Management of slipped capital femoral epiphysis: What hardware we can use in osteosynthesis *in situ*?

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Abstract

Slipped Capital femoral epiphysis (SCFE) is a hip disorder involving children during prepubescence age. Obesity, growth spurts, and endocrine disorders are among the risk factors for SCFE, whose aetiology is thought to be multifactorial. To avoid gait abnormalities, chronic hip pain, femoroacetabular impingement, avascular necrosis of the femoral head, and early hip osteoarthritis, SCFE must be treated early. Epiphysiolysis is primarily treated surgically to prevent secondary slippage locking the physis, but this can also prematurely close the growth plate and prevent remodeling of the proximal femur. The aim of the study is to review the literature on surgical devices used to manage SCFE and identify any potential benefits or drawbacks. Various authors looked into and suggested various hardware to prevent iatrogenic epiphysiodesis. According to the results of these studies, patients with epiphysiolysis can grow their femoral necks following stabilization with dynamic hardware that doesn't compress the proximal femur's growth plate.

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Introduction

Slipped Capital femoral epiphysis (SCFE) is a hip disorder involving children during prepubescence age. Traditionally, it is defined as a postero-medial slippage of the femoral epiphysis on the metaphysis, but, considering that femoral epiphysis is almost "stored" in the acetabulum, it could be better defined as laterally and anterior slippage of femoral metaphysis under the epiphysis.

The overall incidence of epiphysiolysis is relatively low, ranging from 0.33 to 24.58 per 100,000 children from 8 to 15 years old, it is almost twice common in males than in females and the left hip is more involved than the right one. The 25-40% of patients has bilateral involvement with the contralateral slippage occurring within 12-18 months.[1]

Numerous studies conducted in vivo, on targeted physeal biopsies, have shown that SCFE is characterized by: i) hypertrophic area of the growth plate femoral neck; ii) enlargement of the physis also reaching 12 mm (normal range: 2-6 mm); iii) enlargement of the chondrocytes; iv) disorganization of the cellular column; v) increasing concentrations of proteoglycans and extracellular matrix in the physis; vi) widespread disruption of chondrocytes' differentiation and endochondral ossification.

The aetiology of SCFE is considered multifactorial and risk factors include obesity, growth spurts and endocrine disorders. Among children with SCFE, 63% have a weight placed in the 90th percentile or higher, while endocrine abnormalities include hypothyroidism, growth hormone supplementation, hypogonadism and panhypopituitarism.[1]

During a period of rapid growth that occurs with pubertal spurt, stresses due to excess weight on the hypertrophic physeal area (for underlying pathological conditions) can cause displacement of the epiphysis of the femur from its normal position relative to the femoral neck.

The most adopted classification divides the SCFE into "stable" or "unstable" basing on the patient's ability to walk.

A patient with stable SCFE is usually an obese adolescent with a short story of poorly localized hip pain, but able to walk. A patient with unstable SCFE, instead, has severe hip pain that does not allow walking.

The disease can be also divided according to the time of onset: i) pre-slipping: enlargement of the growth plate without a real slippage associated with hip or knee pain especially in the intra-rotation of the hip; ii) subacute: symptoms for 3 weeks and slippage generally under 30°; iii) acute (15% of cases): severe slippage generally associated with simple injuries in previously symptomatic patient; iv) chronic (about 84% of cases): symptoms present longer than 4 weeks. X- ray with modification of the neck in the area of the slippage (bump causing impingement); v) acute on chronic (<1% of cases): it is an undiagnosed chronic form with acute symptoms without ability to walk.

The treatment of epiphysiolysis is mainly surgical, the gold standard remains fixation *in situ*. This treatment avoids secondary slippage locking the physis, but it may cause premature closure of the growth plate and can interfere with proximal femur remodeling.

Materials and Methods

The aim of the study is reviewing the literature about surgical devices used to manage SCFE underlying their advantages or disadvantages.

In literature the best treatment for hip epiphysiolysis is still debated, this is due to the high risk of long-term and irreversible complications that lead to early disability and possible hip reconstruction surgery.

Post-operative complications of SCFE include progression of slippage, osteonecrosis of the femoral head and chondrolysis.

SCFE is commonly treated with stabilization of the epiphysis through the percutaneous fixation of the physis. Percutaneous in situ fixation generally produces good clinical outcomes for stable slips, however, it has been found that they can often occur future complications, leading to femoro-acetabular impingement and damage to the articular cartilage resulting in development of osteoarthritis.[1]

Femoroacetabular Impingement (FAI) is a common evolution of SCFE surgical management and affecting 32% to 90% of all patients (Figure 1). However the high prevalence of femoral acetabular impingement in adulthood, could be considered not as a complication but as the outcome of natural history of SCFE.[1]

In the treatment of unstable (moderate to severe) slips, the modified Dunn procedure has been proposed to reduce the high incidence of osteonecrosis.[2]

Figure 1. Femoro-acetabular impingement after SCFE.

Discussion

The goal of epiphysiolysis treatment is stabilizing the epiphysis avoiding premature closure of the growth plate (epiphysiodesis). We can obtain it using hardware that, without exerting compression, stops sliding and allowing the altered cartilage to recover its functionality.

In mild epiphysiolysis with angulation <30°, fixation with smooth devices or screws are recommended. Histological, ultrastructural and clinical studies reported a normal remodeling of the physis after fixation with smooth devices with architectural restoration and production of proteoglycans and collagen fibrils.[1]

The hardware used to avoid iatrogenic epiphysiodesis (dynamic device) were investigated and proposed by various authors. One of the first was the Hansoon hook-pin. It was a smooth nail with an internal hook that came out to anchor the epiphysis. The smooth part passed through the growth cartilage without create compression between the epiphysis and metaphysis. The "Olmed short threaded screw", was another device that was placed in the epiphysis, avoiding compression on femoral lateral cortex and without injury the growth plate. These two systems, for their technical characteristics, showed difficulties in case of removal.[3]

Sailhan *et al.*[4] reported the results of a cannulated screw with two components, the proximal smooth part was inserted into the epiphysis and into the growth plate, while the thread part in the neck leaving the head protrude 1-2 cm from the lateral cortex. The limits were that, with the growth of the neck, it was necessary to tighten the screw, otherwise grip on the epiphysis may be loosed with the risk of new slips.

Kumm *et al.*,[5] Guzzanti *et al.*,[6] and Wenssas *et al.*[7] reported the results of a 7 mm diameter cannulated screw reducing the length of the thread from 16 mm to 10 mm. The threaded part was inserted into the epiphysis and the smooth one of the screw in the cartilage of growth, the head must protrude 15-20 mm from the lateral cortex of the femur (Figure 2).

With the growth of the neck the head will approach the cortex; it may happen that the screw had to be replaced in patients very young in which the neck grows more than 20 mm.

Pega Medical (Laval, Canada) has introduced Free Gliding (FG) screw to enable neck growth in SCFE-treated patients. The implant assembly includes a distal component that will be fixed to the lateral cortex and a proximal component that will anchor the femoral head. The telescopic design would elongate with growth avoiding screw protrusion at the lateral cortex and pin advancement revision.[8]

The results of FG screw were compared with the standard compression screws, the FG screw allows neck growth unlike the standard screws which cause *coxa breva*. The limit of this hardware is the difficulty to removal, the times of application and the cost seven times higher than standard screws.

Data from these studies confirm that the femoral neck in patients with epiphysiolysis can grow after stabilization with dynamic hardware that does not produce compression on the growth plate of the proximal femur (Figure 3).

Only recently the residual deformity associated with slipping

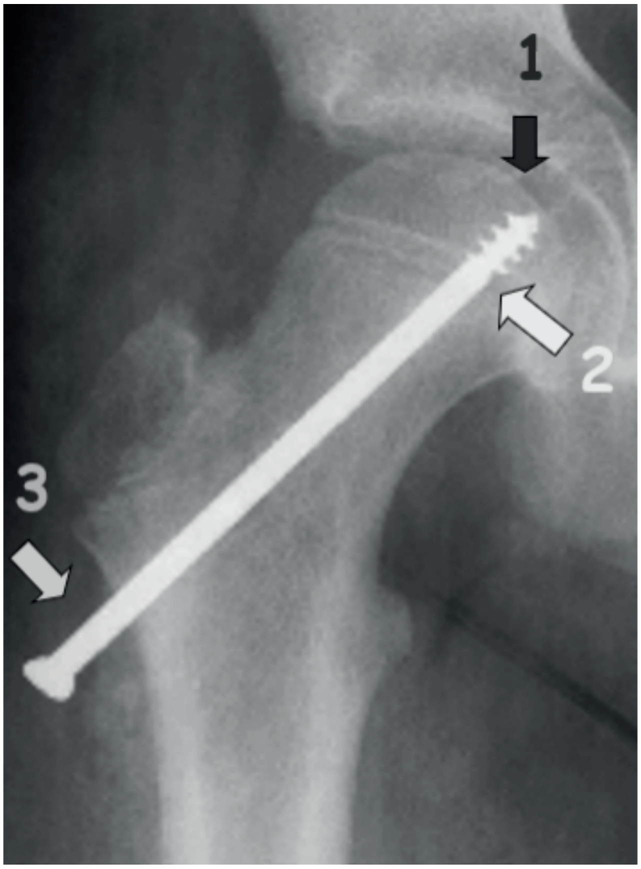

Figure 2. The threaded part of the screw was inserted into the epiphysis (1) and the smooth one of the screw in the cartilage of growth (2), the head must protrude 15 - 20 mm from the lateral cortex of the femur (3).

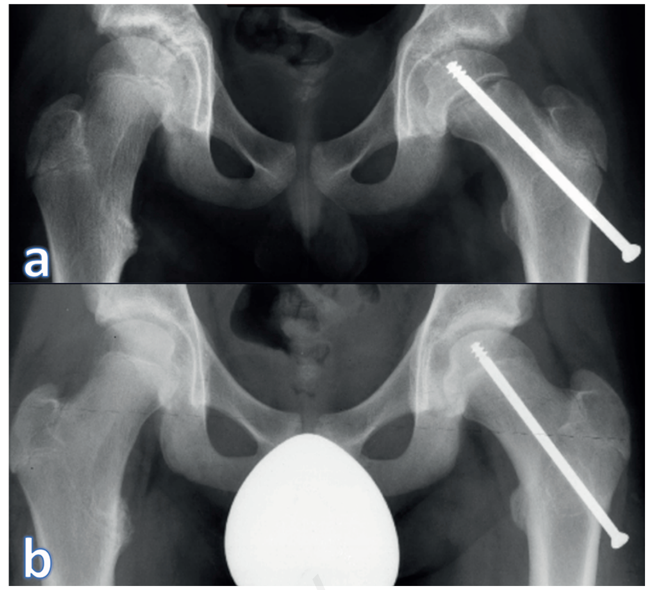

Figure 3. X-rays post-op (a) and after 40 months from baseline (b).

of the healed femoral epiphysis was clearly related to femoro-acetabular impingement and to subsequent degenerative changes that lead to osteoarthritis.

Conclusions

The treatment techniques for SCFE are in constant evolution in the light of the major understanding of the pathogenesis of the intermediate (femoral-acetabular impingement) and long-term (osteoarthritis) consequences of this hip disorder.

In mild forms, early stabilization with non-compression fixation avoids the sliding of the physis, allowing the physeal histological healing and the resumption of neck growth femoral.

In the forms with moderate and severe slippage, when the alterations of the epiphyso-metaphyseal complex may not be reversed, arthroscopic treatment is an available solution to manage long-term complication as femoral acetabular impingement.

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