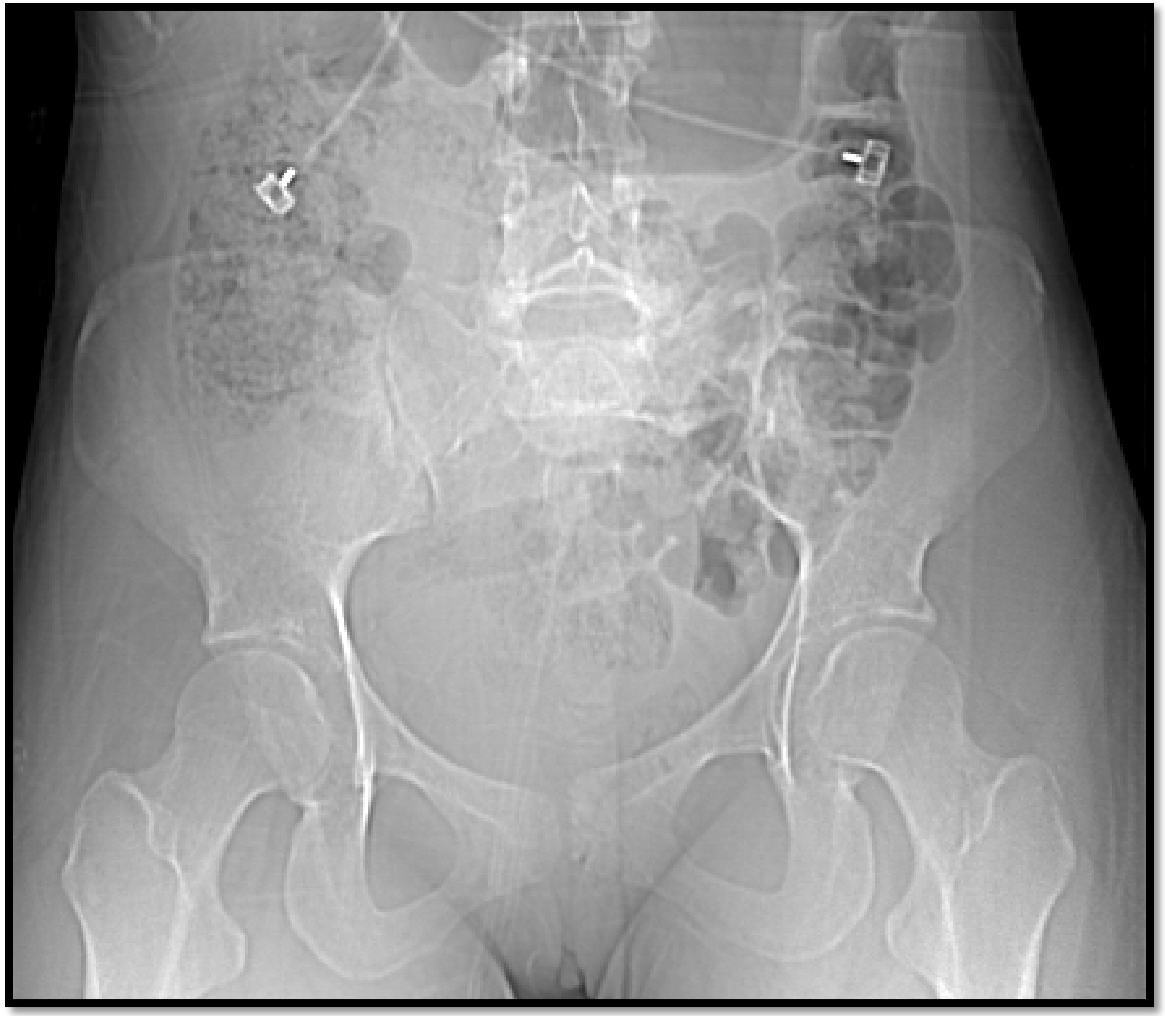
- CT pelvis reformats allow for visualization of transverse fracture lines, sacral kyphosis

- MRI used to assess nerve root / cauda equina compression

Radiologic Findings

- Plain radiography only identifies ~30% of sacral fractures. Advanced imaging is recommended
  - CT with 1-2mm cuts, as well as coronal and sagittal reconstruction to asses bony anatomy
  - MRI is better utilized to assess for areas of neural compression
- **Paradoxical inlet view** of the upper sacrum on the standard AP pelvic radiograph
- L5 transverse process fracture found in 61% of patients with sacral fracture
- ”**stepladder sign**” = anterior sacral foraminal disruption

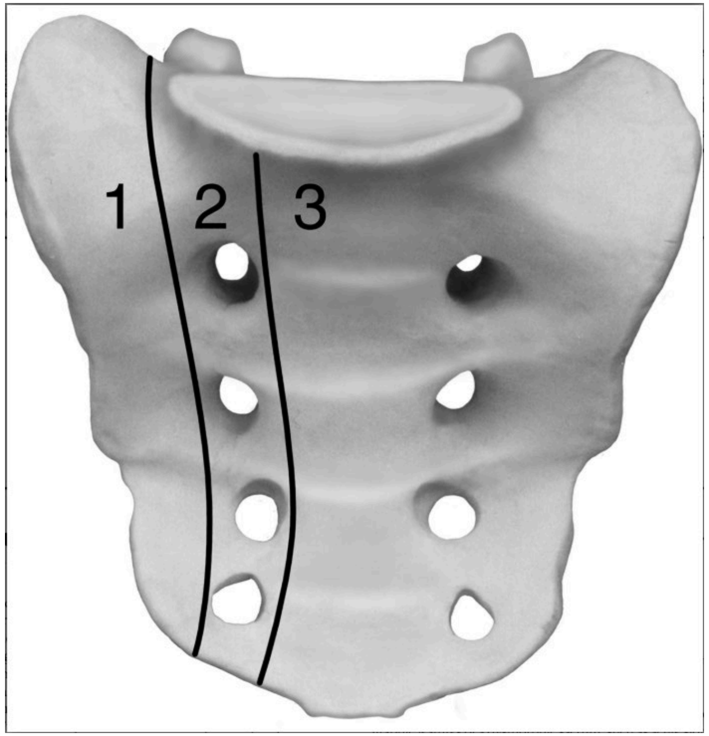
Paradoxical Inlet XR



“ Step Ladder” sign

Fracture Classification

- **Denis Classification –** Does not take spinopelvic stability into account
  - Based upon location of fractures relative to sacral foramen and associated risks of neurologic deficits



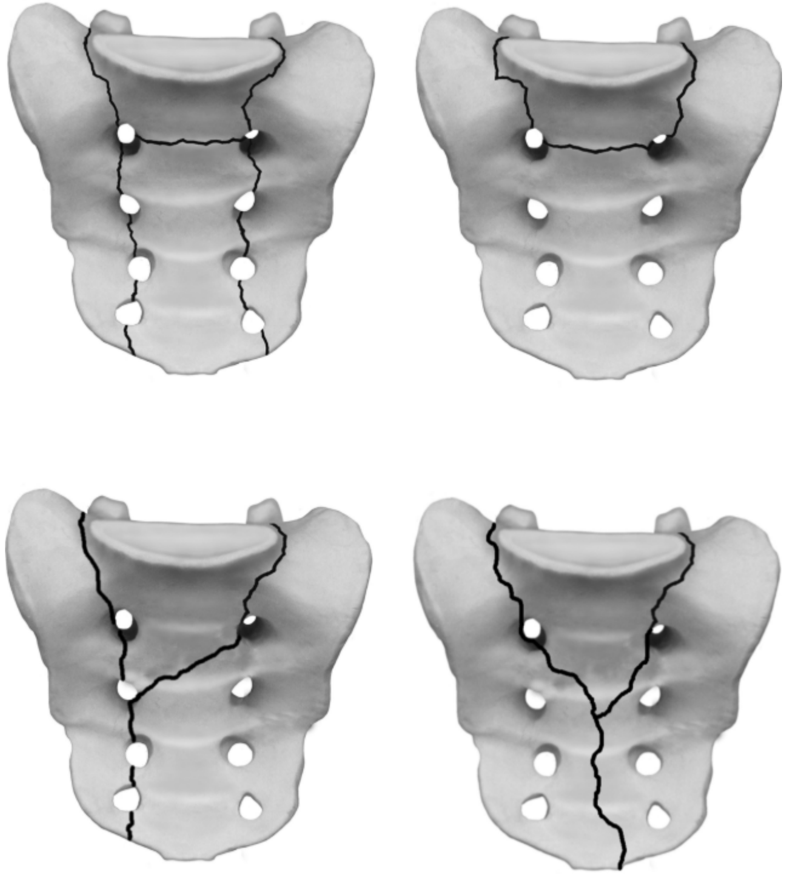
Zone I: 5.9% incidence of predominantly L5 nerve root injury

Zone II: 28.4% incidence of L5, S1 nerve root injury

Zone III (central canal fracture): 56.7% incidence of neurologic injury, usually sacral plexus or cauda equina

Denis Classification – Zone III

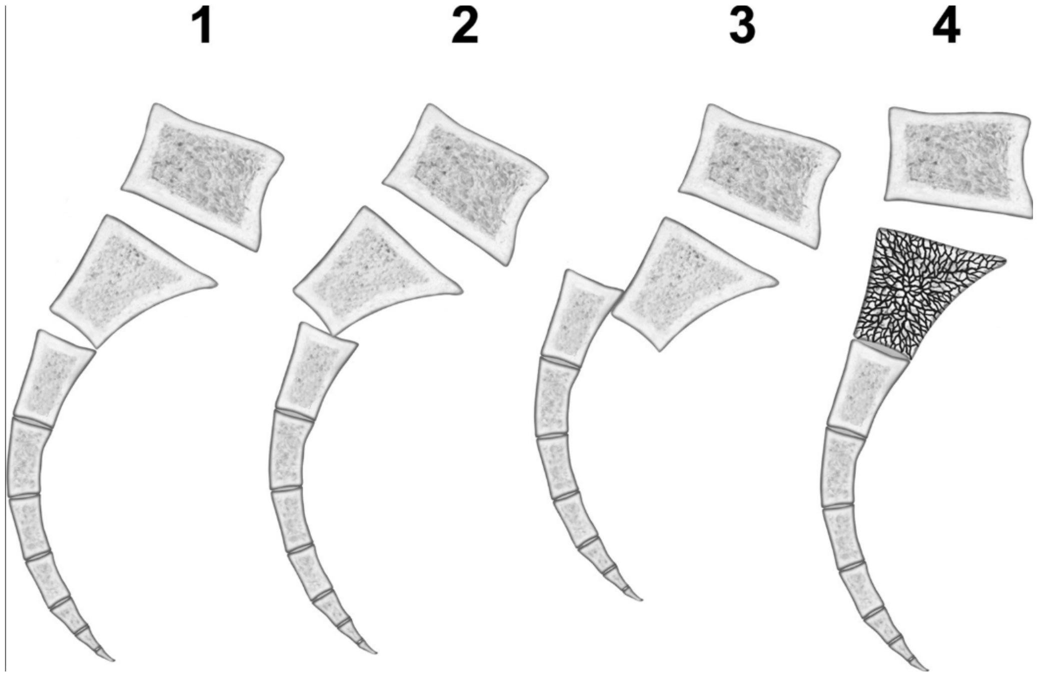
- Not just purely longitudinal or transverse, but complex, multiplanar fractures
- Any fracture that is transverse is, by definition a Denis Zone III, however when combined with bilateral longitudinal fractures, the resulting ”U”, “H”, “Y” and “Lambda” fracture patterns result in spinopelvic dissociation



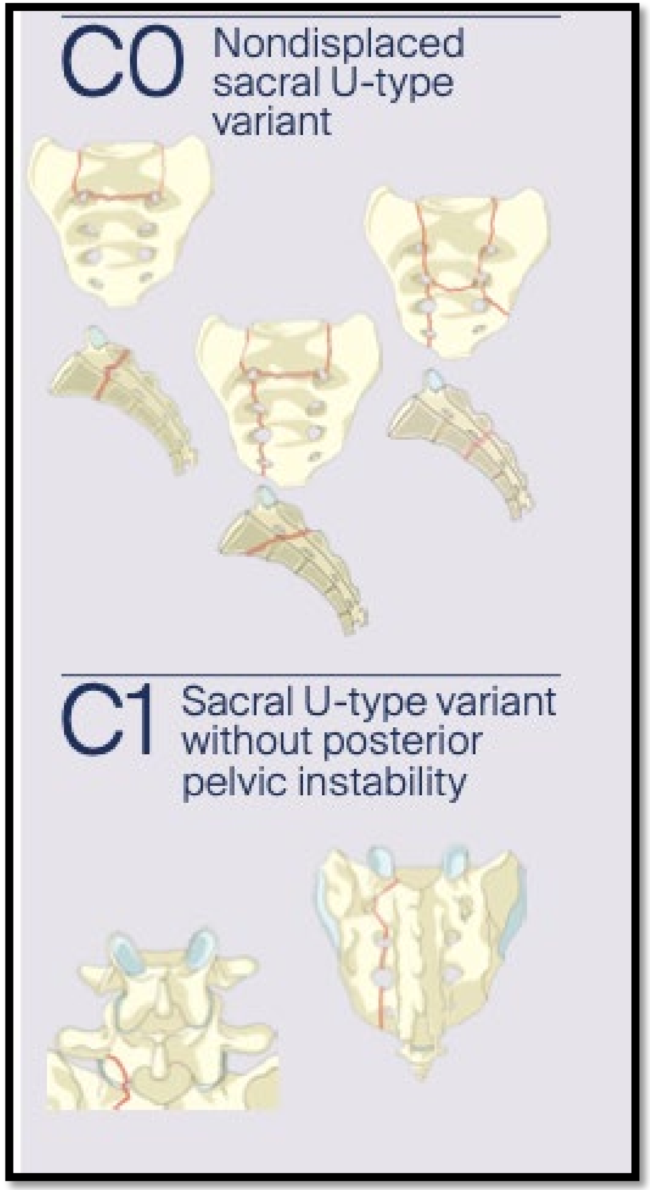
Modifications of Denis Classification

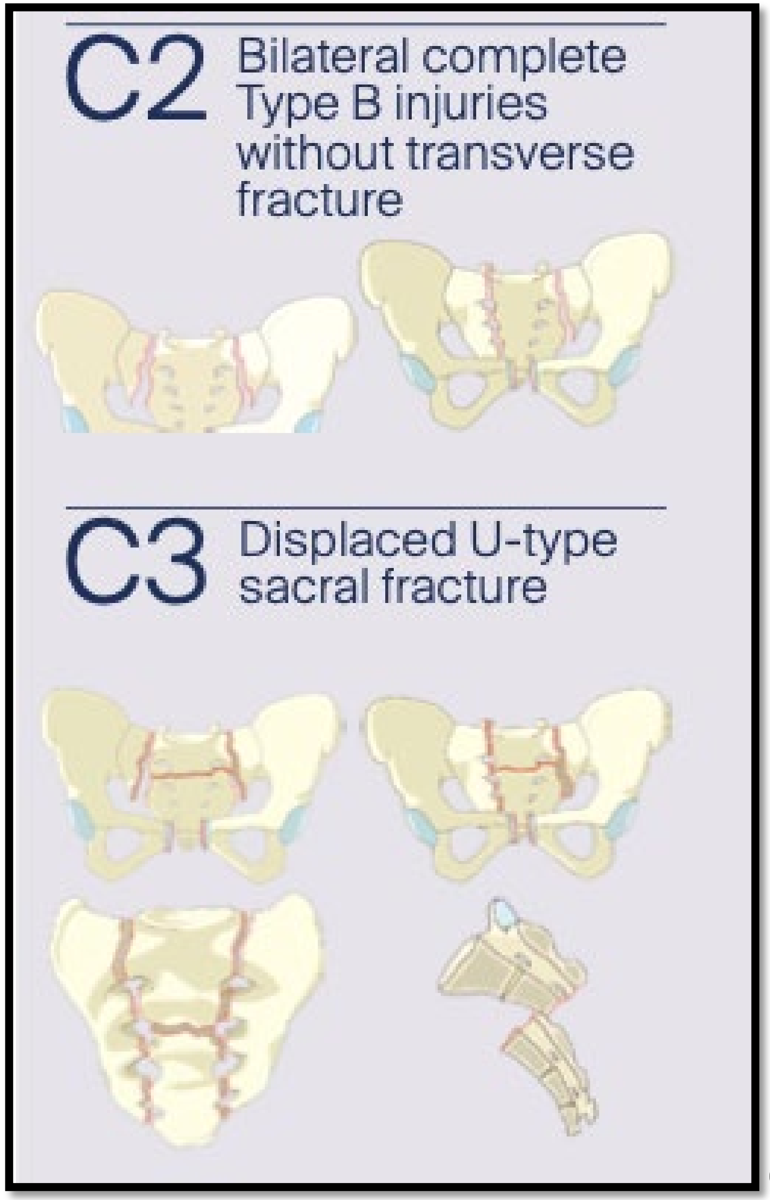
- The Denis Classification did not allow for characterization of displacement and angulation patterns

- Roy-Camille (1-3) and Strange Vognsen – Lebech (4) classified the type IIIs based upon displacement and angulation



AO Sacral Fracture Classification





Importance of kyphosis reduction

- Goal of fixation is to correct and prevent further displacement, which can lead to postural malalignment, chronic pain, and neurologic compromise

- Restoration of appropriate sagittal alignment of the sacral fracture “decreases pain by preventing compensatory lumbar hyperlordosis, allowing for more physiologic alignment of the lumbar spine”

- Normal pelvic incidence (~50 degrees +/- 10 degrees) can be used an objective measure of adequacy in reduction of sacral kyphosis

Hardware Placement

- Anterior pelvic ring injuries and/or acetabular injuries must be addressed first, as the rigidity of lumbopelvic fixation will prevent any further reduction

- Lumbopelvic fixation provides the most rigid fixation of sacral fractures, as compared to transacral screws

    - Obtained by pedicle screws placed at L5, and screw fixation in the ilium
        - If poor bone quality, L5 pedicle is involved, or preexisting L4-5 instability, extension to L4 is warranted
    - Allows for earlier mobilization, if other injures allow
    - S1 screws are not routinely placed due to poor purchase in fractured sacrum

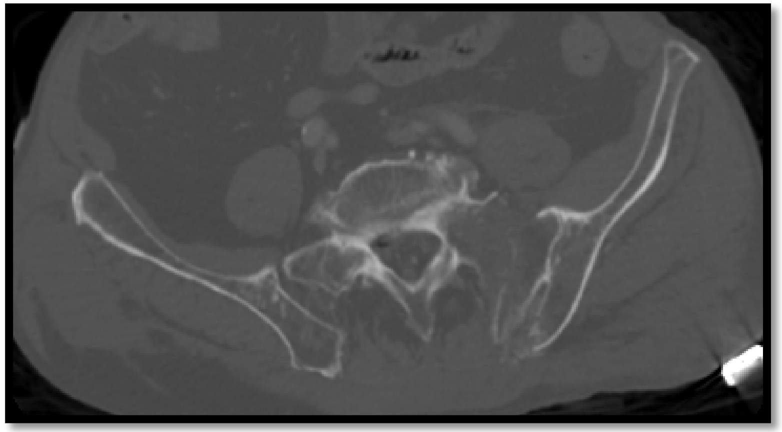
Percutaneous vs Open

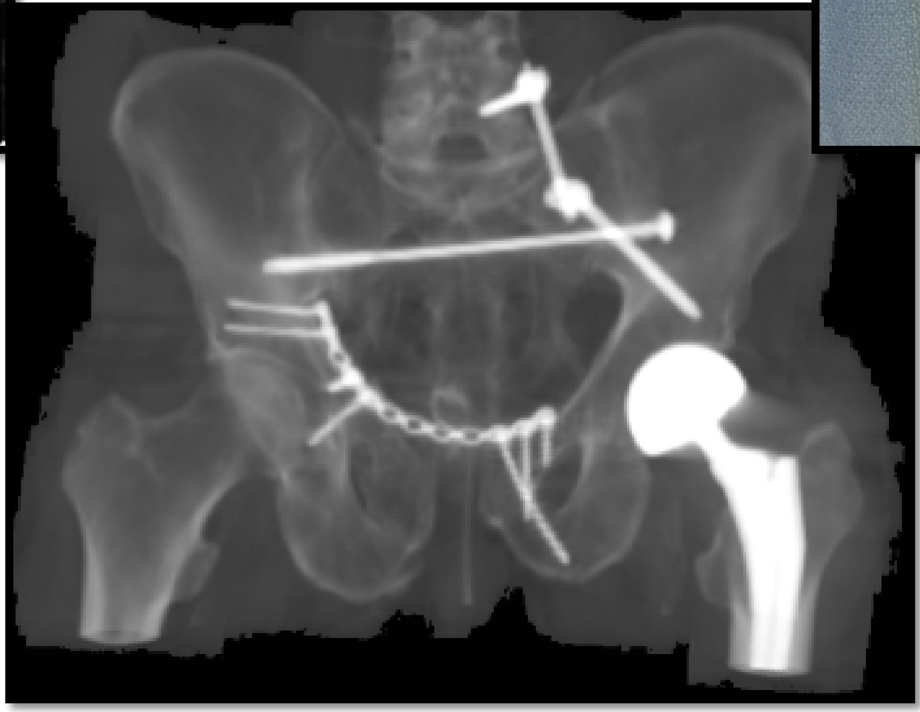
- Percutaneous fixation has been shown to have similar restoration of pelvic incidence, lumbar lordosis, operative time, and length of stay, although not studied in severe displacement

- Percutaneous does have less estimated blood loss, although both open and percutaneous fixation required transfusions at a similar rate

- Percutaneous allows for indirect decompression of sacral nerve roots, whereas open allows for sacral laminectomy and direct decompression

Percutaneous





Neurologic Decompression

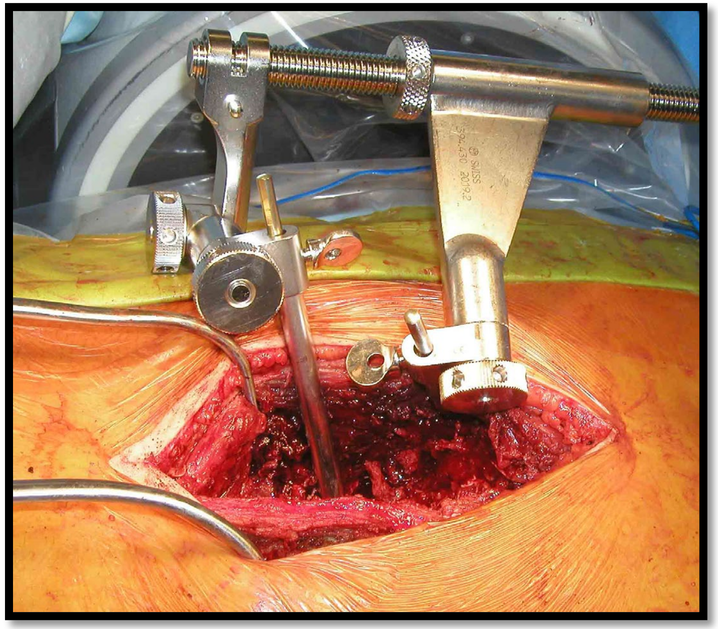
- When neurologic deficits are present, direct decompression by laminectomy may enhance neurologic recovery
  - Although, neurologic injuries secondary to sacral fractures are not considered neurologic emergencies, and surgical timing does not necessarily correlate with neurologic recovery
- Sacral laminectomy should be performed cranial to caudal, decompressing S1-4, lateral to the sacral pedicles, to ensure thorough decompression
  - Up to 80% of patients experience improvement in neurologic function following spinopelvic instability fractures, regardless of treatment

Fracture Reduction – Indirect with traction

- Restoration of length is required for successful fracture realignment
- Bifemoral traction allows for dis-impaction of the cranial and caudal fracture fragments, and allows for restoration of fracture length and some sagittal alignment

Fracture Reduction – Utilization of Distractor

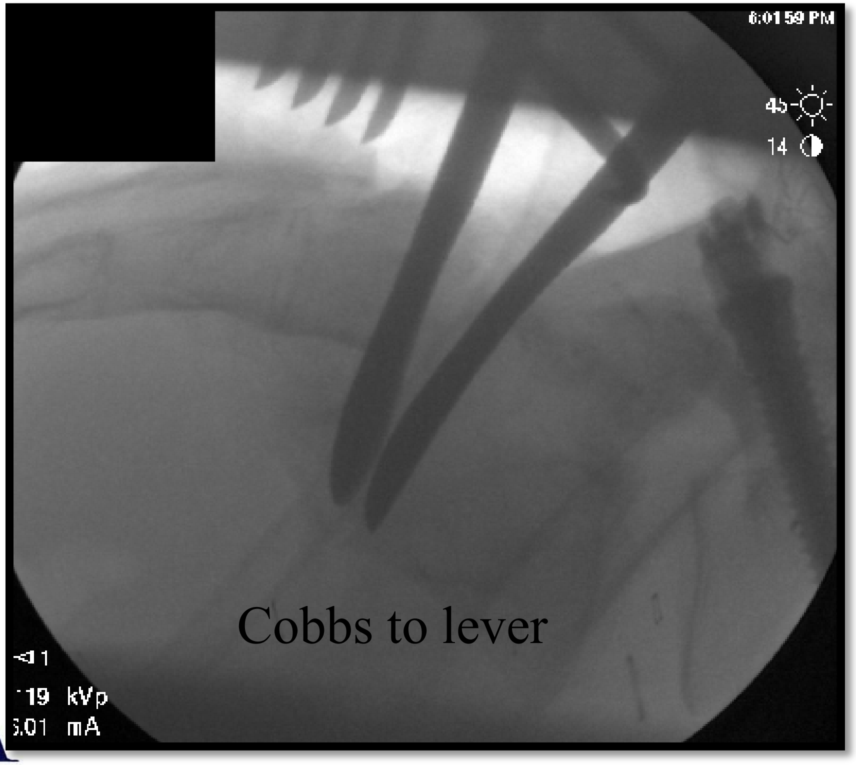
- Femoral distractor utilizes Schanz pins placed ipsilaterally in same trajectory as spinopelvic hardware to hold distraction

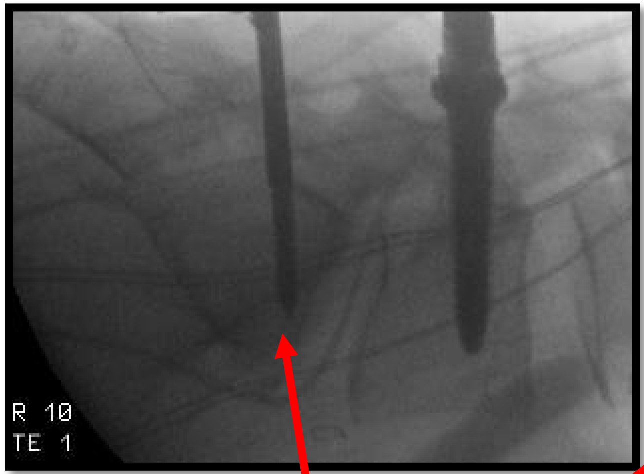


  - Allows for sacral laminectomy, and access to transverse fracture line by mobilization of sacral nerve roots
  - Elevator placed in to fracture line, and a Schanz pin placed in cranial sacral piece, for joysticking of fracture
  - Distraction can be decreased once reduction is obtained, and Iliosacral / transsacral screws can be placed

Fracture Reduction – Utilization of Cobbs and Schantz Pins

- Elevator placed in to fracture line, and a Schanz pin placed in cranial or caudal sacral piece, for joysticking of fracture
- Cobbs can also be places into fracture to tray and dis-impact



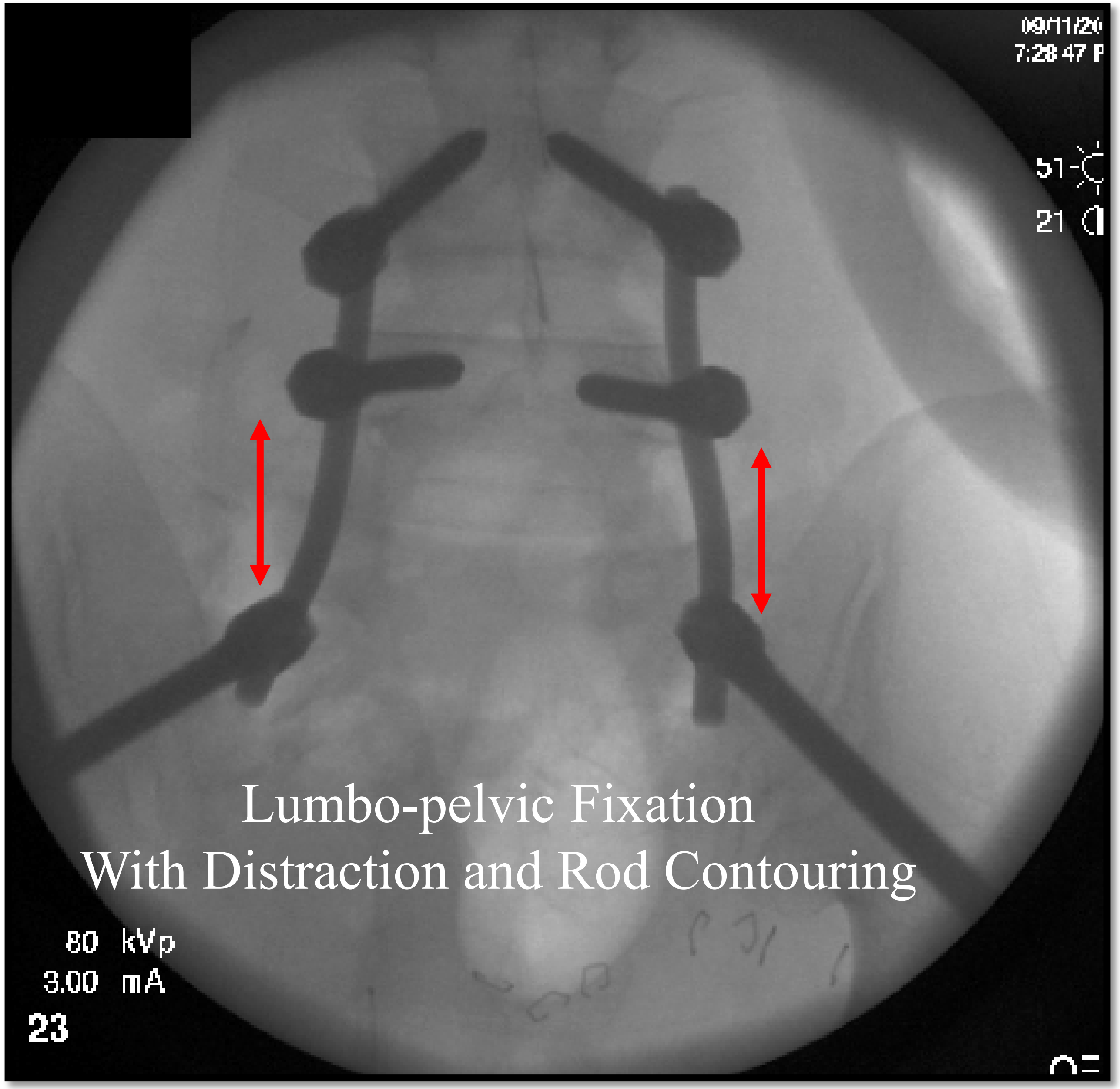


Schanz Pin

Fracture Reduction – Indirect with Contouring of Rods

- Once lumbar pedicle screw and iliac bolt placed, a temporary rod is locked in to place on once screw, allowing for distraction across the other
- Once length is established, 2nd screw is locked down
- Rod is then contoured with in situ benders to correct kyphosis
- Once reduction is complete, contralateral rod is placed, and then initial rod is replaced with a new, unstressed, rod.

Fracture Reduction – Indirect with Contouring of Rods

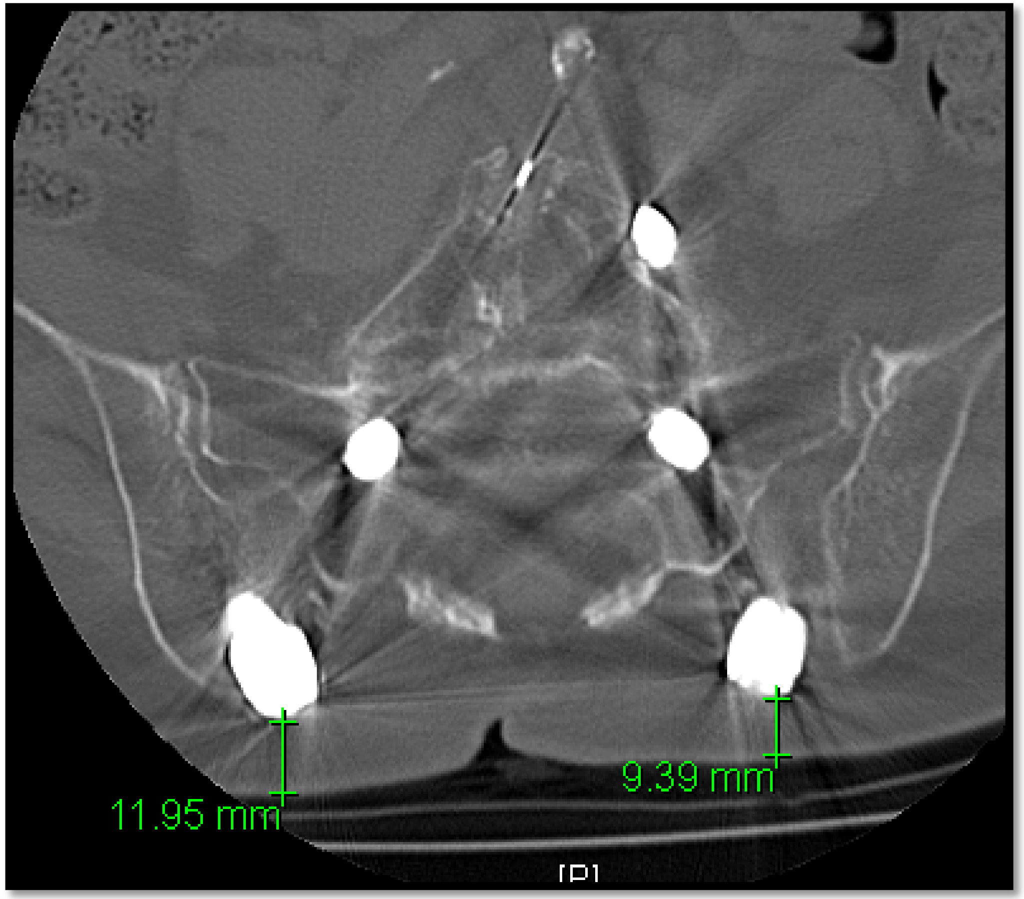


Complications

- Often due to high energy mechanisms, with traumatized soft tissue envelope, predisposing to wound complications
  - Percutaneous screws may be preferable in this situation, however the nature of the injury may necessitate open treatment
- Lack of soft tissue in this area may lead to painful prominent hardware, skin breakdown, and necessitate hardware removal
- Broken hardware usually occurs after fracture has healed, due to micromotion at the SI joint

Complications

traumatized soft tissue envelope



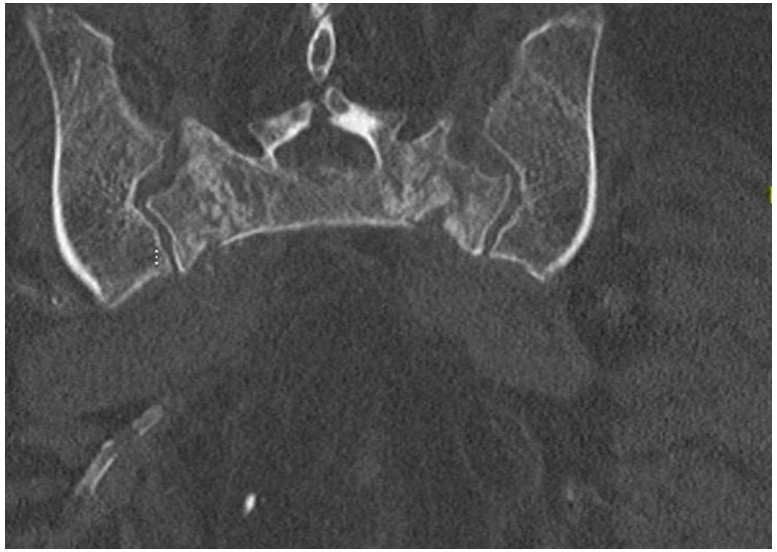
prominent hardware

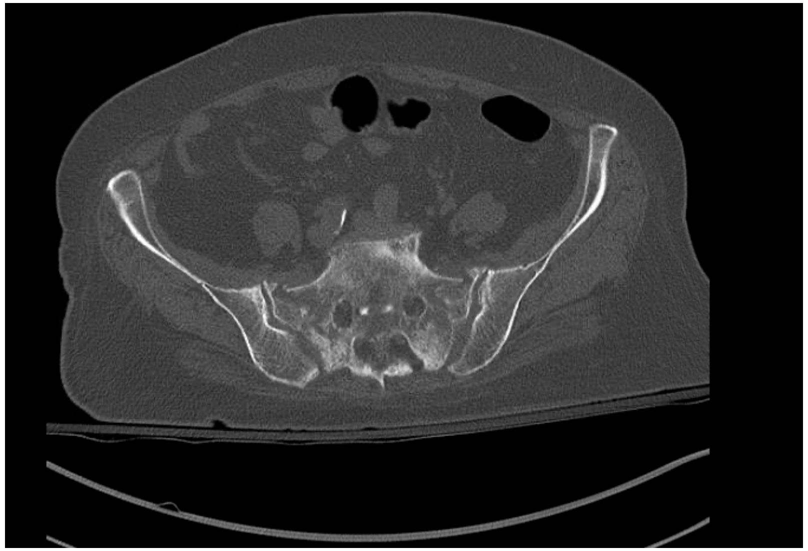
Common Pitfalls

- Sacral fractures can be missed up to 30% of the time, especially insufficiency fractures
- Neurologic compromise is often distal to S1, and will not be picked up on a motor examination
- Distraction across fracture, may predispose to non-union, so caution should be taken when distracting across pedicle screws for reduction

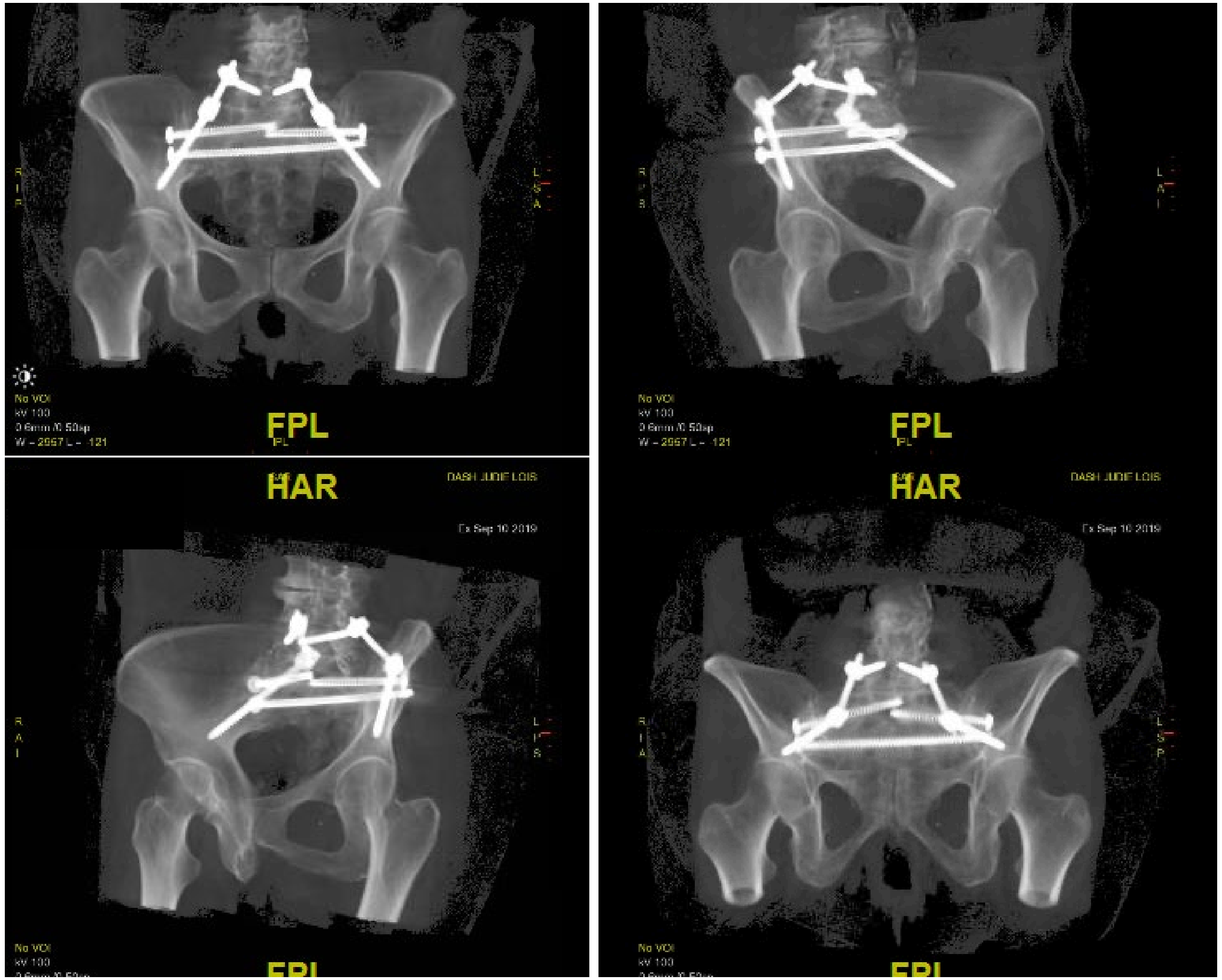
Case Example: Sacral Insufficiency

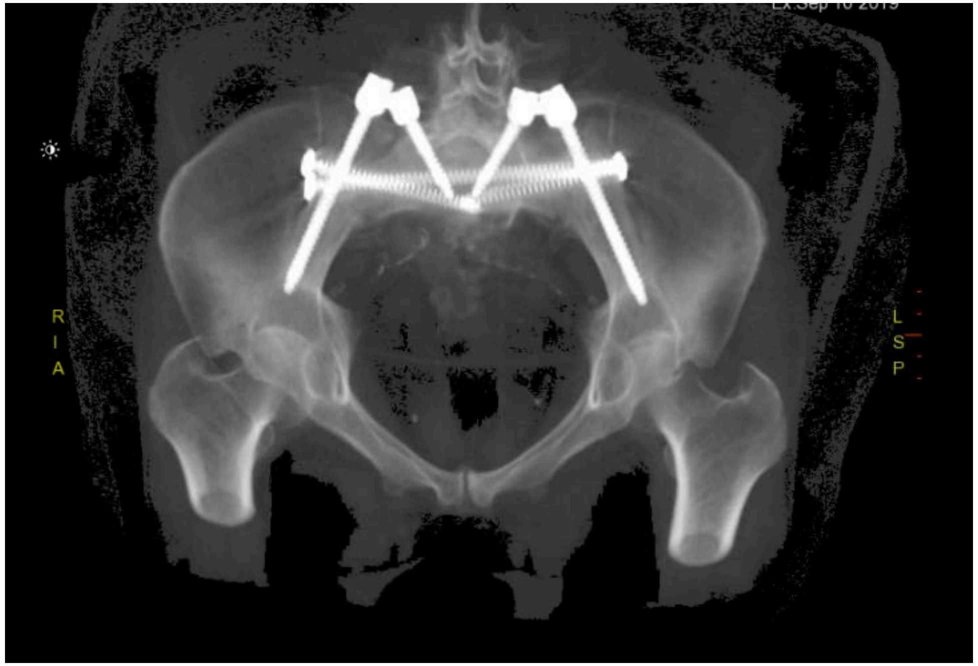
77 year old female, with 2 months of pain during ambulation, following a ground level fall, in the setting of osteoporosis. Neurologically intact





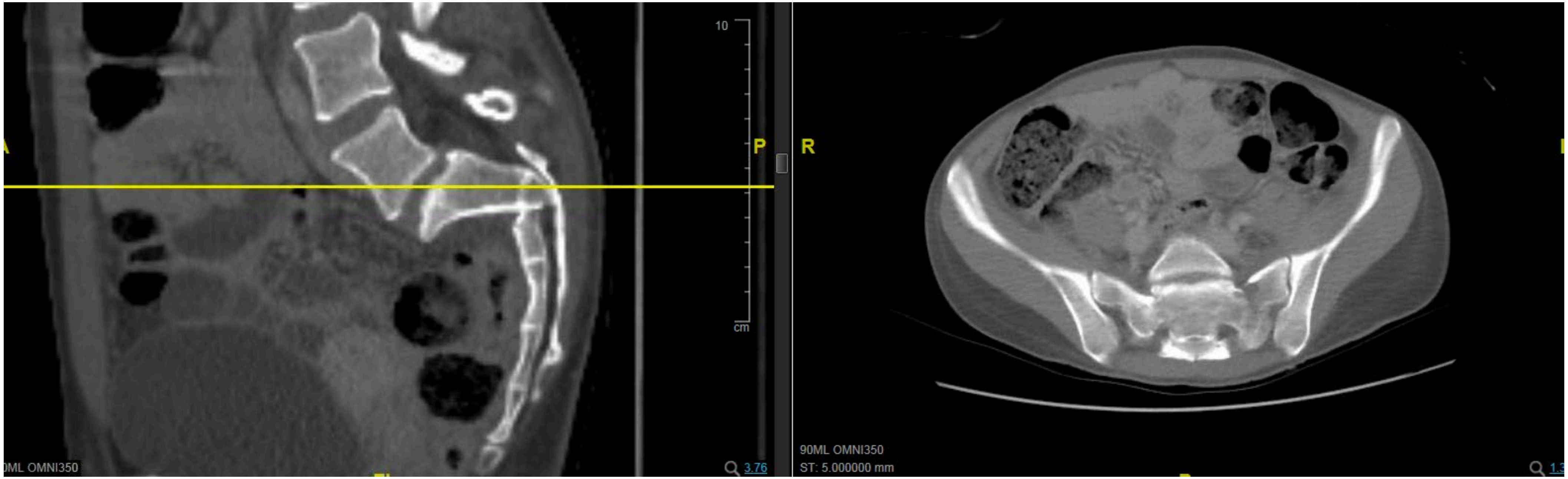
Case Example: Sacral Insufficiency



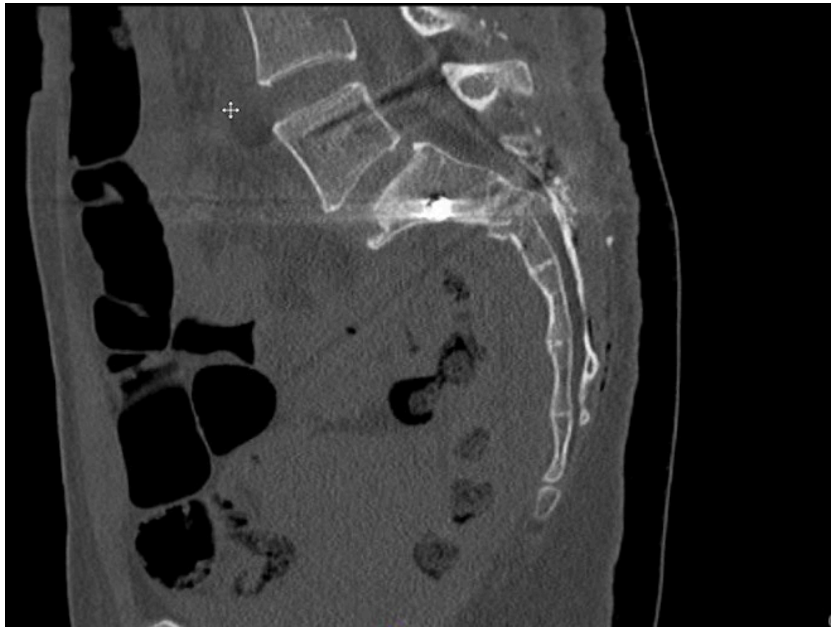


Case Example: Sacral Kyphosis with sacral nerve root dysfunction

18 year old female, struck by a motor vehicle, with loss of S2-4 function

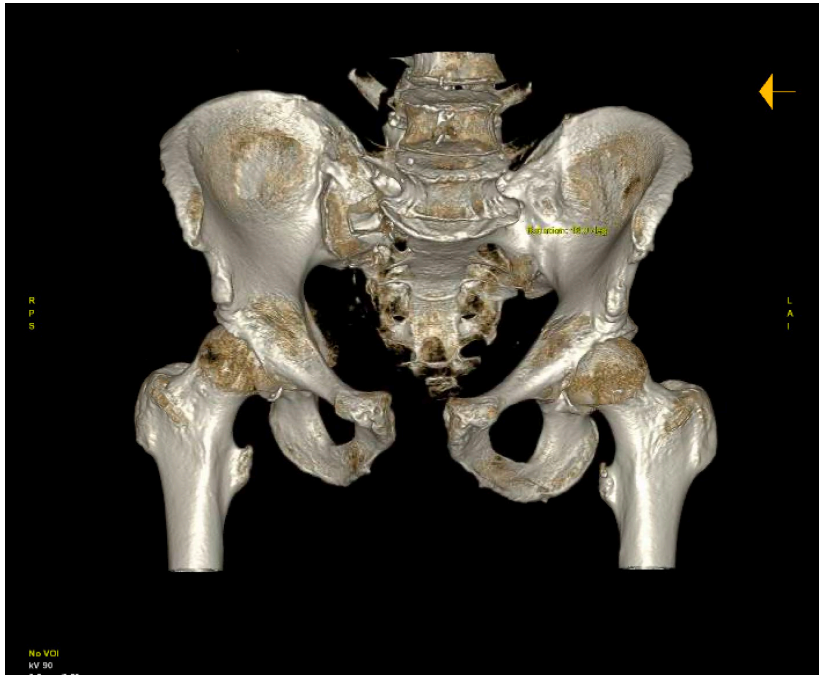


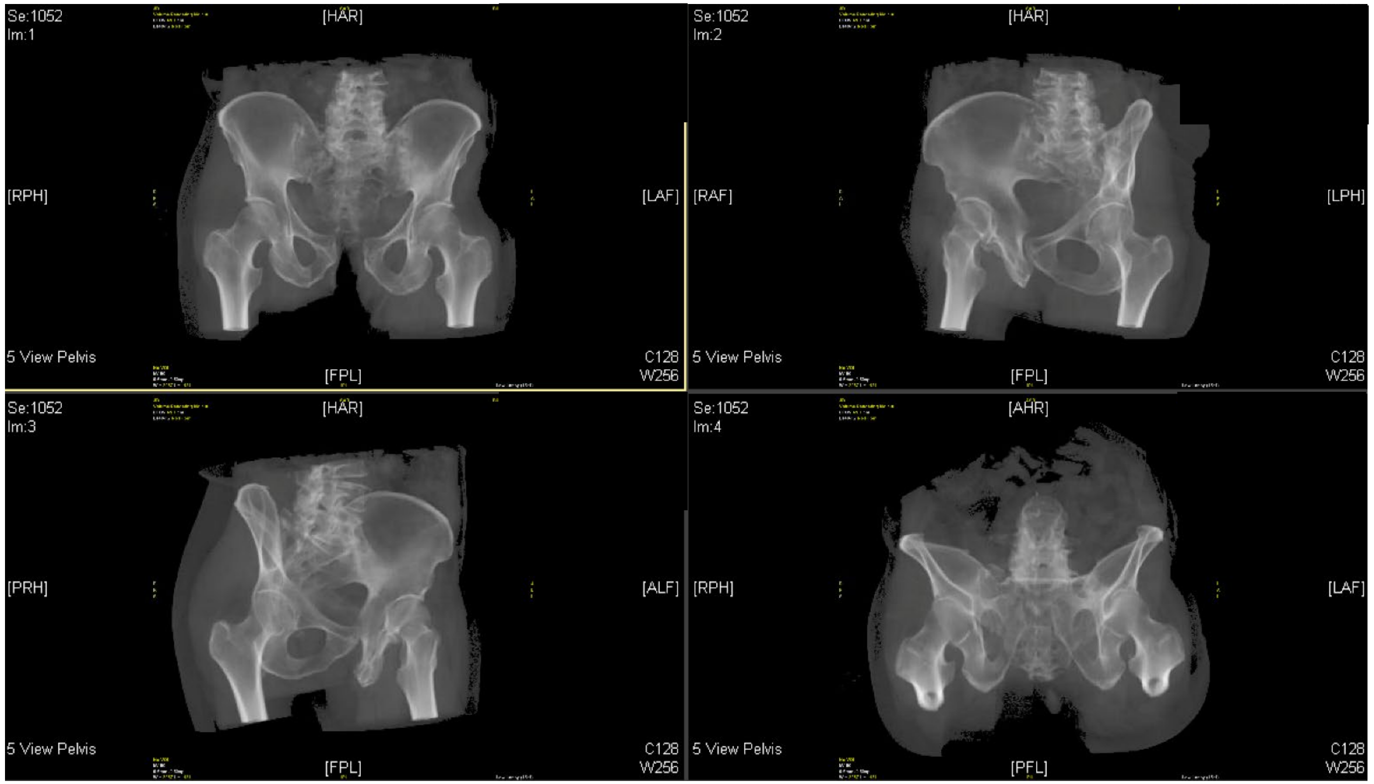
Case Example: Sacral Kyphosis with sacral nerve root dysfunction



Case Example: Combined spinopelvic dissociation and pelvic ring

69 year old male, motorcycle wreck at high speeds, with concomitant pelvic ring injury





Case Example: Combined spinopelvic dissociation and pelvic ring

Pelvic ring injury treated 1st, with anterior plating, and right sided iliosacral screws. Due to poor corridors, lumbopelvic fixation was used

Summary

- Spinopelvic dissociation is a rare, but devasting injury, whose instability can lead to progressive deformity and neurologic compromise if not addressed appropriately
- Occurs in both the young and elderly populations, although due to different underlying mechanisms
- Lumbopelvic fixation is an appropriate treatment option, should iliosacral or transiliac transscaral screw fixation not be an option
- Sacral laminectomy is often needed, both for nerve root decompression, but also for direct fracture reduction

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