Correlation of Magnetic Resonance Imaging to Arthroscopic Findings of Stability in Juvenile Osteochondritis Dissecans

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Purpose: To determine the ability of magnetic resonance imaging (MRI) to characterize the stability of osteochondritis dissecans (OCD) fragments in juveniles. **Methods:** Twenty-eight consecutive patients underwent surgery for OCD between 2004 and 2008. Of these, 23 patients had adequate preoperative imaging. There were 14 boys and 9 girls with a mean age of 12.9 years. Of the 23 lesions, 21 were located in the knee and 2 were located in the talus. On the basis of MRI, a single radiologist (1) indicated the presence or absence of 4 established magnetic resonance signs of instability, (2) classified each lesion according to a staging system for OCD stability, and (3) described the lesion as stable or unstable. These findings were compared with the arthroscopic findings. Arthroscopy was considered the gold standard for diagnosing fragment stability. **Results:** Of the OCD lesions, 13 were found to be stable and 10 were found to be unstable. The final MRI impression was unstable in 21 patients and stable in 2 patients. This yielded a sensitivity of 100% and a specificity of 15% for diagnosing fragment instability. When 2 or more criteria were present, the specificity of MRI to classify lesion instability improved to 92%. The sensitivity, however, dropped to 50%. Concordance between arthroscopic stage and MRI stage was 30% (7 of 23). **Conclusions:** MRI predicted 21 of 23 lesions to be unstable, whereas arthroscopy found only 10 of these 23 lesions to be unstable. The most common pattern of false-positive findings involved lesions with an area of high signal intensity at the bone-fragment interface. MRI should not be used in isolation to determine lesion instability in young patients with juvenile OCD. **Level of Evidence:** Level IV, therapeutic case series.

Osteochondritis dissecans (OCD) is a relatively prevalent disorder in juveniles, affecting adolescents at a rate between 15 and 30 per 100,000. There is evidence that the incidence is growing, particularly in young girls. The percentage of children aged below 10 years in whom OCD develops appears to be increasing as well.[1] The treatment of OCD depends on characteristics of the patient as well as the lesion.[1-4] Young patients with small, stable lesions have been treated nonoperatively with good success.[3,5,6] Factors that seem to predict a poorer outcome include older age of the patient, larger lesion size, and instability of the fragment.[3,4,6,7] Whereas patient age and size of the lesion are easily determined, fragment stability can remain variable up until the time of surgery; surgical decision making is thus largely affected by determination of fragment stability. Magnetic resonance imaging (MRI) has emerged as the modality of choice to characterize the fragment stability in OCD.[8-11] Various classification systems for OCD stability have been proposed based on MRI appearance. De Smet et al.[12] described 4 different magnetic resonance (MR) signs

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Table 1. *De Smet MRI Criteria for Fragment Instability**

	Description
1	A thin line of high signal intensity 5 mm or more in length at the interface between the OCD and the underlying bone
2	A discrete, round area of homogeneous high signal intensity 5 mm or more in diameter beneath the lesion
3	A focal defect with a width of 5 mm or more in the articular surface of the lesion
4	A high–signal intensity line traversing the articular cartilage and subchondral bone plate into the lesion

*Based on data from reference 12.

that indicate instability. In addition, Dipaola et al.[13] proposed a staging system that correlates MRI with arthroscopic findings.

The purpose of our study was to correlate preoperative MRI to arthroscopic findings. Two methods for characterizing OCD by use of MRI were used and subsequently compared with arthroscopic findings. The value of using MRI to accurately predict fragment stability was then assessed. We hypothesized that MRI would not accurately predict fragment stability in a cohort of young patients with juvenile OCD.

METHODS

We identified 28 patients who underwent surgery for the diagnosis of OCD. Two patients did not have preoperative MRI performed and were excluded. One patient who did have a preoperative MRI scan performed was excluded because the MRI scan was performed 2 years before the surgery. One patient was found to have a stellate lesion of the articular cartilage with underlying bony edema. On the basis of the morphology of the lesion, it was not considered to represent OCD by either MRI or arthroscopy and was thus excluded from the study. Finally, a fifth patient was excluded for inadequate quality of imaging. This patient had bilateral Blount disease with accompanying bilateral OCD. A single MRI scan was performed of both lower extremities with a torso coil. This resulted in a field of view too large and image quality too poor to properly characterize the lesion. The remaining 23 subjects represented all arthroscopies performed for the diagnosis of OCD between 2004 and 2008.

Patients had presented with persistent pain, effusion, or locking and catching. All patients had failed an extended period (≥6 months) of conservative management consisting of activity modification and weight-bearing restriction.

The MRI scans were obtained for each patient and subsequently read by a single radiologist who is fellowship trained in musculoskeletal radiology. All MRI evaluations were performed by use of a 1.5-T magnet (GE Medical Systems, Milwaukee, WI) with surface coils for both the knee and ankle. Validated cartilage-sensitive fast spin-echo proton density sequences were obtained in all patients.[14] Proton density–weighted images have a long repetition time (3,000 to 5,000 milliseconds) and an intermediate echo time (30 to 40 milliseconds). Images were acquired with 3- to 4-mm slice thickness, no interslice gap, a field of view of 16 to 18 cm, and a matrix of 256 by 224. T1-weighted, fast spin-echo T2-weighted fat saturated, and short tau inversion recovery sequences were also obtained.

The radiologist was blinded to all patient data and intraoperative findings, as well as the method of treatment. The radiologist indicated the presence or absence of each of the 4 MR signs of instability as described by De Smet et al.[12] (Table 1). The presence of any 1 sign indicates instability. Lesions were also classified according to the system proposed by Dipaola et al.[13] (Table 2). Finally, the radiologist gave each lesion a final diagnosis of stable or unstable.

Table 2. *Dipaola Staging System for Characterizing Osteochondral Lesions*

	Arthroscopic	MRI
Stage I	Irregularity and softening of articular cartilage, no definable fragment	Thickening of articular cartilage and low signal changes
Stage II	Articular cartilage breached, definable fragment, not displaceable	Articular cartilage breached, low signal rim behind fragment indicating fibrous attachment
Stage III	Articular cartilage breached, definable fragment, displaceable, but attached by some overlying articular cartilage	Articular cartilage breached, high signal changes behind fragment indicating synovial fluid between fragment and underlying subchondral bone
Stage IV	Loose body	Loose body

NOTE. Stages I and II are considered stable, whereas stages III and IV are considered unstable.[13]

Table 3. *Sensitivity, Specificity, PPV, and NPV for MRI as Test to Diagnose Fragment Instability*

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Final impression	100	15	48	100
Criterion 1	71	31	44	57
Criterion 2	10	100	100	59
Criterion 3	40	92	80	67
Criterion 4	40	85	67	65
≥2 Criteria	50	92	83	71

The operative reports and intraoperative photographs were then reviewed for each of the included patients. All operations were performed by a single attending surgeon who is fellowship trained in sports medicine. This surgeon also personally dictated each operative report and gave a final impression of fragment stability. Arthroscopy is regarded as the standard for evaluating OCD lesions. Arthroscopy allows for direct inspection and palpation of the cartilage to determine the existence of displaceable fragments, cartilage breach, or underlying soft spots.[13,15,16] In concordance with Guhl[15] and Dipaola et al.,[13] a lesion was considered to be stable if the overlying cartilage was intact (stage I) or if the cartilage was breached, yet with an underlying fragment that was not displaceable (stage II). In most cases of stable lesions, the area in question was identified and the overlying cartilage was palpated thoroughly with a probe. Softening of the cartilage confirmed the presence of the underlying lesion, but such a lesion was considered stable if the cartilage was intact. If a portion of the lesion could be displaced with a probe (stage III) or if a loose body was encountered (stage IV), the lesion was considered unstable.

Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were determined for the overall impression of stability as determined by MRI. Arthroscopic assessment of stability was used as the gold standard. Sensitivity, specificity, PPV, and NPV were then determined for each of the described criteria for lesion instability (Table 3). Finally, concordance between MRI and arthroscopic findings was determined for lesion stage.[13]

RESULTS

The patients had a mean age of 12.9 years (range, 8 to 18 years). There were 14 boys and 9 girls. A majority of the lesions were located in the knee (n = 21), 11 of which were on the medial femoral condyle. Six lesions were on the lateral femoral condyle, three were on the patella, and one was on the trochlea. The remaining 2 lesions were in the talus.

The mean time interval between MRI and arthroscopy was 3.6 months (range, 1 to 9 months). All but 1 patient had arthroscopy performed within 6 months of MRI.

We considered arthroscopy to be the gold standard for determining lesion stability and thus used arthroscopic findings as the modality for final lesion diagnosis. By these criteria, 13 OCD lesions were found to be stable and 10 lesions were found to be unstable. The final MRI impression was felt to be unstable in 21 patients and stable in 2 patients. Both lesions that were read as stable by MRI were in fact stable at arthroscopy. This yielded a sensitivity of 100% and a specificity of 15%. The PPV and NPV were 48% and 100%, respectively (Table 3).

Of the individual criteria for instability, criterion 1 was most frequently present. It was present in 16 of the 23 MRI studies (70%). This relatively high prevalence yielded a sensitivity for this single criterion of 70% and a specificity of 31%. Criteria 2 through 4 were comparatively less prevalent. As such, their sensitivities were lower (range, 10% to 40%) but their specificities were higher (range, 85% to 100%).

Whenever 2 or more criteria were present, the specificity of MRI to determine lesion stability improved to 92%. The sensitivity, however, lowered to 50%.

The correlation between arthroscopic stage and MRI stage was found to be poor. MRI predicted arthroscopic stage in only 7 of 23 subjects (30%) (Table 4).

DISCUSSION

Multiple imaging modalities have been used to characterize OCD lesions. These include plain radiographs, scintigraphy, and MRI.[6,8,9,17-20] To our knowledge, only MRI and nuclear scans have been used to determine fragment stability. Previous studies have compared arthroscopic with MRI findings of stability for OCD.[9,11-13] De Smet et al.[12] reported on 40 patients who underwent arthroscopy for OCD. They reported a sensitivity of 97% and a specificity of 100% for MRI diagnosis of instability. This was consistent with their previous study in which MRI correctly predicted instability in 20 of 21 patients.[9]

In our study we found a much lower specificity for MRI prediction of instability. The most common pattern of false-positive findings involved a lesion with high signal intensity at the bone-fragment interface (criterion 1) that was found to have intact cartilage at

Table 4. *Concordance Between Arthroscopic and MRI Stage as Defined by Dipaola*

Patient No.	Arthroscopic Stage	MRI Stage	Concordant
1	1	3	
2	4	4	Yes
3	2	3	
4	1	3	
5	4	4	Yes
6	3	3	Yes
7	1	3	
8	3	3	Yes
9	1	3	
10	1	4	
11	1	3	
12	4	3	
13	1	3	
14	1	2	
15	3	3	Yes
16	4	3	
17	1	2	
18	4	3	
19	1	3	
20	3	3	Yes
21	4	4	Yes
22	1	3	
23	2	4	

the time of arthroscopy (Fig 1). There are 2 important differences to note between these previous studies and the present study. The mean patient age in our study was 12.9 years. This is much lower than the mean age of the cohort presented by De Smet et al.,[12] at 25.7 years, with a range of 13 to 50 years. One would expect a cohort with a more significant number of older patients to have more advanced (and thus more unstable) lesions on arthroscopy. Interestingly, De Smet and colleagues[21] recently published a comparison of juvenile to adult OCD. In this study the specificity of MRI to predict instability in the juvenile group was 11% when all criteria were used. This is consistent with our findings in which specificity was found to be 15%. The second distinguishing feature between our study and the aforementioned studies pertains to the interpretation of stability at the time of arthroscopy. In previous studies the lesion was considered unstable if the lesion was visible or if there was "softening" of the cartilage around the area of the lesion. In the present study we considered the integrity of the cartilage to be the hallmark of lesion stability. A lesion was considered stable if the overlying cartilage was intact, even if it was indentable. Our definition of stability was patterned after the arthroscopic grading developed by Guhl.[15] Although this may represent

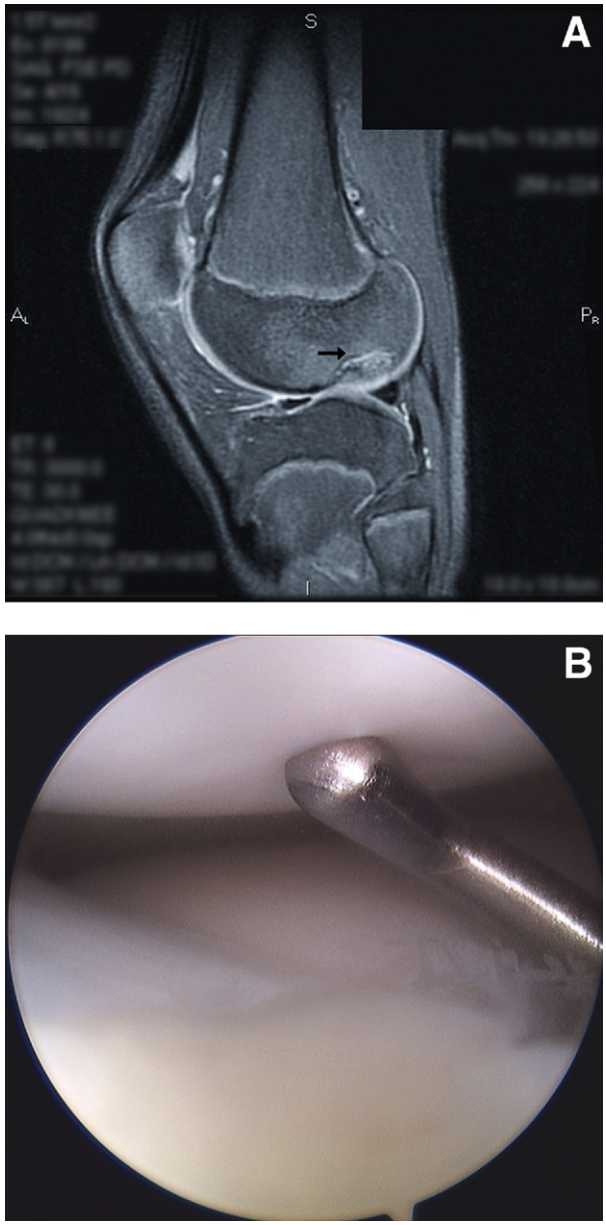

Figure 1. MRI instability: false positive. An unstable lesion on MRI was found to be stable with intact cartilage on arthroscopy. (A) Fast spin-echo proton density–weighted sagittal MR image through an OCD lesion in the lateral femoral condyle. The patient presented with knee pain after an injury that persisted despite 8 months of conservative management. Note the thin line of high signal intensity (arrow) at the interface between the lesion and the underlying bone. The radiologist interpreted this lesion as unstable, based on criterion 1. (B) The same lateral femoral condyle OCD lesion shown arthroscopically through the anteromedial portal in the patient's left knee. Softening of the cartilage confirmed the presence of the underlying lesion, but the cartilage was completely intact and the lesion was stable.

what appears to be a difference in semantics, such distinctions are important to recognize, because the definition of stability very often dictates the method of treatment.

Dipaola et al.[13] reported on 12 patients with OCD lesions of the knee and talus (6 knee and 6 talus). They devised a classification system by which MRI and arthroscopic findings could be compared (Table 2). In their report MRI correctly staged 11 of 12 lesions (92%). One patient with a stage II lesion of the talus was misread as having a stage III lesion on MRI. In the current series only 7 of 23 patients (30%) were correctly staged by the Dipaola system. A potential reason for the poor correlation between arthroscopic and MRI findings may again be related to the age of the patients. The mean patient age in our study was 12.9 years, as compared with 26.5 years in the report of Dipaola et al.

In 2008 Lee et al.[16] evaluated the accuracy of MRI compared with arthroscopy in staging of osteochondral lesions of the talus. They used a staging system specific for the talus that is similar to the system of Dipaola et al.[13] They found that MRI accurately predicted the arthroscopic stage in 81% (42 of 52) of the cases. The mean patient age, however, was 43 years, as compared with 12.9 years in our study.

O'Connor et al.[11] reported on the arthroscopic and MRI findings of 33 OCD lesions. The arthroscopic findings were graded according to Guhl.[15] The MRI scans were staged according to Dipaola et al.[13] The initial MRI interpretations described 21 OCD lesions as unstable (stage III or IV). At arthroscopy, however, 10 of these 21 lesions were found to have intact overlying cartilage. Only 45% of the MRI reports accurately predicted the arthroscopic findings. This is similar to the findings of our study, in which the PPV of an unstable lesion on MRI was only 48%, and the accuracy of MRI to predict arthroscopic findings according to Dipaola et al. was only 30%. O'Connor et al. improved their accuracy to 85%, however, when they included a breach of cartilage as seen on MRI as a requirement for inclusion in the group of lesions considered unstable by MRI. This is analogous to our subset of patients who had 2 or more MR signs of instability present on MRI. In this group specificity improved to 92%.

This study is limited by the selection criteria for the study cohort. In addition to comprising a modest number of patients, the cohort itself was selected based on having had arthroscopy. Patients selected for arthroscopy typically represent those patients considered to have more advanced disease or more long-standing symptoms. As such, the cohort represents only 1 part of the spectrum of OCD seen in the clinical setting. Interestingly, despite this possible selection bias, 13 of the 23 patients were found to have stable lesions on arthroscopy.

An additional potential weakness of the study includes the variable time interval between the performance of MRI and subsequent arthroscopy. Because of this variability, one might expect a variable amount of disease progression to occur during this interval. During this time period, despite conservative management with activity modification and weight-bearing restriction, patients had progression of their symptoms and required surgery. Whereas most young patients have excellent healing potential, conservative management failed in all patients in this cohort, and it is likely that these patients' OCD lesions either remained the same or progressed toward increasingly unstable lesions in the time interval between MRI and arthroscopy. This would be represented by a higher number of unstable lesions on arthroscopy as compared with MRI. In our study, however, the reverse was true. The lesions were more often read as unstable and found to have intact cartilage. This minimizes any effect this variable may have. Three patients (patients 12, 16, and 18 in Table 4), however, had stage III lesions on MRI (Dipaola) but were found to have loose bodies at the time of arthroscopy (stage IV). It is feasible that these lesions progressed in the time from MRI to surgery (mean duration, 3.3 months). If so, accuracy would be improved to 10 of 23 (44.5%) when the Dipaola staging system is used in our series. This is still quite poor and reflects the younger age of this cohort, with the implication that MRI may not be as accurate for diagnosing OCD fragment instability in this population.

Another potential weakness of this report may be that MRI stability was based on the interpretation of only 1 musculoskeletal radiologist. Multiple radiologists would add strength to the results. However, Dipaola et al.[13] found 100% agreement in the interpretation of MRI stability by 2 radiologists. As such, accurate MRI staging does appear to be reproducible without interexaminer variability.

We believe that it is also important to recognize that whereas the classification systems consist of finite categories of lesion morphology, the progression of OCD (like any pathology) represents a continuum of pathology. This fact is illustrated in patient 3. The MRI scan for this patient was read as unstable. On arthroscopy, the area in question was identified. There

was some fissuring of the cartilage around the border of the lesion, but the fissures did not extend to subchondral bone. We considered this lesion to be stable.

Treatment for OCD is guided by lesion size, patient age, and lesion stability. Although MRI is the imaging study of choice to determine lesion stability, it may not be as accurate as previously thought in determining lesion stability, particularly in younger patients. Sound clinical judgment is necessary to determine the need for operative intervention.

Study limitations include a relatively small cohort of patients, selection bias of only patients in whom conservative management failed and who underwent surgery, no control group, variable time between MRI and arthroscopy, and a single radiologist.

CONCLUSIONS

MRI predicted 21 of 23 lesions to be unstable, whereas arthroscopy found only 10 of these 23 lesions to be unstable. The most common pattern of false-positive findings involved lesions with an area of high signal intensity at the bone-fragment interface. MRI should not be used in isolation to determine lesion instability in young patients with juvenile OCD.

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