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Surgical Treatment of Femoral Epiphysis: A Systematic Review with Meta-Analysis

Bianca Gabriella de Oliveira[1]*, Nicholas de Oliveira Marttins[2], Luís Henrique Pimentel Boechat[3], Henrique Oliveira Netto da Cunha[3], Abdias Leal Caldas Neto[4], Laís Cristina Pereira da Silva[5]

[1]*Medical student at Salvador University - UNIFACS, Salvador, BA, Brazil.*
[2]*Resident in Orthopaedics and Traumatology at Hospital Regional de Santa Maria, DF, Brazil.*
[3]*Resident in Orthopedics and Traumatology at Hospital São José do Avaí, Itaperuna, RJ, Brazil.*
[4]*Resident in Orthopedics and Traumatology, Facisa University Center - UNIFACISA, Campina Grande, PB, Brazil.*
[5]*Medical student at Salvador University - UNIFACS, Salvador, BA, Brazil.*
**Corresponding author: Bianca Gabriella de Oliveira.*

Abstract

Epiphysiolysis involves the widening and weakening of the hypertrophic layer of the proximal femoral growth plate during the growth spurt phase, which leads to epiphysiolisthesis. It affects 2 out of every 100,000 adolescents, and is more prevalent in blacks, on the left side and in males. The aim of this study is to evaluate the therapeutic options for slipped proximal femoral epiphysis using the modified Dunn osteotomy, whether performed openly or arthroscopically. Since this is a systematic literature review, it was carried out in the databases indexed in the Medical Literature Analysis and Retrieval System Online (MEDLINE) according to the precepts established by the PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Five studies were selected on children who were submitted to surgical treatment of femoral epiphysiolysis using the modified Dunn osteotomy technique and arthroscopic osteotomy. The arthroscopic osteotomy surgical technique, discussed in recent studies, represents an innovative option to the classic subcapital realignment techniques for the treatment of chronic and stable femoral epiphysiolysis.

Keywords: femoral epiphysis; osteotomy; orthopedic procedures

Introduction

There is currently much discussion in the literature about femoral epiphysiolysis and its therapeutic evolution. It is defined by the widening and weakening of the hypertrophic layer of the proximal femoral growth plate during the growth spurt phase, which leads to epiphysiolisthesis. Pathogenesis is established and measured by the stability of the physis, taking into account the perichondral cartilaginous complex, mammillary process, collagen fibers, thickness and contour of the growth plate and physeal inclination [1]. It affects 2 out of every 100,000 adolescents, and is more prevalent in blacks, on the left side and in males. Etiologically, it has various causes: traumatic (inclination of the left femoral neck when sitting), anatomical (retroversion of the femoral head), familial (heredity 5%), inflammatory (synovitis) and/or hormonal, the most accepted, investigated by glandular or metabolic alteration [2]. The clinical manifestation is given by insignificant complaints at the beginning of the condition, evolving to pain in the inguinal region radiating to the anteromedial thigh and training, limitation of mobility, internal rotation, abduction and flexion of the frame, altered gait due to antalgic claudication. It is clinically classified as prodromal, acute and chronic [1,2].

The prodromal period is characterized by referred pain, episodic claudication, decreased internal rotation and few radiographic alterations, osteopenia and a normal femoral plate/collar ratio. The acute phase affects 10% of patients. The pain is sudden and intense, lasting less than 3 weeks and on physical examination it is possible to notice external rotation and shortening [3]. And finally, chronic is the most frequent classification, with symptoms lasting longer than 03 weeks, external rotation and shortening on physical examination due to muscle atrophy. It is worth noting the possibility of the condition worsening. Another classification is the ability to walk, with unstable patients unable to walk even with the aid of crutches and stable patients who walk with claudication [1,2,3]. Diagnosis is based on clinical suspicion in the face of pain and confirmed by

complementary imaging tests. Radiography, ultrasound, bone scintigraphy, computed tomography and magnetic resonance imaging. The therapeutic approach is precisely defined with a view to preventing slippage, reducing the degree of slippage and salvage to avoid complications. The main and most aggravating complication is osteonecrosis [4].

A simple radiography allows the signs of the disease to be identified, and is always recommended in two views, the front view (anteroposterior) and the Lauenstein view (or frog view or double abduction), due to the three-dimensional condition of the human body to better show the initial signs of slippage. The concept has spread that in chronic and moderate slippage, the epiphysis deviates medially and posteriorly, leading to varus and retroversion deformities. The possibility should be considered that the displacement is of the neck and not the femoral head, which may remain in its original location because it is attached by the round ligament to the bottom of the acetabulum [5,6]. The main purposes of treating slipped capital femoral epiphysis are to prevent the progression of this slippage, restore and stabilize hip function and prevent premature osteoarthritis (OA) of the hip, reducing the risk of avascular necrosis and proximal femoral deformity. However, its treatment is a controversial subject among orthopaedic surgeons [7,8,9].

Its classic treatment is operative and may include internal fixation with in situ screws, often referred to as "pinning" or closed reduction [10,11] Numerous attempts have been made to treat severe SCFE with open and closed reduction techniques, many fraught with very high rates of avascular necrosis and chondrolysis of the epiphysis [12,13]. Therefore, the standard has become in situ fixation of the epiphysis with or without a gentle attempt at closed reduction in cases of acute dislocation, reducing the occurrence of complications, but generating femoral deformities, enabling the development of femoroacetabular impingement (FAI) [14,15]. Ganz and his colleagues then described a modified Dunn's osteotomy, performed through a surgical hip dislocation approach, thus protecting the blood supply to the femoral head, preventing avascular necrosis and also correcting the deformity. The aim of this study is to evaluate the therapeutic options for proximal femoral epiphyseal slippage using the modified Dunn osteotomy, whether performed openly or arthroscopically [16,17].

Materials and Methods

This is a study of a systematic review of the literature, structured according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), with a subsequent PRISMA checklist for analyzing the results. In addition to a flow chart of phases, prioritizing clarity and transparency in the execution of the systematic review and selection of studies.[18] The data search took place on June 5th, 2022, in the databases linked to the Medical Literature Analysis and Retrieval System Online (MEDLINE), using the SPICE strategy to identify the relevant studies:

- Setting: patients with proximal epiphysiolysis
- Perspective: individuals with proximal epiphysiolysis evaluated for surgical treatment
- Intervention: surgery to correct proximal epiphysiolysis
- Comparison: surgical correction using the modified Dunn osteotomy, arthroscopically compared to the open technique.
- Evaluation: effectiveness of the surgical technique

The descriptors in health sciences (DECS) / MESH TERMS were used in combination, according to the following structures: Femoral epiphysis AND Osteotomy AND Orthopedic procedures [19].

Inclusion and exclusion criteria

Studies that met the following criteria were included: (1) age group < 18 years (2) patients undergoing surgical treatment for femoral epiphysiolysis (3) studies addressing patients diagnosed with femoral epiphysiolysis (4) studies published between 2015-2023 (5) original studies. Studies with the following criteria were excluded: (1) experimental animal studies (2) non-original studies - literature reviews, opinion articles (3) studies that dealt with different approaches to the treatment of femoral epiphysiolysis (4) studies published more than fifteen years ago (5) studies that did not meet the other inclusion criteria mentioned above.

The studies were analyzed by two independent reviewers. Production was based on the use of the DECS and Boolean operators mentioned above, selecting studies published in the last fifteen years (2008-2022). At this stage, the titles and abstracts were analyzed, as well as the texts, and studies that did not meet the inclusion criteria were excluded.

The systematic review protocol was registered in the International prospective register of systematic reviews (PROSPERO) under ID CRD42023474382.

Results

A total of 193 papers were selected and articles published more than 15 years ago were removed, leaving 49 papers. After evaluating the titles, 09 articles were excluded, leaving 21 for full reading. Finally, 5 articles were selected for evaluation and discussion of the results. Five studies were selected on children who underwent surgical treatment of the femoral epiphysis using the modified Dunn osteotomy technique and/or arthroscopic osteotomy. The study included 126 patients with a mean age of 12.2 years. Of these, seven were treated using the arthroscopic osteotomy technique and 119 using the modified Dunn osteotomy. The results obtained are related to the variations in the measurements of the epiphyseal-diaphyseal angles (EDA) pre- and post-operatively.

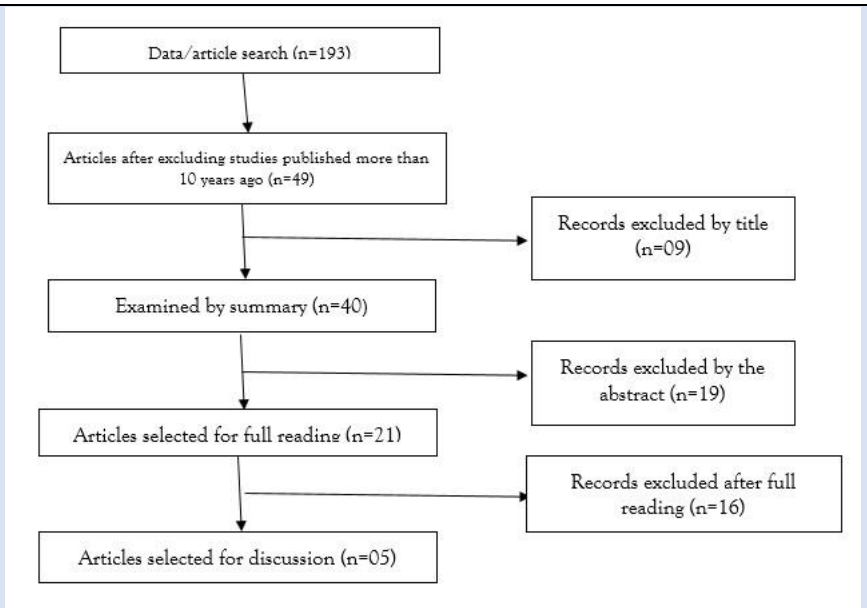

Figure 1: shows the method for selecting articles using the PRISMA methodology as a basis.

Table 1: shows the studies selected for analysis and their respective results (Table 1). [20,24]

Study	Sample	Average age	Arthroscopic osteotomy	Osteotomy modified Dunn technique	EDA pre-surgery*	EDA post-surgery*
Roos e col	7 patients	11 years old	7 patients	-	51.2 +- 12.4	11.2 +- 5.1
Zuo e col	20 patients	13.2 years olds	-	20 patients	63.2 +- 8.1	7.5+-3.5
Lerch e col	46 patients	13 years old	-	46 patients	64 +- 6.5	7 +- 2.3
Slongo e col	23 patients	11.9 years old	-	23 patients	47.6 +- 19	4.6+-2.9
Persinger e col	30 patients	12.3 years old	-	30 patients	65 +- 11.2	16+-3.3

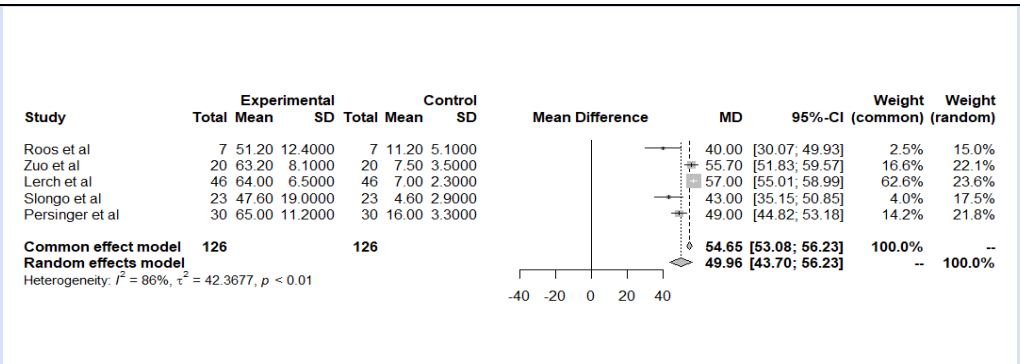

Figure 2: shows the analysis of the variation in pre- and post-operative epiphyseal-diaphyseal angle (EDA) measurements in each study.

The pre- and post-operative epiphyseal-diaphyseal angle (EDA) measurements showed a reduction of approximately 89.0% in the number of cases treated by Dunn's osteotomy.

Discussion

Several aspects of slipped capital femoral epiphysis remain controversial. Loder's work was fundamental in changing the understanding and delimitation of the surgical approach through the evaluation of sliding instability [25] However, two different types of SCFE became apparent; unstable where the patient cannot ambulate even with crutches, and stable where the patient can ambulate. Loder showed that AVN developed in 47% of the unstable slips, but none of the stable hips [25,28]. Loder's classification is often used to define stability, since a stable slip is defined as one in which the patient can ambulate with or without the aid of crutches. An unstable slip, on the other hand, is one in which the individual is unable to ambulate even with help [25]. Its severity, on the other hand, depends on the Southwick sliding angle. This is defined as the angle between the axis and a line perpendicular to the epiphysis in the lateral view of the frog's hip. Then subtract from the normal hip against the lateral view or in the case of bilateral epiphysiolysis, subtract 10 degrees. Slippages are characterized as mild (0-30°), moderate (30-60°) or severe (> 60°).29 Although the diagnosis of SCFE is generally based on radiographic findings, ultrasound can also be used to diagnose and classify the severity of the deformity [30,43,44].

The historical treatment of SCFE included immobilization with plaster, which was replaced by in situ fixation or pinning, to stabilize the physis with a few pins and, more recently, one or two cannulated screws [31]. Although it demonstrates stable closure of the proximal femoral physis and good short-term clinical results, other studies point to the development of early OA in patients, especially in cases of severe deformity. In addition, the hip can remodel into an abnormal junction of the femoral head and neck, and residual deformities can lead to FAI [32,33]. The recognition of this deformity has led some surgeons to try closed or open reduction, and even closed reduction and internal fixation, similar to a femoral neck fracture, but these have not prevailed due to the increased risk of avascular necrosis [34]. Another even proposed a cuneiform osteotomy with removal of the anterior metaphysis without violating the posterior cortex. This therapeutic option allowed the epiphysis to be anatomically reduced in the metaphysis and was theoretically associated with a lower risk of avascular necrosis [35]. Then, in 1970, Dunn's osteotomy was described and has since been modified to its current form [36]. After describing the surgical approach to the dislocation, a modified technique was described to reduce the epiphysis in SCFE using trochanteric osteotomy, an extremely demanding technique, and its results depend on the experience and acumen of the surgeon [37].

In stable cases, treatment can be through arthroscopic osteotomy, with good results [38]. In unstable cases, the currently indicated approach is the modified Dunn procedure, which is a surgical dislocation of the hip, helping to restore the alignment of the proximal femur and reducing the rate of FAI [39]. The approach is carried out according to the technique described by Ganz et al. The patient is positioned in lateral decubitus and the incision is placed in line with the greater trochanter. After opening the fascia lata, a trochanteric osteotomy is performed and the pieces are rotated anteriorly, allowing the hip capsule to be exposed. This capsule is opened and aligned with the femoral neck and a capsulotomy is completed, which allows the hip to be moved after releasing the round ligament. This is followed by a complete assessment of the acetabular cavity and treatment of chondral and labral pathology. This is followed by osteochondroplasty of the head-neck junction with the hip in flexion and internal rotation, despite the osteochondroplasty, a rotation-flexion osteotomy is performed [40]. The surgical technique of arthroscopic osteotomy in the treatment of femoral epiphysiolysis, reported in recent articles, has shown satisfactory postoperative results, close to those achieved using the well-established technique of modified Dunn osteotomy. It represents an innovative option to the classic subcapital realignment techniques for the treatment of chronic and stable femoral epiphysiolysis, allowing adequate access to the hip joint, as well as adequate reduction of slippage, with the consequent theoretical advantage of rapid rehabilitation [22,24].

The two most serious complications of this disease are avascular necrosis and chondrolysis, the treatment of which attempts to prevent or delay their occurrence. The former, which occurs in up to 50% of cases with unstable epiphysiolysis, results from the kinking of blood vessels or the formation of a hematoma, preventing the blood supply to the head of the femur, which is usually associated with severe dislocation and/or fixation with more than one screw [38,39]. This complication, in particular, leads to advanced and early degenerative OA. Chondrolysis, on the other hand, is the acute loss of articular cartilage, generating stiffness and pain in the joints. Usually

reported as a complication of surgical treatment, or the use of a plaster cast on the hip and/or untreated advanced SCFE, its most common cause is the unrecognized perforation of the femoral head by a pin [41,42]. The treatment of this pathology is most effective, successful and safe in its early stages, and its early recognition and treatment should be the central focus of future efforts to reduce healthcare obligations [43]. Roos et al [20] showed an angular variation of 78.0% through arthroscopic osteotomy.

Conclusion

The surgical technique of arthroscopic osteotomy, discussed in recent studies, represents an innovative option to the classic techniques of subcapital realignment for the treatment of chronic and stable femoral epiphysis. It is important to mention that the growing excess weight in the adolescent population is a common predisposing factor, suggesting an increase in incidence and highlighting the importance of studies on the subject. The results are satisfactory when compared to well-established techniques such as the arthroscopically modified Dunn's osteotomy used in cases of unstable femoral epiphysiolysis. Investment in new studies to explore this technique is therefore extremely important in order to obtain increasingly satisfactory clinical results in the treatment of femoral epiphysiolysis.

Declarations

Conflicts of Interest

This study has no conflicts of interest

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