ORIGINAL ARTICLE

TREATMENT OF PROXIMAL FEMORAL EPIPHYSIOLYSIS WITH SUBTROCHANTERIC OSTEOTOMY BY THE ILIZAROV METHOD

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ABSTRACT

Objectives: To evaluate the treatment of severe proximal femoral epiphysiolysis through subtrochanteric osteotomy using the Ilizarov method and to propose a new method for calculating the necessary correction. Methods: A case study was carried out among patients affected by severe proximal femoral epiphysiolysis who underwent subtrochanteric osteotomy with external multiplanar fixation and were evaluated postoperatively using the modified Southwick classification. A method was developed for calculating the angular correction needed for the surgical procedure. Results: Thirteen hips were analyzed: four left hips (30.8%) and nine right hips (69.2%). The majority of the patients (61.5%) were male, with a mean age of 14 years. In relation to pain and function, the results were excellent for 30.8%, good for 46.2% and regular for 23.0%, and none of the patients presented poor results. Regarding mobility, the results were excellent for 46.2%, good for 30.8% and regular for 23.0%. Radiographically, the results were excellent for 7.7%, good for 69.2%, regular for 15.4% and poor for 7.7%. Conclusions: Percutaneous treatment of severe proximal epiphysiolysis using the Ilizarov method is a good treatment option with good indices for improvement of pain and function. The proposed calculation method can help in planning surgical procedures, with variations between calculated and measured angles of the order of 3º.

Keywords – *Dislocated epiphyses; Osteotomy; External fixators; Ilizarov technique*

INTRODUCTION

Proximal femoral epiphysiolysis occurs because of mechanical debilitation of the growth plate, thereby causing anterosuperior displacement of the metaphysis over the femoral epiphysis. This produces three-dimensional deformation, with the metaphysis in a position of varus, extension and external rotation, while maintaining the relationship between the acetabulum and the femoral head[1,2].

The treatment for slippage of the proximal femoral epiphysis consists primarily of preventing progression of the slippage, thereby avoiding greater deformation and complications caused by its progression, while remodeling of the femoral neck takes place.

Late treatment is reserved for cases in which deformation consisting of retroversion of the femoral neck causes symptoms (pain, diminished range of motion or gait difficulties). Such situations are related to anterior femoroacetabular impact, which gives rise to early development of osteoarthritis[3].

Osteotomy of the proximal femur has the aim of correcting deformation of the growth plate. Although it would seem logical to correct the deformation at the specific site, corrective osteotomy in this region is generally associated with high complication rates, especially involving avascular necrosis.

Southwick's three-plane subtrochanteric osteotomy is a good choice for correcting deformation of the femoral neck because it avoids this region, which is commonly associated with complications. Instead, it is performed at a lower level, at which compensatory deformation in flexion, valgus and internal rotation of the subtrochanteric level is provoked.

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The present study evaluated 13 patients with proximal femoral slippage and proposes a calculation method for estimating the correction needed during the surgical procedure that envisages a critical correction angle beyond which there would be no further direct contact with the cortex.

METHODS

The present work involved a case study and was developed at the Institute of orthopedics and Traumatology (IOT) of Passo Fundo, RS. The patients were evaluated retrospectively between 2000 and 2007 and corresponded to 13 hips. Patients affected by proximal femoral epiphysiolysis who were classified as Southwick grades II and III were included in this study.

All the patients underwent complete anamnesis and physical examination, with complementary radiographic examinations on the pelvis, in anteroposterior and Lauenstein views. The angle between the epiphysis and diaphysis was measured on radiographs in abduction and external rotation. Measurements of up to 12° were considered normal, while slight slippage was taken to be < 30°, moderate slippage 30-50° and severe slippage > 50°, with a positive Drennan sign. After the surgical procedure, the patients were evaluated by means of Southwick's modified classification[4], which consists of clinical and radiographic assessments as shown in Table 1.

The patients selected underwent subtrochanteric osteotomy with multiplanar external fixation, in association with *in situ* fixation, depending on whether an open growth plate was present. As part of the routine postoperative follow-up, the patients were advised not to support themselves on the operated side, and they started a physiotherapy program to improve their range of motion, immediately after the operation. The patients with contralateral *in situ* fixation performed during the same procedure (bilateral cases) were unable to walk. After guidance and discharge from hospital, they returned to the outpatient clinic one week later for review and new dressings, and two to four weeks later for control radiographs. Radiographic follow-up was maintained every 30 days until consolidation was achieved, with continuous physiotherapy.

From the radiographs obtained during the initial phase of the investigation, a calculation method was developed for estimating the correction needed during the operation. This consisted of analysis of radiographs in anteroposterior and Lauenstein views (Figures 1A and 1B), in a manner similar to what was proposed by Southwick. Basically, the calculation compared the normal and impaired sides. Lines were traced out along the cervical and diaphyseal axes on the normal and impaired sides and then the respective angles were measured (Figures 1C and 1D). Following this, new lines were traced out from the centers of the femoral heads to the cervical-diaphyseal intersection angle, thus defining the angles α and β, as shown in Figures 1E and 1F. A line perpendicular to the diaphyseal axis passing immediately below the small trochanter was traced out on anteroposterior and Lauenstein radiographs, thereby forming an equilateral triangle with smaller angles (γ and ω) at the intersection of the cervical-diaphyseal lines (Figures 1G and 1H). The angles α and γ and the angles β and ω could then be superimposed (Figures 1I, 1J, 1K, 1L, 1M and 1N) and surgical planning could then be undertaken, in the following manner:

- $\alpha < \gamma$: osteotomy can be performed, with contact between the cortices obtained;
- $\alpha = \gamma$: critical angle at the limit of contact between the cortices on anteroposterior radiographs;

Table 1 – Modified Southwick classification[4]

	Excellent	Good	Regular	Poor
Pain	Absent	Present with exercise	Usually with exercise and occasionally with normal activity	Constant
Function	No limitation	Occasional tiredness; able to walk more than one mile	Becomes tired easily; able to walk up to a quarter of a mile	Unable to walk a quarter of a mile
Range of motion	Up to 20° loss on normal side	40° loss on normal side	60º loss on normal side	Greater than 60º
Radiology	Without incongruence or narrowing	No incongruence; moderate narrowing or loss of sphericity, without cysts or degenerative abnormalities	Moderate incongruence; moderate arthritic abnormalities, without avascular necrosis	Severe incongruence and degeneration; avascular necrosis

$\alpha > \gamma$: no contact between the cortices on anteroposterior radiographs;

$\beta < \omega$: osteotomy can be performed, with contact between the cortices obtained;

$\beta = \omega$: critical angle at the limit of contact between the cortices on Lauenstein radiographs;

$\beta > \omega$: no contact between the cortices on Lauenstein radiographs.

Thus, a critical correction angle was defined, beyond which no further cortical contact would be obtained, thereby making it impossible to use the three-plane osteotomy technique with the Ilizarov method. It should be noted that the bone presents a practically elliptical shape in this region and that the final critical angle of adjustment would be a three-dimensional resultant between the intersections of the radiographic planes. However, a purely two-dimensional calculation from the anteroposterior and Lauenstein radiographs is capable of providing an excellent approximation.

The calculation method described above was applied preoperatively and the surgical correction was evaluated postoperatively, for all the patients. The surgical procedure was indicated after confirming that cortical contact was present, as estimated from the proposed calculation.

The data analysis was performed descriptively through using the SPSS for Windows software, v.15 (SPSS Inc., Chicago, Illinois, USA).

OPERATIVE TECHNIQUE

The patients were positioned in dorsal decubitus under general anesthesia. Firstly, *in situ* fixation was performed on the proximal femoral growth plate, for patients with the potential for progression of the slippage because of the presence of growth plate that was still open, by means of a cannulated screw (Figures 2A and 2B). Following this, under fluoroscopy, proximal Schanz pins were inserted parallel to the horizontal plane, along with an Ilizarov half-ring (performed in adduction in order to evaluate the joint congruence, thereby projecting the valgization needed) (Figures 2C and 2D). Next, with the patella centered, distal Schanz pins were inserted, also parallel to the surgical table. Resulting from this, it was observed that the upper half-ring was positioned in flexion, with the proximal pins oriented cranially in relation to the lower half-ring (Figure 2E). Osteotomy was performed immediately below the small trochanter (Figure 2F). The deformation was corrected by aligning the two half-rings in parallel and fixing them using connecting bars (Figure 2G), with the possibility of also correcting residual deformations according to their connections. Figures 2H and 2I present the radiographic appearance using anteroposterior and lateral fluoroscopy.

RESULTS

Among the patients selected for this study, eight (61.5%) were male and five (38.5%) were female. Ten were white (76.9%) and three were afro-descendents (23.1%). Four left hips and nine right hips were operated. The minimum age was 11 years and six months and the maximum was 17 years and five months (mean of 14 years and five months), with a mean follow-up of two years.

Four patients presented growth plate closure, detected by means of simple radiography, and *in situ* fixation was not performed in these cases. Four patients presented bilateral disease, but in these cases, slippage as far as grade I had occurred on one of the sides affected and in situ fixation of the growth plate of the hip that was contralateral to the osteotomy was performed.

Nine patients presented chronic epiphyseal slippage (duration of symptoms greater than six months), while four presented chronic slippage that become acute.

The mean duration of the procedure, starting from the induction of general anesthesia, was 90 minutes. The mean length of time for which the external fixator was used was 3.5 months (range: two to six months). None of the patients needed blood replacement during or after the operation; nor did any present hemodynamic instability. This was because the surgery was percutaneous, with insertion of the Schanz pins under fluoroscopic guidance and a mini-incision for osteotomy at a site within a safety zone.

The complications encountered during the procedures consisted of three cases of infection of the pin route. None of these patients required intravenous antibiotic therapy, given that there were no cases of deep infection. One potential disadvantage of this method could be arthrofibrosis due to pain, caused by the external fixator itself, but this complication was not found, given that physiotherapy began during the immediate postoperative period.

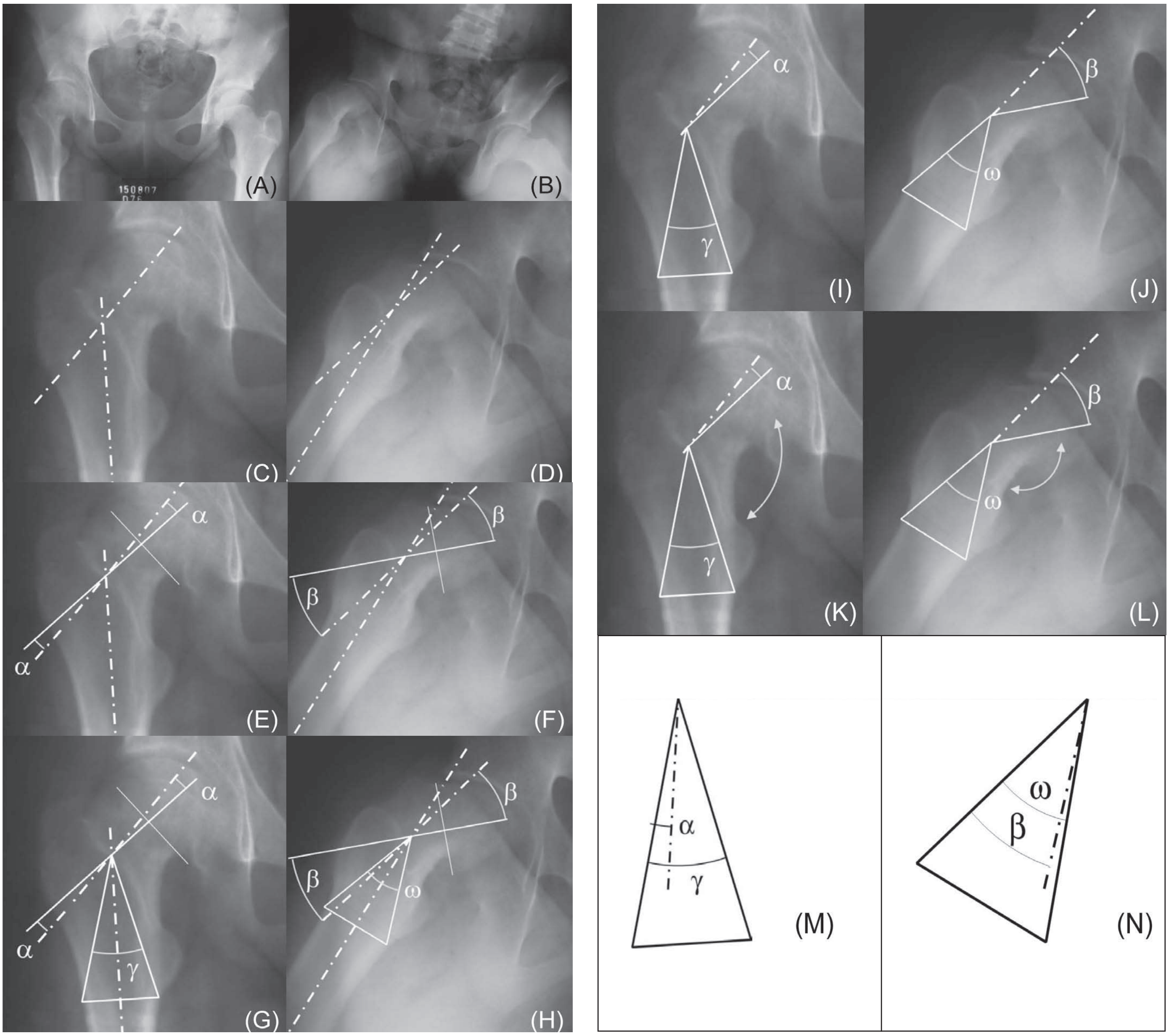

Figure 1 – Method for calculating the estimate for the critical angle: radiographs in anteroposterior view (A) and lateral view (B), showing the proximal femoral epiphyseal slippage to the right; (C) and (D), the definition of the cervical-diaphyseal angles in the anteroposterior and Lauenstein views; (E) and (F), measurements of the correction angles α and β; (G) and (H), determination of the critical angles γ and ω; (I), (J), (K), (L), (M) and (N), isolation of the critical angles in the anteroposterior and Lauenstein views and comparison with the angles needed for correction

Using the Southwick clinical evaluation of pain and function[4], we obtained four excellent results (30.8%), six good results (46.2%) and three regular results (23.0%), and we did not find any poor results relating to these parameters. Regarding range of motion, there were six excellent results (46.2%), four good results (30.8%) and three regular results (23.0%). In the cases in which bilateral abnormalities were detected, although bilateral fixation was applied, we emphasize that the contralateral side presented slippage of up to grade I, without significant abnormality in the range of motion. Radiographically, nine good results were observed (69.2%), one excellent result (7.7%), two regular results (15.4%) and one poor result (7.7%). The effectiveness of the treatment demonstrated that the percutaneous technique could be usefully indicated for treating proximal femoral slippage. The regular results from the radiological evaluation were associated with little cor-

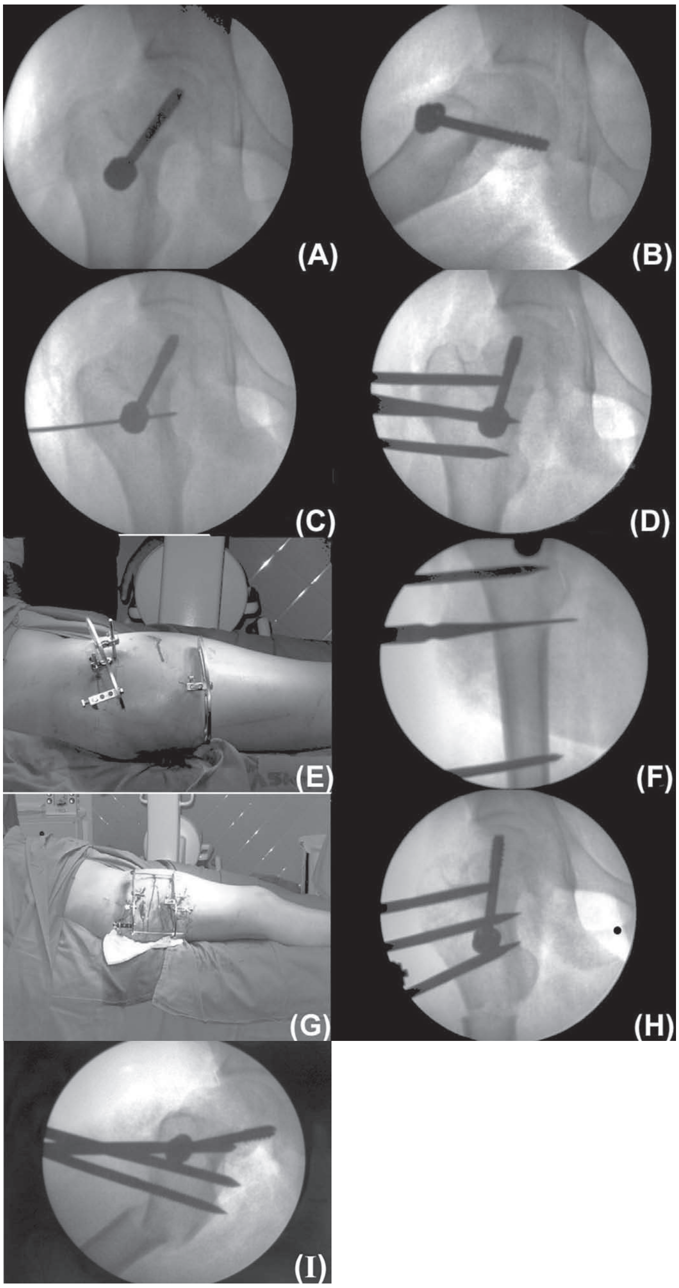

Figure 2 – Operative technique

rection of the varus, which necessitated epiphysiodesis of the greater trochanter in one case and, in the other, distalization of the greater trochanter because the patient presented claudication. The single case with a poor radiological evaluation was associated with development of chondrolysis.

Regarding the calculation method proposed for estimating the corrections, it was observed that in all the cases evaluated, the preoperative planning showed angles that were less than critical. This predicted that osteotomy could be performed without loss of contact between the cortices. In this part of the study, we could see the importance of good-quality radiographs: these made it possible to determine variations in the measured angles, whereas this would not be possible with poorly defined images or with poor patient positioning, which could produce inappropriate rotations. The method was shown to be suitable for estimating the correction needed, with angles measured before the operation and corrections achieved after the operation that had a mean difference of 3º.

DISCUSSION

The main aim in correcting moderate or severe deformations due to proximal femoral epiphyseal slippage is to improve gait function and hip mobility. Secondarily, the aim is to lessen the pre-arthrotic deformation, thereby restoring the anatomy and normal biomechanics of the hip and theoretically avoiding secondary coxarthrosis over the long term. This correction can be achieved in several ways[3], among which osteotomy is used as a routine tool for treating a variety of orthopedic pathological conditions of the developing hip (dysplasia, Legg-Perthes-Calvé disease, coxa vara and proximal femoral epiphyseal slippage).

Among the methods available for treating slippage of the proximal femoral epiphysis, *in situ* fixation remains the procedure of choice for the initial management of stable cases of this condition, with low incidence of progression of slippage, osteonecrosis and chondrolysis[1].

After the initial treatment, the deformation relating to external rotation gradually improves as the inflammation diminishes and the deformity becomes remodeled[1]. In a series of 80 hips that were fixed *in situ*, after a mean follow-up of 3.3 years, Aronson and Carlson[5] observed that 70% of the results were clinically good or excellent. However, when they evaluated the hips according to the degree of slippage, they found that 86% of the mild cases presented good results, 55% of the moderate cases did so and only 27% of the severe cases did so. This makes it possible to conclude that the degree of slippage is directly related to patients' prognosis, such that only patients with mild to moderate slippage of the proximal femoral epiphysis are selected for the procedure of *in situ* fixation.

The treatment of moderate and severe cases (with slippage greater than 30°) remains a challenge for orthopedists, given the complications inherent to patients' own disease and the surgical alternatives for these cases. The use of osteotomy has been studied for managing cases of slippage of the proximal femoral epiphysis. Some authors have proposed correction of the intracapsular cervical region and have advocated that this would theoretically be the only choice capable of correcting the deformity completely, without impairing future reconstructive surgery[6]. However, such surgery is most commonly associated with complications. In patient series treated with intracapsular cuneiform osteotomy, Dunn and Angel[7] and Biring *et al*[8] obtained high rates of avascular necrosis and chondrolysis, reaching 39% and 17%, respectively, in patients with chronic slippage that had become acute. The risk of avascular necrosis is considerable, and Gage *et al*[9] demonstrated necrosis prevalence of 38% among 77 hips treated with femoral neck osteotomy, although they did not report the severity of the dislocation or the correction achieved. Diab *et al*[10] found low complication rates, but subcapital osteotomy was more commonly associated with reoperation. Performing subtrochanteric osteotomy via the conventional access route described by Southwick[4] not only gives rise to excessive surgical exposure but also implies greater blood loss through removal of the trapezoidal fragment and increases the risk of limb shortening[9]. There may also be the need for immobilization using orthoses, depending on the surgical stability achieved. Furthermore, there may be a need for new open surgical procedures, in order to remove the synthesis material in the future. In a series of 51 hips treated using intertrochanteric osteotomy that were evaluated after an average of 24 months, Schai *et al*[6] reported that 55% of the hips did not present any degenerative abnormalities and 28% only presented moderate degenerative signs. In a study on 35 patients and 39 hips, Kartenbender *et al*[11] observed that 77% of the clinical results were excellent or good after a mean follow-up of 23.4 months following the intertrochanteric osteotomy.

The indication of fixation and subtrochanteric osteotomy has the primary aim of stabilizing the slippage, in association with correcting the deformation at a level distant from the center of the deformity, thereby creating compensatory deformation. There is controversy regarding the need or lack of need for fixation of the femoral epiphysis in conjunction with subtrochanteric osteotomy, given that in the original paper by Southwick[4], it was assumed that early fusion of the growth plate would occur due to horizontalization caused by the osteotomy. This would avoid complications from the use of *in situ* fixation, which has led to a necrosis rate of up to 10% in some series. However, *in situ* fixation does away with the need to use postoperative orthoses to immobilize the hip and, for this reason, in the present study we chose to use *in situ* fixation for the patients who presented a growth plate that was still open.

Several benefits from using the percutaneous technique can be demonstrated. Among these, diminished blood loss and lower surgical morbidity are especially observed. In addition, this technique avoids problems associated with internal fixation using plates, such as the possibility of affecting the growth plate, the need for a second procedure to remove the synthesis material and the potential decrease in the deep infection rate[12], along with enabling postoperative adjustments to residual deformities[13]. There were no cases of implant failure in this study. Beauchesne *et al*[14] presented a fracture rate of 5% after fixation using AO plates. This technique has also been indicated for cases in which the skin conditions were inadequate, but this has been correlated with significant infection rates along the path of the pins, with rates in the literature ranging from 0 to 100%, with a mean of 4 to 12%[15]. Kishan *et al*[16] correlated the reduction in osteolysis rates with the use of pins coated with hydroxyapatite, using a pin insertion technique that did not cause thermal necrosis, and with administration of early oral antibiotics. In the present study, we used stainless steel pins, without finding high infection rates.

One potential risk from percutaneous surgery is the duration of exposure to radioactivity caused by using an image intensifier. We did not find any objective data on this risk in the literature. Regarding the mean duration of the procedure, starting from the induction of anesthesia, we found a mean of 90 minutes. The mean length of time using the external fixator was 3.5 months, with a range from two to seven months. Colyer[17] found that external fixators were used for a similar period of time (three to four months). We did not find any references to the duration of the operation in the literature.

El-Mowafi *et al*[18] did not find any significant differences in postoperative evaluations on patients undergoing Southwick osteotomy, compared with those undergoing femoral neck osteotomy, with good and excellent results in 90% and 86.7% of the patients, respectively. However, they cited the capacity to preserve the anatomy of the proximal femur as an advantage of osteotomy of the femoral neck. Complications such as chondrolysis were more common after subtrochanteric osteotomy, while avascular necrosis was more common after osteotomy of the femoral neck. Diab *et al*[19] compared *in situ* fixation alone with intertrochanteric osteotomy associated with *in situ* fixation and did not find any significant difference in hip function, although they were successful in improving mobility through osteotomy.

With regard to the definition of the critical angle, it needs to be emphasized that this may be influenced by the following variables: a) the quality of the radiograph, which may mask the identification of the outlines on the anteroposterior and lateral views, and may change the angles measured; b) the surgical technique and correction made during the surgical procedure, in which the surgeon does not necessarily correct the previously measured angle exactly. In the present study, the difference between the measured and corrected angles was approximately 3º, on both the anteroposterior and the Lauenstein radiograph views. We believe that the preoperative and postoperative angle definitions may serve as a guide for future procedures.

In cases affected bilaterally, neither side presented slippage greater than grade I and therefore one side only underwent *in situ* fixation. The calculation was initially based on the lines traced out on the normal and impaired sides, comparatively. In cases of bilateral slippage of grades II or III, we suggest that the correction for the inclination and declination angles should be made in relation to the normal measurements found in the literature, i.e. 135º-145º for the inclination angle and up to 15º for the declination angle.

We emphasize that, because such cases are severe, normal anatomy will not be reestablished, given that the osteotomy is performed outside the CORA center. Nonetheless, the surgical procedure is rapid, minimally invasive, reestablishes normal gait while avoiding Trendelenburg, and corrects limb length.

CONCLUSIONS

The results obtained demonstrated that the percutaneous technique could be usefully indicated for treating proximal femoral slippage, with patients presenting improvements in pain and function. The calculation method proposed for estimating the corrections was shown to be an important tool for planning the procedure and estimating the correction needed.

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