Pediatric Hip Fractures and Dislocations

John Junsuk Lee, MD MS

Associate Chief of Orthopedic Trauma

Good Samaritan Hospital, West Islip, NY

Disclaimer

- All clinical and radiographic images provided are used with permission of John Lee, MD and Chris Souder, MD, unless otherwise specified

Objectives

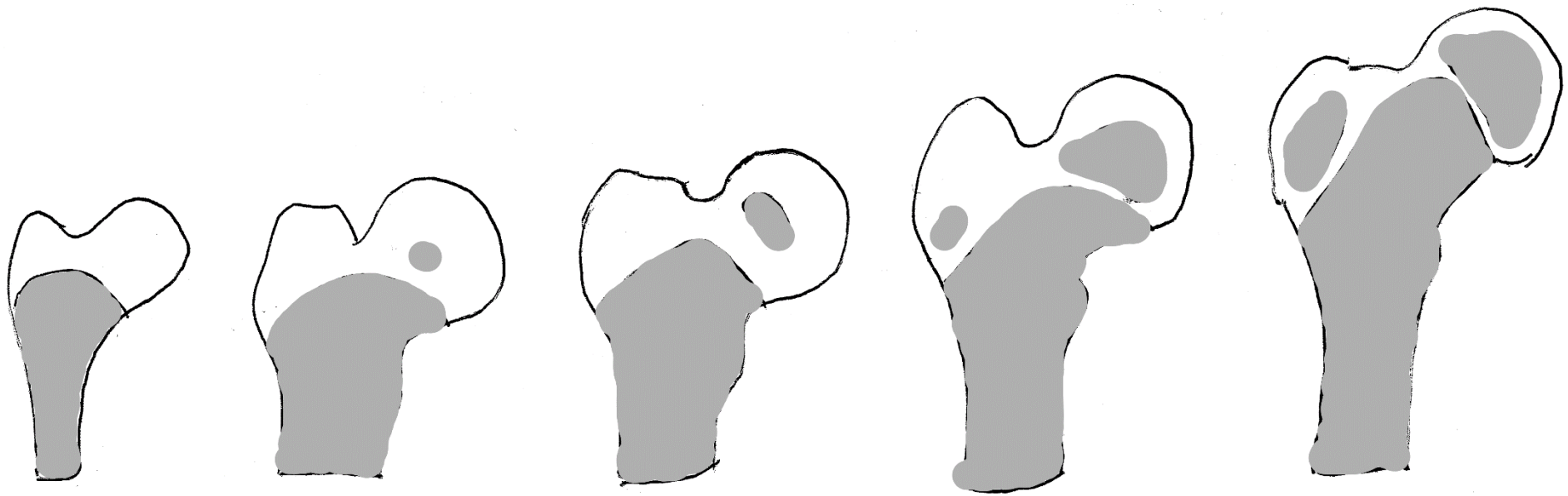
- **Understand the anatomy and development of the pediatric proximal femur**
- **Recognize the fracture types (Delbet classification)**
- **Review the treatment options**
- **Identify complications**
- **Review pediatric hip dislocations**

Pediatric Hip Fractures

- **Rare**
  - **< 1% of all pediatric fractures**
- **Commonly a result of a high energy mechanism**
- **High complication rates and poor outcomes when compared to other pediatric fractures**
- **Poor outcomes can be due to severity of associated injuries**

Courtesy of Chris Souder, MD

Pediatric Proximal Femur



Single Physis → Epiphyseal Nucleus Develops → Greater Trochanter Ossific Nucleus Develops

Maturity at 14 years for girls and 16 years for boys

Pediatric Proximal Femur

7 month old MRI

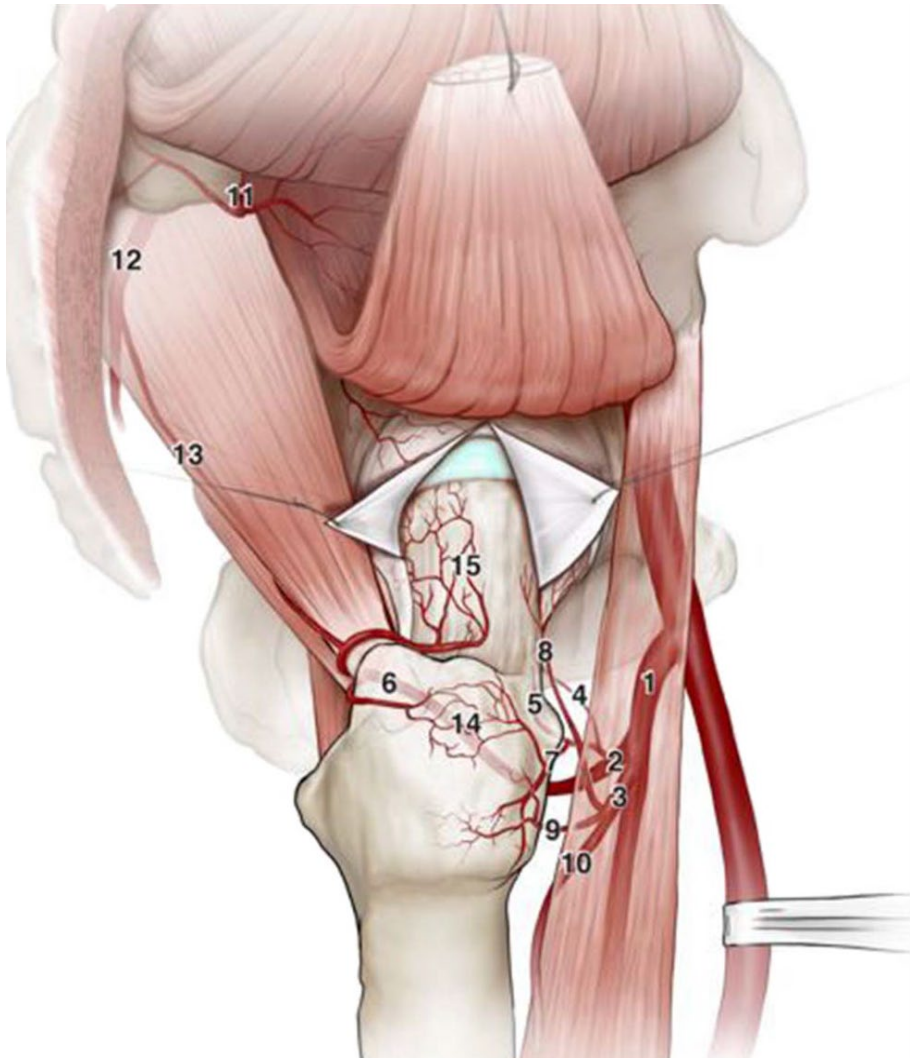
Cartilaginous Physis
Metaphysis
Ossific Nucleus

Pediatric Proximal Femur Development

- **Femoral neck shaft angle**
  - **150 (birth) → 145 degrees (1-3 yrs) → 130 degrees (maturity)**

- **Femoral anteversion**
  - **30 degrees (birth) → 10 degrees (maturity)**

Vascular Supply to Proximal Femur



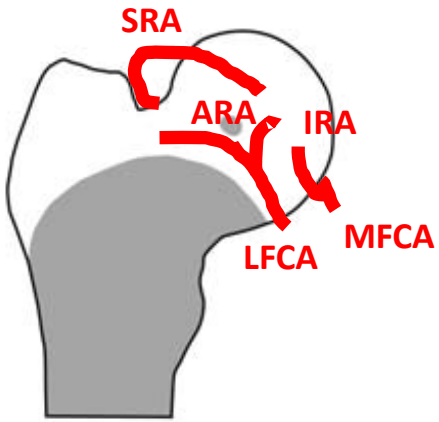
Medial femoral circumflex artery (2) and its branches are primary perfusers of the femoral head: acetabular (4), posterior inferior (5), ascending (6), transverse (7).

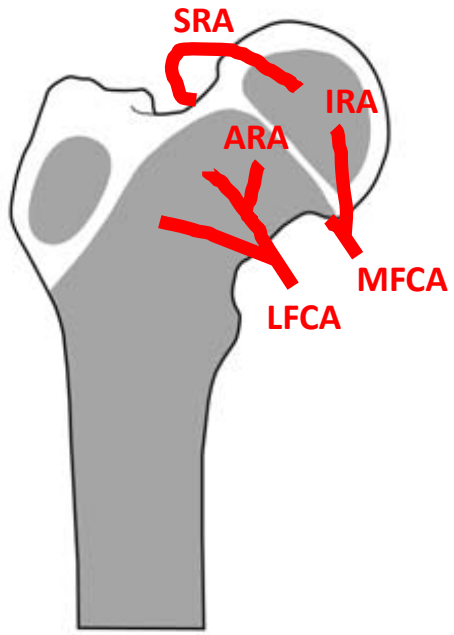
Entire blood supply to proximal femoral epiphysis comes from **superior retinacular vessels (15),** terminal branch of ascending (6), by 3 years of age.

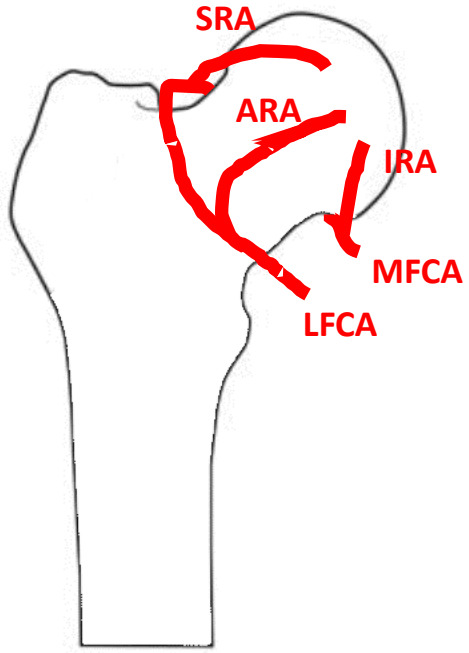
Lateral femoral circumflex artery (3) supplies the greater trochanter, lateral proximal femoral physis, and anteromedial metaphysis. Contribution to femoral head blood supply diminishes by 3 years of age.

Sankar WN, Mehlman CT. The community orthopaedic trauma surgeon taking trauma call: pediatric femoral neck fracture pearls and pitfalls. J Ortho Trauma. 2019;33:S22-S26

Pediatric Femoral Head Blood Supply Development







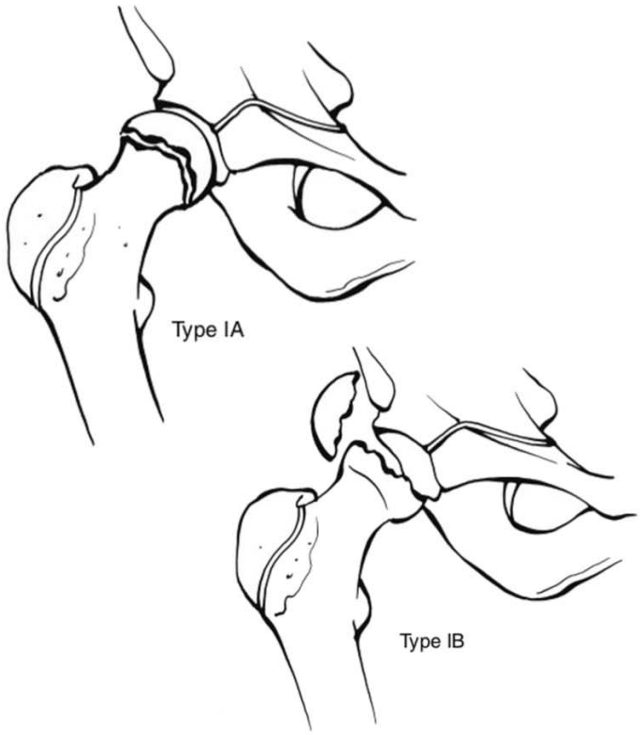
Birth to 4-6 months
Tri-arterial blood supply

4-6 months until Mature
Single vessel supply (ARA blocked by physis)

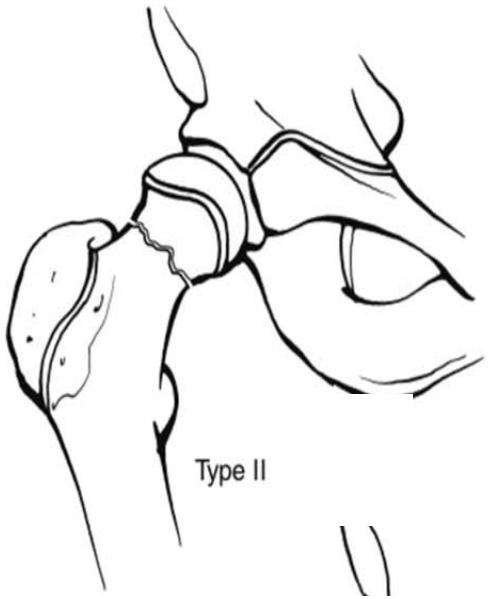
Mature
Tri-arterial blood supply

ARA = anterior retinacular artery; IRA = inferior retinacular artery; LFCA = lateral femoral circumflex artery; MFCA = medial femoral circumflex artery; SRA = superior retinacular artery

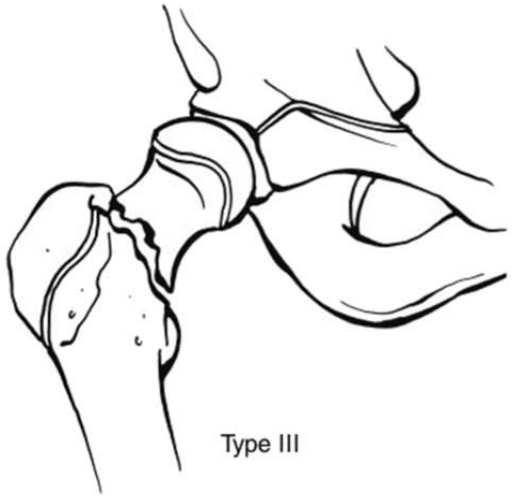
Classification—Delbet



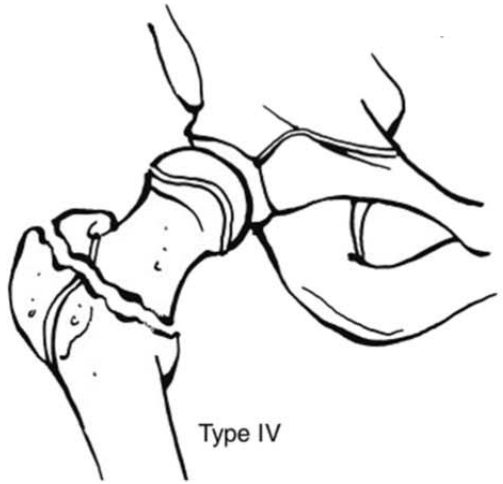
Type I, transphyseal, without (A) or with (B) dislocation of the capital femoral epiphysis



Type II, transcervical



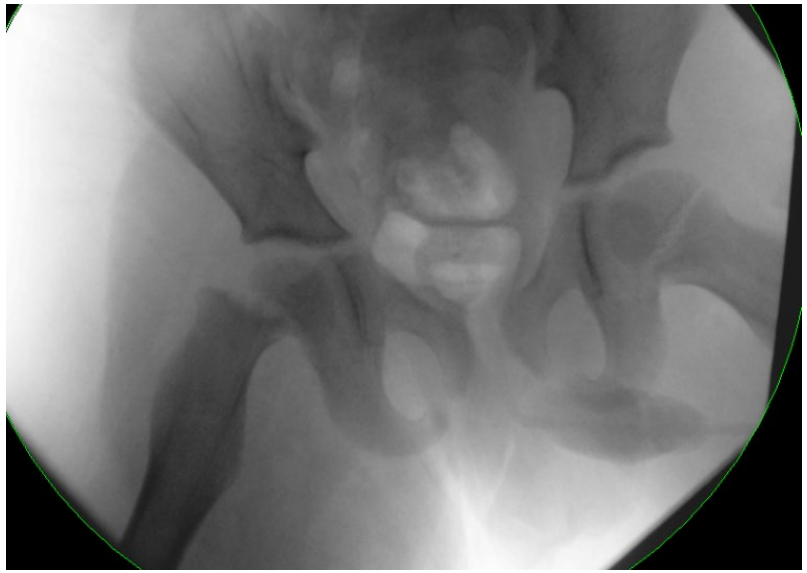
Type III, cervicotrochanteric



Type IV, intertrochanteric

Delbet Type 1

- Transphyseal
- < 10 % of pediatric hip fractures
- Most commonly seen in young children
- Often diagnosed late in newborns/infants
  - Possible non accidental trauma
- Subtypes
  - 1A – no dislocation
  - 1B – dislocation of the epiphysis from acetabulum



Courtesy of Chris Souder, MD

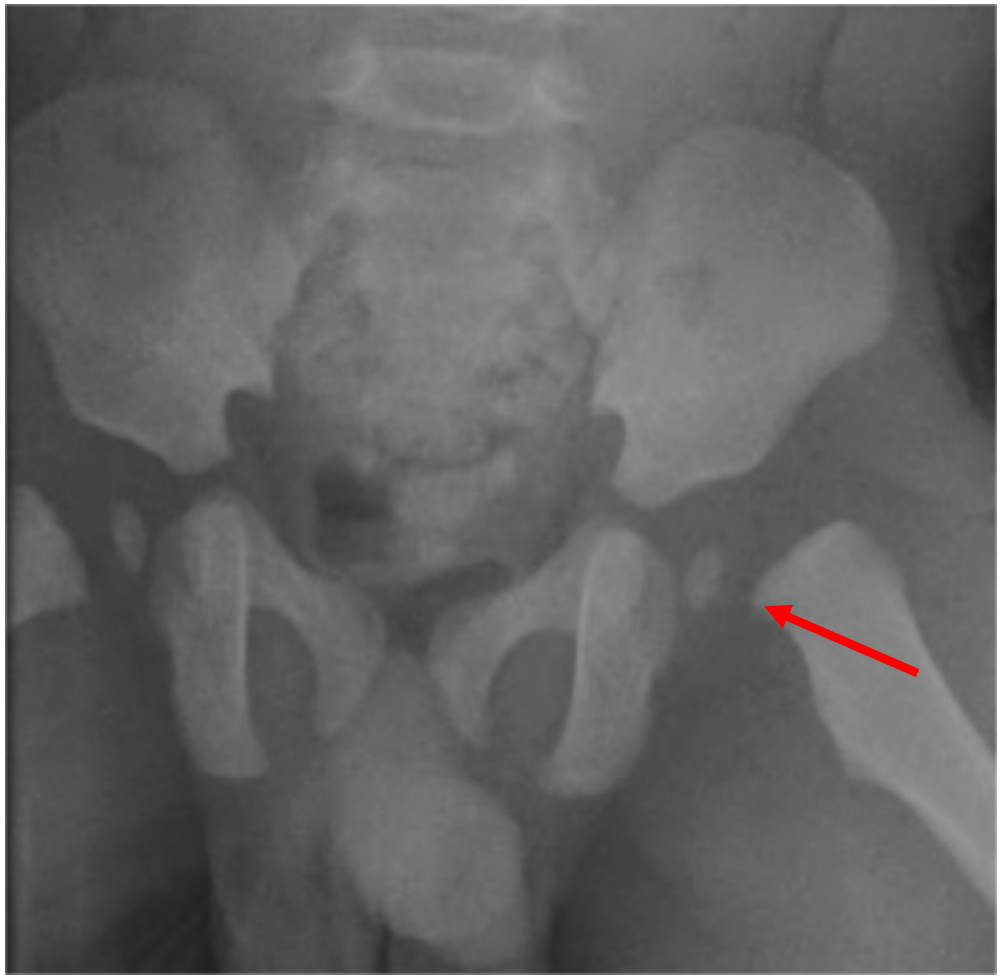
Delbet Type 1

- Usually from severe trauma
- 50% with femoral head dislocation
- Associated injuries in > 60% of cases
  - Pelvic fractures most common associated injury
- High rate of AVN
  - 38% in type 1A
  - ~100% in type 1B

Courtesy of Chris Souder, MD

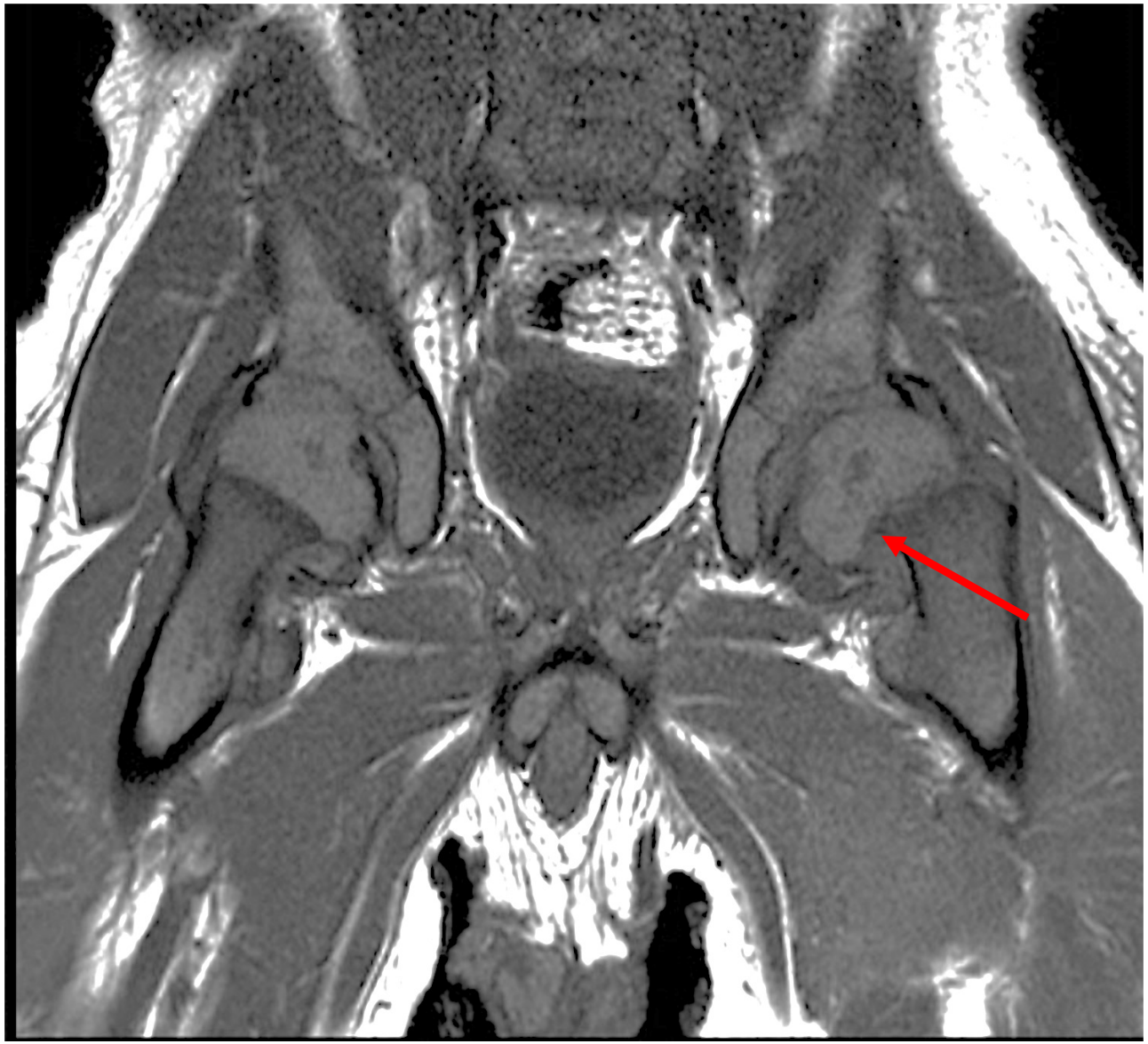
Delbet Type 1

- **Often missed in newborns/infants**
- **Subtle radiographic findings easy to miss**



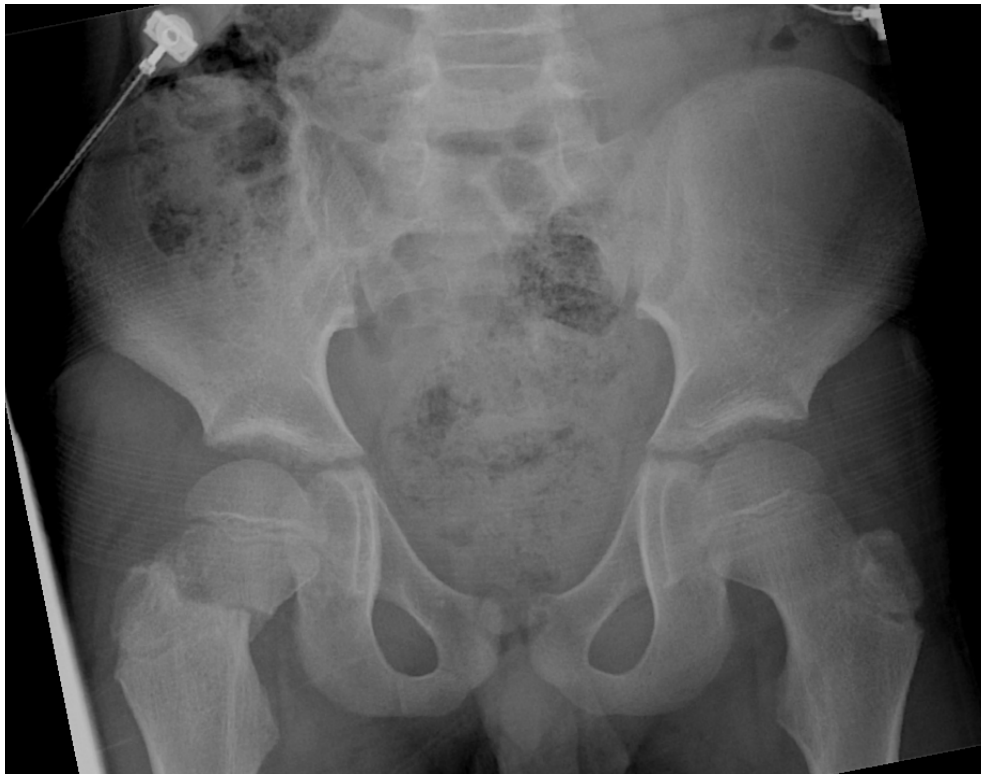
Delbet Type 1

MRI may be more diagnostic



Delbet Type 2

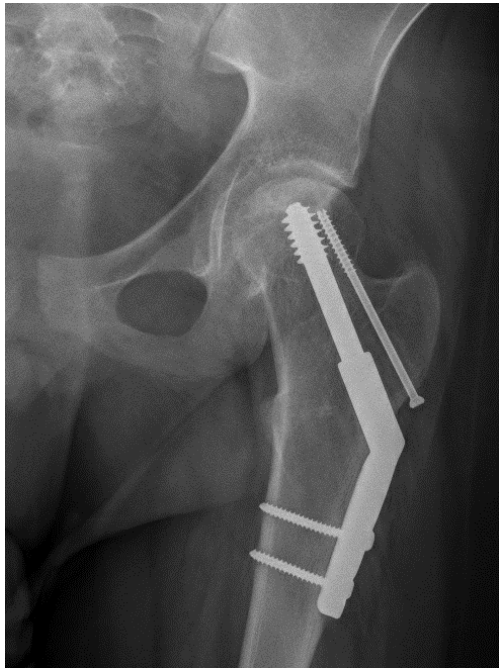
- Transcervical
- Most common
  - ~50% of all pediatric FN fractures
- 70-80% present displaced
- High rates of complication

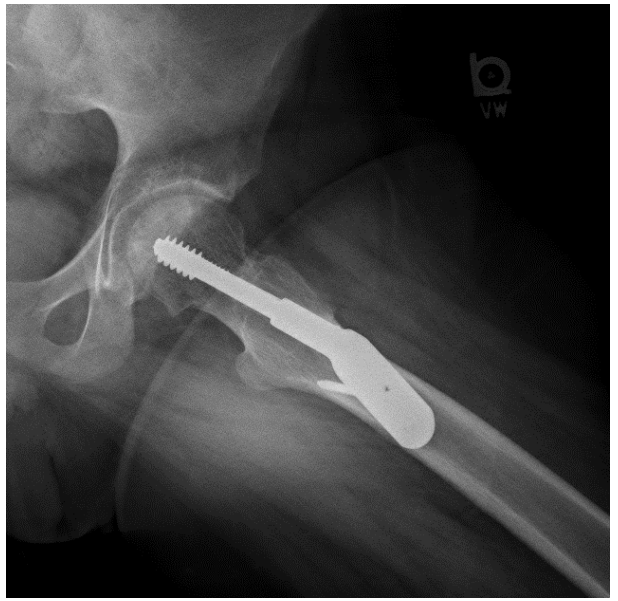


Courtesy of Chris Souder, MD

Delbet Type 2

- **Usually displaced**
- **28-50% AVN rate**
  - **Increased AVN with increased displacement**
    - **Initial displacement is the best predictor of AVN**
  - **Increased AVN in kids over 10 years of age**
- **15% nonunion rate**





Courtesy of Chris Souder, MD

Delbet Type 3

- Cervicotrochanteric (or basicervical)
- ~30% of pediatric hip fractures
- 18-25% AVN rate
  - Related to amount of displacement
- 20% malunion rate
- 10% nonunion rate

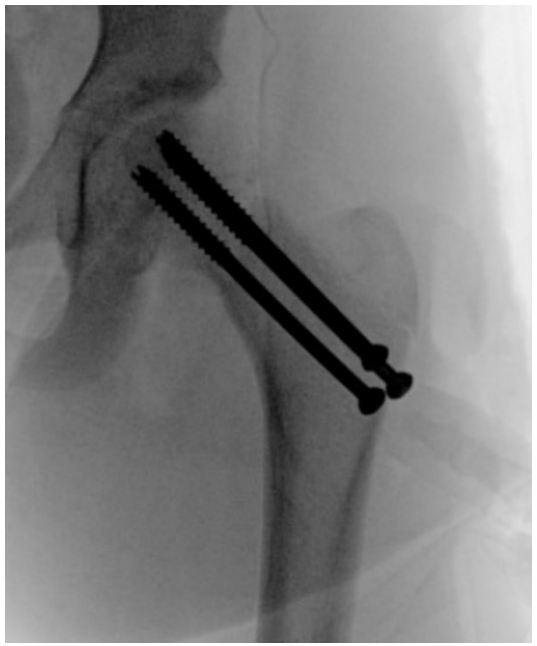
Courtesy of Chris Souder, MD

Delbet Type 4

- **Peritrochanteric or Intertrochanteric**
- **6-15% of pediatric hip fractures**
- **< 10% AVN rate**
- **Most favorable of all pediatric hip fractures**

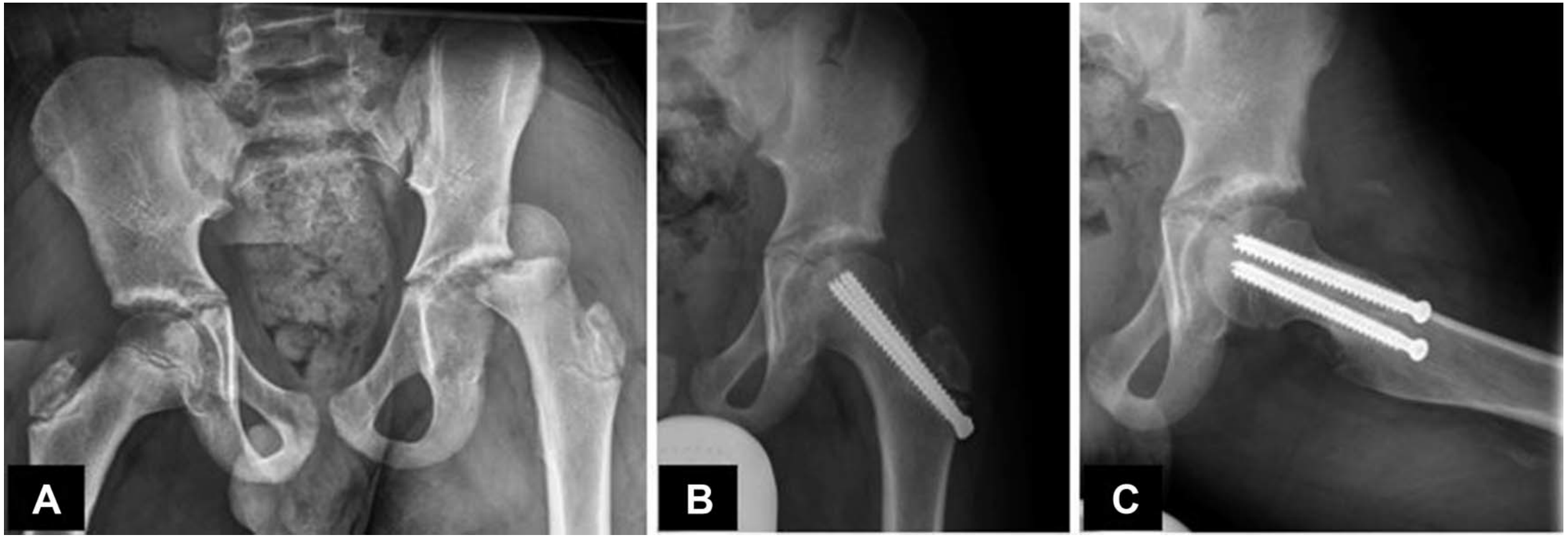
Treatment: Delbet 1

- **< 2 years**
  - **Closed reduction + spica cast**
- **2-9 years**
  - **Smooth pins + spica cast**
- **≥ 10 years**
  - **Transphyseal screw fixation**
- **ORIF required for dislocated epiphysis using a direct anterior, posterior or surgical dislocation approach depending on direction of the dislocation**



Courtesy of Chris Souder, MD

Treatment: Delbet 1B

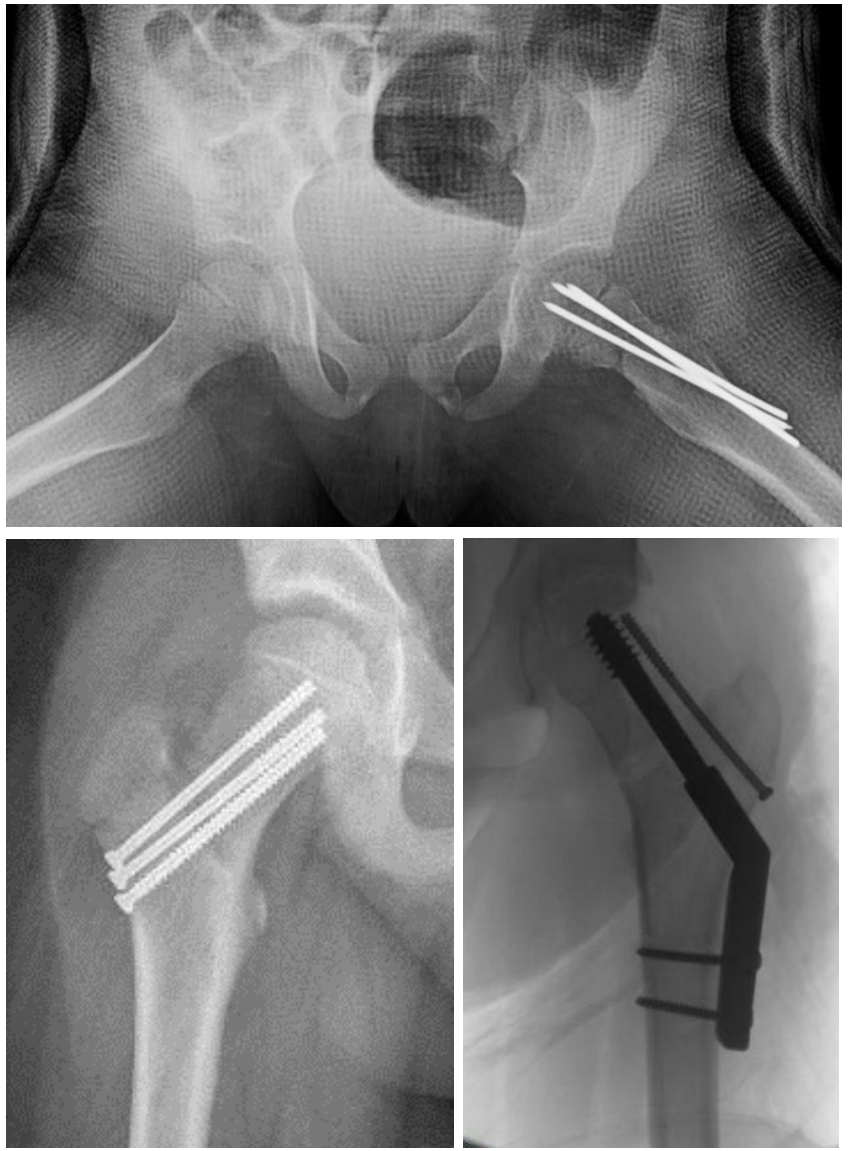


11 year old male, football injury

Sankar WN, Mehlman CT. The community orthopaedic trauma surgeon taking trauma call: pediatric femoral neck fracture pearls and pitfalls. J Ortho Trauma. 2019;33:S22-S26

Treatment: Delbet 2 and 3

- **Nondisplaced in < 6 years old in spica cast**
  - **Consider supplemental fixation ≥ 2 years to prevent displacement in cast**
- **Acceptable reduction**
  - **< 5^{o} angulation**
  - **< 2 mm cortical translation**
- **< 4 years**
  - **Smooth k wires + spica cast**
- **4-9 years**
  - **Physeal sparing cannulated screws**
    - ***Strongly consider including a spica cast***
- **≥ 10 years**
  - **Transphyseal cannulated screws**



Courtesy of Chris Souder, MD

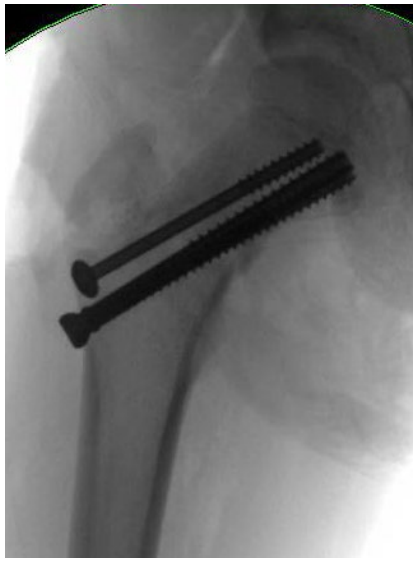
Treatment: Delbet 2 and 3

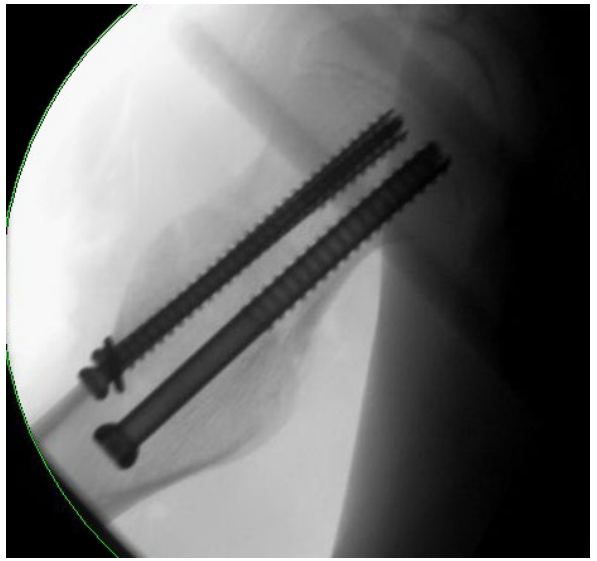
- **For unstable fracture patterns, consider fixed angle constructs**
- **± needle or open capsular decompression**
  - **Possible decrease in rates of AVN**
    - **controversial but minimal morbidity**
- **± single leg spica cast in those potentially non compliant/younger**

Courtesy of Chris Souder, MD

Treatment: Delbet 2

Physeal sparing screw fixation





Courtesy of Chris Souder, MD

Treatment: Delbet 3

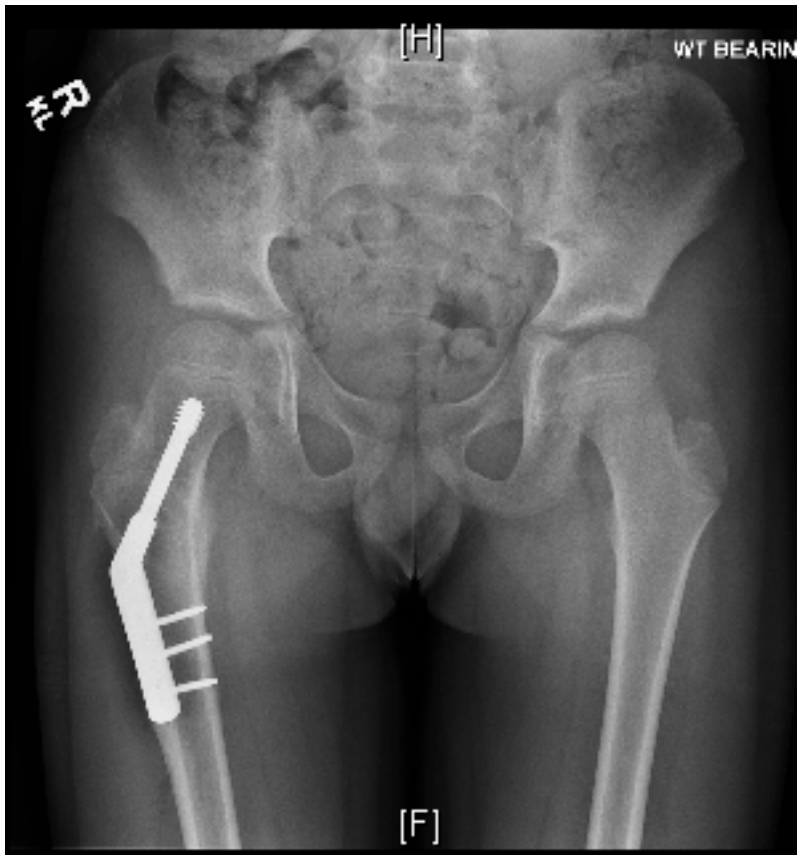
Fixed angle sliding hip screw with antirotational screw

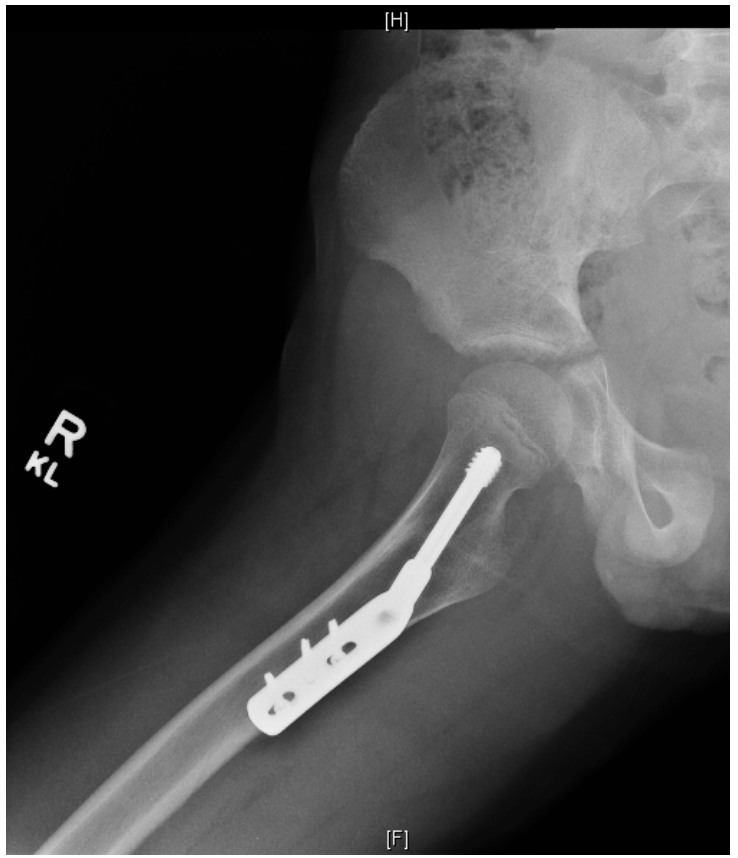
Courtesy of Chris Souder, MD

Treatment: Delbet 4

- **Most favorable outcomes of all pediatric hip fractures**
- **< 6 years**
  - **Non/minimally displaced, < 10 degree angulation**
    - **Closed reduction and spica cast**
    - **Consider pin fixation in ≥ 2 year olds to prevent displacement in cast**
- **> 6 years**
  - **Internal fixation for all nondisplaced and displaced fractures**
  - **Pediatric sliding hip screw or proximal femoral locking plate**
  - **< 10 years: physeal sparing should be considered**
  - **Adolescents get transphyseal fixation**

Treatment: Delbet 4





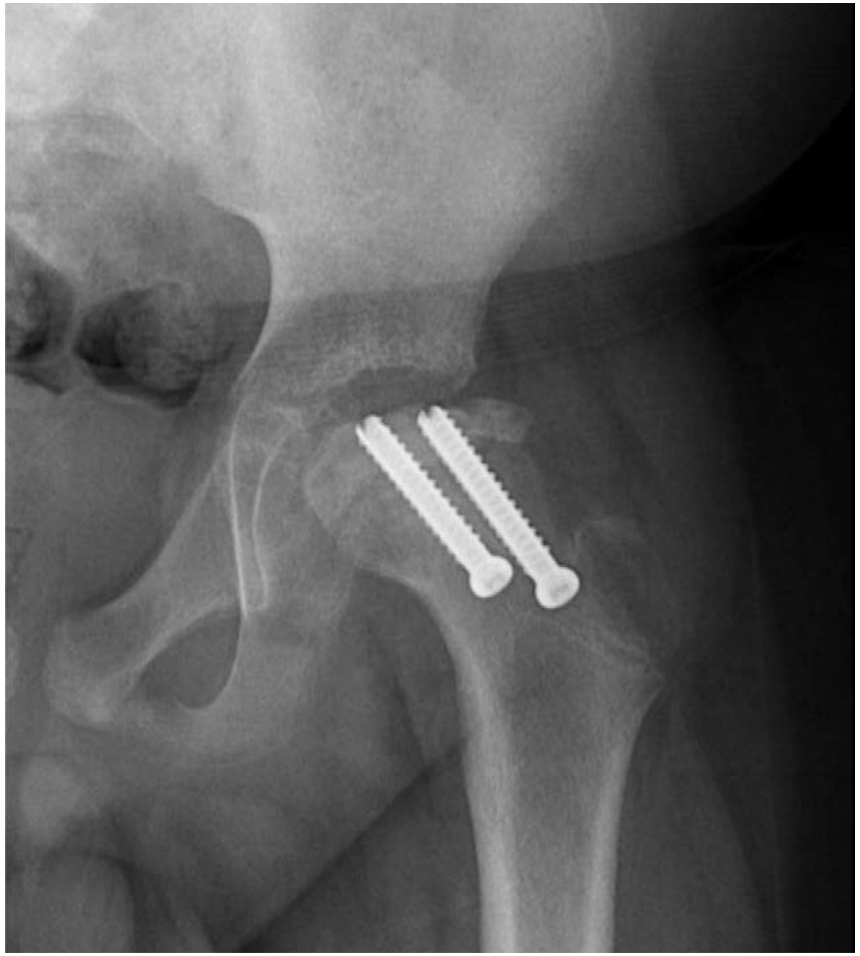
One year out

Implications of Pediatric Hip Fractures

- **Abnormal neck shaft angle**
- **Abnormal femoral neck version**
- **Decreased articulo-trochanteric distance**
- **Limb length discrepancy**

Complications

- **AVN**
  - **Type 1 (38%) > Type 2 (28%) > Type 3 (18%) > Type 4 (5%)**
  - **Risk Factors: older age, initial displacement**
  - **Modifiable Factors: quality of reduction**
    - **Possible benefit to capsular decompression**
    - **Equivocal association with timing of reduction**
  - **May take 2 years to develop**
    - **Important to obtain periodic radiographs**



Complications

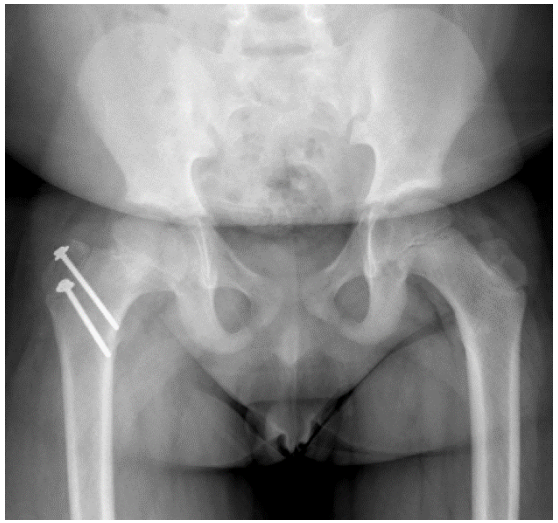
- **Nonunion**
  - **6-12%**
  - **Most common in type 2 fractures**
  - **Least common in type 4**
  - **Causes**
    - **Poor reduction**
    - **Distracted fractures**
    - **Inadequate fixation**
    - **Fracture orientation (higher Pauwel's angle)**
  - **May result in coxa vara or AVN**
  - **Treatment with valgus osteotomy**

Complications

- **Coxa Vara (<120^{o})**
  - **10-32% of cases**
  - **Causes**
    - **Malreduction**
    - **Delayed union or nonunion**
    - **Premature proximal femoral physeal closure with greater trochanter overgrowth**
    - **Casting alone**
  - **Less likely with rigid internal fixation**
  - **Intertrochanteric osteotomy for persistent deformity**

Complications

- **Premature physeal closure**
  - **28% occurence**
  - **Limb length inequality**
    - **Typically does not require treatment in adolescents**
    - **Can be significant in young children**
      - **2-3mm of growth per year**
  - **Trochanteric overgrowth**
    - **Functional coxa vara**
      - **Disturbs natural hip mechanics**
  - **Treatment is trochanteric apophysiodesis in children ≤ 8years of age**



Courtesy of Chris Souder, MD

Complications

- **Delayed SCFE at 9 months**
  - **Causes**
    - **Implant irritation**
    - **Premature initiation of weight bearing**
    - **Coxa vara**
    - **Osteonecrosis**
    - **Delayed union or nonunion**

Complications

- **Femoral neck overgrowth**
  - **Average 6.2 mm in series of 30 patients**
  - **Younger (5.5 years vs 9.9 years)**
  - **Lower rate of osteonecrosis and better functional outcomes**

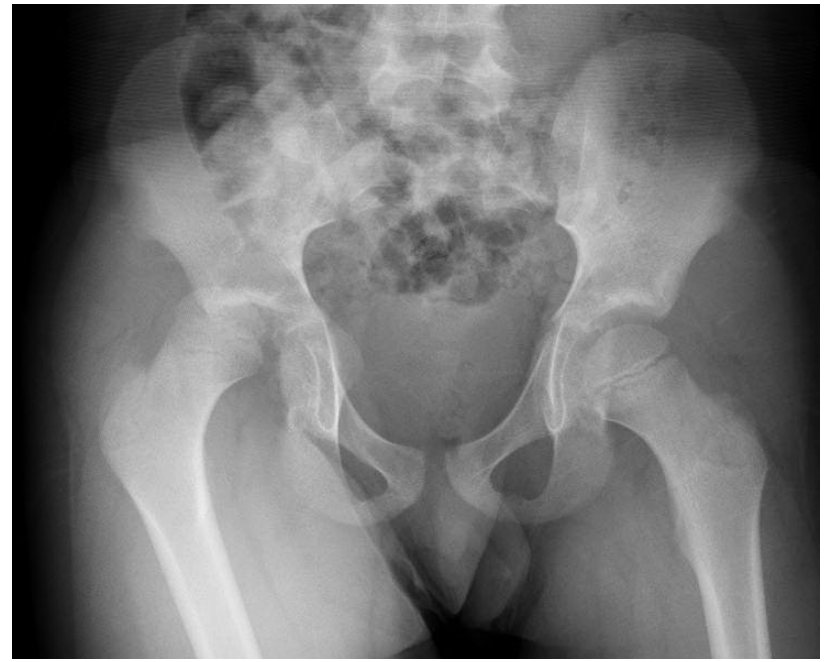
Kuo J Orthop Surg Res 2016

Pediatric Hip Dislocations

- **Very rare**
- **Force required to dislocate increases with age**
  - **Minor injury < 10 years old**
  - **High energy > 12 years old**
- **Mostly posterior dislocations**

Pediatric Hip Dislocations

- **Posterior dislocations**
  - **Hip flexion, adduction and internal rotation**
- **Anterior dislocations**
  - **Hip extension, abduction and external rotation**
- **Inferior dislocations**
  - **Hyperflexed or abducted**



Courtesy of Chris Souder, MD

Pediatric Hip Dislocations

- **Xrays prior to reduction attempt**
- **Urgent reduction within 6 hours**
  - **20x increase in AVN rate with delay > 6 hours**
- **Gentle reduction**
  - **Iatrogenic epiphyseal separation possible**
- **Open reduction following failed closed reduction attempt**

Sankar WN, Mehlman CT. The community orthopaedic trauma surgeon taking trauma call: pediatric femoral neck fracture pearls and pitfalls. J Ortho Trauma. 2019;33:S22-S26

Pediatric Hip Dislocations

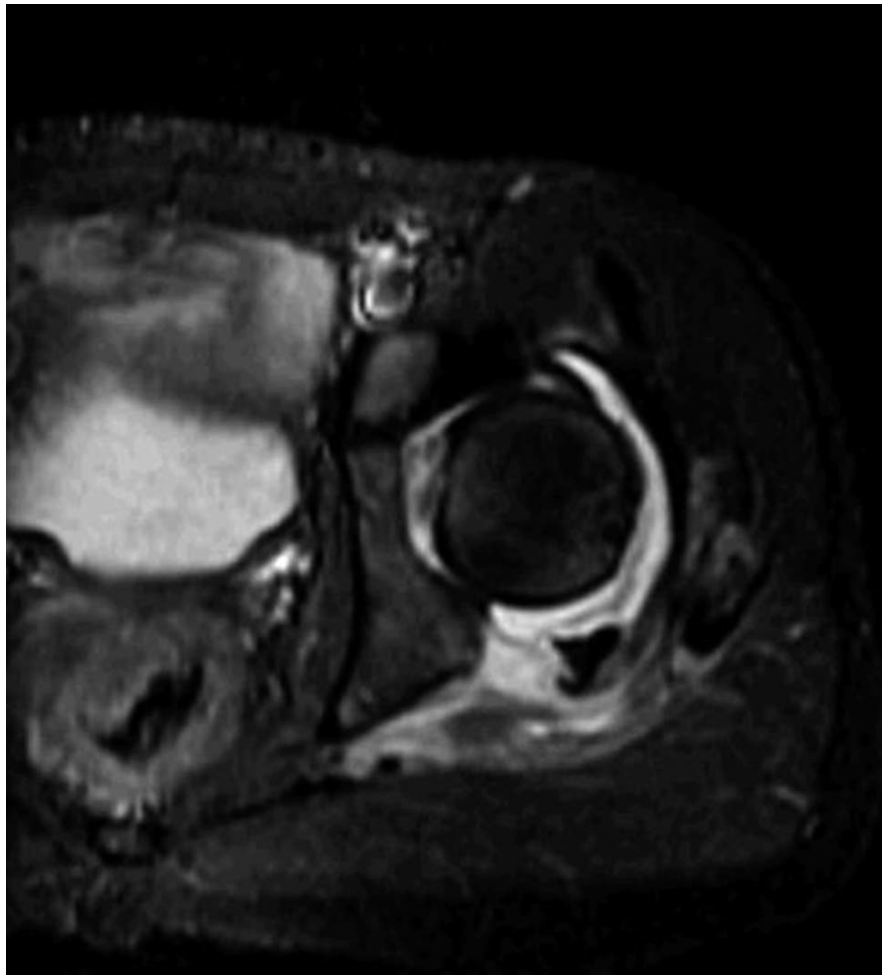
- **Anatomical blocks to reduction**
  - **Osteocartilaginous fragments**
  - **Interposed labrum**
  - **Femoral head buttonhole through capsule**
  - **Torn ligamentum teres**

- **Open reduction if needed from direction of the dislocation**
  - **Surgical dislocation is safe as well**
  - **Direct visualization of the block**

Pediatric Hip Dislocations

- **XR/CT or MRI to <u>confirm concentric reduction</u>**
  - **Possible acetabulum fracture or intra-articular fragments or labrum**
  - **MRI helpful in identifying non-ossified bony fragments and labrum**

- **Post reduction protocol**
  - **< 8 years old or non compliant**
    - **Spica cast 3-4 weeks**
    - **Abduction splinting 3-4 weeks**
  - **Older, more compliant patients**
    - **Protected non weight bearing for 6 weeks**



MRI of a 9 yo boy with large posterior wall cartilage fragment

Kruppa CG, et al. Acetabular fractures in children and adolescents: comparison of isolated acetabular fractures and acetabular fractures associated with pelvic ring injuries. J Ortho Trauma. 2018:32(2):e39-45

Pediatric Hip Dislocations

- **Complications**
  - **AVN (8-20%)**
  - **Myositis ossificans (8-15%)**
  - **Sciatic nerve palsy**
  - **Early secondary arthritis**
- **Poor prognosticators**
  - **Older age**
  - **Severe trauma**
  - **Delay in reduction (> 6 hours)**
  - **Incongruous reduction**
  - **AVN**

Courtesy of Chris Souder, MD

Summary

- **Pediatric hip fractures and dislocations are rare**
- **Require high suspicion in infants and patients with concomitant injuries**
- **Aggressive early treatment leads to lower complication rate**
- **Initial AVN counseling and follow up needed until skeletal maturity**

References

Ratliff AH. Fractures of the neck of the femur in children. JBJS Br 1962

Canale ST, Bourland WL. Fracture of the neck and intertrochanteric region of the femur in children. JBJS 1977

Mehlman CT, Hubbard GW, Crawford AH, Roy DR, Wall EJ. Traumatic hip dislocation in children: Longterm followup of 42 patients. CORR 2000

Vialle R, Odent T, Pannier S, PauthierF, Laumonier F, Glorion C. Traumatic hip dislocation in childhood. JPO 2005

Boardman MJ, Herman MJ, Buck B, Pizzutillo PD. Hip fractures in children. JAAOS 2009

Herrera-Soto. Traumatic hip dislocations in children and adolescents: pitfalls and complications. JAAOS 2009

Hearty T, Swaroop VT, Gourineni P, Robinson L. Standard radiographs and computed tomographic scan underestimating pediatric acetabular fracture after traumatic hip dislocation: report of 2 cases. JOT 2011

Baysal Ö, Eceviz E, Bulut G, Bekler H. Early prediction of outcomes in hip fractures: initial fracture displacement. JPO B 2015

Li H, Zhao L, Huang L, Kuo KN. Delayed slipped capital femoral epiphysis after treatment of femoral neck fracture in children. CORR 2015

Panigrahi R, Sahu B, Mahapatra AK, Palo N, Priyardarshi A, Biswal MR. Treatment analysis of pediatric femoral neck fractures: a prospective multicenter theraupetic study in Indian Scenario. Int Orthop 2015

Podeszwa DA, De La Rocha A, Larson AN, Sucato DJ. Surgical Hip Dislocation is Safe and Effective Following Acute Traumatic Hip Instability in the Adolescent. JPO 2015

Riley PM Jr, Morscher MA, Gothard MD, Riley PM Sr. Earlier time to reduction did not reduce rates of femoral head osteonecrosis in pediatric hip fractures. JOT 2015

Kuo FC, Kuo SJ, Ko JY. Overgrowth of the femoral neck after hip fractures in children. J Orthop Surg Res 2016

Spence D, Di Maurı JP, Miller PE, Glotzbecker MP, Hedequist DJ, Shore BJ. Osteonecrosis after femoral neck fractures in children and adolescents: analysis of risk factors. JPO 2016

Kruppa CG, Sietsema DL, Khoriaty JD, Dudda M, Schildhauer TA, Jones CB. Acetabular fractures in children and adolescents: comparison of isolated acetabular fractures and acetabular fractures associated with pelvic ring injuries. JOT 2018

Patterson JT, Tangtiphaiboontana J, Pandya NK. Management of pediatric femoral neck fracture. JAAOS 2018

Mehlman CT, Sankar WN. The community orthopaedic surgeon taking trauma call: pediatric femoral neck fracture pearls and pitfalls. JOT 2019

Althausen PL, Nielsen RC, Gurnea TP. Use of Proximal Humerus Locking Plates for Fixation of Pediatric Femoral Neck Fractures - Technical Trick. JOT 2020

Lark RK, Dial BL, Alman BA. Complications after pediatric hip fractures: evaluation and management. JAAOS 2020

Figures used with permission. Goldstein RY, Kim YJ. Fractures and Traumatic Dislocations of the Hip in Children. In: Waters PM, Skaggs DL, Flynn JM, eds. Rockwood and Wilkins' Fractures in Children, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019.