

Trapezoidal Bony Correction of the Femoral Neck in the Treatment of Severe Acute-on-Chronic Slipped Capital Femoral Epiphysis

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Purpose: To present the first technical description of a modified surgical technique for trapezoidal bony correction of the femoral neck in the treatment of slipped capital femoral epiphysis (SCFE), performed entirely by arthroscopy. **Methods:** From December 2005 to January 2008, 5 patients with severe SCFE underwent trapezoidal femoral neck bone correction through arthroscopy. Their mean age at the time of surgery was 13.2 years. The time for postoperative follow-up ranged from a minimum of 12 months to a maximum of 39 months (mean, 26 months). The study analyzed data regarding the type of slip, degree of correction obtained, clinical and functional outcomes, and complications. **Results:** Analysis with the modified Harris Hip Score criteria showed a mean of 17.2 points preoperatively and 86.6 points at the last assessment. The mean epiphyseal deviation ranged from 82° at the initial presentation to 14° postoperatively. There were no intraoperative complications, and there was 1 case of avascular necrosis. **Conclusions:** Arthroscopic treatment of SCFE resulted in correction of the angles of epiphyseal slip (from a mean epiphyseal-diaphyseal angle of 82° before surgery to 14° after surgery), with no immediate complications and 1 case of a late complication (avascular necrosis) in this 5-patient series. Clinical improvement was shown by a mean 69.4-point increase in the modified Harris Hip Score. **Level of Evidence:** Level IV, therapeutic case series.

The slipped capital femoral epiphysis (SCFE) in the acute-on-chronic form is characterized by the acute slippage of the femoral head over a chronic

SCFE.¹ Treatment depends on many factors, such as age, type of slip, degree of deviation, extent of existing mobility, and aspect of the joint cartilage. Untreated cases are condemned to fair results regarding range of movement, functional disability, and early osteoarthritis.^{2,3} The major controversies in the treatment arise when there are severe slips, and there are several techniques for their correction, which may be divided based on anatomic site: subtrochanteric, intertrochanteric, or intracapsular (at the femoral neck).⁴⁻⁸ Undoubtedly, osteotomies performed in the femoral neck offer the best correction opportunity^{9,10} because they are held at the apex of the deformity, but they have been related to a high incidence of complications.¹¹⁻¹⁴

Some descriptions of arthroscopic findings in SCFE cases appear in the literature.^{15,16} However, they show

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only exploratory procedures and arthroscopic joint debridement in the treatment of impingement.

The purpose of this study is to present the first technical description of a less invasive way of achieving the femoral neck trapezoidal bone resection in severe cases, performed by arthroscopy, followed by percutaneous femoral epiphysis fixation. The hypothesis was that it would be possible to perform endoscopic femoral neck remodeling, visualize reduction, and help in the fixation of severe cases of SCFE.

METHODS

This is a prospective, observational study, including all consecutive patients submitted to wedge bone correction of the femoral neck by arthroscopy in acute-on-chronic SCFE between December 2005 and February 2008 at a public university hospital. The inclusion criteria were severe SCFE, marked restriction of movements, open femoral capital femoral physis, no prior treatment, progression of the slip (acute-on-chronic SCFE), and no signs of necrosis or chondrolysis.

Five patients were operated on arthroscopically in the period and fulfilled the inclusion criteria; there were 3 boys and 2 girls, and there were 3 left and 2 right hips. Their age at the time of surgery ranged from 11 years 11 months to 14 years 8 months (mean, 13 years 2 months). The time of postoperative follow-up ranged from a minimum of 12 months to a maximum of 39 months (mean, 26 months).

The time between acute worsening of SCFE and surgery, the degree of deformity and correction obtained, and the immediate and late complications were analyzed. For the clinical evaluation, the criteria of the modified Harris Hip Score¹⁷ were applied in the preoperative period and at the last evaluation.

Imaging

The epiphyseal-diaphyseal angles were measured on radiographs, front and frog-leg lateral views, preoperatively and postoperatively. To determine the degree of slippage, the criteria of Southwick⁷ were used: grade I or mild slip, an angle of up to 30°; grade II or moderate slip, between 30° and 60°; and grade III or severe slip, above 60°.

Computed tomography scan was performed in 2 patients for a better understanding of the initial displacement. During follow-up, aseptic avascular osteonecrosis,^{18,19} chondrolysis,²⁰ and loss of reduction were evaluated.

Technique

Patients were placed in the supine position on a radiolucent table, without traction and using a C-arm.²¹ All patients underwent sufficient arthroscopic bone resection to allow reduction of the femoral neck by arthroscopy, and percutaneous fixation was carried out with 2 cannulated screws of 7 mm in diameter, with a thread size of 16 mm.

For arthroscopic access, 2 portals were used, 1 anterolateral and 1 anterior,²² with a 70° arthroscope and 4.5- to 5.5-mm cannulas. The burr was modified: it was cut, reducing the length of its external sleeve, to facilitate bone resection in various directions (Fig 1).

The technique consists of resection of a segment of the femoral neck bone in a trapezoidal shape. The reduction of unstable slips poses some risks to the blood supply. Because of that, we produce a shorten-

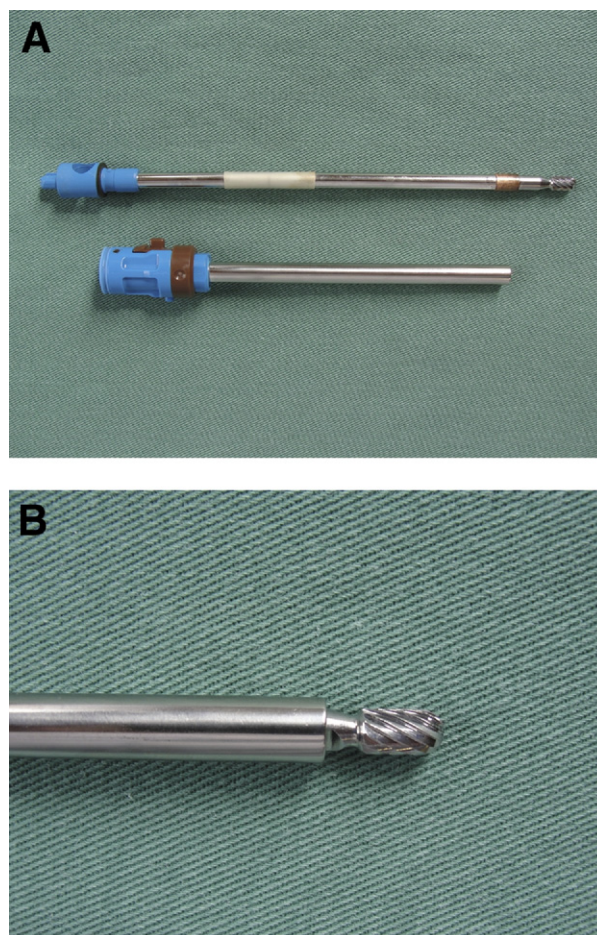


FIGURE 1. (A) Modified burr used in this surgical approach. (B) The external sleeve was cut, reducing its length, to facilitate bone resection in various directions.

ing of the femoral neck with a trapezoid-shaped resection, reducing the risk of stretching the vessels. The surgery starts with the anterior resection, measuring approximately 1.5 cm, using as the proximal limit the growth cartilage of the femoral epiphysis. The largest basis of this trapezoid is located in the anterior region of the neck, perpendicular to the plane of slip of the epiphysis; the lower base is located in the posterior region of the femoral neck, with approximately 0.7 cm, enough to release the femoral head, although it could be augmented until the femoral head was completely released from the neck and no tension was felt in the posterior capsule. The measurement of this wedge is determined during surgery, by trial and error (Video 1, available at www.arthroscopyjournal.org).

The resection is extended to its distal portion forming the minor basis of the wedge. At the end of resection, there must be a complete discontinuity between the epiphysis and the femoral neck, and independent movement between the neck and epiphysis is possible (Fig 2 and Video 1 [available at www.arthroscopyjournal.org]). Fluoroscopy was used to navigate the bone remodeling in conjunction with arthroscopy at all times.

A capsulotomy was not performed. The posterior view was obtained from inside the trapezoid "hole" that was previously resected. The retinacular vessels were difficult to visualize, but the reduction of the head was performed only if it was completely loose.

Afterward, 2 guidewires with cannulated screws were inserted percutaneously, with verification by arthroscopic vision of their correct positioning toward the femoral neck. Epiphyseal reduction was carried out with a smooth maneuver of traction, flexion, and internal rotation of the hip. The guidewires were introduced and checked by fluoroscopy. Fixation of the epiphysis was completed with 2 cannulated screws, with the surgeon looking for compression (Fig 2C).

In the immediate postoperative period, joint movements are stimulated actively and passively. Two crutches are used, and full weight bearing is gradually allowed when there are radiographic signs of consolidation.

RESULTS

The time between the acute worsening of SCFE and the procedure ranged from 1 to 60 days (mean, 23 days). The values of the preoperative modified Harris Hip Score ranged from 11.1 to 39.6 points (mean, 17.2 points), and the score at the final evaluation ranged from 69.3 to 100 points (mean, 86.6 points). Figure 3 shows preoperative imaging in a patient with SCFE. The correction obtained, as shown by the preoperative and postoperative modified Harris Hip Scores, can be observed in Table 1.

There were no intraoperative or immediate postoperative complications. The fixation was possible in all

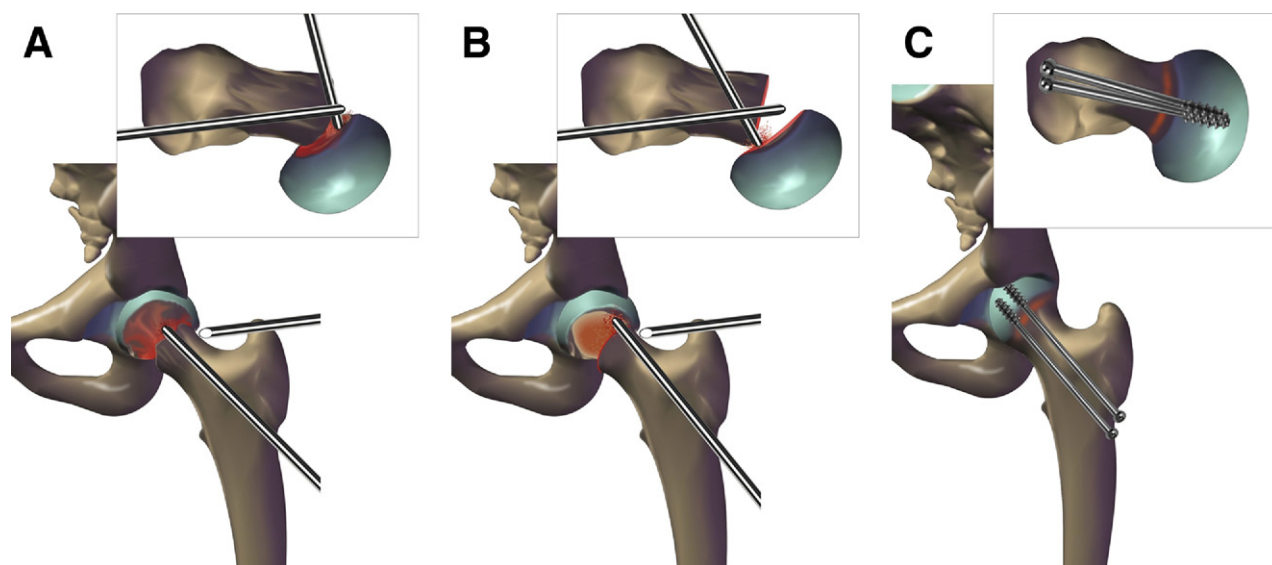


FIGURE 2. Bone resection for trapezoidal bony correction of femoral neck. (A) Initial displacement of epiphysis and introduction of anterolateral and anterior portal accesses. (B) Bone resection of femoral neck in a trapezoidal shape with larger anterior side and smaller posterior side. (C) Reduction of femoral head and fixation of epiphysis with 2 screws.

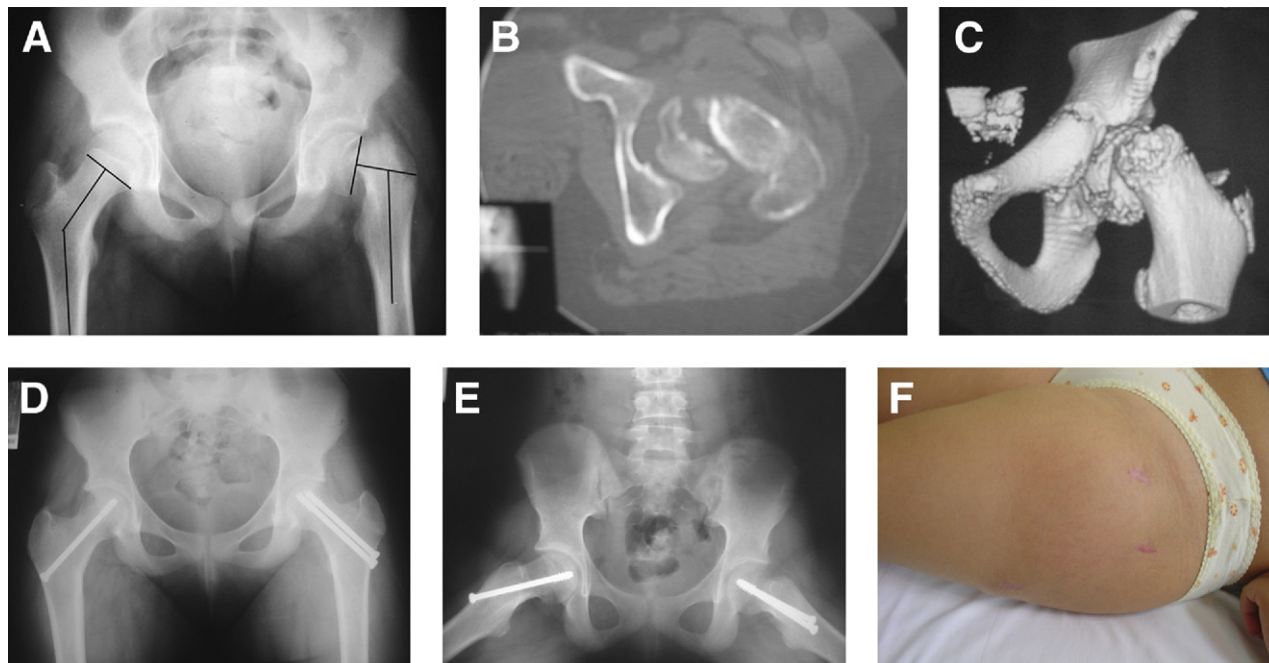


FIGURE 3. Imaging before, during, and after trapezoidal bony correction by arthroscopy in case 1. (A) Preoperative radiograph showing SCFE on left side of a 12.5-year-old girl. (B and C) Preoperative computed tomography scans of same patient. (D and E) Anterior and frog-leg views of left side 2 years postoperatively showing another 15-month in situ fixation performed on right side. (F) Scarring 2 years after surgery.

cases (Fig 3D). The preoperative frog-leg angle ranged from 70° to 90° (mean, 82°). The postoperative correction ranged from 0° to 25° (mean, 14°). On average, full weight bearing was achieved in 3 months (Fig 4).

In 1 patient (case 4) we observed avascular necrosis (AVN) of the femoral head 4 months after surgery, and the screws had to be withdrawn. The patient was advised to avoid weight bearing, using crutches after AVN was detected, and she is under observation.

DISCUSSION

SCFE is a disease of unknown etiology,^{1,23} and although it has been described for more than a century, the treatment of the severe forms is still a challenge, is controversial, and has high complication rates.^{6,10-14} The results referred to in the literature with the open method are controversial and very discouraging based on the complication rates; this makes some authors advocate for postponement of surgery.^{11-14,24} The aim of using this technique was to determine whether it was technically possible to achieve correction by hip arthroscopy.^{22,25}

When the slip occurs with an acute onset over a chronic SCFE, a special clinical situation is designed, where the neck, which has not undergone adaptive remodeling, impinges against the acetabular rim and promotes a great restriction of movements. In this difficult situation, with a large gap between the femoral head and the neck, the major functional impairment would be a reasonable indication for surgical correction at the femoral neck.

We chose the anterior and lateral portals for easier access to the anterior region, where resection of a larger amount of bone is needed. These portals are also safer, avoiding vascular lesions. According to the work of Trueta,²⁶ Chung,²⁷ and Ogden,²⁸ the main vascular supply of the femoral epiphysis is dependent on the posterior medial retinacular arteries. Besides, in acute-on-chronic slips, the anterior retinacular vessels are commonly torn.

Excessive resection can cause shortening of the femoral neck. Conversely, insufficient resection may hinder reduction of the epiphysis and, by tensioning the posterior retinacular vessels, cause an ischemic lesion of the femoral epiphysis. Both conditions should be avoided. The posterior view is indeed dif-

TABLE 1. Demographic Description of Adolescent Patients Who Underwent SCFE Surgical Correction by Arthroscopy and Preoperative and Postoperative Clinical Results

Variable	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Sex	F	M	F	F	F
Side affected	L	L	L	R	R
Age (mo)	150	155	169	143	176
Acute worsening time* (d)	25	1	14	60	15
Front angle (°)					
Preoperatively	75	100	85	100	100
Postoperatively	145	125	130	150	140
Profile angle (°)					
Preoperatively	70	90	90	90	70
Postoperatively	8	26	20	20	0
Modified Harris Hip Score					
Preoperatively	12.1	11	12.1	39.6	11.1
Postoperatively	96.8	100	96.8	69.3	70.4
Articular width (mm)					
Preoperatively	5	4	3	5	4
Postoperatively	5	3	4	2	4
Follow-up (mo)	39	34	26	20	12
Complications	—	—	—	AVN of femoral neck and chondrolysis	—

*The “acute worsening time” refers to the period of intense and acute onset of pain and not the onset of chronic symptoms. The great variability among the patients is because all of them were referred to our specialized service by other hospitals.

ficult, and the arthroscopic optical device is inserted through the trapezoidal “hole.” Operative planning regarding the amount of bone to be resected is done intraoperatively. Even when we tried to calculate before surgery the amount of bone to be resected, this proved unsuccessful, because during surgery, we often saw that it was necessary to resect more or less bone. The most important parameter is to check whether the head is completely loose before performing reduction.

In fact, we believe that the reason for the AVN in case 4 was related to insufficient bone resection in the inferior-posterior region, probably because of a late presentation (60 days). The patient was referred to our specialized center from a distant and poor region of the country and already had a partially healed lesion when admitted. The epiphysis was not free enough in relation to the femoral neck, leading to a huge difficulty in its reduction. We believe that it is essential to completely release the epiphysis before the maneuver of reduction.

The greatest difficulty was found in the resection of the posterior portion of the femoral neck. We suggest that surgeons start opening an anterior wedge, carefully heading to the posterior part of the femoral neck, trying to visualize the bone limits and the retinacular vessels.

We chose to perform fixation with 2 screws parallel to each other and perpendicular to the femoral epiph-

ysis because we believe that the use of only 1 screw would not give enough stability.^{29,30}

A comparison of the results of the analysis using the modified Harris Hip Score preoperatively and at the latest assessment found significant improvement, with a mean of 17.2 points preoperatively to 86.6 at the final evaluation. It is noteworthy that even the patient in whom epiphyseal necrosis developed has also shown an improvement thus far, ranging from 39.6 points initially to 69.3 points at the last assessment.

The technique used was effective in correcting the angles of epiphyseal slip, ranging on average from 82° to 14°. The mean correction achieved by arthroscopy in this study would be considered acceptable in our hospital if achieved by open surgery.

By avoiding the open capsulotomy, it is possible to achieve early mobilization; our previous experience with the open method showed the opposite. Although it was not the aim of the study, it was noted that the aesthetic result is also superior to that of the open method (Fig 3F), because only small incisions are made, for portals and for percutaneous screws. This was a gratifying point for these young patients. If we consider the shorter hospitalization, minor bleeding, and low rate of infection with arthroscopic surgery by itself,^{22,25} it is possible that this technique can yield advantages and theoretically lower complication rates, and we will continue to study this possibility.

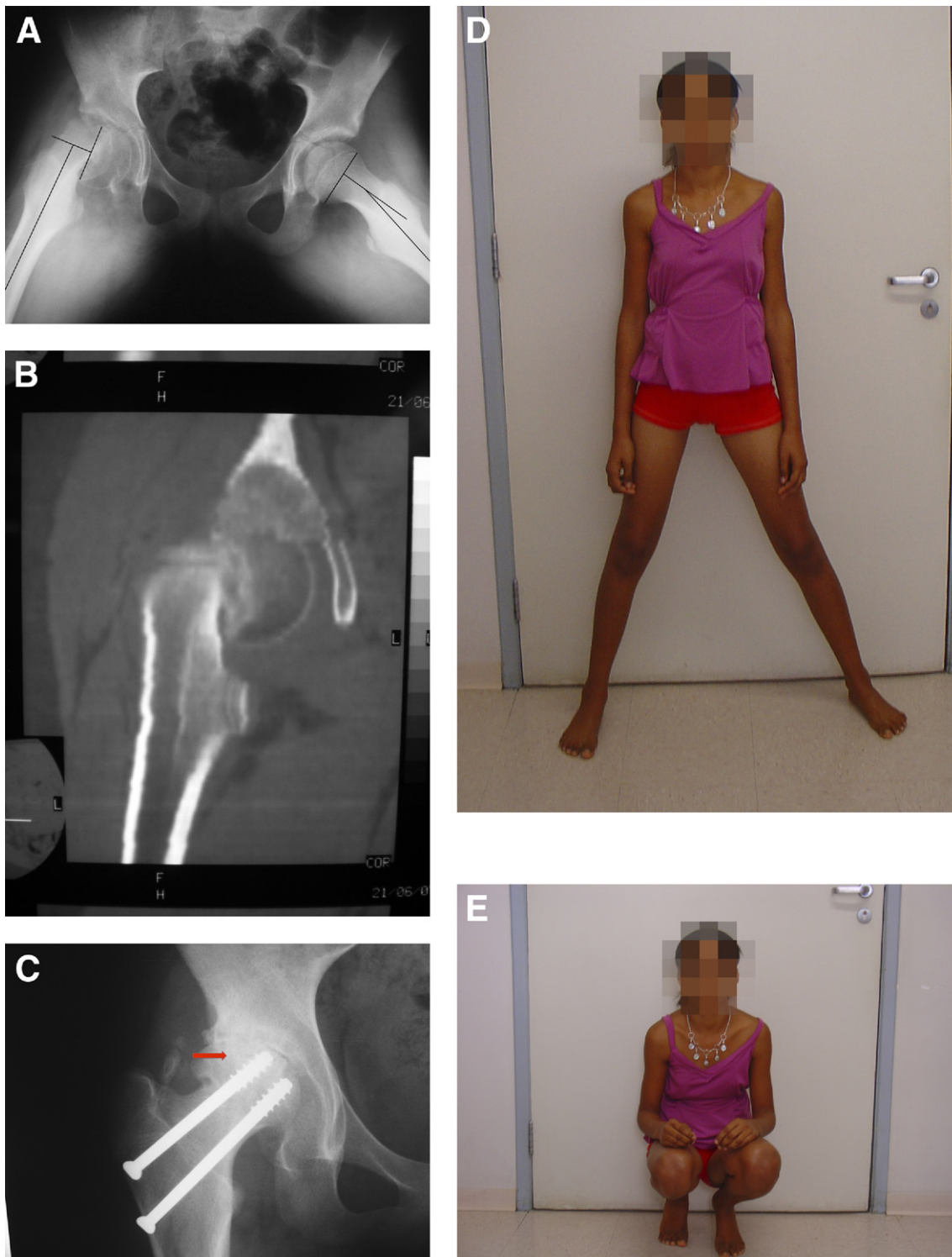


FIGURE 4. Imaging before, during, and after trapezoidal bony correction by arthroscopy in case 4. (A) Radiograph showing SCFE on right side in a 11.9-year-old girl. (B) Preoperative computed tomography scan of right hip. (C) Radiograph taken 1 year after surgery showing AVN (arrow) in right hip. (D and E) Photographs 1 year after treatment, showing (D) abduction of hip and (E) flexion of hip.

Although the results of this study are encouraging, this is a preliminary study, and the short follow-up time and small sample are limitations. Increasing the sample size and the follow-up period is obviously necessary.

CONCLUSIONS

Arthroscopic treatment of SCFE resulted in correction of the angles of epiphyseal slip (from a mean epiphyseal-diaphyseal angle of 82° before surgery to 14° after surgery), with no immediate complications and 1 case of a late complication (AVN) in this 5-patient series. Clinical improvement was shown by a mean 69.4-point increase in the modified Harris Hip Score.

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