Overview of Screw Fixation in Stable and Unstable Slipped Capital Femoral Epiphysis

Aymen Ahmed Bashir Krima, Hosam Mohammed KhairyTawfik,MohmedAbdAlla M. Abdel Salam,YehiaTarekElbromboly

Orthopedic Surgery Department, Faculty of Medicine, Zagazig University, Egypt.

Corresponding author:**Aymen A. Krima**, Email: aymenkrima55@gmail.com

ABSTRACT

The most frequent hip disease in adolescents is called slipped capital femoral epiphysis (SCFE). It is known as the sliding of the proximal femoral epiphysis through the growing cartilage with respect to the femoral neck. It is posteroinferior to the neck because the epiphysis is still in the acetabulum at this point.The goals of treatment of SCFE are preventing further epiphyseal displacement until physeal closure, avoid complications such as AVN and chondrolysis and maintain adequate hip function.Factors that determine the surgical management of SCFE include the severity, stability of the slip and presence of complications. Some advocate that all mild to moderate cases of SCFE be fixed in situ, with attempts at reduction being limited to unstable severe slips.Screw fixation is currently the most frequently used technique and has shown good results. In general, the percutaneous fixation technique limits the risk of necrosis and chondrolysis, but leaves a persistent deformity at the level of the head neck junction that can be responsible for the intermediate and long term evolution of the femoroacetabular impingement and subsequent arthrosis. The aim of the present study was to review using of screw fixation in stable and unstable slipped capital femoral epiphysis.

Keywords: Slipped Capital Femoral Epiphysis;Screw Fixation; Unstable SCFE **DOINumber: 10.14704/NQ.2022.20.12.NQ77185** **NeuroQuantology2022;20(12): 2111-2120**

Introduction

Slipped capital femoral epiphysis (SCFE) is a common adolescent hip disorder. This pathology is defined as the slipping of the proximal femoral epiphysis relative to femoral neck through the growth cartilage. In this location the epiphysis remains in the acetabulum and thereforeit is posteroinferior to the neck**(1)**.SCFE is defined as the posteroinferior slipping of the proximal femoral epiphysis relative to femoral neck through the growth cartilage. Currently, the most commonly used classification is based on stability and the child's ability to walk with or without crutches. A SCFE is defined as stable if the child can walk with or without out crutches and an unstable SCFE is one in which the child cannot walk with or without crutches. Unstable SCFE have been reported to have a poorer prognosis with an up to 50% risk of AVN in comparison with an almost negligible rate in stable SCFE**(2)**.

The incidence of SCFE ranges from 0.33/100,000 to 24.58/100,000 children 8 to 15 years of age, depending upon gender and ethnicity. There is significant variability within racial groups, relative to Caucasians at 1.0, is 5.6 for Polynesians, 3.9 for Blacks, and 2.5 for Hispanics. The average age is 12.0 years for boys and 11.2 years for girls; obese children present earlier than thin children. The average symptoms duration for stable SCFE is 4 to 5 months**(3)**. Although there is a general correlation between symptom duration and SCFE severity. The left hip is affected twice as often as the right. Bilaterality ranges from 18 to 50% and is

more frequent in Africans compared to Hispanic and White peoples. In children with bilateral involvement, 50– 60% present with simultaneous SCFEs; 80–90% of those who present with a unilateral SCFE and subsequently develop a contralateral SCFE do so within 18 months after the first SCFE. The age at presentation is younger for those who present with a unilateral SCFE and develop contralateral involvement compared to those who do not develop a contralateral SCFE**(4,5)**.

The actual cause of SCFE remains, more or less, unknown, several theories exist on the pathogenesis of SCFE, the causes of the physeal disruption is likely to be multifactorial, but in most cases, a relatively weak physis is subjected to loads beyond tolerance. This typically occurs at the time of the pre-adolescent/adolescent growth spurt, when a combination of hormonal and mechanical factors may be causative**(6,7)**.

The most important hormones that may contribute to the development of SCFE are thyroid hormones (T3 and T4), the sex hormones (mainly estradiol, Testosterone) and growth hormone (GH). Parathyroid hormone seems to play a potential destabilizing role too. The hormonal imbalance that may trigger the development of SCFE during puberty is usually subtle and does not necessarily lead to development of a typical hormonal disorder with clinical findings**(7)**. In addition; mechanical factors such as retroversion of femur, increased physeal obliquity and obesity place abnormal stress on the physis. This abnormal shear force may be enough to cause a slip when rapid growth occurs during adolescence**(8)**.

Classifications of SCFE

- The traditional chronological classification based on the patient's history (symptoms durations), physical examination and radiological finding**(5)** as the follow:

1. Acute slip: the duration of symptoms is less than 3 weeks, and account around 10 to 15% of SCFE cases, with an abrupt displacement through the proximal physis**(9)**.
2. Chronic slip : present ≥ 3 weeks of symptoms and account for 85% of all SCFEs**(5)**.
3. Acute-on-chronic slip: chronic symptoms initially and the subsequent development of acute symptoms, as well as a sudden increase in the degree of slip, usually with minor trauma**(5)**.

- Classifications based on stability: physeal stability was predictive of osteonecrosis rates, with around 47% of unstable and 0% of stable slips developing AVN within 6 to 18 months**(9)**.
- Loder's classificationbased on the ability to walk with or without crutches as follow **(5)**:

1. Stable SCFEwhere the child is able to walk, with or without crutches.
2. Unstable SCFEwhere the child can't walk, with or without crutches.

- The radiographic classificationbased on presence or absence of a hip effusion on ultrasonographycrutches as follow **(5)**:

1. Stable SCFE: presence of metaphyseal remodeling and the absence of an effusion.
2. Unstable SCFE: presence of an effusion and the absence of metaphyseal remodeling.

- Classifications based on severity that described by two different methods**(5)**:

1. Based on epiphyseal-metaphyseal angle: This is determined by the amount of displacement of the metaphysis on the epiphysis **(Figure1) (11).**

- **Grade I (mild SCFE)** is epiphyseal metaphyseal displacement <1/3 the

eISSN 1303-5150

width of the metaphysis.

- **Grade II (moderate SCFE)** is epiphyseal metaphyseal displacement 1/3–1/2 the width of the metaphysis.
- **Grade III (severe SCFE)** is epiphyseal metaphyseal displacement >1/2 the width of the metaphysis.

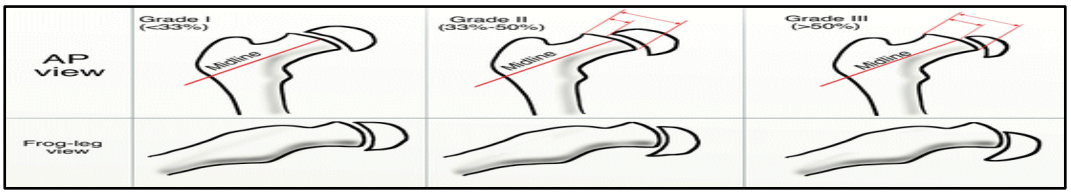

Figure (1): The three types of the slipped capital femoral epiphysis based on radiographic findings: type I displacement <33 %; type II displacement 33–50 %; displacement >50 % (11).

2. **Based on epiphyseal-shaft angle: (Southwick angle):** The angle is calculated by subtracting the epiphyseal shaft angle on the normal side from that on the side with SCFE**(Figure 2)**.A mild slip is less than 30 degrees, a moderate slip is between 30 and 50 degrees, and a severe slip is greater than 50 degrees **(12)**.If bilateral hips are involved, use 145° as "unaffected" hip reference for AP and 10° as "unaffected" hip reference for frog leg lateral **(13)**. This classification is important for long-term prognosis as mild and moderate slips have a much better long-term prognosis than severe slips which demonstrate a more rapid development of degenerative hip disease**(5)**.

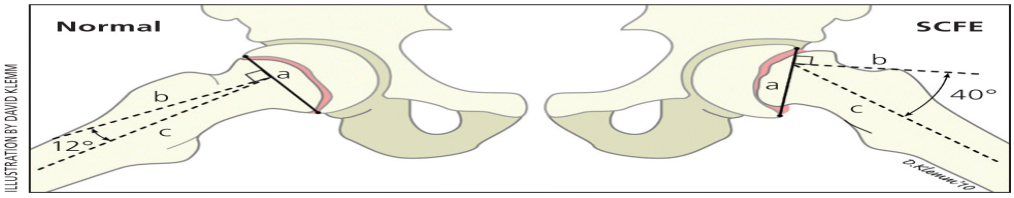

Figure (2): Southwick method for determining SCFE severity using a frog-leg lateral radiograph. The first line (a) is drawn from the anterior to the posterior epiphyseal edges. Next, a line (b) is drawn perpendicular to the first line. A third line (c) is drawn down the middle of the femoral diaphysis. The angle formed by lines b and c is the lateral epiphyseal-shaft angle (LESA). The actual slip angle is the difference between the LESA of the SCFE hip and that of the uninvolved hip**(12)**.

Clinical evaluation of SCFE

SCFE patients can present in a delayed or acute fashion with implications for epiphyseal stability, with the resultant deformity and with the presence of the complications like avascular necrosis or chondrolysis**(9)**.Patients commonly present with longstanding symptoms lasting months. The most common presentations include limp and pain in the affected groin, poorly localized to the hip, groin, thigh, or knee. Knee or distal thigh pain is the presenting symptom in 15 % of SCFE patients, it is imperative that physicians strongly consider SCFE when a child presents with vague hip or knee pain. History of trauma to the area is rare**(6,12)**.Knee pain in SCFE is referred by a reflex arc involving somatic sensory nerves ending at the same spinal level **(Figure 3) (9).**

eISSN 1303-5150

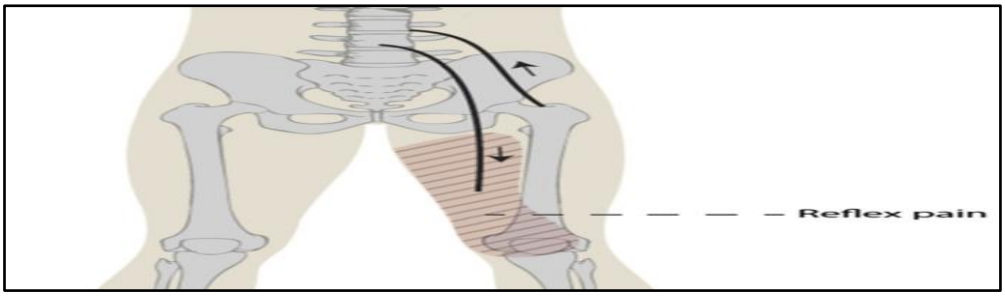

Figure (3): Reflex arc of referred pain in SCFE, in which a reflex of afferent somatic sensory nerves from the hip terminate at a spinal level in proximity to efferent pain signals to the knee and thigh (9).

Patients with unstable SCFE are presented with sudden severe fracture-like pain in the affected hip usually following minor trauma like falling or twisting. The patient is unable to bear weight with or without crutches. The patient usually presents with the affected limb in external rotation, shortening and refuse to move it. Any movement of the affected hip is painful**(14)**.

Radiological evaluation of SCFE

- **Plain radiographs:** Antero-posterior view / frog leg lateral views of pelvis & both hips simultaneously, in case of stable SCFE. Anteroposterior and cross-table lateral views of the involved side should be obtained, in case of unstable SCFE. The Klein line, a line along the superior border of the femoral neck, should intersects the femoral head on the AP radiograph.Failure to do so comprises a positive (Trethowan sign) and may indicate a SCFE**(9)**.Most SCFE is characterized by anterior translation and external rotation of the metaphysis relative to the epiphysis, which, on an AP projection, is located posterior and inferior to the metaphysis**(Figure 4)**.In the early preslip stage, the only positive findings are a widening and irregularity of the physis with sharpening of the metaphyseal border of the head**(9).**
- **MRI:**Can assess vascularity to the femoral head or the extent of AVN. Also it is suitable for diagnosing the early stage of the slip in highly clinically suspected cases of SCFE, and plain x-rays or CT are normal.MRI findings include widening of the physis with bone marrow edema of the metaphysis, joint effusion and synovitis**(15)**.

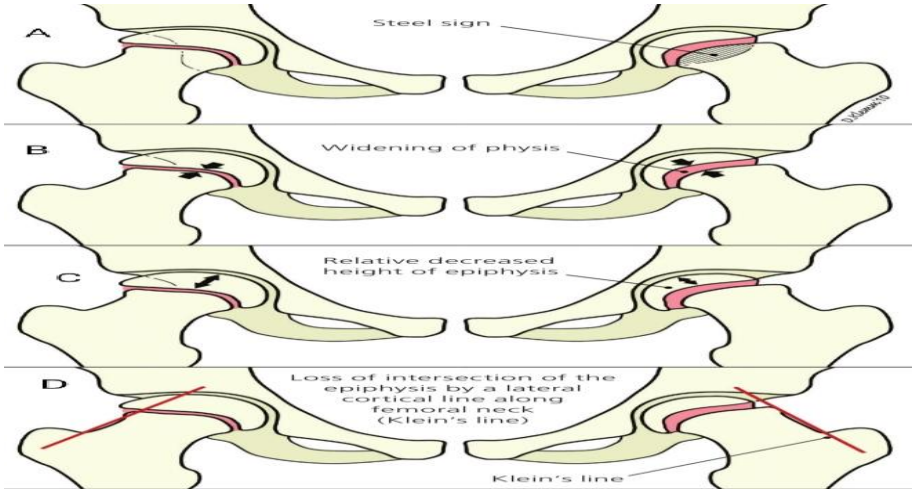

Figure (4): Diagrams of radiographic signs of slipped capital femoral epiphysis (12).

eISSN 1303-5150

Imaging of bone with Tech-99 shows increase uptake in site of slipping and in hip joint in case of chondrolysis while decrease uptake in case of AVN. It is not an important investigation as proper clinical examination and plain radiograph AP and lateral views are sufficient for diagnosis**(16)**.

Treatment of SCFE

The management of unstable SCFE is challenging, and treatment decisions remain controversial. The goal of treatment is to stabilize the slip, while minimizing the risk of AVN and proximal femoral deformity. Treatment options include in situ or incidental reduction and screw fixation, with or without capsular decompression, bone graft epiphysiodesis and surgical dislocation with reduction and fixation of the epiphysis**(17)**.

Nowadays, the most commonly used and successful method is percutaneous in situ fixation using one (or more in severe cases) cannulated screw. This leads to prevention of further slipping and early closure of the physis, but there may be long term consequences of leaving the physis in a non-anatomic position. Deformity occurring after SCFE has been associated with the development of degenerative joint disease due to abnormal joint kinematics and femoroacetabular impingement**(18,19)**.It is used in treatment for mild, moderate, and some severe acute or chronic SCFE. It is simple and faster, less traumatic procedure with a minor loss of blood and the hip joint is not violated**(20)**.

Percutaneous in situ fixation using a fracture table

The patient is placed supine on the fracture table while under general anesthesia. After preparation, cleaning and draping a guide-pin is placed on the skin overlying the proximal part of the femur, and the image-intensifier is used to view the proximal part of the femur and the guide pin in the anteroposterior projection. The guide pin is then placed on the skin over the lateral portion of the thigh, and the image intensifier is used to view the proximal part of the femur in the lateral projection. The guide pin must be perpendicular to the physis and over the center of the femoral head on both images. Lines are drawn on the skin to record the two positions of the guide pin. A skin incision is made, along the longitudinal axis and centered over the point of intersection of the two lines**(21)**.

Since the epiphysis usually slips posteriorly, the point of intersection is located farther anteriorly with increasing degrees of slip. The guide-pin is advanced freehand through the soft tissues, including the fascia lata. Then advanced on power drill through the neck into the epiphysis. Several attempts may be necessary to place the guide-pin in the center of the femoral head and perpendicular to the physis, as visualized on the antero- posterior and lateral images of the hip. After reaming and taping a single cannulated screw is then placed over the guide pin and is advanced until five threads engage the epiphysis. The guide pin is removed, and the wound is closed**(21,22)**.

Percutaneous in situ fixation using a radiolucent table

The criteria for successful in situ screw fixation are that the screw should be placed in the center of the epiphysis, preferably perpendicular to the physis without penetrating the joint. To achieve this perfectly, good biplanarfuoroscopic imaging is mandatory during the procedure**(23)**.

In most studies, in situ fixation has been described with the patient positioned on a fracture table. The

eISSN 1303-5150

advantages are ease of biplanarfuoroscopic imaging, need fewer assistants, and decreased risk for further displacement of epiphysis as there is no need for repeated maneuvering of a limb. The major disadvantage is the inability to examine the hip at the end of the procedure for a range of movements and impingement (to assess the need for osteoplasty) in a sterile field. The other disadvantages of fracture table are the need for position change and repeat draping in bilateral cases or for prophylactic pinning. To overcome these limitations, in situ fixation in the supine position on the radiolucent table has been described**(23)**.Disadvantages of this technique include the need for small incision in the fascia lata to avoid bending of the guide wire during flexion and abduction of the hip. Also this technique should not be used in cases of unstable SCFE as manipulation of hip joint may cause more displacement of the epiphysis and affect vascularity**(20,23)**.

Cannulated screws

Essential characters of the requested screw include; large core diameter at least (6.5mm thread diameter and 4.5mm core diameter), reverse cutting threads**(24)**.There continues to be debate regarding the optimal number of screws (single screw vs. 2 screws) and the type of screw used (fully threaded vs. partially threaded). A bovine model previously demonstrated greater biomechanical stability with use of 2 screws compared with 1; however, single screw fixation was still recommended, as the added stability of a second screw was minimal compared with the anticipated risk for complications**(25)**.Non displaced SCFE does not require 2 screws. In situ fixation of displaced SCFE might be optimized with 2 screws**(25)**.

A single screw has proven adequate for the chronic SCFE. However, the surgeon may feel that 2 screws are better in an acute slip. If 2 screws are used, the first should lie in the central axis of the femoral head with the second below it. The second screw should remain at least 8 mm from the subchondral bone**(24)**.Although there were no differences between screw types in an in vitro model, bone healing around the fully threaded screw may eventually provide greater stability. The use of fully threaded screw remains a reasonable option in the treatment of SCFE, and implant removal may be easier**(26)**.

Close reduction and screw fixation

In situ pinning remains a safe and predictable method for treatment of stable SCFE with no AVN noted, even in severe slips. Attempts to anatomically reduce stable slips led to severe AVN in 20% of cases, thus this treatment approach should be considered with caution. Treatment of unstable slips remains problematic with high AVN rates noted whether treated by in situ fixation or capital realignment (Mod. Dunn)**(27)**.

In most cases of unstable SCFE the slipped epiphysis is reduced when the patient is placed over the fracture table with minimal positioning. This positioning includes minimal internal rotation to the neutral position, mild traction then stabilizing in this position. Under fluoroscopy, comparison between pre and post positioning on AP and lateral projections, in majority of cases some sort of femoral epiphysis reduction occurs.A guide wire is inserted through the neck till epiphysis. Over the pin a cannulated screw is introduced in a manner similar to that in stable SCFE. In its final position the screw should have 3 or 4 threads crossing the physis in the center of the femoral head. To add stability to the fixation some

authors prefer to use another cannulated screw**(27)**.

Open reduction

Since safety of surgical dislocation of adult hips reported to deal with impingement problems without the risk of AVN, there has been interest in open treatment of SCFE using this surgical approach to anatomically realign the slip. This technique is useful for experienced surgeons in treating unstable as well as moderate to severe chronic slips and for correction of late deformity. Open reduction and internal fixation via the surgical hip dislocation approach can be considered in any patient diagnosed with an unstable SCFE**(28)**.

The standard approach for hip dislocation is used. For safe visualization of femoral neck, a sub-periosteal retinacular soft tissue flap containing blood vessels is extended and thus removal of the medial and posterior callus can be removed as well as mild shortening of the neck is done to release tension on retinacular blood vessels after reduction of the head to it anatomical position. After that reduction of the epiphysis to its position then fixation of it to femoral neck by cannulated screw**(29)**.Different studies to patients treated with careful surgical dislocation showed that through this technique open femoral head reduction can be safely done with excellent results. Earlier poor results may be due to lack modern image techniques, less knowledge about protection of retinacular vessels of the epiphysis and multiple joint penetrations with pins**(30)**.

Other open reduction technique for treatment of unstable SCFE include urgent arthrotomy and minimal reduction then fixation of the epiphysis to the femoral neck by 2 smooth k-wires or 2 cannulated screws. This procedure produces also decompression in the hip joint**(31)**.

Osteotomy

Proximal femoral osteotomies might be performed in SCFE to improve orientation of the femoral head. They can be done at the time of original surgery or subsequent to in situ screw fixation to address ongoing symptoms. Surgical techniques are divided by the level of the osteotomy**(15)**.

Prophylactic pinning

The best management of the contralateral, unaffected hip in patients who present with a unilateral SCFE remains controversial. The risk of a contralateral slip in patients who are first seen with a unilateral SCFE is reportedly between 14% and 40%. Many authors support routine prophylactic pinning of the contralateral, normal side to prevent the morbidity associated with a subsequent SCFE. Others argue routine prophylactic pinning for all patients with a unilateral SCFE will result in an unnecessary surgery for most patients**(32)**.

Authors with routine prophylactic pinning with a single cannulated screw argue that this technique is sufficiently free of complications that should be undertaken because the patient is already undergoing a surgical procedure**.**Opponents of prophylactic pinning cite the complications of prophylactic pinning of contralateral hip that may not slip. These complications have been registered up to 34% of prophylactically treated hip. The complications include chondrolysis (2%), AVN (1%) and proximal femoral fracture (1%)**(32)**.

Prophylactic pinning may be indicated in patients at high risk of subsequent slips, such as patients with obesity or an endocrine disorder, or those

who have a low likelihood of follow-up, in whom the surgeon suspects a delay would result in the presentation of a contralateral SCFE**(12)**.The modified Oxford bone score is the best predictor of future development of a contralateral slip in otherwise normal patients.If a modified Oxford bone score of 16 to 18 had been used to prophylactically pin a contralateral hip**(33)**.

In a recent study, they reviewed 32 hips (19 SCFE, 13 prophylactic) in 16 patients treated with FG screws for stable SCFE. We also reviewed 102 hips (63 SCFE, 19 prophylactic, 20 controls) in 55 patients treated with standard screws. Immediate postoperative radiographs were compared with 1- and 2-year follow-up images.Treatment of stable slipped capital femoral epiphysis most commonly involves in situ fixation with a standard cannulated screw, leading to physeal arrest. Recently, Pega Medical (Laval, Canada) introduced the free-gliding (FG) SCFE screw, which employs a growth-friendly, telescopic design. This study examines femoral neck growth and remodeling over the first 2 postoperative years in stable SCFE treated with FG versus standard screws. They concluded greater remodeling of femoral neck cam deformity occurs when treating SCFE using an FG screw**(34)**.

Further research is required to measure the impact of this finding on femoroacetabular impingement and degenerative arthritis.

CONCLUSION:

Single-screw fixation in situ is the preferred method of care for stable slipping capital femoral epiphysis. This approach carries a low risk of complications and a strong probability of long-term success.

The best environment for a successful outcome while reducing the risk of complications is provided by immediate hip joint suction followed by closed reduction and single- or double-screw fixation in the patient with an unstable slipping capital femoral epiphysis.

No Conflict of interest.

REFERENCES:

1- Odorizzi M, De Rosa V, Mameli A. Medium term results after in situ screw fixation of slipped capitis femoral epiphysis: A 33 case series.

2- Lang P, Panchal H, Delfosse EM, Silva MJJoPOB. The outcome of in-situ fixation of unstable slipped capital femoral epiphysis. 2019;28(5):452-7.

3- Herngren B, Stenmarker M, Vavruch L, Hagglund GJBmd. Slipped capital femoral epiphysis: a population-based study. 2017;18(1):1-12.

4- Peck D, Voss LM, Voss TTJAfp. Slipped capital femoral epiphysis: diagnosis and management. 2017;95(12):779-84.

5- Loder RT, Skopelja ENJISRN. The epidemiology and demographics of slipped capital femoral epiphysis. 2011;2011.

6- Millis MJJocso. SCFE: clinical aspects, diagnosis, and classification. 2017;11(2):93-8.

7- Papavasiliou KA, Kirkos JM, Kapetanos GA, Pournaras JJJoPOB. Potential influence of hormones in the development of slipped capital femoral epiphysis: a preliminary study. 2007;16(1):1-5.

8- Gholve PA, Cameron DB, Millis MBJCoip. Slipped capital femoral epiphysis update. 2009;21(1):39-45.

9- Georgiadis AG, Zaltz IJPC. Slipped capital femoral epiphysis: how to evaluate with a review and update of treatment. 2014;61(6):1119-35.

eISSN 1303-5150

10- Mulgrew E, Wells-Cole S, Ali F, Joshy S, Siddique I, Zenios MJJoPOB. Single screw fixation in stable and unstable slipped upper femoral epiphysis. 2011;20(3):147-51.

11- Balasubramanian B, Alshryda S, Madan S. Slipped Capital Femoral Epiphysis. In: Alshryda S, Howard JJ, Huntley JS, Schoenecker JG, editors. The Pediatric and Adolescent Hip: Essentials and Evidence. Cham: Springer International Publishing; 2019. p. 207-52.

12- Peck DJAfp. Slipped capital femoral epiphysis: diagnosis and management. 2010;82(3):258-62.

13- Lasanianos NG, Giannoudis PV. Slipped Capital Femoral Epiphysis. In: Lasanianos NG, Kanakaris NK, Giannoudis PV, editors. Trauma and Orthopaedic Classifications: A Comprehensive Overview. London: Springer London; 2015. p. 439-43.

14- Mooney III JF, Sanders JO, Browne RH, Anderson DJ, Jofe M, Feldman D, et al. Management of unstable/acute slipped capital femoral epiphysis: results of a survey of the POSNA membership. 2005;25(2):162-6.

15- Jarrett DY, Matheney T, Kleinman PKJPr. Imaging SCFE: diagnosis, treatment and complications. 2013;43(1):71-82.

16- Hesper T, Zilkens C, Bittersohl B, Krauspe RJJocso. Imaging modalities in patients with slipped capital femoral epiphysis. 2017;11(2):99-106.

17- Witbreuk M. Slipped Capital Femoral Epiphysis: Pathogenetic and Clinical aspects. 2015.

18- Causey AL, Smith ER, Donaldson J, Kendig RJ, Fisher III LCJTJoem. Missed slipped capital femoral epiphysis: illustrative cases and a review. 1995;13(2):175-89.

19- Larson AN, Sierra RJ, Elizabeth MY, Trousdale RT, Stans AAJJoPO. Outcomes of slipped capital femoral epiphysis treated with in situ pinning. 2012;32(2):125-30.

20- Lee FY-I, Chapman CBJJoPO. In situ pinning of hip for stable slipped capital femoral epiphysis on a radiolucent operating table. 2003;23(1):27-9.

21- Aronson DD, Carlson WJJ. Slipped capital femoral epiphysis. A prospective study of fixation with a single screw. 1992;74(6):810-9.

22- Sucato DJ. Slipped Capital Femoral Epiphysis. Musculoskeletal Key. 2016.

23- Venkatadass K, Prasad VD, Parsana C, Gomathi A, Rajasekaran SJIJoO. A Simple Modified Technique for In-Situ Screw Fixation in Slipped Capital Femoral Epiphysis. 2021;55(4):1022-7.

24- Morrissy RTJJopo. Slipped capital femoral epiphysis technique of percutaneous in situ fixation. 1990;10(3):347-50.

25- Schmitz MR, Farnsworth CL, Doan JD, Glaser DA, Scannell BP, Edmonds EWJJoPO. Biomechanical testing of unstable slipped capital femoral epiphysis screw fixation: worth the risk of a second screw? 2015;35(5):496-500.

26- Miyanji F, Mahar A, Oka R, Pring M, Wenger DJJoPO. Biomechanical comparison of fully and partially threaded screws for fixation of slipped capital femoral epiphysis. 2008;28(1):49-52.

27- Souder CD, Bomar JD, Wenger DRJJoPO. The role of capital realignment versus in situ stabilization for the treatment of slipped capital femoral epiphysis. 2014;34(8):791-8.

28- Adolfsen SE, Sucato DJJOTiO. Surgical technique: open reduction and internal fixation for unstable slipped capital femoral epiphysis. 2009;19(1):6-12.

29- Ziebarth K, Zilkens C, Spencer S, Leunig M, Ganz R, Kim Y-JJCo, et al. Capital realignment for moderate and severe SCFE using a modified Dunn procedure. 2009;467(3):704-16.

30- Persinger F, Davis RL, Samora WP, Klingele KEJJoPO. Treatment of unstable slipped capital epiphysis via the modified Dunn procedure. 2018;38(1):3-8.

31- Alshryda S, Tsang K, Chytas A, Chaudhry M, Sacchi K, Ahmad M, et al. Evidence based treatment for unstable slipped upper femoral epiphysis: systematic review and exploratory patient level analysis. 2018;16(1):46-54.

32- Sankar WN, Novais EN, Lee C, Al-Omari AA, Choi PD, Shore BJJCO, et al. What are the risks of prophylactic pinning to prevent contralateral slipped capital femoral epiphysis? 2013;471(7):2118-23.

33- Popejoy D, Emara K, Birch JJJoPO. Prediction of contralateral slipped capital femoral epiphysis using the modified Oxford bone age score. 2012;32(3):290-4.

34- Morash, K., Orlik, B., El-Hawary, R., Gauthier, L., Logan, K.. Femoral neck growth and remodeling with free-gliding screw fixation of slipped capital femoral epiphysis. Journal of Pediatric Orthopaedics, 2021, 41(4), e309-e315.