

Treatment of chronic, stable slipped capital femoral epiphysis via surgical hip dislocation with combined osteochondroplasty and Imhauser osteotomy

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Abstract

Purpose Treatment of slipped capital femoral epiphysis (SCFE), including the modified Dunn procedure, restores anatomy with significant risk for avascular necrosis (AVN), if performed in the setting of moderate to severe, stable SCFE. The Imhauser osteotomy has been shown to be an effective way to correct residual deformity without the risk of AVN. We sought to evaluate the effectiveness and safety of a combined Imhauser osteotomy and osteochondroplasty, performed via a surgical hip dislocation approach for the acute and delayed treatment of stable SCFE.

Methods A retrospective review was performed on a series of patients who underwent Imhauser osteotomy and osteochondroplasty via surgical hip dislocation for treatment of chronic, stable SCFE. Patients were divided into acute or delayed treatment groups based on whether osteotomy was performed as the initial slip treatment.

Results In total 19 patients (15 male, four female, average age 13.7 years) were reviewed. Six osteotomies were performed acutely in combination with *in situ* pinning, 13 were delayed at least six months after *in situ* pinning (average 21.7 months). Two hips had labral tears that required repair. The mean follow-up was 61 months (23 to 120) (delayed) and 53 months (27 to 61) (acute). The average improvement in slip angle was 40.7° (delayed) and 50.2° (acute) ($p = 0.0916$), final post-operative slip angle averaged 15.8° (delayed) and 17.8° (acute) ($p = 0.544$). Femoral neck length and greater trochanteric height were similar between both groups. Average alpha angle at final follow-up measured 55.8° (delayed) and 60.8° (acute) ($p = 0.542$). No cases of AVN were identified.

Conclusion Imhauser osteotomy combined with osteochondroplasty via surgical hip dislocation approach is a safe and effective treatment of moderate to severe, stable SCFE performed in both the acute and delayed setting.

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Introduction

Slipped capital femoral epiphysis (SCFE) is one of the most common adolescent hip disorders in the United States. The displacement of the femoral neck relative to the femoral epiphysis results in a multiplanar deformity of the proximal femur. Severity of residual deformity following SCFE is directly related to early degenerative hip disease.¹⁻³ Natural history studies of patients with untreated SCFE demonstrate rates of osteoarthritis (OA) in the range of 16% to 64.3% in patients with mild slips to 60% to 100% in patients with severe slips.⁴ Patients may experience significant hip pain prior to radiographic evidence of arthritis, secondary to femoroacetabular impingement (FAI) and labral damage produced by the deformity of the proximal femur.^{3,5,6} Cam, pincer and mixed impingement results in abnormal labral and cartilage degeneration and early hip joint arthrosis.^{7,8}

Although *in situ* pinning remains a common and safe treatment option, restoration of proximal femoral morphology during the treatment of SCFE would likely optimise outcomes. Recent methods of treatment, including the modified Dunn procedure, have shown effectiveness in restoring anatomy, but carry significant risk for avascular necrosis, especially in the chronic, stable slip.^{9,10} The Imhauser proximal femoral osteotomy has been shown to be a safe and effective way to treat patients with residual SCFE deformity with lower risk of chondrolysis and avascular necrosis.^{4,11,12} A number of studies have demonstrated lower rates of radiographic OA following Imhauser osteotomy when compared with rates seen in natural history

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Fig 1 Pre-operative anteroposterior (AP) (a) and frog-lateral radiographs (b) revealing chronic, severe left SCFE.

studies of untreated SCFE.¹¹⁻¹³ However, full restoration of anatomy may be difficult in those hips with severe deformity and significant metaphyseal prominence. Addressing the proximal femoral deformity via a surgical hip dislocation allows the surgeon to address this metaphyseal prominence in the form of an osteochondroplasty, as well as any existing labral and cartilage pathology.^{5,14}

The purpose of this study was to evaluate the comparative effectiveness of a combined Imhauser osteotomy and osteochondroplasty performed via a surgical hip dislocation approach in both the primary and delayed setting, with outcomes related to improvement in radiographic parameters and rate of complications.

Patients and methods

Following Institutional Review Board approval, a retrospective chart review was performed on a consecutive series of patients who underwent an Imhauser proximal femoral

osteotomy and osteochondroplasty through a surgical hip dislocation for treatment of chronic, stable SCFE by a single surgeon (KK). Patients were divided into primary or delayed treatment groups based on whether the osteotomy was performed in combination with *in situ* screw fixation during the initial treatment of the slip (primary) or as secondary procedure done following a previous *in situ* screw fixation (delayed) at least six months prior.

Patients treated in the primary setting underwent *in situ* screw fixation of their epiphysis by the senior surgeon (KK) following exposure via a surgical hip dislocation approach, with subsequent osteochondroplasty and proximal femur osteotomy. Patients treated in a delayed fashion underwent removal of the previously placed *in situ* SCFE screw during the simultaneous hip osteotomy. Surgical hip dislocation was performed as described by Ganz et al.¹⁵ Patient enrolment was at the original treating surgeon's discretion.

With the patient in the lateral decubitus position, a lateral incision centred over the greater trochanter was used. After the fascia lata was incised, the vastus lateralis and gluteus medius muscles were identified. The planned blade plate chisel was seated at the appropriate location and introduced approximately 1 cm to 1.5 cm in depth. The chisel was removed and the trochanteric osteotomy was made using an oscillating saw. The trochanteric wafer was then flipped and reflected anteriorly. After identification and retraction of the piriformis tendon at the base of the greater trochanter, a Z-shape capsulotomy was performed along the anterior neck with the proximal arm extending posteriorly along the acetabular rim and the distal arm extending anteriorly proximal to the lesser trochanter. If performed at presentation, *in situ* screw fixation using a 7.3-mm fully threaded, cannulated screw was carried out. The hip was then dislocated anteriorly and the ligamentum teres transected. With the hip dislocated, the femoral head, acetabulum and labrum were inspected for pathology and addressed accordingly. Osteochondroplasty was performed to reduce the metaphyseal prominence via a T-shaped periosteal reflection off the head/neck junction. After reduction of the hip and closure of the hip capsule, the blade plate chisel was placed into the metaphysis. Placement dictated the amount of flexion deformity correction and position was based on pre-operative radiographic measurements, with an attempt to fully correct the preoperative slip angle. A transverse intertrochanteric osteotomy was performed and fixated with a 90° blade plate in standard AO fashion, transfixing the trochanteric osteotomy and the internally rotated distal fragment. Rotation was estimated based on pre-operative range of motion, hoping to mirror the contralateral hip or achieve at least 15° of internal rotation while the hip was flexed 90°. In some cases, additional trochanter osteotomy



Fig 2 Status post *in situ* pinning left SCFE, pre-operative view prior to left surgical hip dislocation, osteochondroplasty and Imhauser osteotomy performed in delayed fashion six months following.

stabilisation was performed with 3.5 mm cortical screws. All patients were instructed to maintain weight-bearing precautions (touch down only) for six weeks, and an abductor pillow was discontinued at two weeks post-operatively (Figs 1–3).

Patient demographics including age, sex and time to delayed surgery were reviewed. Radiographic parameters included: pre- and post-operative slip angles; femoral neck lengths (FNL); greater trochanter height (GTH); and post-operative alpha angles. Alpha angle was measured on the frog-lateral radiograph as described by Nötzli et al.¹⁶ Severity of the SCFE was classified based on the Southwick angle measured on the lateral radiograph: mild (0 to 300); moderate (300 to 500); and severe (> 500). Complications were recorded. Variables were analysed and compared with the use of Pearson chi-square tests and independent sample t-tests.

Results

A total of 19 patients with chronic, stable SCFE underwent a combined Imhauser osteotomy and osteochondroplasty through a surgical hip dislocation approach between December 2009 and March 2015 were reviewed. All cases were performed by the senior author. There were 15 males and four females. The average age was 13.7 years (12 to 19). Six slips were classified as moderate (slip angle between 30° and 50°) and 13 were classified as severe (slip angle > 50°). Six osteotomies were performed primarily, in combination with *in situ* pinning (mean pre-operative slip angle 68°, range 59° to 80°). While the 13 osteotomies were delayed at least six months after *in situ* pinning (mean pre-operative slip angle 56°, range 42° to

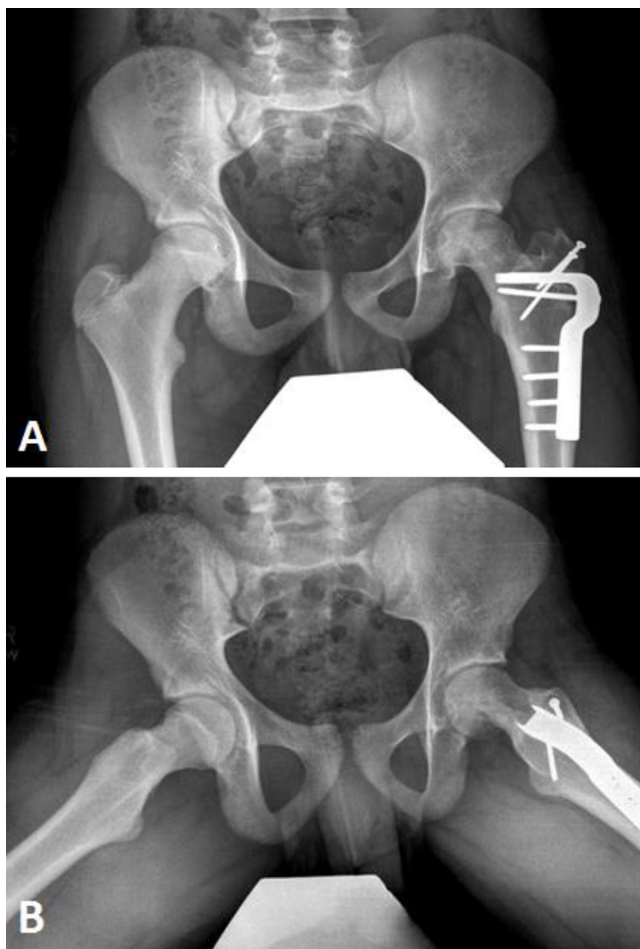


Fig 3 One-year status post corrective osteotomy. (a) AP, (b) frog.

85°). Average time between *in situ* pinning and delayed osteotomy was 21.7 months (6 to 45). All patients underwent osteochondroplasty of the femoral head/neck junction. Two hips had labral tears that required repair (both patients > 24 months status post *in situ* pinning). Five hips required additional trochanteric stabilisation after blade plate fixation. The mean follow-up was 61.7 months (23 to 120) in the delayed group and 53.5 months (27 to 61) in the primary group. Average improvement in slip angle was 40.7° in the delayed group and 50.2° in the primary group ($p = 0.0916$). Final post-operative slip angle averaged 15.8° (7° to 28°) in the delayed group and 17.8° (10° to 30°) in the primary group ($p = 0.544$). Post-operative FNL and greater trochanteric height were similar between both groups. Average alpha angle at final follow-up measured 55.8° (36° to 84°; delayed) and 60.8° (38° to 86°; primary) ($p = 0.542$) (Table 1). One patient in the primary group had failure of instrumentation within two weeks of osteotomy requiring revision open reduction and internal fixation (ORIF). This was thought to be due to non-compliance with weight-bearing restrictions.

Table 1. Radiographic parameters.

Group	Primary	Delayed	p-value
Pre-op slip angle	68.0	56.5	0.064
Post-op slip angle	17.8	15.8	0.544
Post-op alpha angle	60.8	55.8	0.542
Pre-op FNL (mm)	24.0	24.5	0.845
Post-op FNL (mm)	27.5	27.6	0.964
Pre-op GTH (mm)	7.3	11.8	0.254
Post-op GTH (mm)	1.7	6.0	0.284

FNL, femoral neck length; GTH, greater trochanteric height (measured as distance of tip of greater trochanter above centre of femoral head).

One patient (delayed) required bone grafting and revision ORIF for nonunion at the osteotomy site. No cases of osteonecrosis or chondrolysis were identified.

Discussion

Treatment of moderate to severe, stable SCFE remains a challenging problem. Resulting deformity may lead to FAI and early degenerative joint disease. Treatment goals should include epiphyseal stabilisation and deformity correction while minimising complications. In mild cases, isolated osteochondroplasty or osteotomy may be sufficient to restore anatomy and eliminate impingement. However, in more severe cases, combined procedures are often necessary. The impingement in SCFE occurs at the head-neck junction, which makes it difficult to address with extra-articular procedures. Concurrently, intra-articular pathology, such as labral tears and chondral flaps, can also be addressed via intra-articular procedures.

Surgical dislocation with subcapital re-alignment via the modified Dunn procedure has been used to address both physeal stability and residual deformity. The approach also allows for identification of intra-articular pathology. However, preliminary data at our institution showed a 29% rate of avascular necrosis when the procedure was performed for chronic, severe stable SCFE. In addition, proximal femoral anatomy, such as greater trochanteric height and FNL, were more difficult to restore in the chronic setting *versus* in the acute setting. Surgical dislocation of the hip with combined Imhauser osteotomy and osteochondroplasty allows for deformity correction and removal of metaphyseal prominence, as well as identification and treatment of labral and chondral pathology while minimising the risk of AVN.

Schai et al¹³ reported on 61 patients (67 hips) treated with intertrochanteric osteotomy without osteoplasty for SCFE at mean follow-up of 24 years. The 51 patients were found to have unilateral slips in which a comparison could be made to the contralateral hip. Their indication for surgery was a moderate slip (slip angle 30° to 60°), with mild SCFE treated with *in situ* screw fixation and severe SCFE managed with subcapital osteotomy. They noted excellent clinical outcomes in 74.5% of cases with one AVN. Rates of moderate to severe OA were 28% and 17%, respectively.

Table 2. Summary of similar studies and reported avascular necrosis (AVN) rates.

Paper	Technique	AVN rate (%)
Current study	Imhauser with SHD/osteochondroplasty	0
Spencer et al, 2006 ¹⁴	Imhauser with SHD/osteochondroplasty	0
Davis et al, 2017 ¹⁹	Modified Dunn	29.40
Loder et al, 2013 ²⁰	Modified Dunn	21
Sikora-Klak et al, 2017 ²¹	Modified Dunn	29
Schai et al, 2007 ¹³	Imhauser	2
Kartenbender et al, 2000 ¹²	Imhauser	5.10
Maussen et al, 1990 ¹¹	Imhauser	3.80

Kartenbender et al¹² demonstrated similar clinical and radiographic outcomes on 39 hips (35 patients) treated with intertrochanteric osteotomy without osteoplasty for SCFE at mean follow-up of 23.4 years. Indications for surgery included slip angles > 30° (average 51°). Radiographic rates of mild (38.4%), moderate (25.6%) and severe (7.7%) OA were noted. Clinical outcome was rated as good or excellent in 77% of cases, with two cases of AVN. Table 2 summarises AVN rates reported in previous similar studies.

In patients with moderate to severe SCFE with open physes, the Imhauser osteotomy can also be combined with an epiphysodesis for physeal stability. Trisolino et al reported on 45 patients (53 hips) who underwent concurrent osteotomy and epiphysodesis for moderate to severe SCFE.¹⁷ Mean follow-up was 19 years. There were four complications in the early post-operative period, including two cases of AVN and two cases of chondrolysis.

While the Imhauser osteotomy is felt to adequately address the slip deformity, more recent literature has shown that intra-articular pathology (labral tears/chondral flaps) secondary to impingement may play a large role in subsequent pain and degenerative changes seen in the post-SCFE hip.^{5,7} While the modified Dunn procedure has been shown to restore proximal femoral anatomy and allow the surgeon to address intra-articular pathology, it also demonstrates a higher risk of AVN.^{9,18} For this reason, combined intra- and extra-articular procedures have been developed to address both residual deformity as well as chondrolabral pathology.

Spencer et al demonstrated significant improvement in pain and hip range of motion in 19 SCFE patients with FAI treated with surgical hip dislocation and osteochondroplasty with or without intertrochanteric osteotomy.¹⁴ No cases of AVN were seen.

Our indications for surgical dislocation and osteoplasty combined with Imhauser osteotomy include moderate to severe, stable SCFE. In the primary setting, which includes younger patients with open physes, concurrent epiphysodesis can be performed to stabilise the physis. In the chronic setting, the procedure is typically performed secondary to pain or limitations of functional hip motion. Our findings demonstrate the ability to restore proximal

femoral anatomy by reducing both slip angle and alpha angles to normal or near normal values. By restoring anatomy and removing sources of impingement, progression to early degenerative joint disease may be prevented or delayed. No significant differences were observed between the acute and delayed treatment groups with regards to deformity correction or complication rate at latest follow-up. Care should be taken, however, in the setting of prolonged limitations in weight-bearing, as secondary osteopenia may predispose the patient to instrumentation related failure.

In conclusion, Imhauser osteotomy combined with osteochondroplasty through a surgical hip dislocation approach is a safe and effective treatment of moderate to severe, stable SCFE performed in both the acute and ed setting. Proximal femoral anatomy can be restored, labral pathology addressed and the physis stabilised with minimal complication risk. Limitations of this study include its retrospective nature and resulting selection bias towards treatment options.

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COMPLIANCE WITH ETHICAL STANDARDS

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OA LICENCE TEXT

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ETHICAL STATEMENT

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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