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Good Long-Term Clinical Outcome in 50% of Hips With Mild and Moderate Chronic Slipped Capital Femoral Epiphysis Treated With in Situ Fixation

93 Hips With a Follow-up of 50 Years

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Background: There is no consensus regarding the initial treatment of slipped capital femoral epiphysis (SCFE). The aim of this study was to analyze the long-term outcome of in situ fixation (ISF) in chronic SCFE.

Methods: The study consisted of 79 patients (93 hips), treated with ISF from 1955 to 1993. There were 47 male patients (59%) and 32 female patients with a mean age of 12.8 years (range, 8-16 years) at the time of diagnosis. The mean slip angle was 33.4° (range, 12°-80°). The slip was mild (<30°) in 46 hips (49%), moderate (30°-49°) in 33 (36%), and severe (≥50°) in 14 hips. Long-term clinical outcome was based on the rate of total hip arthroplasty (THA) and the modified Harris Hip Score (mHHS) analyzed by telephone (maximum score 91 points).

Results: The mean follow-up time was 51.6 years (range, 30-68 years). Thirty-two hips (34%) had undergone THA at a mean patient age of 55.9 years (range, 21-75 years). The survival rate (percentage of hips that had not undergone THA) was 99% at 20 years of follow-up and fell to 69% (95% confidence interval, 58%-80%) at 50 years. The mean mHHS in 57 of the 61 hips that had not undergone THA was 80.7 points (range, 22-91 points). Good long-term outcome, defined as no THA and mHHS ≥76 points, occurred in 40 of 89 hips (45%). The outcome was worse in hips with severe slips compared with moderate and mild slips ($p = 0.020$), whereas there was no significant differences between moderate and mild slips ($p = 0.817$). The only independent risk factor of outcome was high alpha angle.

Conclusions: At a mean follow-up of 50 years, the clinical outcome in hips with mild or moderate slipping was good in 50% of the hips, and 27% had been converted to THA. These results are well suited for comparison with future studies of more modern treatment concepts.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Introduction

Slipped capital femoral epiphysis (SCFE) is a relatively rare disorder that affects children and adolescents from approximately at the age of 8 years to skeletal maturity. The pathogenesis is a mechanical weakening of the physis between the femoral head and neck, resulting in a deformity with a posterior slip of the femoral head. The degree of slipping can be mild, moderate, or severe.

There is not complete agreement regarding the treatment, although most authors agree that mild and most cases of moderate degrees of slipping should be treated with in situ fixation (ISF) to avoid further slipping[1-3]. No efforts should be done to reduce the slipping by manipulation because this will increase the risk of avascular necrosis (AVN). The deformity of the proximal femur after ISF will to some degree be remodeled by further growth[4-6]. However, the remaining deformity can cause complaints because of rubbing between the prominent anterolateral "bump" of the femoral head/neck and the acetabulum (femoroacetabular impingement [FAI])[7].

Treatment of severe slips has traditionally been ISF or an open procedure with correcting femoral neck osteotomy[8]. In recent years, a new surgical technique using a modified Dunn

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procedure (MDP) has been introduced to avoid postslip deformities and reduce the risk of serious complications[9,10]. The method includes surgical hip dislocation and anatomical reduction of the slip. The experience at the inventor's institution was reviewed by Tannast et al.[11]. They used the MDP for every moderate and severe case of SCFE and had an overall rate of AVN of 2%. According to a systematic review study, this low rate has not been obtained in most other hospitals[12].

It is uncertain which method gives best results. Most studies have relatively short follow-up time, which makes it difficult to draw reliable conclusions. In the long term, there is increased risk of osteoarthritis (OA), leading to the necessity of THA. The primary aim of this study was to evaluate the long-term outcome in patients with chronic SCFE, treated with ISF. This evaluation included the prevalence of THA in addition to an assessment of symptoms and hip function in hips that had not undergone THA. An additional aim was to analyze potential risk factors of poor long-term outcome.

Materials and Methods

Patients for this retrospective study were identified through a search of the radiographic files at Sophies Minde Orthopaedic Hospital (now part of Oslo University Hospital). Criteria for inclusion were chronic SCFE treated with ISF, no concurrent or later corrective surgery, and follow-up ≥30 years. Ninety-nine patients operated from 1955 to 1993 were identified. Twenty patients (23 hips) were excluded from the study for various reasons (Fig. 1). Fifteen patients with 18 affected hips died during the follow-up period. Only 1 of these patients had undergone a THA and was included. The others, who died at a mean age of 47.7 years (range, 16-73 years), were excluded.

Seventy-nine patients (93 hips) were included in the study, 47 men (59%) and 32 women. All were of homogenous Scandinavian ethnicity. Forty-six patients were part of a previous study that was published several years ago,[3] and 33 patients were added after a new search of our radiographic files. The time intervals overlapped, as the first cohort were operated during the period 1955 to 1986 and the second cohort during 1958 to 1993. In the 70 patients (89%) with available medical records, chronic SCFE was defined as pain ≥3 weeks before diagnosis. In the remaining patients, we used the metaphyseal remodeling seen on the primary radiographs as sign of chronic slip. SCFE was unilateral in 65 individuals and bilateral in 14. Side distribution was left hip in 51 hips and right hip in 42.

The preoperative radiographs were available in all the patients. The slip angle (SA) was measured on the preoperative frog-leg lateral radiograph[13]. Slip severity was graded into mild slip (SA <30°), moderate slip (SA 30°-49°), and severe slip (SA ≥50°). The anteroposterior (AP) alpha angle was measured at our previous follow-up, which included radiographic evaluation in adulthood[7]. The alpha angle was available in 51 hips and was measured by one of the authors (A.W.) following the method of Gosvig et al.[14].

ISF of the physis was performed using 1 to 2 screws in 55 hips and 2 cortical allograft bone pegs in 38 hips. The choice of fixation was based on the routines at the time, with mostly bone pegs until the late 1960s, and screws thereafter.

Long-term Follow-up

The long-term outcome was based on the number of hips that had undergone THA and on Harris Hip Score in hips that had not undergone THA. The information on THA was provided by the Norwegian Arthroplasty Register (NAR) and included whether or not the patient had undergone THA, plus age at and side of THA. The survival of the hip was defined as the time from ISF to THA. In hips that had not undergone THA, the survival was the time from ISF to February 2024, when the NAR data were received.

Harris Hip Score (HHS) has a range from 0 points (maximum disability) to 100 points (no pain and normal hip function)[15]. We used a telephone interview to obtain the modified HHS (mHHS), where the maximum score is 91 points because deformity and range of movement (9 points) are not possible to score by telephone[16]. There is no clinically meaningful difference between HHS and mHHS[17]. A good result at mHHS was defined as a score of ≥76 points.

Statistics

SPSS (version 28) was used for statistical analysis (IBM). Categorical data were analyzed with the Pearson χ^2 test. Continuous variables were analyzed using the T-test for independent samples. All tests were 2-sided. Differences were considered significant when the p-value was <0.05. Possible predictors for long-term outcome were analyzed with univariable analysis. Variables with a p-value of <0.05 were reanalyzed with multivariable logistic regression. Kaplan-Meier survival analysis, with conversion to THA as end point, was used to assess long-term prognosis.

Ethics and Disclosures

The study was approved by the Regional Committee of Medical Research Ethics (ref. 622472) and our institutional review board. Informed consent was received from all the participants. There are no conflicts of interest.

Results

The mean age at surgery was 12.8 years (range, 8-16 years). The age was significantly larger in male patients (mean 13.3 ± 1.6 years) than in female patients (mean 12.2 ± 1.1 years) ($p < 0.001$). The mean SA was 33.4° (range, 12°-80°). The mean posterior head-shaft angle in unaffected contralateral hips in patients with available radiographs was 10.2° (range, −7° to 23°). Female patients had a higher mean SA than male patients (37.1° and 31.0°, respectively), but the difference was not statistically significant ($p = 0.070$). The slip was graded mild in 46 hips (49%), moderate in 33 (36%), and severe in 14 hips. SCFE was bilateral in 14 patients, in 6 patients at the initial presentation and in 8 at a mean period of 13 months (range, 5-22 months) later. There was no significant difference in SA between these 2 subgroups (mean 29.8° and 26.1°).

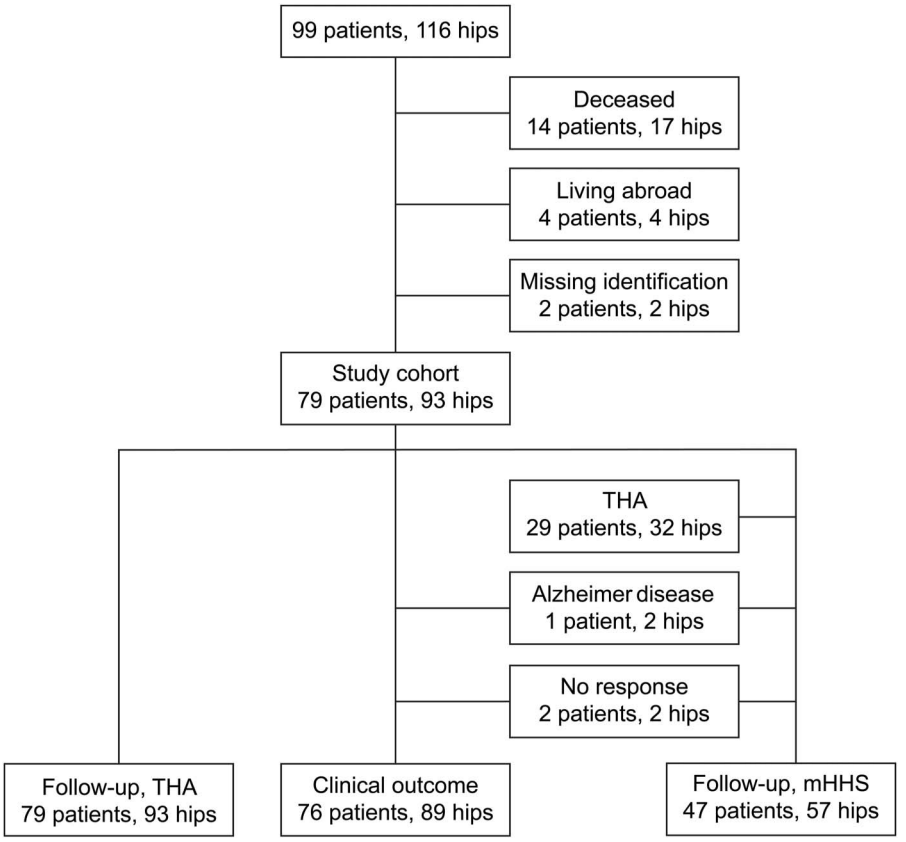

Fig. 1

Flow diagram indicating the number of included and excluded patients in the study. mHHS = modified Harris Hip Score, and THA = total hip arthroplasty; clinical outcome was based on THA and on mHHS in patients who had not undergone THA.

Seventy-eight hips (84%) had no postoperative complications. There were 2 serious complications, AVN in one hip and chondrolysis in another. Both had severe degree of slip, and the outcome was poor with insertion of THA. Two complications necessitated reoperation to improve the fixation: one fracture of the bone pegs and one screw that was too short. Minor complications such as 1 to 2 mm protrusion of a screw or a bone peg were seen in 11 hips (12%) and did not cause reoperation. The screws were usually removed after 2 to 3 years.

Long-term Outcome

The mean follow-up time of the 93 hips, from ISF to the NAR data were received, was 51.6 years (range, 30-68 years). THA had been inserted in 32 hips (34%, 29 patients) at a mean age of 55.9 years (range, 21-75 years). THA had been inserted more often in hips with severe slip (50%) and mild slip (43%) than in moderate slip (15%). The mean time from ISF to THA was 43.5 years (range, 10-66 years). During the follow-up period, 8 of the 65 patients (12%) with unilateral SCFE had undergone THA of the contralateral hip.

Kaplan-Meier survival analysis, with conversion to THA as the end point, is presented in Figure 2 and Table I. The survival rate in hips with mild or moderate slipping was almost 100% up to a follow-up of 30 years. Thereafter, the survival rate decreased in both groups but was higher in moderate slips than in mild slips. When mild and moderate slips were combined, the survival rate was 73% at 50 years of follow-up and 56% at 60 years. In hips with severe slip, the survival was similar to that of milder degrees of slip up to 20 years; thereafter, the survival rate was markedly lower (Table I).

The results at mHHS were obtained in 57 of the 61 hips that had not undergone THA (Fig. 1). The mean follow-up time was 49.4 years (range, 30-66 years). A good result (mHHS ≥76 points) was obtained in 40 hips (70%). The rate of good results was significantly higher in hips with mild slip than in moderate slip (91% vs. 61%; $p = 0.003$). The mean mHHS was 80.7 points (range, 22-91 points). The mean score was significantly higher in hips with mild slip (86.8 points) than in moderate slip (78.5 points; $p = 0.036$) and severe slip (67.3 points; $p = 0.002$). The mean mHHS score was higher in male patients than in female patients (84.5 vs. 73.8 points, respectively; $p = 0.033$).

Good long-term outcome, defined as no THA and mHHS ≥ 76 points, was obtained in 40 of 89 hips (45%) (Fig. 3). Poor outcome occurred in 49 hips (Fig. 4), of which 32 hips had undergone THA and 17 had mHHS <76 points. Of the hips with mild or moderate SA, a good outcome was obtained in 38 hips (50%). Female gender, severe degree of slip, high SA, and high AP alpha angle at skeletal maturity were significant risk factors of poor outcome in univariable

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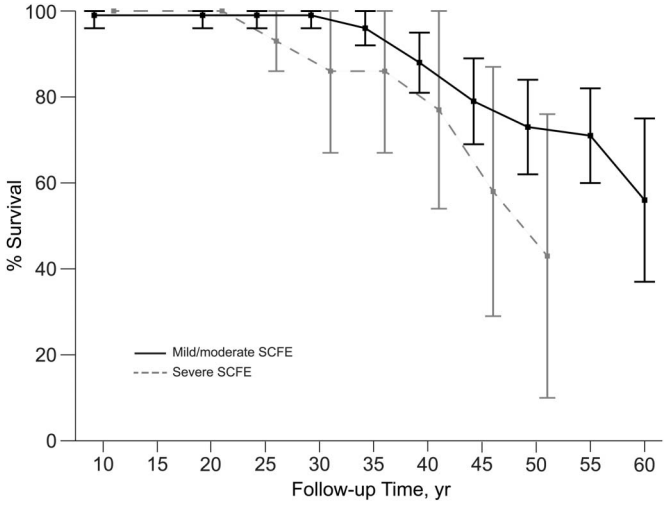

Fig. 2

Kaplan-Meier survival analysis from 10 to 60 years of follow-up with total hip arthroplasty as the end point. The unbroken line shows the hips with mild or moderate grades of SCFE (n = 79), and the broken line shows the hips with severe SCFE (n = 14). SCFE = slipped capital femoral epiphysis.

analysis (Table II). In multivariable logistic regression, the only independent risk factor of poor outcome was high AP alpha angle.

To find the development of the HHS score with increasing follow-up time, the present mHHS was compared with the HHS of our previous study[3]. The mean HHS at the previous examination was 93.2 points, which is equal to 84.2 points at mHHS. The present mean mHHS was 80.7 points, which indicates a small deterioration with 15 years of longer follow-up. Of the 32 hips with a good result at the first examination, 24 hips still had good result. Of the 10 hips with poor HHS at the first examination, 6 hips had undergone THA, 3 had poor mHHS score, and one had improved (mHHS 84 points).

Discussion

This study of SCFE probably has the longest follow-up to date. In hips with mild or moderate degrees of slipping, a good long-term outcome was obtained in 50% of the hips at a mean follow-up of 51 years and only 27% had been converted to THA.

When comparing long-term outcomes of hip disorders in children, the conversion to THA is a suitable measure of failure. We used information from NAR, which was established in 1988 and has a registration completeness of 97%[18]. We have found only one study on the rate of THA after SCFE with a follow-up >40 years, including 172 hips with a median follow-up of 49 years[19]. The prevalence of THA was 37%, which is in keeping with our rate of 34%.

With THA as end point, Kaplan-Meier analysis showed high survival rates in severe and milder degrees of slipping up to a follow-up of 25 years. With longer follow-up, the survival rate was markedly lower in severe slipping, in accordance with Schlenzka et al.[19]. At >30 years of follow-up, the survival was higher in hips with moderate slip than in mild slip. The opposite trend was found by Schlenzka et al.[19]. However, the studies are not directly comparable since different ways of classifying were used. Schlenzka et al.[19] subtracted the posterior head-shaft angle of the opposite hip to obtain the SA, whereas we used the head-shaft angle of the affected hip.

The prevalence of THA is insufficient as a sole outcome measure because the number of hips with symptoms will remain unknown. Thus, clinical scoring systems are important, especially in studies with follow-up <30 years when few hips have undergone THA. Few outcome reports based on PROMs (patient-related outcome measures) have been published. Larson et al.[20] analyzed the clinical outcome of ISF at a mean follow-up of 23 years. Severe slips had more pain at Visual Analog Scale; however, even mild slips frequently

TABLE I Kaplan-Meier Survival Analysis in 93 Hips, with Conversion to Total Hip Arthroplasty as End Point (Percentage and 95% CI)

Follow-up Time, yr	Mild Slip N = 46 %, 95% CI	Moderate Slip N = 33 % 95% CI	Mild/Moderate Slip N = 79 % 95% CI	Severe Slip N = 14 % 95% CI
10	98, 94-100	100	99, 96-100	100
20	98, 94-100	100	99, 96-100	100
25	98, 94-100	100	99, 96-100	93, 79-100
30	98, 94-100	100	99, 96-100	86, 67-100
35	94, 87-100	100	96, 92-100	86, 67-100
40	85, 74-96	94, 85-100	88, 81-95	77, 54-100
45	70, 56-84	94, 85-100	79, 69-89	58, 29-87
50	64, 49-79	88, 74-100	73, 62-84	43, 10-76
55	64, 49-79	81, 62-100	71, 59-83	*
60	46, 25-67	*	56, 37-75	

*Too few remaining hips for meaningful analysis. CI = confidence interval, and N = number of hips.

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Fig. 3-A

Fig. 3-B

Fig. 3-C

Fig. 3-D

Fig. 3-E

Fig. 3-F

Fig. 3 Radiographs of a girl with moderate degree of SCFE of her left hip. **Fig 3-A** Initial AP view at the age of 14 years; **Fig. 3-B**, initial lateral view, showing SCFE with slip angle 45°. **Figs. 3-C and 3-D** AP view 4 months after in situ fixation with 2 screws. **Figs. 3-E and 3-F** Last radiographs at the age of 45 years and a follow-up of 31 years. There was no sign of osteoarthritis. At the last clinical follow-up at the age of 61 years, she had no complaints from her hips and thus a good outcome. AP = anteroposterior, and SCFE = slipped capital femoral epiphysis.

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Fig. 4-A

Fig. 4-B

Fig. 4-C

Fig. 4-D

Fig. 4-E

Fig. 4 Radiographs of a girl with a moderate slip of her left hip. **Fig 4-A** Initial AP view at the age of 11.6 years; **Fig. 4-B** initial lateral view, showing SCFE with slip angle 38°. **Fig. 4-C** AP view 4 months after in situ fixation with 2 screws; **Fig 4-D** lateral view 3 years after in situ fixation; the screws have been removed, and some remodeling has taken place; **Fig. 4-E** last radiograph, AP view at the age of 43 years and a follow-up of 31 years, showing a bony prominence at the superolateral head-neck junction (cam deformity) and osteoarthritis of the left hip. She underwent total hip arthroplasty 6 years later. AP = anteroposterior, and SCFE = slipped capital femoral epiphysis.

TABLE II Risk Factors of Poor Clinical Outcome (THA or mHHS <76 Points) in 89 Hips with Long-term Follow-up

Variables	N	Clinical Outcome		Univariable Analysis	Multivariable Analysis		
		Good	Poor	p	p	Odds Ratio	95% CI
Gender							
Male	54	31	23	0.003*	0.302‡	2.0	0.5-8.0
Female	35	9	26				
Uni/bilateral							
Unilateral	63	28	35	0.883*			
Bilateral	26	12	14				
Radiographic classification							
Mild/moderate	76	38	38	0.020*	0.322‡	0.2	0.0-4.4
Severe	13	2	11				
Treatment							
Screws	53	25	28	0.608*			
Bone pegs	36	15	21				
Slip angle, degrees, mean (SD)	89	29.3 (11.7)	36.8 (18.2)	0.022†	0.442‡	1.0	0.9-1.0
Age at surgery, yr, mean (SD)	89	12.9 (1.6)	12.7 (1.5)	0.495†			
AP alpha angle, degrees, mean (SD)	51	62.4 (18.3)	78.4 (18.4)	0.003†	0.006‡	1.1	1.0-1.1

*Pearson χ^2 test. †Independent samples T-test. ‡Multivariable binary logistic regression, performed only in the 51 hips with available AP alpha angle; AP = anteroposterior, CI = confidence interval, and N = number of hips.

became symptomatic. They found no clear predictor of which patients with mild and moderate slips would develop pain. Another study reported no association between SA and HHS at 20 years of follow-up[21]. Differing results were presented by Poorter et al. who found that severe slips had worse scores on PROMs than mild and moderate slips at 18 years of follow-up[22].

Female sex and higher bone mass index were the only significant risk factors of poor clinical outcome in the study of Escott et al.[21]. In another study, risk factors for the need of THA were female patients and high SA[19]. These 2 factors were confirmed in the univariable analysis in our study. However, multivariable analysis indicated that high AP alpha angle was the only independent risk factor.

The rate of THA was lower in hips with moderate slip than in mild slip. Since the results at mHHS were better in mild slips, the combined clinical outcome (THA plus mHHS) was similar. The reason for the higher prevalence of THA in mild slips is unclear. One reason might be that the individuals with mild slip could have a higher level of physical activity than those with moderate slip. It could also be related to postslip deformities, leading to FAI and OA. Although the femoral metaphysis undergoes remodeling after SCFE[4-6,23,24], persisting postslip deformities were seen in almost one-third of mild slips[25]. Apart from our previous studies[7,25], the role of the alpha angle in the long-term prognosis focusing on OA has not been explored.

Because we had analyzed HHS previously in more than half of the patients, the development of pain and function could be compared. We found a slight deterioration in mHHS over 15 years, which is in accordance with the experience of Carney et al.[1]. They used Iowa hip-rating score at 41 years of follow-up and re-evaluated patients who had been examined 12 years before[5]. They concluded that the natural history of malunited slips was mild deterioration related to the severity of the slip and complications.

There are some limitations in this study. First, it was retrospective and had no control group of patients treated with alternative methods. Second, the number of hips with severe slip (≥50°) was rather small for reliable statistical evaluation. Third, the medical records were not available in all the patients. Fourth, no radiographic or physical examination was performed, as the information was based on the rate of THA and telephone interview for the mHHS. This could involve a confounding variable, since a higher mHHS score was reported by telephone than that obtained by in-person assessment (87 vs. 80 points)[26]. However, another study showed no significant difference between phone interview and face-to-face assessment (85 vs. 86 points)[27]. The strengths of the study are the long follow-up time and the completeness of follow-up (>95%).

What is the clinical significance of this study? Since the number of hips with severe slips was small, the significance is limited to mild and moderate slipping. Previous studies with a follow-up of ≥30 years have shown satisfactory long-term function with a low risk of serious complications after ISF, and the frequency of OA was not higher in moderate slipping than in mild slipping[1,28]. These findings were supported by the

present result at a mean follow-up of 50 years. We therefore recommend ISF for all cases of chronic slips with SA <50°. However, MDP has gained increasing popularity over the years and has been advocated for moderate and severe slipping in several recent studies[11,12,29,30]. Because MDP is a technically demanding procedure with a considerable learning curve, it should be performed only by experienced surgeons[31,32]. Our results, especially the Kaplan-Meier survival analysis, are suited for comparison with those of future long-term studies that evaluate more modern treatment concepts. In addition, there is a need for prospective multicenter studies comparing ISF and MDP.

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