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Leg dominance as a risk factor for femoroacetabular impingement syndrome

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ABSTRACT

One etiological factor of femoroacetabular impingement syndrome (FAIS) is high impact athletics involving deep hip flexion, axial loading and jumping during skeletal development. Previous work has established that there is physiologic asymmetry of the lower limbs regarding function, with the dominant limb being primarily responsible for propulsion and kicking while the non-dominant limb is responsible for stability and planting. The authors hypothesize that the dominant limb will be more likely to undergo hip arthroscopy for symptomatic FAIS. Four hundred and sixty-nine patients at a single surgical center who underwent primary or revision hip arthroscopy for cam-type FAIS were identified. Patients were asked to identify their dominant lower extremity, defined as the lower extremity preferred for kicking. Sixty patients who indicated bilateral leg dominance were excluded. It was assumed that with no association between limb dominance and the need for surgery, the dominant side would have surgery 50% of the time. Enrichment for surgery in the dominant limb was tested for using a one-sample test of proportions, determining whether the rate differed from 50%. The enrichment for surgery on the dominant side was 57% (95% confidence interval 52–62%) which was significantly different from the rate expected by chance (50%), $P = 0.003$. No other significant differences were noted between groups. Limb dominance appears to be an etiological factor in the development of cam-type FAIS. Patients are more likely to undergo arthroscopic treatment of FAIS on their dominant lower extremity, although the non-dominant lower extremity frequently develops FAIS as well.

INTRODUCTION

Femoroacetabular impingement syndrome (FAIS) is defined as the *painful* symptoms caused by impingement of the proximal femur against the edge of the acetabular rim secondary to a bony morphology mismatch. This is a common cause of hip pain in active young adults and is diagnosed in 17% of patients presenting to their primary care provider with hip pain [1]. FAI can be broadly categorized into cam and pincer morphologies; cam morphology describes abnormal bony overgrowth of the head–neck junction of the femur, whereas pincer morphology describes a deep acetabular rim leading to pathologic overcoverage of the femoral head [2, 3].

Patients with FAIS may eventually develop osteoarthritis (OA) of the hip joint and have demonstrated worsening patient reported outcomes when left untreated [4, 5]; however, the natural history of FAI and progression to OA is incompletely understood. Many patients with radiographic findings of FAI are asymptomatic [6]. Furthermore, as many as 37% of asymptomatic patients have some degree of cam morphology and 67% have some degree of pincer morphology [7]. It is important to understand that FAI radiographic findings do not imply that the patient has clinical symptoms of FAIS.

Multiple etiological factors for cam morphology, specifically, have been identified. These include high intensity athletics involving deep hip flexion, axial loading and jumping at a young age [8–11]. A study of a division 1A collegiate American football team found that 95% of 134 hips had at least one radiographic sign of cam or pincer

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morphology [12]. Additional etiologies of FAI with cam morphology include previous slipped capital femoral epiphysis, Legg–Calvé–Perthes disease and femoral neck fractures [13–17].

In this study, lower limb dominance was investigated as a possible etiological factor in the development of FAIS. Previous work has established that the dominant lower extremity is primarily responsible for propulsion during able-bodied gait, while the non-dominant lower extremity is primarily responsible for control [18, 19]. This asymmetry in the function of the lower extremities has been established through studies of ground reaction forces and gait analyses [19–24]. Given these varying forces, the dominant limb may be more susceptible to the development of FAIS, which may eventually lead to higher rates of surgical treatment.

Limb dominance has been explored as an etiological factor in a number of other lower extremity orthopedic conditions including ankle injuries [25, 26], anterior cruciate ligament tears [27, 28] and knee OA [29]. A recent study found that the dominant lower extremity was more likely to undergo a hip replacement for hip OA [30], although another study found that the non-dominant limb underwent a hip replacement more frequently [31].

No studies to date have assessed limb dominance as an etiological factor for FAIS. Given the known association between certain high impact activities and FAI, the authors hypothesized that the dominant lower extremity (kicking leg) would have higher rates of cam-type FAIS leading to hip arthroscopy.

MATERIALS AND METHODS

At a single orthopedic surgical center, all patients of the senior author were asked to indicate their dominant lower extremity on the clinic intake form. The dominant lower extremity is defined as the preferred leg to kick a ball, as contrasted by the non-dominant lower extremity which is planted at the time of kicking. With approval from the University of Utah Institutional Review Board (IRB#71733), charts were reviewed of all hip arthroscopy patients of the senior author who underwent primary or revision procedures for cam-type FAIS between May 2014, when leg dominance data collection began, and January 2017. Based on these criteria, 469 patients were identified. Patients who indicated bilateral symptoms or lack of a dominant lower extremity were excluded.

Patient demographics were summarized as count (%) or mean (standard deviation) with and without stratifying by surgery location. Differences between surgery locations were assessed using a χ^2 test for categorical variables and a *t*-test for continuous variables. Multivariable logistic regression was used to examine the relationships between patient demographics and surgery location. It was assumed that with no association between limb dominance and the need for surgery, the dominant side would have surgery 50% of the time. Enrichment for surgery in the dominant limb was tested for using a one-sample test of proportions, comparing whether the rate differed from 50%. Statistical analyses were conducted (R Statistical Software v3.5.1) and significance was assessed at the 0.05 level and all tests were two-tailed.

A power analysis indicated that with 400 patients there would be 90% power to detect an absolute increase of 8% for the dominant side from 50% (50% versus 58%) at a 0.05 significance level using a two-sided, one-sample test of proportions.

RESULTS

Patient demographics are summarized in Table I, and stratified by limb dominance in Table II. In total, 469 patient charts were reviewed. Sixty patients indicated bilateral leg symptoms or lack of dominant lower extremity and were excluded from this analysis. Among the remaining 409 patients, 235 (57%) had surgery on their dominant side. The enrichment for surgery on the dominant side was 57% [95% confidence interval (CI) 52–62%] and was significantly different from the rate expected by chance (50%), $P = 0.003$.

From simple univariate analysis, laterality of limb dominance was the only patient characteristic associated with the side that patients had surgery (Table I). Patients with right-sided dominance had symptoms and underwent surgery more frequently on the right hip (57%). Patients with left sided dominance had symptoms and underwent surgery more frequently on the left hip (61%). A multivariable logistic regression model predicting surgery on the dominant side yielded results consistent with the simple univariate analysis (data not shown).

DISCUSSION

This is the first study addressing the relationship between limb dominance and cam-type FAIS. As hypothesized, the dominant lower extremity was significantly more likely to develop FAIS.

While there is no previous research addressing the relationship between limb dominance and FAIS, similar studies in the hip OA population can provide context. Stea *et al.* [31] retrospectively reviewed 262 hip arthroplasty patients and found that 50.7% of the right-leg dominant patients had surgery performed on their right hip, and 23.2% of left-leg dominant patients had surgery on their left hip ($P = 0.001$). Limb dominance as a risk factor for

Table I. Patient characteristics (N = 409)

Variables	*Summary*	P-*value*
Sex, *n* (%)		
Male	119 (29)	—
Female	290 (71)	—
Age at surgery, mean (SD)	35.9 (11.4)	—
Body mass index, mean (SD)	25.6 (5.2)	—
Surgery type, *n* (%)		
Primary	334 (82)	—
Revision	75 (18)	—
Laterality, *n* (%)		
Right	225 (55)	—
Left	184 (45)	—
Surgery location, *n* (%)		
Dominant	235 (57)	0.003
Non-dominant	174 (43)	—
Surgery side for right leg dominant, *n* (%)		
Right	208 (57)	—
Left	157 (43)	—
Surgery side for left leg dominant, *n* (%)		
Right	17 (39)	—
Left	27 (61)	—

hip OA was not statistically analysed; however, the data provided show that 42% (92/216) of the patients in this study had surgery on the dominant limb, while 58% (127/216) on the non-dominant limb.

Cawley *et al.* [30] published conflicting research on the significance of hand dominance in 322 THA patients. Of those with unilateral hip OA, patients were more likely to have surgery on the same side as their dominant hand [odds ratio (OR) = 3.3, 95% CI 1.2–9.1; $P = 0.02$]. Those with bilateral hip arthroplasty had more severe symptoms on their dominant side (OR = 4.3, 95% CI 0.84–22.2; $P = 0.03$). The authors concluded that limb dominance was an epidemiological entity and the tasks of the dominant limb (e.g. propulsion) may contribute to more rapid degeneration of the cartilage of the hip joint. A weakness of this study was the use of hand dominance instead of leg dominance as the prevalence of cross-dominance of handedness and footedness has been shown to be at least 5% [32–34].

The findings of the present study demonstrated that the dominant limb was significantly more likely to develop symptomatic FAI leading to arthroscopic hip surgery; however, the 43% of patients with non-dominant limb pathology indicate that FAIS is far from limited to the dominant limb. Other research supports that FAI is not a unilateral phenomenon. In a recent computed tomography analysis of 590 asymptomatic patients with cam and pincer morphology, Mascarenhas *et al.* [35] concluded that hip shape was symmetric regardless of limb dominance. In a cohort of 113 patients with cam-type FAIS, Allen *et al.* [36] found that 77.8% had bilateral cam morphology and 26.1% had bilateral symptomatic FAI, highlighting both the bilateral nature of FAI and the prevalence of asymptomatic radiographic FAI.

Athletes with asymptomatic radiographic FAI have previously been identified in both collegiate and senior cohorts. Kapron *et al.* [12] demonstrated that 77% of asymptomatic American football players on a collegiate team had at least one radiographic sign of FAI with cam or pincer morphology, and 48% had bilateral signs. Anderson *et al.* [6] found that among senior athletes with a mean age of 67 years [standard deviation (SD): 8 years] at the 2012 Senior World Games, 898 of 1081 hips showed radiographic evidence of FAI. However, radiographic signs of FAI were not predictive of OA (OR = 1.79, 95% CI 0.48–6.62; $P = 0.390$). While symptoms of impingement were not assessed, the activity level and lack of association with OA are indicative of preserved hip function. The preponderance of radiographic FAI without symptoms suggests a staged disease process that begins with osseous abnormality and leads, in some cases, to impingement symptoms.

One possible explanation of the results of the current study is that the demands on both dominant and non-dominant limbs can lead to development of cam morphology, but the demands of the dominant limb—owing to the asymmetry of function between limbs—subject it to increased pathologic forces at the hip joint and proximal femoral physis thus leading to higher rates of symptomatic FAI. Whether the activities leading to FAIS are predominantly related to impact, rotation, or increased range-of-motion of the hip is unclear. Additionally, whether it is the specific actions of the dominant limb or the preferential use of the dominant limb that leads to symptoms is unclear. Further research is needed to elucidate the factors leading to abnormal bone morphology and the onset of symptoms.

Table II. Patient characteristics stratified by surgery location

Variables	*Dominant* (N = *235*)	*Non-dominant* (N = *174*)	P-*value*
Sex, *n* (%)			
Male	75 (32)	44 (25)	0.14
Female	160 (68)	130 (75)	—
Age at surgery, mean (SD)	36 (11.4)	35.8 (11.4)	0.89
Body mass index, mean (SD)	25.7 (5.2)	25.5 (5.3)	0.72
Surgery type, *n* (%)			
Primary	193 (82)	141 (81)	0.78
Revision	42 (18)	33 (19)	—

There are several limitations to this study, including its retrospective design. The determination of footedness may have been oversimplified, given that this was determined by a single question regarding preferred lower extremity for kicking a ball. Although kicking has been shown to be the most sensitive indicator of limb dominance, it has been shown that multiple-point questionnaires more accurately determine footedness [32, 34, 37]. Given that the primary endpoint was the laterality of the arthroscopic hip surgery, this study does not directly address the actual symptoms the patient was having in each hip and as a retrospective record review may not identify symptoms of the contralateral hip. Therefore, the possibility of bilateral symptomatic FAI in these patients is not fully excluded. Furthermore, all patients with FAIS were addressed in this study and athletes that may be more active in asymmetric sports (baseball) or symmetric sports (running) were not specifically identified. However, even in daily activities, previous research has shown asymmetry secondary to leg dominance [20, 21, 24]. Cam-type impingement was the primary diagnosis for all patients in this cohort, while depth of socket (pincer-type) was not surgically addressed secondary to senior author preference of preserving socket depth. As cam-type and pincer-type FAIS are thought to have differing pathogeneses [38, 39], further research is needed to address limb dominance in relation to pincer-type FAIS. Finally, both revision and primary cases were included. However, no patients were included twice in the cohort as a primary and a subsequent revision. Furthermore, inclusion of revision cases should not skew the results in favor of dominant or non-dominant limbs as the same limb that was initially more symptomatic during the index procedure is persistently symptomatic at the revision stage.

CONCLUSION

In this study, limb dominance was associated with cam-type FAIS requiring arthroscopic hip surgery. Patients were more likely to undergo arthroscopic treatment for FAIS on their dominant lower extremity. However, the non-dominant lower extremity, while significantly less likely to undergo surgical treatment in this study, frequently develops FAIS as well.

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CONFLICT OF INTEREST STATEMENT

None declared.

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