Surgical hip dislocation for anatomic reorientation of slipped capital femoral epiphysis: preliminary results

ORIGINAL ARTICLE

Surgical hip dislocation for anatomic reorientation of slipped capital femoral epiphysis: preliminary results

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Abstract: *Controversies exist regarding the best treatment for slipped capital femoral epiphysis (SCFE). Subcapital anatomical reorientation of the epiphysis by surgical dislocation and a retinacular soft tissue flap has been described recently as an effective approach. We evaluated the clinical and radiographical efficacy of this technique and compared these to published results.*
A series of 20 SCFE (18 stable, 2 unstable) treated by subcapital re-orientation through surgical hip dislocation and an extended retinacular soft tissue flap was reviewed retrospectively. Preoperatively and at most recent follow-up, patients were clinically examined with regard to pain and function according to the Harris hip score and to the Western Ontario and McMaster universities (WOMAC) score. Radiological examination included measurement of preoperative and postoperative anteroposterior (AP) and lateral (L) Southwick angles; and at follow-up the alpha angle was measured.
The average follow-up time was 24 months. The mean WOMAC score was 2.80 post-operatively. The mean pre-operative slip angle was 40.2 degrees on the AP view and 50.65 degrees on the lateral view. Post-operatively, the mean values were 7,20 degrees on the AP view and 9,45 degrees on the lateral view. The mean post-operative average alpha angle was 43,11 degrees. No cases of avascular necrosis were seen.
Our short term clinical and radiographic results are similar to outcomes published in the recent literature. The small number of technical complications appears favourable considering the surgical complexity of the procedure, and our technique offers clear advantages in treating these complex deformities.

Key words: *Slipped capital femoral epiphyses, Hip, Femoracetabular impingement, Osteotomies, Surgical dislocation*

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INTRODUCTION

Slipped capital femoral epiphysis (SCFE) is a common hip disorder in adolescents and is characterised by posteroinferior migration of the epiphysis on the metaphysis through the physis. An incidence from 0.2 (Japan) to 10 (United States) per 100,000 has been reported (1). The mean age at diagnosis is 13.5 years in boys and 12.0 years in girls, and the age at diagnosis decreases with increasing obesity (1). Most series report bilateral involvement in as many as 63% of patients (1). The traditional classification subdivides SCFE into acute, chronic, and acute-on-chronic slips (2)

but the most frequently employed classification divides SCFE into 'stable' or 'unstable' cases and is based on the ability of the patient to walk (3).

Most investigators agree that once SCFE is diagnosed surgical treatment is indicated, but significant controversies exist regarding the best treatment (4). In fact, a variety of surgical procedures have been described including percutaneous fixation, compensatory osteotomies and direct corrections of the deformity at the head-neck junction. The first two of these are not intended to achieve an anatomically aligned epiphysis (5). Correction at the site of deformity is reported to risk the blood supply to the epiphysis (6, 7) and therefore has not found wide acceptance. Better understanding of femoroacetabular impingement (8), a pathomechanical process of which SCFE can be an initiator (9), has renewed interest in direct correction of the deformity following SCFE. Surgical dislocation and preservation of the retinacular flap allows open subcapital reorientation of the epiphysis, protecting the epiphyseal vascularisation (10).

The aim of our study was to evaluate the clinical and radiographical efficacy of this technique and compare these to published results.

PATIENTS AND METHODS

All patients presenting to one of the authors' clinics with stable or unstable SCFE between January 2007 and October 2009 were included in this retrospective study, which was performed in accordance with the ethical standards in the 1964 Declaration of Helsinki and has been carried out in accordance with relevant regulations of the US Health Insurance Portability and Accountability Act (HIPAA).

Criteria for exclusion from the study were hips with established necrosis before the index procedure, those with chronic epiphysiolysis of 30° or less (for which trimming of the metaphyseal overhang and pinning was performed), and hips with advanced ankylosis. All patients were treated with the technique of surgical dislocation and preservation of an extended retinacular flap, allowing an anatomic subcapital realignment. In four cases the epiphysis was found to be disconnected from the metaphysis or the connection was very easy to mobilise. Initial procedures were performed under the supervision of the senior author (RG), and the learning curve was further facilitated by detailed videos of the procedure. Non–weight bearing on the affected limb with crutches was recommended for 6 to 8 weeks after surgery, and active abduction and passive adduction were restricted for 4-6 weeks. Unrestricted function was allowed after 12 weeks.

Preoperatively and during follow-up the patients were clinically examined with regard to pain, stiffness and function according to the Harris hip score (11) and the Western Ontario and McMaster universities (WOMAC) score (12) (the latter only post-operatively). Radiological follow-up examinations were carried out before the surgical procedure and on the most recent post-operative visit. Preoperative and postoperative AP and L Southwick angles were measured (13), as well as the alpha angle (14) (the latter only on post-operative films).

Our case series was compared with other published series and a statistical analysis was performed. All study data were recorded in a custom made database and analysed by a commercial software package (TexaSoft, WINKS SDA Software, 6th Edition, Cedar Hill, Texas, 2007). Normal data distribution was checked by the test for equality of variance. The case series was compared regarding age, follow up, pre operative and post-operative Southwick angles, alpha angles, post-operative total pain and function score (WOMAC) and total score (HHS) by the independent group t-test. Statistical significance was fixed at $p<0.05$ for all tests performed.

Surgical technique

Surgical dislocation was performed in a lateral decubitus position through a straight lateral incision, the length depending on the thickness of the subcutaneous tissue (5). Fasciotomy was performed in line with the perforating vessels indicating the anterior border of the gluteus maximus muscle. The entire gluteus maximus muscle was released from caudad to cephalad (15) and retracted posteriorly together with the thin fascia of the gluteus medius containing the blood vessels and nerves of this muscle (16). For sufficient proximal release of this muscle the skin incision was undermined, allowing full exposure of the posterior margin of gluteus medius, the posterosuperior tip of the greater trochanter and the insertion of gluteus maximus.

A digastric trochanteric osteotomy was performed using an oscillating saw. The trochanteric fragment should normally not be thicker than 1.5 cm. In the presence of severe fixed external rotation when the oscillating saw could not be properly positioned, the osteotomy was executed with osteotomes cutting more from distal to proximal. Further dis-

Fig. 1- *Chronic SCFE in a 19 old male patient with symptoms over a period of 14 months (case no. 4). Substantial medial and posterior slipping and callus formation at the posterior surface of the neck (arrow). Slight narrowing of the supero-lateral joint space.*

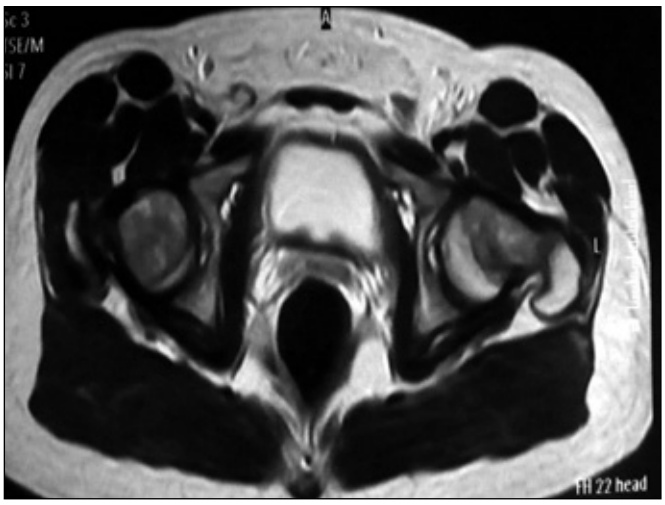

Fig. 2 - *MRI-slice of both hips showing the slip (case no. 4) shows the callus at the posterior head neck junction.*

section then continued to expose the joint capsule between the piriformis tendon and gluteus minimus muscle. This interval is of importance in preserving the blood supply to the femoral head. The mobile trochanter was flipped anterosuperiorly, facilitated by releasing residual fibres of the gluteus medius and posterior insertion of the vastus lateralis down to the mid-level of the gluteus maximus tendon. Gradual mobilisation of the posterior, superior and anterior parts of gluteus minimus exposed the capsule to beyond the acetabular rim. All external rotators initially remained attached to the stable trochanter. A Z-shaped capsulotomy followed, whereby the component axial to the femoral neck began close to the anterosuperior edge of the stable trochanter. The inside-out direction of the capsulotomy along the femoral neck helped to avoid injury to retinaculum, cartilage and labrum, followed by the anterior capsular cut directed toward the anteroinferior acetabular rim and the posterior branch of the capsulotomy along the acetabular rim. Thereafter, the stability of the epi-metaphyseal connection was observed as well as the amount of slip. With gentle flexion and internal rotation, the presence of and range of impingement were assessed. If the epiphysis was disconnected, it was immediately stabilised in situ, without any attempt at correcting the position using two 2-mm Kirschner wires. Tp sublux the femoral head the leg was moved into external rotation, adduction, and flexion and the lower leg placed into a sterile bag on the opposite side of the table. For full dislocation the round ligament was cut with parametrium

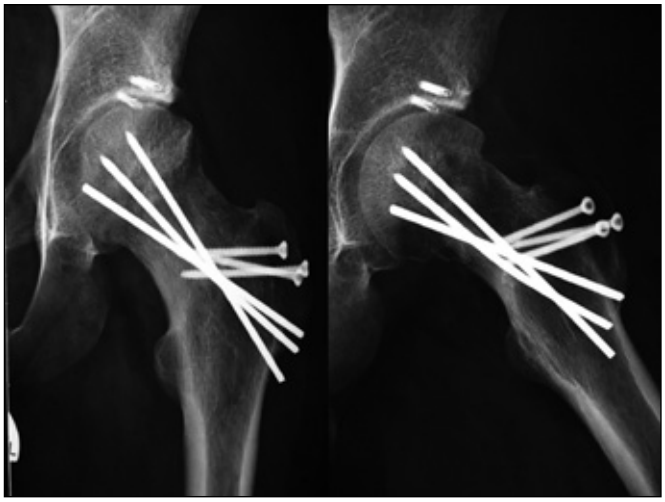

Fig. 3 - *Antero-posterior and lateral X-rays result of subcapital reorientation, 16 months after surgery (case no. 4). Intraoperatively severe acetabular cartilage damage and labrum disconnection were found and treated with debridement and labrum refixation (two bone anchors). Narrowing of the supero-lateral joint space still present.*

scissors, and 360° exposure of the acetabulum could be achieved by manipulation of the leg from the opposite side by the assistant and insertion of special retractors at the anterior acetabular rim and in the acetabular notch. Localisation and extent of cam impingement at the metaphysis could then be demonstrated, along with any damage to the acetabular cartilage and labrum (Figs. 1-3). Labral refixation with suture anchors was performed if necessary. To create the retinacular flap the head was put back into the socket.

The postero-lateral portion of this flap contains the main vessels to the epiphysis and extends from the head-neck junction down to the lesser trochanter, and creation of the flap allows exposure of the postero-lateral surface of the neck. To allow retinacular flap preparation without damaging the vessels, the bone of the stable trochanter proximal to the physis was subperiosteally taken down to the level of the femoral neck using a 'piece-meal' technique. Thereafter, the subperiosteal release of the retinaculum was gradually continued from the lateral and posterior femoral neck using a scalpel and periosteal elevator. The same subperiosteal preparation was applied to the medial flap containing the branch of the medial circumflex femoral artery to the inferior portion of the epiphysis (17). This step is easier to perform with hip dislocated. The final result of the subperiosteal dissection was a soft tissue tube around the neck containing the vessels to the epiphysis and a circumferentially accessible bony neck. Any tension applied to the soft tissue tube was distributed over a long distance reducing the risk of adverse tension or rupture of the vessels. A curved chisel was then driven into the growth plate to slowly separate the epiphysis from the metaphysis. Before and after this step the perfusion of the epiphysis can be tested with a two mm drill hole. Careful external rotation of the leg allowed further exposure of the metaphyseal stump, while spontaneous reduction of the epiphysis into the acetabulum was prevented with a cotton swab placed in the socket. With the epiphysis out of the socket, adverse movements are less likely to produce harmful tension in the retinaculum compared with the situation when the head is reduced. There is always some callus formation at the posterior aspect of the metaphysis, even in acute slips, and if it can not be seen it can be palpated. This callus was removed using a straight osteotome. Shortening of the neck should not be performed, as it may be dangerous and may create a relatively longer retinaculum, followed by compression of the retinacular vessels. The next step was curettage of the remainder of the growth plate from the epiphysis, best performed with manual stabilisation of the mobile epiphysis. Thereafter the epiphysis can be reduced onto the neck stump without abnormal tension in the retinacular flap, but care must be taken that the flap is not folded during the reduction. A 3.0 mm fully threaded wire was then drilled through the fovea capitis in a retrograde direction, and after retraction of this wire below the articular surface the head was carefully repositioned in the acetabulum. Normal alignment of the retinacular flap was assessed and perfusion tested again. Precise spatial alignment of the epiphysis is important and intraoperative fluoroscopic control is recommend after preliminary fixation. When the head position was correct, one or two more fully threaded wires were inserted in an anterograde diection to secure the position of the head. After final repositioning a further check that the retinaculum was falling back in place without a fold was made. Positioning sutures were applied to the retinaculum and capsule without any tension. Finally the trochanteric fragment was refixed about 5 mm more distally with 2 screws. Care was taken, that the trochanter did not compress the soft tissue of capsule and retinaculum.

RESULTS

All 20 patients were reviewed (Tab. I). The average age at surgery was 14.3 years (range: 9-19 years). The average follow-up time was 24 months (13-42 months). All but two patients were able to weight bear at the time of preoperative presentation, at which time all patients presented with limited range of motion of the affected hip, particularly internal rotation. The two non-ambulatory patients (classified as unstable) had a disconnected epiphysis at surgery (case nos. 2 and 5). In two further cases clinically classified as being stable, blood-stained fluid and rupture of the anterior periosteum was seen intra-operatively and the epiphysis was mobilised very easily from the metaphysis (case nos. 15 and 18). In 16 patients the epyphisis was classified intraoperatively as stable. All hips had variable evidence of labral and acetabular cartilage damage. Two cases with chronic hip pain (14 and 16 months, cases 4 and 13) had substantial abrasion of the acetabular cartilage and labral damage, necessitating debridement and labral refixation.
No patient developed osteonecrosis, chondrolysis, infection, deep venous thrombosis, nerve palsy or heterotopic ossification. Patient no. 5 had potential wire penetration into the hip joint on early radiographs; revision surgery was performed and the wire re-positioned properly. No patient developed mal-union or non-union at the metaphyseal-epiphseal junction or greater trochanter. Metal removal was performed in patient 3 for local pain over the greater trochanter. The mean pre-operative slip angle was 40.2 degrees on the anteroposterior view and 50.65 degrees on the lateral view. Post-operatively mean values were normalised with 7.20 degrees epi-metaphyseal angle in the anteroposterior view and 9.45 degrees in the lateral view.

TABLE I - POPULATION DATA

Patient no.	Age at surgery	Follow up (m)	Preop AP slip angle	Postop Ap epiphyseal angle	Preop LL slip angle	Postop LL angle	Alpha angle	Postop Womac pain score	Postop Womac function score	Harris hip score
1	9	42	10	8	55	8	50	0	0	100
2	10	37	35	12	52	2	54	0	0	100
3	12	36	17	7	48	12	48	0	0	100
4	19*	34	39	8	40	10	52	0	0	100
5	15	28	49	7	45	10	54	4	11	90
6	17	26	13	9	42	10	60	2	8	92
7	14	24	25	5	42	10	50	0	0	100
8	16	23	50	6	48	2	46	0	0	100
9	13	22	25	8	52	6	42	2	6	92
10	14	22	15	-2	54	4	56	3	12	98
11	13	22	55	8	50	8	42	0	0	100
12	15	22	35	7	54	9	43	0	0	100
13	17	22	69	0	50	14	ND	0	4	96
14	16	21	61	11	52	12	28	0	0	100
15	12	21	99	13	60	20	30	0	0	100
16	15	20	73	9	54	14	20	0	0	100
17	16	19	62	11	50	24	30	1	3	96
18	9	18	14	6	55	11	32	0	0	100
19	14	16	5	6	50	1	46	0	0	100
20	16	13	53	5	60	2	36	0	0	100
all	***14.28***	***24.4***	**40.2**	**7.2**	**50.65**	**9.45**	**43.11**	***0.6***	***2.2***	***98.2***

The post-operative average alpha angle was with 43.11 degrees (within normal range). Short-term postoperative clinical outcomes were near normal with a mean WOMAC score of 2.80 (0.60 points for pain and 2.20 for function). The mean HHS was 98.2 points, and all but 6 patients had 100 points. The main limitation for these 6 patients was occasional mild pain.

DISCUSSION

To our knowledge, four articles have been published regarding the treatment of SCFE with surgical dislocation (1, 5, 19, 20). Spencer et al (19) presented a comparison between surgical dislocation with femoral head-neck osteoplasty only (Spencer O) and the same procedure associated with inter-trochanteric osteotomy (indicated as Spencer (O+O). Ziebarth combined two case series, from two institutions (20). Comparisons of clinical results of these studies with our study are shown in Table II, and in Table III the radiographic results are compared. Two articles (18, 19) provided only mean clinical values and not detailed results for each patient. Therefore a statistical comparison with our study not possible. No statistically significant difference was found between our study and the other papers (p values are shown in Table III).

TABLE II - COMPARISON OF PUBLISHED CLINICAL RESULTS

	Patients	Follow up	Post-op Womac pain score	Post-op Womac function score	Post-op Harris hip score
Leunig	30	55	***	***	***
Rebello	22	41.6	3.5 (N.A.)	11.1 (N.A.)	***
Spencer (O+O)	6	12	5 (N.A.)	13 (N.A.)	***
Spencer (O)	6	16	3 (N.A.)	7 (N.A.)	***
Ziebarth (a)	30	64.3	***	***	99.57 (p=0.01)
Ziebarth (b)	10	26.3	1.2 (p=0.03)	3 (p=0.02)	***
Present study	*20*	*10.65*	*0.6*	*2.2*	*98.2*

TABLE III - COMPARISON OF PUBLISHED RADIOGRAPHIC RESULTS

	Patients	Follow up	Pre-op slip angle	Post-op slip angle	Post-op alpha angle
Ziebarth (a)	30	64.30	45.60 (p=0.02)	***	40.72 (p=0.02)
Ziebarth (b)	10	26.30	56.60 (p=0.046)	8.60 (p=0.001)	***
Present study	*20*	*10.65*	*40.20*	*7.20*	*43.11*

The widely accepted SCFE treatment today is pinning in situ with single or multiple screws with the goal of preventing further slip progression. However, even mild slips may lead to early acetabular labrum and cartilage damage (5, 21-23), an observation confirmed arthroscopically (24, 25) It has been shown that the metaphyseal bump limits internal rotation and leads to femoroacetabular impingement (26). Remodelling of the epi-metaphyseal contour in severe slips will not reduce impingement but changes the impingement type from pincer to cam resulting in even more damage to the acetabular cartilage (9). Painful SCFE hips treated with surgical hip dislocation revealed cartilage damage in 6 of 8 mild, 16 of 20 moderate, and 10 of 11 in severe slips (9). Another recent study (27) reviewed 52 patients with severe SCFE treated with pinning in situ and reported a high rate of unsatisfactory results (16 fair and 9 unsatisfactory), and underlined the technical difficulties in achieving correct pin placement. Boyer et al (28) presented a series of 149 slips followed for an average of 41 years, showing that 12% of mild slips required additional surgery (not specified), and 15% showed moderate or advanced arthritis, a figure which is high compared with a general prevalence of 1.7% in this age group (29). Finally, percutaneous pinning of unstable slips is reported to have a high rate of epiphyseal necrosis ranging from 10% to 40% (4). Although the severity of displacement, time delay to surgery in unstable slips, and attempts at closed reduction may be responsible for the high rates of necrosis, it is difficult to identify the most important risk factor without open surgery.

For severe slips a number of distant correction osteotomies have been proposed. Intertrochanteric osteotomy (30) and anterior cuneiform wedge osteotomy of the base of the neck (31) are the most popular ones. The first does not sufficiently address impingement at the antero-lateral head-neck junction. Simulation of different corrections for different slip angles can show how limited these osteotomies are in terms of impingement, although an antero-posterior radiograph may show a satisfactory alignment. Furthermore, with distant osteotomies, additional intra-articular observations are limited. Gholve et al (32) expressed some doubts about the usefulness of distant osteotomies, and Kartenbender et al (33) reported a high rate of unsatisfactory results in a group of 35 patients (39 hips) 13.7 years after an Imhaeuser osteotomy with 23% fair or unsatisfactory clinical results and only 66% good or excellent radiographic results. Direct reductions may therefore become more favoured in the future. Femoral neck osteotomy with the execution of an anteriorly based wedge resection does not address the posterior cal-

lus directly, but may reduce tension in the retinaculum during reduction by shortening. Fish (6) reported favourable results, but he had a 4.5% necrosis rate. Velasco et al (7) performed a cuneiform osteotomy in 60 hips. At a mean follow-up of 16 years, osteonecrosis had developed in 7 (11%), chondrolysis in 8 (12%), and degenerative arthritis in 19 (40%) of 48 hips that were followed. Although representing a technique of direct correction of the deformity, the disadvantages are I) that the amount of neck shortening to overcome the adverse retinacular tension of the retinaculum due to the posterior callus is difficult to define, II) that eventually necessary anterior translation of the epiphysis increases the risk of adverse tension of the retinaculum and III) no active control of the blood supply by observing the retinaculum and its tension is possible. Therefore, a certain number of cases may undergo iatrogenic necrosis of the epiphysis. Dunn (34) introduced postero-lateral dissection of the retinaculum to allow some trimming of the callus formation at the posterior neck, the procedure being facilitated by a trochanteric osteotomy. The created space reaching from the head-neck junction to the axilla with the greater trochanter is rather narrow for perfect control of the retinacular tension during callus removal, and this may explain why necrosis of the epiphysis could not sufficiently be eliminated with this procedure (34, 35).

With detailed knowledge of the vascular supply of the femoral head and its extra- and intracapsular topography (17), safe surgical hip dislocation can be executed and has become a well accepted technique (36). Routine execution of the surgical dislocation approach allowed the development of an extended retinacular flap (37). This flap is about 3 times longer than the retinacular release with the Dunn technique. Distribution of tension over a larger distance decreases the risk of an adverse influence on the perfusion of the epiphysis. Dislocation of the femoral head out of the socket during manipulation further decreases the risk of unintended vascular damage, and allows well controlled manual reduction of the epiphysis on the metaphysis. However execution of the procedure is demanding and must be executed carefully and exactly following the original description. Avascular necrosis was not seen in the series reported by the pioneers of this approach (5, 11, 20) and it has not been observed in this study. Rebello et al (18) employed surgical dislocation for subcapital realignment in hips with an open physis and noted the safety of the technique. Trochanteric nonunion is reported as a rare complication of surgical dislocation in patient affected by femoroacetabular impingement (36) but is not common in SCFE patients. Our clinical and radiological follow-up results are comparable with those of others employing the same technique.

Ours was a multicentre retrospective study and had limitations (small number of cases, no case control group, not randomised, not double blinded). The Harris Hip score and WOMAC score are designed for other pathologies and procedures and do not address the specific problems of SCFE. Another major limitation is the short follow-up period. However, we believe that the technique is safe, efficient and reproducible, but it should be learned at a specialised centre.

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