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ORIGINAL RESEARCH ARTICLE

Arthroscopic subcapital realignment osteotomy in the treatment of chronic and stable proximal femoral epiphysiolysis: Early results

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ABSTRACT

Objective: To evaluate the clinical and radiographic results and complications of arthroscopic subcapital realignment osteotomy for the treatment of chronic and stable proximal femoral epiphysiolysis (PFE) in an initial series of patients. According to the literature review, the study presents the first description of an arthroscopic technique of this type of osteotomy. **Methods:** Between June 2012 and December 2014, seven patients underwent arthroscopic subcapital realignment osteotomy for the treatment of chronic, stable PFE. The mean age of the patients was 11 years and four months. Minimum follow-up ranged from 6 to 36 months (mean, 16.5 months). Patients were clinically evaluated according to the Harris Hip Score modified by Byrd and radiographically according to Southwick's quantitative classification and the epiphyseal-diaphyseal angle. Postoperative complications were analyzed. **Results:** With regard to the evaluation of the Harris Hip Score Modified by Byrd clinical score, a preoperative mean of 35.8 points and a postoperative mean of 97.5 points were observed ($p < 0.05$). Radiographically, five patients were classified as Southwick grade II and two as grade III. A mean correction of the epiphyseal-diaphyseal angle of 40° was observed. There were no immediate postoperative complications. One patient developed avascular necrosis of the femoral head, without collapse or chondrolysis at the last follow-up (22 months). **Conclusion:** The arthroscopic technique presented by the authors for the treatment of chronic, stable PFE resulted in clinical and radiographic improvement of the patients in this initial series.

Keywords: Displaced Epiphysis; Hip; Femoral Head; Arthroscopy; Child

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1. Introduction

Proximal femoral epiphysiolysis (PFE) is the most common hip disease in adolescents, with an estimated frequency of 10.8 per 100,000 individuals[1]. Recent studies of the biomechanics of femoroacetabular impingement (FAI) indicate that small anatomical deformities that can arise from PFE are potential causers of permanent acetabular chondral damage[2,3] and lead to early osteoarthritis. There is no consensus on the best treatment option for PFE, especially when considering high grade slips (grades II and III of the Southwick Classification)[4]. Some authors indicate treatment with in situ fixation in these cases because it is a procedure with low complication rates. They believe that remodeling the residual hip deformity during growth allows adequate function[5,6]. Others, like the present authors, indicate correction at the focus of the deformity (subcapital realignment osteotomy) to anatomically reduce the epiphysis and decrease the risk of subsequent chondral degeneration[7].

The main criticism of the authors against the use of the subcapital realignment osteotomy technique is the risk of complications, such as avascular necrosis of the femoral head (ANFH) and chondrolysis, which may vary up to 28% of the cases[8]. However, the increasing number of studies in this area have allowed reducing complications, it is essential to observe the technical details of preservation of the vascular supply of the epiphysis during the procedure[7]. The purpose of this paper is to evaluate the clinical and radiographic results and complications of arthroscopic subcapital realignment osteotomy for the treatment of chronic and stable PFE in an initial series of patients.

According to a review of the existing literature, this is the first description of arthroscopic subcapital realignment osteotomy for the treatment of chronic and stable PFE.

2. Material and methods

A retrospective study of patients who underwent arthroscopic subcapital realignment osteotomy for the treatment of PFE, operated on between June 2012 and December 2014. Patients with chronic and stable PFE (more than three weeks of evolution, without worsening of symptoms)[3] of Southwick grade II or III, without previous treatment, without preoperative signs of necrosis or chondrolysis, and with an open epiphyseal plate were included. During this period, seven patients underwent this treatment, six males (and one female), with left side predominance in five. Age ranged from 11 to 12 years and three months (SD = 6.9, mean 11 years and four months). The minimum follow-up was six and the maximum 36 months (SD = 10.3, mean months). All surgeries were performed by the same surgeon (BDR). All patients were called and re-evaluated. The work was approved by the Research Ethics Committee.

Regarding the clinical aspects, the patients were evaluated pre and postoperatively according to the Harris Hip Score modified by Byrd (MHHS) apud Guimarães *et al.*[9]. The cases were radiographically evaluated in anteroposterior views of the pelvis and batrachium. To determine the degree of preoperative slippage, the Southwick criteria[4] were used and the cases were classified as grade I (up to 30°), grade II (30° to 60°), and grade III (above 60°). The degree of slip correction was also affected, and the measurements of the epiphyseal-diaphyseal angle[4] (EDA) were compared pre- and postoperatively in the batrachial view. During follow-up, the presence of avascular necrosis of the femoral head and/or chondrolysis was analyzed.

The statistical method used to analyze the paired variables (MHHS, EDA) was the Wilcoxon test, considered statistically significant when $p < 0.05$.

3. Surgical technique

In these cases, general anesthesia with femoral nerve block is used. Physical examination of the hip with the patient under anesthetic is done to passively assess the range of motion bilaterally. The patient is placed in the supine position on a radiolucent table. We do not use an orthopedic traction table because of the need for greater hip mobility for the multiple transoperative maneuvers. The pelvis is slightly tilted to the contralateral side and a radiolucent cushion is used under the hemipelvis to be operated on.

The anatomical landmarks are marked with an appropriate pen. A vertical line from the anterior superior iliac spine is drawn towards the center of the patella. The anterior, posterior and proximal border of the greater trochanter of the femur is demarcated. The portals are positioned with fluoroscopic assistance. The first portal established is the mid-anterior portal (MAP), which is the camera portal. Subsequently, the proximal mid-anterior (PMAP), which is the working portal, is established in a location that allows parallel access to the proximal femoral physis.

The arthroscopic approach that we use for subcapital realization is the extracapsular[10] approach that follows the access to the peripheral joint compartment described by Sampson[11]. With the limb to be operated on in neutral position and after establishing the arthroscopic portals, the anterior joint capsule and iliocapsular muscle are dissected with radiofrequency and shaver until adequate exp-

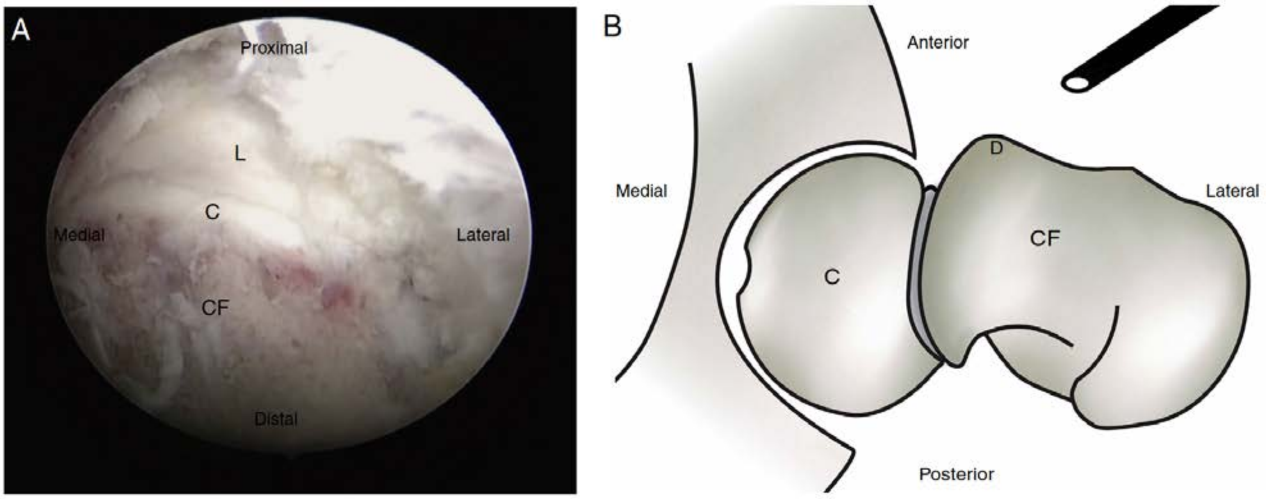

Figure 1. A: transoperative image of hip arthroscopy for subcapital realignment in the treatment of chronic and stable PFE showing exposure of the *labrum* (L), femoral head (C) and femoral neck (CF); **B**: axial section characterization of the left hip showing the femoral head (C), femoral neck (CF) and the CAME-like deformity of the femoral neck (D) resulting from chronic PFE.

osure is obtained. A T-capsulotomy is then performed at the femoral neck, which can be extended as needed. Next, a capsulectomy is performed until adequate exposure of the anterior region of the metaphysis and epiphysis of the proximal femur is obtained in its medio-lateral extension. With radiofrequency, the periosteum is opened longitudinally and detached near the femoral neck, allowing the formation of a retinacular flap together with the epiphysis (**Figure 1**).

After adequate exposure, a femoral osteochondroplasty of the neck-head transition is performed. This allows resection of the CAME-type deformity formed by the chronification of the PFE and better identification of the physis (**Figure 2**). In more severe degrees of slippage, external rotation and extension of the limb may be necessary to expose the epiphyseal plate. Osteotomy is performed 2 mm distal to the physis (to facilitate later neck shortening) with a specific curved osteotome at different locations of the epiphyseal plate until complete separation of the epiphysis and metaphysis. All patients had an open epiphyseal plate, so there were no difficulties during this surgical moment (**Figure 3**).

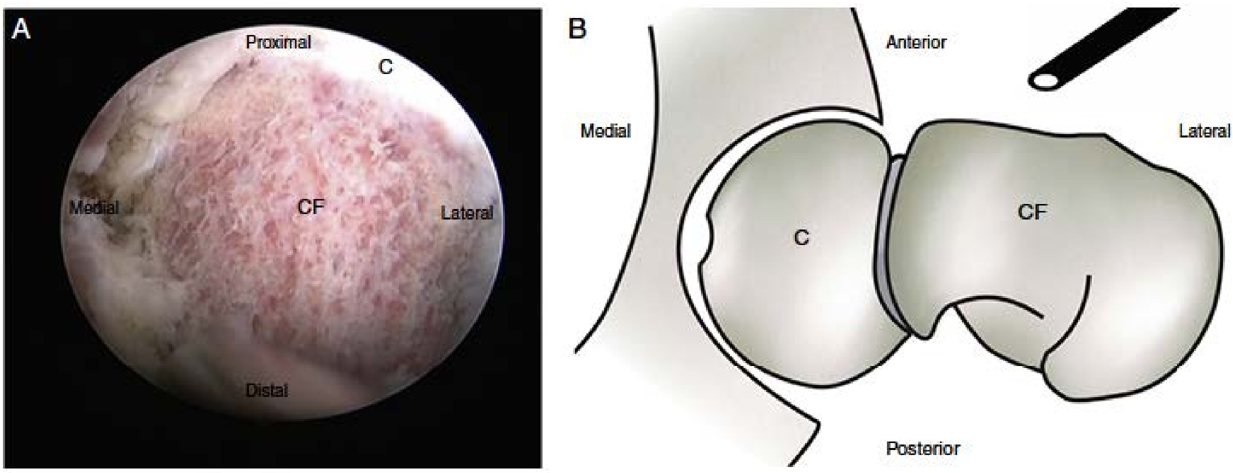

Figure 2. A: transoperative image of the left hip after osteochondroplasty of the femoral neck for correction of CAME-type deformity showing the femoral head (C) and femoral neck (CF); **B**: characterization of an axial section of the left hip showing the femoral head (C) and the femoral neck (CF) after osteochondroplasty of the femoral neck for correction of CAME-type deformity.

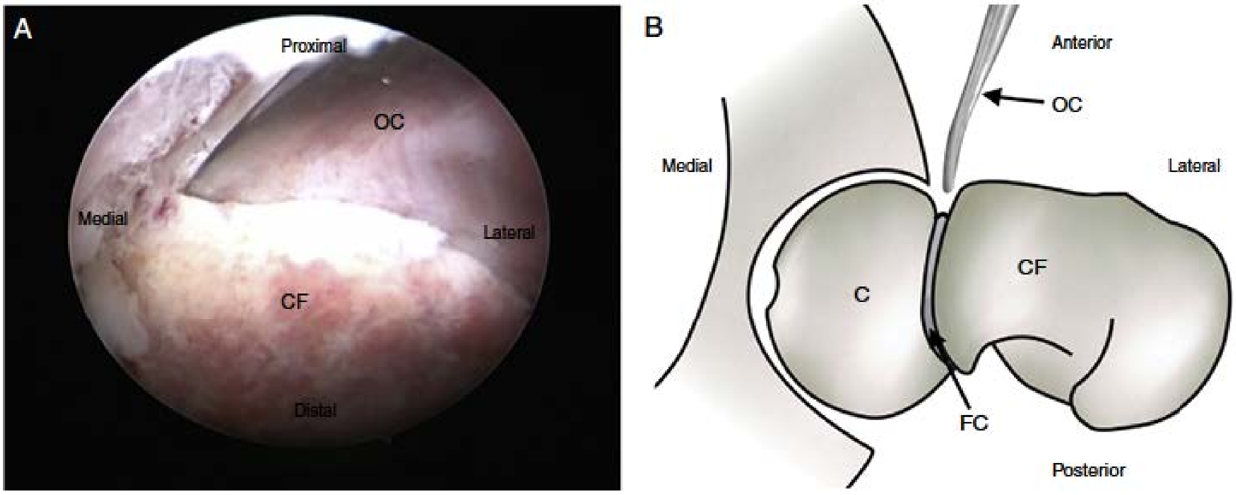

Figure 3. A: transoperative image of the left hip showing the femoral neck (CF) and the curved osteotome (OC) during osteotomy of the neck at the level of the growth physis; **B**: axial section characterization of the left hip showing the femoral head (C), the femoral neck (CF), the growth physis (FC) and the curved osteotome (OC) positioned for osteotomy of the neck.

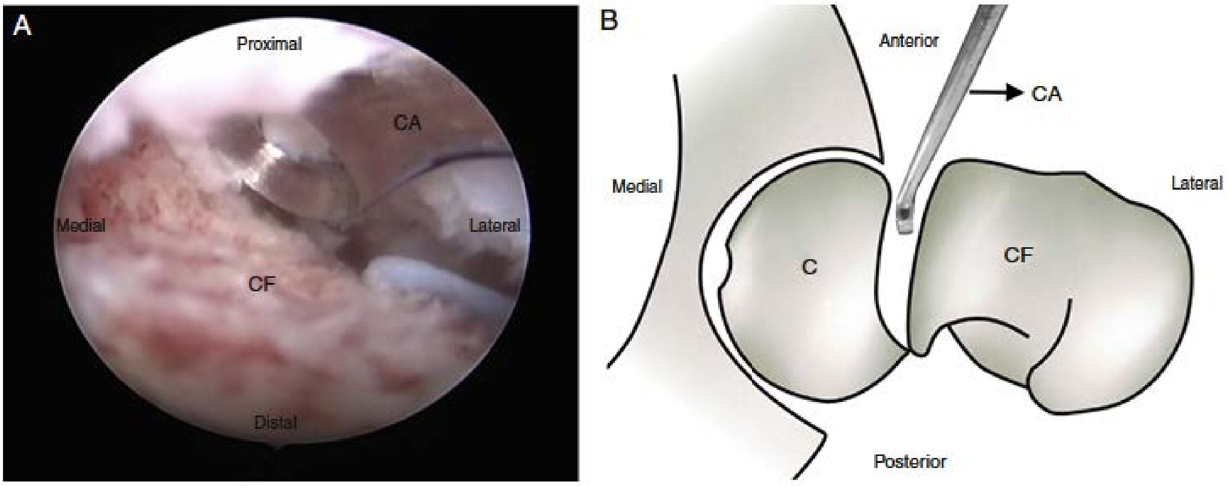

Figure 4. A: transoperative image of the left hip showing the femoral neck (CF) and the arthroscopic curette (CA) during curettage of the femoral neck to shorten it and resect the posteroinferior bone neoformation; **B**: axial section characterization of the left hip showing the femoral head (C), the femoral neck (CF) and the arthroscopic curette (CA).

With the femoral metaphysis separated from the epiphysis, the hip is externally rotated and slightly pulled to allow shortening of the neck and resection of the physis using an arthroscopic curette (**Figure 4**). Then, hip adduction is applied to remove the newly formed bone tissue in the posteromedial region of the femoral neck, which can be an obstacle to subsequent reduction.

Finally, the hip is abducted and rotated internally to reduce the osteotomy (**Figure 5**). A 6.5 cancellous partial-thread screw is used for percutaneous fixation (**Figures 6–8**). To reduce the risk of avascular necrosis of the proximal femoral epiphysis, it is fundamental, at the moment of the neck

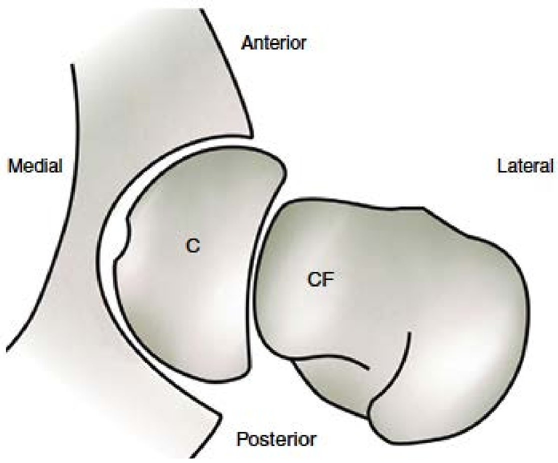

Figure 5. Characterization of an axial section of the left hip showing the femoral head (C) and femoral neck (CF) after osteotomy reduction.

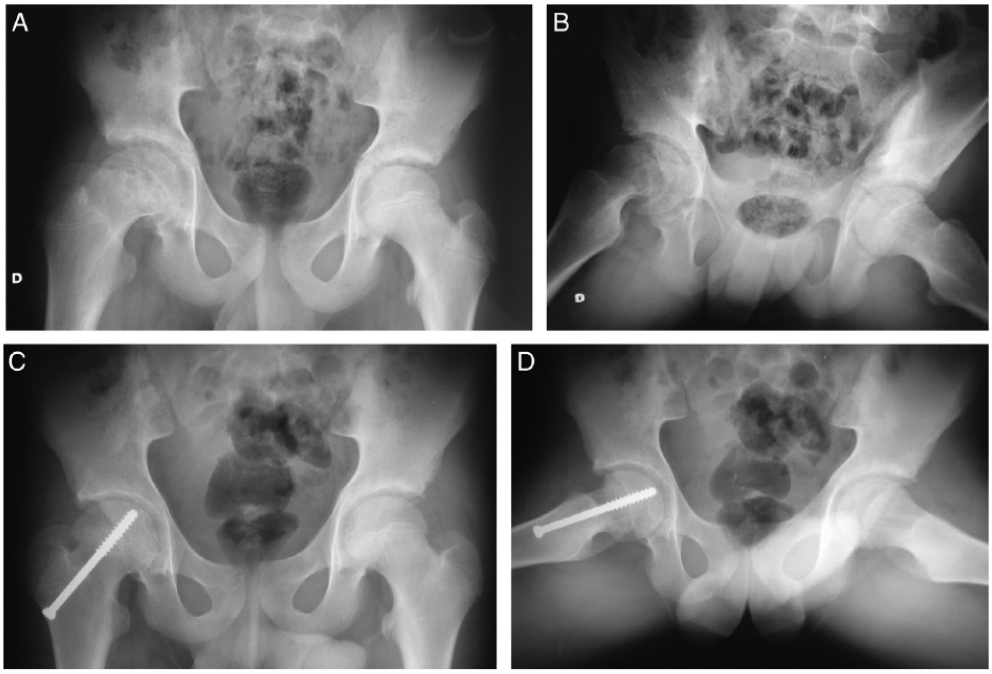

Figure 6. Male patient, 11 years old.
Note: Right hip pain for two months, walking without crutches. RI hip blocked, flexion 80°. **A** and **B**: preoperative radiographs showing Southwick grade II PFE on the right, EDA 54°. **C** and **D**: postoperative radiographs at 20 months follow-up showing correction of the deformity, EDA 8°.

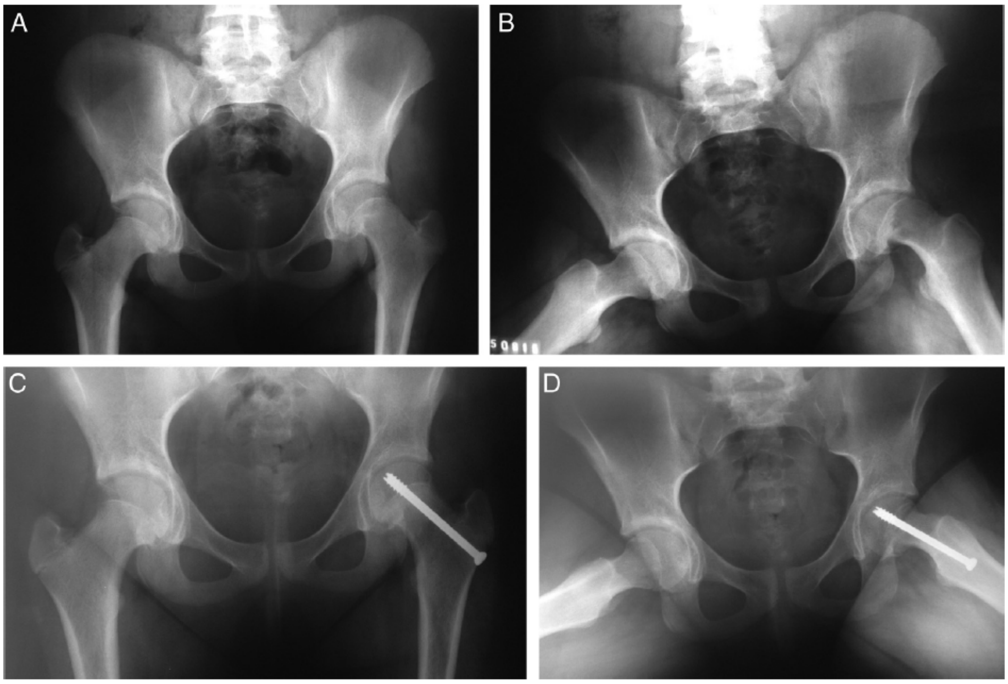

Figure 7. Female patient, 12 years and two months old.
Note: Pain in the left hip for one month, walking without crutches. RI hip blocked, flexion 90°. **A** and **B**: preoperative radiographs showing left PFE, Southwick grade II, EDA 45°; **C** and **D**: postoperative radiographs at six months follow-up showing correction of the deformity, EDA 6°

osteotomy, to avoid directing the osteotome to the posterosuperior retinaculum (that contains the terminal branches of the medial circumflex artery) and the inferior retinacular artery (that addresses the epiphysis from outside the retinacular tissue of the femoral neck at the medial ligament of Weitbrecht), which are not visualized during arthroscopy. Similarly, shortening of the femoral neck and adequate resection of the posteromedial bone neoformation are critical to avoid excessive vessel tension during

Figure 8. Aspect of the incisions made that shows the arthroscopic portals (X) and the incision for percutaneous fixation of the femoral neck (*).

the osteotomy reduction maneuver.

Postoperatively, we keep the patient hospitalized for 24 hours to observe their clinical evolution. We use Naproxen for 30 days to prevent heterotopic ossification and recommend the use of crutches without support of the operated limb for the same period, without restrictions to the range of motion of the hip. At 30 days, postoperatively, we perform control radiographic exams, when total support of the lower limb is allowed.

4. Results

With respect to the evaluation of the MHHS clinical score, a preoperative mean of 35.8 points (SD = 4.1, range 30.8 to 41.8) and a postoperative mean of 97.5 (SD = 2.9, range 93.5 to 100) were observed, with a mean postoperative increase of 61.7. A statistically significant difference ($p < 0.05$) was observed when comparing pre- and post-operative clinical measurements of the MHHS clinical score[9].

As for the radiographic evaluation, five patients were classified preoperatively according to Southwick[4] as grade I and two as grade III. The mean preoperative EDS[4] was 51.2° (SD = 12.4, range 32° to 68°) and mean postoperative EDS 11.2° (SD = 5.1, range 6° to 18°), with a mean postoperative correction of 40°. A statistically significant difference ($p < 0.05$) was observed when comparing the pre- and postoperative radiographic measurements of the EDA[4] (**Table 1**).

No immediate postoperative complications were observed. One patient (case 2) developed ANFH at 60 days after surgery, without collapse or chondrolysis until the last follow-up (22 months). This case presented a large posteromedial bone neoformation at the femoral neck, which we believe was insufficiently resected.

Table 1. Representation of operated cases, description and average measurements

Patient	Sex	Age (months)	Side	Next (months)	MHHS pre-op	MHHS post-op	EDA pre-op	EDA post-op	Complication
1	M	147	E	36	30.8	93.5	62	18	
2	M	130	D	22	30.8	93.5	42	6	ANFH
3	M	132	D	20	34.1	100	54	8	
4	M	133	E	12	37.4	97.9	56	12	
5	F	134	E	10	38.5	97.9	68	18	
6	M	135	E	10	41.8	100	32	11	
7	F	146	E	6	37.4	100	45	6	
Average		136.7		16.5	35.8	97.5	51.2	11.2	

EDA: epiphyseal-diaphyseal angle; D: right; E: left; F: female; M: male; MHHS: Modified Harris Hip Score; ANFH: aseptic necrosis of the femoral head.

5. Discussion

PFE is the most common hip disease of adolescents, with an estimated frequency of 10.8 per 100,000 individuals[1]. Recent studies of API biomechanics indicate that small anatomic hip deformities due to PFE are potential causes of permanent acetabular chondral damage[2] and lead to early osteoarthritis. Anterosuperior displacement of the hollow femoral metaphysis by mild or moderate slippage (Southwick classification)[4] leads to CAME-type APIs and generates progressive lesion of the chondrolabral junction due to the excessive shear force on this structure. In severe PFE, the bio-mechanical degenerative mechanism is of the PINCER-type of APIs, since the large deformity generates compression and primary failure of the acetabular labrum, in addition to a counter-rotation lesion of the posterior inferior acetabular cartilage[8].

Leunig *et al.*[2] showed labral and chondral acetabular lesions in 14 patients with unstable PFE[3] during surgical treatment with the surgical hip dislocation technique and observed that these lesions occurred when the femoral metaphysis was at the level or beyond the line of the epiphysis. Similarly, Sink *et al.*[12] with the same technique demonstrated the presence of intraarticular lesions in 39 patients with PFE, 34 labral and 33 chondral.

Dunn's original procedure for treatment of PFE, described in 1964, consisted of a proximal trapezoidal osteotomy of the femoral neck for subsequent reduction and fixation of the slippage[13]. Its results were first published in 1978, with 78 hips treated (25 acute and 48 chronic) and the evolution of nine cases to ANFH (two complete necroses of the epiphysis)[14]. Ganz *et al.*[15] described the use of the modified Dunn osteotomy hip dislocation technique (subcapital realignment osteotomy) in the treatment of high grade PFE[4]. According to the authors, the approach allows access to the hip and preserves the epiphyseal vascular supply and the adequate resection of the posteromedial bone neoformation of the femoral neck, besides a satisfactory reduction of the epiphysis. Thus, the goal of restoring the anatomy of the proximal femur with a technique that reduces the risk of ANFH is achieved[15].

Leunig *et al.*[16]. published the first results of this technique in 2007, with 30 hips treated with an average follow-up of 55 months. Of these, 24 cases were considered chronic slips and no evolution to ANFH was observed. Two cases (6.66%) were reoperated for failure of screw fixation. Ziebarth *et al.*[7] also retrospectively evaluated this technique in 40 patients, divided into two cohorts from different centers with a mean follow-up of 5.4 and 2.2 years. There was normalization of the alpha angle and the slip angle in all cases and no ANFH or chondrolysis was observed[7].

Other authors have published the results of using the technique described by Ganz and presented a higher number of complications. Sankar *et al.*[17] in a multicenter study that evaluated 27 patients with unstable PFE in a mean follow-up of 22.3 months, observed four patients (15%) with the need of reoperation for fixation failure and seven cases (26%) of ANFH. The average postoperative course for osteonecrosis was 21.4 weeks, and patients who did not develop this complication had significantly lower clinical pain scores and greater postoperative satisfaction[17]. Upasani *et al.*[18] presented the results of 43 patients treated with this technique, 60% of the cases had unstable PFE[3], 40% were considered acute and 86% were classified as severe slipping[4]. There were 22 complications in 16 patients, with 15 reoperations for ANFH, failure of fixation and postoperative hip dislocation. Two patients required total hip arthroplasty.

Two national authors have reported on the arthroscopic treatment of chronic-aggravated (unstable) PFE[3]. Akkari *et al.*[19] presented the results of five arthroscopic cases treated with trapezoid osteotomy, with an average preoperative epiphyseal-diaphyseal angle[4] of 82° and postoperative of 14° and with one case that evolved to ANFH[19]. Dobashi *et al.*[20] presented a case report of a 12-year-old patient who underwent arthroscopic treatment of a Dunn-type osteotomy of the femoral neck, with correction of the slippage from 70° to 30°.

The authors present an option to the classic subcapital realignment techniques for the treatment of chronic and stable PFE[3] that allows adequate access to the hip joint and adequate reduction of slippage, besides the theoretical advantage of rapid rehabilitation of the patient. The time of slip evolution is not a limiting factor for the application of this technique, but it is indicated only in cases with open epiphyseal plate.

According to the literature review, this is the first description of arthroscopic subcapital realignment osteotomy for the treatment of chronic and stable PFE. We reiterate that, prior to the described arthroscopic technique, it is fundamental that the surgeon has adequate training in hip arthroscopy, as well as experience in open subcapital osteotomy, due to the multiple technical difficulties of the proposed treatment.

6. Conclusion

The arthroscopic technique presented by the authors for the treatment of chronic and stable proximal femoral epiphysiolysis resulted in clinical and radiographic improvement of the patients in this initial series, with a mean follow-up of 16.5 months. One case of ANFH was observed, without collapse or chondrolysis at 22 months of follow-up.

Conflict of interest

The authors declared no conflict of interest.

References

1. Lehmann CL, Arons RR, Loder RT, *et al.* The epidemiology of slipped capital femoral epiphysis: An update. Journal of Pediatric Orthopaedics 2006; 26(3): 286–290.
2. Leunig M, Casillas MM, Hamlet M, *et al.* Slipped capital femoral epiphysis: Early mechanical damage to the acetabular cartilage by a prominent femoral metaphysis. Acta Orthopaedica Scandinavica 2000; 71(4): 370–375.
3. Loder RT, Richards BS, Shapiro PS, *et al.* Acute slipped capital femoral epiphysis: The importance of physeal. The Journal of Bone and Joint Surgery 1993; 75(8): 1134–1140.
4. Southwick WO. Osteotomy through the lesser trochanter for slipped capital femoral epiphysis. The Journal of Bone and Joint Surgery 1967; 49(5): 807–835.
5. Bellemans J, Fabry G, Molenaers G, *et al.* Slipped capital femoral epiphysis: A long-term follow-up, with special emphasis on the capacities for remodeling. Journal of Pediatric Orthopedics. Part B 1996; 5(3): 151–157.
6. Jones JR, Paterson DC, Hillier TM, *et al.* Remodelling after pinning for slipped capital femoral epiphysis. The Journal of Bone and Joint Surgery 1990; 72(4): 568–573.
7. Ziebarth K, Zilkens C, Spencer S, *et al.* Capital realignment for moderate and severe SCFE using a modified Dunn procedure. Clinical Orthopaedics and Related Research 2009; 467(3): 704–716.
8. Sucato DJ, De La Rocha A. High-grade SCFE: The role of surgical hip dislocation and reduction. Journal of Pediatric Orthopaedics 2014; 34(1): S18–S24.
9. Guimarães RP, Alves DPL, Azuaga TL, *et al.* Tradução e adaptação transcultural do “Harris Hip Score modificado por Byrd” (Portuguese) [Translation and cross-cultural adaptation of the “Harris Hip Score modified by Byrd”]. Acta Ortopédica Brasileira 2010; 18(6): 339–343.
10. Roos BD, Roos MV, Camisa Júnior A, *et al.* Abordagem extracapsular para tratamento doimpacto femoroacetabular: resultados clínicos, radiográficose complicações (Portuguese) [Extracapsular approach for the treatment of femoroacetabular impingement: Clinical, radiographic and complicational results]. Revista Brasileira de Ortopedia 2015; 50(4): 430–437.
11. Sampson TG. Arthroscopic treatment of femoroacetabular impingement. Techniques in Orthopaedics 2005; 20(1): 56–62.
12. Sink EL, Zaltz I, Heare T, *et al.* Acetabular cartilage and labral damage observed during surgical hip dislocation for stable slipped capital femoral epiphysis. Journal of Pediatric Orthopaedics 2010; 30(1): 26–30.
13. Dunn DM. The treatment of adolescent slipping of the upper femoral epiphysis. The Journal of Bone and Joint Surgery 1964; 46(4): 621–629.
14. Dunn DM, Angel JC. Replacement of the femoral head by open operation in severe adolescent slipping of the upper femoral epiphysis. The Journal of Bone and Joint Surgery 1978; 60(3): 394–403.
15. Ganz R, Gill TJ, Gautier E, *et al.* Surgical dislocation of the adult hip: A technique with full access to the femoral head and acetabulum without the risk of avascular necrosis. The Journal of Bone and Joint Surgery 2001; 83(8): 1119–1124.
16. Leunig M, Slongo T, Kleinschmidt M, *et al.* Subcapital correction osteotomy in slipped capital femoral epiphysis by means of surgical hip dislocation. Operative Orthopadie und Traumatologie 2007; 19(4): 389–410.
17. Sankar WN, Vanderhave KL, Matheney T, *et al.* The modified Dunn procedure for unstable slipped capital femoral epiphysis: A multicenter perspective. The Journal of Bone and Joint Surgery 2013; 95(7): 585–591.
18. Upasani VV, Matheney TH, Spencer SA, *et al.* Complications after modified Dunn osteotomy for the treatment of adolescent slipped capital femoral epiphysis. Journal of Pediatric Orthopaedics, 2014; 34(7): 661–667.
19. Akkari M, Santili C, Braga SR, *et al.* Trapezoidal bony correction of the femoral neck in the treatment of severe acute-on-chronic slipped capital femoral epiphysis. Arthroscopy: The Journal of Arthroscopic & Related Surgery 2010; 26(11): 1489–1495.
20. Dobashi ET, Blumetti FC, Pinto JA, *et al.* Artroscopia do quadril na epifisiólise grave (Portuguese) [Hip arthroscopy in severe epiphysiolysis]. Revista Brasileira de Ortopedia 2010; 45: 59–62.