Slipped Capital Femoral Epiphysis
SCFE

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MD, PAEDIATRIC ORTHOPEDIC SURGEON

ROYAL MEDICAL SERVICES

PEDIATRIC ORTHOPEDICS

DR FIRAS ALIBRAHIM

INTRODUCTION

- **SCFE** :
- an condition of the proximal femoral physis that leads to slippage of the metaphysis relative to the epiphysis.
- Femoral neck and shaft displace upward & anterior relative to the femoral epiphysis and the acetabulum.
- Head remains posterior and downward in the acetabulum
- ..posterior and varus)most common)

Slipped Capital Femoral Epiphysis
SCFE

Chapter Outline

Incidence and Epidemiology
Classification
Etiology
Pathology
Clinical Features
Radiographic Findings
Treatment
Complications
Prognosis

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- Classification
- Etiology
- Pathology
- Clinical Features
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- Complications
- Prognosis

Incidence and Epidemiology

- 2 per 100,000 (1-7)
- Male > Female (2:1.4)
- Left > Right
- Urban – Rural variation
- More in obese
- During adolescence, max skeletal growth
- **boys 13-15 years, avg 14**
- **girls 11-13 years, avg 12**
- **associated with puberty** ” **growth spurt**”
- Bilateral in 20% to 40%, 50 % of the simultaneously

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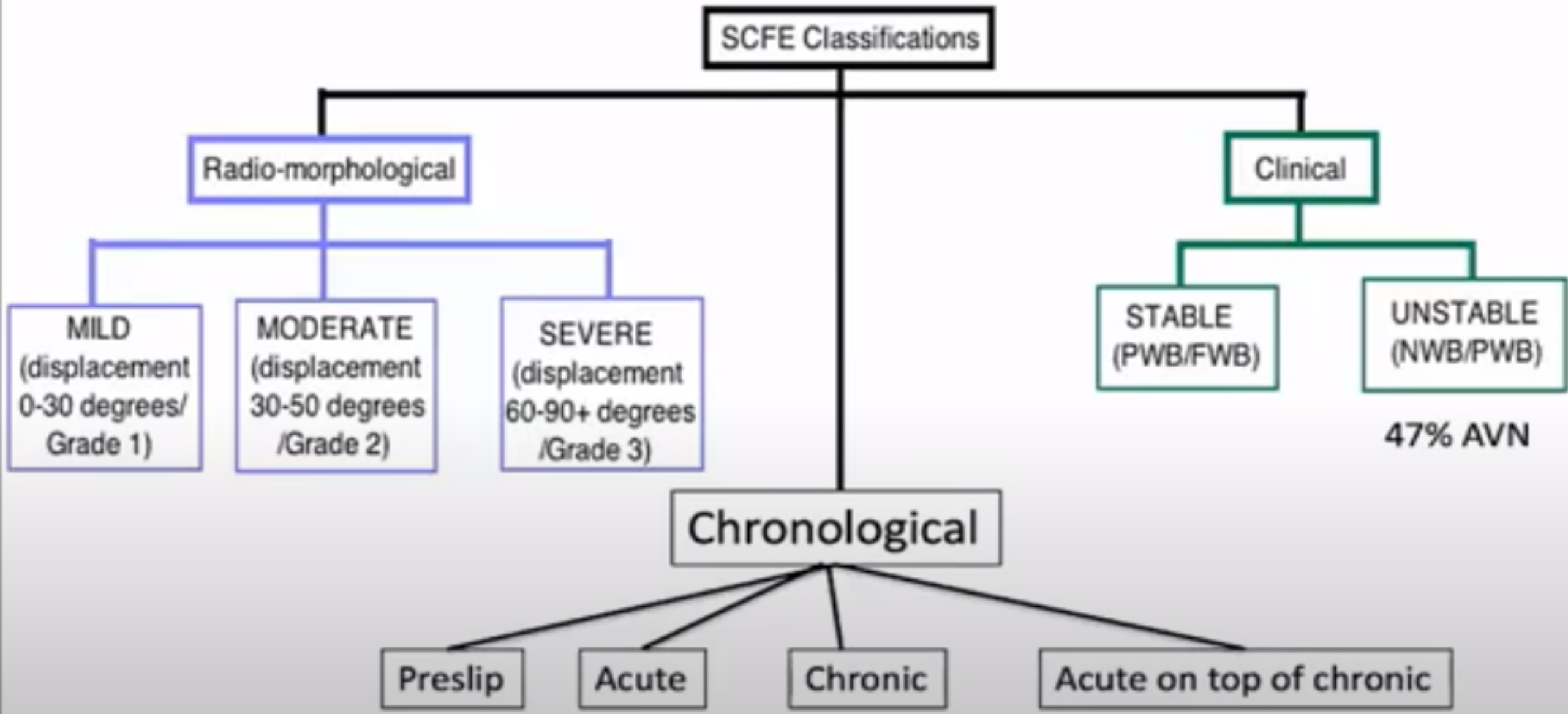
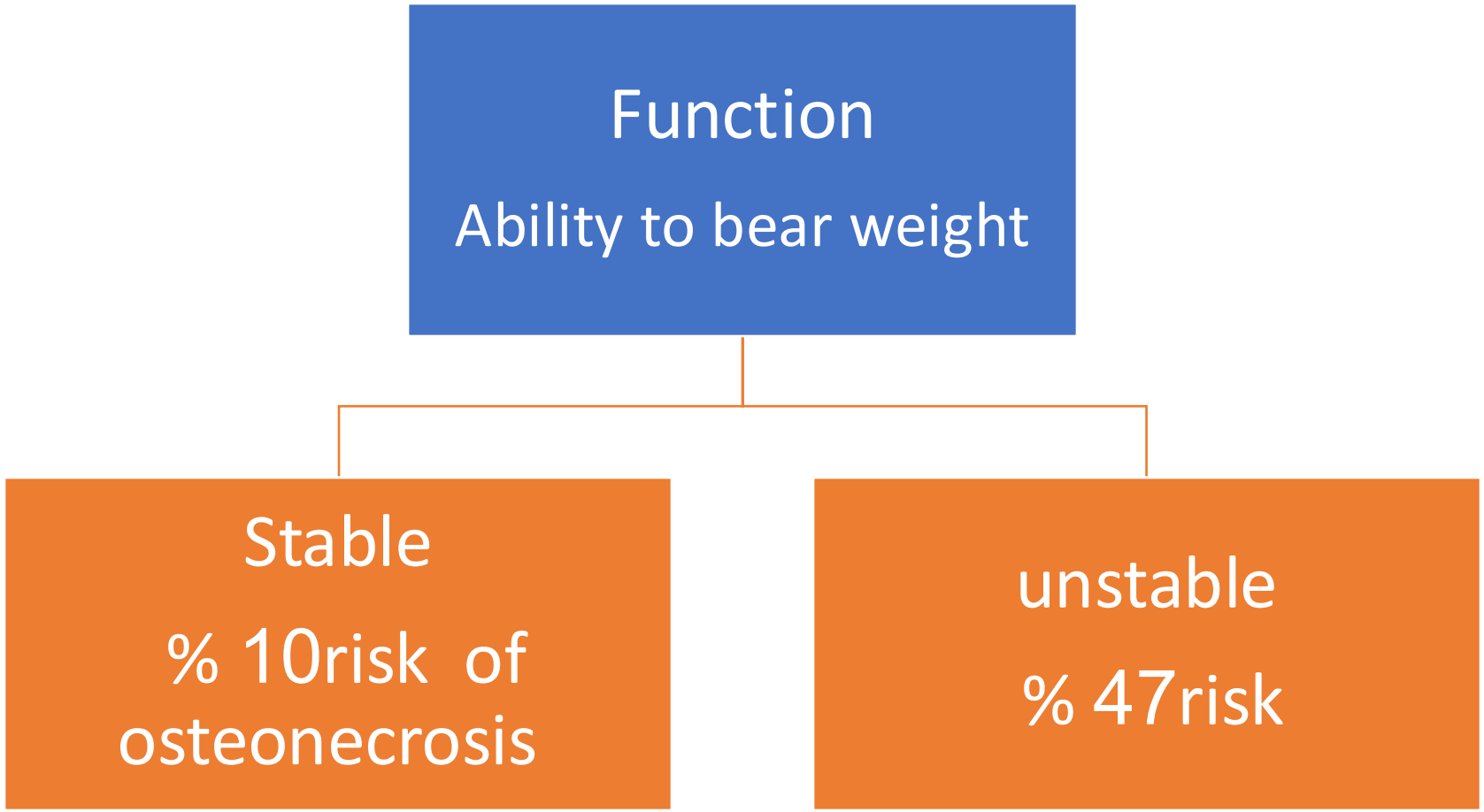
Classification



Classification

I. Loder Classification -- based on ability to bear weight



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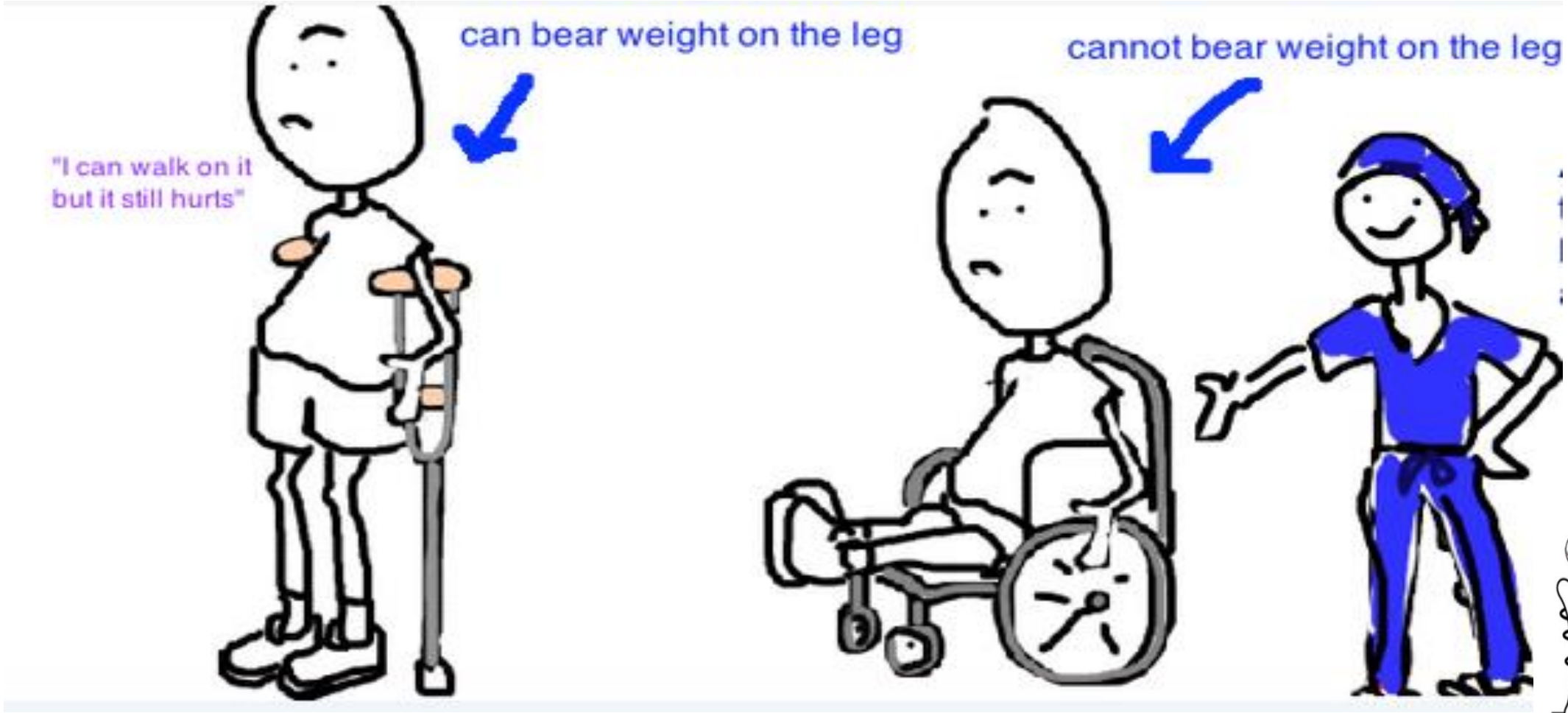
STABLE VS UNSTABLE

(loder classification)



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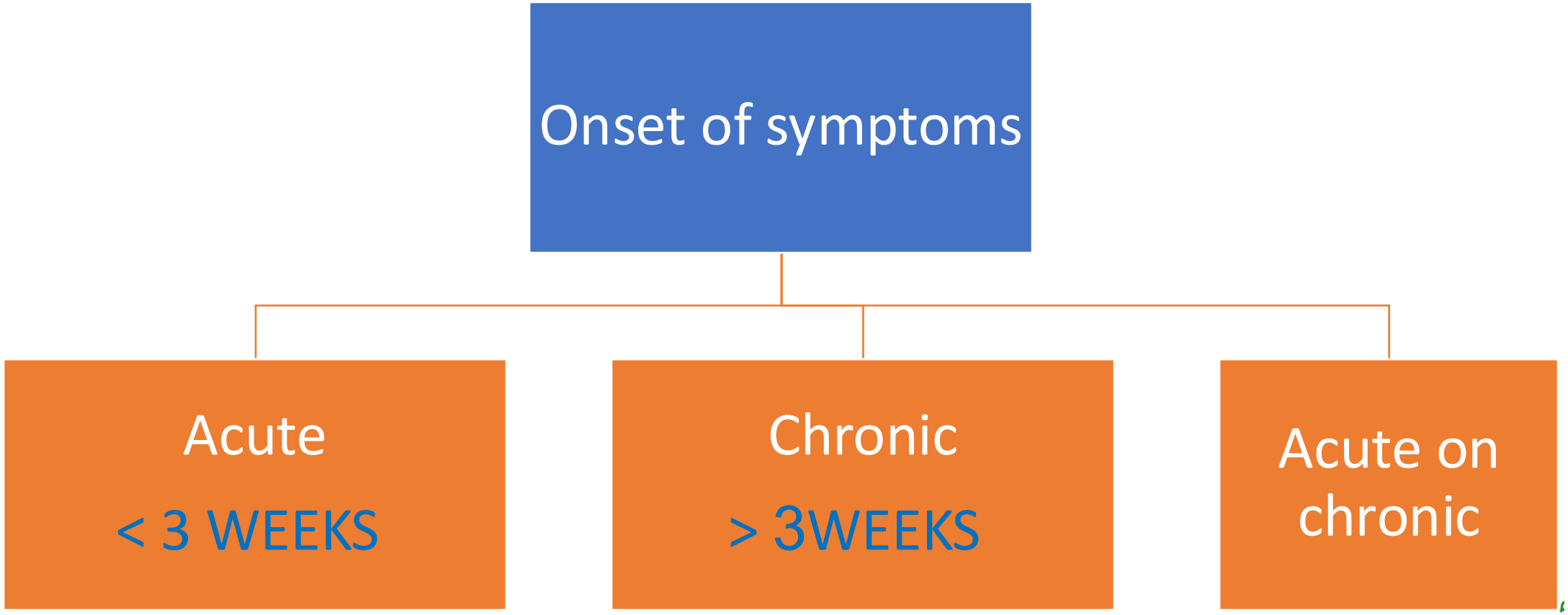
Epiphyseal stability

- Reducible epiphysis is indicative of instability
- Inability to bear wt, + joint effusion in US → 100% sensitivity

Kallio et al, 1993, 1995

- So long the physis is open, mechanical stability is uncertain regardless of ability to ambulate or duration of symptoms.
- **Combine clinical, US, MRI findings** *Ziebarth 2012*

II. **Temporal Classification --** based on duration of symptoms;



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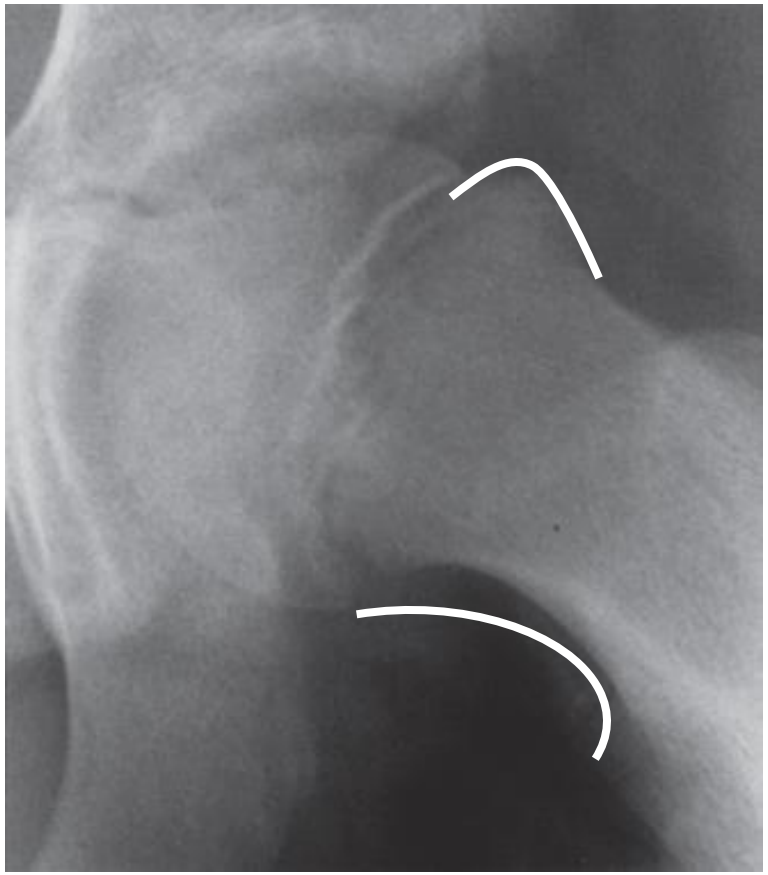
Onset of symptoms classification

- **<u>Acute SCFE:</u>**

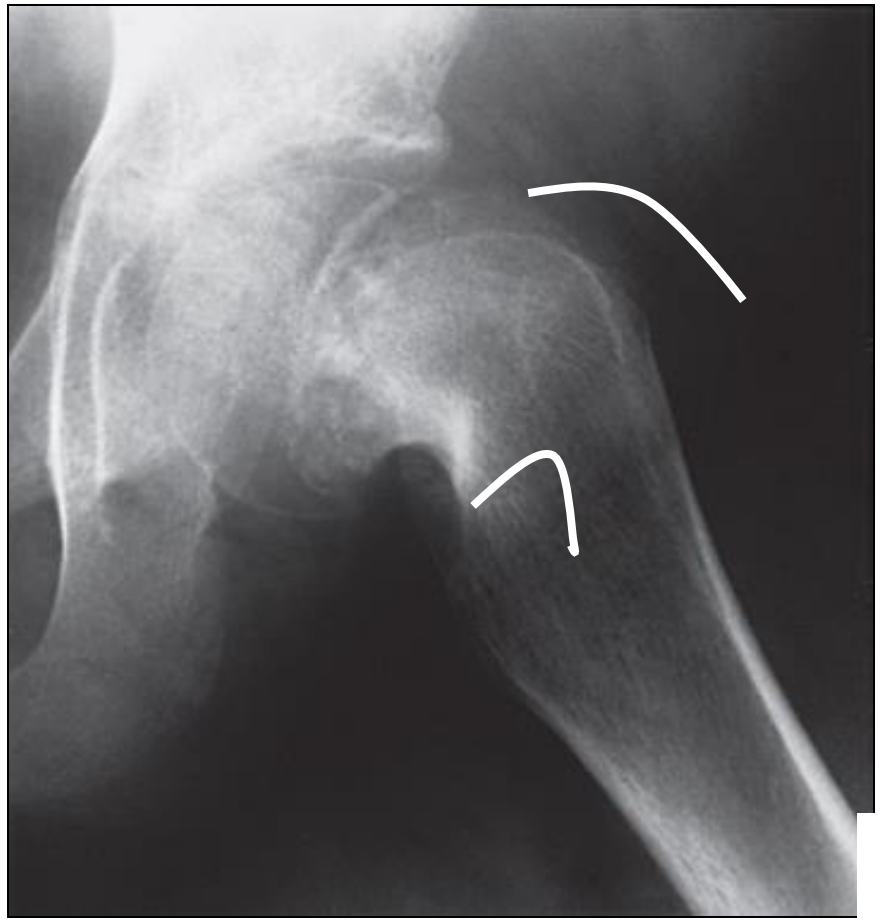
- < 3 weeks
- Sudden fracture-like symptoms
- +/- weight bearing
- AVN = 17%- 47%



Onset of symptoms

- **<u>Chronic SCFE:</u>**

- > 3 weeks
- The most frequent presentation
- Few months hx of vague groin,
- thigh or knee pain an limp

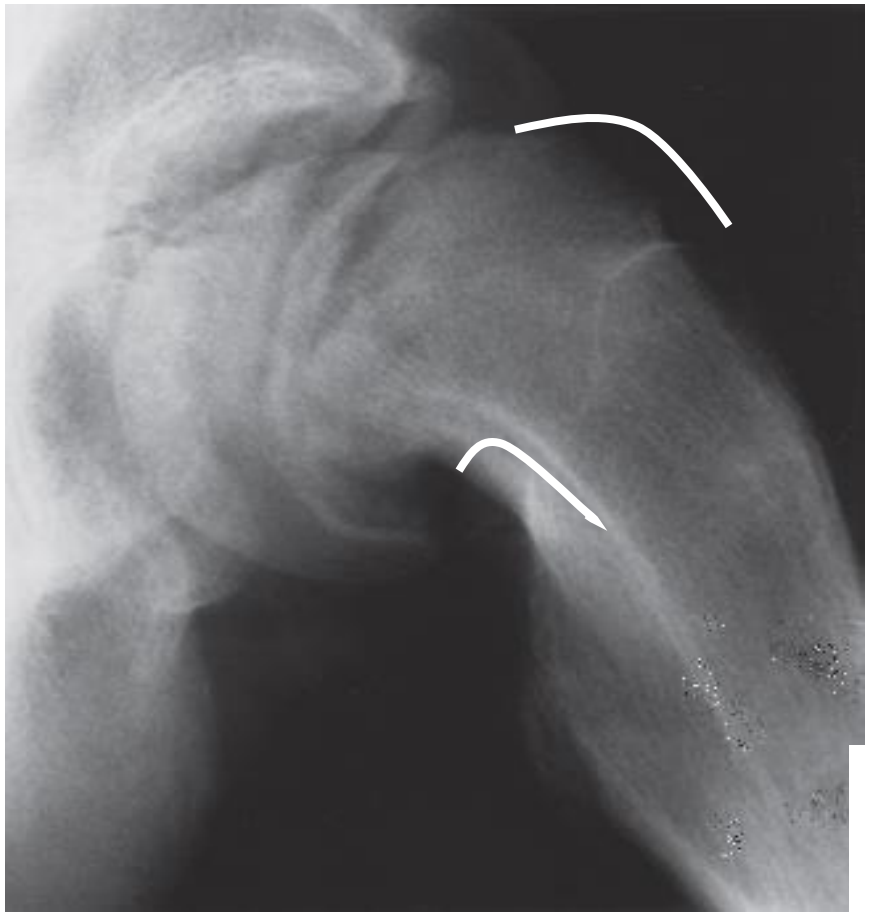


Onset of symptoms

- **<u>Acute on-top of chronic</u>**

- symptomatic more than 3 months ; i.e chronic

- Sudden exacerbation of pain and inability to bear weight; i.e acute



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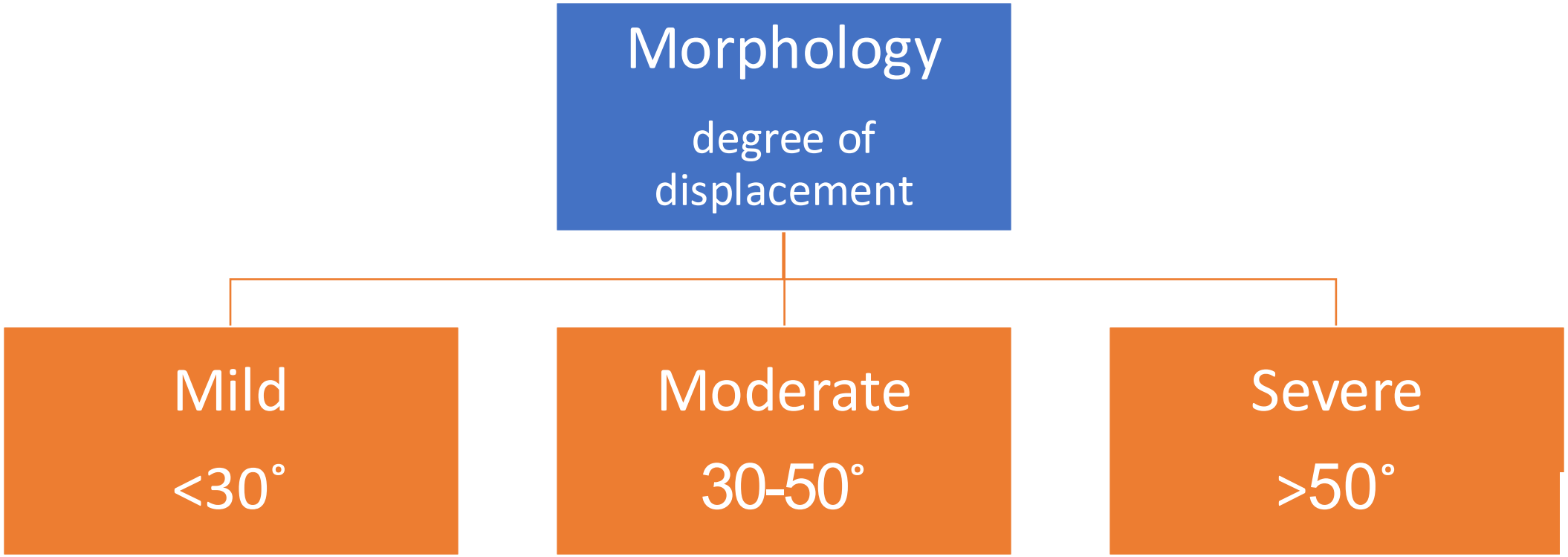
III.Southwick Slip Angle Classification -- based on femoral epipyseal-diaphyseal angle difference



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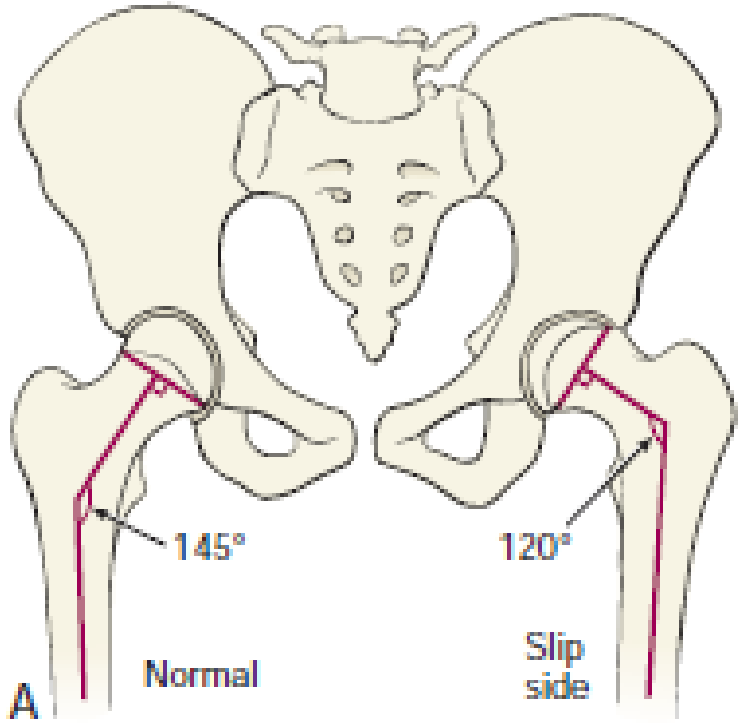
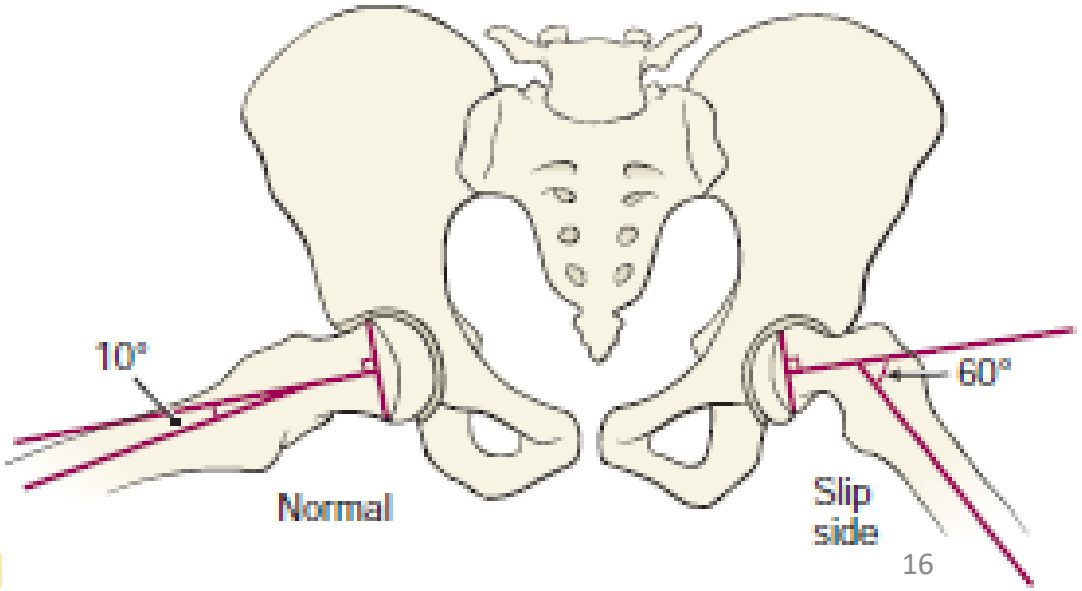
III.Morphological classification

•Degree of displacement of the capital femoral epiphysis on the femoral neck.

•Southwick method: measuring the femoral-head shaft angle on AP and Lateral views, how much difference from the non slip side.

•These normal values are **<u>145 degrees</u>** on the AP view and **<u>10 degrees posterior</u>** on the frog-leg lateral view.





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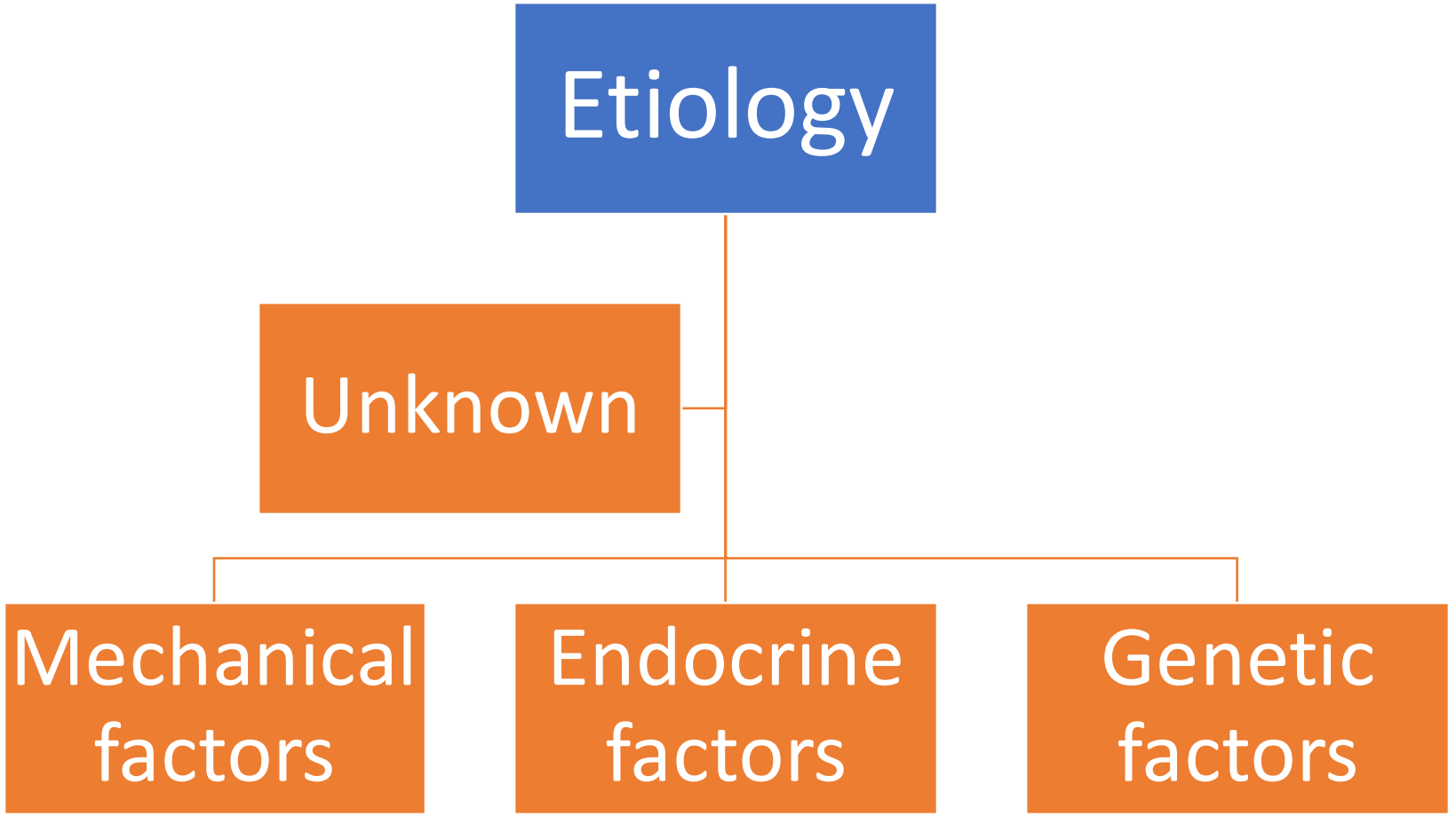

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How does a slipping biomechanically start & progress ?

Alter gait

Increase shear

Weakened Physis

Obesity

Increase loading

Retroversion

Femoral & Aceet

Etiology

- **Mechanical factors**

1. thinning of the perichondral ring complex with maturation, altering the mechanical strength of the physis, periosteum, and perichondral ring
2. Relative or absolute retroversion of the femoral neckand acetabular retroversion .
3. change in the inclination of the adolescent proximal femoral physis relative to the femoral neck and shaft

Etiology

- **Endocrine factors**

Atypical SCFE:

1. <10y an >16y 4 times
2. 10y-15y with below the 50th percentile for weight 8 times

Endocrinopathies :

1. Hypothyroidism before an during treatment
2. GH deficiency during or after treatment
3. Chronic RF i.e. secondary hyperparthrodisim .
4. Obesity.
5. Hypogonadal males (adiposogenital syndrome)
6. Growth spurt&GH administration؟؟؟؟.

Etiology

- **<u>Endocrine factors</u>**

- Risk of bilateral involvement 61% and up to 95% in chronic RF
- High risk for slip progression even after treatment, so keep monitoring…

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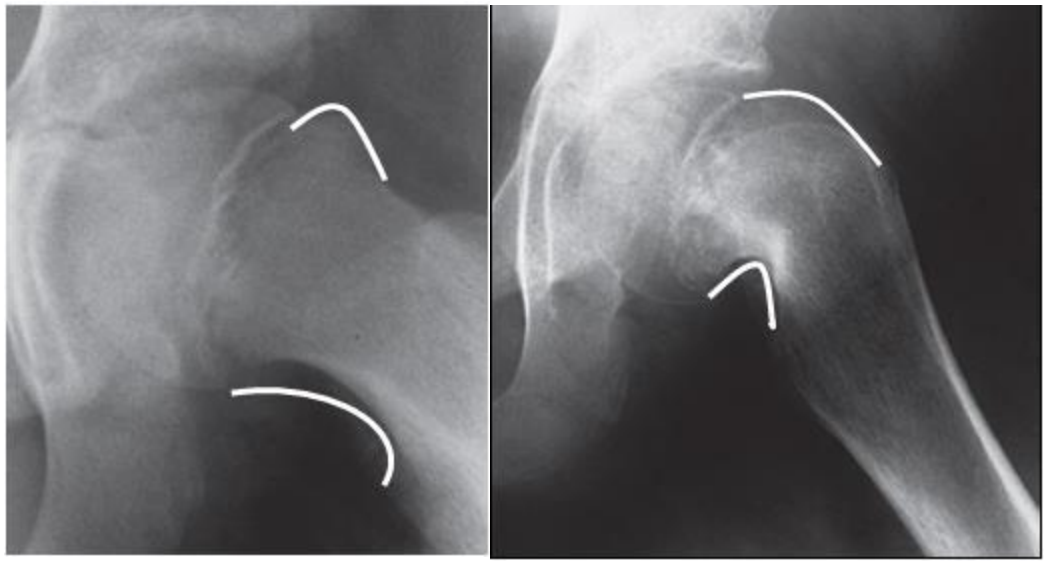
pathology

- **Gross pathology:**



- Periosteum stripped from ant/inf surface of femoral neck.
- Area btw neck & post periosteum fills with callus &.ossifies
- Anterosuperior neck forms “hump” (remodel)
- Acute slips will have hemarthrosis

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pathology

- **Histopathology:**

- **Preslip stage:**

➢ widening of the physis without actual displacement

➢ edematous synovial membrane, capsule and periosteum

➢ Decrease in the resting zone thickness of the physis

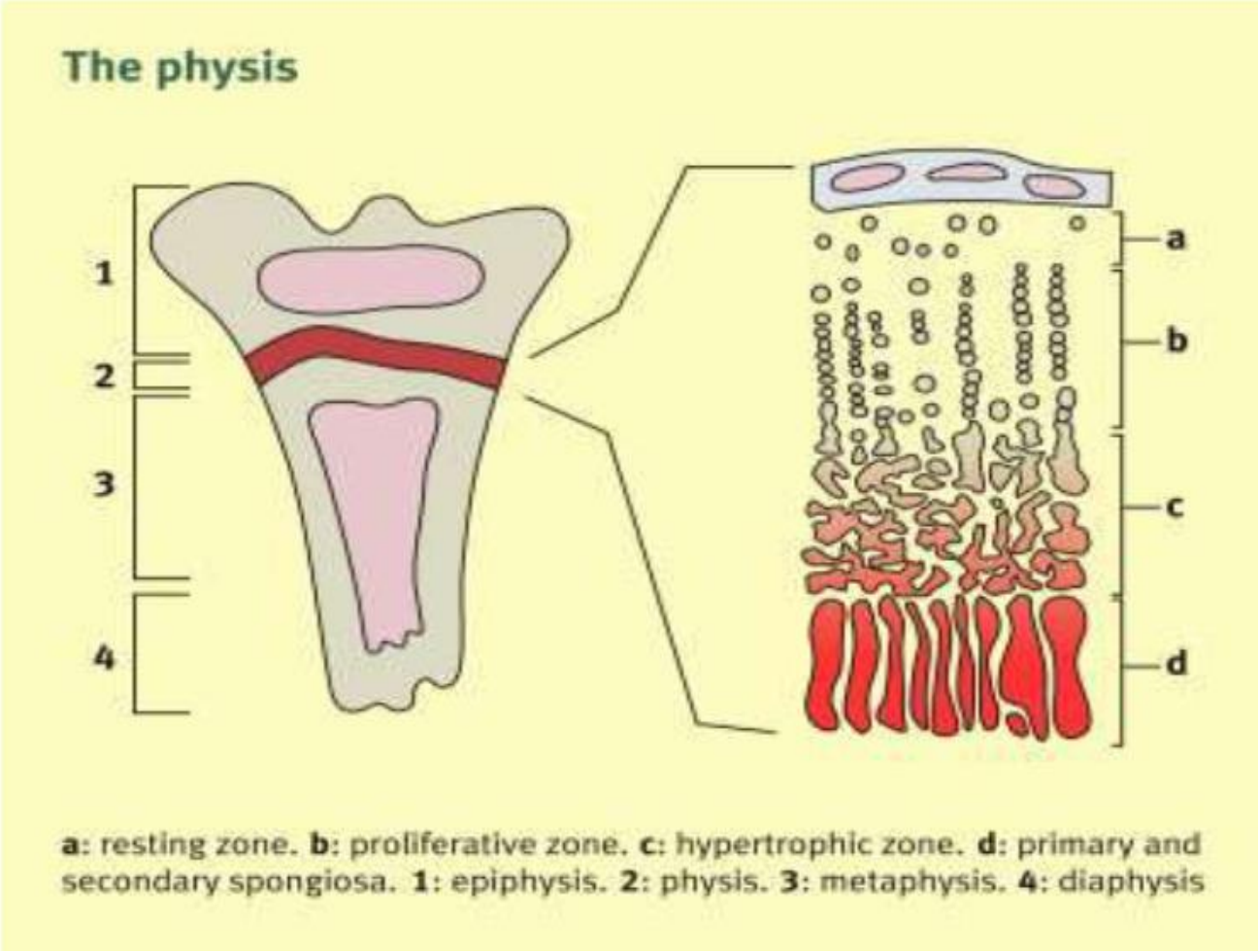
➢ Increase thickness of the hypertrophic zone and the proliferative zone

➢ Decrease number of chondrocyte an increase in matrix tissue in the hypertrophic zone

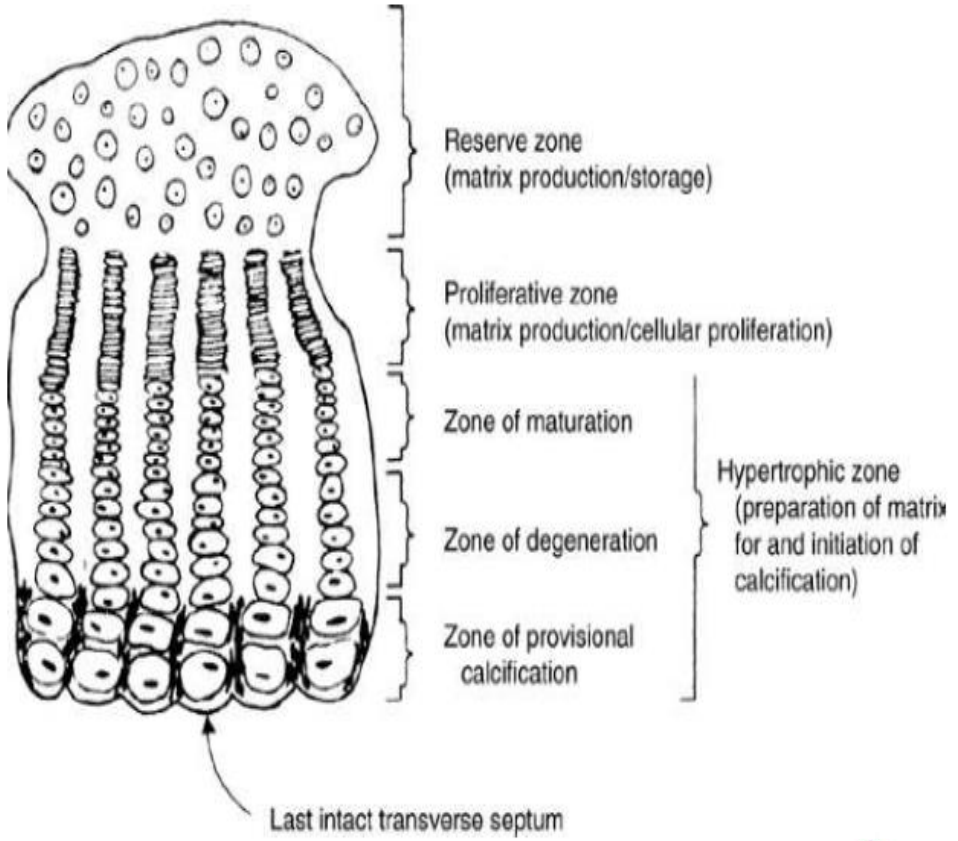
➢ Disruption in the columnar alignment of chondrocyte an arrangements as clumps

➢ Significant changes in the chondrocyte in the hypertrophic zone

THE PHYSIS



PATHO-ANATOMY



SCFE, the hypertrophic zone may constitute up to 80% of the physis width

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Clinical feature

- **<u>Depends</u>**:

- Stable vs Unstable
- Acute vs Chronic
- Presences of complications i.e. AVN or chondrolysis

Clinical feature

- **Stable, Chronic Slipped Capital Femoral Epiphysis**
- **History :**

- Pain

- Groin, thigh or knee .
- Vague or dull in nature.
- Exacerbated by activity.
- Several weeks of duration.

Clinical feature

- **Stable, Chronic Slipped Capital Femoral Epiphysis**
- **Physical examination:**

➢ Antalgic gait with Ext. Rot of the limb

➢ Thigh atrophy

➢ Local tenderness

➢ ROM: ↓ in internal Rot, abduction and flexion

: ↑ in external Rot, adduction and extension

➢ Flexion contracture: chondrolysis

➢ LLD

Clinical feature

- **Unstable Acute or Acute-on-Chronic Slipped Capital Femoral Epiphysis**

- Pain

➢ sudden onset

➢ severe, fracture like

➢ history of minor trauma or twisting injury

➢ unable to bear weight

Causes of Limp & Hip, Thigh or Knee Pain in Children

DISORDER	AGE	SEX	BILATERAL
DDH	0-2yrs	FEMALES 1:4	20%
PERTHES DISEASE	4-6yrs	MALES 5:1	10%
SCFE	10-15yrs	MALES 2:1	25-40%

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Radiographic Findings

- **Plain Radiography:**

- AP view:

➢ Preslip : widening and irregularity of the physis

❑ Trethowan sign.

❑Decreased height of epiphysis

❑ Metaphyseal blanch sign.

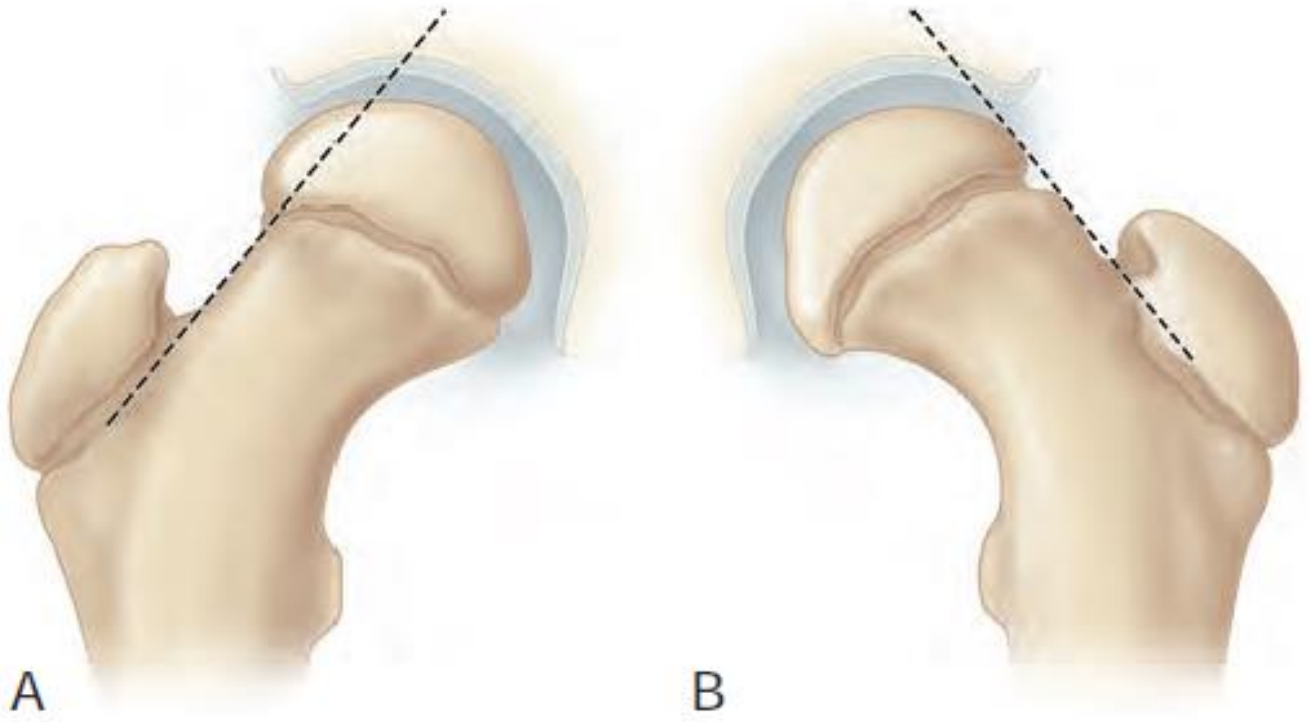
❑ Scham sign.

❑Capeners sign.

- Lateral view

Trethowan sign

AP view



Trethowan's sign is when kleins line does not intersect the lateral part of the superior femoral epiphysis on an AP radiograph of the pelvis.

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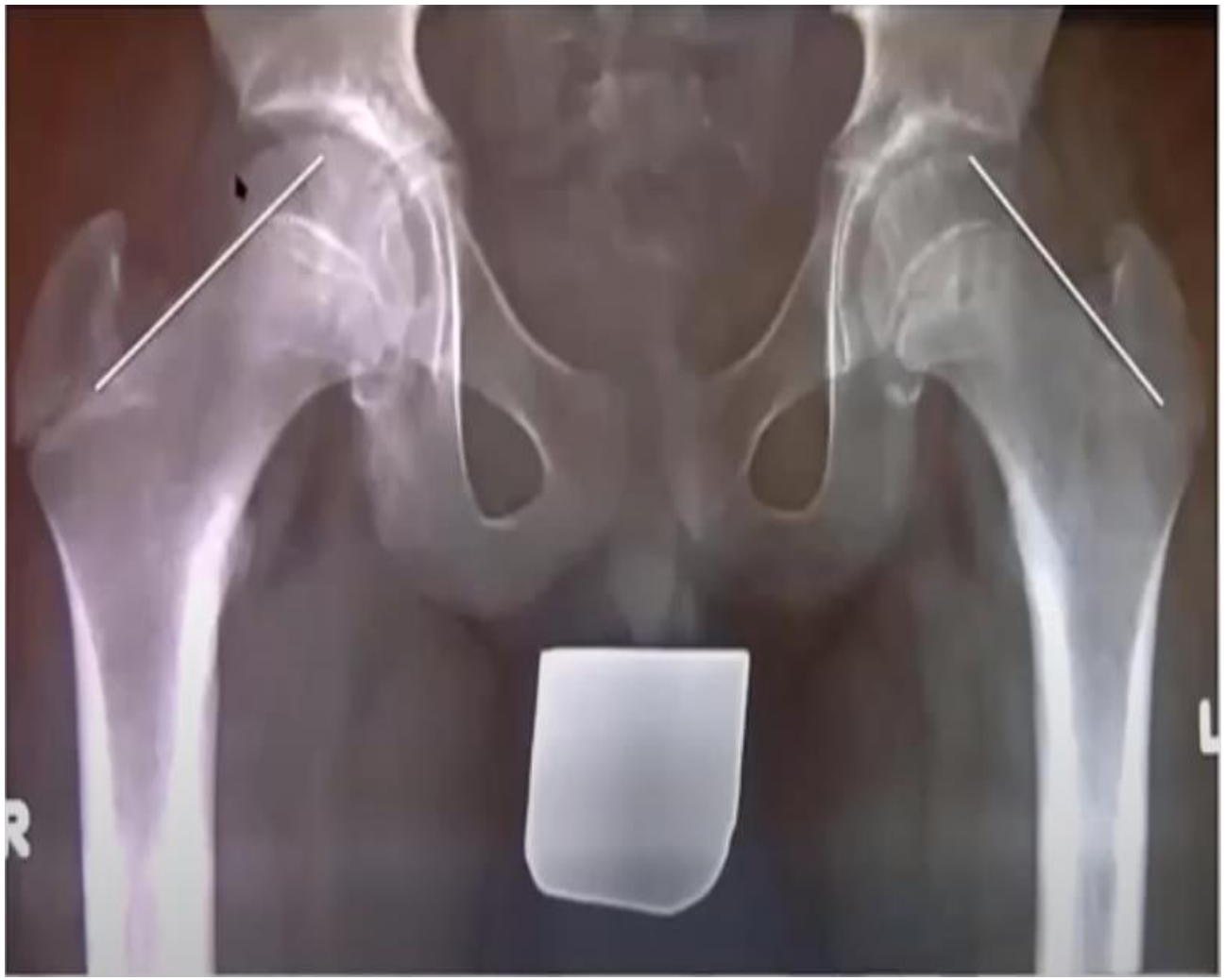
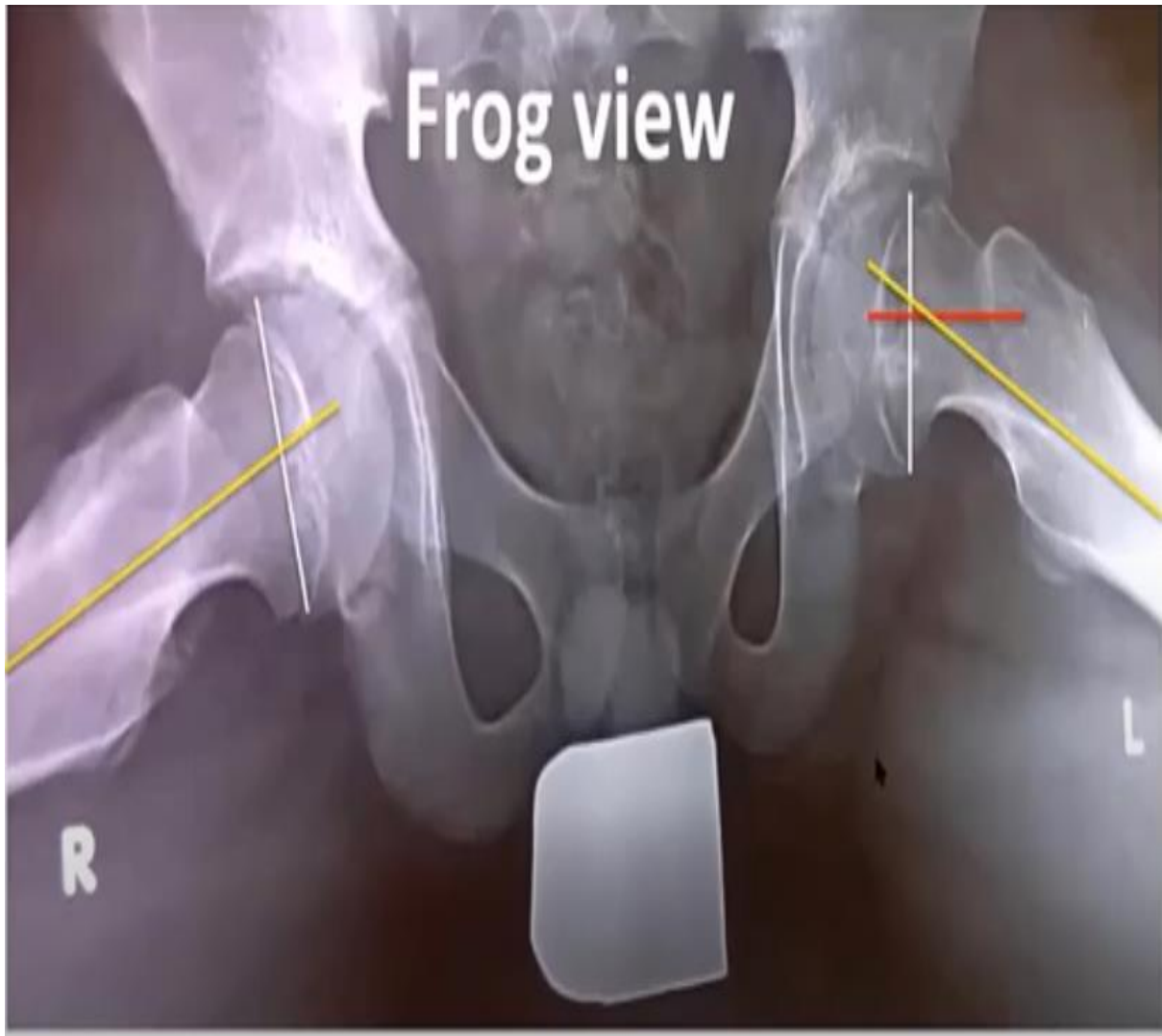
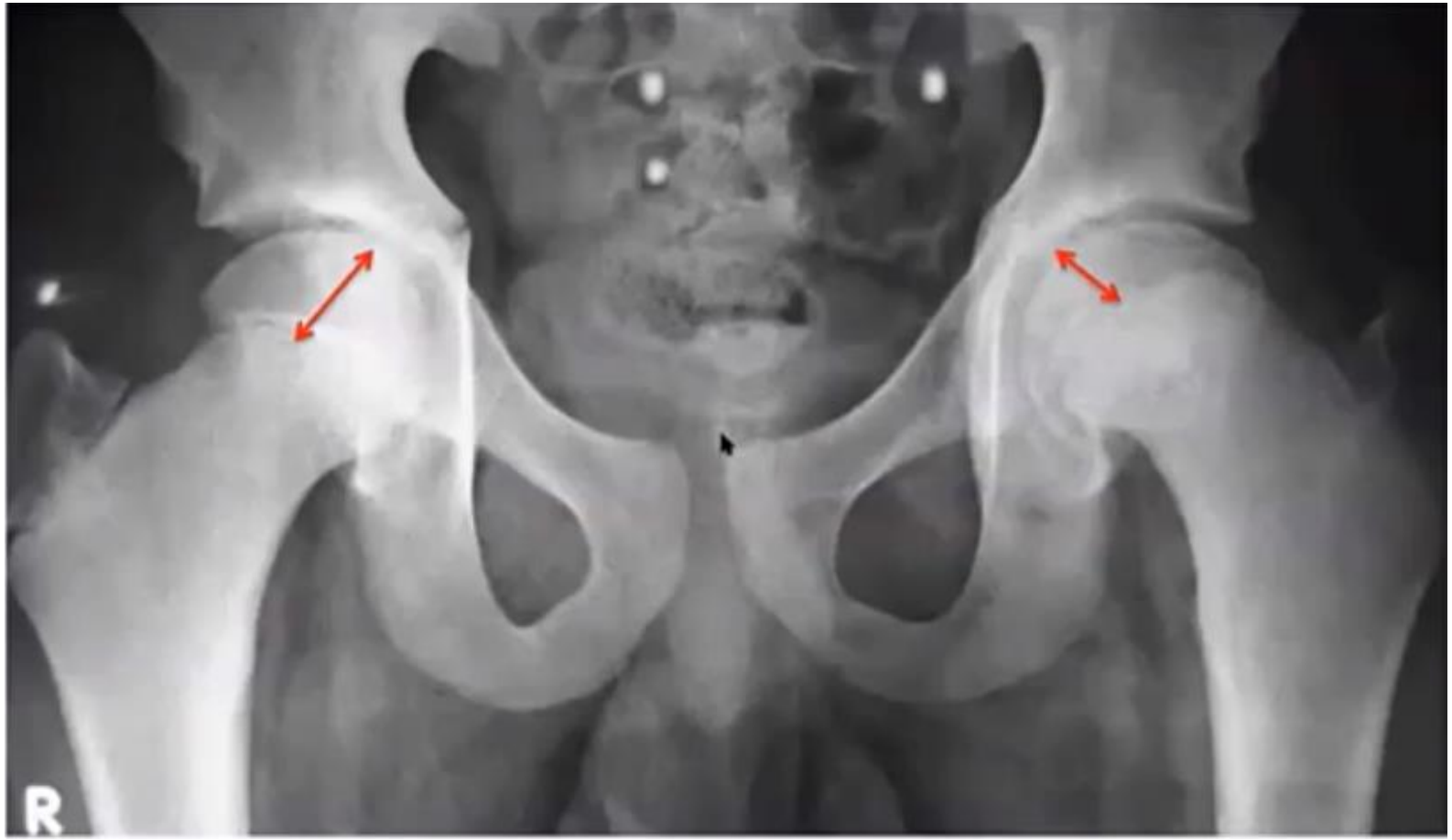

R
L


Frog view
R
L

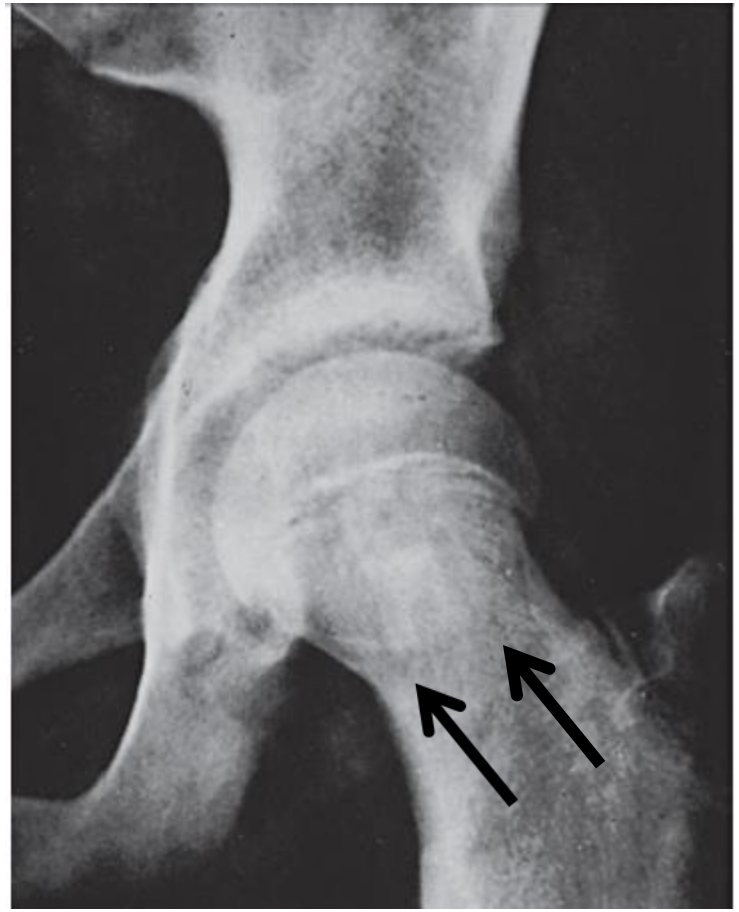
Decreased height of epiphysis



Metaphyseal blanch sign

AP view

- A crescent-shaped area of increased density over the metaphysis of the femoral neck.
- This density is produced by overlapping of femoral neck and the posteriorly displaced capital epiphysis

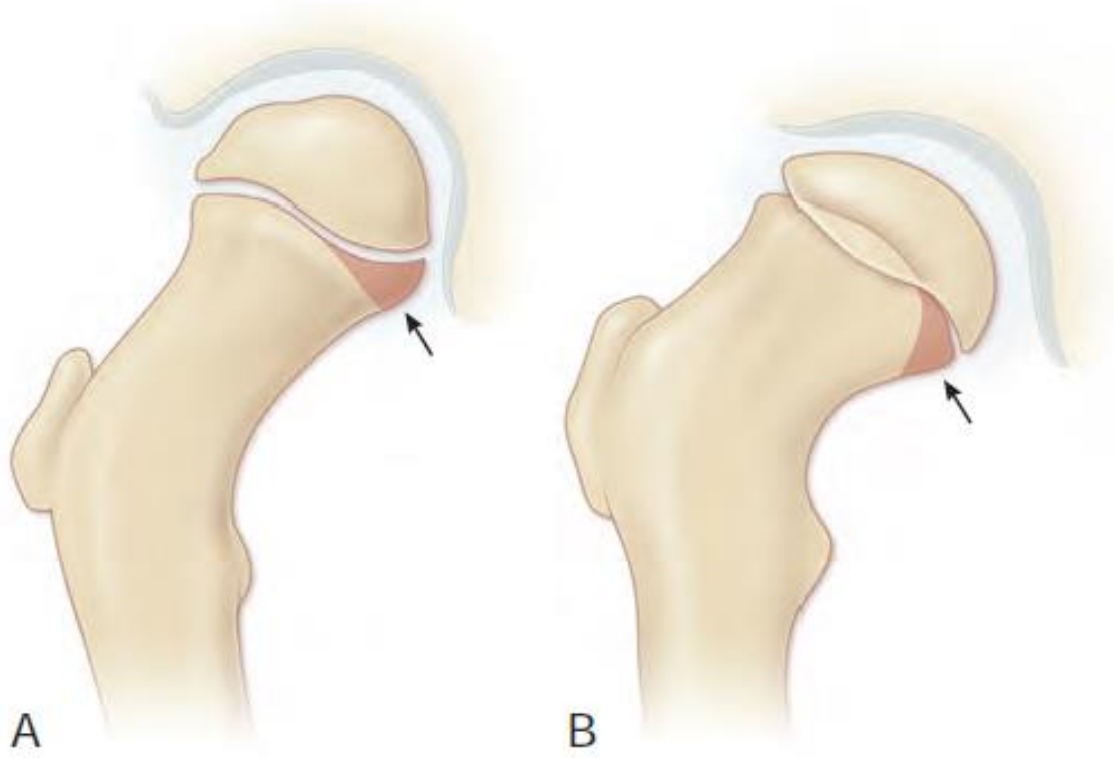


Scham sign

AP view

A) Normal hip, the inferomedial femoral neck overlaps the posterior wall of the acetabulum triangular radiographic density.

B) Displacement of the capital epiphysis – dense triangle is lost



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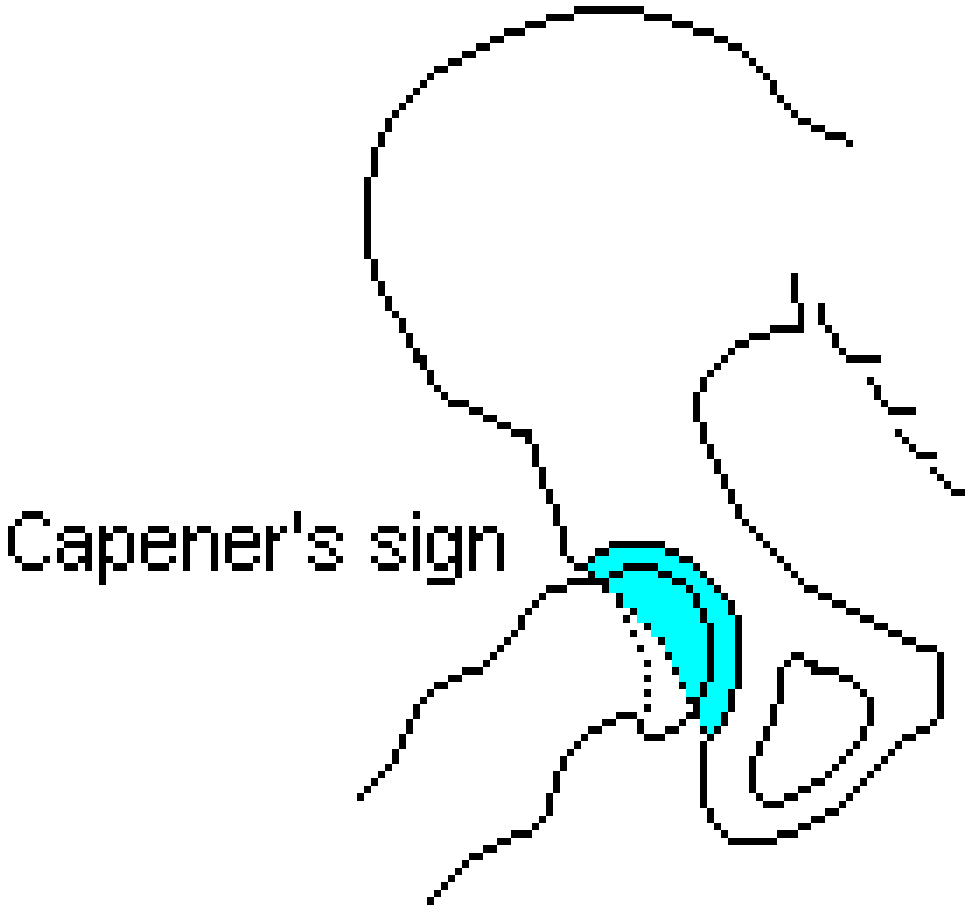
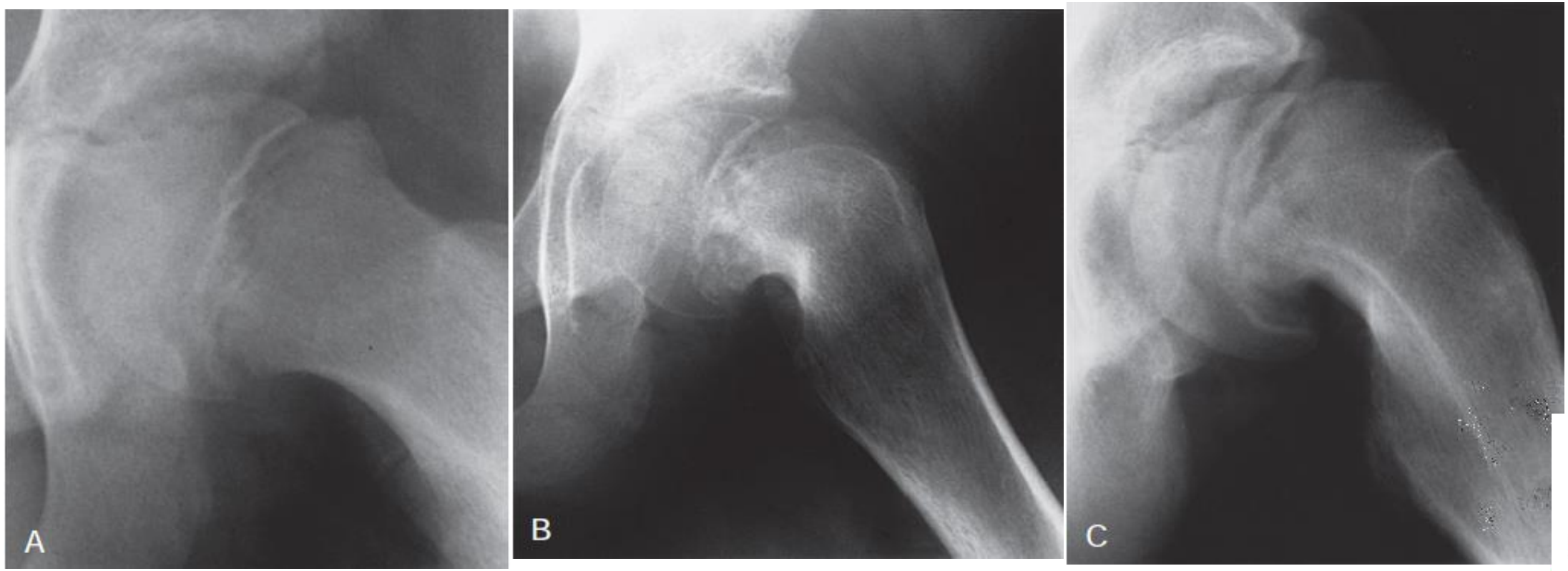
Capeners sign

- AP view in the normal hip the posterior acetabular margin cuts across the medial corner of the upper femoral metaphysis.
- With slipping the entire metaphysis is lateral to the posterior acetabular margin



Lateral view

Frog-leg lateral accentuate the deformity



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PSA“SOUTHWICK ANGLE ”

In a biomechanical saw-bone model, the energy to failure halved with every 5° increase of PSA from 15° to 30° and is virtually non-measurable over 50°

Bellemore et al. 2016

- > 15 increase the risk of starting slipping
  - Barrios et al, 2005,
  - Park et al, 2010,
  - Phillipset al, 2013,
  - Bellemore et al, 2016
  - Boyle et al, 2016

Radiographic Findings

- **Computed Tomography**
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- a
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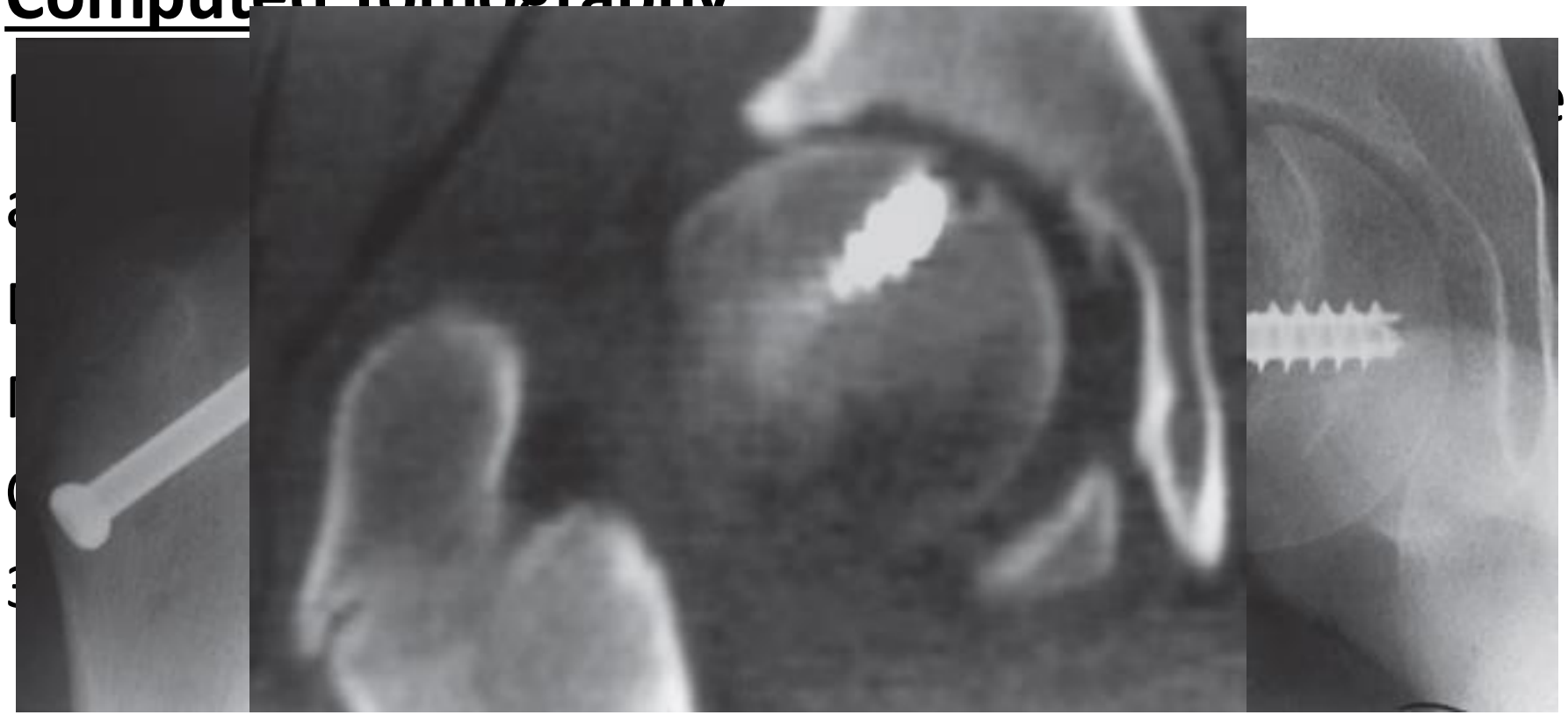

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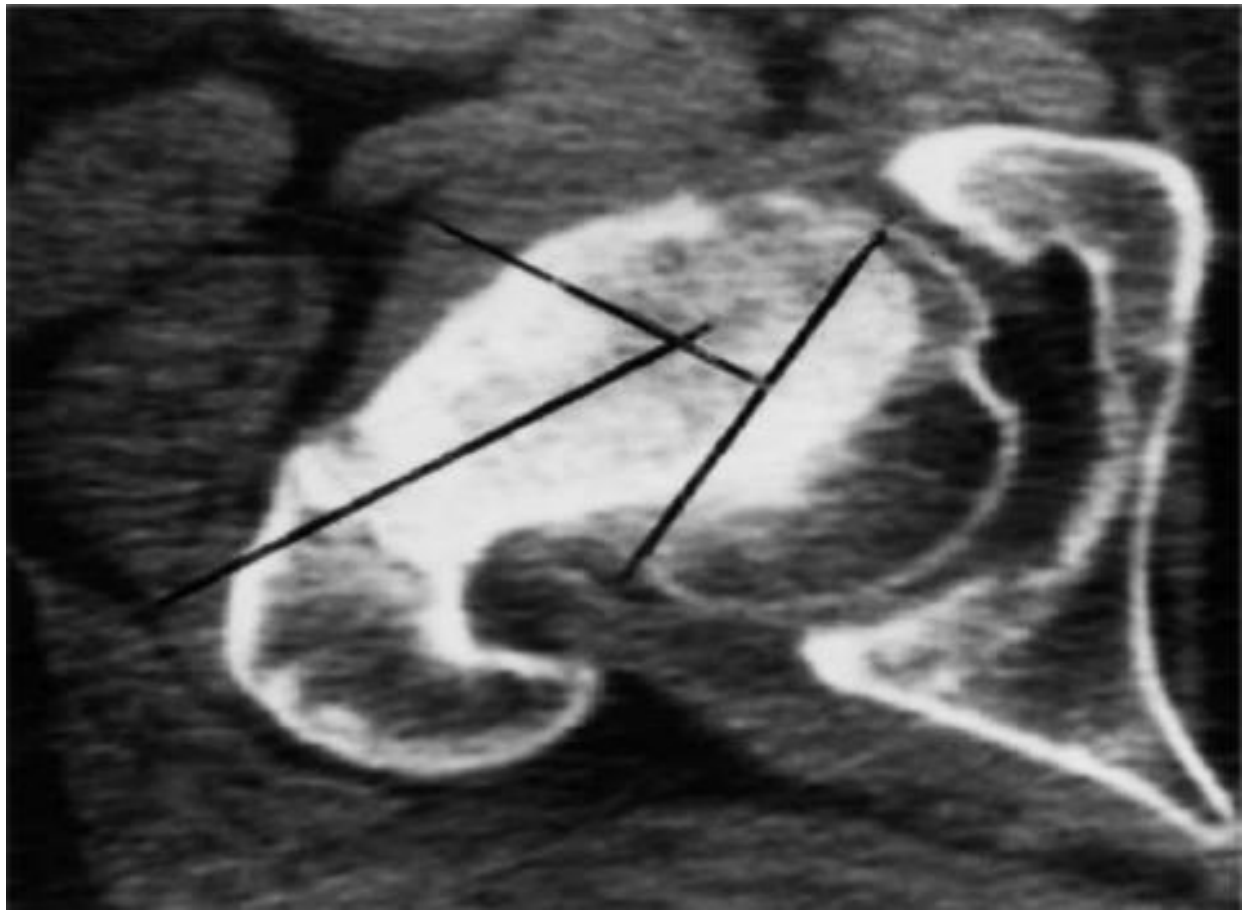
Measurement of the head–neck angle on computed tomography (CT) scan



There is significant Differences in SCFE angles between measurements taken by radiography and computed tomography.

Periera et al. 2017

If the patient is limited in flexion or external rotation, more diagnostic testing should be considered

Jones et al, 2018

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Radiographic Findings

- **Technetium-99 Bone Scan**
- Increased uptake in the capital femoral physis of an involved hip SCFE
- Decreased uptake in the presence of AVN
- Increased uptake in the joint space in the presence of chondrolysis

Radiographic Findings

- **<u>Ultrasonography</u>**
- Useful in the detection of early slips
- Joint effusion
- Step between the femoral neck and the epiphysis created by slipping

Radiographic Findings

- **<u>Magnetic Resonance Imaging</u>**
- Early slip
- Negative other imaging modalities, but suggestive patient
- Findings like physis widening and irregularity
- Detect AVN
- Expensive !!

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OPERATIVE TREATMENT

- in situ pinning
- Open reduction and internal fixation
- Epiphysiodesis
- Osteotomy
- Reconstruction by arthroplasty, arthrodesis, orcheilectomy

NON OPERATIVE TREATMENT

- 1. Absolute Bed Rest
- 2. Traction
- 3. Hip Spica Cast

Treatment

Primary goal

- ***prevent more slippage***

Secndary goals

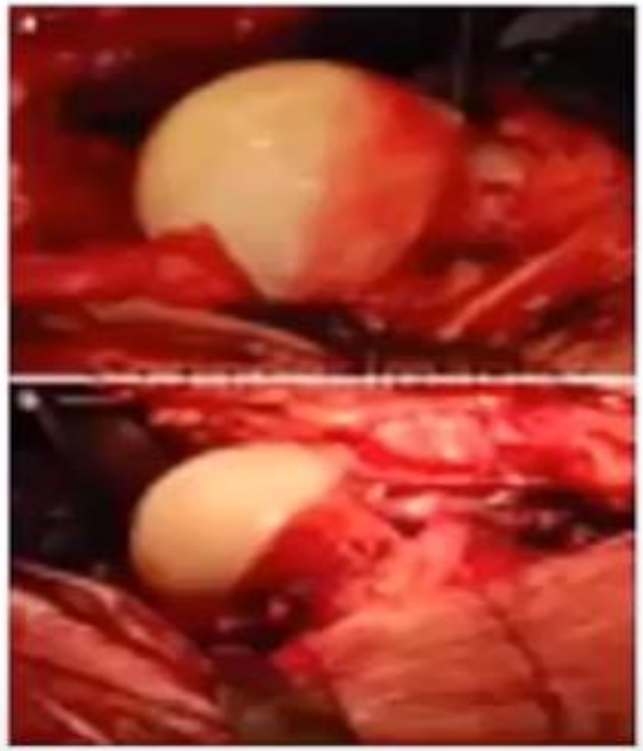
- ***Reduction of epiphyseal displacement***
- ***Closure of the physis***

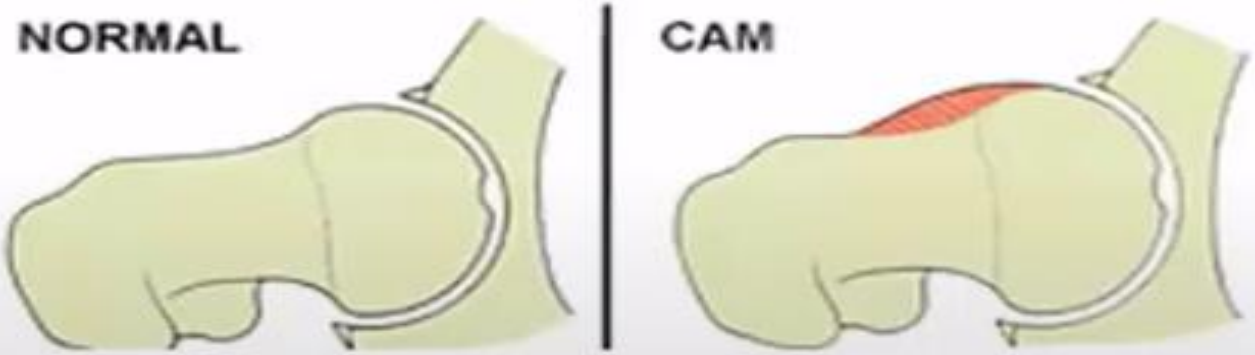
Long term goals

- **1)Restoration of a functional range of motion**
- **2)Freedom from pain**
- **Prevent imingment and OA**
- **3) Avoidance of aseptic necrosis and chondrolysis**

Treatment,

- Mild → Perc pinning
- Moderate → Perc pinning +/- neck osteoplasty





- Severe slip → Reduction of CFE

Modified Dunn's Procedure

Treatment

- **Stable SCFE**

- In situ pinning
- Bone graft epipysiodesis
- Spica cast

Types of in situ pinning

- Epiphysiodeis
- Growth sparing

In Situ pinning epiphysiodesis pinning

- ***Treatment of choice***
- Single cannulated screw provides stable fixations in most grades
- The goal is to stabilize rather than closure of the physis which may or may not occur
- The screw should be in the center of the femoral head and the tip of the screw should not be close to the articular surface

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In Situ pinning

- **<u>Cannulated screw, Design and positioning</u>**
- Multiple designs
- Large core and thread diameters
- Reverse cutting threads
- Effective removal set
- Long partial threaded or fully threaded
- *Single screw is satisfactory*
- <u>Double screws for unstable slips</u> , 66% stiffer
- Location of the screw: central or inferior posterior

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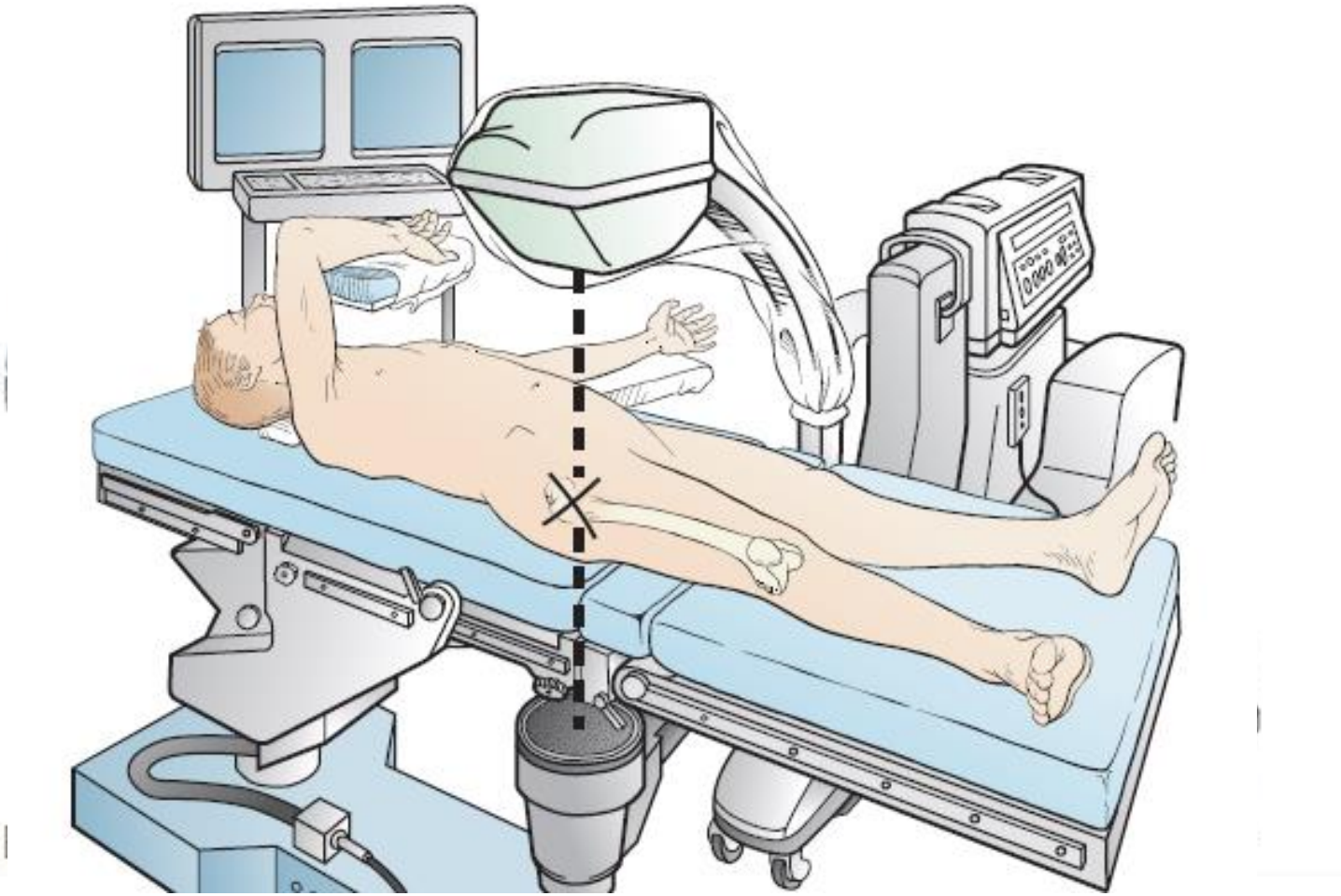
In Situ pinning



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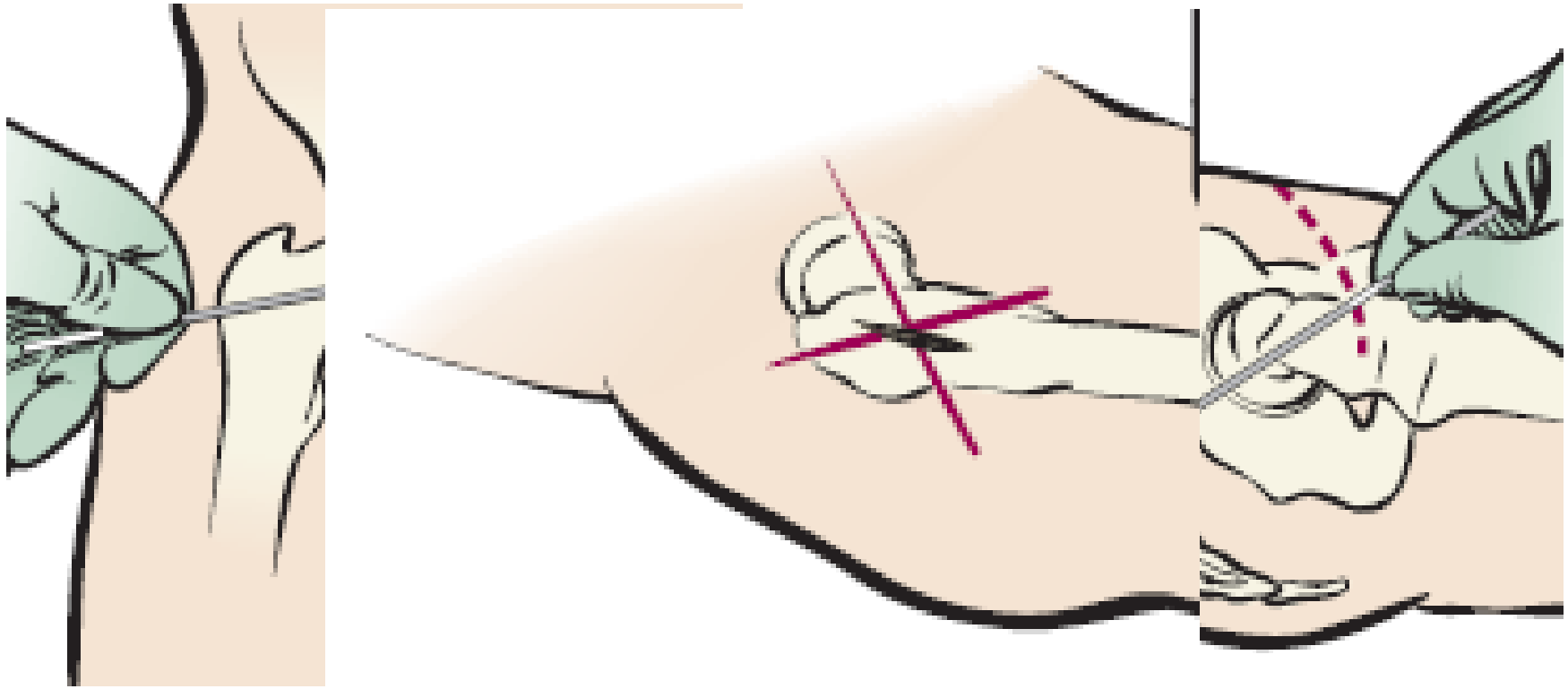
In Situ pinning



In Situ pinning

- **<u>Post operative management:</u>**

➢Range-of-motion exercises - begun early.

➢Protected partial weight bearing with crutches.

➢6 weeks duration.

➢sports and direct contact activities forbidden until physes have closed.

➢Continue monitoring every 3-6 month for either complications or contralateral slip.

The screws removed after physeal closure

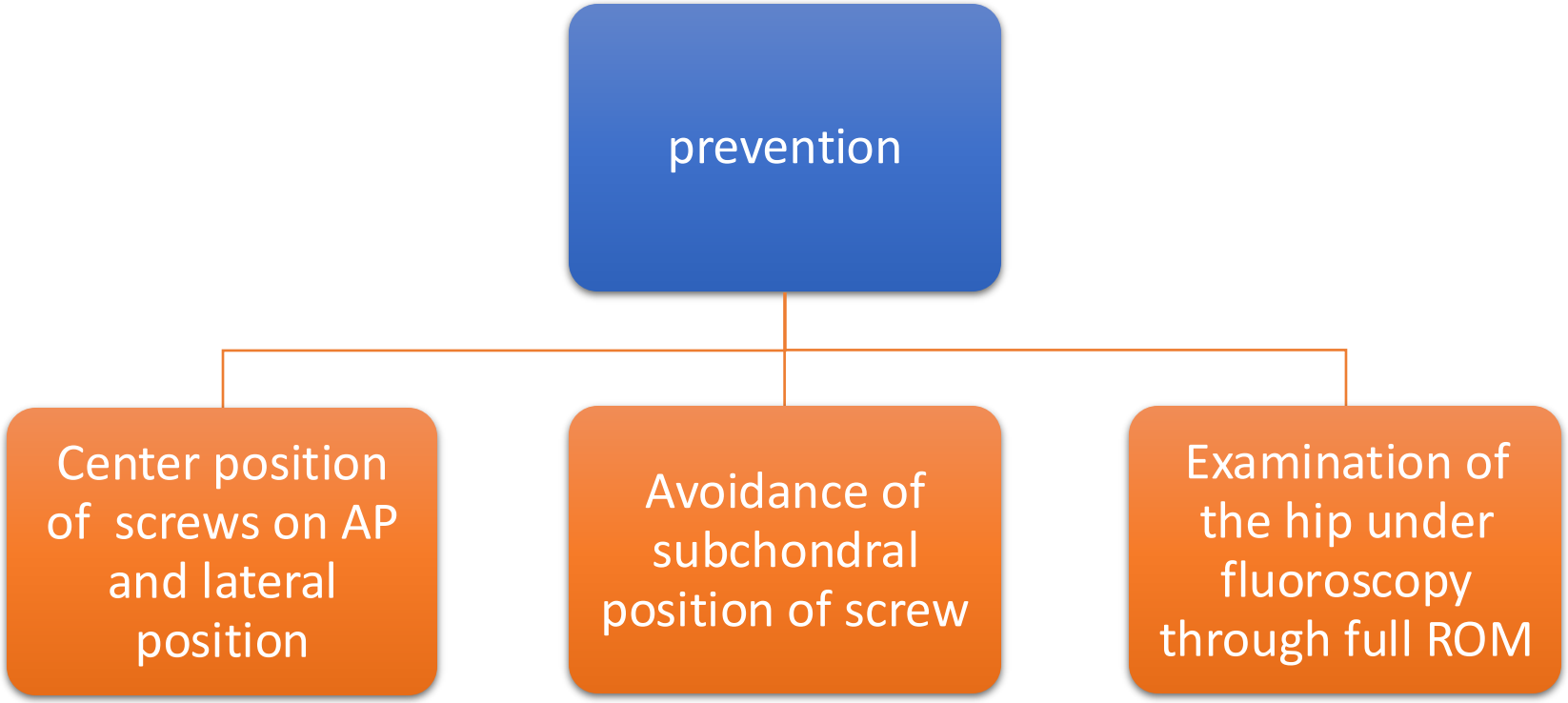
In Situ pinning

- **<u>Screw related complications</u>**

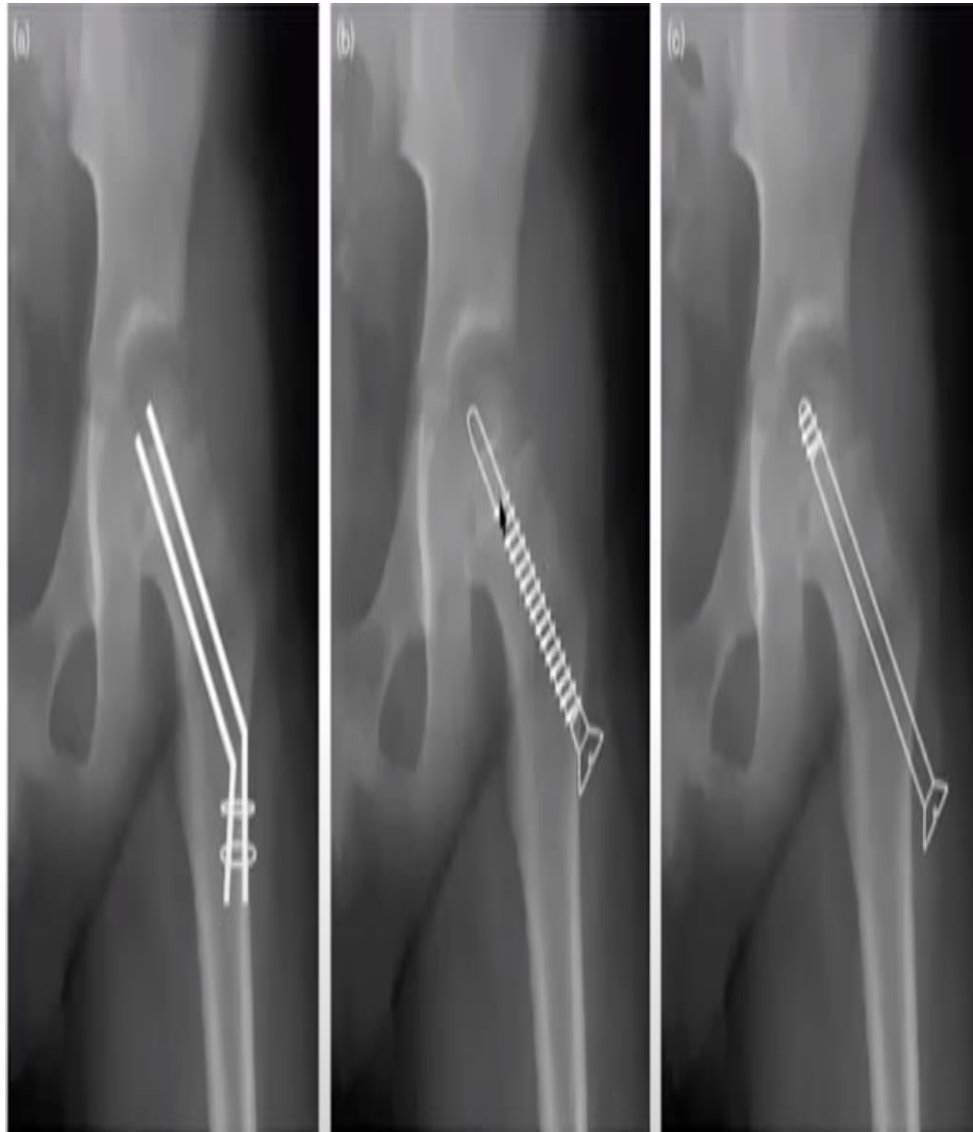
- perforation into the joint space by the screw or guidewire
- Failure of physeal closure
- Implant failure or fracture
- NOF fracture

In Situ pinning

- perforation into the joint space by the screw or guidewire



Physeal sparing pinning



Crossing the physis with non threaded pin/pins

In Situ pinning

- **<u>Routine Removal of Screws:</u>**

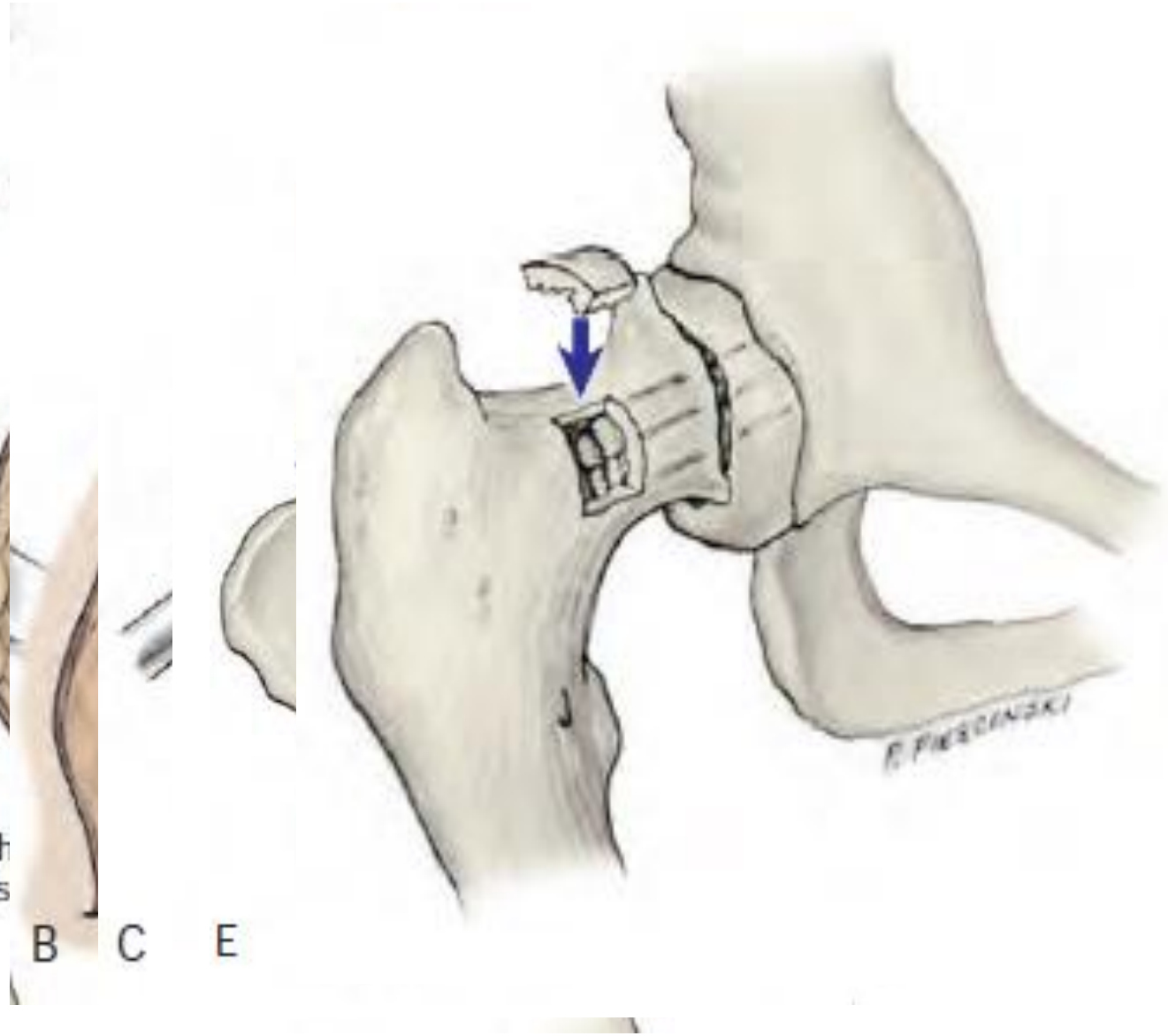
- After physeal closure
- Difficult to remove later
- Risk of fracture

Treatment

- **Stable SCFE**

- In situ pinning
- Bone graft epipysiodesis
- Spica cast

Bone graft epipysiodesis



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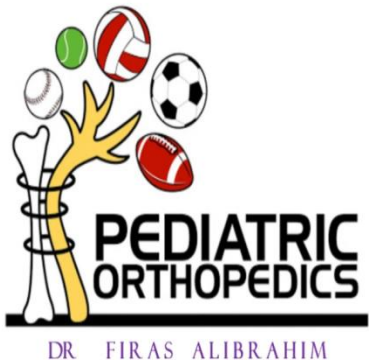
Bone graft epipysiodesis

- **<u>Postoperative Management:</u>**

- Stable slip → protected weight bearing using crutches or a walker
- Unstable slip → Spica cast or traction for 3-6 weeks the protected weight bearing

- **<u>Results:</u>**Contradictory .
- **<u>Disadvantages</u>**
- 1)Graft insufficiency.
- 2)Increase in severity of slip.
- 3)Failure of physeal fusion.
- 4)longer operating time, increased blood loss, longer hospitalization, and longer rehabilitation.



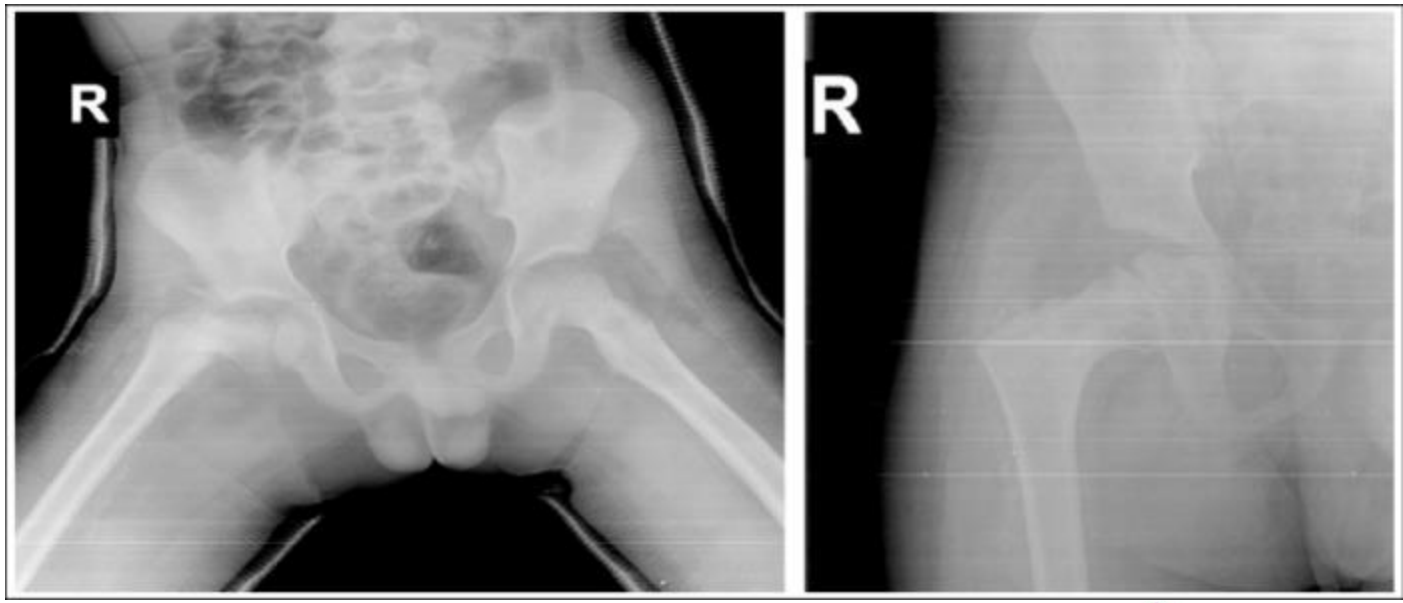
Treatment

- **Stable SCFE**

- In situ pinning
- Bone graft epipysiodesis
- Spica cast

Spica cast

- *When??*
- Mostly used as adjunct.
- Definitive in very rare cases where operative tx is not available or failed.
- *How???*
- Bilateral BK cast
- Holding the hips in Abd & IR
- Weight bearing not allowed usually for 3 - 4 months



PEDIATRIC ORTHOPEDICS

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Treatment

- **Unstable SCFE**

Currently, there is controversy regarding the preferred treatment and the timing of treatment for unstable slips.

Treatment

- **Unstable SCFE**

-Urgent reduction.

-Fixation.

-Decompression of the joint.

-Open reduction.

Treatment

- **Unstable SCFE**
- **<u>Timing of reduction:</u>**

- Peterson and colleagues, 91 unstable slips, reduction within 24 hours, AVN developed in only **<u>7%,</u>** whereas **<u>20%</u>** developed AVN with reduction more than 24 hours after presentation.

- Loder and colleagues, hips treated more than 48 hours after admission had a lower rate of AVN than those treated within 48 hours after admission.

Treatment

- **Unstable SCFE**
- **<u>Minimal closed reduction of the SCFE:</u>**

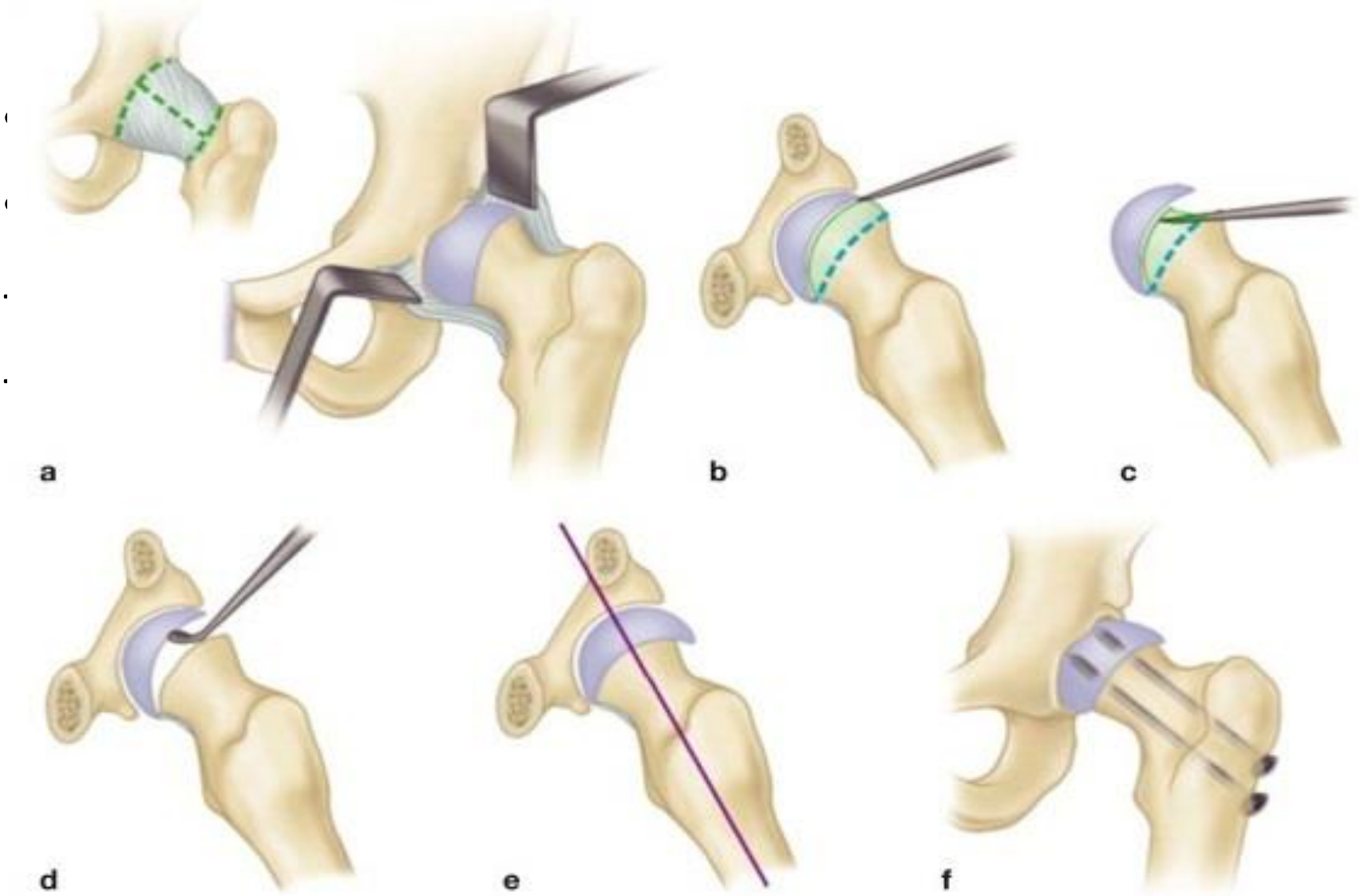
- The most frequently used method of treatment for unstable slipped epiphysis is screw fixation of the head after positioning on a fracture table.
- Positioning usually involves internally rotating the lower extremity to a neutral position with minimal traction, then stabilizing the limb in that position
- Fixation, as described for in situ fixation

Treatment

- **Unstable SCFE**
- **<u>Primary Open Reduction of the SCFE:</u>**

- Dunn procedure
- Modified Dunn procedure

Treatment



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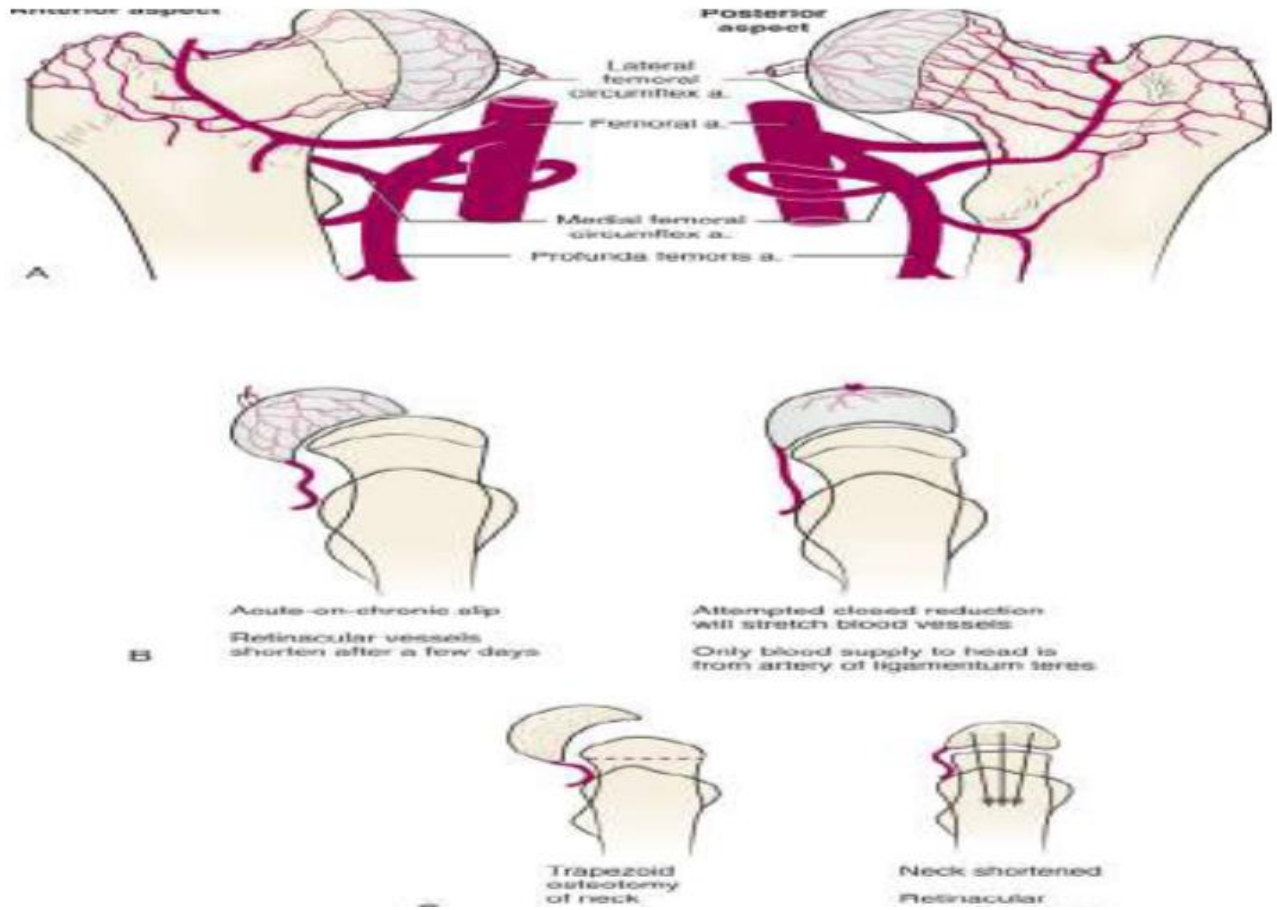

PEDIATRIC ORTHOPEDICS

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Treatment

- **Primary Open Reduction of the SCFE:**

- Dunn procedure

Treatment

- **<u>Primary Open Reduction of the SCFE:</u>**
- **<u>Modified Dunn procedure</u>**

- Ganz..
- Open reduction using surgical dislocation of the hip.
- Reports: less events of AVN compared to Dunn procdure

Treatment

- **Prophylactic Treatment of the Contralateral Hip**

- 20% of patients with typical SCFE present with bilateral involvement
- 20% subsequently develops symptomatic contralateral slip
- Two main factors:

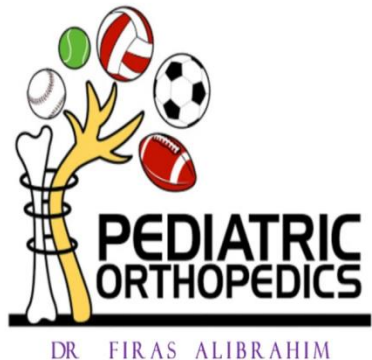
1. Underlying medical condition:

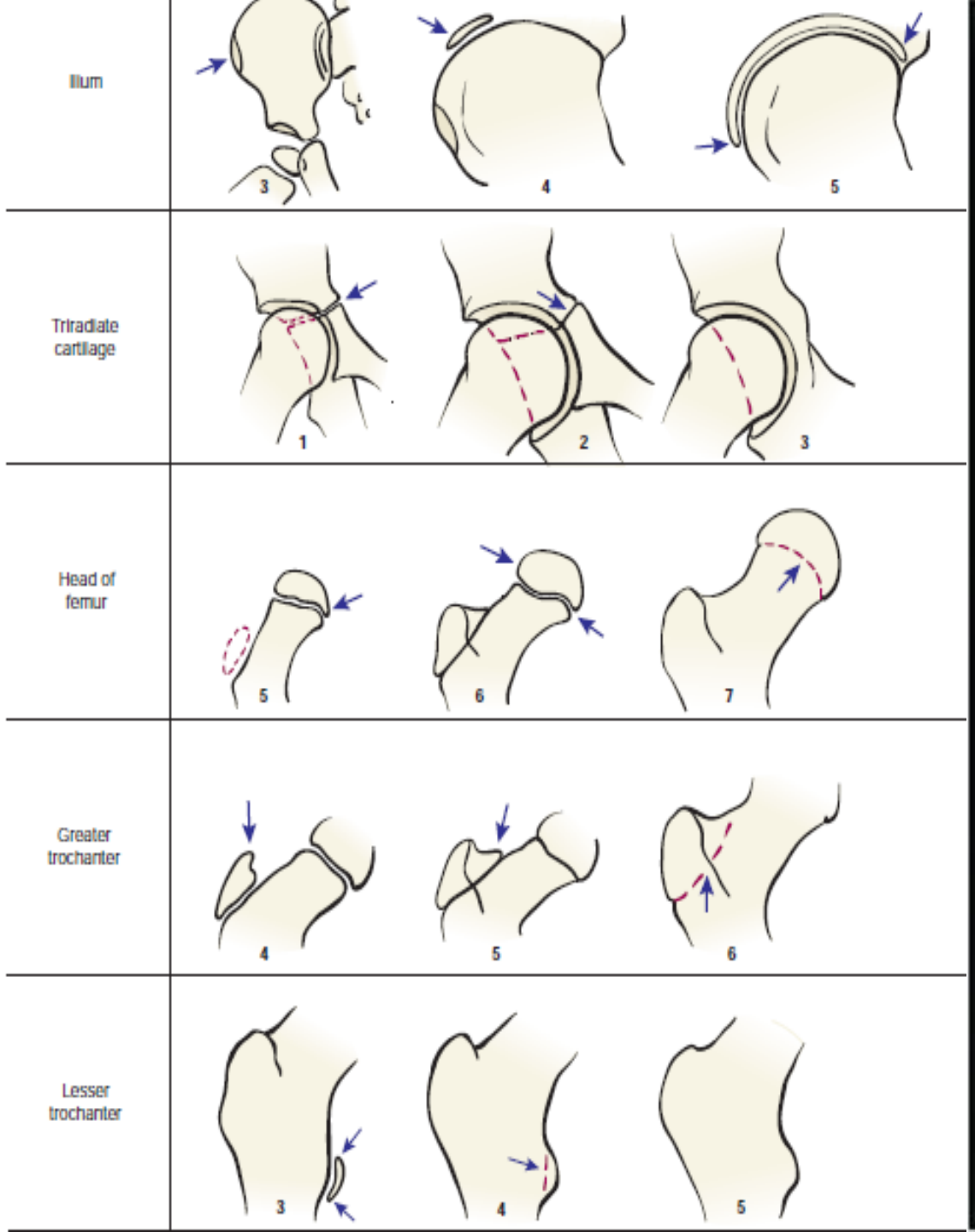
➢ *Chronic renal insufficiency , 95%*

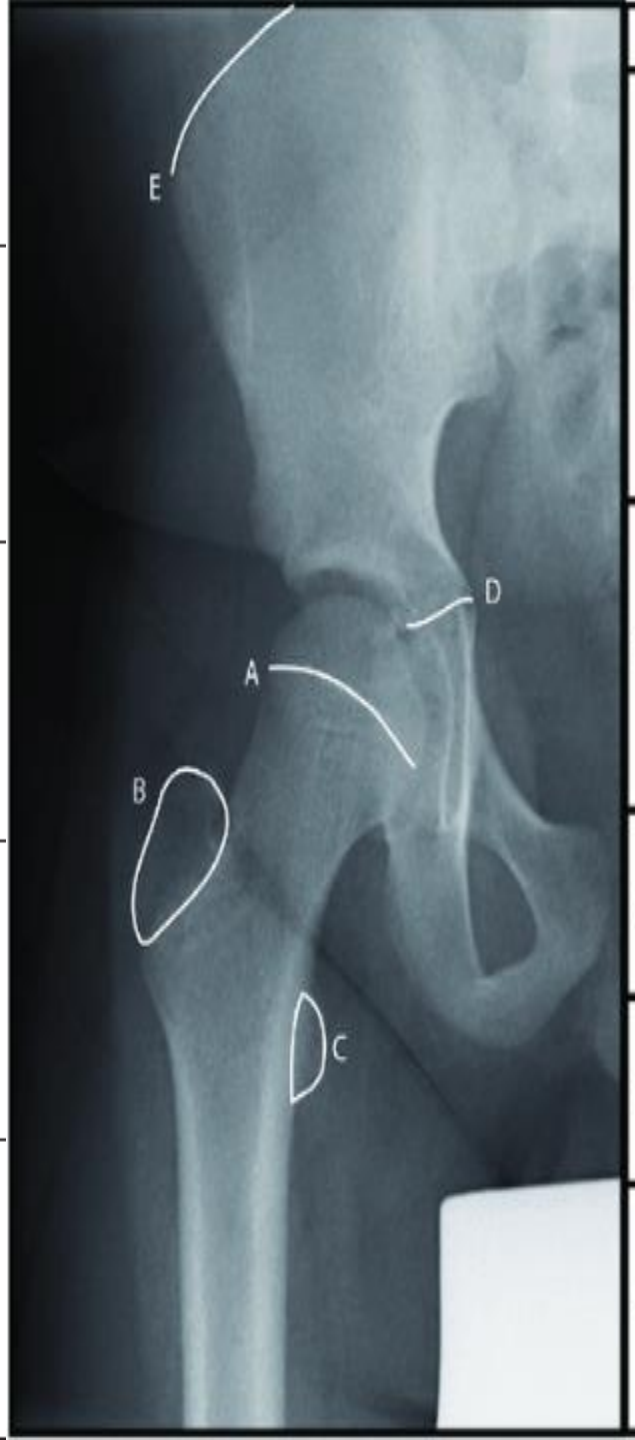
➢ *Endocrinopathies.*

➢ Epiphysiolysis from irradiation therapy.

2.Skeletal maturity (modified oxford score),or Children younger than 10 years at the time of presentation







	PHYSIS	POINTS	DESCRIPTION
A	Femoral Head	5	Straight neck, no fovea, medial beaking of epiphysis
		6	Epiphysis wider than neck, well defined fovea
		7	Physis starting to close
B	Greater trochanter	4	Simple ossified nodule
		5	Smooth connection between nodule and neck
		6	Physis starting to close
C	Lesser Trochanter	3	Physis clearly opened
		4	Physis partially closed
		5	Physis closed
D	Triradiate cartilage	1	Physis clearly opened
		2	Physis partially closed
		3	Physis closed
E	Ilium	3	Absence of ossified apophysis (Risser 0)
		4	Presence of ossified apophysis

Prophylactic Treatment of the Contralateral Hip

- **Modified oxford score**

- 89% of open tri radiate cartilage develop contralateral slip
- < 4% closed tri radiate cartilage develop contralateral slip
- 85% of score 16
- 11% of score of 11
- 0% of score 21

Prophylactic Treatment of the Contralateral Hip

- If not done :

- Parents counseling
- Frequent evaluation clinically and radiologically every six months

Chapter Outline

Incidence and Epidemiology
Classification
Etiology
Pathology
Clinical Features
Radiographic Findings
Treatment
Complications
Prognosis

SCFE: Natural hist.

- Recent evidence

- Metaphyseal deformity, in even a mild SCFE, results in acetabular & labral damage
- OA, 15 – 25% even in mild degree

Fraitzl et al. *JBJS B, 2007*
Leunig et al. *CORR 2010*
Wensaas et al, 2011
Alexandreu et al. 2017

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Complication

SCFE is the most extreme example of Cam-femoroacetabular impingement

Leunig et al Acta Orthop Scand 2000
Rab JPO 1999
Sink JPO 2011

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Complication

- Avascular necrosis
- Chondrolysis
- FAI.
- OA.

One aspect of these complications is that either may occur spontaneously or may be related to treatment.

Complication

- **<u>Avascular necrosis ; AVN</u>**

- The most severe complication
- More in acute displaced slip, unstable slip
- More in treated cases, closed and open reduction more than fixation in situ

Complication

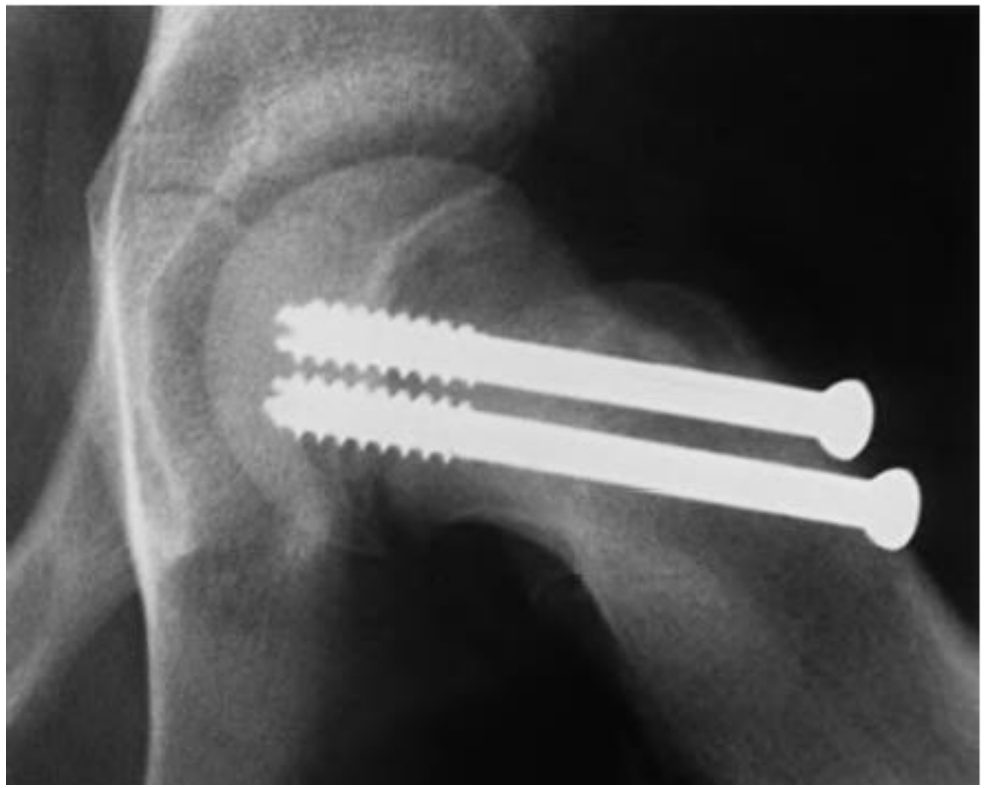
- **Avascular necrosis ; AVN**
- **pathoanatomy :**

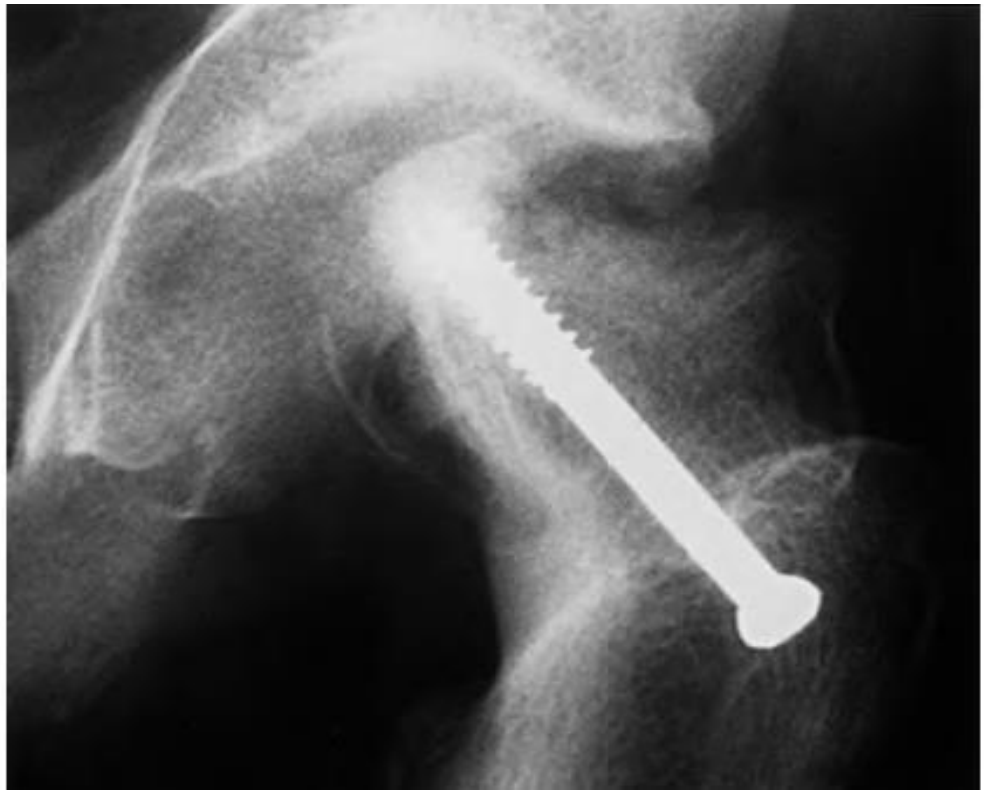
- Blood supply to SCFE age group is from **lateral epiphyseal system**
- Tearing of the periosteum during acute displacement of the epiphysis
- During forcible attempts at reduction that tear the posterior periosteum.
- During intraarticular surgery.
- Intraarticular tamponade by traumatic effusion.

Complication

- **Avascular necrosis ; AVN**
- **Radiographic Findings**

- Evident as early as few weeks after onset of slip i.e. **dense epiphysis**
- All cases are evident after 1 year of slip i.e. **progressive collapse and resorption**
- Two patterns: total or partial involvement
- DX BY :Doppler US , MRI, Bone scan





PEDIATRIC ORTHOPEDICS

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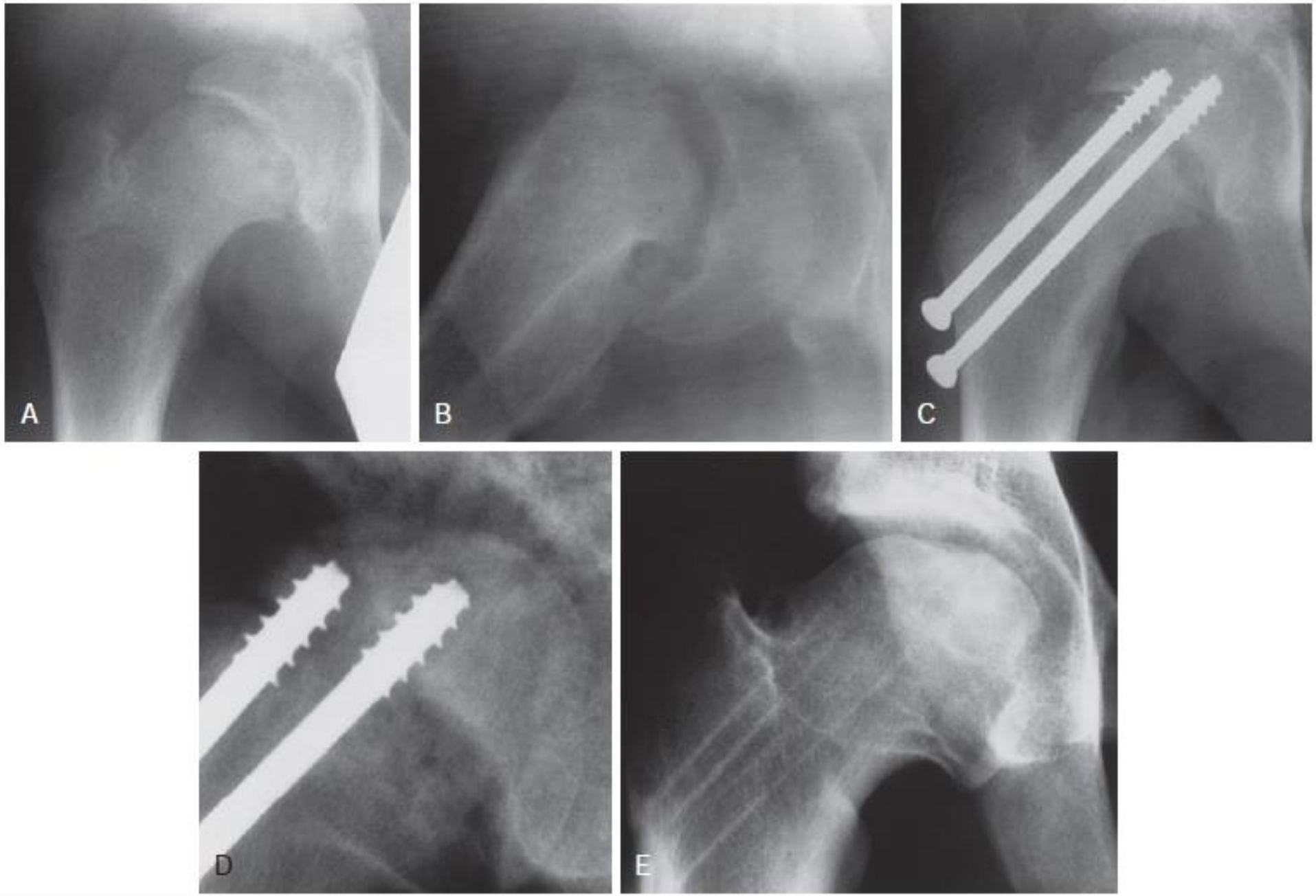
Complication

- **<u>Avascular necrosis ; AVN</u>**
- **<u>Natural history</u>**

- Progressive collapse and resorption
- Healed AVN with residual deformity
- Healed AVN with minimal deformity



PEDIATRIC ORTHOPEDICS

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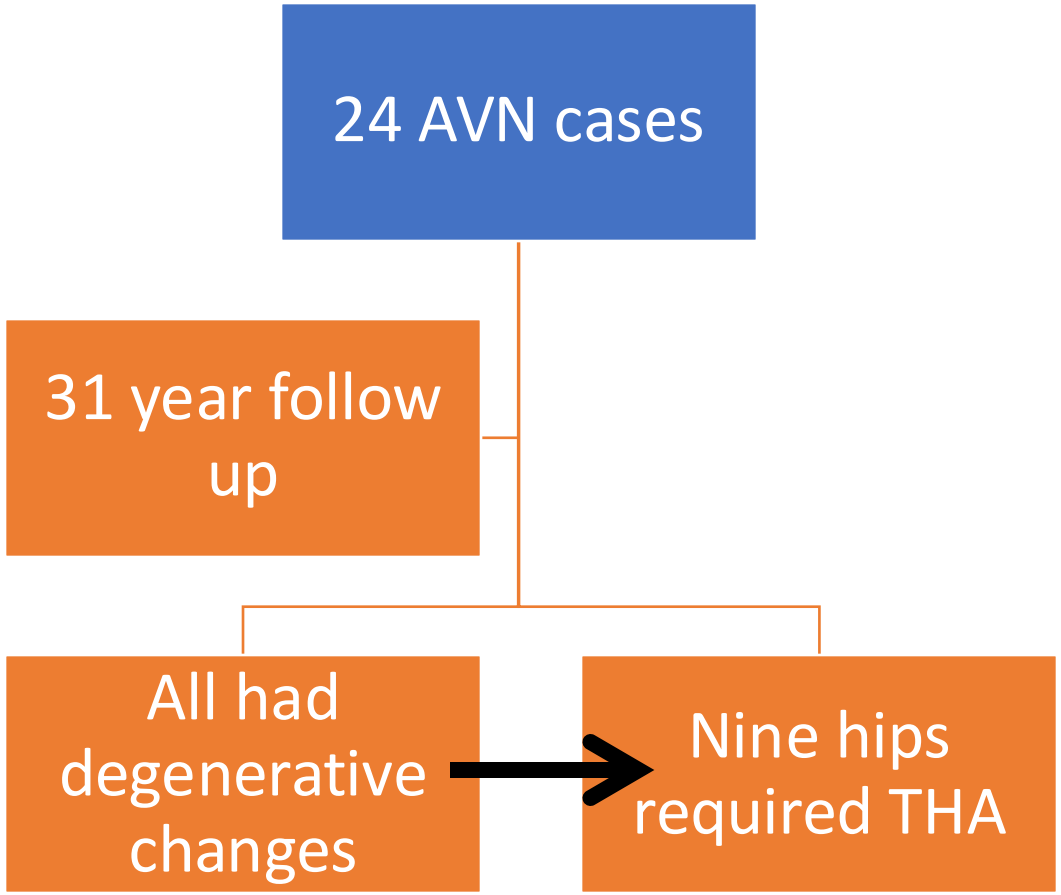
Complication



Complication

A study of primary total hip arthroplasties in patients with prior SCFE found that AVN was the most common indication for arthroplasty, more frequent than joint degeneration associated with femoroacetabular impingement.

Complication

- **<u>Avascular necrosis ; AVN</u>**
- **<u>Treatment :</u>**

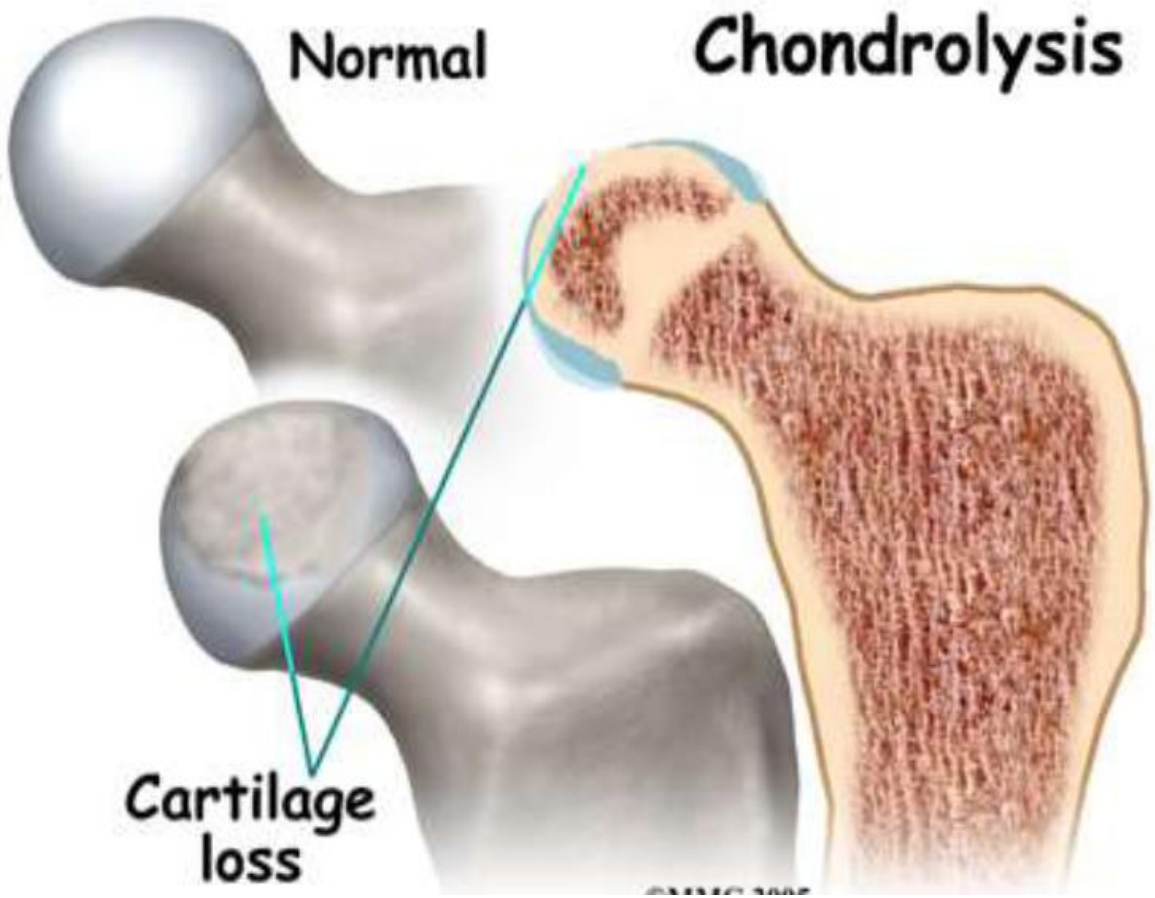
- Prevention
- Patient and family counseling after Dx
- AVN with out collapse → vascularization procedure
- Painless AVN with non functional position deformity, corrective osteotomy to be done
- Painful AVN with poor progressive functional and radiological changes, arthroplasty or hip fusion to be done

Complication

- **Chondrolysis**
- **Radiological finding:**

- Loss of joint space.

- The radiographic criterion - loss of more than 50% ofthe joint space
- or an absolute measurement of 3 mm or less.(normal-4-6mm)
- A technetium bone scan shows increased uptake in an affected joint space.



PEDIATRIC ORTHOPEDICS
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Complication

- **<u>Chondrolysis</u>**
- **<u>Clinical findings:</u>**

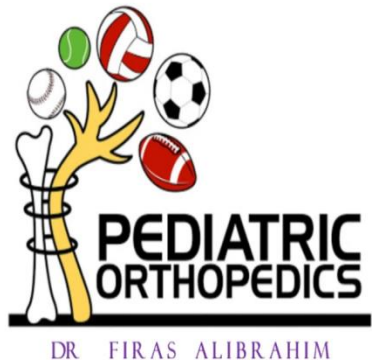
- Stiffness, persistent pain,
- Flexion, abduction and external rotation position
- Decreased and painful ROM

Complication

- **<u>Chondrolysis</u>**
- **<u>Epidemiology :</u>**

- 1.5% in cases of fixation in situ.PIN PENETRATION
- 50% in cases treated with Spica cast.
- Females > Males.
- **Intertrochanteric osteotomy.**

▪ *Symptoms develop between <u>6 weeks and 4 months</u> after treatm*



Complication

- **<u>Chondrolysis</u>**
- **<u>Etiology</u>**

- Precisely unknown

- ↓ In articular cartilage nutrition due to decreased in synovial fluid production
- Autoimmune state induce by antigen produced by SCFE
- High correlation between cartilage penetration by screw or pin

- *Metallic implant penetration.*
- Impingement **- *labrum and acetabulum by*** anterior “pistol grip” deformity of the femoral neck.

Complication

- **Chondrolysis**
- **Pathology**

- Initial findings:

➢ Nonspecific inflammatory process like thickening of the synovium

➢ Gross appearance of cartilage is normal

- Later findings:

➢ Fibrosis of synovium with thickening of capsule

➢ The articular cartilage become thin, soft and attenuated

- Both head of the femur and he acetabulum are affected
- Advanced stages: fibrosis and adhesion of joint
- Chronic stages: destruction of the articular cartilage with exposed raw bone

Complication

- **Chondrolysis**
- **Treatment:**
- CT of the hip to confirm that no implant encroachment is present.
- Aspiration of the hip to rule out a low-grade infection.
- If pin penetration has occurred, the implant must be removed or replaced if the physis is not fused.
- Muscle releases or capsulotomy.

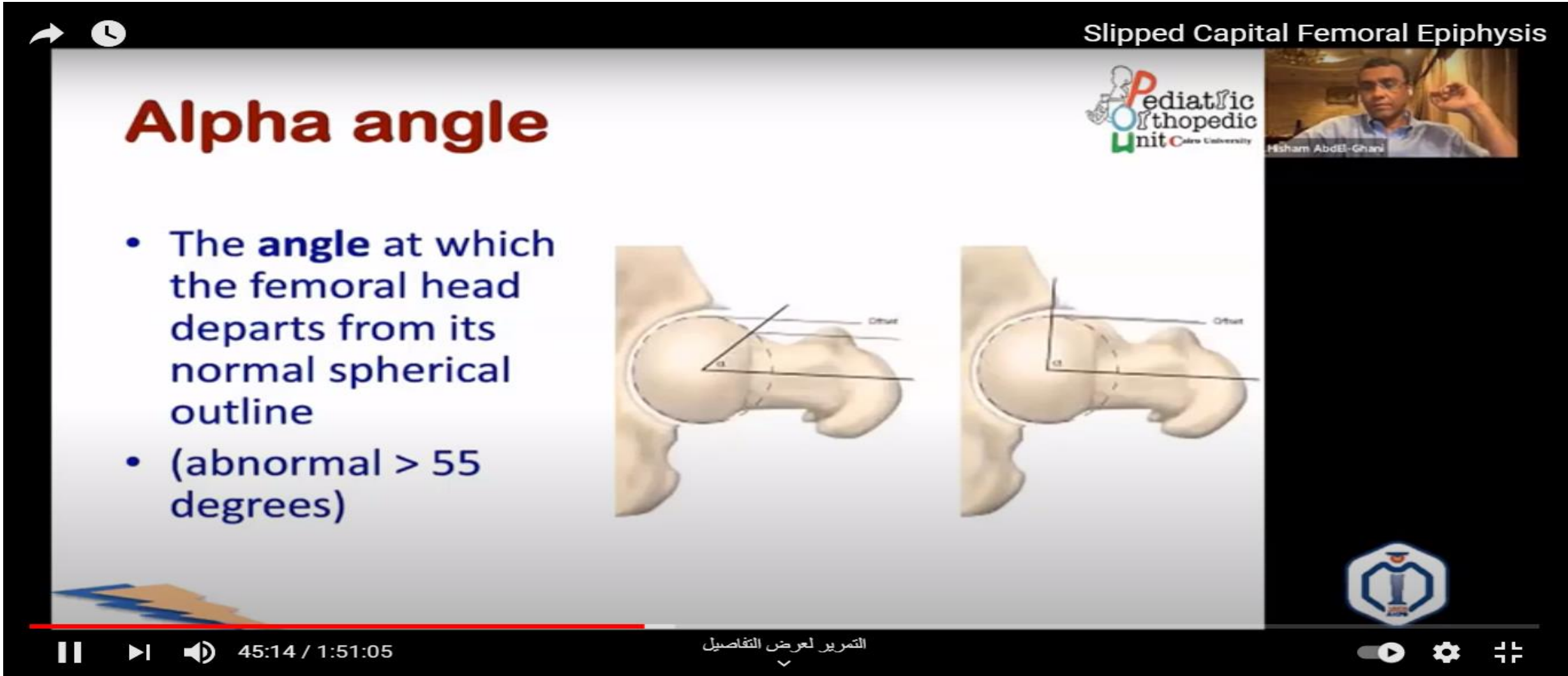
- Supportive i.e. PT, anti inflammatory, traction …
- DISTRACTION Arthrodesis and THA.

OSTEOARTRITS

- Post. Sup. Displacement of GT
- Reduced offset and the normal lever arm of the abductors → lurching of the trunk to maintain upright pattern

- Increase Abd. Force → JRF
- Increase shear forces across the physis, *Leblanc et al, 2017*

FAI & ALPHA ANGLE



Chapter Outline

Incidence and Epidemiology
Classification
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Prognosis

- **<u>Best prognosis:</u>**
- Mild slips
- Pinning in situ without reduction
- **<u>Poor prognosis</u>**
- Reduced hips and corrective ostetomy

Prognosis

- **<u>Remodeling after epiphyseal stabilization</u>**

The prognosis for the development of osteoarthrosis in patients with slipped epiphyses depends on the severity of residual deformity in the absence of AVN and chondrolysis.

Thank you