Femoroacetabular Impingement After Slipped Capital Femoral Epiphysis: Does Slip Severity Predict Clinical Symptoms?

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**Background:** Femoroacetabular impingement (FAI) may be common after slipped capital femoral epiphysis though the actual frequency is unknown. The purpose of this study was to determine the frequency of symptomatic FAI in young adults after slipped capital femoral epiphysis and define its relationship with slip severity.

**Methods:** We retrospectively reviewed a consecutive series of 49 patients (65 hips) to determine patient and slip characteristics and treatments. Patients were then recalled for clinical and radiographic review to assess symptoms, particularly impingement, and outcomes after skeletal maturity.

**Results:** Thirty-six patients (49 hips) were reviewed clinically and radiographically with a mean follow-up of 6.1 years (range: 2.2 to 13.1 y). All patients had reached skeletal maturity. Thirty-one percent (15/49) of patients complained of hip pain or stiffness, whereas 32% (16/49) had clinical signs of impingement. The Southwick slip angle and grade of slip or Loder’s classification of physeal stability were not predictive of impingement at follow-up. The anterior head-neck offset angle (z angle) correlated most strongly with FAI (r = 0.26). No pre-slips or prophylactically pinned hips developed clinical impingement in this review.

**Conclusions:** In the absence of radiographic indicators to predict FAI, we advocate all but those hips pinned prophylactically or for pre-shlip should be followed into adulthood and clinically monitored for impingement. Grade of slip in adolescence cannot be used as a predictive tool for FAI later in life.

**Level of Evidence:** Level II, retrospective study.

**Key Words:** slipped capital femoral epiphysis, femoroacetabular impingement, slip grade


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Slipped capital femoral epiphysis (SCFE) in adolescence is associated with premature osteoarthritis of the hip joint in later life. In recent years there has been growing interest in the concept of cam-type femoroacetabular impingement (FAI) as an etiological factor in the development of osteoarthritis of the hip after SCFE. Importantly, patients with FAI often develop painful symptoms many years before the onset of radiographic arthritis. The development of a safe surgical dislocation of the hip, the use of the subtrochanteric osteotomy, and advances in hip arthroscopic techniques may allow us to treat FAI before irreversible degenerative joint disease occurs. The actual frequency of FAI in young adults after SCFE is unknown. Furthermore, though intuitively, higher-grade slips would be expected to be most associated with later FAI, the actual association between severity of slip and symptomatic FAI is unknown. The purpose of this study was to identify the frequency of symptoms in young adults after SCFE, and to determine whether FAI is directly related to the degree of slip.

**METHODS**

We retrospectively reviewed the records of patients presenting to our institution with SCFE between 1994 and 2001. Patients were identified from both the Hospital In-Patient Enquiry database and the orthopaedic theater registers during these years. The medical charts and radiographs of the patients were reviewed to determine age at presentation, sex, side, weight, duration of symptoms, Loder’s classification of stability, grade of slip, methods of fixation, postoperative complications, and out-patient follow-up. The Southwick angle and slip grade were measured from the immediate postoperative radiographs rather than preoperative radiographs so as to eliminate the effect of any episodes of spontaneous slip reduction during surgery. It also made possible the inclusion of unstable slips in which we did not have preoperative lateral radiographs. The slip angle was determined by subtracting the value of the Southwick head-shaft angle on the normal side from that of the slip side on postoperative frog lateral radiographs. Pre-slips and those pinned prophylactically were graded as 0, Southwick angles of less than 30 degrees were graded as 1,
angles of 30 to 60 degrees were graded as 2, and greater than 60 degrees were graded as 3.

Patients were contacted through hospital records and through their general practitioners. Follow-up assessment consisted of a patient questionnaire, Harris Hip Score, patient review, and clinical and radiographic evaluation. Physical examination was performed by a single surgeon, experienced in hip pathology joint preservation surgery. The examiner had no earlier knowledge of slip grade or radiographic appearance, assessing gait, limb length discrepancy (LLD), range of motion, and clinical signs of FAI (eliciting hip pain with the patient in a supine position, the hip passively flexed to 90 degrees, internally rotated and adducted). Radiographic evaluation consisted of an AP pelvis and Dunn 45 view of the affected hip to assess the presence or absence of a pistol-grip deformity. All radiographic measurements were made by a single person, to eliminate interobserver error. Measurements were made on the same radiographs on 2 separate occasions and mean values were used to reduce intraobserver error. The anterior offset angle (α angle) as described by Nötzli et al\textsuperscript{15} was used to measure the severity of the deformity at the femoral head-neck junction (Fig. 1). The greater the α angle, the smaller the arc of motion required to cause cam-type impingement on the acetabular rim. The maximum anterosuperior asphericity at the femoral head/neck junction was obtained from the Dunn 45 radiograph. This view was obtained through an anteroposterior projection with the hip flexed to 45 degrees, in neutral rotation and 20 degrees abduction (Fig. 2). This showed the maximum anterosuperior asphericity of the femoral head/neck junction.\textsuperscript{16}

Statistical analysis consisted of paired $t$ tests to compare radiographic parameters and binary logistic regression to examine variables against a binary response (impingement). Analysis was performed assuming a nonparametric distribution with a 2-tailed $P$ value. A coefficient of correlation with a minimum $r$ value of 0.7 was used to determine good bivariate correlation. Categorical data were subject to the Fisher exact test. Analysis was carried out using R statistical software version 2.1.0.

**RESULTS**

Between 1994 and 2001 we treated 49 patients (65 hips) with SCFE. There were 19 male (26 hips) and 30 female patients (39 hips). The average age at presentation was 12.2 years (12.9 y for males and 11.7 y for females). For male patients, 74% (14/19) of patients weights were at or above the 97th centile for their age in the sex-specific Irish population at presentation.\textsuperscript{17} For female patients this was slightly lower, with 70% (21/30) of patients weights being at or above the 97th centile for age. From the medical records at the time of presentation, a classification of physeal stability was made in 82% (53/65) of cases. Of these, most were stable (62%; 40/65 hips). As described in the Methods section, slip severity was assessed from the patient records and from the postoperative x-rays. Fourteen percent (9/65) were pre-slips

**FIGURE 1.** The anterior offset angle (α) as described by Nötzli et al.\textsuperscript{15} Defined by a line connecting the center of the femoral head with the center of the femoral neck and a line connecting the center of the femoral head to a point on the femoral head where the normal radius of curvature of the head diverges.

**FIGURE 2.** Dunn 45 view of the left hip with slipped capital femoral epiphysis showing the anterior offset angle.
The affected side being shorter in all cases. Clinical signs of FAI were present in 33% (16/49) of hips though this increased to 38% (16/42) when grade 0 slips were excluded. The mean duration and standard deviation of follow-up for impinging and nonimpinging hips were 6.03 years ± 2.70 and 6.2 years ± 2.94, respectively. Of the patients who showed clinical signs of impingement, 31% (5/16) described no painful symptoms on the Harris hip score before clinical examination. The relationship of symptoms and signs to the Southwick slip grade is summarized in Table 2.

The Southwick angle measured from the early postoperative radiograph correlated poorly with both the anterior offset angle (r = 0.169) and clinical impingement (r = 0.142) at follow-up. The anterior offset angle (α) was the single best correlator with clinical impingement (r = 0.26), though still poor. Loder’s classification of physeal stability also correlated poorly with both pain (r = 0.216) and impingement (r = -0.012). Using binary logistic regression analysis, impingement was not found to be dependent upon the slip angle, the α angle, or a linear combination of both variables at the 95% confidence level (P values being 0.327, 0.063, and 0.127, respectively). However, the α angle was found to be most influential variable (P = 0.063). The mean α angle and standard deviation for clinically impinging slips was 62.1 degrees ± 11.9 (range: 48 to 90 degrees), whereas the mean α angle and standard deviation for nonimpinging slips was 56 degrees ± 10.1 (range: 38 to 81 degrees). The impingement group was found to have higher mean values for both the Southwick and α angles than the nonimpinging group, though these were not statistically significant at the 95% confidence level with the exception of the 1-sided t test for the α angle (P = 0.046) (Figs. 3 and 4). We did not detect a pattern between slip grade and pain. Similarly, there was no detectable pattern between the Loder classification and pain or clinical impingement.

**DISCUSSION**

The current standard of treatment for most cases of SCFE is in situ screw fixation using a single cannulated screw,18–21 with stabilization of the slip and premature physeal closure being the primary goals. In our institution, patients are routinely followed to skeletal maturity and then discharged from the orthopaedic service.

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**Table 1. Comparison of Retrospective Review and Clinical Follow-up Groups**

<table>
<thead>
<tr>
<th>No. patients</th>
<th>No. hips</th>
<th>Females/males (hips)</th>
<th>Mean age (SD) years</th>
<th>Males/females (hips)</th>
<th>No. hips</th>
<th>No. patients</th>
<th>Females/males (hips)</th>
<th>Mean age (SD) years</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>65</td>
<td>36</td>
<td></td>
<td></td>
<td></td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19/30 (26/39)</td>
<td>12.15 (1.22)</td>
<td>17/19 (27/22)</td>
<td>12.73 (1.22)</td>
<td>20.7 (2.09)</td>
<td>11.77 (1.45)</td>
<td>19.19 (2.72)</td>
<td>6.1 (3.01)</td>
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</tr>
</tbody>
</table>

**Table 2. Relationship of Symptoms and Signs to Southwick Slip Grade**

<table>
<thead>
<tr>
<th>Southwick Slip Grade</th>
<th>Number</th>
<th>Mean Harris Hip Score</th>
<th>Pain (%)</th>
<th>Pistol-grip Deformity (%)</th>
<th>FADIR Sign of FAI (%)</th>
<th>Pain and Impingement (%)</th>
<th>Impingement and No Pain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 0 pre-slip/prophylactic pinning</td>
<td>7</td>
<td>98.6</td>
<td>2/7 (29%)</td>
<td>4/7 (57%)</td>
<td>0/7 (0%)</td>
<td>0/7 (0%)</td>
<td>0/7 (0%)</td>
</tr>
<tr>
<td>Grade 1 (0-30)</td>
<td>30</td>
<td>95.6</td>
<td>10/30 (33%)</td>
<td>20/30 (67%)</td>
<td>12/30 (40%)</td>
<td>9/30 (30%)</td>
<td>3/30 (10%)</td>
</tr>
<tr>
<td>Grade 2 (30-60)</td>
<td>8</td>
<td>97.0</td>
<td>3/8 (38%)</td>
<td>6/8 (75%)</td>
<td>2/8 (25%)</td>
<td>2/8 (25%)</td>
<td>0/8 (0%)</td>
</tr>
<tr>
<td>Grade 3 (&gt;60)</td>
<td>4</td>
<td>98.0</td>
<td>0/4 (0%)</td>
<td>4/4 (100%)</td>
<td>2/4 (50%)</td>
<td>0/4 (0%)</td>
<td>2/4 (50%)</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>96.6</td>
<td>15/49 (31%)</td>
<td>34/49 (69%)</td>
<td>16/49 (33%)</td>
<td>11/49 (22%)</td>
<td>5/49 (10%)</td>
</tr>
</tbody>
</table>

FADIR indicates flexion adduction internal rotation maneuver; FAI, femoroacetabular impingement.
This study shows a high proportion of patients with ongoing pain (30%) or signs of clinical impingement (32% to 38%) in young adults after SCFE. Furthermore, the severity of slip correlates poorly with impingement. The results are in keeping with the recent study by DeLullo et al who reported a 26% finding of impingement and 32% finding of pain in 38 treated hips followed up for 7.6 years. However, in their study, the relationship between slip severity and impingement was not addressed. We noted that of the patients complaining of painful symptoms, only about half of these had a positive provocative impingement test. Similarly, there were patients who described no painful symptoms, yet still had a clearly positive impingement test. This highlights the fact that there are several alternative causes for painful symptoms other than impingement after SCFE. Equally, it is possible that patients with some degree of impingement may modify their day-to-day activities such that they do not notice impingement symptoms. Our diagnosis of impingement was based upon clinical assessment using a well-described provocation test, as performed by a senior surgeon familiar with hip impingement syndromes. We do accept that this tool is subjective and as such prone to reliability error though we attempted to minimize this by restricting assessment to a single senior clinician.

None of the traditional classification systems of weight-bearing stability, symptom duration, or degree of slip correlated well with the subsequent development of symptoms. DeLullo et al have reported earlier that slip stability, slip severity, or body mass index had no impact on outcome after SCFE. The lack of association between slip severity and pain or impingement in our series may be accounted for, in part, by remodeling of the slip deformity, which some believe may be significant.

We did not investigate this possible phenomenon in this study. We believe individual anatomic variations in acetabular and femoral neck version, and acetabular depth or head capture may be responsible for the poor correlation between the slip grade and clinical impingement that we observed. Furthermore, any radiographic measurement of deformity is subject to inaccuracies of unstandardized technique, interobserver error, and variations in the individual slip direction.

It is an ongoing challenge to identify a standard radiographic assessment that can reliably predict clinical impingement. The Dunn 45 view used in this study may be most useful in determining maximal deformity.
thereby guiding the surgeon on how much, if any, femoral resection is necessary to eliminate impingement. We found the \( \alpha \) angle at clinical follow-up to be the most reliable indicator of impingement and were able to show a significant difference between the \( \alpha \) angles of clinically impinging hips compared with hips that did not. It is noteworthy that Nötzli et al., measuring the \( \alpha \) angle using magnetic resonance imaging, showed a similar range of \( \alpha \) angles for impinging hips (mean 74 degrees \( \pm \) 5.4, range: 55 to 95 degrees). Their results showed a more significant difference between impinging hips and their control hips (who had a mean \( \alpha \) angle of 42 degrees \( \pm \) 2.2, range: 33 to 48 degrees) than ours. However, as they excluded hips from their study on the basis of earlier hip surgery, posttraumatic deformity, or an abnormal acetabulum, a direct comparison with our study is impossible as obviously all of the nonimpinging hips in this current series were pathologic and as such many had abnormally high \( \alpha \) angles. We believe this may also be a factor responsible for the inability of the \( \alpha \) angle to predict impingement in this study.

A limitation of this study was our inability to obtain complete follow-up of the patients of the original cohort. Despite lengthy efforts we were only able to trace and contact 78% of this population. This is unfortunately a feature of the population in question, as we were contacting them at a highly mobile time of life, with most having moved away from their original addresses. It may also reflect an absence of symptoms in these patients that so many have been lost to follow-up. Of those contacted, all but 2 participants (who were asymptomatic) attended the clinical review. We could find no source of selection bias in terms of who was contacted and who was not. In addition, encouragingly, the group we clinically reviewed was representative of the original group as a whole. Another potential limitation of our study is the small numbers of the severe slips. This made it impossible to draw any statistically meaningful conclusions about this subgroup.

We had expected to show a stronger relationship between either slip grade or anterior offset angle \( \alpha \) and FAI. Our results have led us to believe that measurement of slip grade alone is not sufficient to predict later impingement. We do not know the importance of symptomatic impingement in the development of premature arthritis. Long-term studies of both symptomatic FAI and asymptomatic deformity in SCFE are necessary to clarify their role in joint degeneration. For this reason, and due to the significant number of painful and clinically impinging hips, irrespective of grade, we would recommend that all but pre-slips and prophylactically pinned hips continue to be monitored for FAI and where necessary, referred for treatment. Long-term outcome studies are also needed to determine whether early intervention for SCFE with FAI has a beneficial effect on the prevention of degenerative joint disease.

REFERENCES