

Juvenile Osteochondritis Dissecans of the Trochlea: A Cohort Study of 34 Trochlear Lesions Associated With Sporting Activities that Load the Patellofemoral Joint

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Background: Juvenile osteochondritis dissecans (JOCD) lesions are rarely located in the trochlea and few studies have focused on the causes and outcomes of JOCD lesions in this part of the knee. The purpose of this study is to (1) evaluate the clinical characteristics and outcomes of patients who undergo surgery for JOCD in this unusual location as well as (2) assess the association between trochlear JOCD and participation in sporting activities that load the patellofemoral joint.

Methods: We conducted a retrospective cohort study of 34 trochlear JOCD lesions in 30 patients. Cases that involved traumatic cartilage shear or patella instability were excluded. Preoperative and postoperative magnetic resonance images and x-rays were evaluated and demographic data, sports played, comorbidities, surgical procedures, and clinical data were extracted from medical records. A case-control cohort of 102 femoral condyle lesions was used to assess the correlation between sports played and lesion location.

Results: The cohort comprised 34 consecutive trochlear JOCD lesions in 30 patients (26 males, 4 females). Average age at surgery was 13.8 years (9.3 to 18.0 y). In total, 27 (90%) patients were active, and of these active patients, soccer and basketball were the most common sports played. In the case-control comparison, the correlation between playing either basketball or soccer and the presence of a trochlear JOCD lesion was statistically significant ($P=0.017$). In total, 21 knees (62%) received operative treatment. Sixteen of the surgical patients underwent repair and fixation with bioabsorbable nails. The average length of clinical and radiographic follow-up was 21.1 months. All patients who underwent fixation showed radiographic and/or clinical indications of healing at most recent follow-up. Thirteen of the patients who underwent fixation were active, and all of these patients reported successful return to sports. Thirteen knees

underwent nonoperative treatment, and the majority of these patients had limited follow-up.

Conclusions: We report a significant association between pediatric athletes who play basketball and soccer and the development of trochlear JOCD, suggesting that repetitive loading of the patellofemoral joint may play a role in the development of JOCD lesions. Patients with trochlear JOCD lesions were likely to undergo surgery, and repair and fixation of the lesions produced good outcomes at short-term follow-up.

Level of Evidence: Level III—case-control study.

Key Words: juvenile osteochondritis dissecans, trochlea, knee, pediatrics, basketball, soccer

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Juvenile osteochondritis dissecans (JOCD) is an idiopathic condition characterized by the development of lesions in the subchondral bone of skeletally immature patients and may or may not involve the overlying cartilage. In more serious cases, a segment of avascular subchondral bone and its overlying articular cartilage separate from the surrounding cancellous bone as a loose body. JOCD is a fairly common cause of knee pain and dysfunction in young children and adolescents, particularly those between 10 and 15 years who participate in athletic activities.^{1–3} The most common location of these lesions is the medial femoral condyle with an occurrence of 70% to 85% reported in the literature.⁴ Both nonoperative^{5,6} and operative^{3,7–12} treatments have been described for medial femoral condyle lesions. Surgical options include fixation, drilling, and chondral remodeling with the ultimate goal of revitalizing the osteochondral environment and reestablishing the joint surface.

Unlike osteochondritis dissecans (OCD) lesions on the femoral condyles, lesions on the trochlea are much less common, with a reported incidence of 0.6% to 1%, and are not particularly well-described.^{13–16} In the largest, most recent OCD epidemiological study consisting of 192 patients with 206 OCD lesions, only 4 (1.9%) were located in the central or lateral trochlea.¹⁵ Moreover, the majority of the literature on trochlear OCD consists of case reports,^{17–24} and treatment recommendations by the American Academy of Orthopaedic Surgeons are limited

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to femoral condyle lesions.²⁵ As a result there is a need for a better understanding of trochlear lesions, including their potential causes and treatment recommendations.

The etiology of JOCD is not entirely understood, but several hypotheses have been proposed, including stress or ischemia at the articular surface. For athletic children, this stress at the immature articular surface could result from repetitive microtrauma during athletic activity or single indirect or direct trauma.^{13,16} Another hypothesis is that activity resulting in repetitive loading of the injured articular surface could cause localized avascular necrosis.²⁶ In a recent study assessing femoral condyle lesions in baseball players, McElroy et al proposed that certain joint loading patterns and biomechanics associated with specific athletic positions could predispose young athletes to lesions in specific locations.²⁷ On the basis of this literature and clinical observations, we hypothesize that trochlear JOCD lesions are associated with young athletes who play sports that involve significant loading on the patellofemoral joint, specifically soccer and basketball. These 2 sports involve rapid deceleration before a change in direction or while landing from jumps, activities that increase loading of the patellofemoral joint and put the trochlea at greater risk of injury.²⁸ We focused on basketball and soccer as they have been identified as 2 of the most popular sports played by American adolescents²⁹ that involve this mechanical loading pattern. Soccer and basketball have been previously associated with high rates of and risks for knee injuries.^{30,31}

The primary purpose of this study was to describe the treatment and outcomes of the largest cohort of trochlear JOCD lesions to date. The secondary aim was to determine whether there is a significant association between this rare lesion location and playing basketball and/or soccer.

METHODS

A computerized query of the electronic medical records and Picture Archiving and Communication System was performed to identify radiographic images that fit the following criteria: patients aged 18 or younger, presence of knee magnetic resonance imaging (MRI), date of MRI between 1998 and 2015, patients of the senior author, and diagnoses of “OCD,” “osteochondral lesions,” or “osteochondritis dissecans.” This search returned 648 MRIs (413 patients). Patients were excluded if they had incomplete charts, missing preoperative MRIs, any previous knee surgeries, or a history of patellar dislocation or traumatic osteochondral fracture that either preceded the JOCD or occurred concomitantly. This reduced the sample to 206 knees (179 patients). To conduct the trochlear-specific analysis of this study, we only included patients with confirmed diagnoses of trochlear JOCD.

After nontrochlear lesions were excluded, the sample consisted of 34 knees (30 patients; 26 male, 4 female). The mean age of the cohort at diagnosis was 13.8 years (9.3 to 18.0 y). To determine whether there was a significant association between JOCD lesions in the trochlea and a specific sport, we established an age-matched and sex-matched control

cohort of 102 femoral condyle lesions that was selected from an overall sample of 206 knees with JOCD lesions.

Lesions were identified and diagnosed for location by a single pediatric surgeon at our tertiary care center, and MRIs were assessed for lesion width and length. Lesion location was determined using the Cahill Classification.³² The lesion measurements were made on the sagittal view for lesion height and axial view for lesion width. Because patients with patellar instability were excluded from this study, assessments of patellar instability, patellar tilt, and patella femoral measurements were not collected.

Patient age at diagnosis, height, weight, sports played, comorbidities, and length of MRI follow-up were extracted from electronic medical records. For surgical patients, the physeal closure, details of the procedure, revision surgeries, indications of radiographic healing, and clinical symptoms such as pain were also recorded. Healing was assessed using the most recent successive MRI or x-ray and was defined as >50% of subchondral bony incorporation, meaning at least half of the bone involved in the lesion (progeny bone) had been integrated with the healthy (parent) bone on coronal and sagittal MRI views. In addition, clinical data were reviewed to assess pain and return to sports/activity after surgery.

Operative Versus Nonoperative Treatment

Patients who presented with open or unstable JOCD lesions or stable lesions with symptoms after 3 to 6 months of conservative treatment were treated with diagnostic arthroscopy and transarticular drilling. Depending on the arthroscopic assessment of the lesion, additional procedures were performed. Most unstable lesions were treated openly unless debridement and fixation could be carried out arthroscopically. Postoperative patients wore a partial weight bearing brace that locked knee in extension but allowed for general range of motion in non-weight-bearing settings. We only reported clinical outcomes for the 14 patients who had at least 12 months of either radiographic or clinical follow-up, but included all surgical patients in our analysis of sports association. Patients who were in the nonoperative cohort were treated with a regimen of rest and told to refrain from running, squatting, or jumping for 3 to 6 months until symptoms subsided. In addition, they were given core strengthening and nonimpact hamstring strengthening exercises to further protect the injured knee.

Statistical Analyses

Descriptive statistics of the study population consisted of means and SDs for continuous variables, whereas frequencies and percentages were used to describe discrete variables. Independent samples *t* tests and the χ^2 tests were used to compare differences between patients with lesions in the trochlea versus femoral condyle. Statistical significance was defined as $P=0.05$. All analyses were performed using SPSS version 23.0 (IBM Corp., Armonk, NY).

RESULTS

The sample of trochlear lesions consisted of 30 patients (34 knees) comprising 26 males (86.7%) and 4

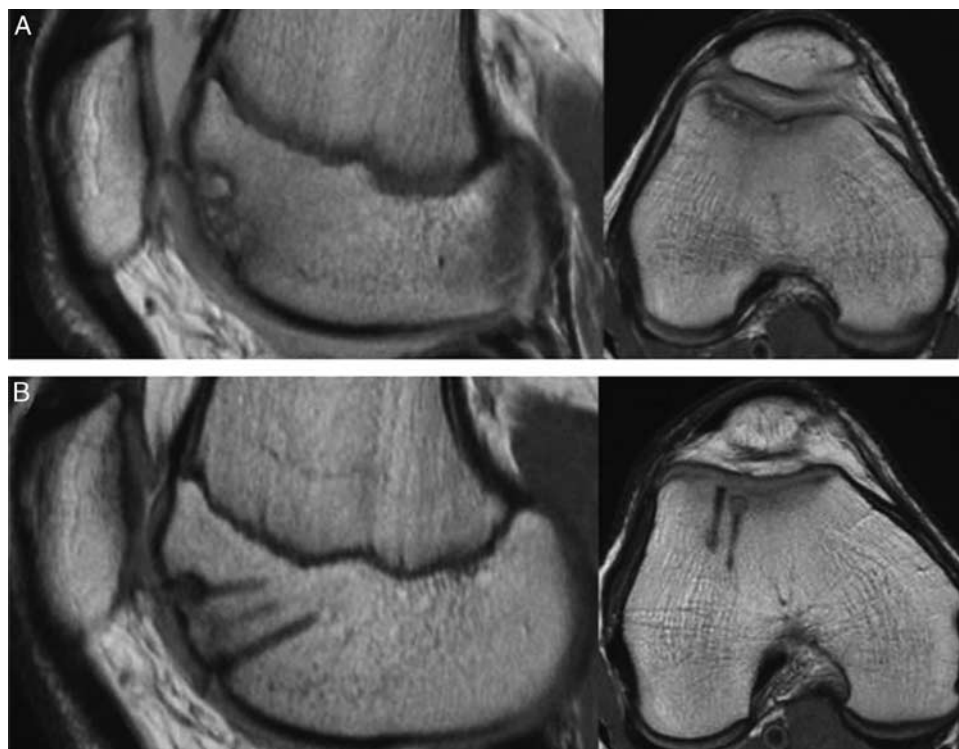


FIGURE 1. Preoperative (A) and postoperative (B) proton density MRI of a 13-year-old boy (patient 9 in Table 1) with an unstable juvenile osteochondritis dissecans lesion on the lateral trochlea who underwent surgical fixation with 6 bioabsorbable tacks. The 2-year postoperative MRI shows smooth articular cartilage, bony incorporation, and a lack of displacement, fragmentation, and loosening, which are signs of healing. MRI indicates magnetic resonance imaging.

females (13.3%). The average age at diagnosis was 13.8 years (9.3 to 18.0 years). Patients typically presented with complaints of anterior knee pain and reported 6 to 12 months of vague anterior knee pain before seeking medical care. The majority of subjects 27 (90%) played sports. In total, 27 (79%) of the knees belonged to subjects who played either basketball or soccer or both; 15 (44%) were soccer players, 17 (50%) were basketball players. Other sports played included football (13%), lacrosse (10%), baseball (16%), tennis (6%), track and cross-country running (CC) (20%), skiing (6%), and swimming (3%). Three knees had coexisting femoral condyle lesions, 4 knees had bilateral trochlear lesions, and 1 patient had coexisting bilateral femoral condyle lesions. The area of the lesions averaged 230.0 mm² (15.5 to 695.8 mm²). In total, 22 knees (64%) underwent operative treatment, and at the time of surgery, all patients in this cohort had open physes.

Surgical Patients

Sixteen of the surgical patients (16 knees) underwent repair and fixation with bioabsorbable nails. Fourteen of the knees that underwent fixation reached clinical and/or radiologic follow-up of at least 12 months, with an average clinical follow-up of 22.2 months (range, 12.0 to 37.3 months) and an average MRI follow-up of 20.2 months (12.0 to 38.0 months). All patients in the surgical cohort who underwent fixation showed radiologic and/or clinical indications of healing

at their most recent follow-up, defined as either bone incorporation on MRI or the absence of pain (Figs. 1, 2). All fixation procedures used 1.6 mm bioabsorbable nails, with an average of 6 nails (range, 4 to 8) per procedure. All knees underwent at least ≥ 1 concurrent procedures including drilling, microfracture, debridement, chondroplasty, and removal of loose bodies. Bone marrow aspirate concentrate (BMAC) augmentation was used in 1 case at the discretion of the operating surgeon with the intention to promote biological healing. Ten (62.5%) fixation procedures involved arthrotomy (Table 1).

Thirteen of the fixation patients with adequate 1-year follow-up were active, and all 13 of these patients reported a successful return to sports. In this relatively short-term average follow-up of 22.2 months, surgical outcomes were good: only 2 patients required a second surgery. The first of these 2 patients underwent a subsequent debridement, chondroplasty, and removal of smart nails 1.5 years after initial fixation. These follow-up procedures were performed because a portion of the lesion had not completely healed, and smart nail remnants may have been causing synovitis. Although bioabsorbable nails typically lose strength around 3 years postoperatively, they are often present in bone or on MRI for up to 2 years while they undergo reabsorption. The second patient underwent chondroplasty and diagnostic arthroscopy, which demonstrated healing of the lesion, 1 year after the initial surgery. After these revisions, both patients reported a

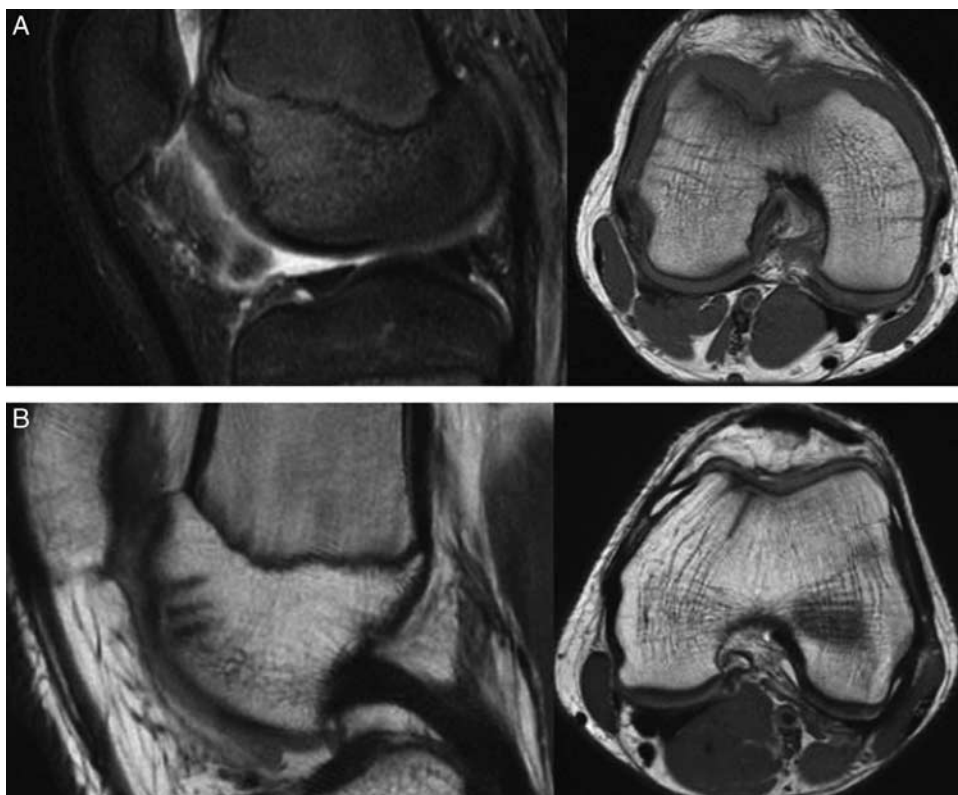


FIGURE 2. Preoperative (A) and postoperative (B) MRI of a 13-year-old boy (patient 11 in Table 1) with a large, unstable juvenile osteochondritis dissecans lesion on the lateral trochlea who was treated with debridement, bone marrow aspirate concentrate, and fixation with 7 bioabsorbable tacks. The 1-year postoperative MRI shows smooth overlying articular cartilage and bony incorporation, which are signs of healing. MRI indicates magnetic resonance imaging.

lack of pain and return to previous levels of athletic activities.

The 6 surgical patients who did not undergo fixation with bioabsorbable nails had an average MRI follow-up of 24.77 months (11.5 to 53.2 months) and an average clinical follow-up of 30.7 months (11.5 to 53.2 months). These patients also healed well; 5 of the 6 patients were active, and these 5 reported a return to activity and sports at their most recent follow-up. Two patients required a second surgery. One patient underwent a knee arthrotomy and cartilage restoration using deNovo cartilage allograft 3 weeks after the initial procedure. The second patient also underwent a deNovo allograft transplant and debridement 1 year after initial chondroplasty, as well as debridement and removal of a loose body.

Trochlear Versus Femoral Lesion Case Control

Demographics of the 2 cohorts were similar in age and sex (Table 2). In general the group of patients with trochlear lesions was highly involved in athletics. When the association between sports played and location of JOCD lesion was analyzed, playing basketball and soccer was more highly associated with the presence of trochlear lesions than control femoral condyle lesions. Specifically, the odds of patients with trochlear JOCD lesions playing either basketball or soccer are 2.84 times higher as

compared with patients with femoral JOCD lesions ($P=0.017$). The association between trochlear JOCD lesions and athletes who played both basketball and soccer compared with those who played neither is even higher (odds ratio = 4.29; $P=0.029$). Although the odds of playing basketball or soccer alone were not significant, the percentages of athletes who had these lesions was still higher than that of athletes with femoral condyle lesions (28% vs. 43%, 33% vs. 49%, respectively).

DISCUSSION

To date this cohort of 34 consecutive trochlear JOCD lesions in 30 patients is the largest cohort of trochlear JOCD lesions reported in the literature. The majority of these patients participated in organized sports, most commonly soccer and basketball. In our case-control comparison with femoral condyle lesions, there was a correlation between trochlear JOCD and playing sports that load the patellofemoral joint. Specifically, the association between soccer or basketball and trochlear JOCD lesions was statistically significant, though further investigation is required to solidify this association because of the small study sample size.

In addition, after 1 year of follow-up, a large majority of these trochlear OCD patients demonstrated healing and

TABLE 1. Characteristics of Patients in the Surgical Cohort

Patient Number	Sex	Age at Time of Surgery		No. SNs	Additional Procedures	Clinical Follow-up (mo)	Radiographic/MRI Follow-up (mo)	Revision Surgery?	Type of Revision
		Fixation?							
1	M	16.3	Y	4	Drilling, microfracture	14.3	14.5	N	NA
2	M	14.8	Y	5	Microfracture	25.0	25.5	N	NA
3	M	10.4	Y	5	Arthrotomy, ORIF	37.3	38.0	N	NA
4	M	14.8	Y	6	Debridement, microfracture	9.7	34.0	N	NA
5	M	14.9	Y	8	Drilling, microfracture, arthrotomy for fixation	19.8	12.2	Y	Chondroplasty, diagnostic arthroscopy (1 y)
6	M	14.5	Y	8	Drilling, debridement, chondroplasty, arthrotomy	14.6	14.6	N	NA
7	M	13.0	Y	5	Fixation of loose body, arthrotomy	27.1	26.4	N	NA
8	M	12.2	Y	8	Debridement, BMAC arthrotomy	8.9	10.9	N	NA
9	M	13.3	Y	6	Drilling, debridement, arthrotomy for fixation	26.2	25.1	N	NA
10	M	12.0	Y	NA		14.1	14.1	N	NA
11	M	13.7	Y	7	Debridement, BMAC, arthrotomy	12.4	12.4	N	NA
12	M	18.0	Y	8	Drilling, arthrotomy for fixation	12.0	12.0	Y	Chondroplasty, microfracture, removal of nail
13	M	16.0	Y	3	Microfracture, drilling	25.8	24.9	N	NA
14	M	16.8	Y	5	Debridement, drilling, fixation loose body, BMAC, arthrotomy	8.8	8.8	N	NA
15	M	14.0	Y	5	Debridement, chondroplasty, BMAC	3.1	3.1	N	NA
16 (Left knee)	M	12.2	Y	5	Debridement, drilling, fixation loose body, arthrotomy	35.9	18.7	N	NA
17	M	14.0	N		Debridement, removal of loose body, microfracture	23.9	23.9	N	NA
16 (Right knee)	M	12.3	N	NA	Removal of loose body	34.3	16.8	N	NA
18	M	13.3	N	NA	Debridement, arthrotomy, allograft placement	11.5	11.5	N	NA
19	M	10.4	N	NA	Debridement, drilling, arthrotomy, cartilage pinning with SN	53.2	53.2	Y	Debridement, deNovo allograft cartilage placement
20	F	13.3	N	NA	Debridement, chondroplasty, removal of loose body	23.9	17.6	Y	Allograft transplant, debridement 1 year later
21	M	14.3	N	NA	Drilling, debridement	46.0	1.0	N	NA
Average		13.8				22.2	19.1		

BMAC indicates bone marrow aspirate concentrate; F, female; M, male; N, no; NA, not applicable; ORIF, open reduction internal fixation; SN, smart nail; Y, yes.

had returned to previous levels of activity. A large percentage (64.7%) of knees in this group required surgery, and we report particularly good results for this surgical cohort where the large majority of patients demonstrate healing

and bony incorporation on MRI and report lack of pain and return to activities at 1-year follow-up. Patients underwent surgery if they presented with unstable defects on MRI or had previously failed 3 to 6 months of conservative

TABLE 2. Demographics of Patients With Trochlear Versus Femoral Condyle Juvenile Osteochondritis Dissecans Lesions

Characteristics	Femoral Lesions		Trochlear Lesions		P	Overall			
	Mean	SD	Mean	SD		Mean	SD	Minimum	Maximum
Age at diagnosis (y)	13.8	1.8	13.9	1.9	0.580	13.8	1.8	9.3	18.2
Total no. sports played	1.8	1.8	1.7	1.0	0.928	1.8	1.3	0.0	6.0
Sex									
Male	83	80%	31	89%	0.314	114	82%	—	—
Female	21	20%	4	11%	—	14	13%	—	—

treatment. The majority of surgical patients underwent lesion fixation with bioabsorbable tacks and experienced positive short-term outcomes with minimal complications. The large majority of the fixation cases were accompanied by concurrent procedures, the 2 most common being drilling to revitalize the bony bed beneath the lesion and debridement. Because there is not yet a fully established protocol for how to treat JOCD lesions in the trochlea, our results offer some insight into the effectiveness of surgical treatment, specifically fixation.

Two recent studies regarding JOCD lesions of the trochlea corroborate our findings. The first multicenter study conducted by the Research in Osteochondritis of the Knee (ROCK) group to report on clinical, radiographic, and functional results of trochlear JOCD treatment was conducted in 2014.³³ In total, 21 adolescents from records at 5 institutions comprised a total of 24 knees, 16 of which had a minimum of 1-year follow-up. Of this cohort, 4 knees (25%) were treated nonoperatively with activity modification, physical therapy and/or cast/bracing, whereas 12 (75%) underwent surgical treatment including drilling, fixation, microfracture, and drilling with fixation.³³ Of the 12 operative knees, 8 (67%) showed radiographic healing with full return to sports and no pain. In the nonoperative cohort, 2 of the 4 knees showed healing and lack of pain, whereas the other 2 worsened, with 1 undergoing a subsequent, successful operation. Similar to our cohort, patients in the ROCK study were very active with all but 1 playing sports at baseline, the most common of which being basketball, football, and soccer.³³

A more recent surgical case series conducted by Kramer et al³⁴ reported 26 patients with 29 JOCD lesions in either the patella (12 lesions) or trochlea (17 lesions). Of these lesions, the majority (76%) underwent transarticular drilling or drilling with fixation, whereas excision and marrow stimulation were performed on 24% of lesions. Similar to our cohort, these 26 patients reported high satisfaction, the ability to return to previous levels of activity, and low residual pain. The authors also reported that internal fixation, female sex, and longer duration of symptoms were risk factors for worse outcomes.³⁴

In addition to reporting positive outcomes for a cohort of surgical trochlear JOCD patients, our secondary aim was to determine whether certain sports were associated with development of JOCD lesions in this unique location. It was noted that the group of patients with trochlear lesions were particularly active and had high levels of participation in sports that repetitively load the patellofemoral joint, specifically basketball and soccer. When compared with an age-matched and sex-matched control cohort of patients with femoral condyle lesions, playing basketball or soccer was significantly associated with developing trochlear JOCD lesions. It is important to note that even though both cohorts of patients with trochlear and femoral condyle lesions were active, only lesions in the trochlear cohort were associated with specific sports. Although this association cannot show that these sports cause trochlear JOCD lesions, it supports the theory that localized microtrauma resulting from repetitive

loading and/or stress could be linked to region-specific lesions, particularly for young, active patients. Because the association between location and specific sports was only seen for trochlear lesions, it suggests that these stressors may be especially important risk factors for developing lesions in this uncommon location.

In their 2016 Catcher's Knee study, Kocher et al similarly showed that the intense load placed across the posterior portion of the femurs of baseball catchers while they maintain a deep squat position was associated with a greater risk of developing posterior JOCD lesions.²⁷ More recently, Gonzalez-Herranz et al²⁶ reported a strong correlation between the location of the knee's mechanical axis and the location of JOCD lesions, which further suggests that repetitive contact stress in the same location could result in specific JOCD lesions. These results emphasize the impact of daily, mechanical stresses experienced by young athletes and highlight the importance of considering these factors when making a diagnosis or identifying risk factors for injury.

Limitations

Because this study evaluated a retrospective cohort, we can only report associations, not causal relationships. In addition, because of the retrospective design, we lack patient-reported outcome measures taken in real-time at the beginning and end of treatment. Our cohort is also predominantly male, which prevented us from completing a sex-based analysis and makes these results potentially less applicable to female patient populations. Further, while our study focused on outcomes for surgical patients, several knees in our trochlear lesion cohort underwent nonoperative treatment. The majority of these patients were lost to follow-up, so we were not able to report on their outcomes or directly compare them with our surgical cohort. Our assumption is that these nonoperative patients improved and no longer needed medical treatment; however, we acknowledge that we cannot make this assertion without follow-up data.

CONCLUSIONS

Our study reports (1) positive outcomes for a large cohort of patients with trochlear JOCD lesions who underwent surgical treatment as well as (2) a significant association between basketball and soccer and the development of trochlear JOCD, suggesting that repetitive loading of the patellofemoral joint may play a role in the development of JOCD lesions in this uncommon location.

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