

# Clinical and radiological features and Classification of Slipped capital femoral

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## Abstract

Slipped Capital Femoral Epiphysis is one of the unique diseases where clinical as well as radiological features are of paramount importance both in planning and prognosis of the disease. This review focusses on the discussing these two features in details

Keywords: Slipped Capital Femoral Epiphysis, Radiological features, Classification

## Introduction

Slipped capital femoral epiphysis is one of the commonest adolescent hip disorders, which is associated with significant morbidity and is associated with significantly increased risk of early degenerative Joint disease and Avascular necrosis [1,2,3]. In SCFE, an anatomical disruption occurs through the proximal femoral physis, with a wide temporal variation [4]. The characteristic feature of SCFE is the variable degree of the posterior translation of the epiphysis and a corresponding anterior translation of the metaphysis. Due to this distortion of the proximal femoral anatomy, the hip joint is predisposed to two major issues- femoroacetabular impingement and subsequent degenerative joint disease and secondly Avascular necrosis (AVN) due to disruption in blood supply of the capital femoral physis [5]. Early diagnosis and prompt and proper treatment is essential to prevent or minimize these issues.

The clinical features and presentation of SCFE is very variable. It depends on four features:

- 1) Temporal acuteness [6]
- 2) Physical stability of the physis which is slipping [7]
- 3) Degree of actual displacement [8,9]
- 4) Amount of deformity which the protruding anterior metaphysis causes to the anterior acetabular rim during extreme hip range especially flexion [10].

In this article, we will be describing each of these features and also explaining how each of these factors play a role in the eventual outcome after SCFE.

## Clinical features:

### Age of onset:

SCFE is predominantly a adolescent hip disorder. The mean age of onset of SCFE is approximately 12.7 to 13.5 years in boys and 11.2 to 12 years in females [11]. However since the last few years, there has been a steady trend towards early development of SCFE. This may be related to relatively early child maturation as well as increasing childhood obesity [12].

### Sex:

The prevalence of SCFE is much more in boys rather than girls with the male-female ratio being approximately 1.5 across various studies [12,13]. However this ratio decreases in unstable slips with the prevalence almost equal in males and females.

### Bilaterality:

There is a wide variability in the incidence of bilaterality in SCFE with various studies showing rates ranging from 20 to 80 %. The second slip usually occurs within one year of the first slip [12,14].

### Race:

There is a significant racial variation in the incidence of Slips. Blacks, Hispanics and the Native American population have much higher prevalence than Caucasion Americans. Asians and Indians fall somewhere in between the two extremes [13].

### Obesity:

Obesity is one of the commonest predisposing factors for SCFE. More than 50% of all adolescents diagnosed with SCFE are more than 95th percentile of weight. Though most of the time, no obvious syndrome or disease is diagnosed,

SCFE is more commonly associated with conditions like hypothyroidism, Downs syndrome, juvenile Diabetes, etc [1,15,16].

## Clinical features:

### History:

The clinical features of SCFE depend on the type of

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**Figure 1:** Clinical picture of a 13 year boy showing obligatory external rotation on flexion of the hip. (Drehmann sign)



**Figure 2a-b:** Anteroposterior and frog leg lateral view of pelvis with both hips showing Klein's line passing through the epiphysis on the left side and passing above the epiphysis on the right side. (Yellow line). Metaphyseal sign of Steel is also seen with the presence of a small lucent zone in the metaphysis (Blue arrow). Both signs are suggestive of SCFE of the right side. ( Xray courtesy: Dr. Maulin Shah, Ahmedabad)

the slip and its chronology.

The most common presenting feature is thigh or hip pain which is chronic, dull aching and is associated with mild restriction in day to day activities [1]. In some cases, the child complains of pain in the knee, so much so that there are many instances where radiological investigations have been performed of the knee itself [17]. It is a well-known dictum in orthopaedics that any pain around the thigh or the knee in a child (without any obvious cause around the knee) arises from the hip, unless proved otherwise [17,18]. However nowadays, more and more non-orthopaedic surgeons – including family physicians and physiotherapists are involved in the management of pain in adolescent kids. SCFE being a relatively rare condition, would be seen by them probably once or twice in their lifetime. This leads to a significant delay in diagnosis, making SCFE one of the commonest causes of litigation for missed orthopaedic diagnosis in the United States. In a series of 20 patients by Uglow et al, only one patient did not have a delay in diagnosis [17].

The pain doesn't have any diurnal variations and is more on terminal movements like squatting. The duration of symptoms may be many months and may in fact go unnoticed and undiagnosed for a long time. The mean duration of symptoms is around 5 months [17,18].

The presentation of an acute/ acute on chronic/ unstable Slip is a diametrically opposite one [19]. Here, a child who has had

chronic hip pain since many months suddenly develops severe hip pain following a seemingly trivial fall. The child is unable to bear weight on that limb or is able to do so, with severe pain. The presentation of an acute/ acute on chronic slip is in fact similar to an acute displaced transcervical femoral neck fracture albeit with two important diagnostic features: the period of chronic hip pain prior to the acute event and the fact that this acute event happened with relatively mild/ trivial trauma, which suggests that the physal cleavage had already happened, which got aggravated [20].

**Examination findings:**

The clinical findings in a chronic slip are very characteristic. The child walks with a out-toeing gait with minimal pain. The child is able to sit cross-legged and squat with some difficulty. There is usually significant abductor lurch in longstanding cases, due to coxa vara and trochanteric overriding [1]. On examination in supine position, the range of motion findings are very characteristic. The child has an external rotation deformity of around 10-20 degrees depending on the amount of displacement the child has [21]. Flexion can be restricted especially terminally due to the anterior bump hitting against the acetabular labrum. Provocative test for eliciting cam type of femoro-acetabular impingement namely the flexion-adduction-internal rotation (FADIR) test is usually not advisable due to the fact that the child has a pre-existing external rotation deformity and he/she is going to



**Figure 3 a-b:** Anteroposterior and lateral view of the pelvis with both hips showing significant metaphyseal rounding and callus on the posteromedial aspect of the left hip suggestive of a chronic Slip.



**Figure 4:** Anteroposterior and lateral view of the pelvis with both hips showing complete disruption of the physal plate along with signs of chronicity in the form of metaphyseal rounding (blue arrow) and posterior callus.

have significant pain on eliciting the FADIR sign[22]. The characteristic sign for chronic SCFE is in fact called as the Drehmann's sign, which doesn't require the clinician to provoke impingement which can be painful[22].

Drehmann's sign was first described by G. Drehmann in 1903; it was further studied by F. Drehmann and the pathogenesis behind it was developed over the next few years[23]. The basic hypothesis behind this sign is that Drehmann's sign is a reasonable means of avoiding pain of FAI while still being able to elicit the significant change in flexion arc in case of SCFE.

In Drehmann's sign, the child is supine on the examination table and the examiner stands on the side of the painful hip. On passive flexion of the hip, the affected side is automatically abducted and external rotated so that the knee points towards the ipsilateral shoulder[22]. This shows that there is severe external rotation happening at the femoral physis with prominence at the femoral neck. Thus the hip assumes the path of least resistance during its excursion and assumes the arc of external rotation and abduction (Figure 1).

The Drehmann sign is an easily elicitable and sensitive sign for a chronic SCFE and should be looked for in any adolescent patient with chronic hip pain.

The examination findings in an unstable, acute on chronic slip are quite dramatic. The child presents with severe pain around the hip region with flexion abduction and external rotation deformity[12]. He/ she does not allow any passive movement of the hip and extremely painful to touch. There is usually some shortening of the extremity.

Imaging/ Radiological features:

The pelvis with both hips- anteroposterior and frog leg lateral view are the two basic xrays to be done in all cases of suspected SCFE[1,5]. The radiographs demonstrate the typical postero-inferior displacement of the epiphysis relative to the metaphysis, which is often only seen on the frog leg lateral view. Frog leg lateral view may be difficult to perform in a child with severe pain [23,24]. In this case, a cross table view may be useful to decrease the patient discomfort during positioning.

There are a few signs which can be seen on the anteroposterior view which helps in proving the diagnosis of SCFE in the early stages [25,26,27]. (Figure 2a-2b)

- 1)Widening and irregularities of the physis as compared to the opposite side
- 2)The anterior aspect of the femoral neck loses its anterior concavity
- 3)Cystic change in the metaphysis, remodelling and periosteal reactions in cases of chronic SCFE.
- 4)A relative loss of height of the epiphysis on AP projection
- 5)Metaphyseal blanch sign of Steel [26]: The metaphyseal blanch sign of Steel is a radiographic double density created by the posteriorly displaced epiphysis overlapping the medial

metaphysis, as seen on the AP radiograph. This is a very early sign and can be easily missed if not looked for, carefully. (Blue arrow)

6)Klein's line [25]: Klein's line is a line drawn along the superior border of the femoral neck on the AP radiograph. In a normal hip, this line should intersect the epiphysis (ie some part of the epiphysis should lie superior to the metaphysis). On the other hand, in a chronic slip, the epiphysis lies flush with or below this line. This denotes a subtle inferior displacement of the epiphysis as compared to the metaphysis. (Yellow line)

As the slip becomes more and more chronic, more changes start becoming apparent on the x-rays (Figure 3). There is metaphyseal remodelling and retroversion of the femoral neck in long standing cases of SCFE[19]. There is metaphyseal rounding at the anterosuperior portion of the neck (Blue arrow) and callus formation on the postero-inferior aspect of the femoral neck on the frog leg lateral view.

The x-ray findings in acute and acute-on-chronic slips are much more apparent[19]. Usually only an AP radiograph can be obtained due to severe discomfort of the patient. This shows an abrupt displacement of the epiphysis with respect to the metaphysis (Figure 4). If it is an acute on chronic slip, then there will be a variable amount of remodelling seen on the anterior metaphysis. As against that, in case of an acute slip (which is in fact very rare), these changes are not seen.

#### Other imaging:

Further imaging in form of CT scan or MRI are needed in specific circumstances. The role of advanced cross-sectional imaging in SCFE is very controversial and needs to be decided on case to case basis and balanced as per the need for additional information versus unnecessary delay in starting treatment.

MRI is indicated in very early cases of suspected SCFE especially in the so-called "Pre-slip" or imminent slip. MRI in this stage shows widening of the physis, bone marrow edema, joint effusion and synovitis [28]. Diffusion MRI may also been performed in some cases to look at the vascularity of the femoral head and prognosticate the treatment in view of pre-existing AVN prior to surgical intervention at presentation. Thus MRI is more of a diagnostic/ prognostic tool rather than a modality which helps in surgical planning.

CT scan is typically needed in case of suspected mild SCFE which is not picked on the standard AP and frog lateral radiographs[5]. This is also useful in mild to moderate slips in order to exactly quantify the amount of displacement and further plan the management vis a vis in-situ fixation versus reduction and fixation. It has been seen in many instances that the CT scan helps to prove that the slip is much more severe than what is apparent on standard x-rays and planning a more rational treatment.

The other indication of doing a CT scan is post-operatively in cases where there is suspicion of intra-articular penetration of the screw threads. This is especially usually when an in situ pinning is performed in moderate/ severe slips and exact visualization is difficult with orthogonal C-arm views.

Three-dimensional CT scanning also helps in visualizing post-SCFE femoral neck deformity as well as acetabular morphology in long-standing cases. Hence CT scan should be considered in every case of severe SCFE with neck deformity in whom a corrective osteotomy is planned [29].

**Ultrasound:** USG has been used in some centres in recent years in suspected cases of SCFE. A visible step may be seen between the epiphysis and metaphysis on the scan which indicates the epiphyseal displacement. Capsular displacement, effusion and metaphyseal rounding are all indicators which help in diagnosing and classifying SCFE [30]. The exact locus standi of USG in SCFE still needs to be ascertained.

### Classification:

Classification of SCFE helps in deciding the treatment modality of the patient and also helps in the prognostication. There are various classification systems of Slips based on the chronological acuity, the stability of the physis, the degree of the slip angle as a indicator for future mechanical damage to the hip joint and other anatomical factors like acetabular and femoral retroversion, anatomical depth, etc.

**Chronological classification:** This is one of the oldest classifications and one which is least useful in determining the eventual outcome of this condition. In this classification, a slip is classified as Acute, Acute-on-chronic and Chronic slip [1,12.]

**Acute slip:** An acute slip is an acute displacement through the physis with resultant slippage of the epiphysis posteriorly and medially. The duration of symptoms is less than 3 weeks, with or without a period of prodromal symptoms. Around 10-15% of all SCFEs present in this manner.

**Chronic slip:** Chronic SCFE is the commonest of all types accounting for around 80 percent of all slips. Here the duration of symptoms is more than 3 weeks and the child presents with all the signs of chronicity namely chronic hip and thigh pain, external rotation deformity and mild limp length discrepancy. As said earlier, the diagnosis of a chronic SCFE is often missed to xrays and other investigations being performed of the knee.

**Acute-on—chronic slip:** Acute-on-chronic SCFE occurs when a child who has had hip pain and symptoms since the past few weeks to months, suddenly has severe exacerbation of the pain due to a trivial fall or trauma. This pain is usually so severe that it precludes walking. It is important to

distinguish and recognize the chronic component of this acute event as the attempted reduction of the chronic component increases the risk of osteonecrosis.

This classification is however less commonly used nowadays, with some clinicians suggesting discarding this schema, which has little correlation with the pathomechanics found in SCFE.

The most frequently used classification and the one which has the most significance in terms of prognostication is described by Randall Loder [7]. This classification describes the mechanical stability of the physis and classifies it into two types- stable and unstable. Stability of the physis can be decided clinically and radiologically. Clinically a slip is a stable slip when the child is able to walk with or without crutches. The slip is unstable if, on the other hand, the child is unable to do so. Radiologically stability of the slip has been studied using ultrasound by some authors [19,30]. A slip is called chronic if there is absence of joint effusion/ hemarthrosis and presence of metaphyseal remodelling. On the other hand, in an unstable slip, there is presence of joint effusion without any metaphyseal remodelling.

Whatever the method of diagnosing stability is, it makes intuitive sense that a child with an unstable slip is likely to experience more complications than a child with a stable slip. This has been proved by literature also. The risk of AVN after a stable SCFE ranges from 1-10% in various series. Against that, the risk of AVN after an unstable SCFE is as much as 30-60 % in most series, in some series it ranges as high as 80%. Hence this classification helps in the prognostication of the slip vis-à-vis AVN [7].

Further studies have put forth interesting facets of physeal stability. Ziebarth et al [31] have argued that mechanical stability of the physis is different than what would be thought of based on the ability of the child to ambulate. In his study of 82 hips treated with safe surgical dislocation and modified Dunn osteotomy, they found that about half of the slips classified as unstable based on weight bearing status, were actually stable mechanically with fused physis. As against that, what was more important was that about 30% of the slips which were classified as stable, were really unstable during the procedure. Hence the authors have suggested that any SCFE with open physis should be considered at risk for an acute disruption and hence treated as an unstable slip.

### Morphological classification:

The morphological classification is based on the displacement of the epiphysis on the AP and lateral views with the accurate assessment of the deformity being made more on the lateral view<sup>1</sup>. The morphological classification uses two parameters: the linear or the percentage displacement of the head on the neck and secondly the so-

called Southwick angle. The Southwick angle is defined as the angle between a line perpendicular to a line that connects the anterior and posterior margins of the physis and a line along the axis of the femoral shaft [5]. To see the amount of posterior angulation of the head with respect to the neck, the corresponding angle of the contralateral unaffected hip is subtracted from the affected side. In case of bilateral slippage, 12° is used as a reference. The severity is classified as mild (0-30°), moderate (30-60°) and severe (more than 60°).

So combining both the methods of morphological classification gives us the following schema:

- 1) Pre-slip: Just widening of the physis, no displacement
- 2) Mild slip: Less than 30% of displacement and 0-30° of Southwick angle
- 3) Moderate slip: Between 30-50% of displacement and 30-60° of Southwick angle
- 4) Severe slip: More than 50% of displacement and more

than 60° of Southwick angle.

Future directions in Imaging and classification:

Research over the past decade or so, has been directed towards diagnosing, quantifying and classifying cartilage status vis-à-vis changes of degeneration and arthritis in the setting of FAI and early degenerative joint disease [5]. With this in mind, methods like delayed gadolinium-enhanced MRI of cartilage (dGEM-RIC) [32], T1rho [33] and gagCEST [34] have made rapid strides. They help in assessing the cartilage glycosaminoglycan content, the cartilage water content and interactions between water molecules and the collagen fibre network. The aim for these advanced techniques is that they should guide surgical treatment according to individual disease and hopefully have an exact idea about the prognosis of the hip as per FAI and degenerative joint disease.

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