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SCIENTIFIC ARTICLE

Magnetic resonance arthrography and the prevalence of acetabular labral tears in patients 50 years of age and older

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Abstract
Objective Arthroscopy for acetabular labral tears has minimal impact on pain and function in older patients, especially in the setting of concomitant osteoarthritis. Still, many physicians seek this diagnosis with MR arthrography. Our purpose is to assess the frequency of acetabular labral tears in older patients with hip pain and correlate likelihood of labral pathology with severity of osteoarthritis as visualized on conventional radiograph.
Materials and methods From 2004 to 2013, 208 hip MRI arthrograms and corresponding radiographs on patients aged 50 years and older were identified. Age, gender, grade and location of labral tear, alpha angle, Tönnis grade, and joint space width were documented. Labral tears and alpha angle were identified and measured on MR arthrogram. Tönnis grade and joint space width were measured on radiographs.
Results and conclusions On MR arthrography, true labral tearing was identified in 73 % of patients. There was some degree of labral pathology in 93.3 % of patients, and this increased to 100 % in patients with moderate to severe osteoarthritis, as defined by Tönnis grade 2–3 or joint space width ≤ 2 mm. There were no statistically significant correlations between labral tear grade and Tönnis grade or joint space width. Given the high frequency of labral pathology and the questionable efficacy of arthroscopic surgical intervention in older patients, MR arthrography should be primarily for those with minimal arthritis on radiograph and potential to benefit from surgery. If further imaging beyond radiographs is necessary in these patients, standard MRI may be a more appropriate imaging tool.

Keywords Acetabular labrum · Labral tear · Osteoarthritis · Magnetic resonance imaging · MR arthrography · Hip arthroscopy · Economic and decision analysis

Introduction

Recent literature suggests acetabular labral tears of the hip are more prevalent in the general population than previously thought. Similarly high rates of labral tears have also been observed in both symptomatic and asymptomatic patients [1–5]. Labral tears are more frequently found in patients with femoroacetabular impingement (FAI), acetabular dysplasia, articular cartilage defects, and bony abnormalities [6, 7]. However, arthroscopic repair of labral tears is less successful in the presence of synovitis or chondral lesions [6].

It is widely accepted that in young patients, especially athletes, arthroscopic labral debridement and repair can be an effective treatment for patients to regain function of the hip [8]; however, there are some conflicting findings in previous studies regarding hip arthroscopy for labral tears in older patients. Wilkin et al. found that arthroscopic labral debridement in patients older than 45 years of age has minimal impact on pain and function, with significant rates of subsequent reoperation and total arthroplasty [9]. On the other hand, Ben Tov et al. found that arthroscopic management of FAI and labral repair in patients older than 50 years old without significant arthritis (Tönnis grade 1 or better) are associated with good outcomes [10]. Philippon et al. found that patients 50 years and older who underwent hip arthroscopy for FAI had early

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conversion to total hip replacement when joint space width was 2 mm or less, but had improvement over preoperative status in pain and function when joint space width was greater than 2 mm [11]. These studies suggest that arthroscopic labral debridement and repair in the older population should be approached with caution, especially in the presence of osteoarthritis [9].

MR arthrography is widely recognized as the gold standard in diagnosing and localizing acetabular labral tears. Although exact estimates of the accuracy of MR arthrography detecting acetabular labral tears vary, recent studies report sensitivities of 90.5 and 94.5 and specificities of 84.6 and 100 [12, 13]. Though less invasive studies can also be utilized in the evaluation of suspected labral tears, no definitive assessment of the accuracy of these alternatives has been published. These studies include ultrasound, clinical exam, indirect MR arthrography, and non-arthrographic MRI [14]. Physicians routinely utilize MR arthrography in the evaluation of older patients with hip pain and suspected labral damage [15]; however, the utility of this diagnostic tool is questionable given the lack of effective management options in the older population. The association of labral tears with cartilaginous damage, as well as the high prevalence of labral tears in both symptomatic and asymptomatic patients, calls into question the value of routinely ordering MR arthrograms for older patients with hip pain.

The frequency of acetabular labral tears in patients 50 years of age or older with symptomatic hip pain has not been quantified. Similarly, there have been no quantitative investigations as to the relationship between the likelihood of a labral tear and a patient's age, gender, or degree of arthritis in this older patient population. Therefore, the purpose of this study is to assess the frequency of acetabular labral tears in symptomatic patients with hip pain and suspected labral tear aged 50 years and older using MR arthrography and correlate the likelihood of a labral tear with age, gender, hip alpha angle, and the severity of arthritis (Tönnis grade and joint space width) in this same population. We hypothesize that there will be a high rate of acetabular labral tears in symptomatic patients with hip pain 50 years of age and older and a direct relationship between the degree of arthritis, based on joint space width and Tönnis grade, and the frequency of labral tearing. Given the questionable effectiveness of arthroscopic management and the expense and risk of complication associated with MR arthrography, the aim is to demonstrate a sufficiently high prevalence of labral tears in the older population with hip pain to question the utility of seeking a diagnosis via MR arthrography.

Materials and methods

After obtaining institutional review board (IRB) approval, the billing records from the Department of Radiology at our institution were used to identify 237 hips of patients 50 years of age or older who underwent MR arthrography and X-ray within 12 months between August 2004 and December 2013. Fifty years of age was the cutoff used in order to correspond to the approximate age cited in previous orthopaedic literature for successful labral debridement or repair. Due to the referral pattern at our institution and approval required by insurance companies, the vast majority of invasive diagnostic procedures such as MR arthrography are referred from either orthopaedic surgeons or sports medicine trained family physicians. Our institution's electronic health system was used to review all patient records. Hips that had MR arthrography performed post-operatively were excluded. In cases where multiple MR arthrograms were performed on the same hip, only the first one was included. For the 16 patients who underwent MR arthrograms of both the right and the left hip, either during the same visit or at different points in time, both hips were listed independently with appropriate corresponding radiograph and treated separately.

In regards to the MR arthrogram, the protocol used for gadolinium injection was a 1:200 concentration of 0.1 cc gadolinium with 15 cc normal saline and 5 cc 0.5 % ropivacaine. The volume injected was 12–16 cc, depending on patient comfort and ease of injection. The MRI sequences consisted of a coronal T-1 and inversion recovery of the entire pelvis, as well as a triplane fat suppressed T-1 and axial gradient echo of the affected hip.

Information on the remaining 208 hips was then collected through the electronic medical record system. Age, gender, side of involved hip, date of radiographic studies, grade and location of labral tear, hip alpha angle, hip Tönnis grade, and hip joint space width were recorded for each hip identified. Radiographic measurements, specifically Tönnis grade and joint space width, were completed de novo by a fellowship trained musculoskeletal radiologist. Grade and location of labral tears were recorded from the MR arthrogram report. These reports were authored by one of four fellowship-trained musculoskeletal radiologists during routine daily review with radiology residents and fellows. These four musculoskeletal radiologists have 4, 9, 14, and 28 years of experience from completion of fellowship. The alpha angle, when not included in the report, was calculated de novo on the axial oblique MR images accessed through the Department of Radiology via the Picture Archiving Communication Systems (PACS). The labral tear grading was divided into three categories (normal, fraying, tearing) based on the MR arthrogram report (Table 1). The position of the tear was recorded and included the following: anterior, posterior, superior, inferior, anterosuperior, anteroinferior, posteroinferior, posterosuperior, circumferential, fully macerated. No reports were discarded due to incomplete reporting.

The standard hip plain film protocol at our institution was used, which consists of a supine AP view of the pelvis and an

Table 1 Labral tear grade descriptions on MRI arthrography

Grade	Description
0	Normal labrum; no labral pathology
1	Labral fraying; labral degeneration; labral irregularity
2	Labral tear; labral separation; focal separation or tearing

Grades *0–2* describe increasing levels of severity of labral pathology based on MR arthrogram report

AP and frog-leg lateral of the hip. Tönnis grade was measured using the standard definitions originally described by D. Tönnis, and later summarized by Troelsen et al. [16] and Philippon et al. [17]. Table 2 summarizes these definitions. Previously described methods by Jacobsen et al. [18] and Terjesen and Gunderson [19] were used to measure joint space width (JSW). Minimum JSW was measured at 3 locations: lateral and medial margins of the subchondral sclerotic line (the sourcil) and along the vertical line through the center of the femoral head. If the minimum JSW was outside of these three standard measurements, an additional measurement at the site of maximal narrowing was made [18, 19]. These measurements were obtained on the view that showed the maximal narrowing.

Using the statistical software JMP 10.0, a chi-squared analysis was used to test for association between labral tear grade and the categorical study parameters of gender, Tönnis grade, and laterality. A logistic regression analysis was used to test for significance between labral tear grade and the continuous study parameters of age, alpha angle, and joint space width. A p-value of <0.05 was used to determine statistical significance.

Results

A total of 208 hip arthrograms were identified, of which 139 were female and 69 were male. There were 111 arthrograms of the right hip, and 97 of the left hip. The mean age of patients was 61 (range: 50–92, standard deviation: 8.9), the mean Tönnis grade was 0.51 (range: 0–3), the mean joint space width at the site of maximal narrowing was 3.94 mm (range: <1–7.8 mm), and the mean alpha angle was 49.8° (range 19–80). There were 58 hips with an alpha angle greater than 55°.

Table 2 Tönnis grade assessing the severity of osteoarthritis on XR

Grade	Description
0	No signs of osteoarthritis
1	Mild: increased sclerosis of the head and acetabulum, slight narrowing of the joint space, slight lipping at the joint margins
2	Moderate: small cysts in the head or acetabulum, increasing narrowing of the joint space, moderate loss of sphericity of the head
3	Severe: large cysts in the head or acetabulum, severe narrowing or obliteration or the joint space, severe deformity of the head, necrosis

Grades *0–3* describe increasing levels of severity of osteoarthritis, as described originally by D. Tönnis

Overall, 73.1 % of MRI arthrograms demonstrated labral tearing, 20.2 % showed labral fraying, and 6.7 % had no labral pathology. Most tears were seen anteriorly and superiorly, with 73.1 % being superior, anterior, or anterosuperior. An additional 14.2 % of the tears were identified either posteriorly or posterosuperiorly. There were 42 patients with labral lesions in two locations, and 17 patients with lesions in three locations.

With regards to osteoarthritis grading, 64.4 % of hips had a Tönnis grade of 0, 23.1 % had a Tönnis grade of 1, 9.1 % had a Tönnis grade of 2, and 3.4 % had a Tönnis grade of 3; furthermore, 7.7 % of hips had a joint space width of ≤ 2 mm.

For the 16 patients who had MR arthrograms of both hips, each hip was treated independently. Based on the histories, five patients had the MR arthrogram performed following recent acute injury, including three motor vehicle accidents, one fall, and one yoga injury. The three patients who were in a motor vehicle accident had labral tears, as well as the patient who sustained a fall. The patient who was injured during yoga had labral fraying. There was one patient who had a history of avascular necrosis, and the MR arthrogram was negative for any labral pathology.

In patients with two MR arthrograms of the same hip, the latter MR arthrogram either showed similar findings to the first or a slight progression of the labral tear. This was true for all patients over 50 who had repeat MR arthrograms of the same hip except one, which initially was negative for a labral tear in 2006 but then was positive for a labral tear 2 years later in 2008. In all cases, the first MR arthrogram was used to maintain consistency and to ensure the same hip was not included multiple times in the data set.

In the data set, in patients with no osteoarthritis or mild osteoarthritis (Tönnis grade 0–1), 73.1 % had labral tearing, 19.2 % had labral fraying, and 7.7 % had a normal labrum, while in patients with moderate to severe arthritis (Tönnis grade 2–3), 73.1 % had labral tearing, 26.9 % had labral fraying, and 0 % had no labral pathology (Fig. 1). Similarly, in patients with a joint space width > 2 mm, 72.4 % had labral tearing, 20.3 % had labral fraying, and 7.3 % had a normal labrum, while in patients with a joint space width ≤ 2 mm, 81.2 % had labral tearing, 18.8 % had labral fraying, and 0 % had no labral pathology (Fig. 2).

There were no statistically significant correlations between labral tear grade and Tönnis grade dichotomized at 2 ($\rho = 0.114$) or between labral tear grade and joint space width dichotomized at 2 mm ($\rho = 0.279$). There were no significant correlations between labral tear grade and the other

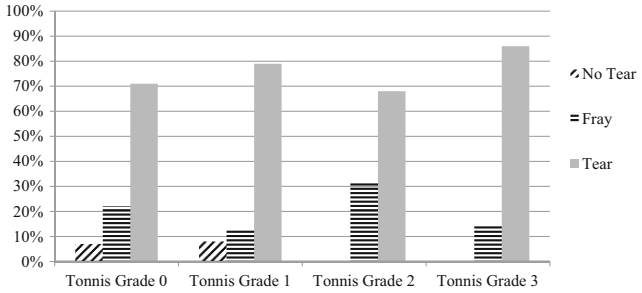

Fig. 1 Frequency of labral pathology stratified by Tönnis grade. The percentages of no tear (*diagonal lines*), labral fray (*horizontal lines*), and labral tear (*vertical lines*) MRI arthrograms are shown for patients with Tönnis grades 0–3

independent variables (laterality $\rho = 0.953$, gender $\rho = 0.235$, age $\rho = 0.765$, alpha angle $\rho = 0.250$).

Discussion

The indications for hip arthroscopy have continued to expand as has our use of diagnostic tools including MRI arthrography. Proper indications for these diagnostic studies is important to decrease the risk to the patient, prevent unnecessary procedures and decrease the overall cost of medical care to patients and the medical system.

We have found the frequency of true acetabular labral tearing in patients 50 years of age or older with symptomatic hip pain is very high (73.1 %). Furthermore, there was some degree of labral pathology in 93.3 % of patients, and this increased to 100 % in patients with moderate to severe osteoarthritis, as defined by Tönnis grade 2–3 or joint space width ≤ 2 mm. The high rate of labral tearing in this patient population calls into question the need for MR arthrography.

Although preferable to diagnostic arthroscopy when considering the expense and risk of complications, MR arthrography of the hip should not be used to evaluate labral pathology without justification. Imaging involves exposure to

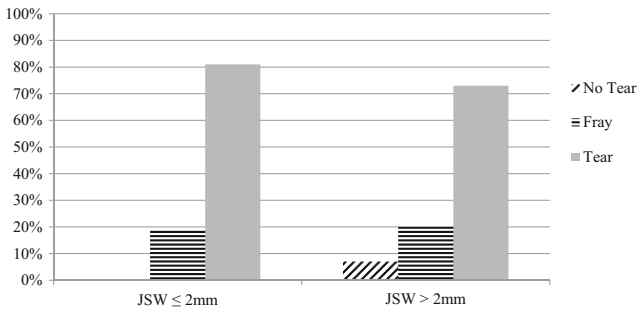

Fig. 2 Frequency of labral pathology stratified by joint space width. The percentages of no tear (*diagonal lines*), labral fray (*horizontal lines*), and labral tear (*vertical lines*) MRI arthrograms are shown for patients with joint space width ≤ 2 mm and > 2 mm

ionizing radiation and intra-articular contrast material and does not come without risk. Pain is a common complication of hip arthrography and present in up to 77 % of cases [20]. Though the precise etiology of post-arthrographic pain is unknown, potential causes of include joint distention or a reactive inflammatory reaction to injected contrast material [21]. Other reported complications of MR arthrography include anxiety, vasovagal reactions, and in rare cases, septic arthritis [22, 23]. Contrast extravasation and vessel or femoral nerve injury are also risks of the procedure [24–26]. A recent retrospective study of approximately 13,300 arthrograms reported an overall complication rate of 3.6 % with 0.3 % of complications classified as severe. Among these, 0.3 % of severe complications were 29 cases of septic arthritis [23]. Significant chondrolysis following arthrography-related septic arthritis of the hip has also been reported [22].

The fact that multiple previous studies have demonstrated high rates of labral tearing in asymptomatic patients suggest that the labral tears found in this patient population may not be the patient's primary pain generator. Lee et al. found 67 % of asymptomatic young women and 33 % of asymptomatic young men with labral tears [2]; furthermore, Register et al. found that 73 % of asymptomatic volunteers had abnormalities on MRI, with 69 % demonstrating a labral tear [4]. Lastly, Lecouvet et al. comments on the large variability in the appearance of the labrum in asymptomatic hips, which is important to consider when interpreting MR images [1]; therefore, any labral pathology found on MRI arthrograms should be supported by careful history and physical exam and may not be the cause of the patient's pain, especially in this patient population.

Furthermore, in this older patient population, most causes of hip pain can be diagnosed and treated without the need for MRI arthrography. For example, hip osteoarthritis and hip fractures account for a large percentage of patients with hip pain in the elderly [27, 28]. Osteoarthritis accounts for much of the dependency in walking, stair climbing, and other lower extremity tasks in this population, and the prevalence of hip OA in the Caucasian population is estimated to be 3–6 % [29, 30]. Traditionally, conventional radiography is the gold standard for diagnosing hip OA [31]. In cases where further visualization is needed, standard MRI is extremely useful in depicting precise articular lesions associated with osteoarthritis to aid in a more targeted approach to treatment [31, 32]. Similarly, hip fractures are a serious health care issue in the aging population [33]. These are often found on radiographs, but it is estimated that 2–9 % are occult fractures that are not clearly visible on initial radiographs [34, 35]. If an occult fracture is suspected despite negative radiographs, MRI is extremely reliable in visualization. According to a study by Verbeeten et al., the sensitivity of MRI for occult fracture was 100 % for both junior and senior radiologist, and the specificity was 100 % for senior radiologists but 93 % for junior

radiologists [35]. Other studies have come to similar conclusions [36, 37]. Other less common hip conditions that present in older adults are also visualized on standard MRI—for example, MRI has the highest sensitivity and specificity for evaluation of avascular necrosis of the femoral head [38]. Neoplasms of the femoral head, such as clear cell chondrosarcoma, if not visualized as a lytic lesion on radiograph, can be seen on MRI [38]. In fact, although MR arthrography is the gold standard for labral visualization, some recent studies have concluded that 3 T MR is near equivalent to 3 T MR arthrography in diagnosing acetabular labral tears [39]. Since standard MRI has shown to be successful in identifying most causes of hip pathology in the older population, it may be more appropriate than the more invasive and expensive MR arthrography.

As discussed in the aforementioned, MRI and MR arthrography can be very useful imaging techniques in detecting specific hip conditions; however, in this patient population, these imaging tools are not always being used in a cost-effective manner. Previous studies have demonstrated that MRI is often over utilized. Keeney showed that, in a study of 213 patients 40–80 years old with hip pain who received hip MRIs, only 7 % had their treatment recommendations influenced by MRI results [40]. Furthermore, Issa et al. estimated that 330–440 million dollars might be spent during the next 10 years on unnecessary hip MRIs in patients with hip osteoarthritis in America [41]. The costs of MR arthrography and MRI outweigh the costs of standard radiography, which is sufficient in many cases. Although prices vary widely between institutions, Issa et al. estimates the national average cost of a standard hip MRI to be between $782–$1600, versus $222 for plain radiographs of the hip [41]. According to 2014 Medicare & Medicaid data, the cost of a hip MR arthrogram with contrast, a standard hip MRI without contrast, and a standard two-view set of hip radiographs are $436, $281, and $44 respectively [42]. Clearly, this difference in price is substantial and demonstrates great potential to lower health care spending. Reducing the unnecessary imaging ordered for older patients with osteoarthritis can substantially reduce healthcare costs, especially given the prevalence of hip osteoarthritis. MRI and MR arthrography should generally be reserved to confirm a diagnosis that would warrant further intervention or a change in treatment plan.

That being said, although MR arthrography may not always lead to a change in treatment for labral pathology, there are potential benefits of pursuing imaging that are less tangible. For example, it may reduce anxiety and provide reassurance to patients in knowing a diagnosis responsible for their pain. Physicians may also feel more comfortable, and physical therapists may be better equipped to curtail an exercise program with a specific diagnosis in mind. MR arthrography may not always be necessary in the sense of directing management, yet it is important to recognize that each patient may have different needs and special situations that should not be overlooked.

Overall, given the poor outcomes associated with the operative management of labral tears in older patients with osteoarthritis and the variable outcomes in older patients without osteoarthritis, the costs and risks of MR arthrography, and the ability to visualize many other causes of hip pain on radiograph or standard MRI if necessary, MR arthrography should not be routinely ordered for the diagnosis and localization of labral tears in the older patient with hip pain. MR arthrography is most beneficial for patients with minimal evidence of arthritis on radiograph who have hip pain due to suspected labral pathology and likely stand to benefit from arthroscopic labral debridement or repair. Furthermore, prior to ordering MR arthrography to evaluate the labrum, it is important to ensure clinically that labral pathology is the primary pain generator in the hip. Since labral tears are often asymptomatic and the pre-test probability of having labral pathology is very high in this patient population, other potential causes of hip pain should be ruled out. The lack of reliably successful management options and high likelihood of labral damage makes MR arthrography excessive in many cases.

This study has key limitations. First, given the nature of the study, patient outcomes could not be reported. Knowing the final diagnosis and management of the patients in the study would have aided in identifying the percentage of patients whose treatment plan changed based on the results of the MRI arthrogram. Although other authors have already documented the inefficacy of arthroscopic repair of acetabular labral tears in older patients with concomitant osteoarthritis, duplicate findings would certainly have strengthened the recommendations to not pursue imaging [35, 37]. The retrospective nature of the study and the absence of arthroscopy as the gold standard to confirm the presence of labral pathology on imaging are important limitations of the study.

Another major limitation is regarding the primary indication for the MRI arthrograms. Although suspected labral pathology is a frequent indication for obtaining hip MR arthrography, it is not certain this was the clinical question at hand. There is the possibility that some of the MR arthrograms were ordered to detect focal chondral defects, delaminations, intra-articular bodies, or pre-radiographic osteoarthritis. This study's focus was specifically on labral pathology; therefore, the utility of MRI arthrogram in regards to the evaluation of non-labral pathology cannot be addressed.

Instead of relying on MR arthrogram reports for information regarding labral pathology, retrospective reading of the films could have been done by a single radiologist to maintain consistency. Although the four radiologists were fellowship trained in musculoskeletal radiology, there is no institution standard for diagnosing labral tear by MRI. Diagnostic reporting, therefore, may have reflected an individual's

training and varying years of experience. Alternatively, there may have been an implicit institutional bias in identifying labral tears.

Furthermore, although this study included 208 hip MRI arthrograms and radiographs, the number of radiographs with arthritis in this sample was limited. Only 16 radiographs showed a minimum JSW of 2 mm or less, and only 26 showed moderate to severe arthritis based on Tönnis grade (grade 2 or 3). Perhaps if the sample size of specifically this subset of patients was substantially bigger, an association may have been found. Lastly, the rates of labral pathology found in this study reflect our institution's specific patient demographic and referral pattern, so they may not be generalizable to other patient populations.

Conclusion

These findings indicate that patients aged 50 years and older presenting with hip pain have a 73 % likelihood of having a concomitant acetabular labral tear. The inefficacy of arthroscopic surgical repair in patients with significant arthritis, coupled with the high likelihood of labral tears in patients aged 50 years and older, makes MR arthrography a nonessential step in the diagnostic process. Other factors that should be considered is the near equivalent ability of standard 3 T MR to identify labral pathology and the high rates of labral pathology in asymptomatic patients demonstrated in previous studies, questioning the clinical relevance of these tears. Therefore, MR arthrography may not indicated for the evaluation of labral pathology in older patients with arthritis. It should primarily be used in older patients with minimal evidence of arthritis on hip radiograph if they have suspected labral pathology and likely would benefit from surgical intervention. Standard MRI has lower costs and risks than MRI arthrography while still being accurate in visualizing most relevant intraarticular pathologies in this patient population, making it a more appropriate imaging tool than MRI arthrography in most cases if further imaging beyond radiograph is warranted [39].

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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