

Diagnostic Accuracy of Clinical Assessment, Magnetic Resonance Imaging, Magnetic Resonance Arthrography, and Intra-articular Injection in Hip Arthroscopy Patients

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Background: Hip arthroscopy has defined elusive causes of hip pain.

Hypothesis/Purpose: It is postulated that the reliability of various investigative methods is inconsistent. The purpose of this study is to evaluate the diagnostic accuracy of these methods.

Study Design: Retrospective review of prospectively collected data.

Methods: Five parameters were assessed in 40 patients: clinical assessment, high-resolution magnetic resonance imaging, magnetic resonance imaging with gadolinium arthrography, intra-articular bupivacaine injection, and arthroscopy. Using arthroscopy as the definitive diagnosis, the other parameters were evaluated for reliability.

Results: Hip abnormality was clinically suspected in all cases with 98% accuracy (1 false positive). However, the nature of the abnormality was identified in only 13 cases with 92% accuracy. Magnetic resonance imaging variously demonstrated direct or indirect evidence of abnormality but overall demonstrated a 42% false-negative and a 10% false-positive interpretation. Magnetic resonance arthrography demonstrated an 8% false-negative and 20% false-positive interpretation. Response to the intra-articular injection of anesthetic was 90% accurate (3 false-negative and 1 false-positive responses) for detecting the presence of intra-articular abnormality.

Conclusions: In this series, clinical assessment accurately determined the existence of intra-articular abnormality but was poor at defining its nature. Magnetic resonance arthrography was much more sensitive than magnetic resonance imaging at detecting various lesions but had twice as many false-positive interpretations. Response to an intra-articular injection of anesthetic was a 90% reliable indicator of intra-articular abnormality.

Keywords: hip arthroscopy; evaluation; magnetic resonance imaging (MRI); magnetic resonance arthrography; hip pathology

Traditionally recognized causes of hip joint pain represent a brief list. These include arthritis, synovial disease, avascular necrosis, loose bodies, and sepsis. Imaging studies have demonstrated variable reliability in assessing these problems. In general, technological advances in MRI have shown the greatest promise at detecting these problems. Arthroscopy has identified the presence of other intra-articular lesions that used to go undiagnosed. The incidence of labral tears, articular injuries, and disruption of

the ligamentum teres is more common than has been suggested by previous literature that included only case reports.^{1,2,17-19,21,30,32} Arthroscopy has also proven to be more sensitive for detecting some of the traditionally recognized disorders, including arthritis, synovial disease, and sepsis.^{4,26,33}

Arthroscopy has provided an increased awareness of the nature of these lesions and has stimulated an interest in improving the value of imaging studies. Recent publications have reported on the reliability of MRI and MRI combined with arthrography (MRA), but none have compared the accuracy of these studies in a single cohort of arthroscopically examined patients.^{15,16,25,31} In addition, the authors of this current report have traditionally relied on the response to an intra-articular injection of anesthetic as an indicator of primary hip joint abnormality. Thus, the purpose of this case series is to correlate the diagnostic accuracy of clinical assessment, MRI, MRA, and intra-

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TABLE 1

Characteristic Features of Hip Joint Abnormality

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- Symptoms worse with activity
 - Straight-plane activities relatively well tolerated
 - Activities on level surfaces better tolerated than on inclines
 - Torsional activities less well tolerated (ie, twisting such as turning, changing directions)
 - Seated position may be uncomfortable (especially with hip flexion)
 - Rising from seated position often painful (may experience catching sensation)
 - Difficulty ascending and descending stairs
 - Difficulty with shoes, socks, hose, and so forth
-

TABLE 2

Examination Findings

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- Groin, anterior, and medial thigh pain
 - "C-sign" characteristic of interior hip pain: hand gripped above greater trochanter
 - Logrolling of leg back and forth: most specific indicator of intra-articular abnormality
 - Forced flexion/internal rotation or abduction/external rotation: more sensitive measure of hip joint pain; reproduces symptoms that patient experiences with activities
-

articular injection with the arthroscopic findings of patients who have had these evaluations.

METHODS

All patients undergoing hip arthroscopy were prospectively evaluated as previously reported.^{11,12} The indication for the procedure was either intractable hip pain unresponsive to conservative measures or imaging evidence of intra-articular abnormality amenable to arthroscopy. Clinical assessment was performed by the senior author, including history, examination, and radiographic interpretation (Tables 1 and 2).^{5,8} Between November 1999 and January 2002, all patients undergoing MRA first underwent a conventional MRI. The indications for MRA included candidates for arthroscopy with either absence of imaging evidence of abnormality or assessment findings not entirely consistent with hip joint abnormality.

All studies were performed using a previously published protocol on a GE 1.5-T superconducting magnet with a torso coil.²⁰ Coronal T1-weighted and coronal and axial fat-suppressed T2-weighted images that included both hips were obtained. Images of the symptomatic hip, which had a small field of view and high resolution (256 × 256), were then performed, including axial, coronal, and sagittal proton density fat-suppressed, fast spin-echo images. This was immediately followed by a specific MRA protocol. A solution of 0.05 mL gadolinium, 3 mL iodinated contrast, and 6 mL 0.5% bupivacaine was injected into the joint followed by high-resolution axial, coronal, sagittal, and oblique axial fat-suppressed T1-weighted images. These studies were interpreted by 1 of 2 experienced musculoskeletal radiologists. After the studies, the patient then performed activities that would create symptoms before the injection to determine his or her response to the anesthetic. This was determined to be a positive response if pronounced temporary improvement in symptoms was noted and a negative response if no improvement was noted or if the improvement was only equivocal.

All patients underwent arthroscopy using the standard supine 3-portal technique as has been previously described by the senior author.^{6,7,9} The arthroscopic findings were recorded using a previously published format.¹²

RESULTS

Between November 1999 and January 2002, 141 patients underwent arthroscopic surgery of the hip. An MRA was indicated and performed in 40 cases, and this group represents the substance of this report (Table 3).

Arthroscopy revealed a total of 69 lesions, with a mean of 1.8 per hip. The 3 most common findings were labral tears (n = 32), chondral damage (n = 22), and disruption of the ligamentum teres (n = 7). These data are summarized in Table 4. The reliability of MRI and MRA in interpreting these most common lesions is summarized in Table 5. In general, for labral tears, both MRI and MRA demonstrated modest specificity, whereas sensitivity was improved with MRA. Both studies demonstrated 100% specificity for chondral damage but poor sensitivity. Both were poor at defining lesions of the ligamentum teres.

Hip abnormality was clinically suspected in all cases. This was 98% accurate with 1 false positive reflected by normal findings at arthroscopy. However, the assessment identified the nature of the abnormality in only 13 cases (32%), including 6 labral tears, 4 cases of degenerative joint disease, and 1 each of loose body, adhesive capsulitis, and instability; this assessment was accurate in 12 cases (92%). Radiographs had normal results in all cases, except 4 cases demonstrating mild degenerative changes.

Conventional MRI demonstrated no evidence of abnormality in 17 cases (42%). It completely demonstrated the abnormality in 4 cases (10%), partly demonstrated the abnormality when more than one lesion was present in 6 cases (15%), and revealed indirect evidence of abnormality reflected by effusion or paralabral/subchondral cyst in 9 cases (22%). There were 4 false-positive interpretations (10%), each due to overinterpreting a labral tear.

By MRI results, there were 8 effusions, 5 paralabral cysts, and 5 subchondral cysts. Among the 8 effusions, all demonstrated a labral tear, and there were also 4 articular lesions, 2 ruptured ligamentum teres, 1 loose body, and 1 synovitis. Among the 5 paralabral cysts, all demonstrated a labral tear, there were 2 articular lesions, and there was 1 rupture of the ligamentum teres. Among the 5 subchondral cysts, 4 demonstrated articular damage, all had a labral tear, there was 1 rupture of the ligamentum teres, and there was 1 loose body.

The MRA revealed no evidence of abnormality in 3 cases (8%) (see Figure 1). It completely demonstrated the abnor-

TABLE 3
Observations of Various Study Parameters^a

Case Number	Clinical Assessment	Magnetic Resonance Imaging	Magnetic Resonance Arthrography	Response to Injection	Arthroscopic Diagnosis
1	Hip pain	Paralabral cyst	Labral tear; paralabral cyst	Yes	Labral tear; rupture ligamentum teres
2	Loose body	Labral tear; subchondral cyst	Labral tear; rupture ligamentum teres; subchondral cyst	Yes	Labral tear; rupture ligamentum teres
3	Degenerative joint disease	Labral tear; chondral damage	Labral tear; chondral damage	Yes	Labral tear; chondral Damage (IV-A)
4	Hip pain	Negative	Negative	Yes	Chondral damage (II-A)
5	Instability	Negative	Labral tear	Yes	Instability
6	Degenerative joint disease	Effusion	Chondral damage; subchondral cyst	Yes	Labral tear; chondral damage (IV-F); synovitis; loose bodies
7	Hip pain	Labral tear	Labral tear	Yes	Fibrous hyperplasia; pulvinar
8	Labral tear	Negative	Labral tear; chondral damage	Yes	Labral tear; chondral damage (II-A)
9	Hip pain	Subchondral cyst	Subchondral cyst	Yes	Labral tear; chondral damage (III-A)
10	Hip pain	Effusion; paralabral cyst	Paralabral cyst	Yes	Labral tear
11	Hip pain	Paralabral cyst	Labral tear; paralabral cyst	Yes	Labral tear; chondral damage (III-A)
12	Labral tear	Negative	Labral tear	Yes	Labral tear
13	Labral tear	Effusion	Labral tear	Yes	Labral tear
14	Hip pain	Negative	Labral tear; chondral damage	Yes	Rupture ligamentum teres
15	Hip pain	Effusion	Rupture ligamentum teres	Yes	Labral tear; chondral damage (II-A); rupture ligamentum teres
16	Hip pain	Negative	Labral tear; paralabral cyst	No	Rupture ligamentum teres
17	Hip pain	Negative	Chondral damage	Yes	Labral tear; chondral damage (IV-A)
18	Labral tear	Negative	Chondral damage	Yes	Labral tear; chondral damage (II-A); rupture ligamentum teres
19	Hip pain	Labral tear	Labral tear	Yes	Chondral damage (IV-A); loose bodies
20	Labral tear	Effusion; chondral damage; loose body	Chondral damage; loose body	Yes	Labral tear; chondral damage (III-F); rupture ligamentum teres
21	Hip pain	Labral tear; synovitis	Negative	Yes	Labral tear
22	Hip pain	Negative	Labral tear	No	Labral tear
23	Adhesive capsulitis	Negative	Labral tear	Yes	Labral tear; chondral damage (III-A); adhesive capsulitis
24	Hip pain	Labral tear	Labral tear	Yes	Labral tear; chondral damage (I-A)
25	Hip pain	Negative	Labral tear	Yes	Labral tear
26	Hip pain	Negative	Labral tear	Yes	Labral tear
27	Degenerative joint disease	Chondral damage; subchondral cyst	Labral tear; chondral damage; subchondral cyst; loose body	Yes	Labral tear; chondral damage (IV-A); loose bodies
28	Hip pain	Negative	Labral tear	Yes	Labral tear
29	Hip pain	Labral tear; paralabral cyst	Labral tear; paralabral cyst	Yes	Labral tear
30	Hip pain	Negative	Labral tear	Yes	Labral tear; chondral damage (IV-A)
31	Hip pain	Effusion; labral tear; chondral damage; osteophyte	Labral tear; chondral damage; osteophyte; rupture ligamentum teres	Yes	Labral tear; chondral damage (III-A)
32	Hip pain	Labral tear	Labral tear	Yes	Adhesive capsulitis
33	Hip pain	Labral tear; subchondral cyst	Labral tear; subchondral cyst	No	Labral tear; chondral damage (III-F)
34	Hip pain	Effusion; labral tear	Labral tear	Yes	Normal
35	Hip pain	Effusion; labral tear	Labral tear	Yes	Labral tear; chondral damage (I-A)
36	Hip pain	Paralabral cyst	Labral tear; paralabral cyst; chondral damage	Yes	Labral tear; chondral damage (IV-A)
37	Hip pain	Negative	Labral tear	Yes	Labral tear
38	Labral tear	Negative	Negative	Yes	Labral tear; chondral damage (I-A)
39	Degenerative joint disease	Subchondral cyst	Labral tear; subchondral cyst	Yes	Labral tear; chondral damage (III-A and F)
40	Hip pain	Negative	Labral tear	Yes	Labral tear; chondral damage (III-A)

^aI to IV, Outerbridge classification; A, acetabulum; F, femoral head.

TABLE 4
Arthroscopic Findings

Finding	No. of Cases
Labral tear	32
Chondral damage	22
Disruption of ligamentum teres	7
Loose bodies	3
Adhesive capsulitis	2
Synovitis	1
Fibrosis	1
Instability	1

TABLE 5
Sensitivity and Specificity of Most Common Lesions

	Sensitivity, %		Specificity, %	
	MRI	MRA	MRI	MRA
Labral tear	25 ^a	66 ^a	67	75
Chondral damage	18	41	100	100
Ligamentum teres rupture	0	29	NA	67

^aDifference in sensitivity between MRI and magnetic resonance arthrography (MRA) for labral tears was statistically significant ($\alpha = .05$) using *z* test of binomial data. All other differences were not statistically significant. NA, not applicable.

mality in 14 cases 35%) (see Figure 2), partly demonstrated the abnormality in 13 cases (32%), and showed only indirect evidence of abnormality in 2 cases (5%). There were 8 false-positive interpretations (20%) due to overinterpreting the labrum in 7 cases (Figure 3) and the ligamentum teres in 1 case.

Response to the intra-articular injection of anesthetic with pronounced temporary alleviation of symptoms was 90% accurate. There were 3 false-negative responses and 1 false-positive response.

DISCUSSION

The incentive for performing this study was based on the following observations. The most recent literature focuses on the reliability of imaging studies to detect labral abnormality.^{15,16,25,31} This is only one of the lesions that have been identified in the joint, and labral abnormality has also been reported in asymptomatic volunteers.^{14,24} Perhaps better results have been observed with MRA, but these have not been compared with MRI results in the same cohort of arthroscopy patients.^{15,16,25,31} There have been few publications on the accuracy of MRI techniques for demonstrating articular damage, and there are no studies regarding its accuracy for detecting lesions of the ligamentum teres.^{23,29,34}

Empirically, the authors of this report relied on the response to a fluoroscopically guided intra-articular injection of anesthetic as an indicator of the presence of symptomatic



Figure 1. A 46-year-old man with left hip pain. Magnetic resonance arthrography did not reveal any articular damage, but arthroscopy demonstrated a 1-cm area of grade IV articular loss (probe) adjacent to the posterior superior acetabular fossa with surrounding superficial grade III articular fragmentation.

hip joint abnormality. In addition, it was felt that the presence of an effusion was likely significant indirect evidence of abnormality. An MRA would obscure this observation; thus, a preliminary MRI was performed to assess for any effusion. In addition, anesthetic was used in conjunction with contrast for MRA so that the authors could continue to observe the patient's symptomatic response to the injection.

The principal shortcoming of this study is that it was not blinded. However, even given this limitation, the clinical observations are still pertinent and provide useful information for those endeavoring to discern the nature of hip joint abnormality.

It should also be noted that this study encompassed less than a third of the 141 patients undergoing arthroscopy during this time period and represented the more difficult diagnostic cases. Those with obvious evidence of hip joint abnormality were not part of this cohort. By including the more obvious cases, it is likely that the sensitivity may have been better.

Like many aspects of the practice of medicine, the most important diagnostic tool is the physician's history and examination.^{5,8} The details of this are beyond the scope of this report, but the general parameters are summarized in Tables 1 and 2. In addition, the physician must be in tune to the patient's perception of his or her problem and other extrinsic factors that may influence subjective aspects of the evaluation (ie, workers' compensation, pending litigation, hysterical personality, unreasonable expectations, etc).

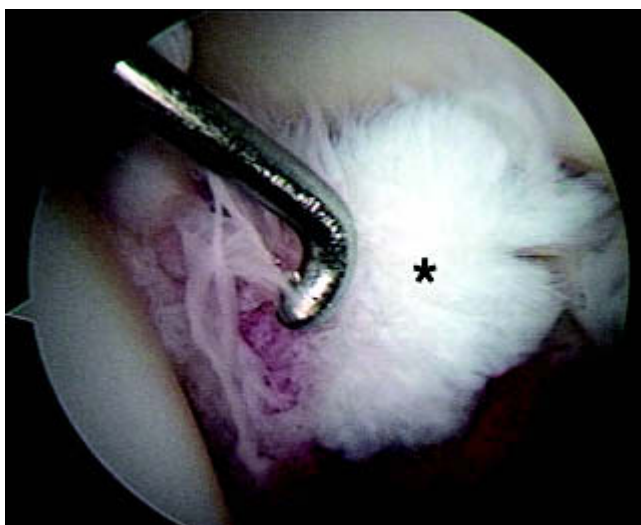
Radiographs are an integral part of the routine evaluation. They may provide useful indicators of underlying disease such as dysplasia or degenerative changes. However, although radiographs may provide useful clues in assessing hip abnormality, their sensitivity is often poor. In this



A



A



B



B

Figure 2. A 15-year-old girl sustained a twisting injury with resultant mechanical left hip pain. A, sagittal T1-weighted fat-suppressed magnetic resonance arthrography image illustrates disrupted fibers of the ligamentum teres (asterisks) silhouetted by contrast within the acetabular fossa; B, arthroscopic view demonstrates a traumatic rupture of the ligamentum teres (asterisk).

study, radiographs aided in the diagnosis in only 4 (10%) of the 40 cases, demonstrating evidence of mild degenerative disease. In the study by Santori and Villar, radiographs had normal results in 60 (56%) of 108 patients with arthroscopic findings of osteoarthritis.³³ McCarthy and Busconi found radiographs to be nondiagnostic in 71 (76%) of 94 patients with arthroscopic evidence of various abnormalities.²⁷

As previously noted, the authors of this study have relied on a fluoroscopically guided intra-articular injection of anesthetic as a useful tool in assessing the hip joint as

Figure 3. A 19-year-old woman with left hip pain. A, coronal T1-weighted fat-suppressed magnetic resonance arthrography image demonstrates suspected tear of the lateral labrum (arrow); B, arthroscopic view demonstrates a normal labral cleft (probe) with no evidence of a pathologic lesion.

the origin of symptoms. The results of this study supported this opinion. Although 90% reliability is quite good, there is still a small chance of both false-negative and false-positive interpretations.

With regard to labral abnormality, previous studies have found MRA to be more successful at detecting these lesions than MRI, with sensitivities ranging from 57% to 91%.^{15,16,25,31} However, there are several studies that have demonstrated evidence of labral abnormality even among asymptomatic volunteers, and the incidence of this increases with age.^{14,24} This evidence is consistent with the findings of 2 separate cadaveric studies that reported a 96% prevalence of labral lesions in specimens with a mean

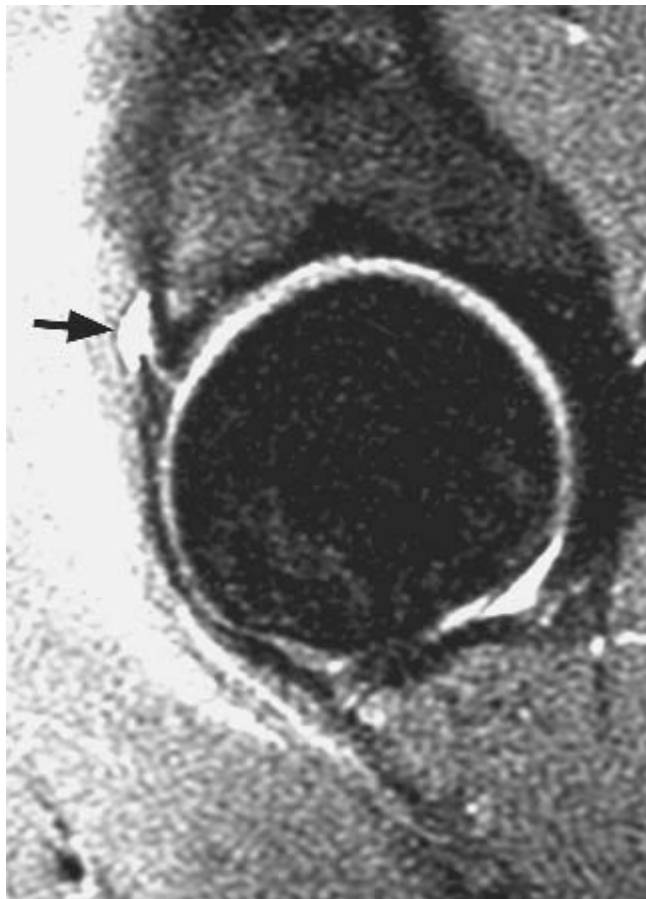


Figure 4. A 26-year-old man with left hip pain. Sagittal proton density fat-suppressed fast spin-echo image demonstrates a tear of the anterior labrum with associated paralabral cyst (arrow).

age of 78 years.^{28,35} Thus, labral abnormality may be a naturally occurring senile process in absence of symptoms. The present study demonstrated fair specificity of both MRI (67%) and MRA (75%), whereas the sensitivity was improved with MRA (66%). Overinterpreting labral abnormality was the principal cause of false positives in both the MRI and MRA groups. However, the presence of a paralabral cyst was a 100% specific indicator of the existence of labral abnormality (Figure 4).

Conventional MRI has demonstrated poor success at quantitating the articular cartilage, with a Pearson correlation coefficient of 0.29 ($P = .02$) between MR and anatomical measurements.²³ Difficulty assessing chondral abnormalities has been partially attributed to the close apposition of the 2 articular surfaces. One study attempted to overcome this difficulty by using distraction while imaging the joint, and this procedure aided in detecting articular defects in cases of osteonecrosis and advanced osteoarthritis.²⁹ A recent study by Schmid et al demonstrated favorable but variable sensitivity (50%-79%) and specificity (77%-84%) of MRA for detecting cartilage lesions.³⁴ From the results reported here, both MRI and

MRA demonstrate poor reliability in assessing articular damage, but when identified, these studies were 100% specific. Subchondral cyst formation also was a reliable indicator of accompanying articular damage with a specificity of 80%.

As mentioned before, the authors of this study have, empirically, felt that the presence of an effusion represented significant indirect evidence of intra-articular abnormality. Even slight asymmetric effusion in a symptomatic hip is important and must be carefully scrutinized. Unlike the shoulder or knee, which has a capacious capsule, the hip capsule is dense and noncompliant, with little room for volume expansion. Thus, any increased fluid should be considered significant. Beltran et al have previously reported on the presence of effusion as a finding associated with rheumatoid arthritis.³ These impressions are supported by the results of this current study, as effusion was 100% indicative of hip joint abnormality. However, this interpretation must be qualified by the fact that these were all cases that were clinically suspected of having intra-articular damage. It is certainly possible to have a transient synovitis or effusion that could resolve spontaneously in the absence of trauma or abnormality.

The arthroscopic diagnosis of lesions of the ligamentum teres was first mentioned in the literature by Gray and Villar in 1997.²² Byrd and Jones later noted this to be the third most common finding among athletes undergoing arthroscopy.¹⁰ Subsequently, they published their study of traumatic lesions of the ligamentum teres, among which only 2 of 23 (9%) were diagnosed preoperatively.¹³ These observations are similar to those of the current report that demonstrated poor ability to identify these lesions on preoperative studies.

It has been the impression of these authors that scanners with small magnets and open scanners are unreliable for detecting subtle hip lesions. These scanners can only rule out obvious diseases such as avascular necrosis or tumors. An effusion or accompanying cyst may provide indirect evidence of joint abnormality, but otherwise, these low-resolution studies should be considered unreliable. As reflected by this study, even high-resolution MRIs are imperfect.

To summarize, the clinical assessment can accurately determine the existence of intra-articular hip abnormality but is often poor at defining its nature. An MRI variably shows evidence of intra-articular damage but has a 42% rate of false-negative interpretation. An MRA is much more sensitive, but the false-positive interpretation rate doubles. Effusion, paralabral cysts, and subchondral cysts are all important indirect indicators of hip disease. The response to an intra-articular injection of anesthetic is a reliable indicator of intra-articular abnormality in 90% of cases.

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