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ORIGINAL STUDY

Midterm results of concomitant epiphyseal fixation and trochanteric osteotomy for severe chronic slipped capital femoral epiphysis

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The management of severe forms of slipped capital femoral epiphysis (SCFE) has been the subject of intense debate in the literature, and controversy remains as to whether the proximal femoral epiphysis should be realigned by intracapsular or extracapsular osteotomies or just fixated *in situ*.

The aim of this study is to evaluate the late results of treatment of severe unreduced slipped capital femoral epiphyses by combined epiphyseal stabilisation *in situ* using a single cancellous screw and biplane corrective trochanteric osteotomy. Eighteen hips with severe chronic slipped capital femoral epiphysis before physeal closure were treated by combined epiphyseal fixation *in situ* using a single cancellous screw, and biplane corrective osteotomy fixed by an angled blade plate. The average follow-up period was 8 years. All patients achieved near-normal hip flexion, internal rotation and abduction, and most were able to bear weight in the early post-operative period. A satisfactory correction of the head-shaft angle was obtained post-operatively on both antero-posterior and frog leg lateral radiographs. There was no instance of chondrolysis, avascular necrosis or early osteoarthrosis.

This procedure appears to offer a workable solution to the problem posed by the severely slipped capital femoral epiphysis.

Keywords : slipped capital femoral epiphysis ; severe ; treatment ; trochanteric osteotomy.

INTRODUCTION

Controversy persists concerning the most satisfactory treatment of severe slip of the capital femoral epiphysis before complete physis closure (*4,23*). The treatment of mild and moderate cases has been simplified by the advances in radiographic imaging, and the development of cannulated screw technology. Most centers agree that the placement of a single screw across the center of the epiphysis stabilising the unreduced epiphysis till physeal closure, is the most effective method for the treatment of mild and moderate cases (*7,11*). However, in patients with severe unreduced slip, stabilisation *in situ* will leave them with the

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problem of altered biomechanics of the hip because of the extension and varus deformity in addition to external rotation and shortening of the lower limb (*6,16*).

Several types of osteotomy have been performed to correct the malalignment between the femoral head and neck in an attempt to solve the problem of the deformity and reduce the risk of future osteoarthrosis (*5,12,14*). The aim of this work is to evaluate the results of treatment of unreduced severe forms of slipped capital femoral epiphysis by combined epiphyseal stabilisation in *situ* using a single cancellous screw and biplane corrective trochanteric osteotomy.

PATIENTS AND METHODS

From 1995 to 2005, 18 hips with chronic severe forms of slipped capital femoral epiphysis were treated surgically in 18 patients at the Mansoura University Hospital. One hip was classified as unstable. The surgical technique involved a single screw fixation of the epiphysis, combined at the same sitting with a biplane corrective trochanteric osteotomy.

Preoperatively, all patients were subjected to a clinical and radiographic examination. Clinical assessment included the recording of pain, limping, hip movements, deformity and limb length measurement. Anteroposterior and frog-leg lateral radiographs were examined to assess the degree of slip of the epiphysis, the width of the joint space and the congruity of the hip joint. The degree of slip was measured according to the method of Southwick (*20*) by measuring the angle between the axes of the femoral head and shaft on the frog-leg lateral radiographs. For unilateral cases the degree of the slip was calculated by substraction of the head-shaft angle of the normal side from that of the affected side. For the bilateral cases, 12° were subtracted from the head-shaft angle to calculate the degree of the slip (fig 1). A mild slip was defined as an angle of less than 30°, a moderate slip 30° to 50°, and a severe slip more than 50°. There were 13 boys and 5 girls with chronic severe slips, the average age was 12 years (range : 9 to 15). The average duration of symptoms was 22 weeks (range : 12 to 32). Twelve cases involved the left side and 6 the right side. The average angle of the slip was 55°, (range : 50 to 65). Two patients had bilateral involvement, but the slip at the contralateral hip was mild, and was treated at the same time by a percutaneous single screw fixation.

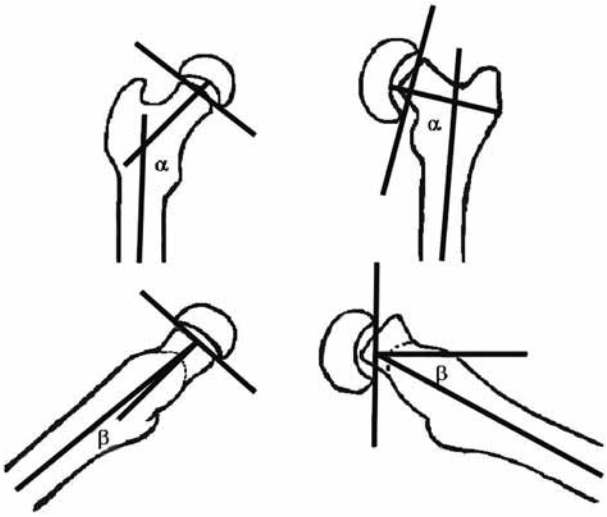

Fig. 1. — The head-shaft angle on the A/P view (α) and the lateral head shaft angle on the frog lateral view (β) to determine the degree of the slip and the angles of the wedge to be removed antero-laterally at the level of the lesser trochanter.

A careful preoperative planning (fig 1) was done for each case with drawings done on tracing paper of anteroposterior and lateral radiographs to determine the size of the anterolateral bone wedge to be removed, the position of the seating chisel (which will determine the position of the blade-plate in the proximal fragment), and the size and angle of the blade-plate to be used.

Surgical Technique

Under general anaesthesia, the patient is placed on a fracture table with the image intensifier placed between the legs, and the limb is prepared and draped. Through a Hardinge lateral approach (*9*), the anterior femoral neck, the trochanteric area as well as the femoral shaft are exposed. The displaced epiphysis is fixed *in situ* through the anterior femoral neck using a single partially threaded cancellous screw under radiographic control on both anteroposterior and lateral views.

According to the preoperative drawings, a guide pin is inserted, under C-arm control, through the anterolateral aspect of the greater trochanter across the femoral neck to identify the entry point and the position of the seating chisel. This must be parallel and 2 cm proximal to the superior cut of the osteotomy on both anteroposterior and lateral views. The seating chisel is driven parallel and in line with the guide pin as verified by the C-arm monitor, taking care to keep clear from the screw

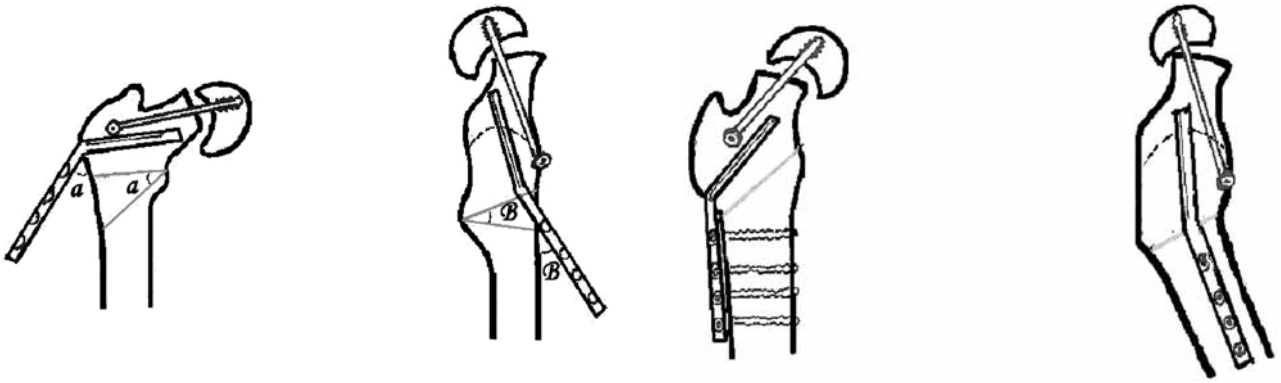

Fig. 2. — The device should be inserted at the same angles as the angles of the osteotomy

fixing the epiphysis. The K-wire and the seating chisel should be inserted at angles exactly the same as the angles of osteotomy (as predetermined in the pre-operative plan). With a water-cooled oscillating saw, the proximal osteotomy cut is started (but not completed) parallel to the seating chisel and just proximal to the lesser trochanter as determined by the preoperative drawings. The blade-plate is then inserted after removing the seating chisel. With a template, the angle for the distal osteotomy is marked, and both cuts are completed with the oscillating saw, and the bone wedge is removed. The osteotomy is closed by flexing, abducting and slightly internally rotating the distal fragment. Compression is applied and the side plate is secured to the femur with screws. After obtaining haemostasis, a suction drain is placed and the wound closed in the usual fashion (fig 2a-d).

Postoperative treatment

All patients started active exercises of the hip and knee as soon as pain was tolerated after surgery. Ambulation was allowed with partial weight-bearing about a week post-operative. Full weight-bearing was permitted after radiographic union of the osteotomy, but not necessarily of the physis.

Follow-up and assessment of results

All patients were followed up both clinically and radiologically.

a) *Clinical follow-up* :

Pain, limping, hip movements, deformity, limb length and function were recorded.

b) *Radiographic follow-up*

Antero-posterior and frog-leg lateral radiographs were examined for union of the osteotomy, physeal fusion, width of the joint space, joint congruity, and evidence of complications (chondrolysis, avascular necrosis, arthrosis and screw penetration).

The criteria proposed by Hall *(8)* were used to evaluate the results. A hip was rated as excellent if the patient had no pain, unlimited function, with a range of motion similar to the uninvolved hip. In the patients who had bilateral involvement, the range of motion had to be equal to 85% or more of the expected normal range. Radiologically, the joint space and the contours of the femoral head and acetabulum should be normal. A hip was rated as good if the patient had no or slight pain and had a range of motion of 75 to 85% of normal. Radiologically, no incongruity or joint space narrowing should be seen. A hip was rated as fair if the patient had moderate pain and limp, restricted function and a range of motion between 50 and 75% of the normal ; radiologically, slight incongruity and joint space narrowing. A hip was rated as poor if the patient had severe disabling pain, less than 50% of normal range of motion and radiologically advanced osteoarthritic changes.

Statistical analysis was performed using the two-sample Student test and the chi-square test. $P < 0.05$ was considered statistically significant.

RESULTS

All 18 patients were followed up for an average of 8 years (range : 1.5 to 10). The osteotomy site had healed at an average of 6 weeks (range : 4 to 10). Physeal fusion was demonstrated in both

Table I. — Overall Results

Results	No. of patients	%
Excellent	15	83.3%
Good	2	11.1%
Fair	1	5.6%
Poor	0	0
Total	18	100%

Table II. — Changes of head-shaft angle on A/P view

Angle	Range	Average
Preoperative	85° – 105°	95°
Postoperative	115° – 125°	120°
Correction	15° – 35°	25°
p value	0.228 "statistically insignificant"	

Table III. — Changes of head-shaft angle on lateral view

Angle	Range	Average
Preoperative	50° – 65°	56°
Postoperative	10° – 20°	14°
Correction	30° – 50°	42°
p value	0.031 "statistically significant"	

antero-posterior and frog-leg lateral radiographs at an average of 8 months (range : 4 to 14).

According to Hall's criteria (*8*), 15 hips were rated as excellent (figs 3 & 4), two as good (fig 5), one as fair and none as poor (table I).

The changes in the head-shaft angle on the antero posterior view are shown in table II, and those on the frog-leg lateral view are shown in table III.

After an average follow-up of 8 years, there was a statistically significant improvement in the range of motion in extension, abduction and internal rotation (table IV). The average range of internal rotation was 35° (range : 30 to 45), the average range of flexion 126° (range : 120 to 135), and the average abduction 42° (range : 30 to 50).

Preoperative shortening of the affected limb was present in all patients, ranging from 1.5 to 3 cm (average : 2 cm). Postoperatively, 14 patients had equal limb length, one patient had increased length of the involved limb by one cm, due to valgus overcorrection. Three patients had shortening of the operated limb averaging 1.8 cm (range : 1.5 to 2.5 cm).

Preoperative joint space narrowing was present in one patient (3 mm). The width of the joint space improved by 5 mm within 2 years after osteotomy (fig 5). Postoperative joint space narrowing was present in one patient, which was restored to normal width (4.5 mm) within one year. One patient had a superficial wound infection, which healed with dressing and antibiotics. No patient had avascular necrosis. None of the patients in this series had manifestations of early arthrosis.

DISCUSSION

The main goal when dealing with SCFE is to prevent further progression of the slip and bring the relationship between the femoral head and acetabulum as close as possible to the anatomic position, in an attempt to avoid the development of osteoarthritis in the future. Theoretically, a joint subjected to abnormally oriented forces, as is the case in severe SCFE, is more prone to undergo changes such as chondrolysis, degenerative arthritis, and stiffness. Therefore, most osteotomies are primarily designed to realign the femoral head with respect to the neck or diaphysis to restore the normal biomechanics of the hip (*6,15*).

Although chronic slips of the capital femoral epiphysis of a mild or moderate degree can remodel after fixation *in situ* (*2,4*), it is generally conceded that a severely slipped epiphysis requires a corrective osteotomy to restore adequate range of motion and to prevent early degenerative changes (*6,23*). This has recently been discussed in a study by Diab *et al* (*4*) who found that an osteotomy does not improve the early outcome after slipped capital femoral epiphysis.

A variety of osteotomies are available to redirect or reconstruct the proximal femur after slipped capital femoral epiphysis. Although they can be used in conjunction with stabilisation of the slip, their primary role is to restore more normal anatomy and mechanics (*3*). Osteotomies of the femoral neck close to or at the site of the deformity are the

Fig. 3. — a : 12-year-old boy with left severe degree chronic slipped capital femoral epiphysis (lateral head-shaft angle 55°) ; b : Postoperative AP view. Proper fixation of the epiphysis and of the osteotomy with good correction of head-shaft angle ; c : Postoperative frog-leg lateral view of the same patient with proper correction of the head-shaft angle ; d : AP view after four years, shows normal head-shaft angle, normal joint space and complete physeal fusion ; e : Frog-leg lateral view of the same patient ; f : Proper remodeling of the proximal femur after four years.

Fig. 4. — a : Ten-year-old boy with right severe degree chronic slipped capital femoral ephysis (lateral head-shaft angle 60°) ; b : AP view after 6 years showing a normal head-shaft angle,a normal joint space and a complete physeal fusion ; c : Frog-leg lateral view of the same patient after 6 years ; d : Proper remodeling of the proximal femur.

best way of restoring a near-normal anatomy, however, they are associated with a very high risk of avascular necrosis (*21,22*). Moreover, the amount of correction obtained by this technique is limited to a maximum of 70° of posterior slip (*6*). Many surgeons therefore prefer osteotomies through the intertrochanteric region that are much safer, and the hip capsule is not opened (*6,18*).

The epiphyseal plate in all the hips in our series was still open, so we combined the biplane osteotomy with epiphyseal stabilisation using a single cancellous screw through the anterior neck to avoid displacement of the epiphysis during fixation of the osteotomy by the angled blade plate and to prevent the possible progression of the slip later on.

Chondrolysis was found postoperatively in one hip which improved to normal within one year. We have not found preoperative joint space narrowing to be an absolute contra-indication to this procedure as the one hip in our series with preoperative joint space narrowing improved to normal within two years after surgery. The improvement of the width of the joint space may be due to restoration of the normal mechanics of the hip.

Fig. 5. — a : 11-year-old girl with bilateral chronic slip, severe on the left (head- shaft angle 55°) and mild on the right with joint space narrowing ; b : Four years after osteotomy and epiphyseal fixation of the left side and percutaneous single screw fixation on the right side ; c : Frog-leg lateral view of the same patient ; d : Final AP view after removal of the implant ; e : Final frog-leg with proper correction of the head-shaft angle and normal joint space (there is an improvement of the right joint space of 5 mm).

According to the stability classification of the slip (*1*) we had one unstable hip, managed by the same protocol and graded postoperatively as fair in agreement with other authors (*10,22*) who noted a relationship between the stability of the slip and the prognosis.

Our results are comparable to those of Southwick (*20*) who reported 75% excellent results in his series after biplane osteotomy and Newman (*13*) who reported 80% excellent results. Our results agree also with the results of Rao *et al* (*17*), who reported 79% excellent results in their series after biplane osteotomy fixed by compression instrumentation. However, Rao *et al* (*17*) did

Table IV. — Changes between average pre- and postoperative hip range of motion

	Pre-operative	Post operative	p value
Internal rotation	– 38°	35°	0.003
External rotation	63°	46°	0.142
Abduction	20°	42°	0.039
Adduction	20°	20°	0.164
Flexion	88°	126°	0.154
Extension	0°	5°	0.006

not fix the epiphysis and stated that this is not necessary, as the slip does not show a tendency to progress after osteotomy. In our series we fixed the epiphysis in all cases as we agree with Busch and Morrissy (*3*), that once a slip begins, the hip remains at jeopardy for progression until the physeal plate closes.

Schai *et al* (*19*) in their long-term follow up (24 years) of 51 patients with unilateral severe slipped capital femoral epiphysis treated by trochanteric corrective osteotomy, reported that 55% had neither radiographic signs nor clinical symptoms of degenerative hip disease, whereas 28% had moderate arthritis. They recommend correction as early as possible to allow for maximum remodeling.

Most of the patients in our series achieved near-normal hip flexion, internal rotation and abduction, without pain and without restriction of function, and most were able to bear weight in the early post operative period.

The adequate correction of the deformity, the use of compression fixation of the osteotomy and the proper fixation of the epiphysis together with avoidance of postoperative immobilisation and early weight bearing were probably responsible for the good results and the low complication rate in our series. From our results and the results of others, we conclude that this procedure appears to offer a workable solution to the problem posed by the chronic severely slipped capital femoral epiphysis.

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