

Treatment of Slipped Capital Femoral Epiphysis-What is new?

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ABSTRACT

Slipped capital femoral epiphysis (SCFE) is an important childhood pathology. Although being relatively rare, correct diagnosis and prompt management is critical in preventing long term complications. Loder and colleagues classified slips into two categories: stable and unstable. Patients with unstable slipped capital femoral epiphyses are unable to weight bear even with crutches. This classification is predictive of the risk of developing avascular necrosis. With regards to treatment, mild and moderate slips are typically managed with pinning-in-situ. The management of severe and unstable slips are more controversial. This paper focuses on treatment options. Surgical techniques, complications and management of complications will be covered in future issues.

Key words: SCFE, SUFE, slipped upper femoral epiphysis, slipped capital epiphysis, avascular necrosis, AVN, stable slip, unstable slip, Southwick osteotomy, pinning in situ

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INTRODUCTION

Childhood hip problems are common. Most are not serious; however, delay in diagnosis and treatment can lead to unfavourable outcomes. Slipped capital femoral epiphysis (SCFE) is not an exception. Although it is a well recognised condition, commonly featured in major journals and commonly appearing in most orthopaedic exams, it is surprising how often the diagnosis is delayed. Incidence varies from 1 to 10:100 000 depending on the race, geography and time of the year.^{1,2}

AETIOLOGY

The cause is not very well understood. Combinations of factors that increase shear forces and / or cause weakness of the growth plate (the physis) in adolescence predispose to slips. The growth plate subsequently breaks down, the femoral head (epiphysis) remains in the acetabulum and the femoral neck moves forward and outward (figure 1). The femoral epiphysis (head) becomes positioned posterior to the neck of the femur.

Factors causing increased shear forces

across the physis include:³

1. Increased weight (>80th centile)
2. Femoral retroversion (>10°)
3. Increased physis height due to a widened hypertrophic zone
4. More vertical slope of the physis
5. Trauma

Weakness of the physis can be caused by several metabolic and pathological conditions including but not limited to:

1. Renal failure osteodystrophy (95% bilateral) (figure 2)
2. Previous radiation therapy
3. Endocrine disorders (65% bilateral):
 - 3.1. Hypothyroidism (usually SCFE is the first presenting feature)
 - 3.2. Growth hormone deficiency
 - 3.3. Growth hormone excess
 - 3.4. Panhypopituitarism
 - 3.5. Craniopharyngioma
 - 3.6. Hypogonadism
 - 3.7. Hyperparathyroidism
 - 3.8. Multiple endocrine neoplasia
 - 3.9. Turner's syndrome.
 - 3.10. Elevation of Leptin level (independent of body weight)^{4,5}

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Figure 1: Pelvis x-ray with left slipped capital femoral epiphysis



Figure 2: Slipped capital femoral epiphysis in a child with renal osteodystrophy. The radiograph shows widening of both physes. There is bilateral slipped capital femoral epiphysis which is better appreciated on the frog lateral views.

Loder and colleagues⁶ proposed the age-weight test to predict the possibility of an underlying endocrine problems in a child with SCFE. In a cohort of 433 patients with 612 SCFEs (285 idiopathic, 148 with underlying causes), the age-weight test was useful to predict patients with underlying endocrine problems. The test is negative when a child age is younger than 16 years and weight is $\geq$ 50th percentile and positive when beyond these boundaries. The probability of a child with a negative test result having an idiopathic SUFE was 93%, and the probability of a child with a positive test result having an atypical SCFE was 52%.

CLINICAL PRESENTATION

Children with SCFE usually present with painful hip and / or knee. Around 20% presented with knee pain only due to pain activation of the medial obturator nerve and the diagnosis in such cases are often delayed. Some children are often unnecessarily investigated with knee x-ray and MRI scan. There are some anecdotal stories of children with SCFE who underwent diagnostic knee arthroscopy because of referred knee pain. Trauma is reported in about 20% of the cases. Sometimes, the pain is severe enough that patient cannot walk at all.³

The involved leg looks short and externally rotated (**figure 3**). Patients usually walk with a limp and prefer to sit in a chair with affected leg crossed over the other. Hip range motion is usually reduced due to the resultant deformity and the associated synovitis. Internal rotation of the hip causes pain. Obligatory external rotation during passive flexion of hip can be elicited (Drehmann sign) (**figure 4**).

INVESTIGATIONS

1. Imaging:

Plain radiograph (AP and true lateral view):

Although frog lateral view is often requested, it is not our preferred view as it may displace unstable slip further and it is less precise in assessing the severity because of the variations in positioning the limbs. Several radiological signs have been described to establish the diagnosis and assess the severity of the slip such as:

- Widening of the growth plate (early sign)
- Trethowan's sign; a line (often referred to as Klein's line) drawn on the superior border of the femoral neck on the AP view will intersect less of the femoral head or not at all in



Figure 3: a child with slipped capital femoral epiphysis. A clinical photograph of a child with SUFE, notice the short and externally rotated right leg (mimic fracture neck of femur). Patient was investigated and treated for knee pain



Figure 4: Drehmann sign. Drehmann sign refers to the obligatory external rotation during passive flexion of the right hip. Compare to the left hip which was normal in this child.

- a child with SCFE, because of the posterior displacement of the femoral epiphysis.
- c. Decreased epiphyseal height as the head is slipped posteriorly behind the neck.
- d. Remodelling changes of the neck with sclerotic, smooth superior part of the neck and callus formation on the inferior border. This may not be seen in acute slip.
- e. Increased distance between the tear drop and the femoral neck metaphysis
- f. Capener's sign: normally, on the AP pelvis the posterior acetabular margin cuts across the medial corner of the upper femoral metaphysis. In SCFE, the entire metaphysis is lateral to the posterior acetabular margin.
- g. Steel's blanch sign which is a crescent shape

dense area in the metaphysis due to superimposition of the neck and the head.

CT-Scan: CT-Scan provides excellent 3D images for preoperative planning. Although these are not required in mild and moderate slips that require pinning in situ only, they can be extremely useful in severe slips when corrective surgery is desirable. Presence of callus which can be easily detected by CT-scan may indicate a chronic slip rather than acute. CT Scan can help assess the position of wires or screws tips to ensure no joint penetration.

Ultrasound: Ultrasound has been proposed to support the diagnosis of unstable slip. It was also suggested to make the diagnosis of slip when there is displacement of ≥ 6 mm, or 2 mm compared with the normal side; however, in clinical practice, it is of limited value.

MRI: MRI scan is valuable in diagnosing SCFE in the pre-slip stage (**figure 5**). Early signs of avascular necrosis (AVN) are only detectable by MRI scan. Metalwork can affect the quality of MRI images and bone scan is useful in this situation..

2. Blood tests:

Blood tests are requested to rule out underlying endocrine problems when the age-weight test is positive or as part of preoperative work up.

CLASSIFICATION

There have been several classifications of SCFE. Contrary to most Orthopaedic classifications, SCFE classifications are of value in management. SCFE was traditionally classified into:

1. Pre-slip: patient has symptoms with no radio-

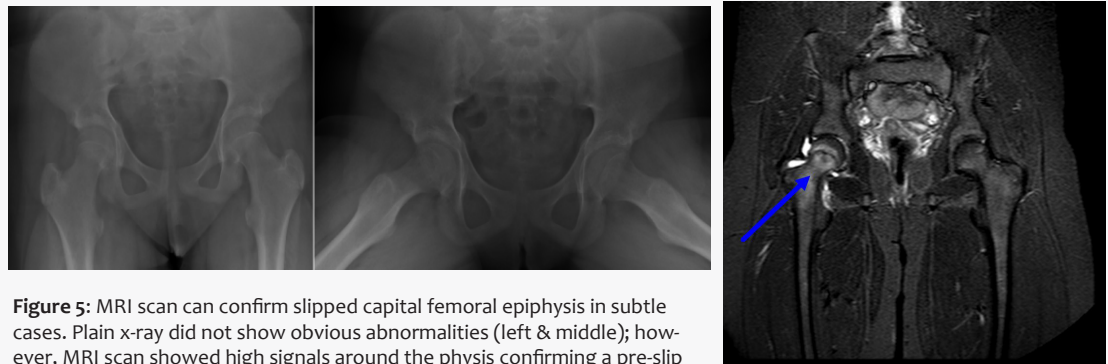
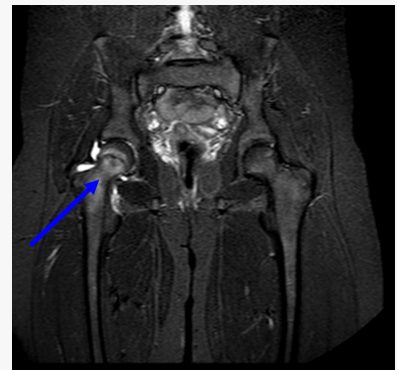


Figure 5: MRI scan can confirm slipped capital femoral epiphysis in subtle cases. Plain x-ray did not show obvious abnormalities (left & middle); however, MRI scan showed high signals around the physis confirming a pre-slip stage (right).



logical findings.

2. Acute: there is an abrupt displacement through the physis with symptoms and signs developing over a short period of time (<3 weeks).
3. Chronic: symptoms duration is more than 3 weeks (often months).
4. Acute on chronic: Sudden deterioration of chronic symptoms; this is usually triggered by a minor trauma.^{3, 7}

Loder and colleagues,^{8, 9} in his classic paper, introduced the concept of slip stability. SCFE is considered “stable” when patients are able to ambulate and bear their weight and “unstable” when patients are unable to ambulate even with crutches. They showed that avascular necrosis (AVN) developed in 47% of unstable slips but none of stable hips. Several published papers confirmed Loder’s findings.¹⁰⁻¹³ It is of note that most stable SCFEs have chronic symptoms whereas unstable SCFEs present acutely.

Loder’s classification has changed our understanding and approach to SCFE. The simplicity of the classification and the high predictive value of AVN promoted its immediate and widespread use. However, authors have debated the

true definition of slip stability. Ziebarth¹⁴ coined the concept of “intra-operative stability” and found that clinical stability of SCFE as defined by Loder does not correlate with intra-operative stability. Kallio^{15, 16} found that physeal instability is better indicated by joint effusion and inability to bear weight. A slip is very unlikely to be unstable in a child who is able to bear weight and has no sonographic effusion and vice versa.

GRADING OF SEVERITY

Severity of the slip is an important aspect of SCFE management. This is often based on radiographic management. The Southwick angle is the most commonly used (figure 6).¹⁷ Mild slip (grade I) has a Southwick angle of less than 30°, moderate slip (grade II) has an angle between 30 and 50° and severe slip has an angle over 50°.

TREATMENT

Natural history of untreated slip is virtually unknown because most published series reported on patients who underwent stabilization. Although some studies reported on “presumed” untreated slips; it is not certain that they were genuinely untreated slips and even if they were true slips, they were probably mild stable slips

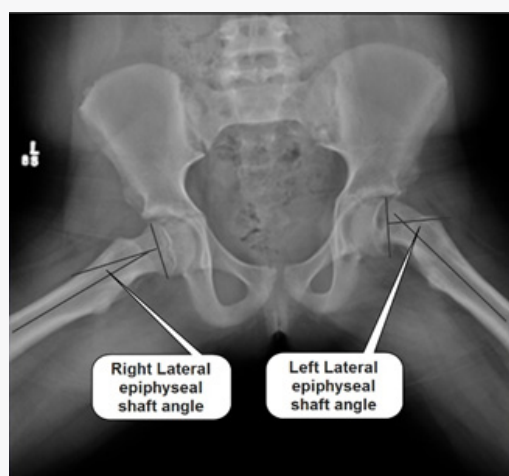


Figure 6: SUFE radiological grading. Southwick angle is measured on the lateral view of the both hips by drawing a line perpendicular to a line connecting the posterior and anterior tips of the epiphysis at the physis. The angle between the perpendicular line and the femoral shaft line is called the lateral epiphyseal shaft angle. The Southwick angle is the difference between the lateral epiphyseal shaft angle of the slipped and the non-slipped sides. In patients with bilateral involvement, 12° is subtracted from each of the measured lateral epiphyseal angles.

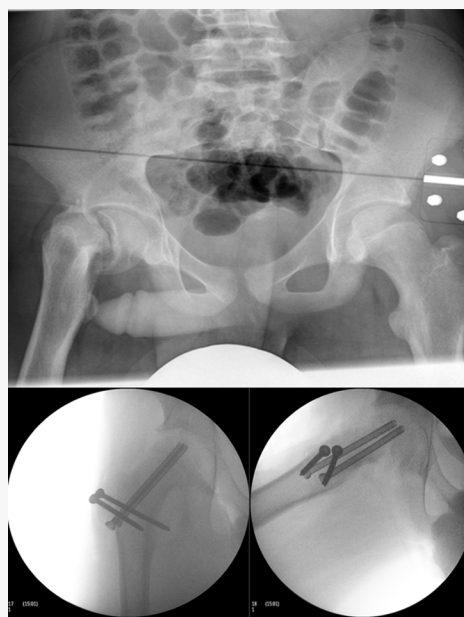


Figure 7: Plain x-ray of severe SCFE which was treated with Ganz surgical dislocation.

Table 1: Pooled summary of studies of stable slips treatments

Intervention	Hips	AVN (%)	CL (%)	Satisfactory patients result *
Hip spica	101	8 (7.9)	21 (20.8)	NR
Epiphysiodesis	485	14 (2.9)	8 (1.6)	67 (67%) excellent 6 (6%) good 10 (10%) fair 7 (7%) poor 7 (7%) failure
Pinning using single screw	525	8 (1.5)	12 (2.3)	113 (47%) excellent 86 (36%) good 19 (8%) fair 10 (4%) poor 11 (5%) failure
Pinning using multiple pins	273	6 (2.2)	11 (4)	76 (67%) excellent 19 (17%) good 0 (0%) fair 16 (14%) poor 3 (3%) failure
Physeal osteotomy	545	63 (11.6)	51 (9.4)	131 (28%) excellent 210 (45%) good 46 (10%) fair 72 (16%) poor 3 (6%) failure
Ganz surgical dislocation	81	3 (3.7)	2 (2.5)	52 (87%) excellent 2 (3%) good 0 (0%) fair 5 (8%) poor 1 (2%) failure
Base of neck osteotomy	92	2 (2.1)	6 (6.5)	22 (60%) excellent 11 (30%) good 2 (5%) fair 2 (5%) poor
Inter-trochanteric osteotomy	336	5 (1.5)	16 (4.8)	121 (44%) excellent 105 (38%) good 35 (13%) fair 15 (5%) poor

* Satisfactory patients result based on closely related rating such as Heyman and Herndon classification, Harris hip score or Iowa hip scores.

that would have favourable outcomes which do not reflect the true outcome of the full spectrum of the condition. Deterioration of mild slip over short period of time is well recognized;¹⁸ therefore, stabilizing SCFE is obligatory when the diagnosis is confirmed. The main aim of treating SCFE is to prevent progression of the slip. Although reduction of slip to an anatomical or near position is desirable, this comes with a substantive risk of AVN and chondrolysis (CL) which must be considered when deciding on treatment choices. The following sections focus on treatments options. Surgical techniques, complications and management of complications will be covered in future issues.

The Loder's two types of SCFE (stable and unstable) are different in term of presenta-

tion, progress and complications; therefore treatments are likely to be different.^{19, 20} In stable SCFE, there is a consensus that the best treatment for mild and most moderate slips is pinning-in-situ (PIS) using a single cannulated screw (SS). Several studies have supported this approach.^{21, 22} If the slip is severe, pinning can be technically difficult if impossible. Gentle reduction is often unsuccessful in a stable slip and forceful reduction is contraindicated as this increase the risk of AVN. The options for stable slipped epiphyses are either PIS (if possible) with re-alignment procedure later if remodelling is suboptimum or primary corrective osteotomy.

In a systematic review and patients level data analyses, Ganz surgical dislocation was shown to be superior to other treatment in severe stable SCFE (see **Figure 7 & Table 1**). It was associated with a high satisfaction rates among patients although AVN rate was slightly higher than pinning in situ (3.1% vs. 1.5%).²²

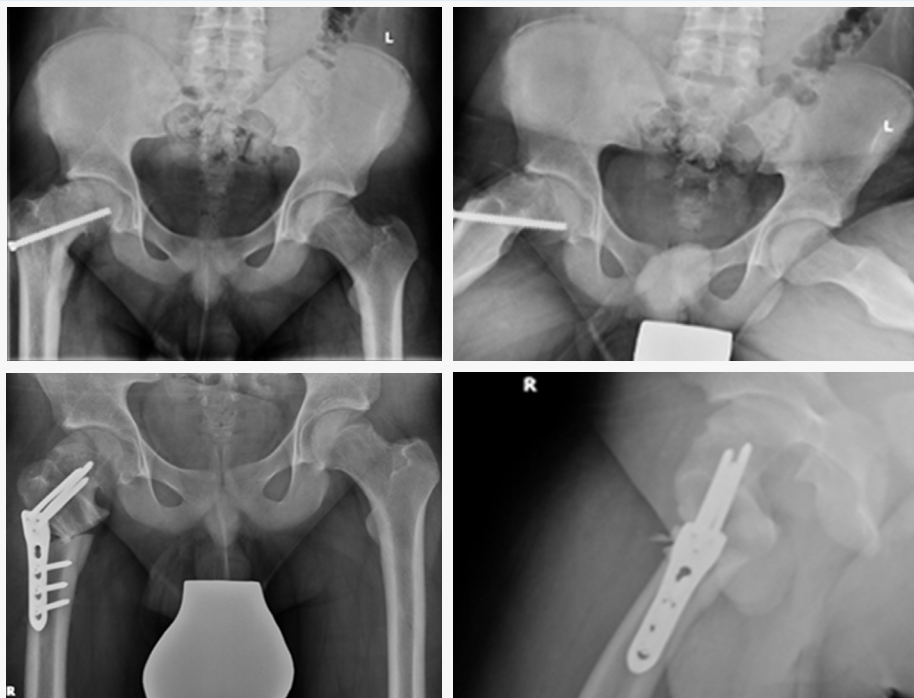
Ganz surgical dislocation technique involves elevating an extended periosteal flap which contains the reticular blood vessels off the bone (see **Figure 8**) and protect the vessels all the way through. The technique provides a better access to visualize, assess and deal with problems of the blood vessels of the femoral head.²³

Realignment procedures can be performed at one of four levels: subcapital femoral neck, intertrochanteric (Imhauser) and subtrochanteric (Southwick) regions. The ability to correct a deformity is greatest with subcapital osteotomy (where the Centre of Rotation of Angula-



Figure 8: Ganz surgical dislocation, an intra-operative photograph of primary corrective surgery of SCFE using Ganz surgical dislocation. The green arrow shows the extended reticular flap

Figure 9: intertrochanteric (Imhauser) osteotomy. Intertrochanteric (Imhauser) osteotomy creates a deformity at the intertrochanteric region (between the greater and lesser trochanter) to compensate for the severe deformity that has been caused by the slip. In the above figure, the osteotomy could have been slightly higher for a better result.



tion (CORA) is) and least with subtrochanteric osteotomy. However, the risk of AVN is highest with subcapital osteotomy and the lowest with subtrochanteric osteotomy. The intertrochanteric (Imhauser) osteotomy (**figure 9**) has been favoured because of the reasonable compromise between the risk of AVN and the ability to correct the deformity. It also has less impact on potential future hip arthroplasty.

The concept of treating unstable slips is essentially the same as for stable slips; they require stabilization; however, there are two important considerations:

1. Being unstable, there is an opportunity for spontaneous or unintentional reduction of the slip.
2. The risk for AVN is very high (50%).

Reduction whether intentional or not has been associated with increased AVN rate.^{19, 21, 24-26} A review of 23 studies of unstable SCFE showed that open reduction using the Parsch technique had the lowest AVN rate of 5% (**Table 2**).¹⁹ All other interventions were associated with a high AVN including the Ganz surgical dislocation. Although several centres around the world²⁷⁻³⁰ started using the Parsch technique, there has been no indication that the Parsch findings have been replicated by other centres. Interestingly, the Parsch centre has abandoned

Table 2: Pooled summary of studies of unstable slips treatments

Interventions	Hips	AVN (%)
Epiphysiodesis	64	7 (11%)
Pinning in situ	115	38 (33%)
Closed reduction and pinning	269	71 (26%)
Open reduction and internal fixation	84	4 (5%)
Physeal osteotomies (Dunn's or Fish)	59	10 (17%)
Ganz surgical dislocation	70	13 (18%)
Total	661	143 (22%)

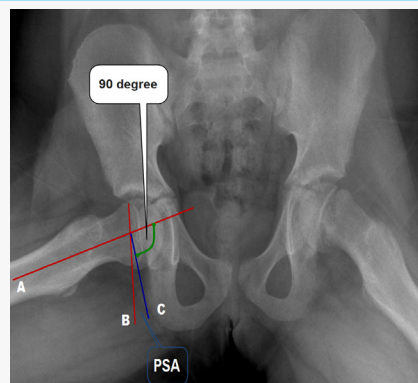


Figure 10: posterior sloping angle. The posterior sloping angle (PSA) measured by a line (A) from the centre of the femoral shaft through the center of the metaphysis. A second line (B) is drawn from one edge of the physis to the other, which represents the angle of the physis. Where lines A and B intersect, a line (C) is drawn perpendicular to line A. The PSA is the angle formed by lines B and C posteriorly as illustrated.

his technique in favour of the Ganz surgical dislocation (personal communication).

The timing of surgery is more relevant to unstable slips rather than stable ones because of the low AVN rate in stable slip. The timing of surgery in unstable slip remains controversial. There is overwhelming evidence that operation within 24 hours provide the least AVN rate. There is controversy about timing of surgery for patients who presented after 24 hours. Some authors recommend delaying surgery for more than a week to allow for soft tissue and synovitis to settle before performing surgery. There is increasing evidence to support such practice.^{13, 19, 31}

Prophylactic pinning of the contralateral asymptomatic side remains controversial. Proponents and opponents have some evidence to support their views.³²⁻³⁴ Most studies showed that the average risk of contralateral lateral slip is around 18%.^{35, 36} Most were mild slips and when treated they rarely went to develop AVN. Risk of prophylactic pinning is in the region of 5% including AVN and periprosthetic fractures.^{34, 36, 37}

We recommend a pragmatic approach for contralateral pinning where the following factors play a role in decision making:

1. Age of the child (< 10 years is associated with a higher risk of bilaterality).
2. Slips associated with renal osteodystrophy and endocrine disorders.
3. Poor compliance of the child and family.
4. The nature of current slip (very bad slip occurred over a very short period of time may justify pinning the other side)
5. Posterior sloping angle > 14 ° (Figure 10) or modified oxford bone score of less than 16.

Phillips and colleagues³⁸ examined the posterior slope angle (PSA) as a predictor for contralateral slip in 132 patients and they found a posterior sloping angle of 14° predict contralateral slip in 83.3% of the cases. The modified Oxford bone score was introduced by Stasikelis³⁹ and is based on appearance and fusion of the iliac apophysis, femoral capital physis, greater and lesser trochanters. Contralateral slips developed in 85% of patients with a score of 16, in 11% of patients with a score of 21, and in no patient with a score of 22 or more.

CONCLUSION

Once SCFE is diagnosed, stabilisation is indicated. Mild and moderate SCFE can be treated by the simplest and long tested method of pinning in situ with good outcome. However, controversy continues on what the best treatment is for severe stable SCFE. Severe deformity causes impingement which lowers patients' satisfaction and function and increases the possibility of premature osteoarthritis. Correcting deformity risks having iatrogenic AVN. Ganz surgical dislocation is the best current method to correct severe stable SCFE. The risk of AVN in experienced hands in the region of 3%.

In unstable SCFE the AVN rate is high; the best treatment is still debatable. Ganz surgical dislocation has not been shown to be superior to other treatment. Open reduction and stabilisation using the Parsch technique showed a very low AVN rates but results have not been replicated by others. The evidence to support early surgery (within 24 hours) is convincing; however, it is rare to get patients to a centre where the expertise and the equipment's are available to operate on them within 24 hours. There is evidence to support delaying surgery for over a week but this is based on small numbers. The types of surgical interventions are being evaluated but the trends support open surgery rather than closed reduction or pinning in situ. Surgical dislocation has not been shown unequivocally superior to other methods.

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Abbreviation list: Antero-Posterior (AP), Avascular necrosis (AVN), Centre of Rotation of Angulation (CORA), Chondrolysis (CL), Magnetic resonance imaging (MRI), Pinning-in-situ (PIS), Single cannulated screw (SS), Slipped capital femoral epiphysis (SCFE), Slipped capital femoral epiphysis (SUFE)

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