Slipped capital femoral epiphysis

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ABSTRACT
Slipped capital femoral epiphysis (SCFE) is the displacement of the proximal femoral epiphysis relative to the metaphysis; anatomically this is a wrong term as the femoral epiphysis retains its normal relationship with the acetabulum and the femoral neck slips proximally and anteriorly. The femoral neck may slip posteriorly (anterior slip) or into abduction (valgus slip) but these conditions are very rare. The condition commonly occurs during the adolescent growth spurt period. Boys are commonly affected than girls and the left hip is more commonly involved.

Epidemiology
Incidence of SCFE is variably described as 1:100,000 to 7:100,000. The incidence is maximal in Polynesians and rare in the Indo Mediterranean regions. In America the condition is more common in African Americans.

SCFE occurs more commonly in boys (M:F ratio 3:2). The left hip is more commonly affected than the right. The difference in incidence among the sexes is gradually changing with the condition occurring more frequently in females than before. Even the side predilection for left hip has also changed over the period of time.

The age of onset is typically 13 to 15 years in boys and 11 to 13 years in girls.

Obesity is strongly associated with the development of SCFE. The classic phenotype for SCFE is described as an obese hypogonadic boy with the so-called “adiposogenital syndrome.”

The condition is bilateral in approximately 20% cases; out of which 50% cases present as bilateral slip. In cases where the slip is sequential the other side is involved within 18 months in 80% cases. These epidemiological data helps in decision making regarding whether to treat the contra lateral hip in cases with SCFE.

Associated Conditions
Studies have found out strong association of certain endocrinological conditions with SCFE, the most important being hypothyroidism and growth hormone deficiency. The other medical conditions include chronic renal disease, panhypopituitarism, cranio-phyngioma, hypogonadism, hyperparathyroidism, growth hormone excess, multiple endocrine neoplasia 2B, Turner’s syndrome, and optic nerve glioma.

SCFE can also occur in patients with Down syndrome, Marfan syndrome, Klinefelter syndrome, Rubinstein–Taybi syndrome, post irradiation etc. Patients who are on Growth hormone supplementation need to be monitored for development of SCFE. Recently Vitamin D deficiency has been demonstrated in children with SCFE.

When the SCFE is atypical with regard to age at occurrence, that is before 10 years and after 16 years, a thorough search for underlying medical disorder is warranted.

Aetiopathogenesis
Mechanical factors are thought to play an important role in the aetiology of this condition as SCFE is more common in obese patients. The higher incidence in the left hip is explained
in theory by the excessive loading of left hip in right handed individuals especially during sitting.

The factors which contribute to SCFE are:

1. Thinning of the Perichondrial ring — the perichondrial ring is a fibrous structure around the physis which gives resistance to shear stress. As age advances the perichondrial ring thins out making the physis weaker to shear stress. In older children mamillary interlocking (interdigitation of cartilage and bone in the vicinity of growth plate) supports the physis against shear. Lack of mamillary interdigitation especially in endocrinological conditions makes the physis vulnerable for slipping.

2. Increased femoral retroversion — CT studies have demonstrated increased femoral retroversion in children with SCFE.

3. Inclination of femoral physis with respect to femoral neck — in the AP view the slope of the proximal physis with respect to the femoral neck was measured. It was found that the slope is higher (i.e. the physis was more vertical) in children with SCFE.

The growth hormone causes adolescent growth spurt whereas the sex hormones causes conversion of cartilage to bone in the physis. It has been postulated that a desynchronisation of growth and sex hormone spurts leads the physis vulnerable to shear stress.

The physis of children with SCFE shows decreased number of chondrocytes in the hypertrophic and proliferative zone and excessive matrix. The epiphysis slips through the Hypertrophic zone of the physis.

**Classification**

SCFE can be classified according to chronology, severity and functionality.

Chronologic Classification

Acute slip — when the duration is less than 3 weeks (2 weeks as per some surgeons).

Chronic slip — when the duration is more than 3 weeks — typically several months — most common presentation.

Acute on Chronic — a patient with vague groin pain for several months presents with severe pain following a trivial trauma.

Morphologic classification

According to the severity of slip.

The slip angle is measured in frog lateral X-ray projection. A line is drawn perpendicular to the base of the epiphysis. The angle made by this line to a line through the long axis of the femoral neck is measured.

**Clinical Features**

The typical patient is an obese adolescent male or female who has vague groin pain for several months. He/she can walk but will have a limp. (Stable slip) The pain may be exaggerated by a trivial trauma.
In acute slip the duration of symptoms is less than 2 weeks.
On examination, the child can have a gait with external foot progression angle.
Passive ROM of the affected hip is restricted especially flexion, abduction and internal rotation. Trendelenberg sign is usually positive.
On attempted hip flexion there is a tendency for axis deviation due to the external rotation deformity. A shortening of 1–2 cm is frequently seen.
Presence of symptoms in the opposite hip should always be asked for and a thorough examination of the opposite hip should also be done.

**INVESTIGATIONS**

- **Plain radiography** An X-ray of the Pelvis AP and frog lateral projection is essential for the diagnosis.
  The radiographic signs are:
  1. Terry Thomas sign — widening of physis in Pre slip.
  2. Metaphyseal Blanch sign of Steel.
  3. Capener’s sign.
  4. **Trethowan sign** — a line passing through the superior border of the neck usually passes through the upper portion of the epiphysis in the AP view. In SCFE this line passes superior to the epiphysis.
  5. Kline’s line.

  A radiological diagnosis can be missed in the pre slip stage or in mild slips and also when a frog lateral X-ray is not taken.

  In children with unstable slips frog lateral X-ray should be avoided; instead a cross table lateral view would be sufficient.

- **Ultrasonography** — will show effusion in acute slip, remodeling changes in femoral neck in chronic slip and effusion and remodeling changes in acute on chronic slip.

- **MRI** — MR imaging is helpful when there is a strong clinical suspicion with negative plain radiographs. MR will show increased signal changes in the region of physis with widening of growth plate.

- **Technetium Bone Scan** — It is not useful as a specific diagnostic study. A decreased uptake in the femoral epiphysis is a definite clue of avascularity.

**DIFFERENTIAL DIAGNOSIS**

A transphyseal Salter Harris type 1 fracture can be clearly differentiated from SCFE clinically. Most children with SCFE have vague groin pain for several weeks. Again, the severity of trauma gives a clue — Salter Harris 1 injury of the proximal femur follows a significant trauma and is often associated with hip dislocation.

**TREATMENT**

The primary aim of treatment is to stabilize the epiphysis to prevent it from further slipping. Secondary aims include facilitation of closure of physis and reduction of the deformity.

The options include *in situ* pinning, screw fixation of the physis, open bone peg epiphysiodesis and deformity correction and screw fixation.

- **In situ fixation** — All stable mild slips can be treated with *in situ* fixation. The actual choice of the implant is not so important as long as the goal of stabilization of the physis is achieved. Commonly used implants include smooth pins, partially threaded cancellous screws, fully threaded cancellous screw and reverse threaded screws.
A single screw through the centre of the physis is the gold standard in mild stable slips. The screw should have adequate purchase in the epiphysis but great care should be taken to avoid intraarticular protrusion. Reverse threaded screws have threads in the proximal part which anchors the metaphysis whereas the smooth portion crosses the physis. These screws have the purported advantage of continuing physisal growth. A fully threaded screw also has better purchase in the metaphysis and is easier to remove than a partially threaded one.

Recently computer navigated screw placement has been introduced to avoid the complication of intraarticular screw penetration. Studies have shown considerable decrease in the intraarticular screw placement with this technique but the procedure is expensive and time consuming.

**Surgical technique** — *In situ* fixation can be done with the patient on a fracture table or on a radiolucent operating table. The entry point for the guide wire needs to be marked prior to making skin incision.

A guide wire is placed over the skin on the anterior aspect of the thigh in the direction of the screw under image intensification in AP view. The trajectory of the screw is marked on the skin. The same procedure is repeated in the lateral view with a wire placed over the lateral aspect. The intersection point will be the starting point for the screw. More the grade of slip, more anterior will be the entry point.

Make a skin incision slightly distal and lateral to the proposed entry point of the screw. A 2 cm incision should suffice. Guide wire is introduced into the femoral neck across the physis and into the epiphysis. The position of the guide wire is verified in AP and lateral images. The wire should be in the centre of the epiphysis. The length of the screw is measured. Appropriate sized drill is introduced over the guide wire and drilled up to 5 mm of the tip of the guide wire.

Cancellous screw is introduced over the guide wire. At least 5 threads should cross the physis ideally. AP, Lateral and continuous screening should be done to confirm that the screw is not protruding into the joint. Some surgeons instill arthrogram dye in to the screw hole to confirm the position of the tip of the screw.

It is important to avoid a subtrochanteric entry point for the screw, which may lead to fracture of the proximal femur.

**Postoperative management** — Touch weight bearing can be done on the operated side if the patient is sensible and trainable. X-rays should be taken at the end of 6 weeks and 3 months. If the X-ray at the end of 6 weeks show widened physis the fixation is not stable enough to permit full weight bearing. Whether to remove the implant or not is controversial but there is a favorable trend towards removal of the screw.

**Bone Peg Epiphysiodesis**

This technique was described by Ferguson in 1931. The procedure gained popularity because it avoided intraarticular penetration of the screw used for stabilizing the slip. The surgical technique involves exposure of the hip through an anterior or anterolateral approach, H shaped capsulotomy to expose the proximal femur, removal of core of tissue from metaphysic, physis and epiphysis and introduction of iliac crest bone graft into the defect.
Treatment of stable slips — moderate and severe.

The treatment options for stable slips with slip angle more than 30° include in situ screw fixation as well as femoral head realignment and fixation. With increasing slip it is technically difficult to introduce the screw in to the centre of the femoral head. Also when the slip eventually heals there will be a significant anterolateral bump which can cause Femoro acetabular impingement and labral tears.

Osteotomies that are done for deformity correction include femoral neck osteotomy (Dunn procedure, Fish technique), Basilar osteotomy and Intertrocanhteric osteotomy.

The recent trend in management of these cases is Realignment of the femoral capital physis through safe surgical dislocation and screw fixation. The approach to the hip joint is through a trochanteric osteotomy (modified Ganz approach — safe surgical dislocation) with extreme care to preserve the blood supply to the femoral head. The blood supply to the femoral head is continuously monitored through a pressure transducer catheter. Excellent results have been reported by several authors with the incidence of AVN less than 20%. The disadvantage of this procedure is the steep learning curve.

When surgical expertise is not available a moderate but stable slip can be managed by in situ screw fixation followed by a definitive realignment procedure later.

Management of Unstable Slips

Unstable slips of any grade are a surgical emergency and warrants prompt treatment. In fact most authors advocate operative stabilization within 24 hours to reduce the chance of AVN. Loder et al. has reported that the incidence of AVN in unstable slips is about 50%.

While the patient is being prepared for surgery he/she should be in bed rest with skin traction.

If surgical expertise to do open realignment by safe surgical dislocation is not available the slip should be fixed with single or multiple screws. No forceful reduction maneuver should be attempted so as to avoid further damage to the tenuous blood supply to the femoral epiphysis.

The patient can be placed on the fracture table. The surgical technique essentially is the same; but a single screw may not be sufficient to prevent further slip. Aspiration of the joint should be done to reduce the tamponade effect.

While planning open realignment of the femoral epiphysis, the epiphysis may have to be temporarily pinned to avoid further displacement.

Postoperative management — Weight bearing should be avoided till there is sufficient closure of the physeal gap. A bone scan can be performed at the end of first week to document the vascularity of femoral epiphysis. If the femoral head is not viable weight bearing is delayed for fear of collapse of the femoral head.

Management of contra lateral hip in unilateral SCFE.

There are a lot of controversies regarding whether to prophylactically stabilize the contra lateral hip or not. The incidence of bilaterality is only 25%. Even though the surgical risk of screw fixation of intact hip is minimal many surgeons refrain from prophylactic fixation of all hips. The concern of intra articular screw placement and subsequent chondrolysis is theoretical but possible.

The acceptable criteria for prophylactic fixation of the contra lateral hip in unilateral SCFE include:

1. Symptomatic hips — painful internal rotation.
2. Early onset slips — slip before 10 years of age — because of high incidence of slip; also to minimise leg length discrepancy arising from proximal femoral epiphysiodesis.
3. Atypical slips — SCFE occurring in children with Endocrinopathies, chronic renal disease, GH supplementation etc.
4. Proper follow up not feasible — especially in the rural settings where regular clinical and radiological monitoring is not possible.

Oxford Bone Score — The modified Oxford Bone Score (OBS) developed by Staskielis, is derived from the 3 consecutive stages of maturation of 5 radiographic parameters including iliac apophysis, triradiate cartilage, proximal femoral epiphysis, greater and lesser trochanter. The score ranges from 16 to 26. An OBS of 16, 17 and 18 had a positive predictive value of developing a contra lateral slip of 96% and a negative predictive value of 92%. Lesser the OBS, greater the risk of developing contra lateral slip.

Concept of Posterior Slope Angle — Posterior sloping angle (PSA) is measured in the Launstein lateral view at the intersection of the plane of the physis and a line perpendicular to femoral neck — diaphyseal axis. Higher the PSA more the risk for developing slip. Barrios et al recommended prophylactic pinning of hips with a PSA above 12°.

Zenios and colleagues tested the interobserver and intraobserver variability in the measurement of PSA and concluded that the PSA is a reliable measure. They recommended pinning of contra lateral hip when the PSA is above 14.5°. Recently several studies have confirmed the validity and reliability of PSA as a predictor of SCFE.
Complications of SCFE

Continuing slip This occurs in untreated cases, slips treated with hip spica and also when the screw fixation is not stable enough. Persistent pain in the hip, inability to do active straight leg raise and persistent widening of the physeal gap in X-rays are indications of continuing slip. Additional screw fixation should be considered in such circumstances.

Avascular necrosis of femoral epiphysis Incidence of AVN in Slipped upper femoral epiphysis has been estimated to be around 10–15%. The incidence is higher in unstable slips (up to 50%), following closed manipulation or open reduction.

With the introduction of in situ single screw fixation the incidence of AVN in stable slips has decreased considerably.

AVN can be diagnosed by an early postoperative Technetium Bone scan study. The scan has to be done within the first week after surgery. Late scans can give false negative results.

Suggested strategies to reduce the incidence of AVN include:

1. single screw fixation in stable slips — screw to be placed in the centre of the epiphysis.
2. stabilization of Unstable slips within 24 hours.
3. Avoid unnecessary manipulation for reducing unstable slips.
4. Aspiration of hip joint in acute unstable slips to prevent tamponade effect on blood supply to femoral epiphysis.
5. Safe surgical dislocation approach for realignment of femoral epiphysis in unstable and displaced slips.

Chondrolysis

Chondrolysis is decrease in joint space due to thinning of the articular cartilage. Decreased range of motion associated with pain and a cartilage thickness of 3 mm or less in X-ray is diagnostic of Chondrolysis.

Intra articular screw penetration is the single most preventable factor in the development of chondrolysis. Studies have shown that in 51% cases with intra articular screw penetration chondrolysis occurred.

Chondrolysis can occur without treatment, after in situ fixation, femoral neck or trochanteric osteotomy or open reduction of SCFE. The diagnosis is usually evident within 6–9 months. There is rapid loss of joint space with progressive stiffness. Some recovery of joint space occurs in due course. Treatment of chondrolysis includes traction, physiotherapy and intra articular
steroids. In resistant cases sub total capsulectomy, operative manipulation followed by postoperative continuous passive motion exercises can be tried. In failed cases where there is significant hip pain and stiffness arthrodesis or arthroplasty should be considered.

**Femoroacetabular Impingement**

Femoroacetabular impingement (FAI) is a disorder caused by abnormal morphology of acetabulum and proximal femoral causing abnormal contact forces across the hip especially in flexion. FAI can lead to labral tears, articular cartilage damage and hip pain.

There are two types of FAI — pincer type and cam type. Pincer FAI is caused by over coverage of femoral head by acetabulum as in coxa profunda or acetabular retroversion. Cam type of impingement is caused by non-spherical femoral head or femoral retroversion.

When a moderate SCFE is stabilized by an *in situ* screw, the entry point of the screw on the femoral is very much anterior. The prominent screw head can cause impingement and labral tears. Also the uncovered anterior and superior portion of the femoral neck significantly impinges on the acetabular margin with hip flexion.

In moderate SCFE treated with *in situ* fixation impingement occurs at 70° hip flexion whereas in severe slip, hip flexion of 50° causes impingement.

Clinical signs of FAI include obligate external rotation and abduction on hip flexion (Drehmann sign) and pain on hip flexion, adduction and internal rotation (FADIR test).

Radiological signs of FAI include crossover sign (crossing of anterior and posterior margins of acetabulum), increased lateral centre edge angle and decreased Tonnis angle.

Surgical strategies to treat FAI include osteochondroplasty and proximal femoral osteotomy. Osteochondroplasty is the removal of the bony bump anteriorly in the femoral neck. This can be done arthroscopically or by open method (through safe surgical dislocation approach). An intertrochanteric flexion osteotomy done through the safe surgical dislocation approach can also remove anterior impingement.

**Proximal Femoral Fracture**

Proximal femoral fracture especially at the subtrochanteric level occurs when the screw entry point is distal. Femoral neck fractures have also been reported after *in situ* slip stabilization following trauma. Multiple entry holes should be avoided for *in situ* screw fixation.

**Conclusion**

Slipped capital femoral epiphysis is not a common condition in our country. Nevertheless the condition has to be recognized and appropriate treatment instituted promptly to avoid disastrous consequences. Newer surgical techniques like femoral capital realignment though safe surgical dislocation has reduced the incidence of Avascular necrosis of the femoral head and femoroacetabular impingement. With Arthroscopy of the hip joint becoming popular, the surgical treatment of Femoroacetabular impingement secondary to SCFE has given predictable results in terms of patient satisfaction.

**References**