

Nonoperative Management of Osteochondritis Dissecans of the Knee

Progression to Osteoarthritis and Arthroplasty at Mean 13-Year Follow-up

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Background: Osteochondritis dissecans (OCD) is a disorder of subchondral bone that commonly affects the knee.

Purpose: To (1) evaluate the rate of arthritis and knee arthroplasty in a population-based cohort of patients with OCD lesions treated nonoperatively and (2) evaluate factors that may predispose patients to knee osteoarthritis and arthroplasty.

Study Design: Case series; Level of evidence, 4.

Methods: Eighty-six patients (mean age, 21.4 years) with OCD lesions treated nonoperatively were identified between 1976 and 2014. Information related to the diagnosis, laterality of lesion, details of treatment, and progression to arthritis was obtained from the medical record. Factors predictive of arthritis and arthroplasty (age, sex, body mass index [BMI], and lesion location) were examined.

Results: At a mean \pm SD follow-up of 12.6 ± 9.8 years from diagnosis, 13 patients (15%) were diagnosed with arthritis, corresponding to a cumulative incidence of 5.0% at 5 years, 10.0% at 10 years, 20.0% at 25 years, and 30.0% at 35 years. The cumulative incidence of arthroplasty was 1.0% at 5 years, 3.0% at 10 years, 8.0% at 25 years, and 8.0% at 35 years. BMI at diagnosis greater than 25 kg/m² (hazard ratio [HR], 15.4; 95% CI, 1.9-124.5), patellar OCD lesions (HR, 15.0; 95% CI, 1.3-345.3), and diagnosis as an adult (HR, 21.7; 95% CI, 2.7-176.3) were factors associated with an increased risk of arthritis.

Conclusion: Arthritis after nonoperative treatment of OCD lesions is a challenging problem, with an estimated 30% cumulative incidence at 35 years after diagnosis. In contrast, the long-term rate of arthroplasty is low. BMI at diagnosis greater than 25 kg/m² and patellar OCD lesions are predisposing factors for arthritis. Diagnosis of OCD as an adult was associated with a greater risk of arthritis.

Keywords: osteochondritis dissecans; knee; nonoperative; osteoarthritis

Osteochondritis dissecans (OCD) is a disorder of the subchondral bone that most commonly affects the medial femoral condyle (MFC) of the knee.^{6,8} Although the pathogenesis of this condition is not completely understood, histologic studies suggest that vascular disruption of subchondral bone results in focal necrosis with subsequent destabilization of the overlying articular cartilage.^{6,16,22} Additionally, repetitive microtrauma, genetic predisposition, and endocrine abnormalities can also be associated with OCD lesions.^{6,15,16,26} While most commonly diagnosed in pediatric patients, symptomatic OCD lesions can also be found in the adult knee and likely represents undiagnosed adolescent lesions.^{8,11,16}

Few studies describe the long-term rate of arthritis in patients with OCD.^{2,16,19} A retrospective series of 18

skeletally immature patients with OCD found that 32% of patients had moderate or severe radiographic arthritis at 34-year follow-up.²⁴ In contrast, other studies have reported a lower rate of arthritis in patients with OCD.^{1,13,14,19} For example, a retrospective series of 20 patients with OCD treated with fragment excision reported that only 1 patient had evidence of joint line narrowing at 9 years after surgery.¹ An additional study of 12 patients treated with open reduction internal fixation of OCD lesions reported that patients had no symptoms of arthritis and had normal knee function at 9-year follow-up.¹⁴ OCD lesions characterized as unstable on radiographic imaging or lesions requiring surgical removal have been associated with poor clinical outcomes or high radiographic rates of degenerative changes in the knee.⁵

These studies help describe radiographic changes after treatment of OCD lesions, but many are limited by small patient cohorts or short follow-up periods.^{1,14,27} Furthermore, some studies have combined both patients treated

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operatively and nonoperatively into the same cohort for analysis.²⁴ The purpose of this study was to (1) evaluate the rate of arthritis and knee arthroplasty in a population-based cohort of patients with OCD lesions treated nonoperatively and (2) evaluate factors that may predispose patients to knee osteoarthritis and arthroplasty.

METHODS

Patients with OCD were identified using the Rochester Epidemiology Project (REP). The REP is a medical record database providing access to the complete medical records (all medical encounters) for all residents of Olmsted County, Minnesota, USA; it has been described in detail previously and has been validated for reliability and accuracy in population-based studies.^{20,23} The information in the REP is derived directly from physician-determined diagnostic codes and assembles comprehensive diagnostic and procedural information from all medical centers in Olmsted County into 1 database.

Residents of Olmsted County with OCD lesions who presented to a physician were identified by searching the *International Classification of Diseases, Ninth Revision (ICD-9)*, and Current Procedural Terminology (CPT) diagnosis codes consistent with osteochondritis dissecans (Appendix) between January 1, 1976, and December 31, 2014. Subsequently, the medical record of each subject was reviewed manually to verify the accuracy of the diagnosis, laterality of lesion, and evaluate details of treatment (surgical vs nonoperative). More specifically, all clinical notes, radiographic images, and operative notes related to the injury were manually reviewed in detail. Available plain radiographs at time of diagnosis were reviewed to describe lesions according to guidelines established by the Research in Osteochondritis of the Knee (ROCK) group.²⁵ For radiographic analysis, only patients with anteroposterior (AP) and lateral radiographs were included. Additionally, available magnetic resonance imaging (MRI) scans were evaluated by a musculoskeletal-trained radiologist and by a senior orthopedic resident to evaluate lesion size and factors associated with lesion stability (edema, cystic changes, breach in articular cartilage, or detachment of lesion). Characteristics for lesions on MRI were collected according to the De Smet classification.³ For MRI analysis, only patients with available MRI were included.

Patients were included in the study if they had an OCD lesion on the femoral condyle (medial or lateral), patella, proximal tibia, or trochlea and were treated nonoperatively.

Subjects were excluded if they had an OCD lesion that was treated surgically. Since previous studies have combined OCD patients treated nonoperatively and surgically into the same study cohort, the purpose of this series was to focus only on patients treated nonoperatively. (A separate study will evaluate patients treated surgically.)

We identified 314 patients diagnosed with OCD during the study period. Of these, 86 patients were treated nonoperatively and were included in the study. Medical records were reviewed to determine if patients developed clinically significant arthritis, which was defined as a diagnosis of symptomatic osteoarthritis by a physician as well as knee radiographs demonstrating degenerative changes in the tibiofemoral or patellofemoral joint (Kellgren-Lawrence grade 3 or 4). Medical records were also reviewed to record if patients received either partial or total joint arthroplasty. Each outcome of arthritis or arthroplasty was confirmed (via chart review) to occur in the knee that had the OCD lesion. This study was conducted after approval from the institutional review board at the supporting institutions (15-005636) and (044-OMC-15).

Statistical Analysis

Descriptive analyses of patient characteristics were performed with use of means and standard deviations for continuous variables, and frequencies and percentages for discrete or dichotomous variables. Sample size was taken into account for all calculations. A Wilcoxon rank-sum test was used when comparing means of continuous variables (due to the nonnormal nature of the data), and the chi-square (χ^2) test was used to compare frequencies for dichotomous variables (Fisher exact test was used when sample size was small). Nonparametric statistical analyses (Kaplan-Meier survival analyses) were undertaken to delineate predicted failure rates over time in groups that developed osteoarthritis and underwent arthroplasty (patellofemoral, unicondylar, or total knee arthroplasty) and to accommodate for loss to follow-up. Patients who died during follow-up or moved outside Olmsted County were censored for analysis. A Cox proportional hazards model was performed for analysis of Kaplan-Meier data. To assess for the relationship between various risk factors (such as age, sex, body mass index [BMI], mechanism of injury, and lesion location) and the incidence of arthritis/arthroplasty (as defined above), a univariate analysis was conducted first. Factors found to be significant determinants of progression to osteoarthritis or arthroplasty were used to conduct a logistic multivariate model due to the

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Ethical approval for this study was obtained from the institutional review boards at the Mayo Clinic (#15-005636) and OMC (044-OMC-15).

TABLE 1
Characteristics of Patients With OCD^a

Patient Characteristic	Total Cohort	Radiographic Cohort	MRI Cohort
Patients, n	86	39	31
Male sex	77 (66)	82 (32)	75 (23)
Race			
White	83 (71)	87 (34)	87 (27)
Black	3 (3)	8 (3)	6 (2)
Hispanic	3 (3)	5 (2)	3 (1)
Native American	1 (1)	0	3 (1)
Unknown	9 (8)	0	0
Age, y, mean ± SD	22.6 ± 15.5	17.6 ± 10.6	20.1 ± 13.6
Juvenile males (<16 y)	43 (37)	59 (23)	52 (16)
Juvenile females (<14 y)	13 (11)	15 (6)	16 (5)
Played sports at diagnosis	65 (56)	67 (26)	61 (19)

^aValues are presented as % (n) unless indicated otherwise. MRI, magnetic resonance imaging; OCD, osteochondritis dissecans.

dichotomous nature of the dependent variables used. Because of lack of radiographs for all patients, juvenile males were defined as those younger than 16 years and juvenile females as those younger than 14 years. For patients who had available radiographs or MRIs, subset analysis was conducted using lesion characteristics as noted above. All analyses were performed using JMP software (version 12.0.1, SAS Institute Inc). All statistical tests were 2-sided, and *P* values <.05 were considered statistically significant.

RESULTS

Radiographic Analysis

Thirty-nine patients (82% male) with a mean ± SD age of 17.6 ± 10.6 years had radiographs available for analysis; 67% of the patients had open physes. The lesions were present on the MFC (82%), lateral femoral condyle (LFC; 15%), and patella (3%). All measurements are reported as mean ± SD. The AP lesion width was 13.9 ± 4.6 mm and lateral lesion width was 15.3 ± 6.2 mm. The AP lesion depth was 4.5 ± 2.2 mm and the lateral lesion depth was 4.4 ± 2.3 mm. The following are other characteristics found on radiographs per the ROCK classification: the parent bone radiodensity was the same in 100% of lesions, progeny bone was not fragmented in any of the lesions, progeny bone was displaced in only 2.5% of lesions, progeny bone center radiodensity was the same as the lesion in 26% of the lesions and less than the lesion in 74%, progeny bone rim radiodensity was the same in 28% of lesions and less than the lesion in 72%, progeny bone boundary was distinct from the lesion in 46% of the lesions, and the lesion contour was concave in 13% of lesions and convex in 87% of lesions. Of all lesions, 87% were located posteriorly (defined as the posterior 50% of the sagittal length of the femoral condyle), with the rest located anteriorly (defined as the anterior 50% of the sagittal length of the femoral condyle) on lateral radiographs. Only 1 patient (3%) in this cohort was diagnosed with osteoarthritis at 10.3 years

after diagnosis, and no patient underwent arthroplasty. Because of this, no analysis could be conducted on radiographic characteristics affecting progression to osteoarthritis or arthroplasty. Additionally, because of the length of the study, many older radiographs were not available for review.

MRI Analysis

Thirty-one patients (75% male) with a mean ± SD age of 20.1 ± 13.6 years had MRI available for analysis; 63% of these patients had open physes. Of all lesions, 80% were present on the MFC and the rest were on the LFC. Signal intensity was increased in 89% of the lesions, with 7% having decreased intensity and 4% having the same signal intensity as the parent bone. A total of 86% of all lesions had a high signal at the fragment-femur interface, while 21% had a disruption of the subchondral bone plate. Of all lesions, 36% had adjacent focal cystic areas, with 1 lesion having a displaced fragment in the joint. The 1 patient with a displaced fragment was diagnosed at an age of 43 years and chose nonoperative management as there were no mechanical symptoms. Focal articular cartilage defects (5 mm or more in width) adjacent to the OCD lesion were found in 7% of lesions. Fifty percent of lesions had a line of high signal intensity (5 mm or longer) between OCD lesion and underlying bone, while 11% had a discrete area (5 mm or more in diameter) of high signal deep to the OCD lesion. Finally, 14% of all lesions had a high signal line traversing the articular cartilage. Only 1 patient (3%) was diagnosed with osteoarthritis at 3.2 years after diagnosis, and no patient underwent arthroplasty. Therefore, we were unable to conduct an analysis on MRI characteristics as risk factors for arthritis or arthroplasty.

Total Cohort

Patient and lesion characteristics can be found in Tables 1 and 2, respectively. The mean ± SD age of the cohort was 22.6 ± 15.5 years, and 66 patients (77%) were male. OCD

TABLE 2
Lesion Characteristics in Patients With OCD^a

Lesion Characteristic	Total Cohort	Radiographic Cohort	MRI Cohort
Side of lesion			
Right	60 (51)	61 (24)	58 (18)
Left	40 (35)	39 (15)	42 (13)
Mechanism of injury			
Sport	71 (61)	85 (33)	58 (18)
Trauma	11 (9)	10 (4)	6 (2)
Other	17 (16)	5 (2)	35 (11)
Effusion on presentation	40 (34)	33 (13)	32 (10)
History of pain in same knee	77 (66)	82 (32)	77 (24)
History of mechanical symptoms in same knee	28 (24)	23 (9)	19 (6)
Lesion location			
MFC	83 (71)	82 (32)	80 (25)
LFC	13 (11)	15 (6)	20 (6)
Trochlea	0	0	0
Patella	4 (4)	3 (1)	0
AP lesion width, mm, mean ± SD		13.9 ± 4.6	13.3 ± 5.2
Lateral lesion width, mm, mean ± SD		15.3 ± 6.2	14.4 ± 3.7
AP lesion depth, mm, mean ± SD		4.5 ± 2.2	5.1 ± 1.8
Lateral lesion depth, mm, mean ± SD		4.4 ± 2.3	4.8 ± 2.1
Nonoperative treatment			
Nonweightbearing	67 (58)		
Brace	69 (59)		
Cast	0		
Assistance device	34 (29)		

^aValues are presented as % (n) unless indicated otherwise. AP, anteroposterior; LFC, lateral femoral condyle; MFC, medial femoral condyle; MRI, magnetic resonance imaging; OCD, osteochondritis dissecans.

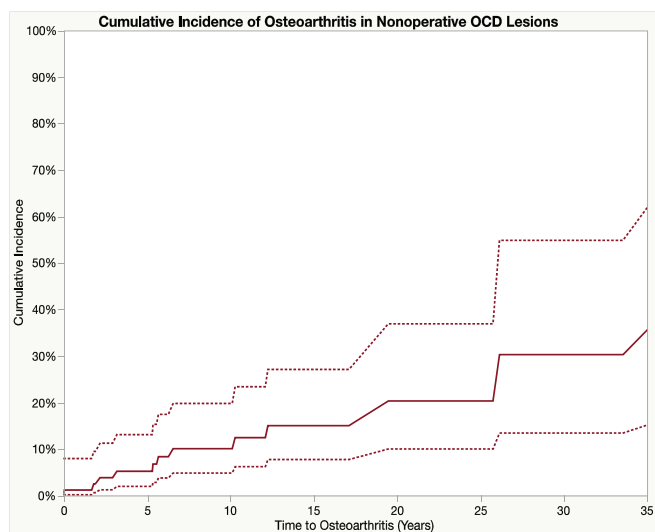


Figure 1. Cumulative incidence of osteoarthritis in patients with osteochondritis dissecans (OCD) treated nonoperatively. The graph represents Kaplan-Meier survival curve for incidence of osteoarthritis, with dotted lines representing 95% confidence interval.

lesions were most commonly located on the MFC (83%) followed by the LFC (13%) and patella (4%).

At a mean ± SD follow-up of 12.6 ± 9.8 years from diagnosis, 13 patients (15%) were diagnosed with arthritis,

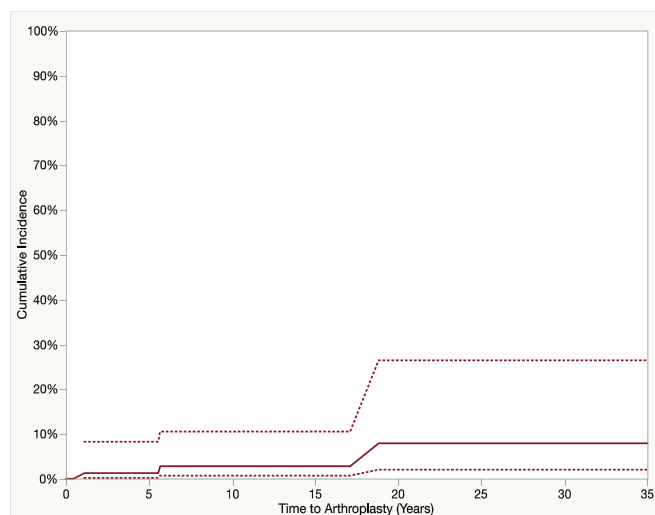


Figure 2. Cumulative incidence of arthroplasty in patients with osteochondritis dissecans (OCD) treated nonoperatively. The graph represents Kaplan-Meier survival curve for incidence of knee arthroplasty, with dotted lines representing 95% confidence interval.

corresponding to a cumulative incidence of 5.0% at 5 years, 10.0% at 10 years, 20.0% at 25 years, and 30.0% at 35 years (Figure 1). Additionally, 7 patients (8%) underwent knee arthroplasty, including 1 patient treated with unicompartmental

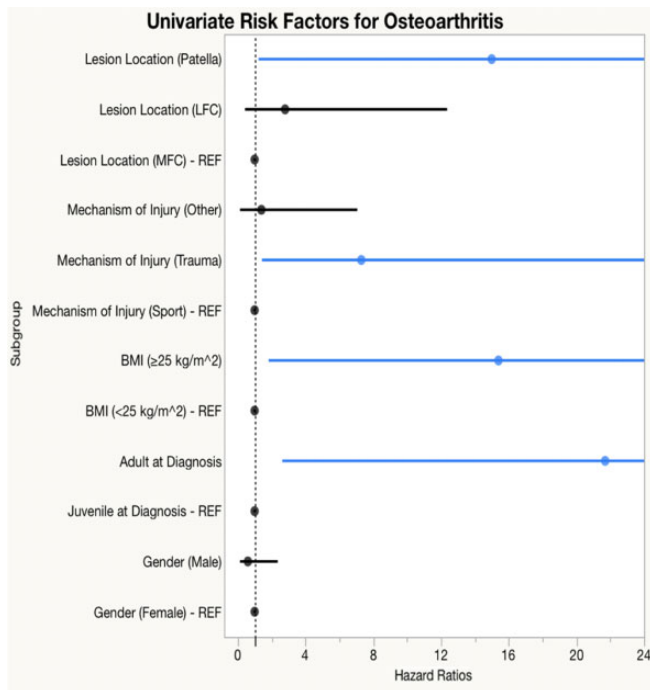


Figure 3. Factors associated with osteoarthritis in patients with osteochondritis dissecans (OCD) treated nonoperatively. “REF” denotes variable used as reference. BMI, body mass index; LFC, lateral femoral condyle; MFC, medial femoral condyle.

knee arthroplasty and 6 patients with total knee arthroplasty. The mean age at arthroplasty was 58.5 years. The cumulative incidence of arthroplasty was 1.0% at 5 years, 3.0% at 10 years, 8.0% at 25 years, and 8.0% at 35 years (Figure 2).

In the univariate analysis, factors predictive of arthritis in patients with OCD were evaluated (Figure 3). There was no sex-based difference in the likelihood of arthritis. Being an adult at diagnosis (hazard ratio [HR], 21.7; 95% CI, 2.7-176.3) was associated with a significantly higher risk of osteoarthritis compared with juvenile patients. Similarly, BMI at diagnosis greater than 25 kg/m² (HR, 15.4; 95% CI, 1.9-124.5) and traumatic mechanism of injury (HR, 7.3; 95% CI, 1.5-36.2) were associated with a higher likelihood of arthritis. Patients with patellar OCD lesions were more likely to develop arthritis (HR, 15.0; 95% CI, 1.3-345.3) than patients with lesions on the MFC. Figure 4 demonstrates factors associated with knee arthroplasty in patients with OCD. For arthroplasty, none of the following, namely, sex, BMI, age at diagnosis, or lesion location, was associated with increased risk for future knee arthroplasty.

DISCUSSION

OCD is an idiopathic condition that primarily affects the subchondral bone and may lead to destabilization of the overlying articular cartilage. Treatment options vary

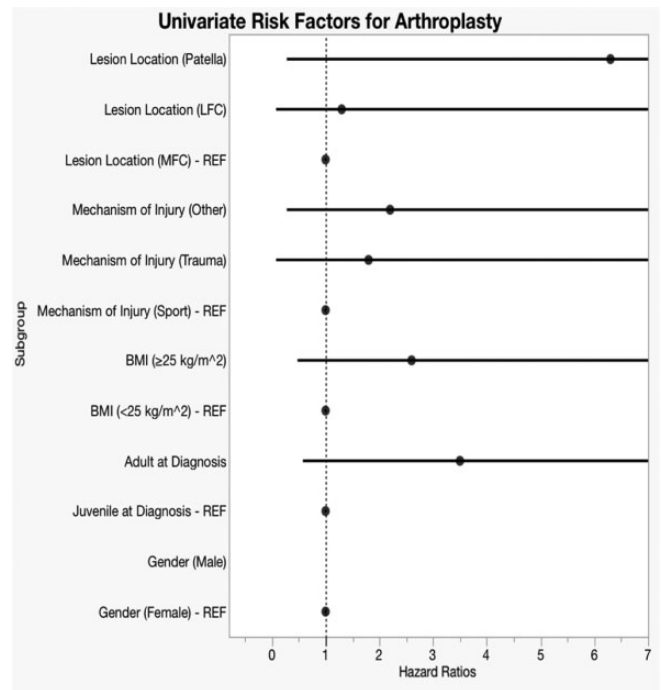


Figure 4. Factors associated with arthroplasty in patients with osteochondritis dissecans (OCD) patients treated nonoperatively. “REF” denotes variable used as a reference. Values for male sex could not be computed. No females progressed to arthroplasty. BMI, body mass index; LFC, lateral femoral condyle; MFC, medial femoral condyle.

significantly, from activity modification to surgical stabilization or lesion removal.⁶ The purpose of this study was to assess the incidence of symptomatic arthritis in patients with OCD lesions amenable to nonoperative treatment.

The incidence of arthritis in this cohort was similar to other long-term follow-up studies of OCD patients.^{13,24} A previous cohort including both juvenile (skeletal immature) and adult patients with OCD reported a low rate of arthritis in patients with juvenile lesions at 30-year follow-up.¹³ However, this same study reported that patients with symptomatic OCD lesions diagnosed after skeletal maturity (adult patients) had a high rate (80%) of radiographic arthritis.¹³ A significant percentage of skeletally immature patients with stable OCD lesions will demonstrate spontaneous healing of the lesion and may have a lower risk of developing arthritis.^{4,6,19,26} In contrast, patients diagnosed with symptomatic OCD lesions after skeletal maturity likely have lower capacity for healing,⁶ leading to lesion progression and subsequent degenerative changes. In support of these findings, younger patients in this cohort had a significantly lower risk of arthritis and arthroplasty compared with patients who were older at diagnosis. Despite this, the rate of arthroplasty in this cohort was less than 10% at 35 years after diagnosis. Together, this information may indicate that few patients with OCD lesions amenable to nonoperative treatment develop arthritis disabling enough to warrant joint arthroplasty. Alternatively, since OCD lesions are typically diagnosed in relatively young

patients, even at long-term follow-up these patients may still be too young to develop end-stage arthritis. Additionally, surgeons may be hesitant to offer joint arthroplasty to younger patients even in the presence of end-stage osteoarthritis. It is important to note that these results likely reflect the best-case scenario for patients with OCD, since the treating physician elected to treat each patient nonoperatively. In contrast, OCD patients who are recommended for operative treatment may have more rapid progression to clinically significant arthritis and the need for arthroplasty. Additionally, the small number of patients with patellar OCD lesions limited analysis for the risk of patellofemoral arthritis and is likely too small to draw meaningful conclusions.

OCD patients with BMI at diagnosis greater than 25 kg/m² were significantly more likely to be diagnosed with arthritis. Previous investigations have shown that increased BMI results in greater tibiofemoral contact and shear pressures⁹ and significantly increases the risk of knee arthritis.^{12,18} BMI can change over time, which may influence the development of arthritis. Additionally, among obese patients with OCD, weight loss may alter the natural history of the disorder and should be encouraged by physicians. Similarly, patients with patellar OCD lesions were more likely to be diagnosed with arthritis. A retrospective series of 25 patients with patellar OCD reported that 62% of subjects had a fair or poor result at a mean of 6 years after operative treatment.²¹ Although not completely understood, high contact pressures in the patellofemoral compartment¹⁰ may limit the ability to off-load the OCD lesion and may reduce the likelihood of healing. Additionally, patellar lesions are more difficult to follow radiographically,¹⁷ and signs of lesion progression or articular cartilage involvement can be missed and patients treated inappropriately with nonoperative modalities.

The results of this study should be interpreted in the context of the following limitations. All patients in this cohort were treated nonoperatively, and these results likely reflect the optimum outcome for patients with OCD. In contrast, patients who had mechanical symptoms, radiographic or MRI appearance indicating unstable lesions, or severe pain (ie, who were not eligible for nonoperative treatment) were not included in this study and may represent a subgroup of patients with OCD who develop more clinically significant arthritis and subsequent need for arthroplasty. Radiographs at the time of diagnosis were not available for every patient, as some individuals were diagnosed at a time preceding the medical record archive, which limited the ability to analyze lesion radiographic characteristics as a risk factor for osteoarthritis. Additionally, among patients who had radiographs at diagnosis available for review, only 1 patient developed osteoarthritis and no patients received total knee arthroplasty. Therefore, the ability to assess lesion stability, lesion location, or growth plate status on the development of arthritis was limited. A post hoc sample size calculation was conducted for a hypothetical Kaplan-Meier scenario for the current study using the following parameters: a 1:1 matching study with survival of 90% for the first group and survival of 70% for the second group (eg, using Kaplan-Meier to

compare factors such as lesion size progressing to osteoarthritis), power of 0.8, and alpha of 0.05. The analysis revealed the current study needed a total of 133 patients with radiographs, which is a larger number than we included. Although this is a potential limitation of this study, the low incidence of osteoarthritis (only 1 patient) and arthroplasty (0 patients) prevented us from performing this analysis in the current cohort.

Additionally, the outcome of arthritis was based primarily on clinical symptoms sufficient to seek care by a physician, rather than radiographic grading criteria alone. Since only patients who sought care from a physician were reviewed, the results in the study may underestimate the true incidence of arthritis in patients with OCD. Also, patients who died or permanently moved outside of Olmsted County were lost to follow-up (these patients were censored for analysis), although other studies have validated that dropout in this population does not affect clinical outcomes significantly.⁷ The mean follow-up of this cohort may not have been long enough to capture the development of arthritis or arthroplasty. Additionally, since diagnostic modalities and treatment options for OCD changed during the study period, some patients in this cohort treated nonoperatively may have been treated surgically at a later time point or vice versa. It is unknown if the number of patients in this cohort is an accurate representation of the disease burden, since epidemiologic studies on OCD are lacking. Patient BMI may have fluctuated during the study period, which could limit evaluation of BMI as a risk factor for arthritis and arthroplasty. Although several predictive factors of arthritis were evaluated, the large confidence intervals may have resulted from the relatively small cohort size. Despite these limitations, the population-based design allowed for comprehensive evaluation of a patient cohort, and long-term follow-up allowed for evaluation of outcomes such as arthritis and arthroplasty, which may take longer than 5 to 10 years to manifest—a limitation of other studies evaluating outcomes of OCD lesions.

CONCLUSION

Arthritis after nonoperative treatment of OCD lesions is a challenging problem, with an estimated 30% cumulative incidence at 35 years after diagnosis. In contrast, the long-term rate of arthroplasty is low. BMI at diagnosis greater than 25 kg/m² and patellar OCD lesions are predisposing factors for arthritis. Older age at diagnosis was associated with a greater risk of arthritis.

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APPENDIX

List of ICD-9 and CPT Codes Used to Identify Patients With Osteochondritis Dissecans^a

ICD-9	CPT
732.7	29877
	29879
	29885
	29886
	29887
	29892

^aAll patients were reviewed to confirm presence of osteochondritis dissecans lesion involving the knee. CPT, Current Procedural Terminology; ICD-9, *International Classification of Diseases, Ninth Revision.*