Descriptive Epidemiology From the Research in Osteochondritis Dissecans of the Knee (ROCK) Prospective Cohort

The ROCK Group*†
Investigation performed at multiple sites

Background: Osteochondritis dissecans (OCD) occurs most commonly in the knees of young individuals. This condition is known to cause pain and discomfort in the knee and can lead to disability and early knee osteoarthritis. The cause is not well understood, and treatment plans are not well delineated. The Research in Osteochondritis Dissecans of the Knee (ROCK) group established a multicenter, prospective cohort to better understand this disease.

Purpose: To provide a baseline report of the ROCK multicenter prospective cohort and present a descriptive analysis of baseline data for patient characteristics, lesion characteristics, and clinical findings of the first 1000 cases enrolled into the prospective cohort.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: Patients were recruited from centers throughout the United States. Baseline data were obtained for patient characteristics, sports participation, patient-reported measures of functional capabilities and limitations, physical examination, diagnostic imaging results, and initial treatment plan. Descriptive statistics were completed for all outcomes of interest.

Results: As of November 2020, a total of 27 orthopaedic surgeons from 17 institutions had enrolled 1004 knees with OCD, representing 903 patients (68.9% males; median age, 13.1 years; range, 6.3-25.4 years), into the prospective cohort. Lesions were located on the medial femoral condyle (66.2%), lateral femoral condyle (18.1%), trochlea (9.5%), patella (6.0%), and tibial plateau (0.2%). Most cases involved multisport athletes (68.1%), with the most common primary sport being basketball for males (27.3% of cases) and soccer for females (27.6% of cases). The median Pediatric International Knee Documentation Committee (Pedi-IKCD) score was 59.9 (IQR, 45.6-73.9), and the median Pediatric Functional Activity Brief Scale (Pedi-FABS) score was 21.0 (IQR, 5.0-28.0). Initial treatments were surgical intervention (55.4%) and activity restriction (44.0%). When surgery was performed, surgeons deemed the lesion to be stable at intraoperative assessment in 48.1% of cases.

Conclusion: The multicenter ROCK group has been able to enroll the largest knee OCD cohort to date. This information is being used to further understand the pathology of OCD, including its cause, associated comorbidities, and initial presentation and symptoms. The cohort having been established is now being followed longitudinally to better define and elucidate the best treatment algorithms based on these presenting signs and symptoms.

Keywords: pediatric; adolescent; OCD; demographics; cartilage

Osteochondritis dissecans (OCD) is a relatively uncommon disease that primarily affects adolescents, with an incidence of 9.5 per 100,000 patients.[14] OCD is defined as "a focal idiopathic alteration of subchondral bone and/or its precursor with risk for instability and disruption of adjacent articular cartilage that may result in premature osteoarthritis."[6] The majority of the occurrences have no known cause, and of the theories proposed, none have been universally accepted by the orthopaedic community.[1,2,9,21,23] OCD lesions occur in many joints of the body, and the literature provides evidence that the knee is the most common.[11] When OCD occurs within the knee, it is believed that the characteristics are not uniform and that they vary according to the location, the patient's age, the activity level of the patient, and the duration of its presence. Just as the presentation of OCD within the knee is variable, so are the treatment approaches regarding appropriate care. As with most pathologies, the signs and symptoms and objective information at the time of presentation help direct care and management decisions. A better understanding of the signs and symptoms, the appearance on imaging modalities, and the findings on physical examination and arthroscopic evaluation, when present, will assist providers in establishing more complete and effective treatment algorithms.

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OCD of the knee was initially described by König in 1888.[17] The original presentation of OCD was a locked knee resulting from loose bodies. Despite the notable number of investigations and amount of interest in OCD since that time, there persists a dearth of established, reliable, and accepted OCD treatment protocols. Many authors have reviewed the causes as well as the presenting signs and symptoms of these lesions.[14,19] Others have analyzed different treatments based on a given stage of the disease at initial presentation.[3,12,19] Attempts have even been made to determine best treatment options by creating algorithms to help providers decide between surgery or nonoperative care.[4,10,28] Despite this work, research has not established a clear understanding of the issues, causes, symptoms, imaging appearance, and treatment of OCD.

The Research in Osteochondritis of the Knee (ROCK) group was established in 2008 to investigate all aspects of OCD lesions. ROCK is an international, multicenter research group devoted to examining and furthering clinical understanding of the cause, pathology, genetic factors, and physical and radiographic appearance of knee OCD lesions. The ROCK group designed and implemented a prospective cohort to collect ongoing data on individuals with knee OCD. The purpose of this first analysis is to understand the variability in OCD presentation. The primary aim is to provide a description of patient characteristics, presenting clinical signs and symptoms, radiographic appearance, initial treatment course, and arthroscopic appearance of the first 1000 knees enrolled into the prospective cohort.

METHODS

Study Design

The ROCK prospective cohort is a 25-year longitudinal study with the goal of recruiting patients from 23 institutions throughout the United States. The study protocol has been registered with ClinicalTrials.gov (NCT02771496) and can be accessed there (ROCK protocol). Institutional review board approval was obtained at each participating institution before subject enrollment. This study used data collected during the baseline time point from this prospective cohort.

Participants

Patients who sought care at any of the ROCK institutions between April 2013 and November 2020 were included in this study. Patients were included once the diagnosis of knee OCD was confirmed by radiography or magnetic resonance imaging (MRI). The following criteria were used for exclusion in the final analysis of this study: (1) diagnosis of a focal chondral defect, (2) patients 26 years or older at the time of enrollment, (3) missing data regarding OCD lesion location, (4) incomplete or unverified screening form, and (5) incomplete or unverified patient baseline form.

Data Collection

Once a patient was deemed eligible and provided informed consent, she or he completed a baseline questionnaire. This survey included patient history (history of OCD, family history of OCD, current symptoms, and acute vs chronic presentation of pain), sports history (athlete or not by self-report, multi- or single-sport athlete, primary sport, the highest level of athletic participation in the past year, frequency of sports participation), and sports specialization (quit other sports to focus on primary sport, and training >8 months out of the year). Patients also completed 4 validated patient-reported outcome measures. All patients completed the visual analog scale (VAS) for pain and the Knee injury and Osteoarthritis Outcome Score Quality of Life subscale (KOOS-QoL). Scores for the VAS ranged from 0 to 100, with higher scores representing greater levels of pain. The KOOS-QoL was scored 0 to 4 and then transformed to a 0 to 100 scale.[24] Lower KOOS-QoL scores represent greater knee problems. Patients who were 18 years or older at the time of enrollment completed the International Knee Documentation Committee (IKDC) subjective questionnaire and the Marx activity score questionnaire. The IKDC score ranges from 0 to 100, with higher scores signifying better knee function and lower symptoms.[13] The Marx activity score represents the frequency of physical activity participation, where the minimum score of 0 indicates engagement in an activity less than once a month and a maximum score of 16 denotes participation in high-level physical activity multiple times per week.[20] Patients who were 17 years or younger completed the Pediatric International Knee Documentation Committee (Pedi-IKDC) subjective questionnaire and the Pediatric Functional Activity Brief Scale (Pedi-FABS). The Pedi-IKDC score range follows that of the IKDC.[15] There is a 30-point score range (0-30) for the Pedi-FABS, with results paralleling the Marx score for frequency of physical activity.[8]

Surgeons completed 3 questionnaires: an initial history and physical examination questionnaire, an imaging questionnaire, and (when appropriate) a surgical questionnaire. The initial history and physical examination questionnaire included results of the physical examination, diagnostic imaging assessment (radiographs and MRI scans), and treatment plan. The physical examination included height (inches), weight (pounds), body mass index (BMI), generalized laxity (tight, normal, lax), lower leg alignment (obvious varus, normal, obvious valgus), and knee effusion (none, fluid wave, easily ballotable, tense knee). The diagnostic imaging assessment included number of OCD lesions, OCD location (medial femoral condyle [MFC], lateral femoral condyle [LFC], lateral tibial plateau [LTP], patella, and trochlea), and OCD dimensions.

The treatment plan was a summary of the agreed upon plan of care between the surgeon, patient, and the patient's family. This included the following items in isolation or combination: no treatment intervention, activity restriction (eliminate impact or painful activities), physical therapy, casting, bracing, restricted weightbearing, and/or

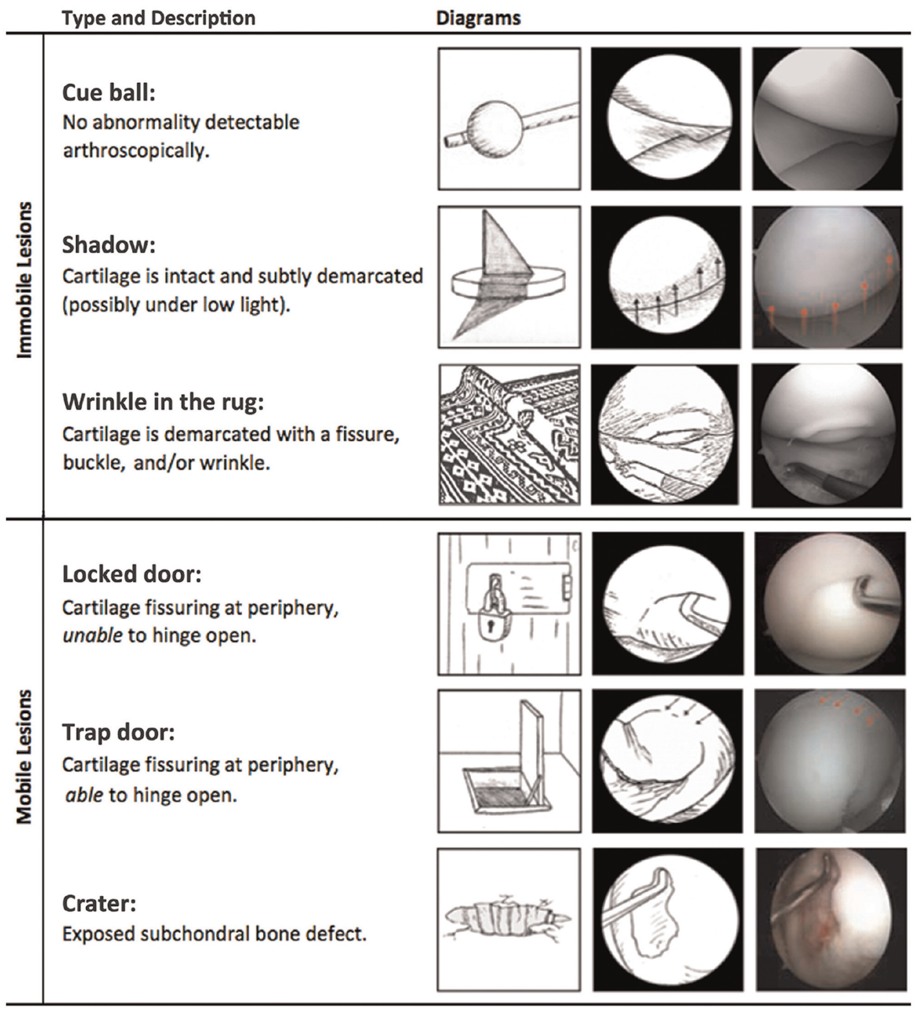

Figure 1. Arthroscopic classification system for osteochondritis dissecans lesions developed by the Research in Osteochondritis of the Knee (ROCK) study group. (Reprinted with permission from Carey JL, Wall EJ, Grimm NL, et al. Novel arthroscopic classification of osteochondritis dissecans of the knee. *Am J Sports Med*. 2016;44(7):1694-1698. ©2016, Sage Publishing).

surgery. The imaging questionnaire required surgeons to determine the location of the lesion and to measure the length and depth of the lesion on MRI scans (sagittal and coronal views) and plain radiographs (anterior-posterior [AP], notch, and lateral). Additional questions inquired about physeal patency (open, closing, closed), effusion, cartilage thickness (normal, thickened, thinned, variable), and cartilage contour (normal, abnormal). The surgical questionnaire entailed intraoperative characteristics of the OCD lesion and included an International Cartilage Regeneration and Joint Preservation Society (ICRS) classification (grades 1-4) and an assessment of lesion mobility (immobile, mobile). Based on the lesion mobility selection, lesion type was further defined as "cue ball," "shadow," or "wrinkle in the rug" for immobile lesions or "locked door," "trap door," or "crater" for mobile lesions (Figure 1).[5] Questionnaires were either completed in REDCap or filled out on paper with answers later entered into REDCap by each corresponding site's research coordinator.

Statistical Methods

Patient characteristics, lesion characteristics, and patient-reported outcome measures were portrayed using descriptive statistics. For continuous data, histograms were used to determine whether parametric assumptions of normality were met. Parametric, continuous data were presented as mean and standard deviation. Nonparametric, continuous data were presented as median and interquartile range (IQR). Categorical data were presented as counts, proportions, and percentages. Data were stratified by sex (male, female) and lesion location (MFC, LFC, patella, trochlea) for clinical relevance. Data were analyzed using IBM SPSS Statistics for Windows (Version 28; IBM Corp).

RESULTS

The initial cohort consisted of 1132 enrolled knees. After application of the exclusion criteria (Figure 2), a total of

TABLE 1
Patient Characteristics[a]

	Total Cohort	Males	Females
Age, y	13.1 (11.7, 15.0)	13.4 (12.1, 15.1)	12.6 (10.7, 14.5)
Height, in.	63.0 (59.0, 67.5)	64.0 (59.8, 69.0)	61.0 (57.0, 64.0)
Weight, lb	120.0 (95.0, 152.0)	128.1 (98.1, 160.0)	110.6 (88.8, 136.1)
Body mass index	21.2 (18.6, 24.1)	21.3 (18.6, 24.3)	20.8 (18.5, 23.7)
Race			
White	642 (71.1)	438 (71.0)	204 (71.3)
Black	150 (16.6)	104 (16.9)	46 (16.1)
Asian	11 (1.2)	9 (1.5)	2 (0.7)
American Indian	1 (0.1)	0 (0.0)	1 (0.3)
Native Hawaiian	1 (0.1)	1 (0.2)	0 (0.0)
Mixed	47 (5.2)	30 (4.9)	17 (5.9)
Prefer not to disclose	4 (0.4)	3 (0.5)	1 (0.3)
Other	26 (2.9)	16 (2.6)	10 (3.5)
Not recorded	21 (2.3)	16 (2.6)	5 (1.7)
Ethnicity			
Not Hispanic or Latino	807 (88.5)	562 (91.1)	245 (85.7)
Hispanic or Latino	67 (7.3)	39 (6.3)	28 (9.8)
Prefer not to disclose	9 (1.0)	5 (0.8)	4 (1.4)
Not recorded	20 (2.2)	11 (1.8)	9 (3.1)

[a]Data are expressed as median (interquartile range) or n (%) of knees. Height: missing data for 160 patients. Weight: missing data for 141 patients. Body mass index: missing data for 162 patients.

1004 knees, representing 903 patients from 27 surgeons and 17 different institutions across the United States (Northeast, 6 institutions; Southeast, 5 institutions; Mid-continent, 3 institutions; Pacific, 2 institutions), were included in the final analysis. Male patients accounted for 68.9% (692/1004 knees) of the study population and female patients accounted for 31.1% (312/1004 knees). The majority of patients were White (71.1%; 642/903 patients) and of non-Hispanic or Latino ethnicity (89.4%; 807/903 patients). Additional patient characteristics can be found in in Table 1.

Data on sports participation were available for 55.5% of the patients in the cohort (501/903). The vast majority of patients considered themselves athletes, with 91.4% (458) answering yes to this question and 8.6% (43) answering no. Athletic status was similar by sex, with 93.9% of males (324/345) and 85.9% of females (134/156) considering themselves athletes. The majority of males and more than half of females were multisport athletes (males: 71.7%, 246/343; females: 59.1%, 81/137). There were 24 primary sports identified (baseball, 62 knees; basketball, 106; cheerleading, 9; dance, 6; equestrian, 3; field hockey, 1; football, 61; golf, 1; gymnastics, 21; ice hockey, 11; ice skating, 1; lacrosse, 21; martial arts, 2; motocross, 1; running [track and field/cross country], 9; skiing, 2; soccer, 101; softball, 7; swimming, 3; tennis, 7; volleyball, 13; water polo, 1; wrestling, 4). There were 56 patients with no identified primary sport. For male patients, the top primary sports were basketball (27.3%; 89/362 patients), soccer (20.2%; 66/362), baseball (18.7%; 61/362), and football (18.4%; 60/362). For female patients, the top primary sports were soccer (27.6%; 35/134), gymnastics (15.7%; 20/134), basketball (13.4%; 17/134), and volleyball (10.2%; 13/134).

The most common competition level was youth league (57.3%; 246/429 knees) followed by high school (25.6%; 110/429 knees) and competitive recreational leagues (10.3%; 44/429 knees). The most commonly reported frequencies of participation were 4 or more days per week (65.9%; 267/405 knees) and 2 or 3 times per week (27.4%; 111/405 knees). There were fewer patients (33.2%; 126/379 knees) who reported quitting other sports to focus on a single sport compared with nonspecialized patients (66.8%; 2253/379 knees); however, in 63.7% of knees (261/410), patients reported training >8 months out of the year in one sport.

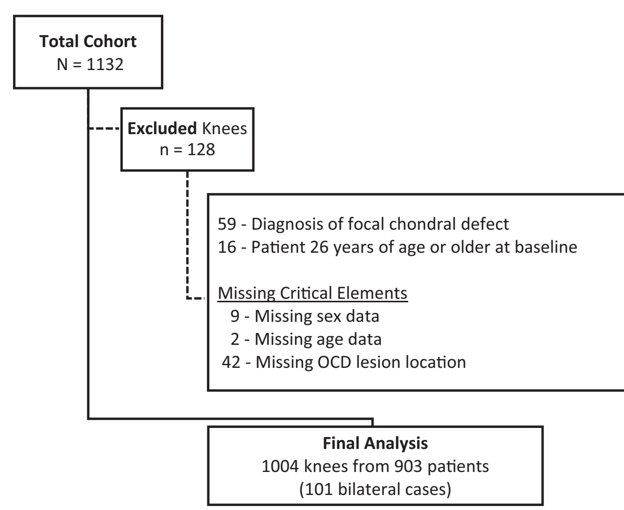

Figure 2. Patient flow chart. OCD, osteochondritis dissecans.

The majority of OCD lesions were located in the MFC (66.2%; 665/1004 knees), followed by the LFC (18.1%;

TABLE 2
Types of Providers Seen by Patients for Knee OCD[a]

	n (%)
No. of providers seen for indexed OCD	
1	237 (41.9)
2	176 (31.1)
3	105 (18.6)
4	25 (4.4)
5	15 (2.7)
6	4 (0.7)
7	1 (0.2)
8	0
9	0
10	3 (0.5)
Type of provider	
Athletic trainer	71 (7.1)
Physical therapist	154 (15.3)
Chiropractor	13 (1.3)
Primary care provider	190 (18.9)
Sports medicine physician	185 (18.4)
Orthopaedic surgeon	352 (35.1)

[a]Missing data on 438 knees for number of providers seen for indexed osteochondritis dissecans (OCD).

182/1004 knees), trochlea (9.5%; 95/1004 knees), patella (6.0%; 60/1004 knees), and lateral tibial plateau (0.2%; 2/1004 knees). There were 101 patients (11.2%) who were treated by ROCK physicians for bilateral knee OCD lesions and enrolled into the prospective cohort. Within the patient history questionnaire, patients were asked, "Have you been diagnosed with an OCD lesion in any other joint?" Data on this question were available for 91.6% of the cohort (920/1004 knees), with a total of 14.2% (131/920 knees) of the cohort self-reporting a previous OCD. These included 78.6% (103/131 knees) in the contralateral knee, 4.6% (6/131 knees) in the elbow, 3.1% (4/131 knees) in the ankle, and 11.5% (15/131 knees) in the indexed knee; 2.3% of knees did not have data on previous OCD joint location (3/131 knees).

Nearly two-thirds of patients (65.2%; 591/907 knees) self-reported that they had received treatment for their OCD before being seen by a ROCK physician and enrolled into the cohort. The number of previous healthcare professionals seen for their condition ranged from 1 to 10 (Table 2). Baseline pain data were available for 91.0% of the cohort (914/1004 knees), with 79.2% of knees presenting with pain at the initial presentation (724/914 knees) and patients endorsing knee pain for a median duration of 8 months (range, 0-120 months). The frequency of pain presentations by duration can be found in Figure 3. In the majority of knees, 69.5% (490/705 knees), patients did not recall sustaining an injury at the onset of pain.

The KOOS QoL was provided to all patients, and data were available for 91.5% of the cohort (919/1004 knees), with a median score of 43.8 (IQR, 25.0, 56.3). There were 970 patients <18 years of age; 89.0% of knees (861/970) had Pedi-IKDC data, with a median score of 60.9 (IQR, 45.7, 73.9); and 81.6% of knees (792/970) had Pedi-FABS data, with a median score of 21.0 (IQR, 5.0, 28.0). A total of 34 patients were 18 years or older; 70.6% of knees

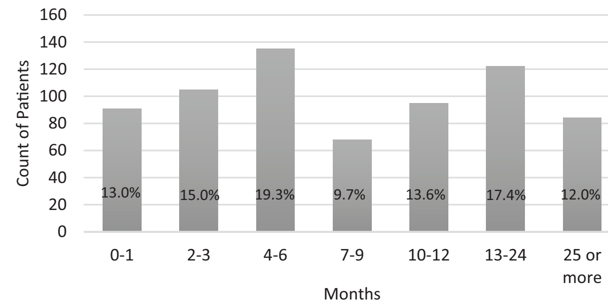

Figure 3. Data on length of time that knee pain was present were available for 96.7% of patients (700 knees) who reported pain in their knee at initial presentation. Graph shows the number and percentage of patients within each time frame.

(24/34) had IKDC data, with a median score of 55.7 (IQR, 38.2, 72.7); and 79.4% of knees (26/34) had Marx activity data, with a median score 11.5 (IQR, 5.5, 16.0). Patient-reported outcome scores by lesion location can be found in Table 3.

The majority of knees were considered to have normal ligament integrity (94.7%; 702/741 knees), whereas 1.9% of knees were classified as tight (14/741 knees) and 3.4% of knees were classified as lax (25/741 knees). The majority of knees were considered to have normal lower limb alignment (87.4%; 685/783), whereas equal percentages had either obvious valgus alignment (6.3%; 49/783) or obvious varus alignment (6.3%; 49/783). The indexed knee did not have an effusion on examination for 80.5% of knees (735/913 knees), whereas 14.6% of knees (133/913 knees) had a fluid wave, 3.9% (36/913 knees) were easily ballotable, and 1.0% (9/913 knees) were tense knees.

Radiographic data were available for 95.8% of knees (962/1004) at baseline, of which 90.0% of knees (866/962) had an MRI and 92.7% of knees (892/962) had radiographs. The location, width, and depth of OCD lesions measured on MRI and radiographs can be found in Table 4. On MRI, the majority of lesions were identified in knees with open physes (75.3%; 592/786) compared with closing physes (15.0%; 118/786) and closed physes (9.7%; 76/786). Other MRI characteristics can be found in Figure 4. During the radiograph evaluation, a progeny bone was seen in 54.7% of knees (423/774). The progeny bone was fragmented in 32.1% of knees (135/421). When evaluating the position of the progeny bone, 81.2% of knees (341/419) were totally in situ, 11.7% (49/419 knees) were partially in situ, and 7.1% (30/419 knees) were not in situ. The boundary between the parent bone and progeny bone was classified as distinct in 65.0% of knees (253/389) and indistinct in 35.0% of knees (136/398). The shape of the progeny bone's articular side was convex in 64.6% of knees (252/390), concave in 15.9% (62/390 knees), and linear in 19.5% (76/390).

The most commonly recommended treatment plans consisted of surgical intervention (55.4%; 557/1004 knees), activity restrictions or elimination of impact or painful activities (44.0%; 442/1004), and bracing (30.0%; 301/1004). Less commonly prescribed treatments at the time

TABLE 3
Patient-Reported Outcome Scores Stratified by Lesion Location[a]

	MFC (n = 665)		LFC n = 182		Patella n = 60		Trochlea n = 95	
	Score	n	Score	n	Score	n	Score	n
KOOS QoL	43.8 (25.0, 56.3)	606	50.0 (31.3, 62.5)	168	43.8 (25.0, 62.5)	56	37.5 (25.0, 56.3)	87
Pedi-IKDC	60.3 (46.7, 73.9)	566	62.0 (44.6, 73.9)	159	62.5 (50.0, 78.5)	54	57.1 (41.3, 73.9)	82
Pedi-FABS	20.0 (5.0, 27.0)	505	21.5 (6.0, 28.0)	154	20.0 (5.0, 26.0)	54	24.0 (5.0, 28.0)	77
IKDC	55.2 (32.8, 72.7)	16	54.0 (33.9, 93.1)	5		0	62.1 (55.2, 62.1)	3
Marx	11.0 (0.0, 16.0)	19	9.0 (5.5, 14.0)	5		0	16.0 (6.0, 16.0)	3

[a]Scores are expressed as median (interquartile range). Score ranges: KOOS, 0-100; Pedi-IKDC, 0-100; Pedi-FABS, 0-30; IKDC, 0-100; Marx activity scale, 0-16. A total of 34 knees were 18 years or older; 970 knees were 17 years or younger. IKDC, Pediatric International Knee Documentation Committee Subjective Form; KOOS QoL, Knee injury and Osteoarthritis Outcome Score Quality of Life; LFC, lateral femoral condyle; MFC, medial femoral condyle; Pedi-FABS, Pediatric Functional Activity Brief Scale; Pedi-IKDC, Pediatric International Knee Documentation Committee Subjective Form.

TABLE 4
Size of Lesion Measured on Magnetic Resonance Imaging and Radiographs[a]

	MFC	LFC	Patella	Trochlea
MRI				
Coronal				
Width	14.0 (11.6, 17.0)	15.4 (12.0, 19.7)	12.0 (10.5, 16.0)	14.0 (11.0, 16.8)
Depth	7.4 (5.8, 9.0)	7.2 (5.6, 10.0)	7.0 (6.0, 8.3)	7.0 (4.7, 11.0)
Sagittal				
Length	20.0 (16.0, 25.0)	20.0 (15.0, 25.0)	14.0 (10.8, 19.4)	18.6 (14.0, 21.0)
Depth	8.0 (6.0, 10.0)	7.3 (5.8, 10.0)	7.6 (6.0, 9.6)	7.0 (5.0, 9.6)
Radiograph				
AP				
Width	15.0 (12.0, 18.7)	16.0 (11.8, 20.0)	15.0 (10.5, 19.7)	13.7 (10.0, 21.0)
Depth	6.0 (4.0, 8.0)	7.0 (5.0, 11.3)	6.0 (4.5, 8.7)	4.6 (2.8, 6.0)
Notch				
Width	15.9 (11.7, 20.0)	19.0 (15.0, 25.5)	15.2 (10.0, 21.7)	17.5 (11.3, 20.8)
Depth	8.0 (5.0, 12.0)	8.0 (5.1, 10.4)	9.5 (4.3, 11.0)	5.0 (2.0, 6.0)
Lateral				
Length	20.3 (15.9, 26.0)	19.6 (15.0, 26.9)	13.3 (10.2, 18.0)	18.3 (15.0, 21.0)
Depth	7.0 (5.0, 9.0)	6.0 (4.1, 8.0)	5.0 (4.0, 7.0)	5.7 (4.2, 7.0)

[a]Data are expressed in millimeters as median (interquartile range). AP, anteroposterior; LFC, lateral femoral condyle; MFC, medial femoral condyle; MRI, magnetic resonance imaging.

of baseline presentation consisted of restricted weightbearing (11.8%; 118/1004), physical therapy (10.8%; 108/1004), no physical activity restrictions (2.7%; 27/1004), and casting (2.3%; 23/1004). Treatment plans by lesion location can be found in Table 5.

A decision to proceed with a surgical intervention occurred in 66.9% of knees (622/930), of which a total of 511 knees (82.2%) had data on intraoperative characteristics. Lesions were classified as immobile in 48.1% of knees (246/511) and mobile in 51.9% of knees (265/511). Lesion mobility and cartilage classification can be found in Table 6.

DISCUSSION

The ROCK group was established with the objective of filling the voids in the knowledge of OCD. Since inception, the group has established radiographic,[27] MRI,[7] and arthroscopic[5] classification systems to more accurately classify these lesions and allow clinical comparisons of these relatively rare lesions on a larger scale. The current study presents the variability seen within the continental United States in youth presenting with OCD of the knee. Although the findings of this study are comparable with many of the previous works on the subject, some new and interesting findings have been uncovered. The MFC is the most commonly reported location of an OCD in the knee, with an incidence of 66% in this cohort supporting the findings in previous cohorts from the Kaiser Permanente Group (64%)[14] and Europe (77%).[9] The incidence of lesions found in the patella mirrored the incidence rate found by Hefti et al[9] but was higher than the rate found by Kessler et al.[14] Lesions of the patellofemoral joint, although noted in the OCD literature, have been discussed less. We believe this is due to the relatively small numbers in previous reports with smaller cohorts.[22,25,26] The fact that 15% of the current cohort had lesions of the trochlea or patella

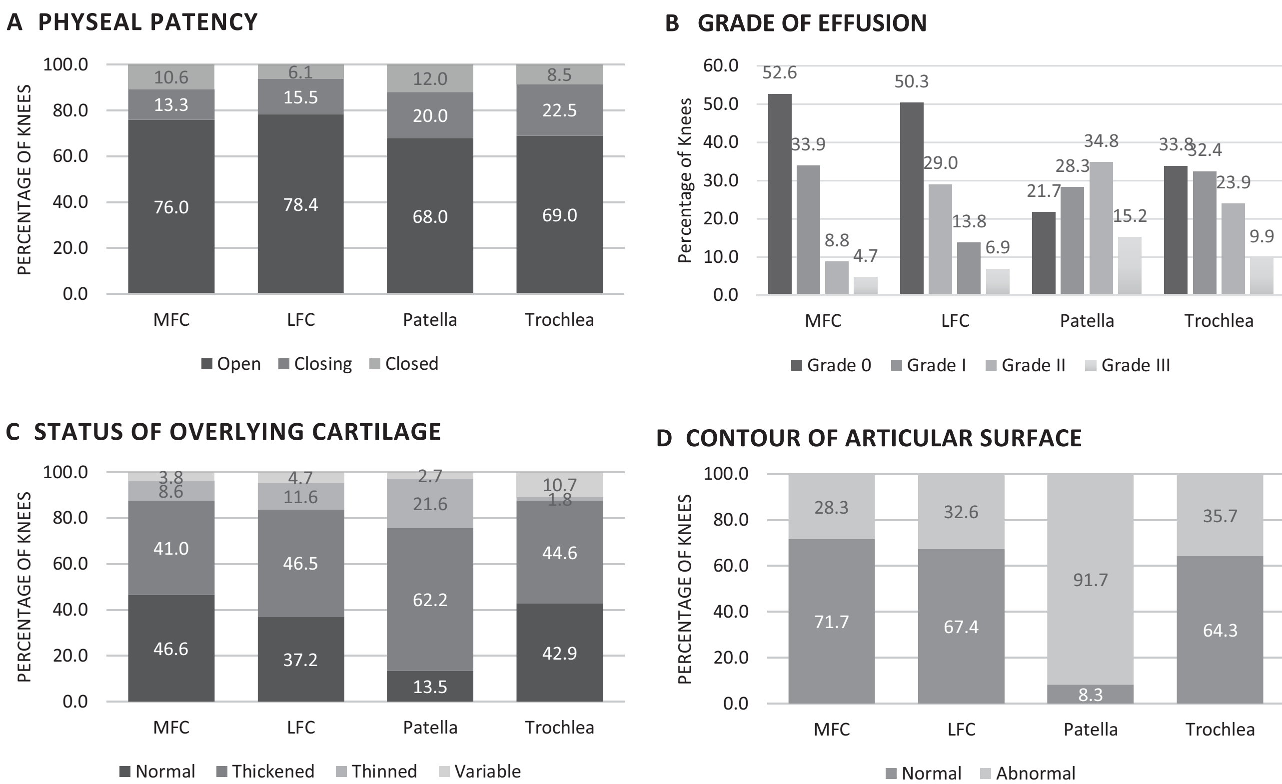

Figure 4. Percentages of patients with osteochondritis dissecans (OCD) lesion characteristics seen on magnetic resonance imaging. OCD lesions are stratified by lesion location: medial femoral condyle (MFC), lateral femoral condyle (LFC), patella, and trochlea. (A) Growth plate status classified as either an open growth plate, a closing growth plate, or a closed growth plate. (B) The presence or absence of a joint effusion was determined based on fluid in the lateral gutter or patella suspended off of the femur. (C) Cartilage status was judged against adjacent cartilage. (D) The articular contour was classified as normal or as abnormal if it was proud, depressed, or both.

TABLE 5
Treatment Plan Stratified by Lesion Location[a]

	MFC (n = 665)	LFC (n = 182)	Patella (n = 60)	Trochlea (n = 95)
No restriction	15 (2.3)	7 (3.8)	3 (5.0)	1 (1.1)
Restricted activity	296 (44.5)	81 (44.5)	23 (38.3)	42 (44.2)
Physical therapy	70 (10.5)	20 (11.0)	6 (10.0)	12 (12.6)
Casting	18 (2.7)	5 (2.7)	0 (0.0)	0 (0.0)
Bracing	221 (33.2)	57 (31.3)	10 (16.7)	13 (13.7)
Restricted weightbearing	90 (13.5)	18 (9.9)	3 (5.0)	7 (7.4)
Surgery	352 (52.9)	98 (53.8)	46 (76.7)	60 (63.2)

[a]Data are expressed as n (%) of knees. Percentage totals will not tally to 100% because patients may have been prescribed multiple treatment options at the initial visit. LFC, lateral femoral condyle; MFC, medial femoral condyle.

highlights the importance of a thorough clinical and radiological evaluation to ensure accurate diagnosis of OCD in all regions of the knee at initial presentation. Isolated lesions of the tibia plateau remain rare, but they do exist. This disease is not exclusive to a single joint. Previous reports suggested that bilateral lesions occur in 7.3% to 12.6% of patients.[9,14] In the current cohort, nearly 11% of patients developed lesions in both the right and left knees. Albeit a small percentage (7.6%), lesions in joints other than the knee were also identified. This population presents a unique subgroup that may warrant further investigation.

The patient characteristics of the current study portray a preponderance of knee OCD affecting young White males. Overall, nearly two-thirds of the patients in this cohort are males. This follows similar trends where males

TABLE 6
Lesion Mobility and International Cartilage Regeneration and Joint Preservation Society (ICRS) Classification[a]

	MFC (n = 402)	LFC (n = 106)	Patella (n = 48)	Trochlea (n = 65)
Mobility				
Immobile	182 (55.2)	49 (53.3)	1 (2.2)	13 (27.1)
Cue ball	110 (63.6)	23 (50.0)	0 (0.0)	7 (58.3)
Shadow	41 (23.7)	17 (37.0)	1 (100.0)	5 (41.7)
Wrinkle in rug	22 (12.7)	6 (13.0)	0 (0.0)	0 (0.0)
Mobile	143 (44.8)	43 (46.7)	44 (97.8)	35 (72.9)
Locked door	46 (33.3)	10 (23.8)	0 (0.0)	6 (17.6)
Trap door	47 (34.1)	16 (38.1)	21 (47.7)	10 (29.4)
Crater	45 (32.6)	16 (38.1)	23 (52.3)	18 (52.9)
ICRS classification				
Normal – Grade 0	126 (40.8)	30 (34.9)	1 (2.3)	11 (22.9)
Nearly normal – Grade 1	99 (32.1)	26 (30.2)	1 (2.3)	11 (20.9)
Abnormal – Grade 2	25 (8.1)	9 (10.5)	4 (9.1)	5 (10.4)
Severely abnormal – Grade 3	20 (6.5)	3 (3.5)	14 (31.8)	5 (10.4)
Severely abnormal – Grade 4	39 (12.5)	18 (20.9)	24 (54.5)	16 (33.4)

[a]Data are expressed as n (%) of knees. Mobility missing data: MFC, 77 knees; LFC, 14 knees; patella, 3 knees; trochlea, 17 knees. Immobile classification missing data: MFC, 9 knees; LFC, 3 knees; trochlea, 1 knee. Mobile classification missing data: MFC, 5 knees; LFC, 1 knees; trochlea, 1 knee. ICRS classification missing data: MFC, 93 knees; LFC, 20 knees; patella, 4 knees; trochlea, 17 knees. LFC, lateral femoral condyle; MFC, medial femoral condyle.

represent 60% to 80% of knee OCD patients and the common age of initial presentation is 11 to 15 years of age.[9,14] In the current study, female patients had an earlier initial presentation than male patients by a year. Although this difference may not indicate a statistical difference, it may serve as a clinically relevant finding potentially due to the differences in skeletal maturity between sexes. The predominant races and ethnicities in this cohort were White, non-Hispanic, and Latino. This finding is in contrast to the findings of Kessler et al,[14] who reported the distribution of race to be relatively similar among White and Black participants (35.4% and 27.6%, respectively). Moreover, Kessler et al used electronic health records from a large healthcare system located in southern California, and their cohort had a much larger distribution of Hispanic or Latino ethnicity, at 26.6%. It is conceivable that the population of southern California is not generalizable to the entire US population. Recently, significant efforts have been initiated to understand health disparities among non-White populations and identify institutionalized healthcare policy and practice barriers to health development. Of the ROCK institutions involved in patient recruitment, 7 were children's hospitals that accept Medicaid insurance, which may reduce racial disparity and enhance healthcare access to populations that have had lower rates of access to health care. A review of treatment disparity for OCD is beyond the scope of this article but is an area that requires additional investigation into the investment of health development for all children.

Not surprisingly, symptomatic OCD is more commonly seen in individuals participating in sports that require explosive movements in the lower extremities, like basketball and soccer. Although these were the most common sports played in this group of individuals, OCD lesions do not appear to be isolated to sports that involve cutting tasks or substantial acceleration and deceleration profiles of the lower extremity. It is also interesting to note that individuals who have a primary sport in which they train and play 8 months of the year or more do not necessarily have a higher incidence of OCD. This builds upon previous evidence that the cumulative effect of frequent sport participation during the prepubescent transition to adolescence may be associated with the development of knee OCD, rather than direct trauma.[16,18] Most patients in the current study had pain in their knee for an average of 8 months before their initial evaluation, and consequently the majority of patients did not recall any injury to their knee.

The high percentage of stable lesions in the current study contrasts with a previously reported, higher percentage of unstable lesions.[9] This may reflect a selection bias, as many of the reported figures have been derived from studies looking at the outcomes of different surgical techniques, but it also may demonstrate that physicians in general are getting better at diagnosing OCD earlier in the course of its evolution. Certainly, it will be interesting to see whether the results and treatment outcomes for these individuals reflect this earlier diagnosis.

This is the first release of descriptive findings from the ROCK cohort database, and with any database, there are limitations when interpreting the data. The main limitation that must be considered is patient selection bias. These data are from patients with OCD who sought care from a small sample of specialized surgeons, and the findings may not be generalizable to all patients with OCD in the United States. A surgeon who specializes in cartilage restoration techniques may attract more unstable or unsalvageable lesions, whereas a surgeon who specializes in arthroscopy may attract patients with stable lesions. Furthermore, this cohort included only surgeons as recruiters. Another limitation is attrition bias. Because some data were missing for variables of interest at the baseline time point, it is possible that subsequent reports may alter the findings reported in this article as the database becomes more comprehensive. Because we do not know the ethnic distribution in the population at risk, we cannot comment on whether the condition is disproportionately found in any specific ethnic group.

The results of the present study reflect the largest collection to date of patients with knee OCD. It is the goal of the ROCK group to use the compendium of expert opinions and augment our current understanding with evidence supplied from this database. We hope that this study will achieve its 10-year follow-up outcome, elucidating the current diagnostic guidelines and care pathways, to ultimately improve the management and outcomes of this disease. We believe that the findings of this study have improved the understanding of knee OCD and that this study will establish a foundation upon which further studies can be based to improve and advance the treatment and prognosis of knee OCD.

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REFERENCES

1. Barrie HJ. Hypertrophy and laminar calcification of cartilage in loose bodies as probable evidence of an ossification abnormality. *J Pathol*. 1980;132(2):161-168.
2. Cahill B. Treatment of juvenile osteochondritis dissecans and osteochondritis dissecans of the knee. *Clin Sports Med*. 1985;4(2):367-384.
3. Cahill BR, Phillips MR, Navarro R. The results of conservative management of juvenile osteochondritis dissecans using joint scintigraphy: a prospective study. *Am J Sports Med*. 1989;17(5):601-606.
4. Carey JL, Grimm NL. Treatment algorithm for osteochondritis dissecans of the knee. *Clin Sports Med*. 2014;33(2):375-382.
5. Carey JL, Wall EJ, Grimm NL, et al. Novel arthroscopic classification of osteochondritis dissecans of the knee. *Am J Sports Med*. 2016;44(7):1694-1698.
6. Edmonds EW, Shea KG. Osteochondritis dissecans: editorial comment. *Clin Orthop Relat Res*. 2013;471(4):1105-1106.
7. Fabricant PD, Milewski MD, Kostyun RO, et al. Osteochondritis dissecans of the knee: an interrater reliability study of magnetic

resonance imaging characteristics. *Am J Sports Med*. 2020;48(9):2221-2229.
8. Fabricant PD, Robles A, Downey-Zayas T, et al. Development and validation of a pediatric sports activity rating scale: the Hospital for Special Surgery Pediatric Functional Activity Brief Scale (HSS Pedi-FABS). *Am J Sports Med*. 2013;41(10):2421-2429.
9. Hefti F, Beguiristain J, Krauspe R, et al. Osteochondritis dissecans: a multicenter study of the European Pediatric Orthopedic Society. *J Pediatr Orthop B*. 1999;8(4):231-245.
10. Heyworth BE, Edmonds EW, Kocher MS, et al. Variation in surgical treatment of knee osteochondritis dissecans (OCD) among high-volume OCD surgeons. *Orthop J Sports Med*. 2015;3(7 suppl 2):2325967115S0007.
11. Heyworth BE, Kocher MS. Osteochondritis dissecans of the knee. *JBJS Rev*. 2015;3(7):1-12.
12. Hughston JC, Hergenroeder PT, Courtenay BG. Osteochondritis dissecans of the femoral condyles. *J Bone Joint Surg Am*. 1984;66(9):1340-1348.
13. Irrgang JJ, Anderson AF, Boland AL, et al. Development and validation of the International Knee Documentation Committee Subjective Knee Form. *Am J Sports Med*. 2001;29(5):600-613.
14. Kessler JI, Nikizad H, Shea KG, Jacobs JC, Bebchuk JD, Weiss JM. The demographics and epidemiology of osteochondritis dissecans of the knee in children and adolescents. *Am J Sports Med*. 2014;42(2):320-326.
15. Kocher MS, Smith JT, Iversen MD, et al. Reliability, validity, and responsiveness of a modified International Knee Documentation Committee Subjective Knee Form (Pedi-IKDC) in children with knee disorders. *Am J Sports Med*. 2011;39(5):933-939.
16. Kocher MS, Tucker R, Ganley TJ, Flynn JM. Management of osteochondritis dissecans of the knee: current concepts review. *Am J Sports Med*. 2006;34(7):1181-1191.
17. König CF. Ueber freie Korper in den Gelenken. *Dtsch Zeitschr Chir*. 1887;27:90-109.
18. Launay F. Sports-related overuse injuries in children. *Orthop Traumatol Surg Res*. 2015;101(1):S139-S147.
19. Lindén B. The incidence of osteochondritis dissecans in the condyles of the femur. *Acta Orthop Scand*. 2009;47(6):664-667.
20. Marx RG, Stump TJ, Jones EC, Wickiewicz TL, Warren RF. Development and evaluation of an activity rating scale for disorders of the knee. *Am J Sports Med*. 2001;29(2):213-218.
21. Milgram JW. Radiological and pathological manifestations of osteochondritis dissecans of the distal femur: a study of 50 cases. *Radiology*. 1978;126(2):305-311.
22. Peters TA, Mclean ID. Osteochondritis dissecans of the patellofemoral joint. *Am J Sports Med*. 2000;28(1):63-67.
23. Ribbing S. The hereditary multiple epiphyseal disturbance and its consequences for the aetiogenesis of local malacias—particularly the osteochondrosis dissecans. *Acta Orthop Scand*. 2009;24(1-4):286-299.
24. Roos EM, Toksvig-Larsen S. Knee injury and Osteoarthritis Outcome Score (KOOS)—validation and comparison to the WOMAC in total knee replacement. *Health Qual Life Outcomes*. 2003;1:1-10.
25. Smith JB. Osteochondritis dissecans of the trochlea of the femur. *Pediatr Radiol*. 1990;6(1):11-17.
26. Wall EJ, Heyworth BE, Shea KG, et al. Trochlear groove osteochondritis dissecans of the knee patellofemoral joint. 2014;34(6):625-630.
27. Wall EJ, Polousky JD, Shea KG, et al. Novel radiographic feature classification of knee osteochondritis dissecans: a multicenter reliability study. *Am J Sports Med*. 2015;43(2):303-309.
28. Wall EJ, Vourazeris J, Myer GD, et al. The healing potential of stable juvenile osteochondritis dissecans knee lesions. *J Bone Joint Surg Am*. 2008;90(12):2655-2664.