Management of Slipped Capital Femoral Epiphysis: The Hawai'i Experience

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Abstract

Slipped capital femoral epiphysis (SCFE) is a growing problem amongst children in Hawai'i as well as throughout the world. With increasing rates of childhood obesity, SCFEs are affecting more patients at younger ages. This makes the treatment of SCFEs critical as many children with SCFEs have significant growth remaining. There are a host of treatment options based on different classification schemes which can make it difficult to determine the appropriate care for a SCFE patient. In our practice, patients are treated based on a combination of angular displacement, stability as defined by Loder, and patient age. The procedures vary from single screw in-situ fixation for a mild deformity to a modified Dunn procedure for a high-grade deformity in the skeletally immature patient. For all our open fixation methods, epiphyseal perfusion is monitored with an 18-gauge needle attached to an arterial monitor and we routinely remove fixation after physeal closure. Excellent outcomes have been noted for the modified Dunn in our practice. This article describes the algorithm used to treat SCFE in Hawai'i at a tertiary children's medical center.

Keywords

slipped capital femoral epiphysis, Hawai'i, pacific island. modified dunn, intertrochanteric osteotomy, screw fixation, gliding, growing, intraoperative monitoring, arterial perfusion, obesity

Abbreviations

AVN = avascular necrosis
SCFE = slipped capital femoral epiphysis
STSB = screw tip to subchondral bone

Introduction

Mechanism

Slipped capital femoral epiphysis (SCFE) is a result of shear forces overwhelming the proximal femoral physis in prepubescent and adolescent children. The epiphysis remains posterior in the acetabulum as the metaphysis shifts anterior and rotates externally. The impact of the shear stress across the physis is amplified with increased body weight and high impact activities. Hip morphology such as acetabular and femoral neck retroversion can contribute to the increased risk of SCFE.[1]

Signs and Symptoms

Patients with SCFEs often present with either hip and/or knee pain.[2] They will typically have an antalgic gait with increased external rotation of the affected leg.[3] This can be identified with a positive Drehmann test where the patient externally rotates their affected leg when the hip is flexed. In patients with a SCFE, internal rotation is usually painful or not possible due to impingement.

Incidence

The incidence of SCFE varies among different ethnicities. Pacific Islanders have a 4-5 times higher incidence of SCFE compared to European populations.[4] There is also a higher incidence of SCFEs in Samoans.[5] With a large population of both Samoans and Pacific Islanders in Hawai'i, SCFEs are commonplace amongst pediatric orthopedic practices here in Hawai'i.

Risk Factors

SCFEs have been shown to be associated with childhood obesity as well as low socioeconomic status.[6,7] One study from Scotland noted that as childhood obesity rates increased during their study period, there was a 2.5 fold increase in the incidence of SCFEs from 1981 to 2000.[8] There is also evidence that endocrine factors such as hypothyroidism, hypogonadism, and hypopituitarism are risk factors for developing a SCFE.[9]

Complications

The SCFE deformity has significant implications on hip biomechanics. The resulting femoroacetabular impingement leads to accelerated degenerative changes and an increased likelihood of developing osteoarthritis of the affected hip. One of the most severe complications of SCFEs is avascular necrosis (AVN) of the femoral head.[10-12]

Classification

Temporal Classification

SCFEs can be characterized based on the duration of symptoms. Acute SCFEs are symptomatic for a duration of three weeks or less while chronic SCFEs are symptomatic for greater than three weeks. Acute on chronic SCFEs are defined as an exacerbation of symptoms in a chronic SCFE. This classification has not been shown to have significant prognostic value and is therefore not as applicable in the clinical setting.[13]

Loder Classification

Loder used symptomatology to define the stability of SCFEs in his paper written in 1998. He defined a SCFE as stable if the patient was able to ambulate with or without crutches. If they were unable to ambulate with or without crutches, it was deemed to be unstable.[14] This definition has been shown to be highly predictive of development of AVN. Their original series had an AVN rate of 47% in the unstable group and 0% in the stable group.[13] More recently the rate of AVN in unstable SCFEs have been shown to be less than originally described but remains significant at 21%.[15]

Degrees of Displacement

Another way to grade the severity of SCFEs is to look at the degree of displacement. Southwick defined the angle of displacement as the measure between the femoral epiphysis and the diaphysis (Figure 1). Mild SCFEs have a Southwick angle < 30 degrees, moderate 30-60 degrees, and severe > 60 degrees. This classification is useful in guiding treatment options and choice of fixation.[16]

The severity of the slip also predicts the natural history of SCFEs with more severe slips resulting in higher rates of osteoarthritis and poor patient outcome scores. There is an emphasis on restoring normal hip biomechanics in unstable SCFEs to prevent femoroacetabular impingement and degenerative joint changes.[10,12,16,17]

In Situ Screw Fixation

The standard treatment for mild chronic SCFEs is epiphysiodesis with a single screw through the femoral neck and into the epiphysis. This serves to neutralize the shear forces across the physis and prevent further slip. Some recommend that at least 5 threads cross the physis to provide optimal biomechanical stability and prevent slip progression.[18,19] Screw penetration is a potential complication that can lead to chondrolysis. In order to avoid chondrolysis, a screw tip to subchondral bone (STSB) distance of 2.5-5mm is recommended.[20] In a recent cadaveric study by Heffernan, et al, it was determined that only about 20% of C-arm radiographs were able to accurately determine STSB distance within a 1mm tolerance. They recommend using the known screw pitch of the in-situ screw to estimate the STSB distance to avoid screw penetration.[21] We use the approach-withdraw method to minimize the risk of screw penetration. This involves rotating the leg from an internally rotated position to an externally rotated position while viewing the in-situ screw under fluoroscopy.[3] The STSB distance will decrease and then increase as the leg is rotated thus allowing you to determine the true STSB distance.

The number of screws needed to maintain stability is controversial. Karol, et al, found a 33% increase in stiffness with 2 screws in a bovine model.[22] However, clinical studies suggest a higher rate of complications like pin penetration and osteonecrosis with the use of multiple screws.[2]

In the setting of an acute unstable SCFE with a Southwick angle < 30 degrees, our standard treatment is urgent fixation (Figure 2a). Due to the inherently unstable nature of these SCFEs, we prefer to use 2 fully threaded screws. We routinely remove all SCFE screws after physeal closure and this is easily accomplished with the fully threaded screws. We also do a needle decompression of the capsule and monitor perfusion with an 18-gauge needle fluoroscopically guided into the epiphysis and attached to an arterial line monitor.[24]

Implant Selection

Although epiphysiodesis is optimal in children close to bone maturity, it may be less desirable in younger patients with significant bone growth remaining. Arresting the femoral capital growth can result in a short femoral neck, coxa vara, and relative trochanteric overgrowth. These deformities can disturb regular hip biomechanics and potentially result in pain and gait imbalance.[25]

Figure 1. Photo demonstrating the Southwick angle of a left SCFE.[40]

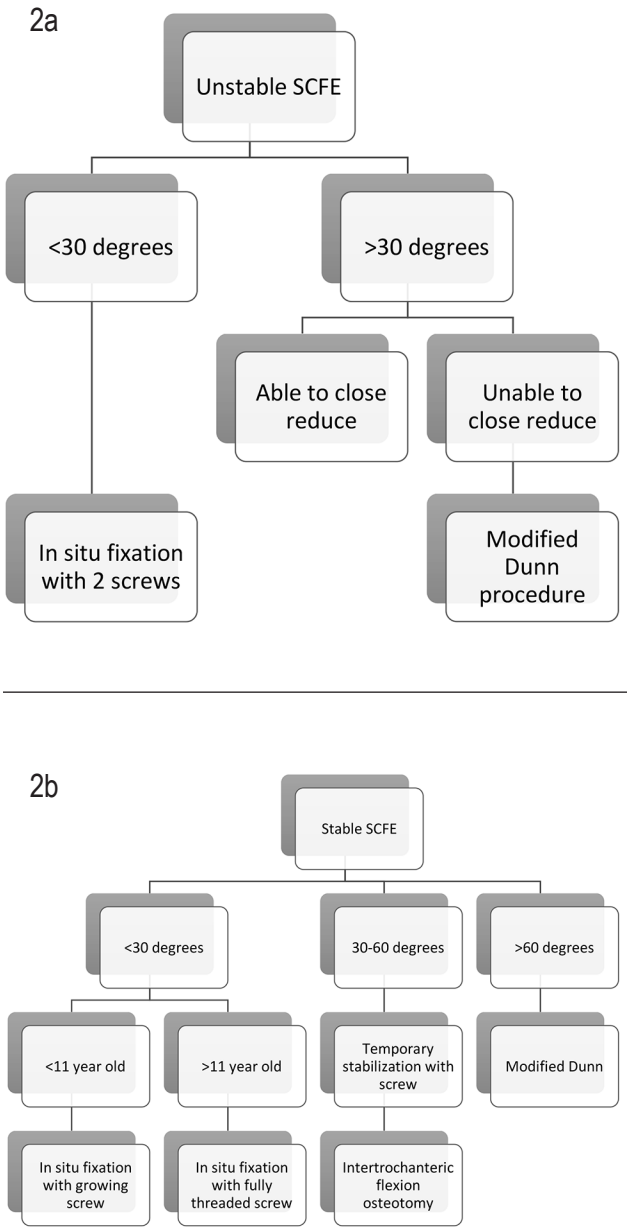

Figure 2.
2a: Algorithm for Treating Unstable SCFE.
2b: Algorithm for Treating Stable SCFEs.

With these complications in mind, attention has turned to implants which preserve femoral neck growth. Studies looking at such implants have demonstrated that preserving the femoral capital physis allows for improved remodeling of the SCFE deformity.[26-29] Preserving growth has become increasingly more relevant as younger children are developing SCFEs at an earlier age. One study in Scotland noted a correlation between the increased rate of SCFEs at an earlier age with an increase in childhood obesity rates.[8]

The Synthes SCFE screw is a partially threaded screw with a shaft diameter equal to the threads to facilitate removal (Figure 3). One disadvantage to this screw is that the screw must be left proud in order to allow for growth. This may be symptomatic as the iliotibial band can rub against the head of the screw, especially in younger patients where the screw needs to be left even more proud to facilitate additional growth.

Another growth facilitating SCFE screw is the Pega Medical free gliding screw. This screw has a telescoping design which allows for continued growth without being prominent (Figure 4). The Pega screw relies on a compression force across the physis to prevent slip progression. One potential concern with that is the amount of compression may not be enough to prevent further deformity. In a biomechanical animal model study by Upasani, et al,[30] they found that an even distribution of threads 40%-60% in a 16mm partially threaded screw across the physis gave optimal biomechanical stability.[30] If too many of the threads were in the physis the construct failed with the screw plowing in the neck. The growth implants currently available are designed to have the threads fully inserted in the epiphysis with none crossing the physis. This may reduce the load to failure. A biomechanical study comparing the Pega and the Synthes SCFE screws with a standard fully threaded screw found them to both be as effective as the standard fully threaded screw.[28] Currently there is very little clinical information in terms of long-term outcomes or hardware complications, so more studies are needed before it becomes standard of practice. We are currently incorporating this screw into our practice for select patients that are generally less than eleven years of age (Figure 2b).

Intertrochanteric Flexion Osteotomy

In a moderate SCFE deformity (30-60 degrees) the metaphysis of the femoral neck begins to impinge on the anterior acetabulum and external rotation cannot accommodate for the deformity in flexion. This leads to significant acetabular and labral damage and accelerates degenerative changes in the hip joint.[31] Moderate deformities also lead to limited hip flexion and abduction, increased trunk sway, reduced step distance and velocity, and decreased strength at the hip and knee.[32,33]

In our practice, a stable moderate SCFE is treated with an in-situ screw fixation urgently on initial presentation to prevent slip progression (Figure 2b). We address the remaining deformity

Figure 3. Synthes In-Situ SCFE Screw

Figure 4. Pega Gliding Screw

with an intertrochanteric flexion osteotomy. The osteotomy is fixed with a ninety-degree blade plate. Extra care is taken to avoid a z-deformity of the femur to allow for a total hip arthroplasty in the future if it is required. The intertrochanteric osteotomy anteverts the femoral head relative to the shaft and prevents further impingement by moving the metaphyseal femur away from the anterior acetabulum. The osteotomy also allows for correction of the rotational deformity and restores the articular-to-trochanteric distance thus improving extensor strength and hip mechanics. This procedure can also be used in patients with mild SCFE and residual impingement not amenable to arthroscopic treatment alone. Several retrospective groups have studied the outcome of the intertrochanteric flexion osteotomy and have demonstrated improved functional scores and less radiographic osteoarthritis compared to untreated deformities.[34,35] There is limited evidence regarding the impact of intertrochanteric osteotomies on total hip arthroplasty. One study by Haverkamp, et al, found that there was no difference in 10- or 15-year survival rates of total hip arthroplasties amongst patient with intertrochanteric osteotomies compared to patients without a previous osteotomy.[36]

Modified Dunn Procedure

We treat severe chronic stable SCFEs as well as moderate or severe unstable SCFEs with a modified Dunn procedure since an intertrochanteric osteotomy is insufficient for deformity correction (Figure 2a, 2b). The procedure is performed by surgically dislocating the hip by a trochanteric flip approach as described by Ganz. The epiphysis is mobilized on its vascular pedicle of the ascending cervical vessels and is then reduced with two or three 3.0mm K-wires. We remove the posterior femoral neck callus to aid in the reduction of the epiphysis and we remove the physeal cartilage in the femoral head fragment to improve epiphysiodesis. Epiphyseal perfusion is monitored with an 18-gauge spinal needle attached to an arterial line monitor. Measurements are taken before reduction, after reduction, and continuously during capsular closure to ensure adequate perfusion throughout the procedure. There is some controversy regarding the use of the modified Dunn on a stable SCFE with a severe deformity.[37] We have had success with this operation on severe stable SCFEs and believe that the benefits of preventing impingement and further degenerative joint disease outweigh the potential risks. The rates of avascular necrosis after the Modified Dunn procedure vary widely with reports between 2%-26%.[38,39] This suggests that both the technical considerations of surgery and patient selection are key to achieving excellent results.

Conclusion

SCFEs are a growing problem amongst children in Hawai‘i as well as throughout the world.[8] The algorithm implemented at the tertiary children's medical center in Hawai‘i takes certain variables into account to assist with clinical decision making. Excellent outcomes have been noted thus far with utilization of this algorithm in Hawai‘i.

Conflict of Interest

None of the authors identify any conflicts of interest.

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