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Original article

Arthroscopic subcapital realignment osteotomy in chronic and stable slipped capital femoral epiphysis: early results☆

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ABSTRACT

Objective: This study aimed to evaluate the clinical and radiographic outcomes, as well as the complications of arthroscopic subcapital realignment osteotomy in chronic and stable slipped capital femoral epiphysis (SCFE). As indicated by the literature review, this is the first time this type of arthroscopic osteotomy was described.

Methods: Between June 2012 and December 2014, seven patients were submitted to arthroscopic subcapital realignment osteotomy in chronic and stable SCFE. The mean age was 11 years and 4 months, and the mean follow-up period was 16.5 months (6–36). Clinical results were evaluated using the Modified Harris Hip Score (MHHS), which was measured pre- and postoperatively. Radiographs were evaluated using the Southwick quantitative classification and the epiphysis–diaphysis angle (pre- and postoperatively). Complications were assessed.

Results: The mean preoperative MHHS was 35.8 points, and 97.5 points post-operatively ($p < 0.05$). Radiographically, five patients were classified as Southwick classification grade II and two as grade III. The mean correction of the epiphysis-diaphysis angle was 40°. No immediate postoperatively complications were observed. One patient presented femoral head avascular necrosis, without collapse or chondrolysis at the most recent follow-up (22 months)

Conclusion: The arthroscopic technique presented for subcapital realignment osteotomy in chronic and stable SCFE showed satisfactory clinical and radiographic outcomes in a 16.5 months follow-up period.

☆ Study conducted at the Hospital Ortopédico de Passo Fundo (HOPF), Cirurgia do Quadril, Passo Fundo, RS, Brazil.

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Osteotomia artroscópica de realinhamento subcapital no tratamento da epifisiólise proximal do fêmur crônica e estável: resultados precoces

Palavras-chave:
Epífise deslocada
Quadril
Cabeça do fêmur
Artroscopia
Criança

RESUMO

Objetivo: Avaliar os resultados clínicos e radiográficos, bem como as complicações da osteotomia de realinhamento subcapital por via artroscópica para tratamento da epifisiólise proximal do fêmur (EPF) crônica e estável, relativos a uma série inicial de pacientes. Conforme análise da literatura, o estudo apresenta a primeira descrição de técnica artroscópica desse tipo de osteotomia.

Métodos: Entre junho de 2012 a dezembro de 2014, sete pacientes foram submetidos à osteotomia de realinhamento subcapital por via artroscópica para tratamento da EPF crônica e estável. A idade média dos pacientes foi de 11 anos e quatro meses. O seguimento mínimo foi de seis a 36 meses (média de 16,5 meses). Os pacientes foram avaliados clinicamente de acordo com o Harris Hip Score modificado por Byrd e radiograficamente conforme a classificação quantitativa de Southwick e o ângulo epifisio-diafisário. Complicações pós-operatórias foram analisadas.

Resultados: Com relação à avaliação do escore clínico Harris Hip Score Modificado por Byrd, observou-se média pré-operatória de 35,8 pontos e pós-operatória de 97,5 pontos ($p < 0,05$). Radiograficamente, cinco pacientes foram classificados como grau II e dois como grau III de Southwick. Observou-se correção média do ângulo epifisio-diafisário de 40°. Não houve complicações pós-operatórias imediatas. Um paciente evoluiu com necrose avascular da cabeça femoral, sem colapso ou condrólise no último seguimento (22 meses).

Conclusão: A técnica artroscópica apresentada pelos autores para tratamento da EPF crônica e estável resultou em melhoria clínica e radiográfica dos pacientes nesta série inicial.

Introduction

Slipped capital femoral epiphysis (SCFE) is the most common disease of the adolescent hip, with an estimated frequency of 10.8 per 100,000 individuals.[1] Recent studies on the biomechanics of femoroacetabular impingement (FAI) indicate that small anatomical deformities that may arise from SCFE potentially cause permanent acetabular chondral damage,[2,3] leading to early osteoarthritis.

There is no consensus regarding the best SCFE treatment option, especially 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 this procedure has a low complication rate. They believe that the residual hip deformity remodels during growth allowing proper function.[5,6] Others, including the present authors, indicate correcting the deformity site (subcapital realignment osteotomy) in order to achieve an anatomical reduction of the epiphysis and decrease the risk of subsequent chondral degeneration.[7]

The main criticism of the authors contrary to the use of the subcapital realignment osteotomy technique is the risk of complications such as avascular necrosis (AVN) of the femoral head and chondrolysis, which can occur in up to 28% of cases.[8] However, the growing number of studies in this area has led to a reduction in complications. It is essential to observe technical details to preserve the vascular supply of the epiphysis during the procedure.[7]

This study aimed to assess the clinical and radiographic results and the complications of arthroscopic subcapital realignment osteotomy as a treatment for chronic and stable SCFE in an initial series of patients.

According to our literature search, this is the first description of arthroscopic subcapital realignment osteotomy for the treatment of chronic and stable SCFE.

Materials and methods

This was a retrospective study of patients who underwent arthroscopic subcapital realignment osteotomy for treatment of SCFE, operated from June 2012 to December 2014. Patients with chronic SCFE (over three weeks of symptoms, without pain exacerbation), stable,[3] Southwick grade II or III, without prior treatment, without preoperative signs of necrosis or chondrolysis, and with an open epiphyseal plate were included. During this period, seven patients underwent the treatment, six males and one female; the left side was affected in five cases. Age ranged from 11 years to 12 years and three months old (SD = 6.9, mean = 11 years and four months). Minimum follow-up was six months and the maximum was 36 months (SD = 10.3, mean 16.5 months). All surgeries were performed by the same surgeon (BDR). All patients were called upon for a reassessment. The study was approved by the Research Ethics Committee.

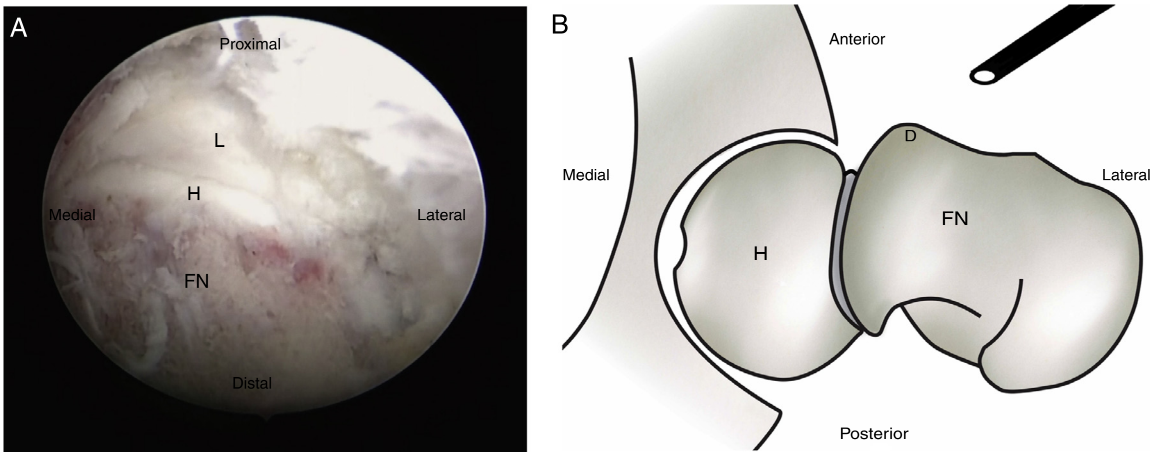

Fig. 1 – (A) Intraoperative image of hip arthroscopy for subcapital realignment in the treatment of chronic and stable SCFE, disclosing the exposure of the labrum (L), femoral head (H), and femoral neck (FN). (B) Axial characterization of the left hip showing the femoral head (H), femoral neck (FN), and CAM-type deformity of the femoral neck (D) resulting from the chronicity of the SCFE.

Regarding 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 the pelvic anteroposterior and frog leg views. To determine the degree of preoperative slippage, the Southwick[4] criteria were used and the cases were classified as grade I (up to 30°), grade II (30°–60°), or grade III (above 60°). The degree of slip correction was also determined, by comparing the pre- and postoperative measures of the epiphyseal-diaphyseal angle[4] (EDA) in the frog leg view. During follow-up, the presence of AVN and/or chondrolysis was analyzed.

The statistical method used for the analysis of paired variables (MHHS, EDA) was the Wilcoxon test, considered statistically significant at $p < 0.05$.

Surgical technique

General anesthesia with femoral nerve block was used to all cases. Physical examination of the hip with the patient under anesthesia was used to passively assess bilateral range of motion.

The patient was placed in the supine position on a radiolucent table. The orthopedic traction table was not used, due to the need for greater hip mobility for the multiple intraoperative maneuvers. The pelvis was slightly tilted to the contralateral side, and a radiolucent cushion was placed under the affected hemipelvis.

The anatomical references were marked with an appropriate pen. A vertical line was drawn from the anterosuperior iliac spine toward the center of the patella. The anterior, posterior, and proximal borders of the greater trochanter of the femur were marked. The portals were positioned with the assistance of fluoroscopy. The first portal was the mid-anterior (MAP), which is used for the camera. Subsequently, the proximal mid-anterior portal (PMAP), which is the working portal, is positioned to provide a parallel access to the proximal femoral physis.

The arthroscopic approach used for subcapital realignment was extracapsular,[10] following the access to the peripheral joint compartment described by Sampson.[11]

With the affected limb in a neutral position and after establishing the arthroscopic portals, the anterior joint capsule and the iliocapsular muscle were dissected with radiofrequency and shaver to obtain proper exposure. Then, a T-capsulotomy of the femoral neck was made, which could be extended as required. Subsequently, capsulectomy was made until a proper exposure of the anterior metaphysis and epiphysis of the proximal femur in its mid-lateral extension was obtained. With radiofrequency, the longitudinal opening of the periosteum and its detachment from the femoral neck were made, forming a retinacular flap together with the epiphysis (Fig. 1).

After proper exposure, an osteochondroplasty of the femoral neck-head transition is made, which allows the resection of a CAM-type deformity originated by the SCFE chronicity; it also allows a better identification of physis (Fig. 2). In more severe degrees of slippage, external rotation and limb extension may be required to expose the epiphyseal plate. The osteotomy is performed 2 mm distal to the growth plate (to facilitate a subsequent neck shortening) with a specific curved osteotome at different locations of the epiphyseal plate, until the epiphysis and metaphysis are completely separated. All patients had open epiphyseal plate, and no difficulties were observed at this surgical step (Fig. 3).

When the femoral metaphysis was separated from the epiphysis, the hip was externally rotated and gently tractioned to enable the shortening of the neck and growth plate resection using arthroscopic curette (Fig. 4). Subsequently, the hip was adducted to remove the neoformed bone tissue in the posteromedial femoral neck region, which can be an obstacle to subsequent reduction.

Finally, abduction and internal rotation hip maneuvers were performed for osteotomy reduction (Fig. 5). A 6.5

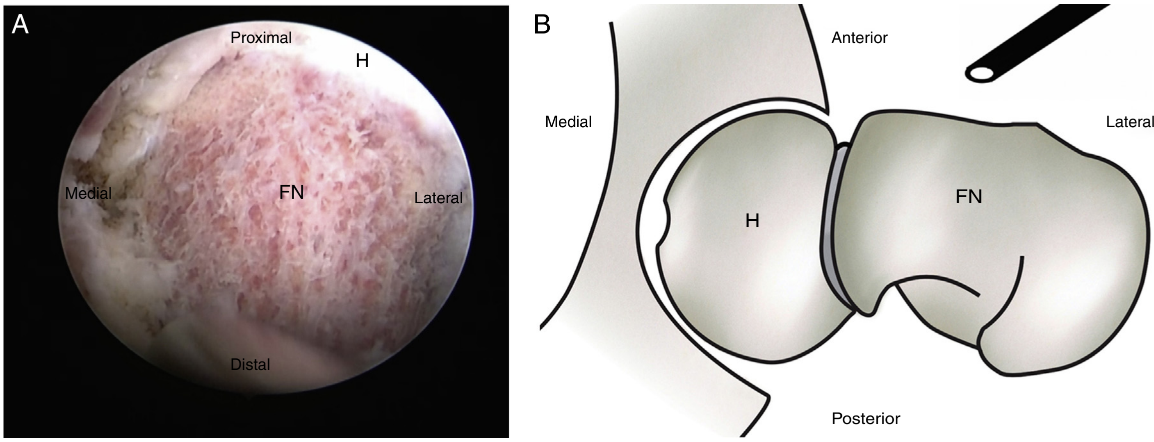

Fig. 2 – (A) Intraoperative image of the left hip after femoral neck osteochondroplasty for the correction of CAM-type deformity showing the femoral head (H) and femoral neck (FN). (B) Axial characterization of the left hip, showing the femoral head (H) and femoral neck (FN) after femoral neck osteochondroplasty for the correction of CAM-type deformity.

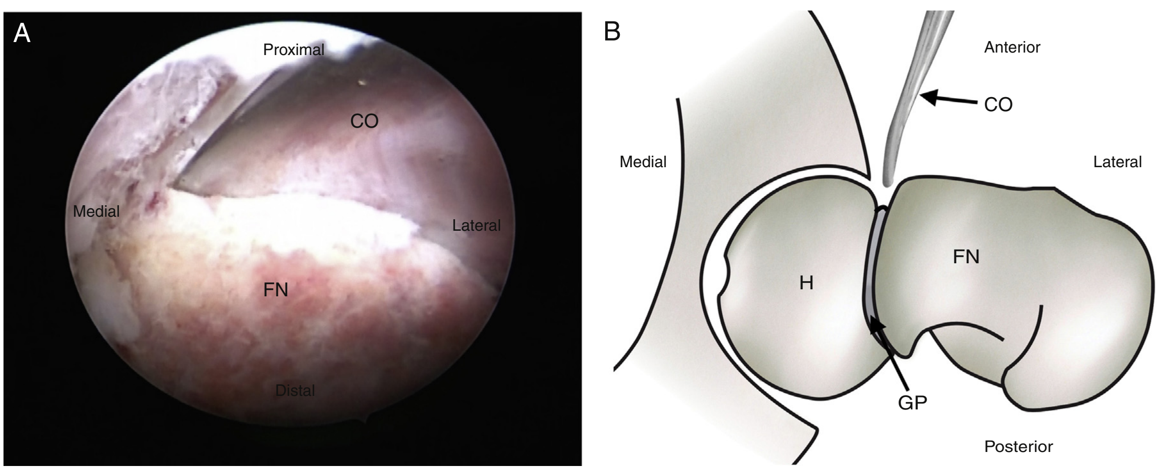

Fig. 3 – Intraoperative image of the left hip showing the femoral neck (FN) and the curved osteotome (CO) during neck osteotomy at the level of the growth plate. (B) Axial characterization of the left hip showing the femoral head (H), femoral neck (FN), the growth plate (GP), and the curved osteotome (CO) positioned for neck osteotomy.

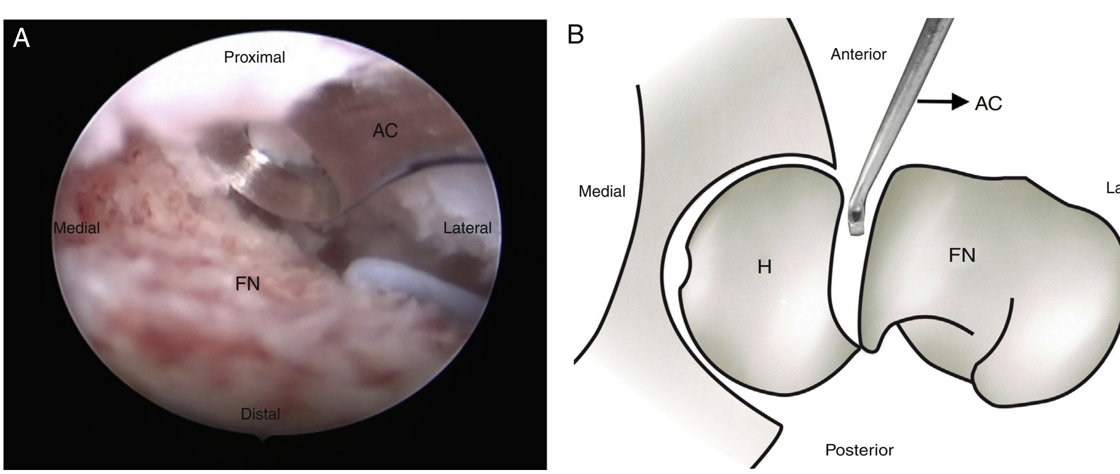

Fig. 4 – (A) Intraoperative image of the left hip showing the femoral neck (FN) and arthroscopic curette (AC) during curettage of the femoral neck for shortening and resection of the posterior-bone formation. (B) Axial characterization of the left hip showing the femoral head (H), the femoral neck (FN), and the arthroscopic curette (AC).

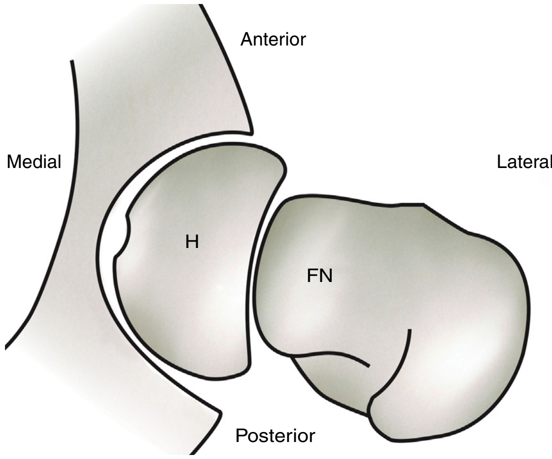

Fig. 5 – Axial characterization of the left hip showing the femoral head (H) and femoral neck (FN) after osteotomy reduction.

partially threaded cancellous screw was used for percutaneous fixation (Figs. 6–8).

To reduce the risk of avascular necrosis of the proximal femoral epiphysis, at the time of the neck osteotomy it is essential to avoid directing the osteotome toward the posterosuperior retinaculum (which contains the terminal branches of the medial circumflex artery) and toward the lower retinacular artery (which is directed toward the epiphysis outside the retinacular tissue of the femoral neck in the medial Weitbrecht ligament), which are not visualized during arthroscopy. Likewise, shortening of the femoral neck and appropriate resection of the posteromedial bone formation are essential to avoid excessive tensioning of the vessels during the osteotomy reduction maneuver.

Postoperatively, patients were hospitalized for 24 h for observation of clinical outcome. Naproxen was used for 30 days to prevent heterotopic ossification; patients were oriented to use crutches without weight bearing on the operated limb for the same period, without restrictions to the hip range of motion. At 30 postoperative days, control radiographs were made and full weight bearing was authorized.

Results

Regarding the assessment of the MHHS score, the mean preoperative score was 35.8 points (SD = 4.1, range = 30.8–41.8) and the mean postoperative score, 97.5 (SD = 2.9, range = 93.5–100), with a mean postoperative increase of 61.7. There was a statistically significant difference ($p < 0.05$) when comparing the pre- and postoperative MHHS.[9]

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

There were no immediate postoperative complications. One patient (case 2) evolved with AVN 60 days after surgery, without collapse or chondrolysis until the last follow-up (22 months). This case had a large posteromedial bone formation

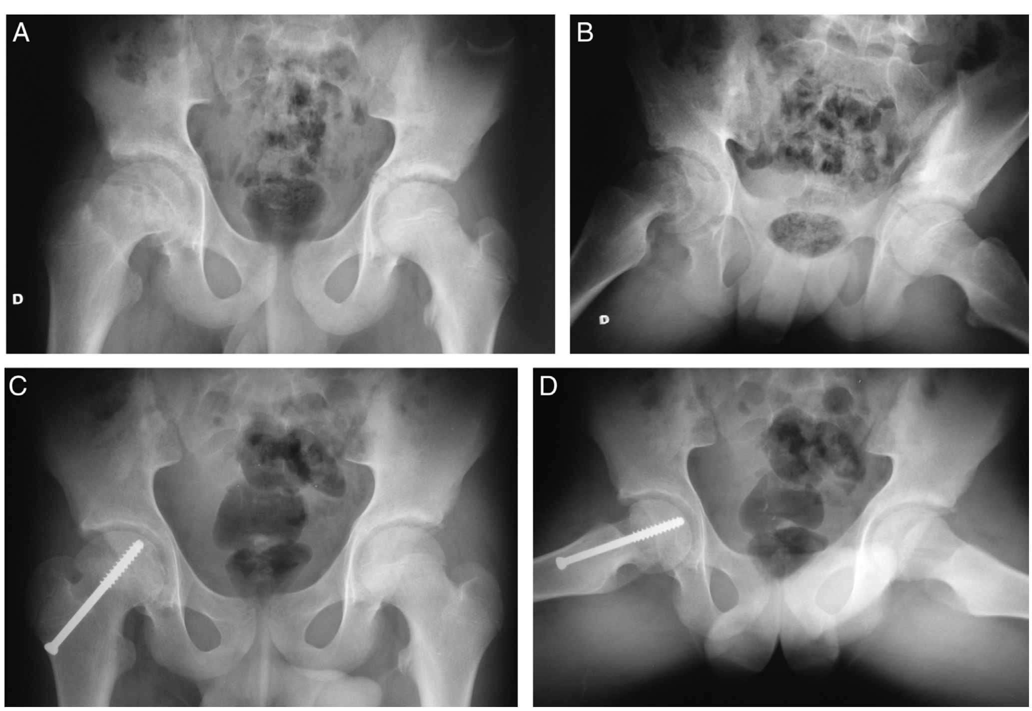

Fig. 6 – Male patient aged 11 years. Pain in the right hip for two months, was able to walk without crutches. Hip locked in IR, 80° of flexion. (A) and (B) Preoperative radiographs showing Southwick grade II SCFE on the right, EDA 54°. (C) and (D) Postoperative radiographs at 20 months of follow-up showing the correction of the deformity, EDA 8°.

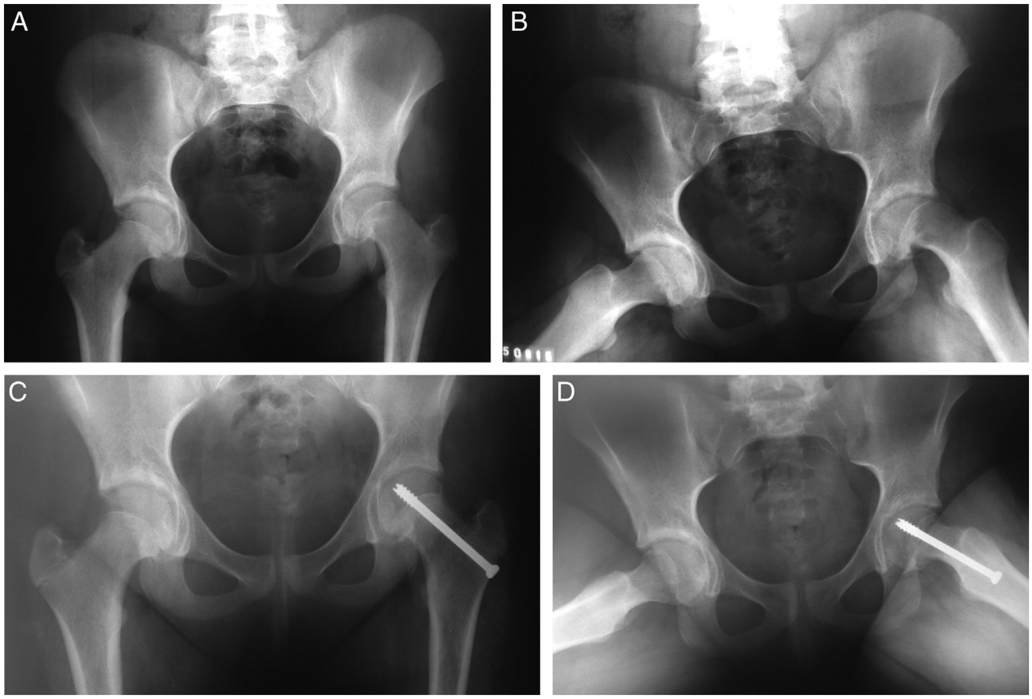

Fig. 7 – Female patient aged 12 years and two months. Pain in the left hip for one month, was able to walk without crutches. Hip locked in IR, 90° of flexion. (A) and (B) Preoperative radiographs showing Southwick grade II SCFE to the left, EDA 45°. (C) and (D) Postoperative radiographs at six months of follow-up disclosing deformity correction, EDA 6°.

in the femoral neck, which the authors believe to have been insufficiently resected.

Discussion

SCFE is the most common disease of the adolescent hip, estimated at 10.8 per 100,000 individuals.[1] Recent studies on the biomechanics of FAI indicate that small anatomical deformities of the hip that may arise from SCFE are a potential cause of permanent acetabular chondral damage[2] and lead to early osteoarthritis.

The anterior displacement of the femoral metaphysis caused by mild or moderate slips (Southwick classification)[4] leads to CAM-type FAI and generates a progressive injury on the chondrolabral junction due to excessive shear stress on the structure. In severe SCFE, the degenerative biomechanical mechanism is PINCER-type FAI, since the large deformity generates compression and primary failure of the acetabular labrum, as well as contrecoup injury in the posteroinferior cartilage of the acetabulum.[8]

Leunig et al.[2] evidenced labral and chondral acetabular injuries in 14 patients with unstable SCFE[3] during surgery using the surgical dislocation of the hip technique; they observed that these injuries occurred when the femoral metaphysis was at or extended beyond the epiphyseal line. Likewise, Sink et al.,[12] using the same technique, demonstrated the presence of intra-articular injuries in 39 patients with SCFE, 34 labral and 33 chondral.

Table 1 – Operated cases, description, and mean measurements.

Patient	Gender	Age (months)	Side	Follow-up (months)	MHHS pre-op	MHHS post-op	EDA pre-op	EDA post-op	Complications
1	M	147	L	36	30.8	93.5	62	18	
2	M	130	R	22	30.8	93.5	42	6	AVN
3	M	132	R	20	34.1	100	54	8	
4	M	133	L	12	37.4	97.9	56	12	
5	F	134	L	10	38.5	97.9	68	18	
6	M	135	L	10	41.8	100	32	11	
7	F	146	L	6	37.4	100	45	6	
Mean		**136.7**		**16.5**	**35.8**	**97.5**	**51.2**	**11.2**	

EDA, epiphyseal-diaphyseal angle; R, right; L, left; F, female; M, male; MHHS, modified Harris Hip Score; AVN, aseptic necrosis of the femoral head.

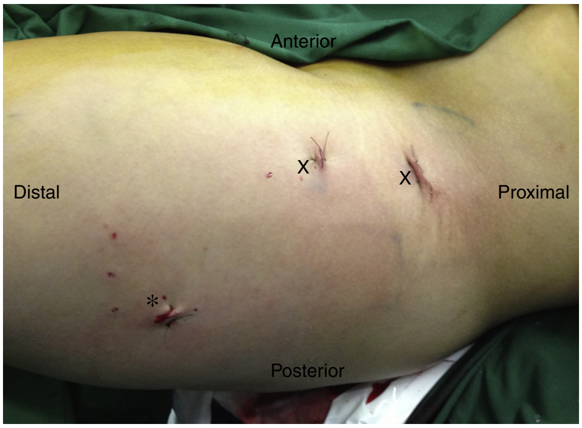

Fig. 8 – Aspect of the incisions showing the arthroscopic portals (X) and the incision for percutaneous fixation of the femoral neck (*).

Dunn's original procedure for the treatment of SCFE, described in 1964, consisted of a trapezoidal proximal femoral neck osteotomy for further reduction and fixation of the slippage.[13] Their results were first published in 1978, comprising 78 hips (25 acute and 48 chronic); nine cases progressed to AVN (two cases with complete epiphyseal necrosis).[14]

Ganz et al.[15] described the use of the surgical hip dislocation technique in a modified Dunn osteotomy (subcapital realignment osteotomy) in the treatment of high-grade SCFE.[4] According to the authors, this approach provides access to the hip, preserves the epiphyseal vascular supply, and allows adequate resection of the posteromedial bone formation in the femoral neck and satisfactory reduction of the epiphysis. This makes it possible to restore the anatomy of the proximal femur with a technique that reduces the risk of AVN.[15]

Leunig et al.[16] published the first results of this technique in 2007, with 30 hips treated and a mean follow-up of 55 months. Of these, 24 cases were considered chronic slips, and no case progressed to AVN. Two cases (6.66%) underwent reoperation due to failure of the fixation with screws. Ziebarth et al.[7] also retrospectively evaluated this technique in 40 patients, divided into two cohorts from different centers, with mean follow-ups of 5.4 and 2.2 years. The alpha angle and the slip angle were normalized in all cases, with no cases of AVN or chondrolysis.[7]

Other authors who have published their results on the use of the technique described by Ganz showed a greater number of complications. Sankar et al.,[17] in a multicenter study that evaluated 27 patients with unstable SCFE[3] in mean follow-up of 22.3 months, observed four patients (15%) requiring reoperation for failure of fixation and seven cases (26%) of AVN. The mean postoperative course until osteonecrosis was 21.4 weeks; patients who did not develop this complication presented a significantly lower clinical pain score and greater postoperative satisfaction.[17] Upasani et al.[18] presented the results of 43 patients treated with this technique; 60% of cases patients had unstable SCFE,[3] 40% were considered acute, and 86% were classified as severe slip.[4] Those authors observed 22 complications in 16 patients; there were 15 reoperations due to AVN, fixation failure, and postoperative hip dislocation. Two patients received indication for total hip arthroplasty.

Two Brazilian studies reported the arthroscopic treatment of chronic-acutized SCFE (unstable).[3] Akkari et al.[19] presented the results of five cases treated with arthroscopic trapezoidal osteotomy with a mean preoperative EDA[4] of 82° and a mean postoperative EDA of 14°; one case developed AVN.[19] Dobashi et al.[20] presented a case report of a 12-year-old patient who underwent a Dunn-type arthroscopic femoral neck osteotomy; the slippage was corrected from 70° to 30°.

The present study presented an alternative to classical techniques of subcapital realignment for the treatment of chronic and stable SCFE[3] that allows adequate access to the hip joint and appropriate reduction of the slippage, with a theoretical advantage of rapid rehabilitation. The period of slippage evolution is not a limiting factor for the application of this technique; nonetheless, it was only indicated in cases with open epiphyseal plate.

According to a literature search, this is the first description of an arthroscopic subcapital realignment osteotomy for the treatment of chronic and stable SCFE. The authors reiterate that, prior to the performance of the arthroscopic technique described, it is essential that the surgeon receives adequate training in hip arthroscopy, as well as experience in open subcapital osteotomy, due to the multiple technical difficulties of treatment.

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 patients in this initial series, with a mean follow-up of 16.5 months. One case of AVN, without collapse or chondrolysis, was observed at 22 months of follow-up.

Conflicts of interest

The authors declare no conflicts of interest.

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