Systematic Review

Prevalence of Femoroacetabular Impingement Imaging Findings in Asymptomatic Volunteers: A Systematic Review

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Purpose: The aim of this study was to determine the prevalence of radiographic findings suggestive of femoroacetabular impingement (FAI) in asymptomatic individuals. **Methods:** A systematic review was performed using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Studies reporting radiographic, computed tomographic, or magnetic resonance imaging (MRI) findings that were suggestive of FAI in asymptomatic volunteers were included. Cam, pincer, and combined pathologic conditions were investigated. **Results:** We identified 26 studies for inclusion, comprising 2,114 asymptomatic hips (57.2% men; 42.8% women). The mean participant age was 25.3 ± 1.5 years. The mean alpha angle in asymptomatic hips was 54.1° ± 5.1°. The prevalence of an asymptomatic cam deformity was 37% (range, 7% to 100% between studies)—54.8% in athletes versus 23.1% in the general population. Of the 17 studies that measured alpha angles, 9 used MRI and 9 used radiography (1 study used both). The mean lateral and anterior center edge angles (CEAs) were 31.2° and 30°, respectively. The prevalence of asymptomatic hips with pincer deformity was 67% (range 61% to 76% between studies). Pincer deformity was poorly defined (4 studies [15%]; focal anterior overcoverage, acetabular retroversion, abnormal CEA or acetabular index, coxa profunda, acetabular protrusio, ischial spine sign, crossover sign, and posterior wall sign). Only 7 studies reported on labral injury, which was found on MRI without intra-articular contrast in 68.1% of hips. **Conclusions:** FAI morphologic features and labral injuries are common in asymptomatic patients. Clinical decision making should carefully analyze the association of patient history and physical examination with radiographic imaging. **Level of Evidence:** Level IV, systematic review if Level II-IV studies.

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A common cause of hip pain is femoroacetabular impingement (FAI). In this condition, abnormal bony morphologic features of the acetabulum or femoral head, or both, lead to abnormal joint contact and stresses with deep flexion and rotation motion.[1,2] FAI is frequently associated with labral injury. In fact, some studies have shown that nearly all participants with labral tears have variable degrees of FAI morphologic features.[3-6] A variety of radiographic measures and findings have been reported in the literature to aid in the diagnosis of FAI.[4,7]

In patients with symptomatic FAI that has failed conservative treatment, either open or arthroscopic hip preservation surgery may be indicated. These techniques address both bony (FAI) and soft tissue (labrum) pathologic conditions. It is thought that FAI may be the precursor to idiopathic hip osteoarthritis. Thus, elimination of FAI may slow or prevent the progression of degenerative changes. Currently, there is no role for prophylactic hip preservation surgery to prevent this progression in asymptomatic individuals with radiographic evidence of FAI.[8] It is unknown what the radiographic prevalence of FAI is in asymptomatic individuals.

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The authors report the following potential conflict of interest or source of funding: S.N. receives support from Össur, Stryker, AlloSource, Arthrex, Athletico, DJ Orthopaedics, Linvatec, Miomed, and Smith & Nephew and M.S. receives support from Smith & Nephew and Linvatec.

Received July 2, 2014; accepted November 26, 2014.

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0749-8063/14551/$36.00

http://dx.doi.org/10.1016/j.arthro.2014.11.042

Several studies have reported the presence of radiographic findings suggestive of FAI in select cohorts of asymptomatic patients. The goal of this study was to systematically review the literature for studies that reported the prevalence of radiographic findings suggestive of FAI and labral injuries in asymptomatic volunteers. The authors hypothesized that the prevalence of FAI and labral injuries would be less than 50%.

Methods

A systematic review was performed using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines with a PRISMA checklist.[9] Three independent reviewers (one board-eligible orthopaedic surgeon in sports medicine fellowship training and 2 orthopaedic surgery residents) completed the search. The search was performed on April 13, 2013 using an explicit search algorithm: (((((hip[Title/Abstract])) AND (asymptomatic[Title/Abstract]))) AND ((((radiograph[Title/Abstract]) OR radiographic[Title/Abstract]) OR imaging[Title/Abstract]) OR x-ray[Title/Abstract]) AND (English [lang]))) NOT arthroplasty[Title/Abstract] AND (English[lang]. The following databases were queried: MEDLINE, SPORTDiscus, CINAHL, and Cochrane Central Register of Controlled Trials. Studies that reported radiographic, computed tomographic, or magnetic resonance imaging (MRI) findings (or findings from a combination of these modalities) that were suggestive of FAI in asymptomatic volunteers were included. Cam, pincer, and combined pathologic conditions were investigated. Exclusion criteria included non−English language articles; participants who had undergone total joint arthroplasty or those who were symptomatic; participants with hip osteoarthritis, hip dysplasia, slipped capital femoral epiphysis, or Legg-Calve-Perthes disease; studies using ultrasonographic or bone scan imaging modalities; articles investigating joints other than the hip; systematic reviews or meta-analyses; letters to the editor; topic reviews; and articles dealing with hip pathologic conditions other than impingement. Both electronically published and print journal articles were acceptable. However, meeting abstracts and proceedings were disallowed. All references within included studies were cross-referenced for potential inclusion if omitted from the initial search. Figure 1 shows the search algorithm used to generate the final studies for inclusion and analysis.

Each study was analyzed for several radiographic variables suggestive of FAI—specifically the alpha angle and the lateral and anterior center edge angles (CEAs), head-neck offset, ischial spine sign, crossover sign, posterior wall sign, coxa profunda, and acetabular protrusio. In addition, radiographic signs of hip arthritis were also investigated, including joint space narrowing (distance), subchondral sclerosis, subchondral cysts, osteophytes, Tonnis classification, and Kellgren-Lawrence classification. Studies were also analyzed for the number of overall participants who were diagnosed with a cam or pincer deformity or labral injury (according to each study's criteria). Demographic data recorded included sex and age.

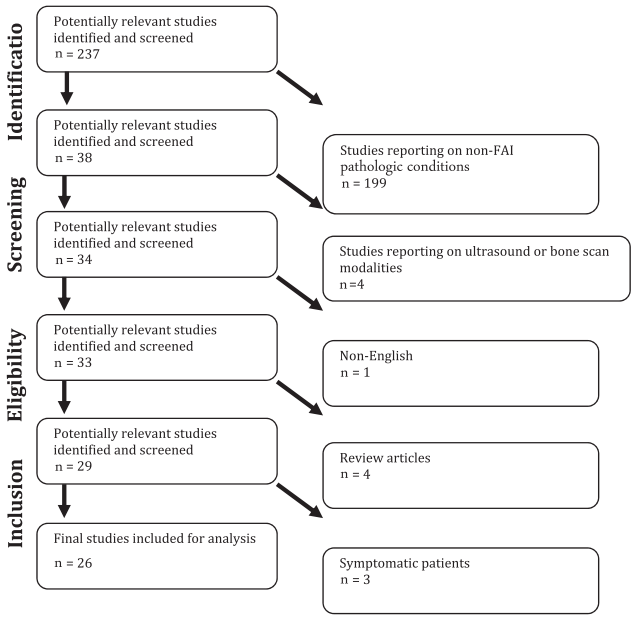

Fig 1. Systematic review search algorithm within MEDLINE database according to Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. After application of all exclusion criteria, 26 studies were identified for inclusion and further analysis.

Descriptive statistics were calculated for each study and parameter or variable analyzed. Continuous variable data were reported as mean ± standard deviation (weighted means when applicable). Categorical data was reported as frequencies with percentages. For all statistical analysis, $P < .05$ was deemed statistically significant.

Results

Before screening, 237 studies were identified. After applying inclusion and exclusion criteria, 26 studies remained (Table 1). These comprised 2,114 asymptomatic hips (57.2% in men and 42.8% in women) with a mean overall age of 25.3 ± 1.5 years. Of the 2,114 asymptomatic hips analyzed, approximately 33% were in athletes (most commonly collegiate football players; n = 298), army recruits (n = 244), and hockey players (n = 127). The mean alpha angle (measured on MRI and radiography) in asymptomatic hips was 54.1° ± 5.1°. The overall prevalence of an asymptomatic cam deformity was 37% (range, 7% to 100% between studies). Comparing the athletic group to the general population, there was an almost 3:1 prevalence of cam deformity (54.8% *v* 23.1%) (Fig 2). Of the 17 studies that measured alpha angles, 9 used MRI without

Table 1. Study Characteristics

Author	Publication Year	Level of Evidence	Type of Asymptomatic Patient	No. of Participants	No. of Hips	No. of Symptomatic Hips	No. of Asymptomatic Hips	Mean age of Patients With Asymptomatic Hips	Minimum Age	Maximum Age	No. of Asymptomatic Men	No. of Asymptomatic Women
Kolo et al.[10]	2012	III	Dancers	44	87	59	28	27.1	20	34	0	14
Nepple et al.[11]	2013	III	Normal	157	157	124	33	26.05	13	59	9	24
Larson et al.[12]	2013	IV	Collegiate National Football League	125	239	75	164	NA	NA	NA	164	0
Philippon et al.[13]	2013	III	Youth ice hockey players, youth skiers	88	88	0	88	14.5	10	18	61	0
Bittersohl et al.[14]	2012	III	Normal	64	64	29	35	24.9	21	29	14	21
Zilkens et al.[15]	2012	III	Normal	71	71	40	31	24.5	21	29	12	19
Miguel et al.[16]	2012	III	Normal	222	222	122	100	31	NA	NA	42	58
Schmitz et al.[17]	2012	IV	Normal	21	42	0	42	34	27	43	16	5
Register et al.[18]	2012	III	Normal	45	45	0	45	37.8	18	66	27	18
Audenaert et al.[19]	2012	III	Normal	30	30	10	20	NA	18	35	20	0
Mamisch et al.[20]	2011	III	Normal	25	25	13	12	25.25	23	31	4	8
Kapron et al.[21]	2011	III	Collegiate football	67	134	0	134	21	17	26	67	0
Bittersohl et al.[22]	2011	IV	Normal	10	10	0	10	26.5	24	31	3	7
Ranawat et al.[23]	2011	III	Normal	100	200	100	100	34.3	13	61	44	56
Reichenbach et al.[24]	2011	III	Normal	244	244	0	244	19.9	NA	NA	244	0
Silvis et al.[25]	2011	III	Hockey players	39	39	0	39	NA	NA	NA	39	0
Hack et al.[26]	2011	III	Normal	200	400	0	400	29.4	21	50	89	111
Reichenbach et al.[27]	2010	III	Army recruits	244	244	0	244	19.9	NA	NA	244	0
Bittersohl et al.[28]	2009	III	Normal	36	36	26	10	26.5	24	31	3	7
Bittersohl et al.[29]	2009	III	Normal	35	35	25	10	26.4	24	31	3	7
Allen et al.[30]	2009	IV	Normal	113	201	201	65	NA	NA	NA	NA	N/A
Tiderius et al.[31]	2007	IV	Normal	18	18	10	8	28	20	47	NA	N/A
Clohisy et al.[32]	2007	II	Normal	80	85	61	24	35	18	49	13	11
Naish et al.[33]	2006	IV	Normal	6	6	0	6	NA	22	34	0	6
Peelle et al.[4]	2005	II	Normal	100	100	78	22	34	17	58	8	14
Lecouvet et al.[34]	1996	III	Normal	200	200	0	200	44	15	82	84	116
Totals				2,384	3,022	973	2,114					

NA, not available.

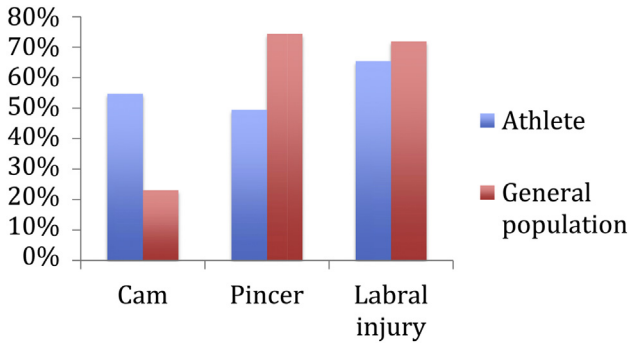

Fig 2. Comparison of prevalence of femoroacetabular impingement (FAI) morphologic characteristics and labral injury between the athletic and general populations.

intra-articular contrast and 9 used radiography (1 study used both). The mean lateral and anterior CEAs were 31.2° ± 4.9° and 30° ± 7.8°, respectively. The overall prevalence of asymptomatic hips with pincer lesions was 67% (range 61% to 76% between studies). The athletic population had a prevalence of 49.5%. Pincer deformity was poorly defined but was diagnosed using radiography (4 studies; 15%) (Table 2). No studies used computed tomography to define pincer lesions. Labral injury was found on MRI without intra-articular contrast in 68.1% of hips (65.4% of hips in athletes).

Discussion

The purpose of this study was to determine the prevalence of FAI and labral tears in asymptomatic individuals. The authors hypothesized that the prevalence would be low. The hypothesis was partially confirmed. The prevalence of cam deformity was 37% and the prevalence of pincer deformity was 67%. Interestingly, there was an almost 3:1 ratio of cam deformity in the athletic population compared with the nonathletes. The prevalence of labral injury was 68%. These findings should be used to assist surgeons in clinical decision making in patients with hip pain. Emphasis on patient history and physical examination is underscored, and reliance on imaging alone is unwise. These findings further highlight the emphasis that many authors have placed on categorizing FAI as a clinical diagnosis.[1,35] Furthermore, the high prevalence of cam deformity in the athletic population raises the issue of whether cam deformity leads to labral injury or if labral injury is associated with cam deformity.

Table 2. Breakdown of Pincer Radiographic Findings

	n
Ischial spine sign	111
Crossover sign	161
Posterior wall sign	3
Coxa profunda	78
Acetabular protrusio	1

The current investigation found a 37% prevalence of cam deformity, which is higher than values reported in other studies. Hack et al.[26] reported a prevalence of 14%, whereas Reichenbach et al.[27] reported a prevalence of 24%. This discrepancy may result, in part, from the large proportion of athletes (33%) included in the study population. It has been reported that vigorous sporting activity during adolescence increases the risk of cam impingement.[36] The formation of this deformity may terminate once growth plates have closed.[37] If the athlete population is removed, the prevalence of cam deformity is 23.1%. Furthermore, the study population was 57.2% men, possibly further increasing the overall cam deformity prevalence; some have postulated that cam deformity is a disease of young men.[38]

The alpha angle is a commonly used radiographic measure to define cam FAI. It is generally considered abnormal if greater than 50° to 55°.[39] Several studies have also recommended correcting the alpha angle to less than 55° when treating symptomatic patients with FAI.[40,41] The current study illustrates that an asymptomatic patient population has an average alpha angle that is essentially pathologic (54°). There are other radiographic measures used to characterize cam morphologic conditions, including head-neck offset and offset ratio. These measures were less well reported in this review and are not included.

Both lateral and anterior CEAs are used for measuring the amount of femoral head coverage. Elevated CEA and crossover, posterior wall, and ischial spine signs are radiographic descriptors of pincer morphologic characteristics. They may represent focal anterior overcoverage with subtle loss of cranial acetabular anteversion, or they may represent more global acetabular retroversion. Normal values have been accepted as greater than 25° and greater than 20° for the lateral and anterior CEAs, respectively.[7] The current study has shown that approximately two thirds of asymptomatic individuals have pincer morphologic characteristics on imaging studies. However, the high prevalence may be confounded in several ways. Unfortunately, pincer morphologic characteristics were poorly defined among the studies. The report of pincer deformity included the presence of radiographic parameters such as the crossover sign and posterior wall sign, with poor reliability for the diagnosis of this morphologic condition.[42] Zaltz et al.[43] reported that the crossover sign overestimates true acetabular retroversion, thereby introducing even greater heterogeneity in pincer assessment in this analysis. Furthermore, the included studies used radiography rather than computed tomography for measuring pincer deformity, which is highly affected by pelvic tilt, rotation, and distance from the beam source.

Labral injury is a well-documented cause of hip pain, with MRI proving a sensitive modality for establishing diagnosis. The current study investigated 7 studies using conventional MRI. More than two thirds of

asymptomatic patients had MRI findings suggestive of a labral tear. In a recent meta-analysis,[44] conventional MRI had a higher specificity for detecting a labral lesion compared with MR arthrography (MRA) but a lower sensitivity (79% *v* 64% and 66% *v* 87%, respectively). Zlatkin et al.[45] found MRA to have 100% sensitivity in detecting lesions. More recently, however, Reurink et al.[46] compared MRA with arthroscopic findings of labral injury. They found MRA to have a high positive predictive value, a low negative predictive value, and a sensitivity of only 86% in the diagnosis of labral pathologic conditions.

Limitations

The limitations of a systematic review are based on the limitations of the studies analyzed. The heterogeneity in defining cam and pincer morphologic conditions is a significant source of selection bias. Other sources of selection bias include the heterogeneity in participant age, sex, activity level, and sports played. Detection bias is present in that the radiographic techniques, quality, and adequacy are also highly variable. Assignment of FAI morphologic features was made by both radiography and MRI on different radiographic (anteroposterior and a variety of lateral techniques) and MRI views (both arthrographic and nonarthrographic sagittal, coronal, axial, oblique, and radial series) and with different threshold values to determine "normal" and "abnormal." Additionally, there is no perfect definition of what a "normal" hip radiograph constitutes. Thus, this makes characterization of "abnormal" challenging. Arthroscopic correlation of imaging findings is the gold standard for confirmation of labral injury; however, this was lacking in the included studies.

Conclusions

FAI morphologic features and labral injuries are common in asymptomatic patients and may have an increased presence in athletes. Clinical decision making should carefully analyze the association of patient history and physical examination with radiographic imaging.

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