Systematic Review

Does Femoroacetabular Impingement Cause Hip Instability? A Systematic Review

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Purpose: To determine whether femoroacetabular impingement (FAI) is associated with hip instability. Methods: A systematic search examining FAI and hip instability was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Clinical and basic science studies were included. Instability had to be documented with either a clinical or imaging examination. Studies were excluded if they did not define diagnostic criteria for FAI, involved prosthetic hips, were not in English, were review articles, or reported Level V evidence (case reports, expert opinion). Rates of FAI morphologic features in patients with documented hip instability were determined. Mechanisms and rates of FAI-induced hip subluxation were examined in basic science studies. Results: The search yielded 1,630 relevant studies. Seven studies (4 clinical and 3 basic science) met inclusion criteria. Four studies investigated an association between FAI and hip instability in 92 patients with an average age of 31 years. Seventy-six patients experienced frank dislocations and 16 experienced posterior subluxation events. The prevalence of FAI was documented in 89 patients with hip instability. The rates of cam and pincer morphologic characteristics were 74% and 64%, respectively. The average lateral center edge angle and prevalence of acetabular retroversion were 30° and 70%, respectively (n = 76 patients). All 3 basic science studies had real-time visualization of FAI-induced hip subluxations. Conclusions: High rates of FAI morphologic characteristics are present in patients with hip instability. FAI morphologic characteristics may predispose the hip to instability through anatomic conflict caused by pincer or cam lesions (or both) levering the femoral head posteriorly. Level of Evidence: Level IV, systematic review of Level III, Level IV, and non-clinical studies.

The hip joint has historically been considered highly stable, and hip instability has traditionally been associated with high-energy injury mechanisms. However, low-energy or atraumatic hip instability is an increasingly recognized source of hip pain and dysfunction. The pathomechanics of this form of hip instability are still being defined. However, it has been associated with previous trauma, repetitive microtrauma, systemic conditions, and anatomic abnormalities. Impingement of total hip arthroplasty components is a well-known mechanism of atraumatic prosthetic hip instability. This commonly occurs when there is a decreased head to neck ratio (analogous to cam impingement) or when the femoral component levers off a prominent osteophyte or malpositioned acetabular component (analogous to pincer impingement). Femoroacetabular impingement (FAI) is encountered in the native hip when abnormal femoral or acetabular morphologic features (or both) result in anatomic conflict between the proximal femur and the acetabular rim. If impingement between prosthetic hip components can result in hip instability, it is plausible that impingement occurring in the native hip could also lead to instability through a similar mechanism.

The purpose of this systematic review was to determine if FAI is associated with hip instability. Our hypothesis was that FAI morphologic characteristics are associated with hip instability.

Methods
A systematic search of the PubMed and Scopus databases was performed on March 15, 2015 using the following search terms: (“femoroacetabular impingement” OR “hip impingement” OR “cam impingement” OR “pincer”) AND (instability OR dislocation OR subluxation...
OR stability OR motion). Guidelines for the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were followed. Titles from the search results were screened by 2 authors (C.D.C., B.D.G.) to find relevant studies for further review. The following criterion had to be met for inclusion: English language studies investigating an association between FAI and hip stability. Studies involving patients with both symptomatic and asymptomatic FAI were included. Instability had to be documented with either a clinical or imaging examination. Studies were excluded if they did not define diagnostic criteria for FAI, involved prosthetic hips, involved animals, were not written in English, were review articles, or reported Level V evidence (case reports, expert opinion). Authors of included studies were contacted for additional information if needed.

Descriptive statistics are presented. Continuous variables are presented as mean with standard deviation. Categorical data are presented as frequencies using percentages.

**Results**

The search strategy yielded 1,630 results. There were 721 duplicate results and 67 non-English studies that were excluded. After 2 authors (C.D.C., B.D.G.) screened the remaining 910 results, 29 studies were selected for further review, and 9 (4 clinical and 5 basic science) were found to meet criteria for inclusion. However, 3 of the basic science studies reported on results from the same cohort of patients, and the most relevant study with the largest cohort was included, and the 2 others were excluded. Relevance was determined based on author consensus. Seven studies (4 clinical and 3 basic science) were included in the systematic review (Fig 1).

Four clinical studies investigated an association between FAI and hip instability in 92 patients with an average age of 31 years (Table 1). Seventy-six patients experienced frank dislocations (74 posterior and 2 anterior), and 16 patients experienced posterior subluxation events defined by an acute instability event associated with posterior acetabular rim fracture on imaging.

High rates of radiographic FAI morphologic features were found in patients being treated after hip instability events. Krych et al., Philippon et al., and Steppacher et al. reported rates of cam and pincer impingement in a total of 89 patients (average age, 31 years) with...
instability events. Cam and pincer morphologic characteristics were found in 66 (74%) and 57 (64%) patients, respectively. Steppacher et al.12 and Berkes et al.9 reported an average alpha angle of 58° in 56 patients. Krych et al.10 and Steppacher et al.12 reported an average lateral center edge angle of 30° in 75 patients and documented acetabular retroversion in 54 of 75 (72%) patients.

Krych et al.,10 Philippon et al.,11 and Berkes et al.9 reported on 39 athletes who sustained instability events, 30 of whom had morphologic features consistent with FAI. Twenty-eight patients were treated with surgery that addressed both traumatic capsulolabral injury and the underlying FAI pathologic condition. Twenty-six (93%) returned to their previous level of sport participation. Krych et al.10 also managed 10 athletes with FAI and an instability event non-operatively with protected weight bearing and range of motion, and all 10 returned to their previous level of sport participation.

Three basic science studies used advanced imaging techniques to correlate FAI with femoral head subluxation (Table 2).6,13,14 Charbonnier et al.13 used magnetic resonance imaging (MRI) to construct 3-dimensional (3D) models of the hips of 11 professional dancers. They then obtained motion capture data of the dancers in ballet positions of extreme hip flexion, abduction, and rotation. These data were applied to the 3D hip models to dynamically visualize FAI and femoral head subluxation. Despite no dancer having radiologic evidence of impingement morphologic characteristics, rates of FAI were as high as 70% in certain positions. Additionally, subluxation occurred at rates as high as 39%, and translation distances averaging 5 mm were seen with extreme hip flexion. Subluxations were always correlated with FAI, suggesting that subluxation was a direct response to FAI. Cartilage and labral lesions on MRI corresponded to sites at which FAI was visualized, which in this cohort were superior and posterior sites.

Kolo et al.6 performed MRI on 30 professional dancers’ hips (11 of whom were also included in the study by Charbonnier et al.13) to quantify subluxation of the hip joint in extreme flexion. 3D models of each hip were constructed from MR images in the supine position. Each dancer underwent MRI in the splits position, and these data were applied to the 3D models to visualize FAI and subluxation in extreme flexion. None of the patients had radiologic signs of impingement except for one patient with a cam lesion. However, chondral lesions greater than 5 mm were reported in 29% of dancers, and labral lesions were visualized in 47%. In a control group of nondancers, both chondral and labral lesions were reported less frequently (7% Table 2. Characteristics of Basic Science Studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Publication Year</th>
<th>Level of Evidence</th>
<th>Number of Hips</th>
<th>Average Age</th>
<th>Patient Type</th>
<th>Imaging Modality</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charbonnier et al.13</td>
<td>2011</td>
<td>Basic science</td>
<td>22</td>
<td>25</td>
<td>Dancers</td>
<td>Dynamic MRI</td>
<td>FAI and subluxation commonly occur at extreme ranges of motion even in the setting of normal hip morphologic characteristics</td>
</tr>
<tr>
<td>Kolo et al.6</td>
<td>2013</td>
<td>Basic science</td>
<td>59</td>
<td>25</td>
<td>Dancers</td>
<td>Dynamic MRI</td>
<td>Average hip subluxation in splits position was 2.05 mm and associated with pincer impingement</td>
</tr>
<tr>
<td>Wassilew et al.14</td>
<td>2013</td>
<td>Basic science</td>
<td>30</td>
<td>37</td>
<td>Adults with symptomatic FAI</td>
<td>Dynamic 4D CT</td>
<td>High rates of posterior subluxation with extreme ranges of motion in patients with FAI</td>
</tr>
</tbody>
</table>

4D, 4-dimensional; CT, computed tomography; FAI, femoroacetabular impingement; MRI, magnetic resonance imaging.
and 29%, respectively. Mean femoroacetabular subluxation in a side split position (extreme flexion) was 2.05 mm (0.63 to 3.56 mm). Despite normal hip morphologic characteristics in this cohort of dancers, extreme hip positions appeared to cause FAI and result in cartilage and labral injury. Additionally, this extreme motion also resulted in femoroacetabular subluxation.

Real-time visualization of FAI and subluxation has also been documented in nondancers. Wassilew et al. used 4D volume computed tomography (CT) in 30 patients with clinical and radiographic signs of FAI to visualize FAI and femoral head subluxation. Dynamic CT was performed in positions of maximum flexion as well as abduction with external rotation. Anterior impingement and posterior subluxations were seen in 90% and 70% of patients, respectively. Posterior impingement and anterior subluxations were seen in 77% and 40%, respectively. The authors concluded that all FAI subtypes can result in impingement and subluxation.

**Discussion**

FAI morphologic features are frequently seen in patients who experience hip instability, suggesting that pathologic anatomic conflict may render the hip joint vulnerable to instability. Basic science studies lend further support to this concept by showing impingement-induced subluxation events in real time. Although these studies do not prove that FAI causes instability, they do show an association and suggest a mechanism by which instability can result from FAI. The majority of reported instability events occurred in a posterior direction and were associated with anterior FAI. Krych et al. suggested a mechanism of instability in which anterior anatomic conflict levers the femoral head posteriorly. This mechanism is supported by the posterior labral contrecoup lesion often seen in patients with anterior FAI, which is thought to result from posterior subluxation of the femoral head. Hip subluxation induced by FAI can be shown using dynamic fluoroscopy (Video 1, available at www.arthroscopyjournal.org). After correction, dynamic fluoroscopy should show restoration of normalized arthrokinematics and congruency throughout a physiologic range of motion (Video 2, available at www.arthroscopyjournal.org).

Recently there has been increasing interest in defining the influence of femoral and acetabular version on outcomes after hip preservation surgery. Although the orientation of femoral and acetabular components is a well-known factor affecting stability in prosthetic hips, less is known about the effect of version on stability in the native hip. Acetabular retroversion is associated with FAI in the native hip and could contribute to an elevated risk of posterior instability in patients with FAI. Acetabular retroversion was documented in 54 of 75 (72%) patients with instability by Steppacher et al. and Krych et al. This is considerably higher than the 37% rate of acetabular retroversion found in asymptomatic hips in a study by Larson et al. However, the former studies included the crossover sign as a marker of acetabular retroversion, which may overestimate this finding. None of the studies included in the present review evaluated femoral orientation, so conclusions regarding its influence on stability could not be made.

FAI may also predispose the hip to instability through attenuation of the static and dynamic stabilizers of the hip. The acetabular labrum is an important contributor to hip stability and is frequently torn in patients with FAI. Tearing of the labrum and loss of its stabilizing effect may further destabilize hips in patients with FAI who are already predisposed to instability directly from bony impingement. Chronic capsular attenuation and pain inhibition of the dynamic hip stabilizers may further predispose patients with FAI to hip instability. The mechanism by which FAI predisposes the hip to instability is likely multifactorial, with contributions from abnormal osseous morphologic features, weakened static stabilizers, and dynamic factors.

Numerous studies have shown an association between FAI and the development of osteoarthritis. The mechanism of progressive chondral wear is thought to involve repetitive anatomic conflict between the proximal femur and acetabulum, resulting in chondral delamination and eventual joint degeneration. However, to date longitudinal studies have been unable to definitively prove that FAI causes osteoarthritis. Although FAI likely contributes to the development of osteoarthritis through direct articular injury at areas of impingement, instability resulting from FAI may also lead to cartilage injury. This could explain the posterior-inferior contrecoup acetabular lesion often encountered in patients with FAI. Additionally, it is plausible that instability and joint incongruity resulting from FAI could lead to accelerated mechanical wear through abnormal loading and altered contact stress and force distribution.

In addition to the studies included in this systematic review, there are 2 case reports of low-energy posterior hip dislocations associated with FAI. Manner et al. described a 16-year-old boy who sustained a posterior hip dislocation after a fall onto a flexed knee during a soccer game. After uneventful closed reduction, the hip dislocated 2 additional times during the following 4 days despite standard precautions. On evaluation, he was found to have anterior FAI, and a surgical hip dislocation was performed for capsulolabral repair and FAI correction. The authors visualized anterior femoroacetabular contact with hip flexion resulting in dislocation intraoperatively. The instability persisted despite provisional capsular repair; however, stability was achieved after
FAI correction with femoral osteochondroplasty. Lax-Perez et al. reported a 28-year-old man with mixed FAI who also sustained a low-energy posterior hip dislocation during a soccer game. He was treated with open reduction and internal fixation of an associated rim fracture and had no recurrent instability. Although the authors believed that FAI contributed to this patient’s instability, the FAI was not surgically addressed.

Emerging data suggest that patients who experience symptomatic hip instability (traumatic and atraumatic) may be predisposed to instability because of their bony morphologic characteristics. FAI morphologic features were frequently encountered in patients with instability in several series. Radiologic and basic science studies support the concept that anatomic conflict between the proximal femur and acetabulum increases joint translation and may predispose to subluxation or frank dislocation. The clinical relevance of the high prevalence of FAI morphologic features in patients with instability is difficult to interpret because radiographic markers of FAI are common in asymptomatic individuals. A recent systematic review reported a 37% and 67% prevalence of asymptomatic cam and pincer lesions, respectively, in the general population. Although our review found considerably higher rates of cam impingement in patients with instability (74% vs 37%), the rate of pincer impingement was similar (64% vs 67%). This suggests that cam impingement may predispose to instability more than pincer impingement. Increased awareness of the potential link between FAI and hip instability may lead to improvements in treating and preventing this phenomenon.

Limitations

Because there are limited studies reporting on FAI and hip instability, this review included a small number of patients, and this is a considerable limitation. Many previous studies of hip instability occurred before the concept of FAI had been well defined and did not consider the potential influence of joint morphologic characteristics on hip stability. The rates of FAI in these studies were therefore not documented. However, among those studies that did assess FAI markers in patients with hip instability and were included in our analysis, selection bias could result in including relatively more patients with FAI, falsely elevating the prevalence of FAI in patients with instability. Interpretation of hip imaging and definitions of cam and pincer deformities vary between authors and institutions, which introduces variability in how FAI is defined. Although some studies confirmed the presence of FAI with MRI, arthroscopy, or direct surgical visualization, others defined it using radiographic markers alone, which are commonly present in asymptomatic patients. Some studies defined pincer impingement based on the presence of a crossover sign, which may overestimate acetabular retroversion. Finally, although a correlation between markers of FAI and clinically meaningful hip instability was found, no study was able to prove that FAI caused instability. Further investigations are required to better define the mechanism by which FAI may contribute to hip instability.

Conclusions

High rates of FAI morphologic characteristics are present in patients with hip instability. FAI morphologic characteristics may predispose the hip to instability through anatomic conflict caused by pincer or cam lesions (or both) leveraging the femoral head posteriorly.

References


18. Ferro FP, Ho CP, Briggs KK, Philippon MJ. Patient-centered outcomes after hip arthroscopy for femoroacetabular impingement and labral tears are not different in patients with normal, high, or low femoral version. Arthroscopy 2015;31:454-459.


**Video 1.** Live fluoroscopic video showing femoroacetabular impingement (FAI)-induced hip subluxation with flexion and internal rotation. Note the vacuum sign and subluxation that occurs as the cam lesion engages the acetabulum and subluxates the femoral head out of the acetabulum.

**Video 2.** Live fluoroscopy of the same patient showing resolution of hip subluxation after arthroscopic FAI correction.