

## The results of downgrading moderate and severe slipped capital femoral epiphysis by an early Imhauser femur osteotomy

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### Abstract

**Purpose** Patients with moderate and severe slipped capital femoral epiphysis (SCFE) develop osteoarthritis earlier in life in association with mechanical impingement.

**Methods** To correct deformity and diminish impingement, we performed epiphysiodesis combined with an Imhauser intertrochanteric osteotomy (ITO) in moderate and severe slipped capital femoral epiphysis. We downgraded the angle of the head relative to the acetabulum into an angle corresponding to a mild slip or even an anatomical position. Our hypothesis is that the avoidance of anterior impingement at an early stage can prevent the development of osteoarthritis.

**Results** The results of 28 patients (32 hips) were evaluated. Outcome parameters were SF-36, Harris Hip Score, range of motion, Kellgren–Lawrence score, chondrolysis and avascular necrosis. After a median follow-up of 8 (range 2–25) years, the group was clinically, functionally and socially performing well. Radiologically, there was no sign of chondrolysis or avascular necrosis, and more than 80% of the patients did not show any signs of osteoarthritis.

**Conclusions** Based on these results, we conclude that a one-stage Imhauser ITO combined with epiphysiodesis performed on patients with moderate and severe SCFE gives satisfactory results.

**Keywords** Epiphysiodesis · Epiphysiolysis capites femoris · Imhauser osteotomy · Intertrochanteric osteotomy · Slipped capital femoral epiphysis · Slipped upper femoral epiphysis

### Introduction

The long-term prognosis of slipped capital femoral epiphysis (SCFE) is largely influenced by the residual deformity, which in turn is related to the extent of slip. One of the methods for classifying the extent of slip is the Southwick classification [1, 2] which, based on lateral head shaft angle, places slip into one of three categories: mild ( $<30^\circ$ ), moderate ( $30\text{--}60^\circ$ ) and severe ( $>60^\circ$ ). The femoral head is mostly displaced medially and posteriorly. This displacement causes the metaphysis to move upward and laterally in relation to the femoral head, possibly resulting in anterior impingement with flexion of the hip [3] (Fig. 1a, b). It is thought that repetitive early mechanical abrasion of the prominent metaphysis against the anterior rim of the acetabular cartilage can trigger osteoarthritis [4, 5]. Patients with mild SCFE ( $<30^\circ$ ) have good prognoses, but patients with moderate and severe SCFE have an increased chance of developing osteoarthritis [6–8].

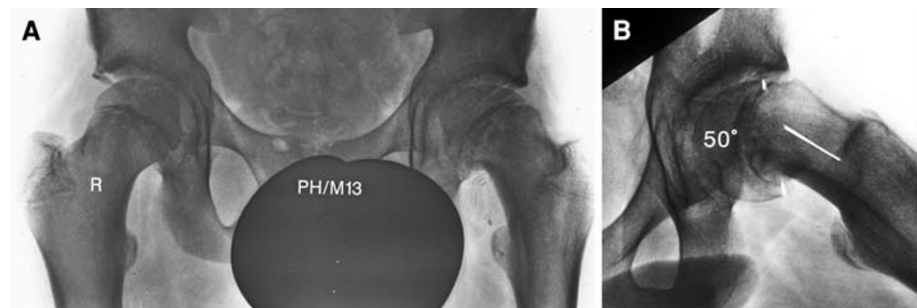
The primary objective of SCFE treatments is stopping further slippage, chondrolysis and avascular necrosis (AVN). The choice of treatment is also influenced by the stability of the slip, as described by Loder [9]. In cases of unstable SCFE, most surgeons perform an early gentle reduction of the head followed by epiphysiodesis; for stable slips, the standard approach is to stabilize the slip by in situ epiphysiodesis without reduction [10].

Various techniques have been described to correct the residual deformity. Some authors recommend performing

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**Fig. 1** Pre-operative slipped capital femoral epiphysis (SCFE)



an intertrochanteric osteotomy (ITO) as a secondary procedure after closure of the growth plate [11, 12]. In cases of severe chronic slips, many authors advise performing a subcapital osteotomy to correct the deformity completely; however, this procedure can have a high incidence of AVN and chondrolysis [13–18].

We hypothesized that an early ITO performed concurrently with the epiphysiodesis in patients with a moderate or severe slip of the femoral epiphysis would prevent the metaphysis from damaging the anterior part of the acetabulum and, thereby, diminish the incidence of osteoarthritis at a later stage. We also expected that the occurrence of chondrolysis and AVN would be low or absent with this procedure.

The aim of the study reported here was to investigate the outcomes of epiphysiodesis combined with an Imhauser ITO performed in one session in moderate and severe slips. The objective of this combined surgical approach is to improve the position of the head in relationship to the acetabulum in order to obtain better prognostic features.

## Materials and methods

### Subjects

This retrospective study assesses the results of a consecutive series of 28 patients who had moderate to severe SCFE in a total of 32 hips. These patients were treated with a combined epiphysiodesis and Imhauser ITO performed by the same surgeon at the AMC Amsterdam between 1978 and 2003. Patient data are presented in Table 1. A total of 13 patients had bilateral slips versus 15 who had unilateral slips. Of the 13 bilateral patients, four underwent bilateral ITO simultaneously. The other nine had a moderate to severe SCFE on one side only and a mild slip contralaterally and underwent only a K-wire transfixation on the controlateral side. A review of the medical histories of this patient cohort revealed that 13 patients had sustained a trauma. None of the patients had a deviant endocrinological history.

Approval of the medical ethical committee was obtained.

**Table 1** Patient data

Demographic/clinical data	Patient cohort ( $n = 28$ )
Gender ratio of patient cohort, $n$	M: 16, F: 12
Mean age at surgery, years	13 (range 9–17)
Unilateral (left/right), $n$	15 (10/5)
Bilateral, $n$	13
ITO unilateral (left/right), $n$	24 (15/9)
ITO bilateral, $n$	4
Acute on chronic, $n$	5
Chronic (hips), $n$	27
Trauma in history, $n$	13

ITO intertrochanteric osteotomy; M male; F female

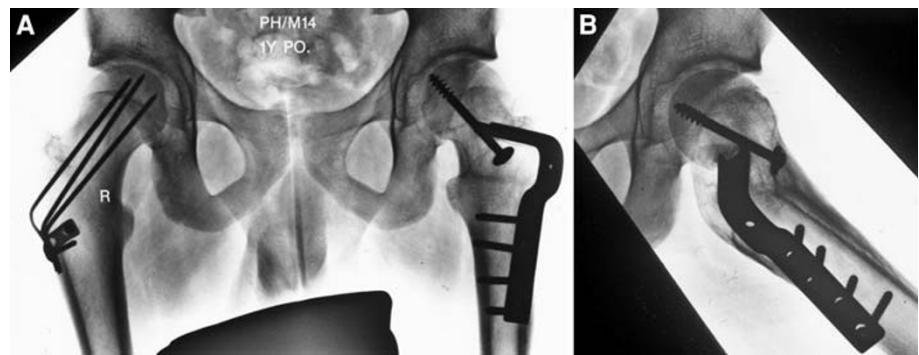
### Surgery

Prior to surgery, patients were treated by bed rest on springs and slings for an average of 14 (range 0–28) days. During this time, we designed a time-schedule for operating on the patient. We did not perform gentle reduction on any of our patients. A cannulated screw epiphysiodesis was performed via an open procedure with the use of one 5.0-mm screw. During the same surgical session, following the epiphysiodesis, the Imhauser three-dimensional ITO was performed and fixed with a 90° blade plate [19] (Fig. 2a, b). Thus, the alignment of the head was changed in three directions relative to the acetabulum: flexion, varus and derotation. Peroperative fluoroscopy was performed to verify the position of the seating chisel and screws. All patients with an unilateral slipped hip were treated with a preventive K-wire fixation at the controlateral hip. Patients were not allowed to bear weight for 6 weeks.

### Outcome assessments

Data are based on patients' notes and the X-ray results. Patients were traced and asked to complete questionnaires [part of the Harris Hip Score (HHS) and Short-Form Health Survey (SF-36)] at home; they also were invited for a clinical and radiological evaluation.

**Fig. 2** One-year postoperative SCFE after epiphysiodesis and Imhauser osteotomy



The range of motion and body mass index (BMI) were determined during the clinical examination, and hip function was measured using the HHS [20]. The completed SF-36 questionnaire was used as a measure of the general health of the patients relative to the Dutch general population [21].

Osteoarthritis of the hip at follow-up was quantified from the X-rays using the Kellgren–Lawrence scale (0–4) [22, 23]. The presence of chondrolysis and avascular necrosis was also assessed from the X-rays. Of the six patients who were not able to come to the clinic, the most recent X-rays available were used instead.

**Statistical analysis**

Results were analyzed using SPSS ver. 12.0 software (SPSS, Chicago, IL). Due to skewed distributions, continuous data (HHS, SF36, range of motion) were described as medians and ranges. The outcomes were analyzed non-parametrically using Mann–Whitney *U* tests in for independent comparisons and Wilcoxon signed-rank tests for pre- and post-operative comparisons. Categorical variables were described as numbers and percentages and were compared using the chi-square test. A *p* value <0.05 was taken to be significant.

**Results**

Of the 28 patients, 24 responded to the questionnaires. Twenty-two patients were able to come to the clinic for re-assessment and radiographic evaluation. The median period of follow-up of all patients was 8.2 years (range 2.0–25.7).

Two early postoperative complications were seen. The first was a leaking wound without infection, and the second was a patient who developed calf thrombosis in the operated leg. Both complications were successfully treated. No long-term complications occurred.

All osteotomies healed uneventfully. Neither chondrolysis nor avascular necrosis were seen on the X-rays.

Of the 32 slips, 22 were classified moderate and ten as severe. From the 22 moderate slips, 21 were downgraded to a mild slip and one was still a moderate slip (from 52° to 35°). Of the ten severe slips, seven were downgraded to moderate slips and three were even downgraded to mild slips. The mean slip was significantly improved from 52° (range: 30–74°) to 22° (range 0–56°) (*P* < 0.01).

Compared to the preoperative examination, the range of motion was significantly improved 1 year after the operation and also at the last clinical examination (Table 2).

The HHS had an ‘excellent’ median score of 93 (range 49–100), with 17 (71%) patients scoring excellent/good and seven (29%) scoring fair/poor. The outcomes of the SF-36 were not significantly different from the those of the Dutch general population match for age [21] (Table 3).

The Kellgren–Lawrence score in our group was ≤1 in 80% on the anteroposterior X-ray and ≤1 in 100% on the false profile X-ray. Chondrolysis and AVN were not observed.

The preoperative lateral head shaft angle was not correlated with the outcome variables HHS, SF-36 and the Kellgren–Lawrence score. These outcome variables were also not correlated by the length of the follow-up.

Whereas normal values for BMI are between 19 and 25 kg/m<sup>2</sup> [24], in our group the BMI was 26.1 (range 18.7–39.1) kg/m<sup>2</sup> preoperatively and 28.5 (range

**Table 2** Outcomes of the clinical examination (*n* = 28)

Range of motion	Time point		
	Pre-operative	1-year post-operative	Last follow-up
Flexion (°)	97 (40–140)	113 (90–140)*	108 (70–125)*
Adduction (°)	20 (0–40)	26 (10–50)*	25 (10–40)*
Abduction (°)	33 (10–66)	39 (20–60)	41 (25–55)*
Internal rotation (°)	–12 (–45–45)	24 (0–40)*	25 (–15–50)*
External rotation (°)	53 (20–80)	50 (30–75)	46 (10–70)

All values are given as the mean, with the range given in parenthesis

\* *p* < 0.05 compared to pre-operative status

**Table 3** Outcome SF-36 ( $n = 24$ )

SF-36 measure	PF	RP	BP	GH	VT	SF	RE	MH
Study population (median)	83	100	79	80	68	100	100	86
Study population (mean $\pm$ SD), $n = 28$	76 $\pm$ 26	70 $\pm$ 42	72 $\pm$ 31	77 $\pm$ 21	68 $\pm$ 24	82 $\pm$ 29	88 $\pm$ 40	81 $\pm$ 18
Norm NL data (age 16–35 years) (mean $\pm$ SD), $n = 530$	93 $\pm$ 10.6	86 $\pm$ 28.2	82 $\pm$ 18.6	79 $\pm$ 16.8	71 $\pm$ 16.0	88 $\pm$ 18.5	84 $\pm$ 30.4	79 $\pm$ 15.0

SF-36 Short Form Health Survey; PF physical functioning; RP role physical; BP bodily pain; GH general health; VT vitality; SF social functioning; RE role emotional; MH mental health; NL Netherlands; SD standard deviation

16.3–47.5) kg/m<sup>2</sup> at the last follow-up. More than half of the patients were and continued to be overweight.

## Discussion

We have evaluated the long-term results following the treatment of moderate and severe SCFE with an epiphysiodesis and an ITO in one session. By performing the osteotomy, we were able to downgrade the severe and moderate slips into moderate and mild slips and even, if possible, into an anatomical position to improve the position of the head relative to the acetabulum.

Previous cohort studies reported a relationship between the severity of the slip and the incidence of osteoarthritis. Carney and Weinstein [6] described a group of 28 patients (31 hips) with 41 years of follow-up. The 17 mild slips scored significantly better in terms of radiological grade assessment and Iowa Hip Rating than the 14 moderate and severe slips. Hansson et al. [7] claimed that mild slips can give excellent results as well; however, they stated that more long-term studies are needed to determine whether corrective osteotomies are required for slips  $>30^\circ$ . Ordeberg et al. [8] also concluded, after reviewing the long-term results of 49 patients, that patients with pronounced slipping have the highest incidence of arthrosis.

The risk of osteoarthritis is thought to be associated with repetitive trauma between the femoral metaphysis and acetabulum during flexion. It has been shown that anterior impingement by the prominent metaphysis can damage the anterior part of the acetabulum [4, 25].

Although most slips have remodeling potential, there may not be enough to prevent osteoarthritis in moderate and severe slips. In their respective patient series with severe slips, Wong-Chung and Strong [26] reported the remodeling to be only  $11.7^\circ$  and Belleman et al., to be only  $13.5^\circ$  [27]. This is not nearly enough to remodel the severe slip to a mild slip.

To prevent damage to the anterior part of the acetabulum, an osteotomy can be performed to correct the lateral head shaft angle. Both subcapital and intertrochanteric osteotomies have been described. The anatomical position

can be better regained with a subcapital osteotomy; however, this procedure can be associated with high rates of AVN and chondrolysis, varying from 4.5% up to 28.5% [15, 17]. Diab et al. [28] compared the ITO with the subcapital osteotomy and concluded that ITO is a safe, effective and reproducible realignment procedure. This conclusion supports our findings. No sign of chondrolysis and AVN was observed in any of our patients, and all osteotomies healed uneventfully. Jerre et al. [29] described a better short-term outcome of the ITO (11 patients) in comparison with the subcapital osteotomy (22 patients). However, their long-term results of the ITO were worse (see Table 4), which may have been caused by the fact that they used an older ITO technique (before the Southwick ITO was introduced).

The timing of performing the osteotomy relative to the epiphysiodesis is controversial. Performing the ITO at an early phase should be beneficial if damage by impingement plays a role in the aetiology of osteoarthritis. Other options are to perform the osteotomy at closure of the growth plate or with a decline in the range of motion [5, 11, 12]. Theoretically, the less the anterior acetabulum is exposed to abrasion from the prominent metaphysis, the better. For this reason, we advocate performing an ITO at the same time as the epiphysiodesis [30, 31]. This also eliminates the necessity of a second surgery, thereby reducing the burden for the patient. To date, we have not found indications of severe osteoarthritis based on the Kellgren–Lawrence scale. Nevertheless, Maussen et al. [32] showed in their cohort that patients with severe slips performed worse in later life, even after an intertrochanteric corrective osteotomy. In our study, we did not observe any relationship between preoperative lateral head shaft angle and the outcome parameters.

A number of studies have evaluated the outcome of the corrective ITO itself (Table 4). The use of different scoring systems of hip function and different methods of evaluating the radiographs makes it difficult to compare these studies. Unfortunately, in many previous studies, the timing of the ITO procedure relative to the epiphysiodesis was not reported. If the osteotomy is performed much later than the epiphysiodesis, damage may already have occurred to

**Table 4** Literature overview of the long-term results of corrective ITO for SCFE

Author, year	ITO ( <i>n</i> )	Lateral head-shaft angle (°)	Follow-up (years)	Scoring system	Excellent/good (%)	Fair/poor (%)
Parsch et al. 1999 [37]	49	40 (20–50) 7 (>50)	3	Iowa	84	6
Maussen et al. 1990 [32]	26	10: 30–40 16: 40–60	21	D'Aubigné Kellgren	77% maximum score	1 of 10 OA 15 of 16 OA
Kartenbender et al. 2000 [38]	35 (15 second stage)	51 (30–75)	23	Southwick class	77 clinical, 67 radiological	23 clinical 33 radiological
Schai et al. 1996 [30]	51	30–60	24	D'Aubigné	55	45
Carney and Weinstein CORR [6]	29		31	Iowa Radiograph		Mean fair 2.5 (0–3)
Jerre et al. 1996 [29]	11	61.3	51.4	HHS	36	64

SCFE slipped capital femoral epiphysis; OA osteoarthritis

initiate a degenerative process. In general, the studies show that the outcome gets worse with the length of follow-up time. In our study, we were unable to detect a relation between follow-up time and outcome variables. However, a larger study population and a longer follow-up time may be needed to detect such a relationship.

The occurrence of SCFE is known to be related to BMI [33–35]. As expected, the BMI in our group was high, with more than half of our patients being overweight. Based on the increasing obesity problem in children in Europe and the USA, it is likely that the incidence of SCFE will increase. An increase in SCFE has already been shown in Japan [36]. Based on current knowledge, the optimal treatment of SCFE cannot yet be established. Since most effects of SCFE only become apparent after many years, more long-term studies are needed in which treatment and outcome variables are standardized.

## Conclusion

Based on the results of our study, we conclude that performing an ephysiodesis at the same time as an Imhauser ITO to prevent early impingement on the anterior acetabulum in moderate and severe SFCE gives early satisfactory results. After a follow-up period of 8 (range: 2–25) years, all of our patients in the study group are performing well clinically, functionally and socially. The X-rays showed no signs of chondrolysis or AVN, and more than 80% of the patients did not show any signs of osteoarthritis.

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