# Fractures of the Pelvis and Acetabulum in the Pediatric Patient

## Not your typical pediatric fracture

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# Objectives

- To highlight differences between adult and pediatric pelvic and acetabular fractures
- To discuss initial management of pelvic and acetabular fractures
- To discuss surgical treatment indications for pediatric pelvic and acetabular fractures
- To discuss complications related to pediatric pelvic and acetabular fractures

# Pelvic Fractures

# Background

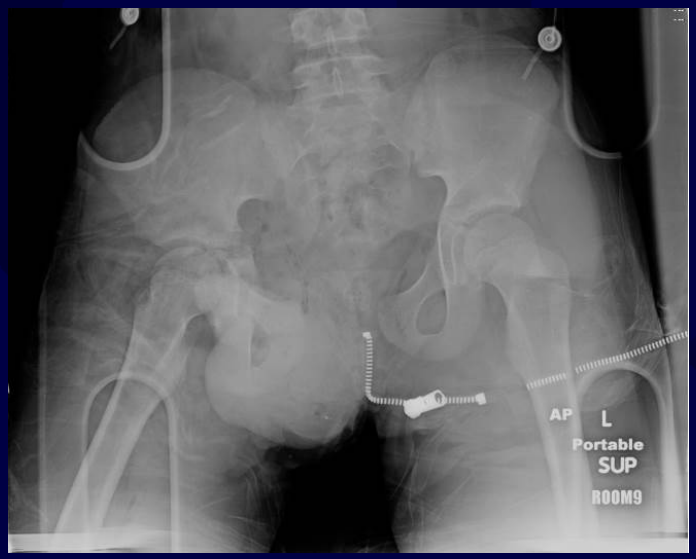
- 2.4-7.5% of all childhood fx's
- High energy injuries
- Most often stable fx's (90%)

# Pediatric Vs. Adult Pelvic Fx

- Pediatric
  - Elastic joints (symphysis & SI)
  - Avulsion fx's common
  - Remodeling?
  - Mechanism
    - ped vs auto
    - Passenger
    - Fall from height
    - Child abuse
  - Severe intrapelvic injury with nondisplaced fx's (less common)
- Adult
  - Inelastic joints
  - Fx commonly in > 1 place (hard pretzel)
  - Mechanism
    - High energy vs low energy
      - MVC
      - Fall from standing
  - Intrapelvic content injury often accompanied by severe displacement

# Pediatric Vs. Adult Pelvic Fx

- Poorly defined
- When is pelvis pediatric vs. adult?
  - < 18?
  - Open triradiate?




# Pediatric Considerations

- Ligaments stronger than bones
- High incidence of LC2/LC3: crescent fractures
- Increased incidence of Open Frxs

Slide courtesy of Wade Smith, MD

# Initial Evaluation & Management

- Trauma protocol (ATLS/PALS)
  - Airway, breathing, circulatory status
- Life-threatening injuries
- C-spine immobilization
- Comprehensive neurologic exam
- Mechanism of injury
- Medical & surgical history

# Initial Evaluation & Management

- Visual inspection
  - Pelvis, perineum, scrotum/ vagina for ecchymosis, lacerations
    - May not be obvious
  - If urethral injury suspected ⇒ retrograde urethrogram
  - Log roll
- Palpation
  - ASIS, symphysis, crests, SI joints
- Hip ROM
- Treat/prevent hypothermia

Picture courtesy of Wade Smith, MD

# Open Pelvis Fractures

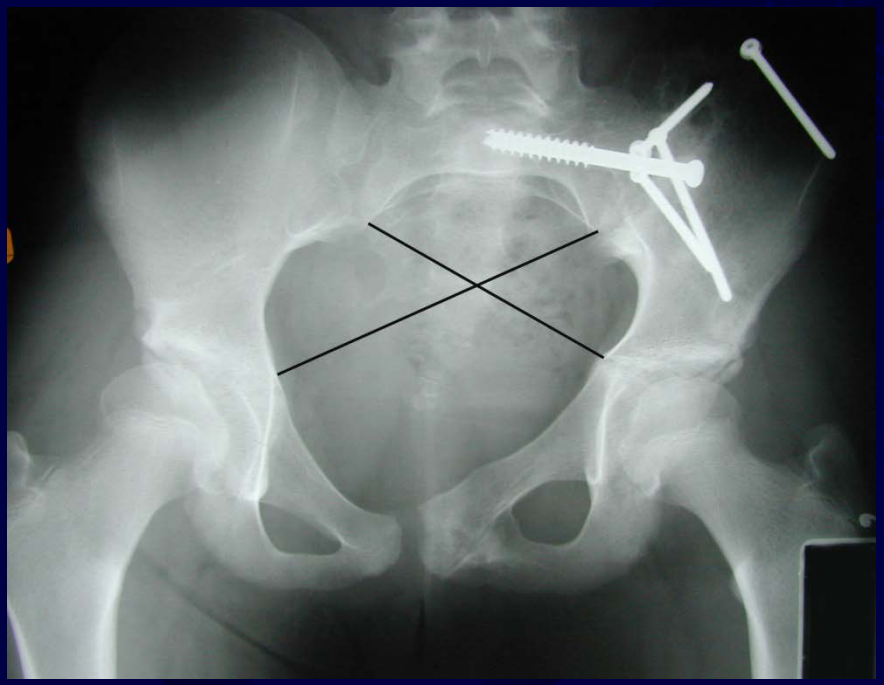
- Cover wounds in ED
- Antibiotics/ Tetanus
- **Explore in the OR!**
- Historically 20-50% mortality
- Aggressive I&D
- Stabilization
- Diverting colostomy

Slide courtesy of Wade Smith, MD

# Diagnostic Tests

- Routine Trauma AP pelvic XR
  - May not need if:
    - GCS > 10
    - HD stable
    - No SCI
    - Negative pelvic exam
    - No hematuria
- When fx present, consider CT scan, inlet, outlet
  - When stable

# Diagnostic Tests



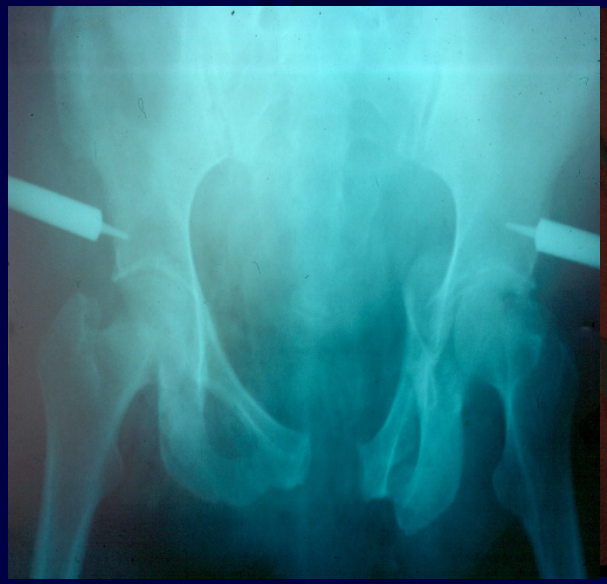
- Pelvic obliquity
- Keshishyan et al
- Difference in length border SI to triradiate
- Pelvic asymmetry if > 4 mm difference

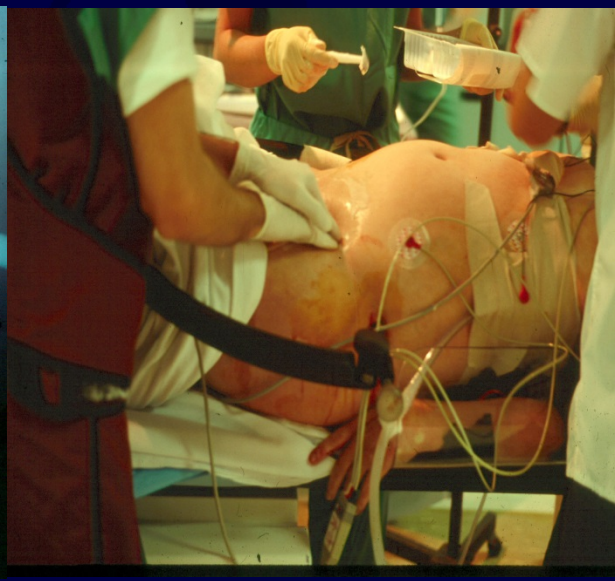
Image courtesy of Wade Smith, MD

Keshishyan RA, et al. Pelvic polyfractures in children. Radiographic diagnosis and treatment. Clin Orthop Relat Res. 1995 Nov;(320):28-33.

# Initial Management

- Similar to adults:
  - Rapid identification
  - Resuscitation
  - Resuscitation
  - Resuscitation
  - Mechanical Fixation where indicated
  - Angiography/PPP



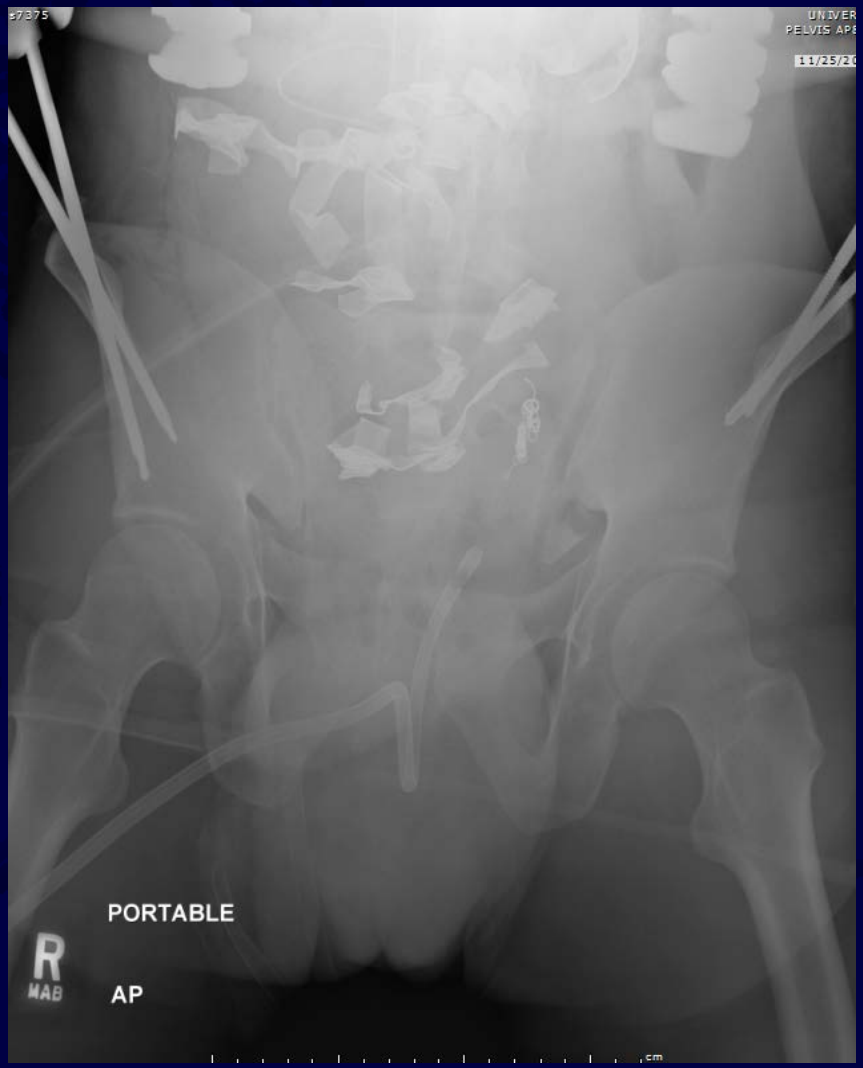


Pictures courtesy of Wade Smith, MD

# Mechanical Stabilization

**Function**

- Splint/stabilize bone
- Splint soft tissues
- Decrease/stabilize pelvic volume
- Decrease pain/catecholamines
- Protect blood clot



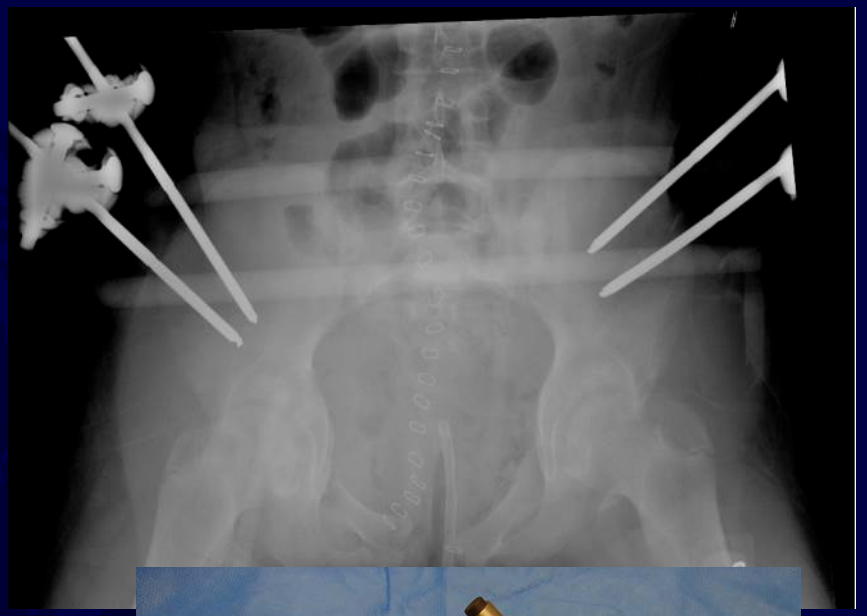
# Mechanical Stabilization

**Keep It Simple!**

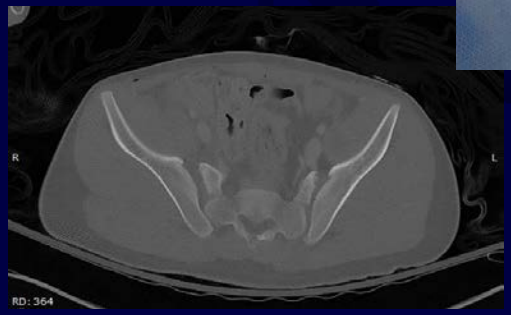
- Pelvic wrap, binder
  - Broad surface area
- Tape legs together
- External fixation
- Resuscitation clamp
- Allow access for laparotomy
- Skeletal traction

Slide adapted from Wade Smith, MD

# Ex Fix Considerations in the Pelvis



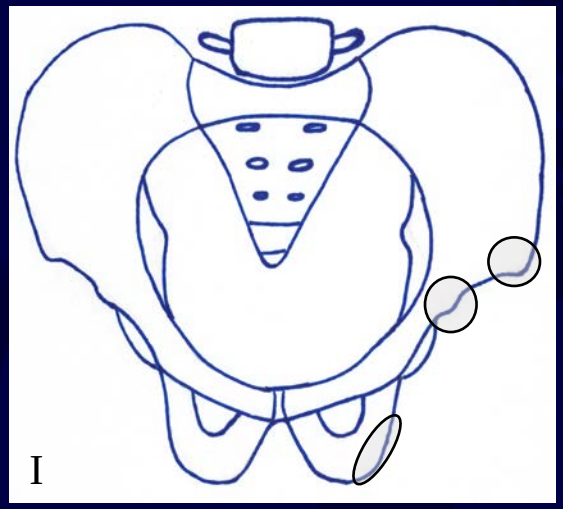
- Simple frames
- Pin location
  - Iliac Crest frames
  - Anterior (AIIS) frames
    - Uses flouro/OR
- Provide poor posterior control
- Wasting time?

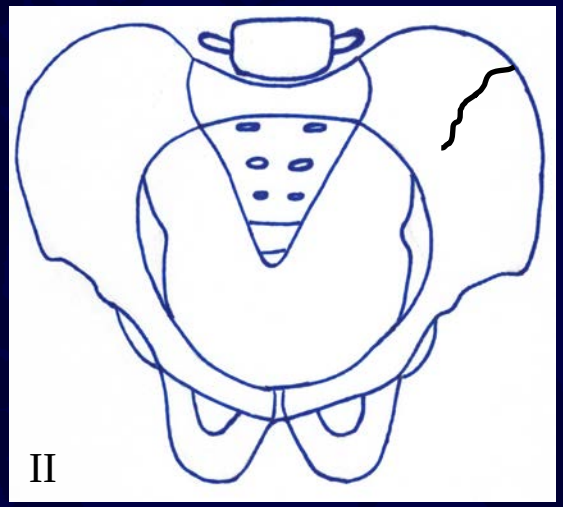


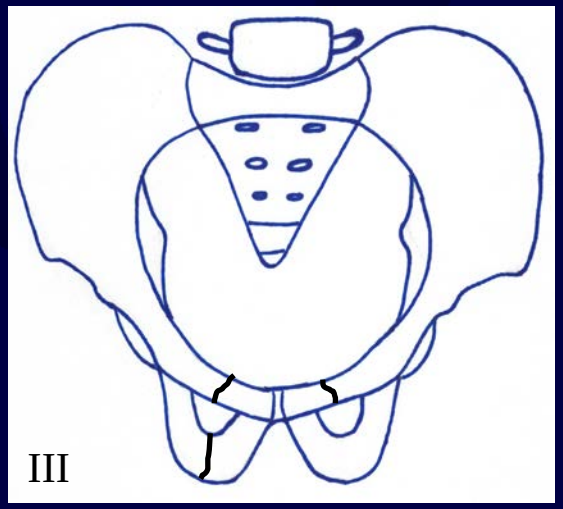
# Fx Classification

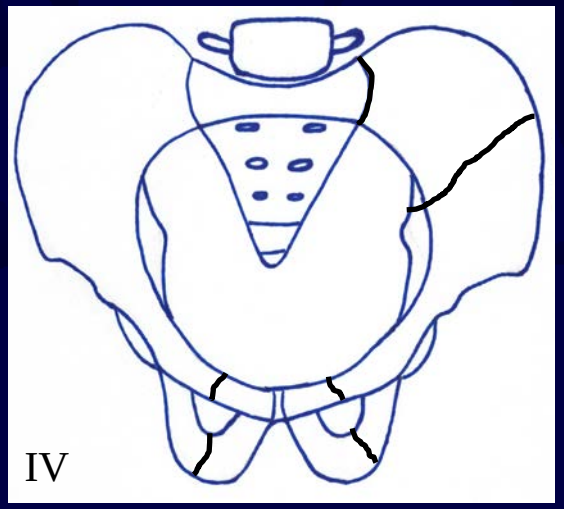
- Torode & Zieg
  - Type 1
    - avulsion fx
  - Type 2
    - iliac wing fx
  - Type 3
    - “simple” ring (anterior)
  - Type 4
    - Ring disruption (bilateral rami, SI joint)
    - Unstable
- Tile
  - Type A
    - Stable
  - Type B
    - Unstable rotationally
    - Incomplete posterior disruption
  - Type C
    - Unstable vertically and rotationally
    - Complete posterior disruption

# Torode & Zieg Classification



# Tile Classification

- Applicable in patients near skeletal maturity
  - More often adult type patterns
- Type A – Stable
- Type B – Rotationally unstable, vertically stable
- Type C – Rotationally and vertically unstable

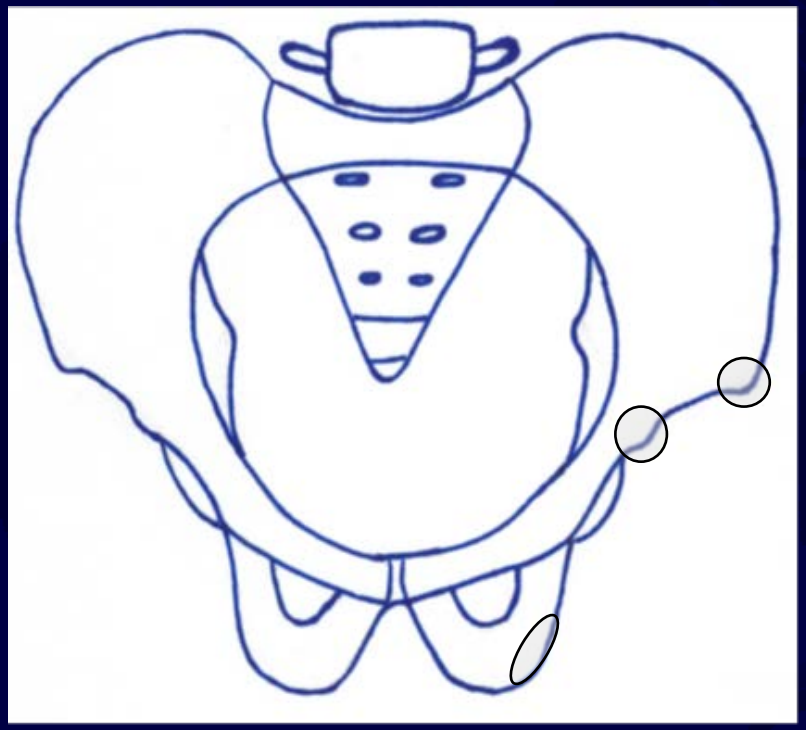
# Secondary Ossification Center

- Iliac Crest : first seen at age 13 to 15 and fuses at age 15 to 17 years
  - Used in Risser staging
- Ischium : first seen at age 15 to 17 and fuses at age 19 to 25 years
- ASIS : first seen about age 14 and fusing at age 16

***Important to know these secondary ossification centers so they will not be confused with avulsion fractures**

Slide courtesy of Joshua Klatt , MD and Steven Frick, MD

# Relative Percentages of Pelvic Avulsion Fracture Locations

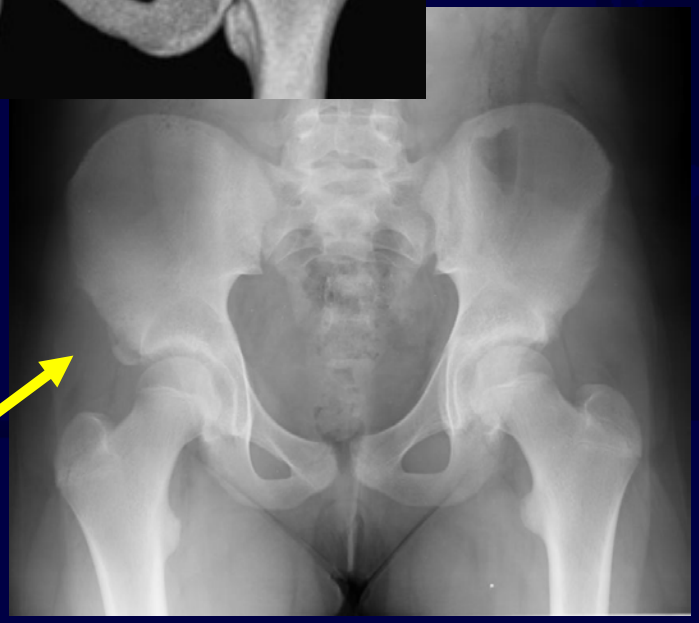


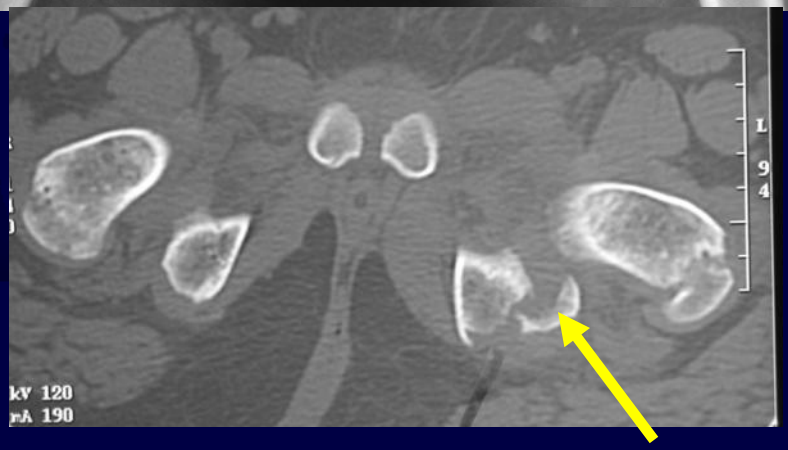
- Fx's occur through apophysis (Torode I)
  - Ischial tuberosity – 54%
  - AIIS – 22%
  - ASIS – 19%
  - Pubic Symphysis – 3%
  - Iliac Crest – 1%

Rossi F, Dragoni S. Acute Avulsion Fractures of the Pelvis in Adolescent Competitive Athletes. *Skeletal Radiol.* 2001;30(3):127-31.

Slide adapted from of Joshua Klatt , MD and Steven Frick, MD

# Examples of Avulsion Fx's





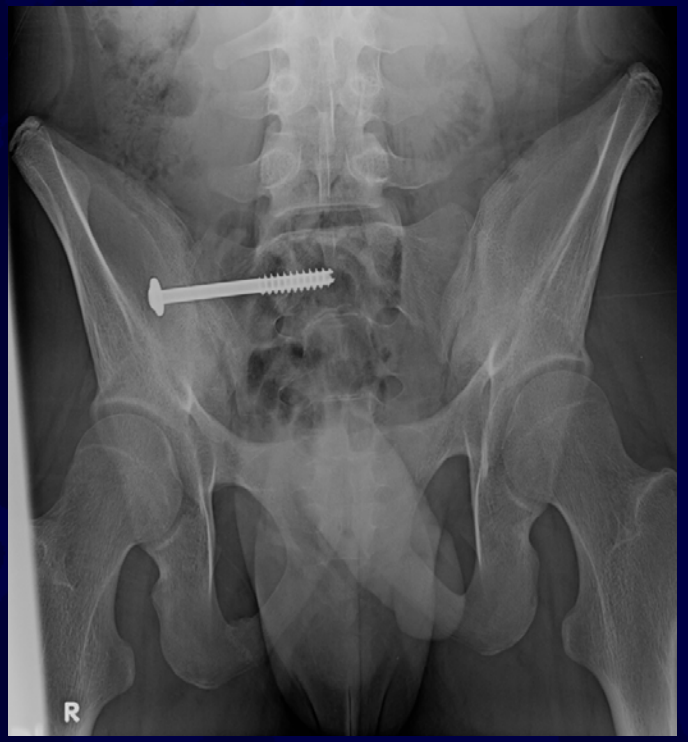

Images courtesy of Journal of Orthopaedic Trauma, Joshua Klatt , MD and Steven Frick, MD

# Pediatric Pelvic Fractures Require Surgery Sometimes Too!

- Watts, 1976: 66 peds/trauma deaths- 42% died of pelvic fracture/exsanguination
- Bucholz (’82), Ebraheim (94’), Torode (’85): 30% of survivors have residual impairments
- Few articles but differing conclusions regarding effect of surgery on outcome

# Treatment

- Indications for operative treatment
  - Open pelvic fx
  - Instability (Torode 4, Tile C)
  - Displacement > 2 cm
  - >1 cm pelvic asymmetry?



# Treatment

- Smith et al. JBJS, 2005, pp 2423-2431
  - All patients had open triradiate cartilage and unstable pelvic fx
  - 6 yr f/u
  - Short MSK Function Assessment (SMFA)
  - Pelvic asymmetry did not remodel
- All pts with > 1.1 cm pelvic asymmetry had at least 3/4:
  - nonstructural scoliosis
  - lumbar pain
  - Trendelenburg gait
  - SI tenderness

# Treatment Summary by Torode Classification

- Torode & Zieg 1
  - Symptomatic
  - Protected WB 4 wks
  - Stretch & strengthen

- Torode & Zieg 2
  - Symptomatic
  - Protected WB 4 wks
  - Stretch & strengthen
- Torode & Zieg 3
  - Symptomatic
  - Protected WB 6 wks
- Torode & Zieg 4
  - Bedrest/Symptomatic +/- traction (< 2 cm displacement)
  - > 2 cm displacement ⇒ fix
    - Ex-fix (rotation)
    - ORIF
    - Percutaneous

# Complications

- ~~Nonunion~~
- ~~Instability~~
- Malunion
- Leg-length inequality
- Low back pain
- Myositis ossificans
- Neurologic defects

# Complications

- Study of German Trauma Registry
- 208 pediatric pelvic fx's compared to 13,317 adults
- No cases in children of
  - VTE
  - ARDS
  - MOF

Zwingmann J, et al. Pelvic fractures in chldren results from the German pelvic trauma registry: A cohort study. Medicine (Baltimore) 2015 December; 94(51): e2325.

# Acetabular Fractures

# Background

- Uncommon
- 1-15% of pelvic fractures
- Even less literature than ped pelvic fx
- Most often in adolescents

Image courtesy of Joshua Klatt , MD and Steven Frick, MD

# Background

- High energy injury mechanism most common
- Triradiate cartilage
  - In younger pts, fx's through triradiate can occur with lower injury mechanisms

Image courtesy of Joshua Klatt , MD and Steven Frick, MD

# Pediatric Vs. Adult Tab Fx

- Pediatric
  - Elastic joints
  - ~~Remodeling?~~
  - Growth arrest
  - Mechanism
    - ped vs auto
    - Passenger
    - Fall from height
    - Child abuse
  - Pattern depends on position of hip at impact
- Adult
  - More common than in children
  - Mechanism
    - High energy vs low energy
      - MVC
      - Fall from standing
  - Pattern depends on position of hip at impact

# Classification

- Watts
  - Type A
    - Small fragment a/w hip dislocation
  - Type B
    - Nondisplaced a/w pelvic fx
  - Type C
    - Fx w/hip joint instability
  - Type D
    - Central fx/dislocation

Image courtesy of Joshua Klatt , MD and Steven Frick, MD

# Classification

- Bucholz
  - Open triradiate cartilage
    - Acetabular growth abnormality frequent complication
    - Results in acetabular dysplasia, hip incongruity
  - Two injury patterns described
    - Shear Fx
      - Salter-Harris I or II
      - Thurston-Holland fragment may be visualized
      - Central displacement distal acetabulum
    - Crush Fx
      - Salter-Harris V
      - Narrow growth plate suggests injury
      - Worse prognosis, growth disturbance common

# Treatment

- Indications for operative treatment
  - Incongruent hip joint (fx fragment, labrum [MRI])
  - Displaced fx of weightbearing dome
  - Fx involving any displacement of triradiate cartilage
  - Joint instability

“Treatment Should Not Be Commenced Until a Full Understanding of The Fracture Is Achieved.”

Letournel

# Treatment - Exposure

- Surgical approach is chosen based on pattern of injury, displacement
  - Determine where you need to get direct access to in order to fix the fx, then choose approach based on that
  - Indirect access is often possible for reduction of AC through posterior approach, PC through anterior approaches
    - Reduction and fixation of wall fx's requires direct access

# Treatment - Exposure

| Anatomic Location | Exposure(s) |
|---|---|
| Anterior Column | Anterior Intrapelvic Approach (AIP), Ilioinguinal, Smith Peterson (SP) |
| Anterior Wall | AIP, Ilioinguinal, SP |
| Posterior Column | Posterior approaches (ie. Kocher-Langenbeck [KL]) |
| Posterior Wall | Posterior approaches (ie. KL) |
| Both Columns | Anterior or Posterior (typically side with greater displacement), Dual approaches, Extended Illiofemoral (rare) |

**Standard posterolateral approach for hip arthroplasty is not the same as KL and not an acceptable approach for fixation of acetabular fx's!

# Treatment

- Heeg & Ridder (Clin Orthop Relat Res. 2000)
- 29 pts (2-16 y/o)
- 14 yr avg f/u
  - 13 nonop
  - 2 arthrotomy
  - 14 ORIF
- Satisfactory outcome in all pts with nondisplaced fx
- 21% fair or poor results
- Central fx dislocation (Watts D) poor results

“The quality of the initial surgical reduction was the factor most commonly associated with the eventual development of posttraumatic osteoarthritis as well as with the eventual development of a fair or poor clinical outcome”

**Matta J. Fractures of the acetabulum: accuracy of reduction and clinical results in patients managed operatively within three weeks after the injury.** ***J Bone Joint Surg Am.*** **1996;78:1632-45.**

# Complications

- Premature fusion of triradiate cartilage ~5%
  - Acetabular dysplasia
  - Shallow acetabulum
  - Hip subluxation

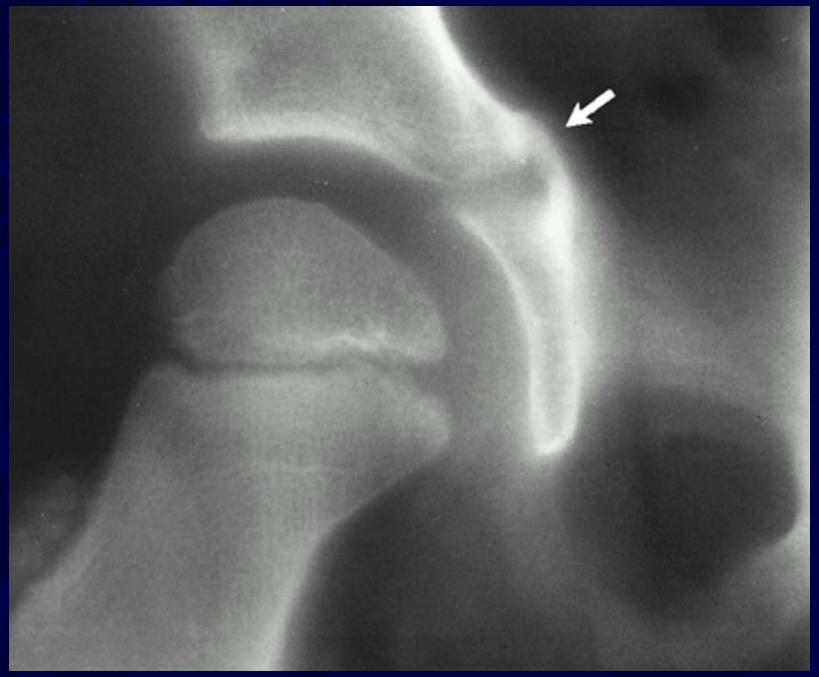


Image courtesy of Joshua Klatt , MD and Steven Frick, MD

# Complications

- Age is most important risk factor in the development acetabular dysplasia following pediatric acetabular fracture
- Greatest risk is in children < 10 y/o at the time of injury

# Operative Treatment
## *Late Reconstruction (Salvage)*

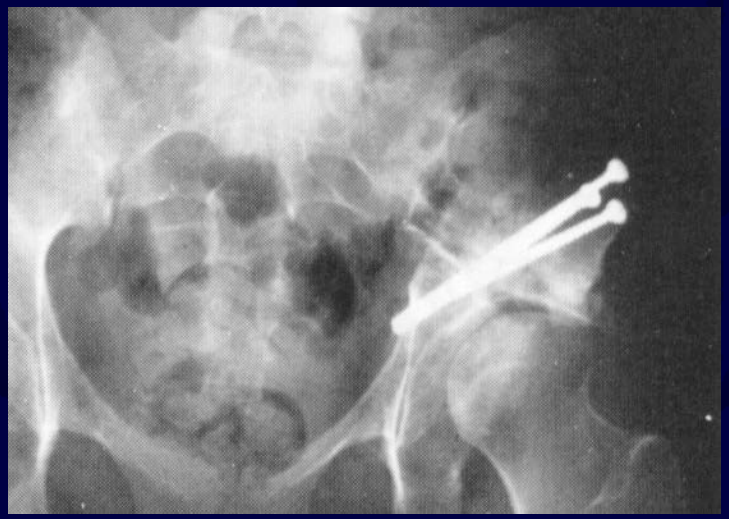
- Two case reports
  - Blair and Hanson: JBJS(A) 1979
  - Scuderi and Bronson: CORR 1987
- Conservative management initially
- Premature closure of triradiate cartilage
- Symptomatic treatment
- Chiari osteotomy 2 to 3 years prior to maturity

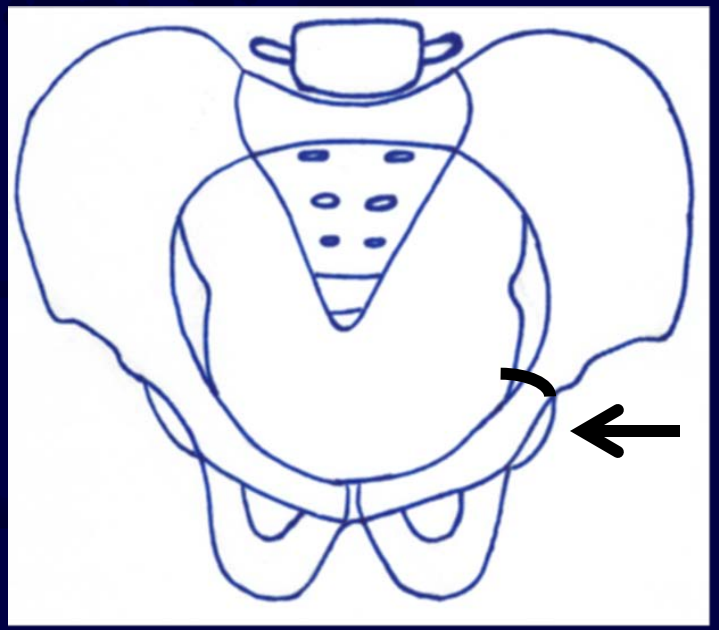
Slide courtesy of Joshua Klatt , MD and Steven Frick, MD

# Operative Treatment
## *Late Reconstruction (Salvage)*

Conclusion:

- Long-term results unknown
- Salvage procedure





Chiari Osteotomy

Image courtesy of Joshua Klatt , MD and Steven Frick, MD

# Summary – Peds Pelvic Fx's

- Stable fx's can be treated nonoperatively
- Unstable fx's and those with > 2 cm displacement typically need surgical treatment
- Low risk of VTE after pelvic fx in pediatric patients
- Remodeling does not likely occur to an appreciable degree
- >1 cm of pelvic asymmetry at time of healing will likely lead to chronic sequelae

# Summary – Peds Acetabular Fx's

- Rare
- Nonoperative treatment reserved for nondisplaced fx's
- In adolescents treat with similar principles as adult acetabular fx's
  - In younger patients attempt smooth wire fixation when crossing physis
- Follow closely for growth plate injury/physeal bar formation/dysplasia in young pts