Pediatric Pelvis and Acetabulum Fractures

Ahmed Thabet MD
Assistant Professor, Orthopedics
Paul Foster School of Medicine
Texas Tech University Health Science Center at El Paso

Christopher D. Souder, MD
Assistant Professor of Surgery & Perioperative Care
Dell Medical School
University of Texas at Austin

Disclosure

- Clinical and radiographic images provided are used with permission of Ahmed Thabet, MD or Chris Souder, MD, unless otherwise specified

- Figures used with permission from Tornetta P, Ricci WM, eds. Rockwood and Green's Fractures in Adults, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019.

Objectives

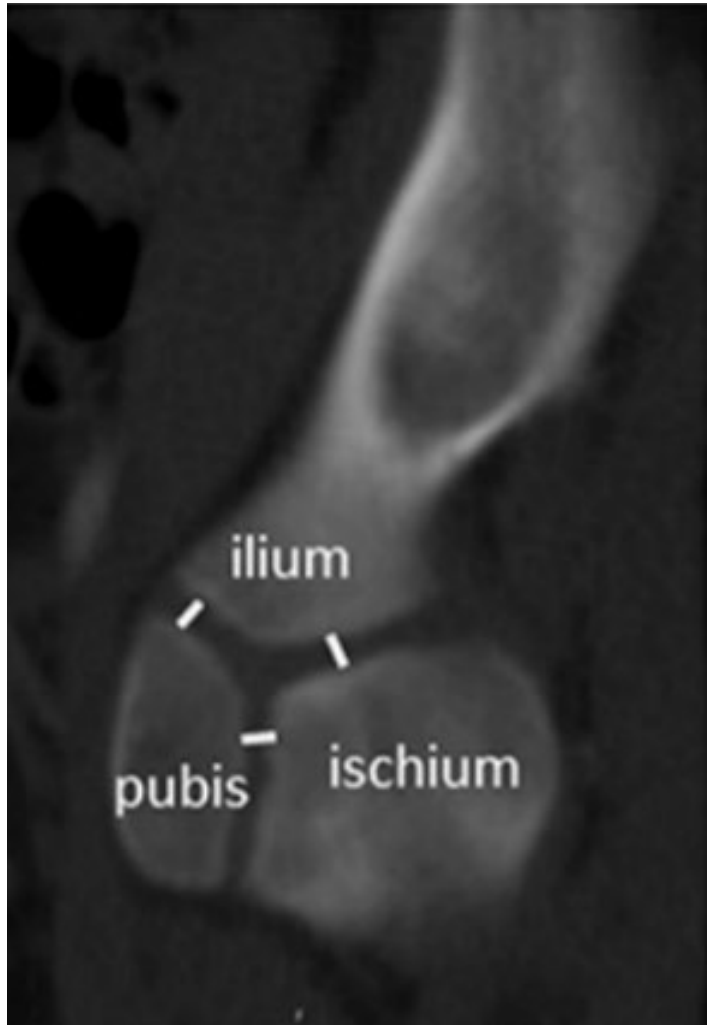
- **Differences between pelvis and acetabulum fractures in children and adults**
- **Review the clinical assessment of pelvis and acetabulum fractures**
- **Establish emergency treatment for pediatric pelvis and acetabulum in children**
- **Discuss definitive treatment of pediatric pelvis and acetabulum fractures**
- **Identify complications associated with pediatric pelvic and acetabular fractures**

Unique Pediatric Considerations

- **Greater plasticity of the pelvic bones**
- **Greater elasticity at the SI joint and pubic symphysis**
  - **Allows greater energy to be dissipated before fracture**
    - **10,000 N to break the pelvis of 1-year kid compared to 3000-6000 to cause fracture of 14-years**
  - **Higher likelihood of a single fracture of the ring**
  - **Can have significant intrapelvic injury with nondisplaced fractures**
- **Presence of apophyses**
  - **Growth plates are weaker locations/more susceptible to injuries**
    - **Allow for occurrence of avulsion fractures**

Patho-anatomy

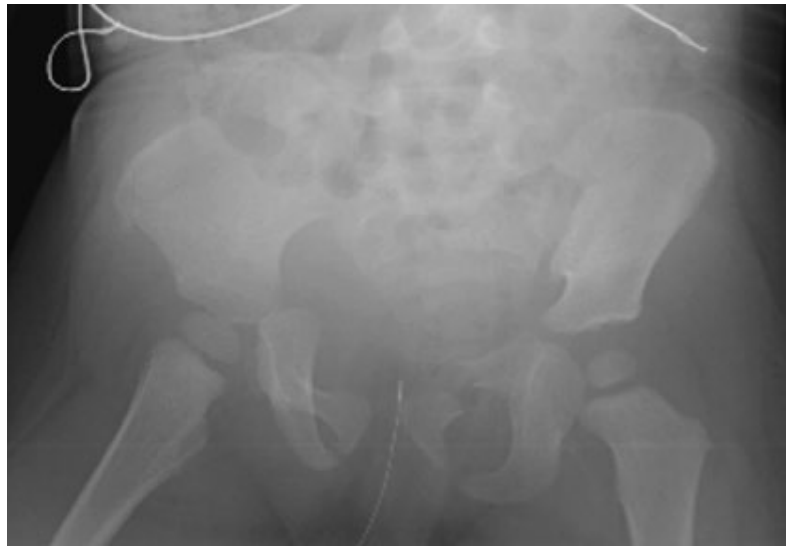
- **The pelvis has three primary ossification centers joined at the <u>triradiate cartilage (TRC)</u>**
  - **Ilium**
  - **Pubis**
  - **Ischium**
- **TRC fuses at 12-14 years**



Pelvic fractures

Epidemiology

- **Rare injuries**
  - **Less than 1% of all pediatric fractures**
- **Found in 5% of admitted children to Level I trauma centers with blunt trauma**
- **Mortality is high as high 25%**



Mechanism of Injury (MOI)

- **MVC:**
  - **Occupants of wheeled vehicles**
- **Auto vs Pedestrian**
  - **Struck by motor vehicle while riding bike or motorcycle**
- **Fall from heights**

Associated injuries

- **Found in 58% to 87% of cases**
- **Most common associated injury is another fracture**
- **Associate with approximately half of children with pelvic fractures**
  - **Lower extremity**
  - **Spine**
  - **Traumatic brain injury (TBI) ----9%-50%**
    - **Leading cause of death**
  - **Thoracoabdominal injuries------14% -33%**
    - **2nd leading cause of death**

Associated injuries

- **Open fractures**
  - **Rare occurrence**
  - **High rates of infection**
  - **Must be identified promptly and treated with I&D and repair**
- **Peripheral nerves injuries occur in ~3% of cases**
- **Vascular injuries are found in less than 1%**
  - **Compared to 3.4% in adults**
- **Low rates of hemorrhage in children due to:**
  - **Good vascular response by vascular constriction in response to hemorrhage**

Associated injuries

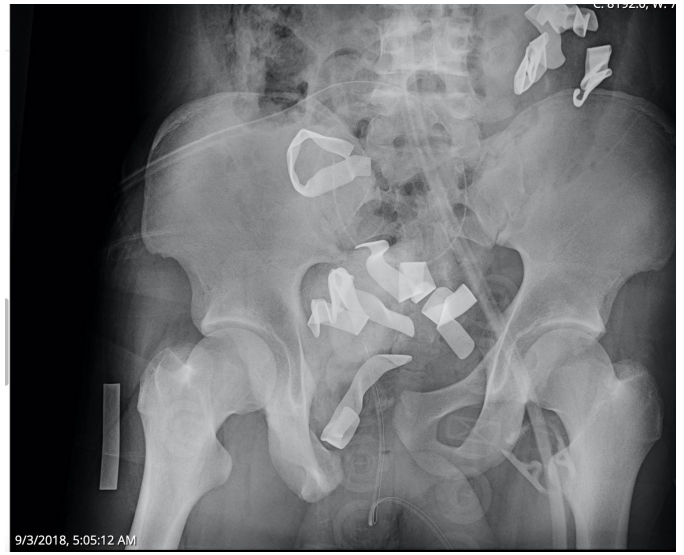
- **Rectal or vaginal lacerations (2%-18%)**
  - **Most seen in open fractures**
  - **Rare in children**

- **Genitourinary injuries (urethral and bladder lacerations) (4%)**
  - **Hematuria is present in up to 50% of pediatric pelvic fractures**
    - **17% have a GU injury**

Morbidity and Mortality

- **Significant hemorrhage requiring transfusion occurs in up to 30%**
  - **Anterior and posterior injury**
  - **Unstable injuries**

- **Mortality rates of 2- 12%**
  - **“Demetriades, J Trauma 2003, Heinrich SD 1994, JBJS A’’**



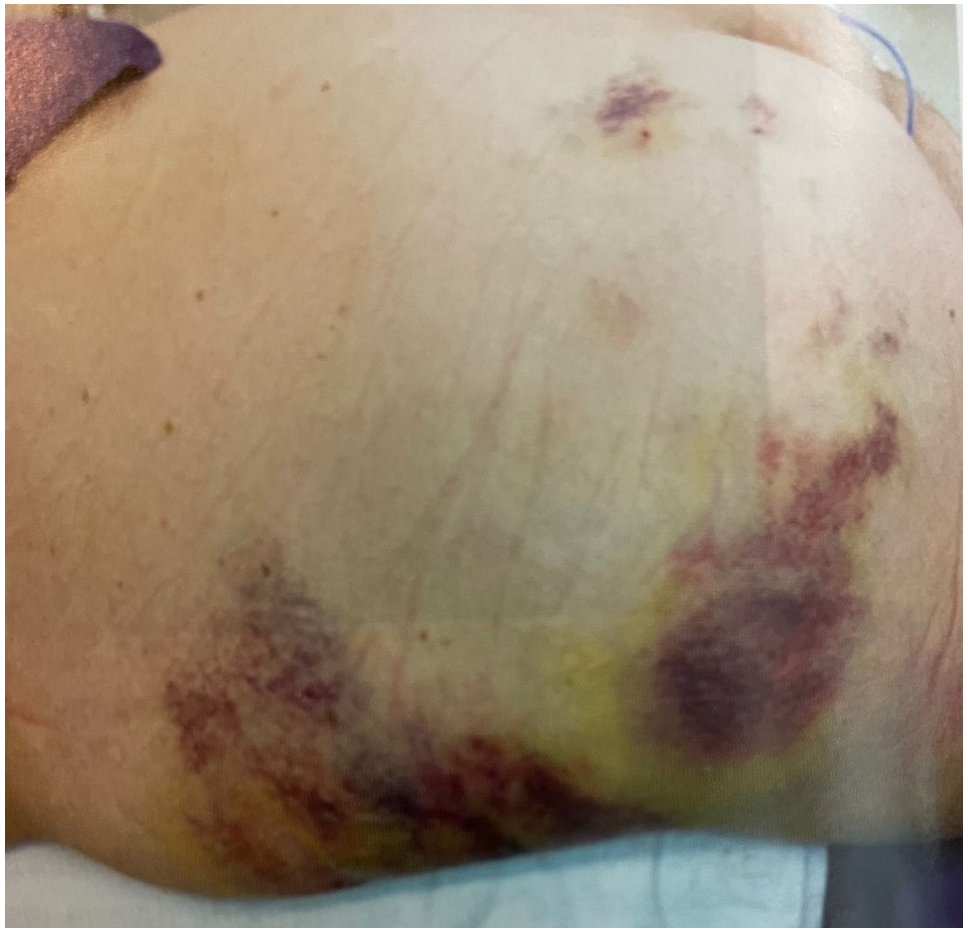
Initial Evaluation and Management

- **ATLS protocol:**
  - **Primary survey**
    - **Airway**
    - **Breathing**
    - **Circulation**
    - **Disability**
    - **NV exams**

- **GCS score: reliability of clinical exam is decreased when GCS <13**

Initial inspection

- **Complete evaluation of pelvis and perineum area**
  - **Lacerations**
  - **Ecchymosis**
    - **MUST log-roll the patient for complete inspection**
- ***Morel-Lavallee lesion***
  - **Shearing off of skin and subcutaneous tissues from underlying muscles**
    - **Creates a large space which allows hematoma accumulation**



Initial Evaluation

- Palpation of pelvic bony landmarks
  - ASIS, AIIS, iliac crest, symphysis pubis
    - Manual manipulation should be carefully performed when needed
      - Painful
      - Can potentially disrupt a clot
        - Lead to further intrapelvic bleeding

Initial Evaluation

- **Inspect the perineum**
  - **Genitourinary evaluation**
    - **Urethral injury→blood at the meatus, gross hematuria**
      - **Retrograde urethrogram indicated if urethral injury suspected**
      - **Higher rates in males**
    - **Bladder injury**
      - **Intra- and/or extra-peritoneal injuries**
      - **Cystogram used for diagnosis**
  - **Rectal evaluation**
    - **Digital rectal exam indicated in high-risk scenarios**
      - **Widely displaced fractures with blood in the perineum**

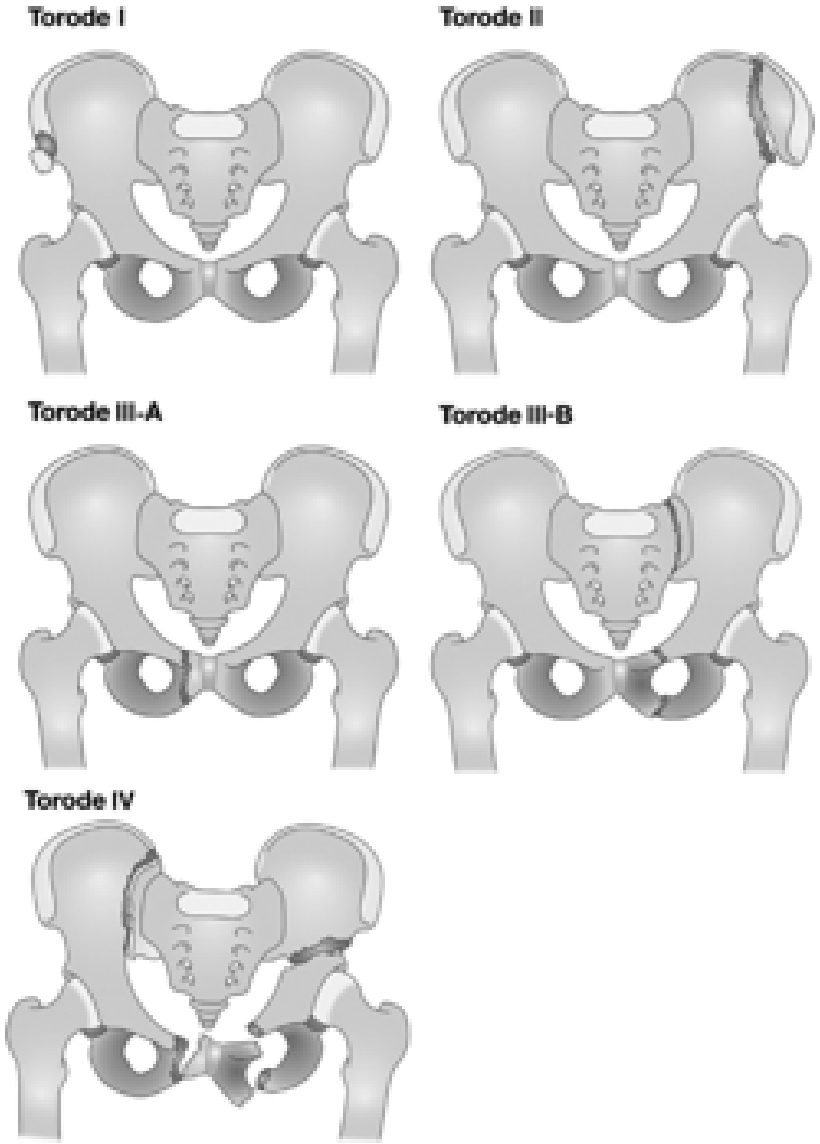
Imaging

- **AP pelvis XR obtained on all polytrauma patients**
  - **Component of initial trauma radiograph series**
  - **ATLS protocol**

- **Additional images obtained when hemodynamically stable**
  - **Inlet**
  - **Outlet**
  - **CT scans**
    - Improved visualization of SI joints and sacrum
    - Helpful for pre-operative planning
    - 3D reconstructions

Fractures Classification

- **Modified Torode and Zieg classification:**
  - **Type I**
    - **Avulsion fracture**
  - **Type II:**
    - **Iliac wing fractures**
  - **Type III:**
    - **56% of all pediatric pelvic fractures**
    - **IIIA—Stable anterior ring disruption**
    - **IIIB—Stable anterior and posterior ring disruption**
      - **Increased need for transfusion, increase length of stay, more frequent admission to ICU, more associated injuries**
  - **Type IV**
    - **Unstable ring disruptions**



Fracture Classifications

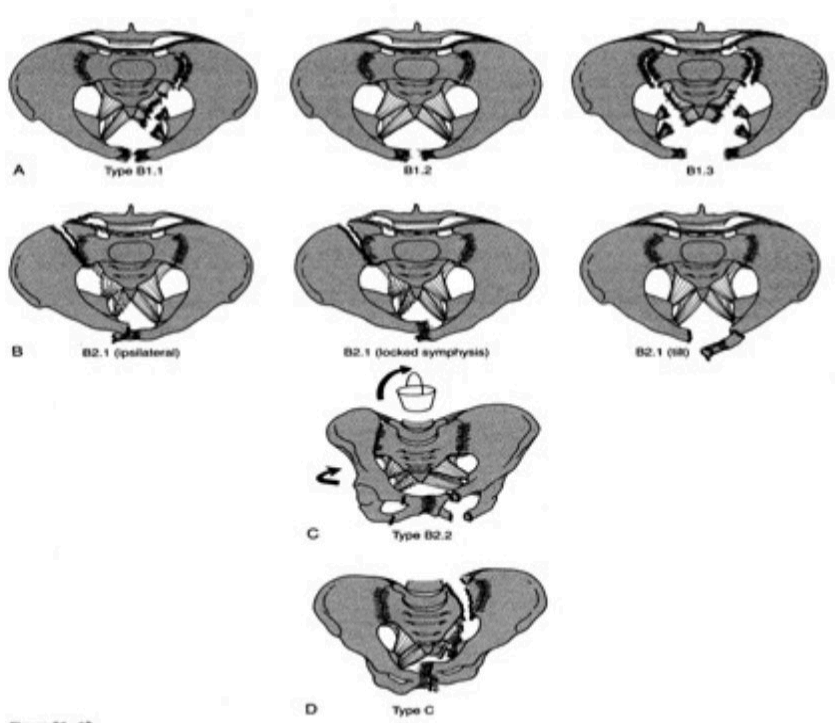
- **Based on skeletal maturity**
  - **Immature**
    - **Open triradiate cartilage (TRC)**
    - **Rarely require surgical intervention**
  - **Mature**
    - **Closed triradiate cartilage (TRC)**
    - **Classified and treated as adults**

Tile Pelvis Fractures Classification in adults

Type A: Pelvic ring stable
- A1: fractures not involving the ring (i.e. avulsions, iliac wing or crest fractures)
- A2: stable minimally displaced fractures of the pelvic ring

Type B: Pelvic ring rotationally unstable, vertically stable
- B1: open book
- B2: lateral compression, ipsilateral
- B3: lateral compression, contralateral or bucket handle-type injury

Type C: Pelvic ring rotationally and vertically unstable
- C1: unilateral
- C2: bilateral
- C3: associated with acetabular fracture



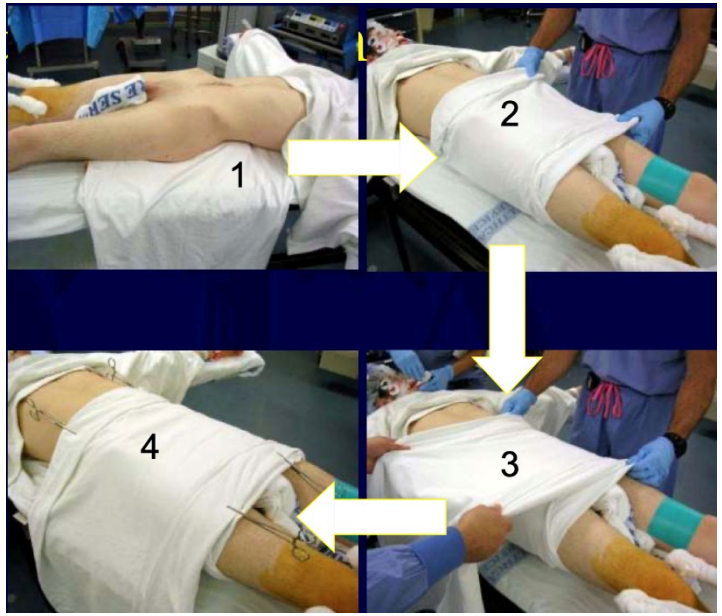
Treatment

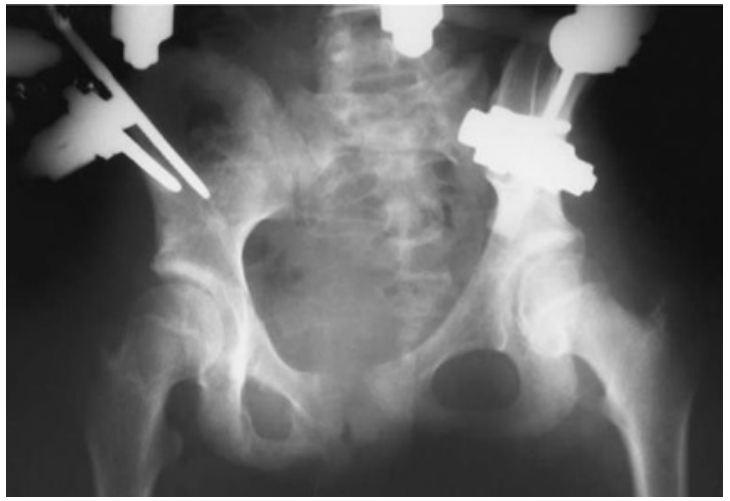
- **Life threating hemorrhage must be addressed**
  - **Follow ATLS protocol**

- **Multidisciplinary approach for associated injuries:**
  - **Head**
  - **Thoracoabdominal injuries**
  - **Urogenital injuries**

Initial Treatment

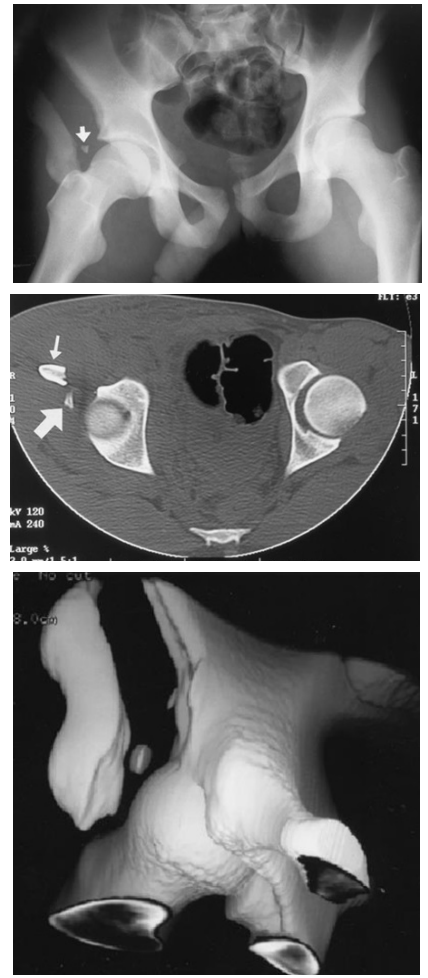
- **Resuscitation**
- **Resuscitation**
- **Resuscitation**
  - **ABCDEs of ATLS**
- **Hemodynamically unstable patients:**
  - **Other sources of bleeding should be rule out 1st**
  - **Pelvic binder or sheet at the *level of greater trochanters***
    - **Binder vs sheets application varies among institutions**
  - **Pelvic ex fix if hemodynamic instability persists**
  - **IR embolization indications**
    - **Arterial bleeding**
    - **Patient with hemodynamic instability and no other sources identified**





Treatment of Pelvic Ring Fractures

- **Isolated iliac wing fractures: (Torode and Zieg type II):**
  - **Rare (5%-14%)**
    - **More commonly seen in conjunction with additional pelvic fractures**
  - **Treatment guided by associated injuries**
    - **Pelvic ring injury**
    - **Abdominal injury**
  - **Fractures are treated non-operatively**
    - **Partial WB with crutches**
  - **ORIF is rarely needed**

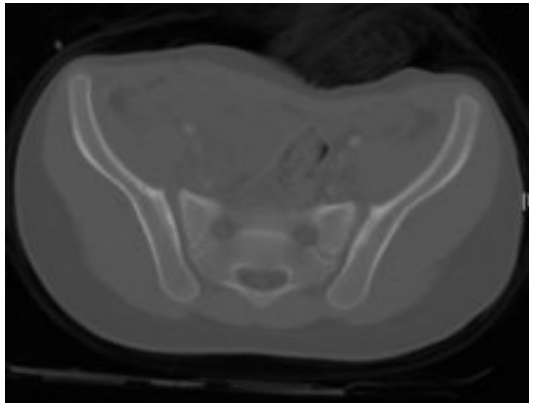


Treatment of Pelvic Ring Fractures

- **Simple ring fractures (Torode & Zieg IIIA & IIIB)**
  - **Stable fractures**
  - **Typically, minimally displaced**
- **Non-WB vs protected-WB**
  - **Close radiographic follow up to monitor fracture displacement**
    - **ORIF may be needed to aid in mobilization and pain control**
  - **Spica cast may be useful in younger kids to enforce restrictions**
- **Expect recovery in 6-8 weeks**

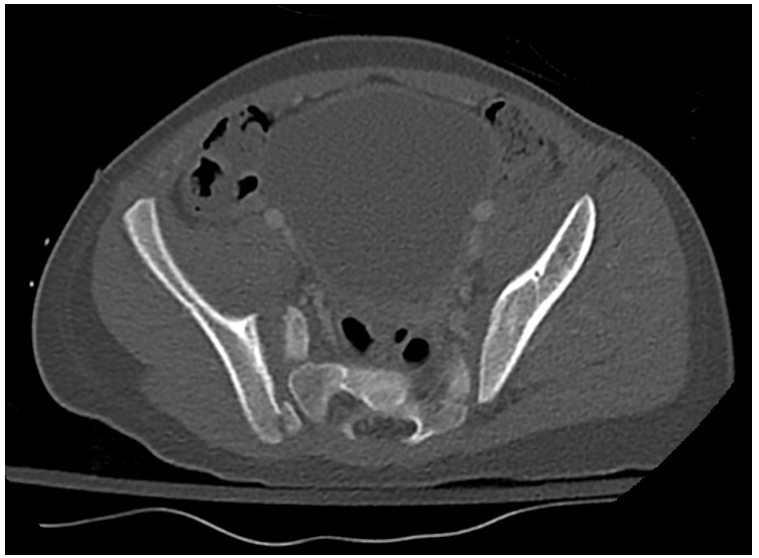
Treatment of Pelvic Ring Fractures

- **Widening of the symphysis pubis**
  - **Usually associated with posterior ring injuries**
  - **Plain radiographs and CT are helpful**
    - **Look for posterior involvement**
  - **Consider fixation if**
    - **Widening >2.5cm**
    - **Stress films demonstrate >1cm difference**



Treatment of Pelvic Ring Fractures

- **Fractures near or through the sacroiliac (SI) joint:**
  - **Most are Type IIIB fractures**
  - **Disruption can occur thru the chondro-osseous physis instead of SI joint**
  - **Crescent fractures may be associated with rotational instability**



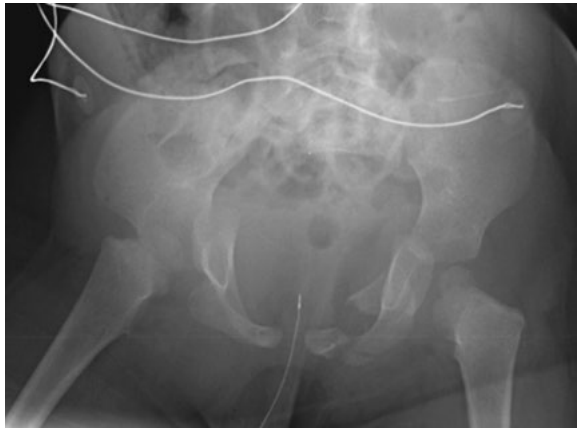
- **Stable, minimally displaced fractures are treated non-operatively**
  - **Non-WB x 4-6 WEEKS**
  - **Spica cast is occasionally needed in young children**

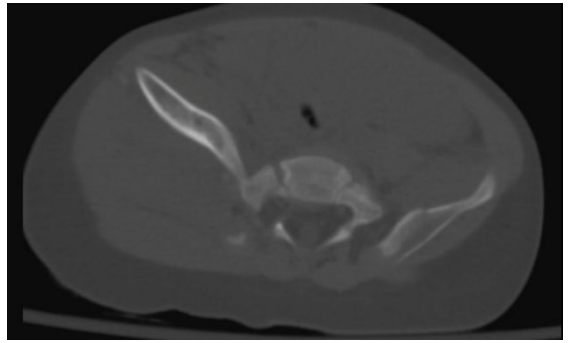
Treatment of Pelvic Ring Fractures

- **Unstable ring fractures (Torode & Zieg IV)**
  - **Double anterior ring disruptions (straddle injuries)**
    - **Beware of associated bladder injury**
    - **Produces a floating anterior segment**
    - **Weightbearing progressed as pain improves**
    - **Typical recovery in 6-8 weeks**

Treatment of Pelvic Ring Fractures

- **Unstable ring fractures (Torode & Zieg IV)**
  - **Anterior and posterior ring disruptions (double ring injuries)**
    - **Often associated with vertical instability (Malgaigne type)**
    - **Highest association with intra- and retroperitoneal bleeding**
      - **Intra-abdominal injuries may guide treatment**
  - **Minimally displaced fractures**
    - **Weightbearing restrictions with close radiographic follow-up**
    - **Spica cast in young children if needed for activity restrictions**



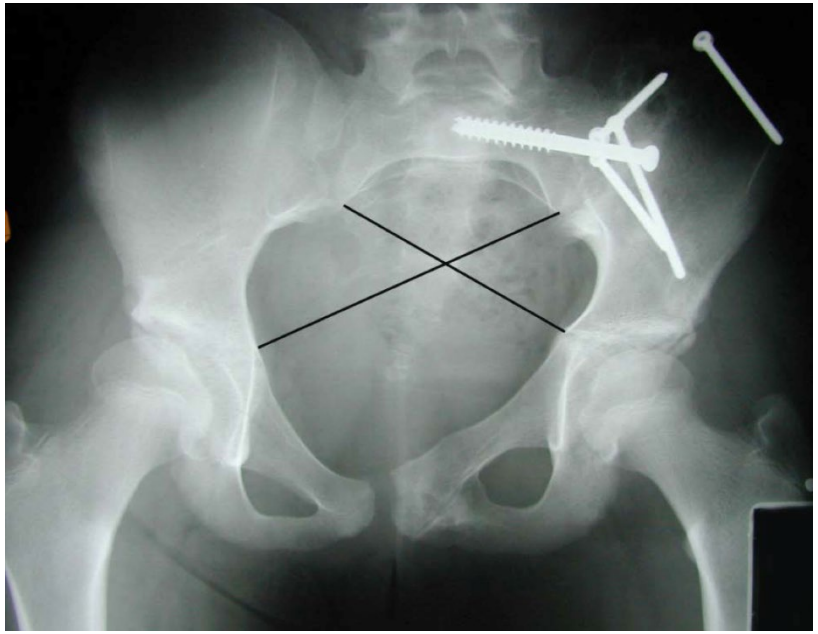


Treatment of Pelvic Ring Fractures

- Unstable ring fractures (Torode & Zieg IV)
  - Anterior and posterior ring disruptions (double ring injuries)
    - Closed reduction and spica casting
      - Symphyseal disruptions
    - Skeletal traction
      - Vertical displacement
      - Traction required for 2-4 weeks until early healing occurs
    - ORIF
      - Relative indications
        - ≥1.1 cm of pelvic asymmetry is present
        - >2cm of displacement
      - Techniques and approaches similar to adults
        - Implant and fixation modifications needed in young children

Treatment of Pelvic Ring Fractures

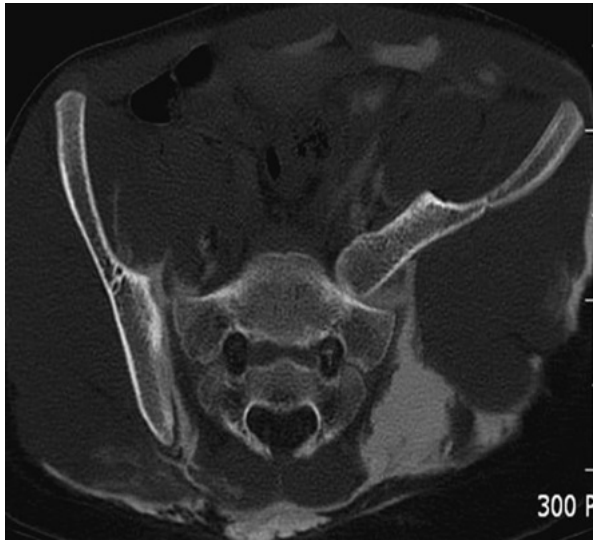
- **Pelvic asymmetry**
  - **Difference in length between two diagonal lines drawn from the border of the sacroiliac joint to the contralateral triradiate cartilage**
    - **Keshishyan et al. *CORR* 1995**
  - **This deformity does not remodel**
  - **Differences >1cm have been found to result in poor outcomes**
    - **Smith et al. *JBJS* 2005**



Treatment of Pelvic Ring Fractures

- **Unstable ring fractures (Torode & Zieg IV)**
  - **Multiple crushing injuries**
    - **Highest association of massive hemorrhage**
    - **High rate of concomitant GI or GU injury**
      - **Requires multidisciplinary approach**
    - **Associated injuries often times guides treatment**

    - **Treatment principles include**
      - **Stable pelvic fixation**
        - **Internal and/or external fixation**
      - **Multiple debridements (when associated with open fractures)**
      - **Soft-tissue management**
      - **Vigilant observation for infections**



Treatment of Considerations

- **Pediatric pelvic fractures require <u>less surgical fixation</u>**
  - **Decreased association with severe hemorrhaging**
    - **Less need for surgical fixation to control bleeding**
  - **Thick periosteum and strong ligaments restrict amount of displacement**
    - **Decreases fracture motion and increases fracture healing**
      - **Decreases need for prolonged immobilization**

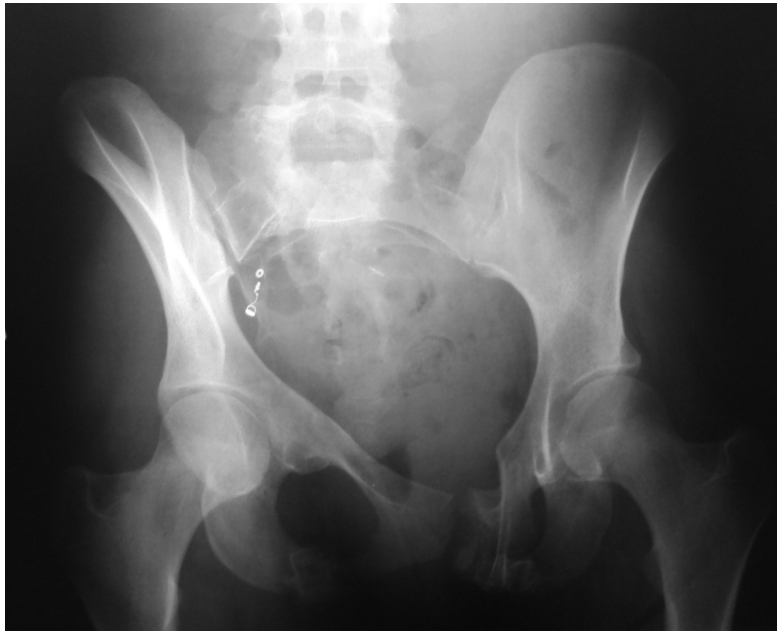
Treatment of Considerations

- **Pediatric pelvic fractures <u>posses some remodeling potential</u>**
  - **Less need for anatomic reduction**
  - **Pelvic asymmetry, SI joint malposition, acetabular orientation <u>*DO NOT*</u> remodel**

- **Long term morbidity is low after pediatric pelvic fractures**

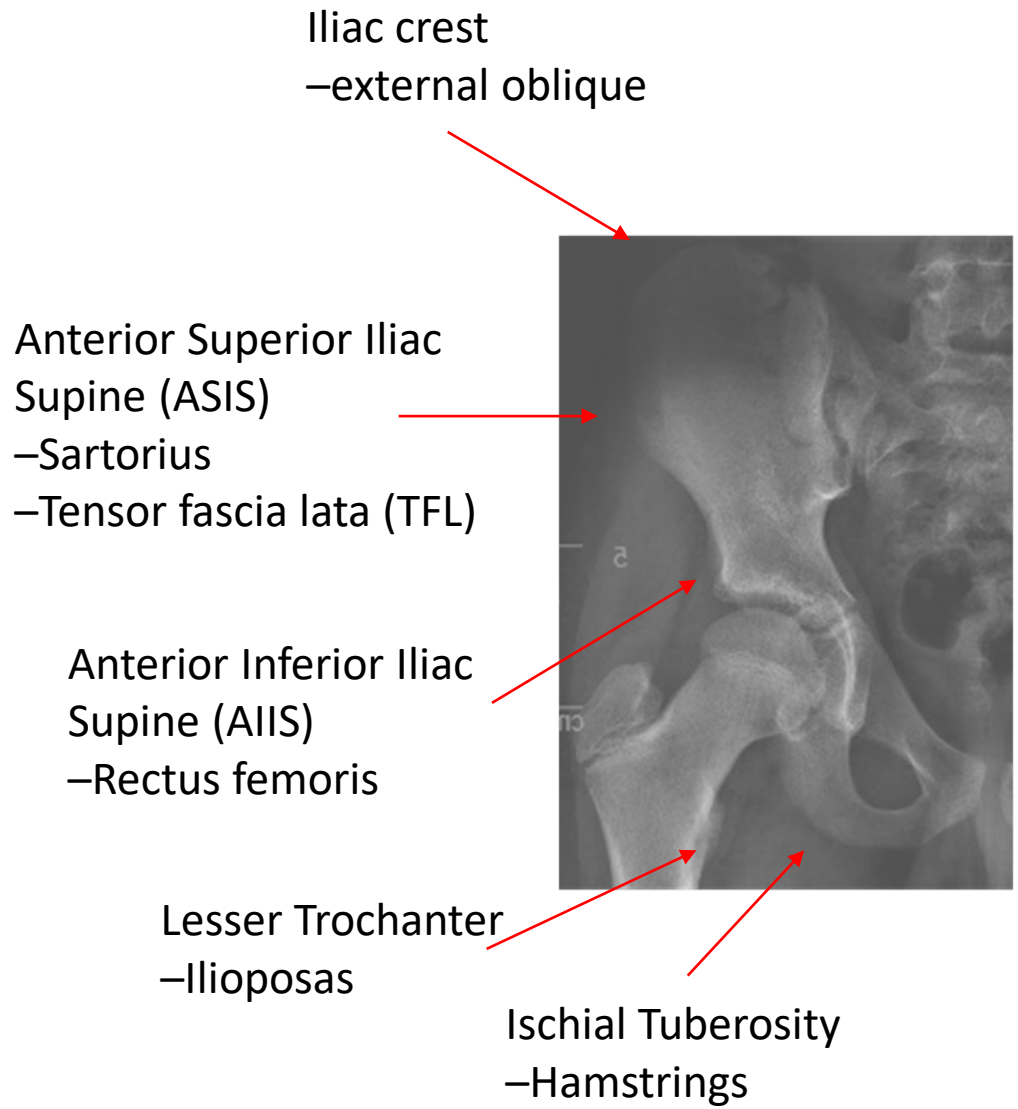
Complications

- **Pelvic deformity**
  - **Nonstructural scoliosis**
- **Limb length discrepancy**
- **Low back pain**
- **Sacroiliac pain**
- **Genitourinary complaints**
  - **Erectile dysfunction, incontinence**
- **Psychiatric disturbance**
  - **Post-traumatic stress disorder (PTSD)**
  - **Depression**



Pelvic avulsion fractures

- **Classified as pelvic fractures**
  - **Accounts for up to 15% of all pelvic fractures**
  - **Differ greatly from more traumatic pelvic ring injuries**
- **Commonly occur between the age 11-17**
  - **When secondary ossification centers are present**



Pelvic avulsion fractures

- **Frequently associated with sporting activities**
  - **Forceful contraction of large muscles during rapid acceleration or deceleration moment**
    - **Muscles crossing both hip and knee joints**
    - **Muscles originating on a pelvic apophysis**
  - **Results in an avulsion of a secondary ossification center**

Pelvic avulsion fractures

- **Most commonly presents in the outpatient setting**
- **Present with localized swelling/tenderness at site of avulsion**
- **Hip motion is limited due to guarding**
- **Pain ranges from mild to severe**
- **Pain exacerbated when involved muscle put on stretch**
  - **Ischial spine avulsion fractures—hip flexion and knee extension produces pain**
    - **Puts hamstring musculature on stretch**

Pelvic avulsion fractures

- **Radiographs are typically sufficient**
- **Comparison views may be helpful**
  - **AP pelvic radiographs allow for identification and comparison**
- **Children with delayed presentation of these fractures may mimic malignancy so MRI may be needed**
  - **Thorough H&P is vital**
  - **Possible lab work**

Treatment: Avulsion fractures

- **Non-OP treatment successful in almost all patients**
  - **Rest followed by structured rehab**

- **Operative Rx for avulsion fractures:**
  - **Surgical consideration for ischial tuberosity with**
    - **Displacement over 15-20 mm**
      - **Goal is to avoid late symptoms**
    - **Late surgery considered in setting of**
      - **Chronic pain**
      - **Symptomatic prominence after healing**
        - **Anterior hip impingement with HO from AIIS fracture**
      - **Concern about labral involvement**

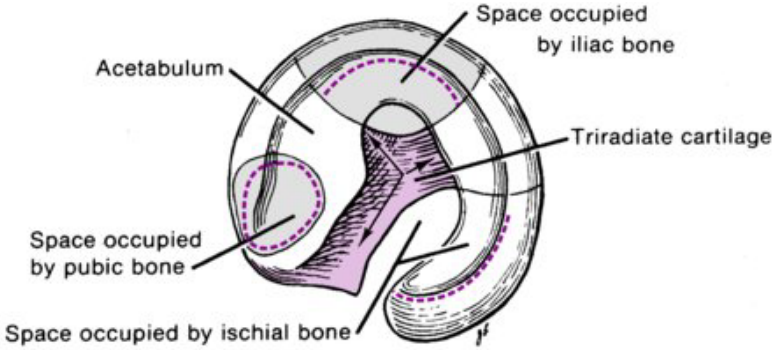
Acetabulum fractures

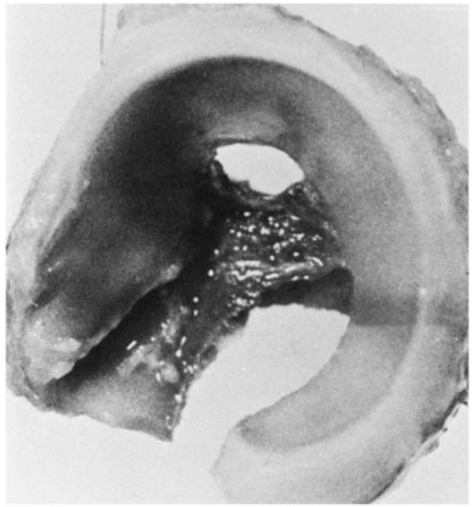
Acetabular fractures

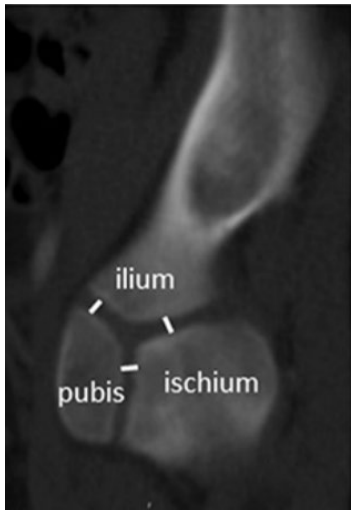
- **Acetabulum fractures uncommon in children**
  - **2-17% of pediatric pelvic fractures**
    - **Overall, 0.5-0.7% of pediatric fractures**

- **Involves the triradiate cartilage (TRC) in skeletally immature**
  - **Composed of**
    - **Ilium**
    - **Pubis**
    - **Ischium**
  - **Closes at 12-14 years of age**

  - **Potential for growth arrest after injury**
    - **Acetabular deformity**
    - **Acetabular dysplasia**



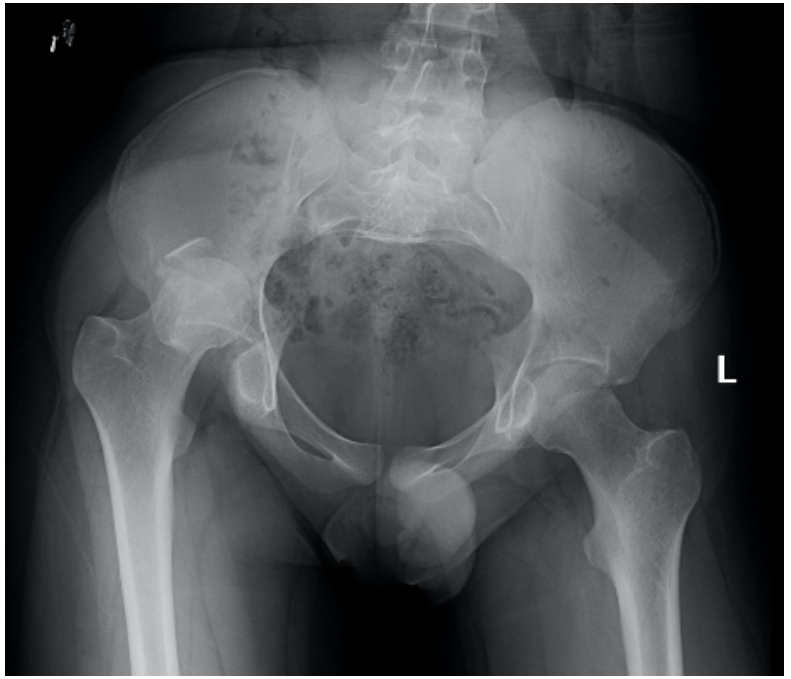




Oetgen ME, et al. Age-Based Normative Measurements of the Pediatric Pelvis J Orthop Trauma. 2017; 37(7):e205-e209

Mechanism of Injury

- **Most associated with high energy trauma**
  - **MVCs**
  - **Auto vs pedestrian**
- **Less commonly seen with low energy sports injuries**
- **Specific fracture pattern based on position of the leg at the time of impact**
  - **Direction of the force will determine**

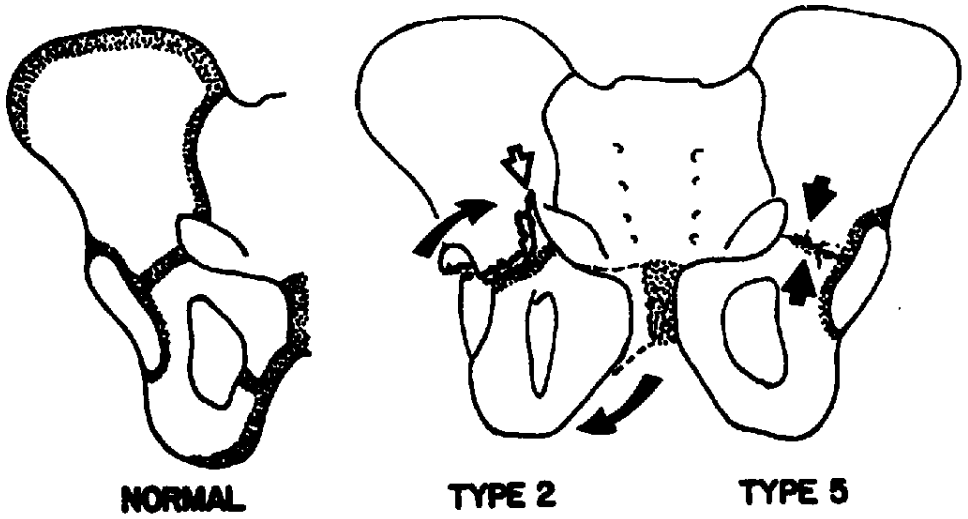


Classification

- **Watts classification:**
  - Type A – Small fragments after hip dislocation
  - Type B – Stable linear fractures without displacement
  - Type C – Linear fractures with hip joint instability
  - Type D – Fracture secondary to central fracture-dislocation of the hip

Classification

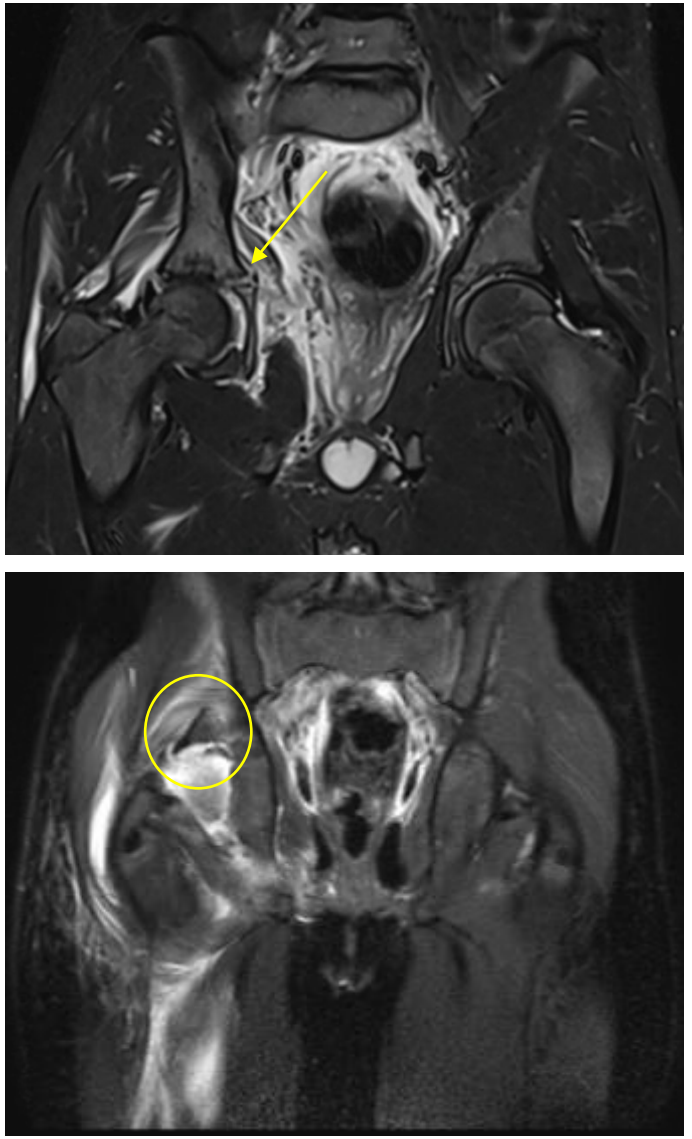
- **Bucholz classification**
  - **According to Salter-Harris (SH) classification**
    - **SH I or II—shearing mechanism**
      - **Favorable prognosis**
    - **SH V—crush injury**
      - **Poor prognosis with frequent growth arrest**
- **Adult classification can be applied in more mature patients**
  - **Letournel & Judet**



de Ridder VA, et al. Operative Treatment of Pelvic and Acetabulum Fractures. J Orthop Trauma. 2019;33 Supple 8;S33-S37

Imaging

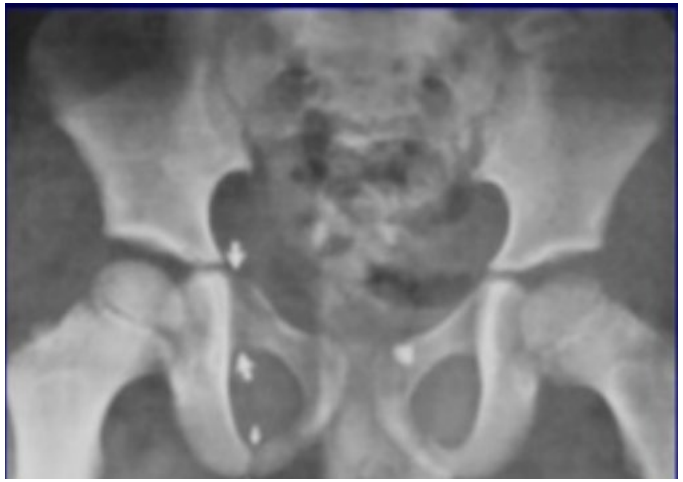
- AP of pelvis
- Judet views
  - Obturator oblique
  - Iliac oblique
- CT scan
  - Useful in more mature patients
- MRI
  - Useful in evaluating TRC
  - Accurate size assessment of cartilaginous posterior wall fragments



Treatment

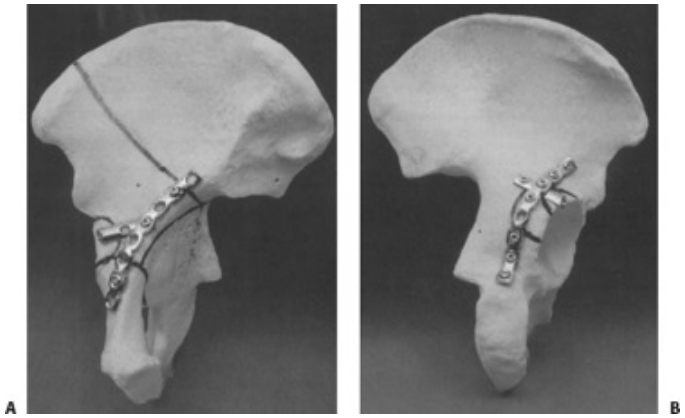
- **Goals of treatment**
  - **Restore articular congruity**
  - **Preserve alignment of triradiate cartilage**

- **Non-operative treatment**
  - **Minimally displaced (<2mm)**
    - **Non-weightbearing x 6-8 weeks**
    - **Close radiographic follow up**
    - **Spica cast used if child is unable to comply with weightbearing restrictions**
  - **Excellent outcomes expected if joint congruency maintained**



Treatment

- **ORIF**
  - **Joint displacement >2mm**
  - **Joint instability (posterior or anterior wall)**
  - **Incongruent joint**
    - **Bony fragments or soft tissue retained within articular surface**
  - **Malalignment of TRC**
    - **Displacement may lead to growth arrest**
      - **Subsequent dysplasia**
  - **Approach and fixation similar to adults**
    - **Cartilaginous fragments might require suture fixation**



Complications

- **Outcomes are typically good if a congruent, stable joint is maintained**
- **Patient should be informed about possibility of growth arrest**
  - **TRC arrests can lead to subsequent hip dysplasia and/or hip subluxation**
  - **MRI is useful tool to assess the closure of triradiate cartilage**

Take home message

- **Pediatric pelvis and acetabulum fractures are rare injuries**
- **Elasticity of pediatric bone, strong ligaments and the presence of physes distinguish pediatric pelvis and acetabulum fractures from adult fractures**
- **Non-Op Rx is the main treatment modality**
- **Pelvic asymmetry and LLD are the main complications of nonoperative treatment**
- **Operative treatment is indicated in certain situations with marked displacement**