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Femoroacetabular Impingement in Ballet Dancers: A Narrative Review of Prevalence, Biomechanics, and Treatment

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***Abstract*—** Femoroacetabular impingement (FAI) syndrome is a prevalent hip disorder among ballet dancers, arising from extreme ranges of motion, repetitive high-load movements, and early onset of professional training. This narrative review summarises current evidence regarding FAI in ballet dancers, focusing on its biomechanical determinants, clinical presentation, diagnostic evaluation, and treatment strategies. Ballet-specific movements place the hip at high risk for impingement and subluxation, potentially leading to labral and cartilage injuries. Clinical assessment, including FADIR and FABER tests, combined with radiographs, MRI, and, when indicated, CT, provides a comprehensive evaluation of structural and soft tissue pathology. Non-operative management with targeted physical therapy and core strengthening is effective for symptom relief, while arthroscopic surgery offers superior outcomes in refractory cases. Factors such as preoperative chondral damage and high alpha angles may influence surgical prognosis. Despite advances in diagnosis and treatment, long-term outcomes and the impact of interventions on the development of hip osteoarthritis remain unclear. Early detection, targeted rehabilitation, and timely surgical intervention are essential to preserve hip function and career longevity in ballet dancers.

Keywords— femoroacetabular impingement syndrome, FAI, ballet dancers, cam morphology, pincer morphology, FADIR, FABER

1. INTRODUCTION

When observing the performing arts, such as ballet, one experiences the culmination of countless hours devoted to perfecting every movement: each pirouette, arabesque, or *grand jeté*. While repetitive training ultimately results in exceptional technical proficiency, which is undoubtedly aesthetically rewarding for spectators, it may also carry substantial health consequences over years of intensive practice. Ballet dancers are particularly prone to hip-related disorders [17], not only due to the repetitive nature of training but also because of the demands to perform movements at extreme ranges of motion.

One of the most common hip-related conditions among professional ballet dancer is femoroacetabular impingement syndrome (FAI). Accordingly, this narrative review aims to summarise current evidence regarding FAI in ballet dancers, with a focus on its prevalence, biomechanical factors, and available treatment strategies.

2. FAI SYNDROME

Femoroacetabular impingement (FAI) syndrome [7] refers to a condition in which structural irregularities of the femoral head–neck junction and the acetabulum lead to abnormal contact within the hip joint. This altered anatomy results in atypical distribution of mechanical forces and progressive joint overload, ultimately contributing to damage of the labrum and articular cartilage [2]. During movements performed at extreme ranges of motion, direct mechanical conflict between the femoral neck and the acetabulum may occur, resulting in pain and functional limitation [1].

In order to improve the process of diagnosis and subsequent management of patients with FAI syndrome, the Warwick Agreement consensus statement was introduced in 2016. This document addresses key questions regarding the diagnosis of FAI syndrome, including its clinical symptoms and signs, as well as the role of diagnostic imaging in establishing an accurate diagnosis. Additionally, it outlines appropriate treatment strategies and discusses the prognosis of the condition [7]. An overview of selected core terminology and guiding principles from the consensus statement is presented in Table 1.

Issue	**Consensus**
How should FAI syndrome be diagnosed?	Symptoms, clinical signs and imaging findings must be present in order to diagnose FAI syndrome.
	Symptoms: Pain in the hip or groin related to specific motion or position. Additional symptoms may be present such as clicking, locking or stiffness within the hip joint.
	Clinical signs: Diagnosis of FAI syndrome does not depend on a single clinical sign. The flexion adduction internal rotation (FADIR) test is the most commonly used during diagnosis. Usual result: limited range of motion, restricted internal rotation and flexion.
	Diagnostic imaging: An antero-posterior radiograph of the pelvis and a lateral femoral neck view of the symptomatic hip should be performed to gain an overview of the hips, identify cam or pincer morphologies, and identify other causes of hip pain. Cross-sectional imaging is possible in the need of further assessment of hip morphology and surrounding tissues.
What is the appropriate treatment of FAI syndrome?	Conservative care, rehabilitation and surgery are possible ways of treatment.
What is the prognosis of FAI syndrome?	Patients treated for FAI syndrome experience improvement in pain complaints as well as the possibility of returning to full sporting activity.

TABLE 1. TERMINOLOGY RELATING TO FEMOROACETABULAR IMPINGEMENT (FAI) [7]

FAI syndrome morphologies

Three morphologies of the FAI syndrome are mentioned in specialist literature:

1. cam morphology
2. pincer morphology
3. mixed morphology.

Cam morphology is characterised by an abnormal shape of the femoral head-neck junction leading to mechanical conflict with the acetabular rim, which is most pronounced during movements involving hip flexion, adduction, and internal rotation. [1]

Pincer morphology is characterised by the excess of the anterosuperior part of the acetabular rim, causing abnormal contact between the acetabulum and the femoral neck. This repetitive impingement may lead to the disconnection of the rim (labral injury) and damage to the adjacent articular cartilage. As a chronic adaptive response, ossification of the acetabular rim may occur.

Mixed morphology represents the most common form of femoroacetabular impingement syndrome, characterised by the coexistence of cam and pincer features.

A figure illustrating the different morphologies of femoroacetabular impingement syndrome is presented below.

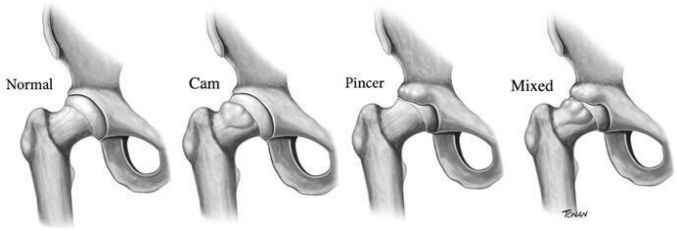

Fig. 1 Comparison of femoroacetabular impingement (FAI) morphologies with normal hip anatomy [22]

Epidemiology of FAI

The femoro-acetabular impingement is said to be the most common among young and physically active individuals aged between 30 and 40 years of age who are regularly exposed to movements of an extreme range of flexion and internal rotation in the hip joint. The condition is particularly prevalent among dancers, athletes, football players, hockey players and yoga enthusiasts [1]. With regard to the epidemiology of specific FAI morphologies, **cam-type impingement** accounts for approximately 37% of cases, whereas **pincer morphology** is reported in up to 67% of patients [2]. Cam morphology is more frequent among men, while pincer morphology predominates among women. [5] Notably, the coexistence of cam and pincer features (mixed morphology) represents the most common presentation of femoroacetabular impingement syndrome.

Biomechanics and Onset of FAI Syndrome in Ballet Dancers

Ballet dancers are particularly susceptible to developing femoroacetabular impingement (FAI) due to the intense physical demands of their discipline, which often begins in early childhood [21] and involves many years of repetitive, high-load movements. Training typically includes extreme ranges of hip motion—such as deep flexion, external rotation (turnout), and forceful jumps—which place considerable stress on the hip joint. In individuals who have not yet reached skeletal maturity, repeated

high-intensity loading at these extreme ranges may induce adaptive changes in the proximal femoral growth plate, contributing to overgrowth and potentially the formation of cam morphology [6,8,4].

In dancers, the most frequently observed manifestations of FAI syndrome are typically located at the superior and posterosuperior regions of the acetabular rim. This distribution is thought to result from a levering mechanism during extreme hip movements, which can lead to repetitive subluxation and contribute to overall hip instability [9],[10],[3],[11].

Interestingly, certain ballet movements, including *développé à la seconde*, *grand écart facial*, *grand écart latéral*, and *grand plié*, appear to place the hip at greater risk of subluxation due to extreme ranges of motion and high mechanical loading. Movements such as *grand plié*, *battements*, and *développés* are also foundational components of classical ballet technique, introduced from the earliest stages of training and repeated extensively throughout a dancer's development. Dynamic motion analysis confirms that these movements often result in frequent hip impingements and subluxations, with the highest contact forces observed in the superior and posterosuperior acetabular regions, consistent with radiological patterns of labral stress [3].

This combination of early exposure, repetitive practice, and biomechanical demand may contribute to abnormal contact between the femoral head–neck junction and the acetabular rim, increasing the risk of femoroacetabular impingement (FAI) syndrome [11],[22].

Symptoms and diagnosis

Symptoms and physical examination

The primary symptom of femoroacetabular impingement syndrome is pain typically located in the groin and in the greater trochanteric area, which arises during high-intensity activities involving extreme hip motion, such as the flexion of the internally rotated lower limb. Initially, the pain is often intermittent, but may become more persistent as the condition progresses over time [1].

Symptoms are also frequently provoked by prolonged sitting followed by a sudden transition to a standing position. [17]

Physical examination plays a key role in the assessment of FAI. Commonly used tests include the **FADIR test**, which involves flexion, adduction and internal rotation. In individuals with FAI, this test is typically positive, causing pain in the groin or lateral hip, reflecting intra-articular stress often associated with labral or cartilage pathology. Although FADIR is considered sensitive for detecting labral abnormalities in dancers, it is relatively nonspecific and should not be used in isolation. [12].

Another frequently employed manoeuvre is the **FABER test,** which involves flexion, abduction and external rotation, which can help identify asymmetry between the hips and reveal impingement on the affected side. Similar to FADIR, a positive FABER test may indicate intra-articular issues, but its specificity is limited. Therefore, both tests are best interpreted in conjunction with imaging studies and a comprehensive clinical assessment to improve diagnostic accuracy.

Diagnostic imaging

Radiographic imaging is the most commonly used tool in the diagnosis of femoroacetabular impingement (FAI) syndrome, though computed tomography (CT) and magnetic resonance imaging (MRI) can provide additional valuable information. Standard radiographs are typically obtained in anteroposterior (AP) and supine Dunn 45° projections [5]. Radiographic signs suggestive of FAI include the **crossover sign**,

posterior wall sign, and **ischial spine sign**, which, together with the **alpha angle**, should be assessed to identify pincer or cam morphology [1][3].

Cam morphology is characterised by asphericity of the femoral head-neck junction in all three dimensions. On radiographs, this can be quantified by **an increased alpha angle**, **a decreased head-neck offset ratio**, and **a reduced head-neck offset**. These parameters together indicate abnormal femoral head contour and reduced clearance between the femoral neck and acetabulum, which can lead to impingement during hip motion. Although these measurements can be obtained on standard radiographs, their interpretation should consider the projection used and normative values for the population studied, as thresholds may vary [23].

MRI is useful for assessing both bony and soft tissue structures, including the labrum and cartilage, and can also evaluate hip function during extreme ranges of motion. In a study conducted in Switzerland involving 30 adult professional female ballet dancers, an MRI scan was performed in both supine and split positions. Interestingly, the prevalence of classical cam or pincer morphology in this population was low, despite the extreme hip mobility observed. The authors suggested that the combination of repetitive stress and joint hypermobility, rather than overt structural deformities, may contribute to early hip osteoarthritis development. However, the small sample size limits the generalizability of these findings [3],[16].

Comparative studies indicate that the superior alpha angle in ballet dancers (38.9° ± 6.9°) is lower than in other athletes (46.7° ± 10.6°), suggesting that despite their high flexibility and extreme hip ranges of motion, ballet dancers may present with less pronounced cam morphology. This highlights the potential role of biomechanical stress and hypermobility in joint degeneration rather than purely structural abnormalities [26][24].

CT imaging may be used in selected cases, particularly when precise assessment of the bony anatomy is required for surgical planning. Overall, combining radiographs, MRI, and, when indicated, CT provides the most comprehensive evaluation of FAI, allowing for accurate diagnosis and tailored management [25].

3. TREATMENT AND ITS RESULT

Non-operative management

The non-operative approach to FAI syndrome is based on conservative treatment, which focuses on patient education, structured physical therapy, non-steroidal anti-inflammatory drugs (NSAIDs), and, in some cases, intra-articular injections [2]

Among these approaches, physical therapy plays a central role, contributing to improved hip mobility, core stability, and pain reduction. Targeted strengthening of the core and active rehabilitation exercises appears particularly effective in alleviating symptoms, whereas intra-articular musculoskeletal injections have demonstrated only limited and short-term benefit [2]. Non-operative strategies are generally recommended before considering surgical intervention.

Operative management

For patients with persistent symptoms despite conservative care, arthroscopic hip preservation surgery offers a means to reduce pain and restore function [13],[14]. Ballet dancers undergoing arthroscopic treatment have shown a high rate of return to dance, typically resuming training after approximately seven

months [15]. Surgical correction involves femoral osteoplasty for cam morphology and acetabular osteoplasty for pincer morphology [16],[17].

Evidence from a retrospective cohort of 626 individuals with FAI indicates that preoperative factors—including chondral damage, high alpha angles, elevated body mass index, and female sex—may negatively influence return to high-level sport following surgery [26],[17].

Current studies suggest that patients treated arthroscopically experience greater improvements in symptoms and functional outcomes compared with those managed exclusively with physical therapy [18]. However, direct comparisons between operative and non-operative management remain limited, and long-term studies are needed to evaluate the impact of these treatments on the development of hip osteoarthritis.

4. CONCLUSION

Femoroacetabular impingement (FAI) is a significant concern for ballet dancers due to extreme hip motion, repetitive loading, and early intensive training. The interaction between cam, pincer, and mixed morphologies and biomechanical demands predisposes dancers to labral and cartilage injuries, hip subluxation, and potential long-term joint degeneration.

Accurate diagnosis relies on clinical assessment (FADIR, FABER) complemented by radiographs, MRI, and, when indicated, CT. Non-operative management, particularly structured physical therapy and core strengthening, effectively reduces symptoms, while arthroscopic surgery provides superior outcomes in refractory cases. Preoperative factors such as chondral damage or high alpha angles may limit surgical recovery.

Despite advances in understanding and management of FAI in ballet dancers, long-term comparative studies of operative versus non-operative approaches are limited, and the effect of these interventions on the future development of hip osteoarthritis remains incompletely understood. Future research should aim to identify preventive strategies, optimise early detection, and evaluate long-term outcomes to safeguard hip health and career longevity in dancers.

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