

Long-term evolution of slipped capital femoral epiphysis treated by *in situ* fixation: a 26 years follow-up of 11 hips

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Abstract

Slipped capital femoral epiphysis (SCFE) may lead to femoro acetabular impingement and long-term function impairment, depending on initial displacement and treatment. There are several therapeutic options which include *in situ* fixation (ISF). The objective of this study was to evaluate long-term functional and radiographic outcomes of patients with SCFE treated with ISF. We conducted a single-center, retrospective study evaluating the clinical and radiographic outcomes of SCFE *in situ* fixation with a mean follow-up of 26 years (10-47). Analysis of preoperative and last follow up radiographs was performed. The functional status of the hip was evaluated according to the Oxford hip score-12 and the radiographic osteoarthritis stage was rated according to Tönnis classification. Signs of femoro acetabular impingement were sought. Ten patients (11 hips) were included. The average initial slip was 33.5° (10-62). At final follow up, the average Oxford hip score was 19.3 (12-37), it was good for groups who had a small initial slip (16.7) or moderate (17) and fair for the severe group (27). Average Tönnis grade was 1.3 (0-3). The average alpha angle was 65.3° (50-80°). Femoro acetabular impingement was likely in 100% of patients with severe slip, in 50% of patients with moderate slip and in 33% of patients with a slight slip. *In situ* fixation generated poor functional results, substantial hip osteoarthritis and potential femoro acetabular impingement in moderate to severe SCFE's. However, in cases with minor displacement, functional and radiographic results are satisfactory. The cut off seems to be around 30° slip angle, above which other treatment options should be considered.

Introduction

The treatment of slipped capital femoral epiphysis (SCFE) is a controversial subject.¹⁻⁵ *In situ* fixation (ISF), a widely used technique, limits the initial risk of necrosis and chondrolysis, but leaves a persistent deformity at the level of the head neck junction which can be responsible for the intermediate and long term evolution of hip impingement and subsequent osteoarthritis.^{6,7} On the other side, realizing a sub-capital osteotomy (Dunn or modified Dunn osteotomy),⁸ re-establish a better anatomy and limits the risk of hip impingement and the evolution into osteoarthritis on one hand, but increases the risk of the necrosis of the head on the other.⁹ Estimating the risk of the evolution into hip impingement and subsequent osteoarthritis depending on the importance of the initial displacement seems to be a defining element in the initial therapeutic strategy.¹⁰⁻¹²

The objective of our study is to evaluate the long term functional and radiological outcome in patients presenting with slipped capital epiphysis treated by ISF, by looking for hip impingement.

Materials and Methods

We realized a monocentric, retrospective, continuous study evaluating the clinical and radiological evolution of patients presenting with slipped capital femoral epiphysis treated by ISF with a minimum follow up of 10 years. A search by the key word (slipped capital femoral epiphysis) was made in our establishment allowing the selection of 35 patients operated between 1950 and 2002. Among these patients, 16 were impossible to contact for further follow up, and 9 were excluded because they underwent a secondary osteotomy. Finally we were left with 10 patients (11 hips), 8 men and 2 women. The average age at the time of the intervention was 13.9 years (12-17). Patients were divided into acute and chronic cases of slipped capital epiphysis by reviewing their respective medical files (acute if the duration of symptoms was less than 3 weeks, and chronic if more).¹³ The element of stability could not be investigated.¹⁴ The severity of displacement was measured radiologically using the Southwick angle,¹⁵ and subdivided into 3 stages: stage 1 if the angle was inferior to 30°, stage 2 if the angle was between 30° and 60° and stage 3 if the angle was beyond 60°.

All patients were contacted by phone and were given a questioner allowing the evaluation of the status of the hip using the Oxford Hip score-12 (OHS-12).¹⁶ The results were considered excellent if the OHS-12 was below 19,

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good if the results were between 19 and 26, average if between 27 and 33 and bad if beyond 33. If the patient underwent a total hip arthroplasty then the results were bad. A prescription was given to all patients in order to undergo a radiological evaluation including a standing AP pelvic X-ray, an axial lateral view of Dunn and a false profile view of Lequesne. The pre-operative radiological evaluation was realized by the same examiner (J.M), including the measurement of the fundamental angles (VCA, VCE, HTE and CC'D) and the alpha angle searching for signs of hip impingement.^{10,17} The diagnosis of impingement was evoked by the presence of pain upon hip flexion, and the presence of a radiological bump or an alpha angle exceeding 55°.¹⁸ The staging of osteoarthritis was done using the Tönnis classification.¹⁹ The operative complications were also classified (chondrolysis and avascular necrosis).

Results

The average follow up between the time of the surgical intervention and the latest follow-up was 26 years (10-47), only one patient presented with a bilateral slipped capital epiphysis. There were 8 chronic and 3 acute cases of slipped capital epiphysis. The average delay before the intervention was 4.6 days (1-9). The average amount of displacement was 33.5° (10-62), 6 hips presented with a displacement of stage 1, 2 of stage 2 and 3 of stage 3. Only one avascular necrosis was found and there were no cases of chondrolysis. Seven patients

had a preventive concomitant contralateral fixation. At the time of the last follow-up 2 patients had already underwent a total hip arthroplasty, one for an avascular necrosis of the femoral head 8 months following the initial intervention and the second 41 years after the occurrence of the slipped capital epiphysis for secondary osteoarthritis. For the 9 remaining hips, the average oxford score was 19.4 (12-37), the average Tonnis stage was 1.2 (0-3), the average VCE angle was $37,7^{\circ}$ ($28-58^{\circ}$), the average HTE angle was $8,9^{\circ}$ ($3-17^{\circ}$), the average VCA was $42,9^{\circ}$ ($31-55^{\circ}$) and the average CC'D was $126,2^{\circ}$ ($117-138^{\circ}$). The average alpha angle was $64,3^{\circ}$ ($50-80^{\circ}$) and an anterior bump was found in 6 different radiographs. Patients presenting with a stage 1 displacement had an excellent average Oxford score at the time of the last follow-up found at 16.6 (12-21), an average Tonnis score of 1 (0-2) and an average alpha angle of $59,8^{\circ}$ ($50-78^{\circ}$). Patients presenting with a stage 2 displacement had an excellent average Oxford score found at 17 (14-20), an average Tonnis score of 1 and an average alpha angle of $62,5^{\circ}$ ($57-68^{\circ}$). Finally, the patients presenting with a stage 3 displacement had an average Oxford score found at 28 (17-39), an average Tonnis score of 2 (1-3) and an average alpha angle of $77,5^{\circ}$ ($75-80^{\circ}$) (Table 1). All patients with a stage 2 or 3 Southwick presented a radiographic bump against 1 out of 5 for those with stage 1. Hip impingement was found in 100% of the patients with a stage 3 displacement against 50 % in those with a stage 2 displacement and 33% in those with stage 1 if we include the patient who underwent a total hip arthroplasty.



Figure 1. Evolution at a 37 years follow-up of a chronic slipped capital epiphysis stage 1 treated by 2 pins. Evolution towards radiological osteoarthritis (stage 2 of Tonnis) and a diminution of the anterior offset with a presence of a bump indicating a probable impingement.

Table 1. Patients' characteristics.

Sex	Date of birth	Age at diagnosis	Side	Southwick pre-op LV angle/stage	Southwick Post-op LV	Alpha angle post-op	Time follow up	Oxford total	VCE revision	HTE revision	VCA revision	CC'D revision	Alpha revision	Tonnis	Bump	Impingement
M	25/10/55	13 y 1 m	L	10°/1	10°	50°	41 y (THA)									
M	26/01/55	17 y	L	15°/1	0°	63°	10 y	19	29	10	48	122	50	0	N	N
M	21/08/66	12 y	R	20°/1	13°	60°	18 y	14	30	5	40	138	66	1	Y	N
M	29/12/52	12 y 6 m	L	20°/1	17°	45°	47 y	21	30	3	55	133	50	1	N	N
M	04/02/64	12 y 10 m	L	20°/1	18°	54°	36 y	17	42	8	43	125	55	1	N	N
M	13/12/58	16 y 10 m	L	23°/1	19°	70°	36 y	12	40	6	45	117	78	2	Y	Y
M	24/11/64	11 y 11 m	R	39°/2	20°	50°	36 y	14	37	11	40	126	57	1	Y	N
M	10/02/56	15 y 2 m	R	40°/2	30°	60°	11 y	20	45	13	32	125	68	1	Y	Y
F	21/04/87	12 y	R	60°/3	20°	58°	13 y	39	58	7	52	128	75	3	Y	Y
F	14/03/76	15 y	L	60°/3	45°	76°	13 y	17	28	17	31	122	80	1	Y	Y
M	29/12/52	15 y	R	62°/3°	55°	79°	8 m (THA)									

Discussion

The objective of the study was to assess the long term radiological and clinical evolution of patients with SCFE treated by ISF (Figure 1). Our study demonstrates that the functional prognosis depends on the degree of the initial displacement. The same can be said about the evolution into radiological osteoarthritis knowing that the limit of that displacement being between 30° and 60°, the fact that is confirmed by the literature.^{3,20}

There are also limitations to our study. First is the small number of patients, a fact that can be explained by the difficulty of contacting the patients retrospectively after more than ten years of the initial intervention. Second, even if validated, the estimation of the functional becoming using the Oxford hip score-12 is influenced by the subjectivity of the patients and does not include a physical examination. In addition to that, the diagnosis of hip impingement, which is primarily clinical,²¹ is based on a questionnaire filled on the phone leading to a bias in the interpretation procedure. Finally, concerning the reported results, our study does not have a control group allowing for a functional and an activity level comparison with a pool of patients of the same age subject to different types of hip surgery or any intervention with the main goal of restoring the anatomy of the proximal femur (ostetomy). Nevertheless, the value of this study resides in its long term follow-up giving an added value to the stated conclusions. The ISF by a screw is actually the reference procedure in the cases where there is a mild displacement.^{22,23} This technique insures good results according to the literature,²⁴⁻²⁶ but puts a question mark on the functional and radiological long term becoming of the hips fixed in a non-anatomical position and with a persistent deformity at the level of the head neck junction.²⁷ Many studies report bad outcomes manifested by a decrease in the range of motion (mainly when it comes to internal rotation),^{28,29} hip pain secondary to impingement,^{10,30-33} and a premature evolution into osteoarthritis.^{24,34-36} The different studies evaluating the ISF with a long term follow-up demonstrate an important rate of osteoarthritis despite an early and optimal surgical intervention, Monin *et al.*³ report 60 % of osteoarthritis with an average follow-up of 19 years with a 100% rate of osteoarthritis when the initial displacement exceeds 40°. Larson *et al.*³⁷ report with an average follow up of 16 years a 5% rate of hip arthroplasty knowing that 1/3 of the patients present with pain interfering with their daily activities. Wensaas *et al.* report an osteoarthritic evolution in 28% of the cases with an average follow-up of 33 years.³⁶ Finally, Hansson *et al.*²⁴ found osteoarthritis in 31% of the patients with an average follow up to 30 years. In our series, there is 22% of patients with radiological

osteoarthritis (stage 2 or 3 of Tönnis) at the time of the last follow-up. The evolution towards hip impingement can be explained by the diminution of the anterior offset at the level of the head neck junction creating a cam effect induced by an early contact of the anterior part of the neck with the anterior border of the acetabulum during hip flexion, a mechanism that is at the origin of the pain.

The different studies insist on the clinical character of the diagnosis of impingement, which undermines the radiological diagnosis, keeping in mind the great inter-individual morphological variability of the proximal femur specially the possibility of asymptomatic radiological bump (24% for Hack *et al.*)^{21,38} Wensaas *et al.*¹⁷ depict the radiological signs of impingement more frequently and up to a statistically significant level with the patients operated by ISF *versus* the control group with an average follow-up of 37 years. This study also finds a correlation between the severity of the persistent deformity and the bad clinical and radiological evolution. Similarly, Delullo *et al.*²⁹ found a correlation between the persistence of the deformity of the head-neck junction and the diminution of the functional scores with an average follow up of 7.6 years; they also noted an augmentation in hip pain. Our study is not in contradiction with the literature in that regard, since we also found a correlation between the severity of the initial displacement on one hand and the bad functional scores (OHS-12) and the evolution into hip impingement on the other (100% in patients with a displacement exceeding 60°). We also found that the bigger the displacement is, the higher the alpha angle value, knowing that it remained stable with time. We depicted only one diminution in the alpha angle (from the time of the intervention to the time of the last follow-up) which can lead us to think that we cannot count on bone remodeling after ISF for a better outcome. The evolution towards hip impingement concerns 20% of our patients presenting with a minor slipped capital epiphysis. This goes hand in hand with the recent studies describing subclinical cases of slipped capital epiphysis that remained undiagnosed during childhood only to be accounted for as one of the reasons of hip cam impingement later on in the patient's life.²⁹ Nevertheless, the clinical tolerance of hip impingement for minor displacement is good. Finally we find an interesting long term evolution at the level of the hip joint. The angles VCA and VCE are mildly superior than the normal value due to the displacement of the center of the femoral head inferiorly and posteriorly, the cervico-diaphysal CC'D angle is at the lower limit (varus) due to the inferior displacement of the femoral head and the residual growth of the greater trochanter. The average alpha angle, which reflects the presence of hip impingement, is above the normal value. No other article to our knowledge has reported such coxometric results with such a long term follow up. If it is certain that

the abstention or the continuous traction are no longer viable solutions,^{39,40} the modified Dunn osteotomy seems to be an alternative to the ISF.^{8,41,42} This surgery is performed by an anterior approach, respecting the posterior circumflex artery and diminishing the risk of necrosis of the femoral head in comparison to a posterior approach. The reduction and the fixation in a good position of the proximal epiphysis allows protecting the hip from impingement and osteoarthritis.⁴³ Anyway, two other options can be discussed: performing an ISF associated with an offset procedure (bumpectomy) by a minimally invasive anterior approach or arthroscopy thus preventing the evolution towards hip impingement,⁴⁴ or performing an ISF with a secondary per-trochanteric osteotomy.¹⁵ This final option, with all the anatomical modifications that it brings to the table, can make a potentially necessary future arthroplasty complicated. From this work comes the following indications: in the case of a stage 1 displacement (<30°) the in situ fixation seems to be the best solution with moderate medium and long term risks, in the case of a stage 2 (30-60°) or stage 3 (>60°) the results of the in situ fixation are less promising and the Dunn osteotomy by an anterior approach can be discussed. In addition to those two scenarios and in the case of a stage 2 displacement, an in situ fixation can be complemented by an offset procedure. ISF is then the treatment of choice in the case of a small displacement, the patient must be informed about the risk of the evolution towards hip impingement, which also necessitates a close follow up and surveillance by the orthopedic surgeon who will follow the child in his adult life.

Conclusions

ISF in a non-anatomic position in the patients presenting with slipped capital epiphysis may have long term consequences. In correlation with the initial displacement, it can be at the origin of hip impingement or of osteoarthritis if the initial displacement was stage 2 or 3. On the other hand, in the case of minor displacement, the consequences are less pronounced with the results of the functional scores found to be satisfactory. The limit is situated somewhere around 30°, an amount of displacement beyond which other therapeutic options can be considered.

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