Juvenile Osteochondritis Dissecans of the Knee: Predictors of Lesion Stability

Walter P. Samora, MD,† Julie Chevillet, DO,‡ Brent Adler, MD,§ Gregory S. Young, MS,‖ and Kevin E. Klingele, MD*†*

Background: Recent data suggest magnetic resonance imaging (MRI) is the best method to analyze the status of the cartilage and subchondral bone in patients with juvenile osteochondritis dissecans (JOCD).

Methods: MRI analysis of 122 knees and 132 JOCD lesions in 109 patients who underwent arthroscopic treatment for osteochondritis dissecans lesions of the knee between March 2003 and January 2011.

Results: Agreement between MRI and arthroscopic grading was 62.1%. MRI sensitivity was 92% and specificity was 55%. Positive predictive value of MRI was 33% and negative predictive value of MRI was 97%. In a multivariable logistic regression model, the odds of a unstable lesion on the lateral femoral condyle nonweight-bearing location were 15.7 times greater than the odds of an unstable lesion on the medial femoral condyle weight-bearing area (95% confidence interval: 2.6-95.7, $P = 0.003$.) The odds of the lateral femoral condyle weight-bearing lesion having an unstable grade were also greater than for a medial femoral condyle weight-bearing lesion, but the results were not statistically significant (odds ratio, 1.70, $P = 0.349$).

Conclusions: A high T2 signal retrograde to the lesion may commonly appear with an early, stable arthroscopic grade lesion. MRI continues to be reliably sensitive to JOCD lesions and a good predictor of low-grade, stable lesions. However, MRI predictability of high-grade, unstable JOCD lesions is less reliable. Lesions in atypical locations, such as the nonweight-bearing surface of the lateral femoral condyle, more commonly present as higher, arthroscopic grade lesions.

Level of Evidence: Level IV, retrospective case series.

Key Words: juvenile osteochondritis dissecans, MRI, arthroscopy

(*J Pediatr Orthop* 2012;32:1–4)

From the *Department of Orthopaedics, Nationwide Children's Hospital; †Department of Orthopaedics; ‖Center for Biostatistics, The Ohio State University; §Department of Radiology, Nationwide Children's Hospital, Columbus, OH; and ‡Department of Orthopaedics, Parrish Medical Center, Titusville, FL.

None of the authors received financial support for this study.

The authors declare no conflict of interest.

Reprints: Kevin E. Klingele, MD, Department of Orthopaedics, Nationwide Children's Hospital; Clinical Assistant Professor, Orthopaedics, Ohio State University, 700 Children's' Drive Suite A2630, Columbus, OH 43205-2696. E-mail: Kevin.Klingele@nationwidechildrens.org.

Juvenile osteochondritis dissecans (JOCD) is a leading cause of knee pain in the pediatric and adolescent population.[1] Lesions are of unknown etiology and most commonly affect the lateral aspect of the medial femoral condyle (MFC).[2–4] Nonoperative management is well described for JOCD lesions, and is often a reliable method for young patients with stable lesions. A multitude of surgical treatments exist for JOCD lesions, which have failed nonoperative management or are unstable at presentation. The treatment best suited for each lesion is often determined by the assessment of lesion stability.[5,6] Physical examination, plain radiographic examination, bone scan, and magnetic resonance imaging (MRI) findings have all been used in this determination.

Patients with stable JOCD lesions may be asymptomatic, but most commonly present with pain, minimal or no effusion, full range of knee motion, and tenderness over the area of involvement. In contrast, unstable lesions are more likely to present with effusion, limited range of motion, and loose body or mechanical symptoms. Reliability of physical examination findings in predicting lesion stability, however, has proven to be poor.[6–8] Radiographs have also shown little reliability in predicting stability of OCD lesions.[2,9] Smillie[3] observed that the relative density of the bone fragment and sclerosis at the base of the lesion could indicate chronicity of the lesion. Cahill and Berg[10] reported good sensitivity for monitoring the clinical course of JOCD lesions with technetium bone scans.

More recent data suggest the best method to analyze the status of the cartilage and subchondral bone is MRI.[2,5,6,9] Features of a low-grade, and therefore stable, lesion on MRI include poor definition of the fragment, a low fragment rim signal, absence of articular cartilage breach, and/or softening and thickening of articular cartilage. Features of high-grade, and therefore unstable, lesion include a definable fragment, a high T2 signal deep to fragment, an articular cartilage flap, and an identifiable loose body.[6] It is thought that this high signal deep to the chondral fragment on T2 imaging, in conjunction with a chondral breach on correlating T1 images, is predictive of a high-grade, unstable lesion. De Smet et al[11] found this high signal in 72% of unstable lesions.

The purpose of this study was to determine the predictive value of MRI with regard to preoperative JOCD lesion stability. In addition, the relationship between lesion stability and anatomic location, age of the patient, and physeal status was examined.

METHODS

After institutional review board approval, the medical records of all patients who underwent arthroscopic treatment for osteochondritis dissecans lesions of the knee between March 2003 and January 2011 at a single institution were reviewed retrospectively.

Patients who initially presented with radiographic evidence of osteochondral lesions were sent for an MRI. The decision to pursue arthroscopic treatment of these lesions was under the discretion of the senior author. Factors that contributed to operative treatment included age, duration of symptoms, failure of conservative treatment, level of pain, and MRI staging.

Preoperative MRI was performed with a standard sequence using a quadrature knee coil on a GE (General Electric, Fairfield, CT) 1.5-Tesla LX or Excite unit. Each OCD lesion was graded according to the Dipaola classification[12] by a pediatric radiologist blinded to the findings of arthroscopy (Table 1). The anatomic location of each JOCD lesion was classified with a modification to the Cahill and Berg classification (Fig. 1).

For statistical analysis, grade I and grade II lesions, as described by Dipaola et al,[12] were defined as "stable" lesions; grade III and grade IV lesions were defined as "unstable" lesions. Lesions located in anteroposterior (Fig. 1A) areas A and B were considered lateral femoral condyle locations. Areas D and E were considered MFC locations. No lesions in this study were located in area C. From a lateral view (Fig. 1B), lesions in the A region were considered nonweight bearing (NWB), and lesions in the B and C regions were considered weight bearing (WB). For lesions that crossed over into more than 1 area, the area of greatest involvement was chosen.

Standard arthroscopic treatment was performed and documented by the senior author (K.K.). Arthroscopic grade of each OCD lesion, as defined by Guhl[13]

TABLE 1. The Arthroscopic and MRI Classification of JOCD

Grade	Arthroscopic (Guhl[13])	MRI (Dipaola et al[12])
I	Irregularity and softening of cartilage No fissure No definable fragment	No break in articular cartilage Thickening of articular cartilage
II	Articular cartilage breached Not displaceable	Articular cartilage breached, low signal rim behind fragment indicating fibrous attachment
III	Definable fragment, displaceable, but still attached partially by some cartilage, that is, a flap lesion	Articular cartilage breached with high signal T2 changes behind fragment suggesting fluid behind the lesion
IV	Loose body and defect of the articular surface	Loose body with defect of the articular surface

JOCD indicates juvenile osteochondritis dissecans; MRI, magnetic resonance imaging.

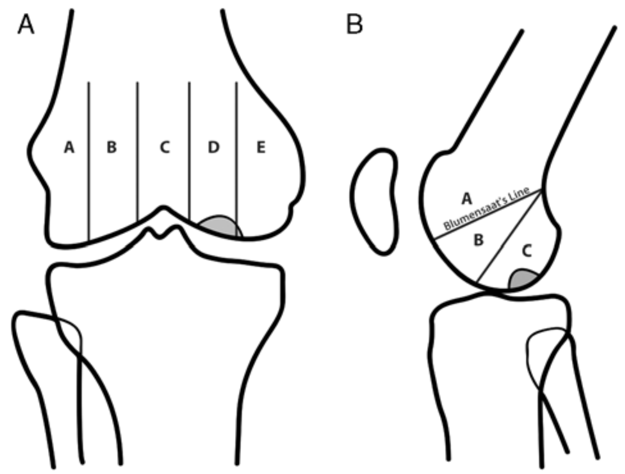

FIGURE 1. Anatomic classification of knee osteochondritis dissecans based on lesion location on anteroposterior (A) and lateral (B) radiographs. Note the "classic" location denoted. The Blumensaat line is a condensed linear shadow on lateral radiographs of the knee that provides an indication of relative position of the patella.

(Fig. 1), was either documented or translated from the surgical description of each lesion.

Exclusion criteria included patients with closed physes, incomplete radiographic evaluation, osteochondral fractures related to trauma, patellar dislocations, and associated ligamentous injury.

The κ statistic was used to quantify the agreement of MRI and surgical staging. Sensitivity, specificity, positive predictive value, and negative predictive value of the MRI grading were calculated and 95% confidence intervals (CI) produced using the Clopper-Pearson method. The Fisher exact test was used to compare categorical outcomes and multivariable logistic regression was used to model surgical stage (stable vs. unstable) based on patient age and injury location.

RESULTS

One hundred seventy-one patients were identified. Sixty-two patients were excluded because of associated polytrauma, simultaneous ligamentous injury, unavailable preoperative MRI images, or evidence of closed physes (N = 20). This resulted in total of 109 patients: 122 knees and 132 OCD lesions. Eighty-one male and 28 female patients were involved in this study. Mean patient age was 12.9 years at the time of surgery (range, 6 to 20 y). All patients had open physes. One hundred twenty-three lesions were located in the WB areas and 9 lesions in the NWB area. Eighty-six lesions were located on the MFC, 41 lesions on the lateral femoral condyle, and 5 lesions on the patella. By MRI classification, 60 lesions (45%) were considered stable and 72 (55%) lesions were unstable. In comparison, arthroscopic assessment revealed 106 stable lesions (80%) and 26 unstable lesions (20%) (Table 2).

Assuming all lesions were independent, agreement between MRI and arthroscopic grading was 62.1% (fair)

TABLE 2. Frequency Table of Surgical Stage by MRI Stage

	Surgical Stage		
MRI Stage	Stable	Unstable	Total
Stable	58 (55%)	2 (8%)	60 (45%)
Unstable	48 (45%)	24 (92%)	72 (55%)
Total	106	26	132

Column percentages are given in parentheses.
MRI, magnetic resonance imaging.

as compared with 47.3%, as would be expected by chance ($\kappa = 0.28$, $P < 0.001$). MRI sensitivity was 92% (95% CI: 75%-99%) and specificity was 55% (95% CI: 45%-64%). Positive predictive value of MRI was 33% (95% CI: 23%-45%) and negative predictive value of MRI was 97% (95% CI: 89%-100%).

Location of lesion and documented stability were compared (Table 3). The Fisher exact test showed a significant relationship between surgical stage and location ($P < 0.001$). A multivariable logistic regression model was used to predict surgical stage (stable vs. unstable) by location using the most prevalent locations of the lateral femoral condyle (LFC) (WB and NWB) and MFC (WB only). Age was also included as a continuous predictor. Results indicated that the odds of a unstable lesion on the LFC NWB location were 15.7 times greater than the odds of an unstable lesion on the MFC WB area (Table 4; 95% CI: 2.6-95.7, $P = 0.003$.) The odds of the LFC WB lesion having an unstable grade were also greater than a MFC WB lesion, but the results were not statistically significant (odds ratio, 1.70, $P = 0.349$). Age was not a significant predictor in the multivariable model (odds ratio for a 1-year increase: 1.17, $P = 0.224$). However, patients with LFC NWB lesions tended to be older (mean,15.3; range, 13 to 18) than those without (mean, 12.8; range, 6 to 20).

DISCUSSION

The prognostic value of MRI for the severity of OCD lesions is often debated.[6,9] Most practicing surgeons rely on the absence or appearance of the high signal deep to the subchondral bone on the T2 images, described by De Smet et al,[11] to predict an unstable lesion and therefore an indication for surgical intervention. It has been thought that this signal represents synovial fluid deep to the chondral fragment secondary to a breech in the

TABLE 3. Freqency Table of Surgical Stage by Location

Location	Stable	Unstable	Total
LFC NWB	2 (25%)	6 (75%)	8
LFC WB	27 (82%)	6 (18%)	33
MFC NWB	0	1 (100%)	1
MFC WB	75 (88%)	10 (12%)	85
Patella WB	2 (40%)	3 (60%)	5
Total	106 (80%)	26 (20%)	132

Row percentages are given in parentheses.
LFC indicates lateral femoral condyle; MFC, medial femoral condyle; NWB, nonweight bearing; WB, weight bearing.

TABLE 4. Multivariable Logistic Regression Results for Predicting Unstable (vs. Stable) Arthroscopic Stage

Factor	Odds Ratio	95% Confidence Interval	P
Location			
LFC WB	1.70	0.56-5.17	0.349
LFC NWB	15.72	2.58-95.74	0.003
MFC WB	1.0 (referent)	—	—
Age (1-year increase)	1.17	0.91-1.51	0.224

Age was modeled as a continuous variable.
LFC indicates lateral femoral condyle; MFC, medial femoral condyle; NWB, nonweight bearing; WB, weight bearing.

articular cartilage surface, which can be evaluated by T1 images. However, many patients with a high T2 signal behind the lesion have intact articular cartilage at the time of arthroscopy. It has been thought to represent a healing response via vascularized granulation tissue.[9] Wall et al[2] demonstrated no predictive value in gadolinium studies in determination of what this signal represents, nor of healing. A radiologic clear space was thought to represent dense fibrous tissue of a nonunion.

For this study, the strength of the magnet was uniformly 1.5 Teslas, a higher strength than used in previous studies. In terms of predictive value of MRI in assessing JOCD stability, this study reiterates the findings of O'Conner et al.[9] In that study, MRI was found to be 85% accurate in predicting arthroscopic grade of OCD lesions based on MRI findings using a 0.5-Tesla coil and similar grading systems.[9] The negative predictive value of 97% generated from this study reflects this previous work. Our population showed an MRI sensitivity of 92% and a specificity of 55%.

The primary difference between MRI grade II and grade III is the high T2 signal behind the fragment. There was a marked difference between the MRI and arthroscopic grades of grade III lesions with MRI often predicting a higher grade lesion than was present (Table 5) and resulting in a relatively low specificity. This may suggest variability in the high T2 signal with regard to its temporal appearance. Yoshida et al[5] documented changes in signal intensity with healing progression, which may be reflected by earlier appearance of the high T2 signal behind the OCD lesion. Alternatively, this high signal may be reflective of edema within the fracture line, which, if it

TABLE 5. Frequency Table of Surgical Stage by MRI Stage

		Surgical Stage				
		Stable		Unstable		
MRI Stage		1	2	3	4	Total
Stable	1	12	2	0	1	15
	2	36	8	0	1	45
Unstable	3	29	15	6	5	55
	4	1	3	1	12	17
Total		78	28	7	19	132

MRI, magnetic resonance imaging.

progresses, would contribute to progression to an unstable lesion. With grades II and IV more predictably evaluated, the status of the articular cartilage is reasonably predicted by the T1 images. This is reflected in the MRI specificity of 55% and the positive predictive value of only 33%.

Location of the lesion does seem to have prognostic significance. Historically, the most typical, or classic, location for OCD lesions of the knee is the posterolateral aspect of the MFC, which is consistent with our population. Yoshida et al[5] delineated 4 areas of OCD involvement: medial condyle, lateral condyle, intercondylar, and inferocentral regions. Lateral condylar lesions and inferocentral lesions of the MFC showed better healing potential than the intercondylar region.

Our population indicated that lesions in atypical locations such as the lateral femoral condyle were more likely to present as higher grade lesions. The odds of an unstable lesion for the LFC NWB location were 15.7 times greater than the odds of an unstable lesion of the MFC WB area, although the number of LFC NWB lesions in our set was small. Atypical areas, such as the NWB portion of the lateral femoral condyle, have negative prognostic significance.

CONCLUSIONS

The high T2 signal deep to the JOCD lesion has received much attention in terms of being a significant predictor of lesion stability. This study reiterates that a high T2 signal retrograde to the lesion may commonly appear with an early, stable arthroscopic grade lesion. MRI continues to be reliably sensitive to JOCD lesions and a good predictor of low-grade, stable lesions. However, MRI predictability of high-grade, unstable JOCD lesions is less reliable. Lesions in atypical locations, such as the NWB surface of the lateral femoral condyle, more commonly present as higher, arthroscopic grade lesions. Strong consideration should be made for early surgical treatment in patients who present with atypical osteochondral lesions.

REFERENCES

1. Crawford DC, Safran MR. Osteochondritis dissecans of the knee. *J Am Acad Orthop Surg*. 2006;14:90–100.
2. Wall E, Von Stein D. Juvenile osteochondritis dissecans. *Orthop Clin N Am*. 2003;34:341–353.
3. Smillie IS. Treatment of osteochondritis dissecans. *J Bone Joint Surg Br*. 1957;39-B:248–260.
4. Flynn JM, Kocher MS, Ganley TJ. Osteochondritis dissecans of the knee. *J Pediatr Orthop*. 2004;24:434–443.
5. Yoshida S, Ikata T, Takai H, et al. Osteochondritis dissecans of the femoral condyle in the growth stage. *Clin Orthop Relat Res*. 1998; 346:162–170.
6. Kocher MS, Tucker R, Ganley TJ, et al. Management of osteochondritis dissecans of the knee: current concepts review. *Am J Sports Med*. 2006;34:1181–1191.
7. Conrad JM, Stanitski CL. Osteochondritis dissecans: Wilson's sign revisited. *Am J Sports Med*. 2003;31:777–778.
8. Hefti F, Beguiristan J, Krauspe R. Osteochondritis dessicans. *Clin Orthop Relat Res*. 1982;167:67–54.
9. O'Connor MA, Palaniappan M, Khan N, et al. Osteochondritis dissecans of the knee in children. A comparison of MRI and arthroscopic findings. *J Bone Joint Surg Br*. 2002;84:258–262.
10. Cahill BR, Berg BC. 99m-Technetium phosphate compound joint scintigraphy in the management of juvenile osteochondritis dissecans of the femoral condyles. *Am J Sports Med*. 1983;11:329–335.
11. De Smet AA, Ilahi OA, Graf BK. Untreated osteochondritis dissecans of the femoral condyles: prediction of patient outcome using radiographic and MR findings. *Skeletal Radiol*. 1997;26: 463–467.
12. Dipaola JD, Nelson DW, Colville MR. Characterizing osteochondral lesions by magnetic resonance imaging. *Arthroscopy*. 1991; 7:101–104.
13. Guhl JF. Arthroscopic treatment of osteochondritis dissecans. *Clin Orthop Relat Res*. 1982;167:65–74.