Original article

Evolution of slipped capital femoral epiphysis after in situ screw fixation at a mean 11 years' follow-up: A 222 case series

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A B S T R A C T

Introduction: Slipped capital femoral epiphysis (SCFE) can lead to hip impingement, more or less rapidly depending on initial slippage severity and on surgical technique. Various surgical options are applicable, including in situ fixation (ISF). The aim of the present study was to look for long-term signs of radiological impingement in hips treated for SCFE by ISF, in order to identify a slip threshold beyond which impingement more regularly appears.

Material and methods: A multicenter retrospective study assessed the clinical and radiological evolution of patients operated on by ISF for SCFE, with a minimum 10-year’s follow-up. Coxometric analysis of postoperative and last follow-up radiographs was performed. Functional outcome was assessed on Oxford hip score and radiographic osteoarthritis on the Tönnis classification. Alpha angle was measured on lateral views to highlight hip impingement.

Results: Two hundred and twenty-two hips were included, with a mean 11.2 years’ follow-up. Mean age at diagnosis was 12.8 years. Mean preoperative Southwick angle was 38.8°, with 43% of hips at stage I, 42% at stage II and 15% at stage III. At latest follow-up, mean Oxford score was 14.86, with 88% of hips rated Tönnis 0 or 1. Only 15 cases of impingement were diagnosed. There seemed to be a non-significant trend for hip impingement in SCFE exceeding 35°.

Conclusion: ISF led to hip impingement in moderate to severe initial epiphyseal displacement. However, in smaller displacement, the consequences were milder, with perfectly satisfactory function scores and no clinical or radiological evidence of impingement. The threshold seemed to be around 35° slippage, beyond which other surgical options than ISF should be considered. Thus, it seems reasonable to propose isolated ISF in SCFE < 35° and to treat symptomatic impingement by surgery in stage II slips.

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1. Introduction

Slipped capital femoral epiphysis (SCFE) is the most frequent hip complaint in adolescents. Treatment seeks to prevent worsening of epiphyseal slippage on the metaphysis, and percutaneous in situ fixation (ISF) using a single cannulated screw has long shown efficacy [1]. Residual deformity may nevertheless lead to femoroacetabular impingement or osteoarthritis of the hip in the medium-to-long-term [2]. The present study reviewed SCFE patients managed by ISF at a minimum 10-years’ follow-up, to assess clinical and radiological outcome according to initial Southwick slip angle. The secondary objective was to determine a slip threshold as of which femoroacetabular impingement became more frequent after isolated ISF.

2. Material and methods

A multicenter (Lille, Berck, Marseille, Toulouse, Strasbourg) retrospective study included all cases of uni- or bi-lateral, stable or unstable SCFE managed by ISF using 1 cannulated screw, with a minimum 10-years’ follow-up. Exclusion criteria were: surgery by head repositioning, and history of bone disease. Preoperative

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Scientific analysis was performed by the biostatistics laboratory of Lille University Hospital. A descriptive analysis was made, with comparative analysis of each parameter on non-parametric Wilcoxon test for small samples. The significance threshold was set at $P < 0.05$. Correlations between preoperative variables and onset of impingement were assessed on Spearman correlation coefficient.

3. Results

Two hundred and twenty-two patients were included (222 hips), with minimum 10 years’ follow-up. There were 131 boys (59%) and 91 girls, with a mean age at diagnosis of 12.8 years (standard deviation, 2.06 years). Involvement was of the left hip in 61% of cases (136 patients). Mean preoperative Southwick angle was 38.8° (range, 14–70°). Slip severity was 43% stage I ($n = 53$), 42.3% stage II ($n = 52$) and 14.7% stage III ($n = 18$).

Mean age at last follow-up was 28.2 years, for a mean follow-up of 11.2 years.

At last follow-up, mean AR angle was 11.4° (range, 3–46°), VCE angle 30° (10–68°) and VCA angle 31° (8–70°). There were no significant differences between preoperative versus follow-up cox-ometric variables ($P < 0.05$). Mean alpha angle at follow-up was 69° (range, 27–110°; normal value, $< 50°$).

Mean global Oxford score was 14.86, corresponding to satisfactory joint function not requiring formal treatment (range, 12–37). Eighty-eight percent of hips were Tönnis grade 0 or 1 at follow-up (122 grade 0 and 73 grade 1); i.e., free of osteoarthritis or incipient signs, such as moderate joint-line impingement.

Seventeen hips underwent revision surgery during the mean 11.2 years’ follow-up. There were 4 main indications: femoroacetabular impingement in 6 cases, disabling pain due to advanced osteoarthritis in 6 cases, head necrosis in 3 cases, and joint impairment due to excessively long fixation screws in 2 cases (with early revision).

Fifteen hips showed pain in flexion and/or abduction, correlating with signs of femoroacetabular impingement; 6 of these had undergone surgical revision. The Wilcoxon test for small samples found no link between pre- or postoperative Southwick angle and onset of femoroacetabular impingement. The Wilcoxon two-sample test performed in all cases of revision, on the other hand, revealed a correlation between preoperative Southwick angle and occurrence of surgical revision ($P = 0.019$).

Spearman correlation between preoperative Southwick angle and severity on follow-up Oxford score showed a highly significant coefficient of 0.0003: the greater the angle, the poorer the score. ROC survival curves, to determine an epiphysial slip threshold beyond which impingement would be significantly more frequent and Oxford score impaired, plotting onset of impingement against preoperative Southwick angle, found median sensitivity and specificity both around 0.53 (i.e., non-significant) for 35.5–39.5° slip; there was thus a non-significant trend for impingement after ISF in SCFE exceeding 35.5–39.5°.

In the same analysis performed on all patients with Oxford score $> 12$ (i.e., in pain), the ROC curve for onset of pain according to initial epiphysial slip found comparable sensitivity and specificity around 0.53 for 35.5–39.5° slip.

4. Discussion

The present study found that functional prognosis (on Oxford hip score) was related to initial epiphysial slip. There appeared to be a 35° threshold beyond which femoroacetabular impingement became more frequent; this bears out literature reports [7–11]. In the 222 hips, there were only 15 cases of femoroacetabular impingement and little medium-term osteoarthritis, with 88% of

Radiographic osteoarthritis was assessed on the Tönnis classification [6]. Signs of femoroacetabular impingement comprised: convexity at the junction between femoral head and neck, head flatness, osteophytes, and herniation pit (Fig. 1). Any revision surgery, other than to remove the cannulated screw after growth-plate fusion (not considered as a revision procedure), was noted.

Radiography comprised Dunn lateral hip view, with measurement of the Southwick posterior slip angle [3], considered pathological when greater than 7°. SCFE was classified according to three grades of increasing severity: stage I, 7–30°; stage II, 31–60°; and stage III, > 60°.

The preoperative study variables were thus: age at diagnosis, SCFE stage, and Southwick slip angle.

Surgical data confirmed that the technique systematically involved ISF.

Postoperative radiological data were assessed on antero-posterior (AP) hip view and Dunn lateral view. Coxometry comprised measurement of the VCA, VCE, AR and CCD angles (vertical-center-anterior, vertical-center-edge, acetabular roof, and caput-collum-diaphyseal angles, respectively).

Minimum follow-up was 10 years. Clinical examination screened for femoroacetabular impingement, with clinical assessment on the Oxford-12 Hip score [4]. Radiologic assessment comprised the same data as an immediate postoperative assessment, plus the alpha angle on lateral view, described by Nötzli et al. [5]; this is the angle subtended by:

1. a line between the center of the femoral neck and the center of the femoral head;
2. a line between the center of the femoral head and the point at which the head becomes non-spherical.

patients graded 0 or 1 on the Tönnis classification; this is less in line with the literature.

Monin et al. [7] found a 60% rate of osteoarthritis at a mean 19 years’ follow-up, and actually 100% at 10 years in case of >40° slip. Wenssaas et al. [12] found significantly greater incidence of radiological signs of femoroacetabular impingement (convexity, flattening, osteophytes and herniation pit) after isolated ISF at 37 years’ follow-up compared to a control population free of hip pathology. One hypothesis to explain the relative sparseness of clinical as compared to radiological signs is based on the pathophysiology of anatomic remodeling. Delullo et al. [13] found that operated patients generally showed very satisfactory evolution, but with slightly poorer function and pain scores than in an age-matched reference population; femoral head-neck junction remodelling may play a role in this. In the present series, there was no significant difference in AR, VCA or VCE angles between immediate postoperative values and those at a mean 11.2 years’ follow-up. Mean VCA and VCE angles at the upper limits of normal clearly indicate downward and backward displacement of the femoral head. Remodelling of the acetabular side should thus apparently not be relied upon. Alpha angle could not be measured on postoperative view, but at last follow-up had a mean value of 69°, indicating that the impact of remodelling of the femoral head-neck junction convexity was slight. The study thus confirms the marginal involvement of bone remodelling in short-to-medium-term course after ISF for SCFE. To the best of our knowledge, this is the first report of such coxometric results in SCFE with such long follow-up.

Statistical analysis disclosed a trend for more frequent femoroacetabular impingement beyond a threshold 35.5° epiphyseal slip; the trend was non-significant, but in line with the literature [7–11]. It thus seems reasonable to perform only isolated ISF in SCFE with Southwick angle < 35°; beyond 35°, management concerns incipient femoroacetabular impingement as well as in situ fixation itself.

Certain authors take the same attitude even with very low Southwick angles, especially with an arthroscopic approach, which becomes technically more difficult beyond 30° slip [14]. Ilizaliturri et al. [15] reported 8 cases of secondary treatment in which the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score improved by 9.6 points without complications (P < 0.001). Lenug et al. [16], in a preliminary study, even suggested associating arthroscopy to ISF in a single step; follow-up is presently insufficient to assess this option. Moreover, the femoroacetabular impingement induced by epiphyseal slippage is not focal as in adults, making complete arthroscopic treatment of slip-related impingement very complicated [14].

In the literature, most studies of osteochondroplasty by hip dislocation, with or without intertrochanteric osteotomy, reported relief of hip impingement symptoms. The osteochondroplasty is not performed in the same step as ISF [17–19]. This surgery, however, often leaves a residual metaphyseal convexity, regularly leading to trochanteric non-union and intra-articular adherences [20].

Superior femoral derotation and valgization osteotomy has long been described and may be associated to osteochondroplasty of the femoral neck if need be [21]. The interval at which proximal femoral osteotomy should be performed remains controversial, and the present non-significant results do not tip the balance in favour of one-step ISF with osteotomy, as recommended by Witbreuk et al. [22].

Finally, peri-acetabular osteotomy, as described by Ganz et al., may be associated to ISF in a single step. This option has been reported for SCFE sequelae, but should be reserved to cases of acetabular retroversion associated with extensive defect in the posterior acetabular wall [23].

Thus, a review of the literature combined to the present findings failed to support a more aggressive primary attitude in ISF for SCFE between 35° and 60°. Moreover, at 11.2 years’ follow-up, there were few cases of femoroacetabular impingement in the present series. Eighty-eight percent of patients showed little or no osteoarthritis on Tönnis score and had very satisfactory Oxford function scores. It thus seems reasonable to consider treating femoroacetabular impingement only when it becomes symptomatic rather than proposing heavier surgery from the outset.

**Disclosure of interest**

The authors declare that they have no conflicts of interest concerning this article.

**References**


