Original Article

Osteochondritis Dissecans of the Capitellum of the Elbow: Improved Outcomes in Surgically Treated Versus Nonoperatively Treated Patients at Long-Term Follow-up

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Purpose: To (1) report the long-term outcomes associated with both operative and nonoperative management of capitellar osteochondritis dissecans (OCD), (2) identify factors associated with failure of nonoperative management, and (3) determine whether delay in surgery affects final outcomes. **Methods:** All patients who received a diagnosis of capitellar OCD from 1995-2020 within a geographic cohort were included. Medical records, imaging studies, and operative reports were manually reviewed to record demographic data, treatment strategies, and outcomes. The cohort was divided into 3 groups: (1) nonoperative management, (2) early surgery, and (3) delayed surgery. Delayed surgery (surgery $\geq$6 months after symptom onset) was considered failure of nonoperative management. **Results:** Fifty elbows with a mean follow-up period of 10.5 years (median, 10.3 years; range, 1-25 years) were studied. Of these, 7 (14%) were definitively treated nonoperatively, 16 (32%) underwent delayed surgery after at least 6 months of failed nonoperative treatment, and 27 (54%) underwent early surgical intervention. When compared with nonoperative management, surgical management resulted in superior Mayo Elbow Performance Index pain scores (40.1 vs 33, $P = .04$), fewer mechanical symptoms (9% vs 50%, $P < .01$), and better elbow flexion (141° vs 131°, $P = .01$) at long-term follow-up. Older patients trended toward increased failure of nonoperative management ($P = .06$). The presence of an intra-articular loose body predicted failure of nonoperative management ($P = .01$; odds ratio, 13). Plain radiography and magnetic resonance imaging had poor sensitivities for identifying loose bodies (27% and 40%, respectively). Differences in outcomes after early versus delayed surgical management were not observed. **Conclusions:** Nonoperative management of capitellar OCD failed 70% of the time. Elbows that did not undergo surgery had slightly more symptoms and decreased functional outcomes compared with those treated surgically. The greatest predictors of failure of nonoperative treatment were older age and presence of a loose body; however, an initial trial of nonoperative treatment did not adversely impact the success of future surgery. **Level of Evidence:** Level III, retrospective cohort study.

Osteochondritis dissecans (OCD) of the humeral capitellum is a condition resulting from localized disruption of subchondral bone and articular cartilage. The cause is not universally agreed on, but the current literature suggests repetitive mechanical stress leading to subchondral stress fracture of the capitellum.[1-6] As a

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result, this disease process is commonly seen in adolescent overhead throwers and gymnasts.[7] Early youth sports specialization and subsequent overuse injuries are becoming more common, and thus, the incidence of capitellar OCD may increase in young athletes in the future.[8-10] Patients with capitellar OCD typically present with lateral elbow pain, stiffness, and occasional mechanical symptoms. Physical examination may show a small effusion, crepitus, decreased range of motion, and/or pain with loading of the radiocapitellar joint. Once suspicion is raised, the diagnosis is confirmed through imaging. Optimal advanced imaging remains controversial, with ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) all being used. Assessment of the stability of the capitellar OCD lesion, as originally proposed by Takahara et al.,[11] is performed after completion of imaging. Loss of motion, partial detachment, or loose fragments noted on imaging are associated with unstable lesions.[11]

The treatment of capitellar OCD, although controversial, is based primarily on the stability of the lesion and quality of the articular surface. Nonoperative management is typically recommended for stable lesions and involves a period of rest from aggravating activities. Short- to medium-term outcome studies suggest that this is a reasonable approach, although many patients do not respond to nonoperative treatment and the long-term outcomes of patients treated nonoperatively remain unknown.[12,13] Surgical intervention is indicated in patients who have an unstable lesion or in whom nonoperative management has failed.[14] A wide variety of both open and arthroscopic surgical procedures may be used, and the indications for specific interventions remain controversial.[14] Surgical outcomes are generally favorable in the short to mid term, with most patients returning to sports.[15-21] Long-term outcome data are scarce, and debate remains over the optimal treatment algorithm.[22,23]

There is a paucity of literature describing the long-term outcomes of both nonoperative and surgical treatment of capitellar OCD lesions. Similarly, factors predictive of failure of nonoperative management have not been fully elucidated. The purpose of this study was to (1) report the long-term outcomes associated with both operative and nonoperative management of capitellar OCD, (2) identify factors associated with failure of nonoperative management, and (3) determine whether delay in surgery affects final outcomes. We hypothesized that operative and nonoperative management would have similar long-term outcomes, older age would lead to increased failure of nonoperative management, and a delay in surgery would not affect final outcomes.

Methods

After institutional review board approval patients younger than 24 years who received a diagnosis of capitellar OCD from 1995-2020 were retrospectively identified. This was done by using a geographic cohort from the Rochester Epidemiology Project (REP) system. This is a medical record linkage system that pools medical record data from clinics, hospitals, and other medical facilities within Minnesota. The REP database contains the data of approximately 500,000 unique individuals living within southeast Minnesota.[24] Patients were identified via *International Classification of Diseases* and Current Procedural Terminology (CPT) codes (Appendix Table 1). These codes identified all patients within this geographic region and time frame with a diagnosis or procedure that could be related to capitellar OCD. Patients were included if they had a confirmed clinical diagnosis of capitellar OCD, imaging consistent with the diagnosis, and a minimum follow-up period of 1 year. Patients were excluded for the absence of capitellar OCD after review of the medical chart; the presence of acute osteochondral injury, hemophilic arthropathy, or Panner disease; and/or inadequate follow-up.

General demographic data were collected on all patients. Athletic involvement, including designation of throwing athletes, was documented and collated. Hand dominance, history of trauma to the elbow, physical examination findings, and clinical histories were reviewed and included. The presence of mechanical symptoms was recorded. A “mechanical symptom” was defined as documented crepitus, popping, catching, or locking of the elbow by patient report or on examination.

Both preoperative imaging and postoperative imaging of the affected elbow were collected and reviewed. The imaging was reviewed by 2 senior orthopaedic surgery residents (Z.V.B. and M.E.U.). Discrepancies were discussed with 1 senior staff orthopaedic surgeon when applicable (C.L.C.). Capitellar lesions identified on plain radiography were graded according to the criteria described by Takahara et al.[11] The status of the capitellar growth plate was documented. In addition, OCD lesions identified on MRI were graded using the criteria set forth by Nelson et al.[25] Lesion location, greatest dimension, presence of a loose body, and/or any other concomitant findings were documented. The sensitivity of plain radiography, CT, and MRI for detecting loose bodies was calculated by using the presence of loose bodies at the time of surgery as the gold standard. The availability of follow-up imaging in the medical record was variable, with only 26 elbows (52%) having a radiographic follow-up period greater than 1 year. Postoperative imaging analysis was performed in this group to document progression to osteoarthritis.

Table 1. Baseline Demographic Characteristics of All Patients Included in Analysis

	Data
No. of patients	50
Nonoperative cohort, n (%)	7 (14)
Delayed operative cohort, n (%)	16 (32)
Operative cohort, n (%)	27 (54)
Mean follow-up (range), yr	10.5 (1-25)
Mean age (range), yr	14.7 (9-24)
Sex, n (%)	
Male	40 (80)
Female	10 (20)
Mean BMI (range)	23.7 (17.5-36.6)
Overhead athlete, n (%)	28 (56)
Ethnicity	
White	45 (90)
Black	2 (4)
Other	3 (6)
Mean time from symptom onset to presentation (range), mo	14.2 (0-96)
Laterality, n (%)	
Right	31 (62)
Left	19 (38)
Dominant arm, n (%)	29 (52)
Mechanical symptoms at presentation, n (%)	30 (60)
History of trauma, n (%)	
None	35 (70)
Acute	3 (6)
Remote	12 (24)
Lesion grade on radiograph, n (%)	
0	7 (15)
I	33 (69)
II	3 (6)
III	5 (10)
Lesion stability, n (%)	
Stable	15 (31)
Unstable	34 (69)
Mean lesion diameter, mm	10.6
Physeal status, n (%)	
Open	10 (21)
Closed	37 (79)

BMI, body mass index.

The cohort was divided into 3 groups for subgroup analysis: those who underwent definitive nonoperative management, those who underwent early surgical intervention (surgery < 6 months after symptom onset), and those who underwent a trial of nonoperative management of at least 6 months before proceeding to surgery (delayed surgery). To compare clinical outcomes at final follow-up, the nonoperative cohort and the 2 surgical cohorts were compared. To identify factors associated with failure of nonoperative management, patient characteristics were compared between the nonoperative cohort and the delayed-surgery cohort. Finally, to determine whether a delay in surgery affects final outcomes, the early-surgery and delayed-surgery cohorts were compared.

Activity modifications, brace use, analgesic use, and physical therapy were documented to characterize nonoperative management. To characterize surgical interventions, we documented open versus arthroscopic approaches, specific procedure performed, concomitant procedures, and postoperative restrictions. The Mayo Elbow Performance Index (MEPI) score was calculated for each patient visit to provide an objective means of analyzing improvement. The MEPI analyzes pain, range of motion, instability, and strength to provide an objective clinical outcome score.

Statistical Analysis

All statistical tests were 2-sided, and $P < .05$ was considered significant. Simple descriptive statistics were performed on demographic and activity variables. Shapiro-Wilk tests were performed to assess for non-normal distributions of continuous variables. For these non-normally distributed variables, Wilcoxon signed rank tests were performed to assess for statistical significance. The BlueSky program (version 7.4; BlueSky Statistics, Chicago, IL) was used to track data and perform all statistical calculations.

Results

Demographic Characteristics and Management Strategies

An initial search using *International Classification of Diseases* and CPT codes identified 255 patients for detailed record review. Through manual review of medical records, patients were subsequently excluded for the following reasons: absence of capitellar OCD after review of the medical chart (n = 200), presence of acute osteochondral injury (n = 6), presence of hemophilic arthropathy (n = 2), presence of Panner disease (n = 1), and inadequate follow-up (n = 1). This left 45 patients for our final cohort. Of the patients included in this study, 5 (11%) had bilateral capitellar OCD. Thus, a total of 45 patients (50 elbows) with a mean follow-up period of 10.5 years (median, 10.3 years; range, 1-25 years) underwent treatment of OCD of the humeral capitellum and were included in the final analysis. There were 40 male and 10 female elbows, with a mean age of 14.6 years (range, 9-24 years) and mean body mass index of 24 (range, 18-37). Of the patients, 28 (56%) were overhead throwing athletes (Table 1). Twenty-seven elbows underwent early operative intervention, 7 were definitively managed nonoperatively, and 16 failed at least 6 months of nonoperative management before undergoing delayed surgery. The mean delay to operative intervention in the delayed-surgery cohort was 73 weeks. There were 26 elbows (52%) with a radiographic follow-up period greater than 1 year. These elbows had a mean radiographic follow-up period of 6.3 years (median, 3 years; standard deviation, 6.1 years).

Table 2. Long-Term Outcomes Comparing Patients Treated Nonoperatively and Those Treated Operatively

	Nonoperative Treatment (n = 7)	Surgery (n = 43)	*P* Value
Mean follow-up (range), yr	16.9 (3-25)	9.4 (1-24)	
Mean initial overall MEPI score (range)	71 (40-80)	69.4 (34-80)	.72
Pain score (0-45)	23.6	21	.49
ROM score (0-20)	18.6	19.3	.49
Instability score (0-10)	9.3	9	.70
Strength score (0-20)	19.1	19.9	.10
Mean final overall MEPI score (range)	83 (65-95)	89.9 (65-95)	.05*
Pain score	33	40.1	.04*
ROM score	20	20	.99
Instability score	10	9.9	.74
Strength score	20	19.9	.74
Ongoing mechanical symptoms, n (%)	3 (50)	4 (9)	.01*
Return to sport, n (%)	4 of 6 (67)	34 of 39 (87)	.20
Same or higher level	2 (33)	29 (74)	.06
Decreased level	2 (33)	5 (13)	.20
Failure to return	2 (33)	5 (13)	.20
Mean range of motion, °			
Flexion	131	141	.01*
Extension	3	3	.99
Pronation	77	79	.55
Supination	84	85	.47
Progression to osteoarthritis on radiographic follow-up > 1 yr, n (%)	1 of 4 (25)	6 of 22 (27)	.90
Mean time from symptom onset to development of osteoarthritis (range), mo	36	93.1 (14-263)	.44

MEPI, Mayo Elbow Performance Index; ROM, range of motion.
*Statistically significant.

Nonoperative Versus Operative Long-Term Outcomes

To determine whether operative management or nonoperative management led to superior long-term outcomes, data at final follow-up were compared between the definitive nonoperative cohort and patients who received surgery at any time point (Table 2). There were 7 elbows treated nonoperatively, with a mean follow-up period of 16.9 years (median, 18.2 years; range, 3-25 years), compared with 43 elbows treated operatively, with a mean follow-up period of 9.4 years (median, 8.5 years; range, 1-24 years).

The average MEPI score at final follow-up was 83 (range, 65-95) in the nonoperative cohort compared with 90 (range, 65-95) in the surgery cohort ($P = .05$). On analysis of the individual subsections of the MEPI score, pain was the only factor found to be significantly different between the 2 cohorts ($P = .04$). Persistent mechanical symptoms were reported by 3 of 6 patients (50%) in the nonoperative group compared with 4 of 43 (9%) in the surgery group ($P = .01$). Range of motion at final follow-up was also greater in the surgery cohort, with mean elbow flexion of 141° compared with 131° in the nonoperative cohort ($P = .01$). Final mean extension was nearly full in both groups (3° shy in both). Mean pronation and supination remained equivalent between the 2 groups. The rate of return to sport in the surgical group was 87% compared with 67% in the nonoperative cohort ($P = .20$). Surgical patients returned to sport at the same level or at a higher level more often than nonoperative patients (74% vs 33%), but this difference failed to reach the level of statistical significance ($P = .06$). Multiple other factors, including progression to osteoarthritis on radiographic follow-up at more than 1 year, as well as return to sport, were analyzed and failed to reach the level of significance in this study (Table 2).

Factors Predictive of Failure of Nonoperative Management

The mean age of the definitive nonoperative cohort was 12.6 years (range, 10-15 years). Patients in whom nonoperative management failed and who underwent delayed surgical intervention had a mean age of 15.2 years (range, 12-24 years; $P = .06$) (Table 3). In the nonoperative cohort, 4 lesions (67%) were considered stable, as compared with 7 lesions (44%) in the delayed-surgery cohort ($P = .33$). Takahara grading of plain radiographs in the nonoperative cohort showed 4 grade I lesions (67%), 1 grade II lesion (16%), and 1 grade III lesion (16%). Takahara grading of plain radiographs in the delayed-surgery cohort showed 4 grade 0 lesions (26%), 9 grade I lesions (60%), 2 grade II lesions (13%), and 0 grade III lesions (0%). The mean lesion diameter was 14 mm in the nonoperative cohort compared with 10 mm in the delayed-surgery cohort

Table 3. Baseline Patient Characteristics Comparing Patients Successfully Treated Nonoperatively Versus Patients in Whom Nonoperative Management Failed

	Nonoperative Treatment Successful (n = 7)	Delayed Surgery Required (n = 16)	*P* Value
Age, yr	12.6	15.2	.06
Sex			.20
Male	5 (71)	15 (94)	
Female	2 (29)	1 (6)	
BMI	24.4	23.9	.96
Overhead athlete, n (%)	3 (43)	10 (63)	.38
Ethnicity, n (%)			.50
White	7 (100)	14 (88)	
Black	0 (0)	0 (0)	
Other	0 (0)	2 (12)	
Laterality, n (%)			.67
Right	5 (71)	10 (63)	
Left	2 (29)	6 (37)	
Dominant arm, n (%)	3 (50)	9 (64)	.55
History of trauma, n (%)			.11
None	2 (29)	11 (69)	
Acute	1 (14)	0 (0)	
Remote	4 (57)	5 (31)	
Mean time from symptom onset to presentation, mo	4.6	11.8	0.17
Mechanical symptoms, n (%)	4 (57)	8 (50)	0.87
Mean range of motion, °			
Flexion	138	140	.08
Extension	5	8	.39
Pronation	76	76	.40
Supination	83	84	.67
Mean initial MEPI score	70.6	71.3	.90
Mean lesion size, mm	14.2	10.2	.10
Loose body, n (%)	1 (14)	12 (56)	.01*
Radiography	1 of 7 (14)	3 of 11 (27%)	
MRI	1 of 4 (25)	2 of 5 (40)	
CT	1 of 1 (100)	6 of 7 (86)	
Physeal status, n (%)			.83
Open	2 (33)	4 (28)	
Closed	5 (67)	12 (72)	
Lesion grade on radiograph, n			.32
0	0	4	
I	4	9	
II	1	2	
III	1	0	
Lesion stability, n (%)			.33
Stable	4 (67)	7 (44)	
Unstable	2 (33)	9 (56)	

BMI, body mass index; CT, computed tomography; MEPI, Mayo Elbow Performance Index; MRI, magnetic resonance imaging.
*Statistically significant.

($P = .1$). Multiple other factors were compared between the 2 cohorts, including presence of open physes, hand dominance, and participation in overhead throwing sports (Table 3).

The presence of an intra-articular loose body correlated with failure of nonoperative treatment ($P = .01$; odds ratio, 13). A loose body was identified in 1 elbow (14%) in the nonoperative cohort compared with 11 elbows (69%) in the delayed-surgery cohort. In the delayed-surgery cohort, these 11 elbows had intra-articular loose bodies identified at the time of surgery. Only 3 of the 11 elbows had loose bodies identified on radiographs at the time of presentation (sensitivity, 27%). Preoperative MRI identified the loose bodies in 2 of 5 elbows (sensitivity, 40%), and preoperative CT identified the loose bodies in 6 of 7 elbows (sensitivity, 86%). These numbers were too small to prove a statistically significant difference. In 4 of the 11 elbows (36%), intra-articular loose bodies were never identified on any imaging modality prior to surgery.

Delayed Versus Early Operative Intervention

Patients in whom a trial of at least 6 months of nonoperative intervention failed and who underwent

Table 4. Interventions and Final Outcomes in Patients Undergoing Delayed Versus Immediate Operative Intervention for Osteochondritis Dissecans of Humeral Capitellum

	Delayed Surgery (n = 16)	Early Surgery (n = 27)	*P* Value
Mean follow-up (range), yr	7.8 (1.7-24)	10.3 (1-21)	
Surgical approach, n (%)			
Open	1 (6)	3 (11)	
Arthroscopic	13 (81)	21 (78)	
Both	2 (13)	3 (11)	
Operative intervention, n (%)			
Debridement	14 (88)	20 (74)	
Loose body excision	12 (75)	16 (59)	
Fragment fixation	7 (44)	4 (15)	
Microfracture	9 (56)	11 (41)	
OATS	1 (6)	1 (4)	
OCA	0 (0)	3 (11)	
Concomitant procedure, n (%)	6 (38)	13 (48)	
Capsulectomy	2 (13)	2 (7)	
Synovectomy	3 (19)	7 (26)	
Plica excision	1 (6)	1 (4)	
Ulnar nerve decompression	0 (0)	1 (4)	
ICRS score, n (%)			
0	0	0	
1	3 (19)	11 (41)	
2	3 (19)	3 (11)	
3	2 (13)	2 (7.4)	
4	8 (50)	11 (41)	
Mean final overall MEPI score (range)	92 (80-95)	88.8 (65-95)	.18
Pain	42	39.1	.27
ROM	20	19.8	.74
Instability	10	9.8	.41
Strength	20	20	.99
Mean improvement from preoperative MEPI score (range)	20.7 (0-35)	21.2 (0-50)	.89
Ongoing mechanical symptoms, n (%)	0 (0)	4 (15)	.13
Return to sport, n (%)	12 of 14 (85)	22 of 24 (92)	.32
Same or higher level	11 (79)	18 (75)	.38
Decreased level	1 (7)	4 (17)	.19
Failure to return	2 (14)	3 (13)	.46
Mean range of motion, °			
Flexion	142	140	.39
Extension	3	3	.78
Pronation	81	77	.98
Supination	86	84	.34
Progression to osteoarthritis on radiographic follow-up > 1 yr, n (%)	3 of 8 (37)	3 of 14 (21)	.24
Mean time from surgery to development of osteoarthritis (range), mo	111 (14-263)	87 (24-228)	.76
Need for revision operation, n (%)	3 (19)	4 (15)	.74

ICRS, International Cartilage Repair Society; MEPI, Mayo Elbow Performance Index; OATS, osteochondral autograft transfer system; OCA, osteochondral allograft.

delayed surgery were compared with the cohort of patients who underwent early (<6 months) surgical intervention. There were 16 elbows in the delayed-surgery cohort, with a mean follow-up period of 7.8 years (median, 5.9 years; range, 1.7-24 years), compared with 27 elbows in the early-surgery cohort, with a mean follow-up period of 8.6 years (median, 11.9 years; range, 1-21 years) (Table 4). The most common operative interventions consisted of arthroscopic debridement and loose body excision. No statistically significant differences in surgical approach (open vs arthroscopic), specific procedure rate, or concomitant procedure rate were identified. MEPI scores in the delayed-surgery cohort improved from a mean of 71 preoperatively to 92 (range, 80-95) postoperatively. MEPI scores in the early-surgery cohort improved from a mean of 68 preoperatively to 89 (range, 65-95) postoperatively. No statistically significant difference was found between the delayed- and early-surgery cohorts regarding postoperative MEPI scores ($P = .18$). Revision operations were required in 4 patients (15%) in the early-surgery cohort, comprising repeated OCD debridement (n = 2), ulnar nerve transposition (n = 1), and osteocapsular arthroplasty (n = 1). Revision operations were required in 3 patients (19%) in the delayed-surgery cohort, consisting of repeated OCD debridement (n = 2) and osteocapsular arthroplasty (n = 1). Multiple other factors—including return to sport, final range of motion, and progression to osteoarthritis on radiographic follow-up at more than 1 year—were compared between the 2 groups (Table 4).

Discussion

In this study, only 14% of elbows were definitively treated nonoperatively for capitellar OCD. Overall outcomes improved in patients treated surgically and nonoperatively at a mean of 10.5 years of follow-up. However, patients treated surgically tended to have less pain, better motion, higher functional scores, and fewer mechanical symptoms than those treated without surgery. Of the 23 elbows that underwent an initial course of nonoperative treatment of at least 6 months' duration, 16 (70%) ultimately underwent surgery. Factors that most strongly correlated with failure of nonoperative treatment were older age and the presence of loose bodies. Fortunately, outcomes were still favorable for patients receiving delayed surgery, and they were comparable to those in the group receiving early surgery.

Multiple long-term outcome variables, as listed in Table 2, were investigated, and comparisons were made between the nonoperative and operative cohorts. Surgical management resulted in higher MEPI scores (7-point difference), fewer mechanical symptoms (9% vs 50%), and better final range of motion (flexion, 141° vs 131°). Previously published long-term outcomes have suggested that 50% to 56% of patients treated nonoperatively had persistent symptoms with activities of daily living at 5.2 years and 12.6 years of follow-up, which is similar to findings in our study, in which 50% of nonoperative patients reported persistent mechanical symptoms.[26-28] There is a paucity of literature regarding nonoperative range of motion or objective outcome scores, and therefore, this study helps address a critical deficit in the current literature. In this study, there were only 7 elbows that had been treated nonoperatively, and they had outcome scores and range of motion that were significantly inferior to those in the surgery group. Short- to medium-term outcomes of surgical management have shown reliable results in terms of return to sport, range of motion, and improvement in pain, but this study suggests that improvements in pain, mechanical symptoms, and motion are both durable and superior when compared with nonoperative management.[15,17,29-35] Although this study failed to show a statistically significant difference in return-to-sport rates between the 2 groups (67% in nonoperative group vs 87% in operative group), surgical patients were more likely to return to sport at the same level or at a higher level (74% vs 33%, $P = .06$). On the basis of the long-term improvements in pain, range of motion, and mechanical symptoms, as well as possible return to sport, clinicians should have a low threshold for recommending surgery to patients with persistent symptoms, potentially even those with historically stable lesions.

Various factors such as range of motion, lesion size, age, radial head enlargement, capitellar physeal status, and radiographic stage have been previously proposed as predictors of the success of nonoperative management, but the evidence remains poor and often conflicting.[11-13,27,36-39] The importance of age as well as open physes is particularly controversial, with data both in support of[12,13] and against this factor[27] as a predictor of the success of nonoperative management. This study, therefore, aimed to provide additional information in this regard. Our findings showed that younger age trended toward improved success rates for nonoperative treatment ($P = .06$). It is interesting to note that physeal status, arm dominance, radiographic stage, and overhead throwing did not have a significant impact on the success rate, although the study did not have adequate power to definitively prove or disprove these possible relationships (Table 3).

The presence of loose bodies was the greatest predictor of progression to surgery, as patients with loose bodies were more likely to undergo surgery than patients without them. Many of the loose bodies were not detected preoperatively on imaging, unless CT scans were performed. The recent literature has documented the superiority of CT over MRI for preoperative detection of loose bodies in patients with OCD of the capitellum.[40] Therefore, these data suggest that CT imaging should be performed if there is clinical concern for a loose body but it is not identified on radiography or MRI.

In this study, 16 of 23 patients (70%) who underwent a trial of nonoperative management ultimately required a delayed operation because of persistent symptoms. There is a scarcity of existing literature reporting on the failure rate of nonoperative management; however, Funakoshi et al.[13] recently reported that 49 of 97 patients (51%) who underwent a trial of nonoperative management ultimately elected to undergo surgery because of persistent symptoms. Given these high failure rates of nonoperative management, this study sought to determine whether a delay in operative intervention had a negative impact on long-term clinical outcomes. To our knowledge, no existing literature has evaluated this question. The early-surgery and delayed-surgery cohorts were compared extensively, and there were no substantial differences in terms of the types of surgical procedures performed between these groups. Long-term outcomes between the 2 groups were not statistically different, with similar improvements in the MEPI score (21 points in the early-surgery group and 21 points in the delayed-surgery group), low rates of persistent mechanical symptoms (15% and 0%, respectively), similar arcs of motion

(137° and 139°, respectively), and reasonable return-to-sport rates (92% and 85%, respectively).

Limitations

There were several limitations to this work that merit discussion. The retrospective design introduced bias when data were not accurately reported in the medical record. It may also be that patients with more severe capitellar OCD were more likely to receive an appropriate *International Classification of Diseases, Ninth Revision* or CPT code because these patients tend to present to clinicians more often. There were likely several asymptomatic or minimally symptomatic patients with capitellar OCD who never presented to a physician or who never received a formal diagnosis and, therefore, were not included in this study. Selection bias may also have impacted the results in that patients with more severe disease may have been more likely to be treated with early surgery. The uncommon nature of capitellar OCD in the study population led to a small sample size, which made it difficult to perform more robust subgroup analyses. The MEPI may not adequately represent outcomes in the study population because full points for range of motion are awarded for any arc of motion greater than 100°. This shortcoming was identified, however, and specific data regarding range of motion were reported. The REP database did not allow us to categorize specific surgical techniques used for each procedure performed in this cohort. Finally, only 52% of patients had more than 1 year of radiographic follow-up, which made it difficult to assess the prevalence of degenerative changes, including differences between groups.

Conclusions

Nonoperative management of capitellar OCD failed 70% of the time. Elbows that did not undergo surgery had slightly more symptoms and decreased functional outcomes compared with those treated surgically. The greatest predictors of failure of nonoperative treatment were older age and presence of a loose body; however, an initial trial of nonoperative treatment did not adversely impact the success of future surgery.

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Appendix Table 1. ICD-9, ICD-10 and CPT Codes Used to Identify Potential Study Patients

Code	Type	Description
M93.22	ICD-10	Osteochondritis dissecans of elbow
M93.221	ICD-10	Osteochondritis dissecans, right elbow
M93.222	ICD-10	Osteochondritis dissecans, left elbow
M93.229	ICD-10	Osteochondritis dissecans, unspecified elbow
M93.82	ICD-10	Other specified osteochondropathies of upper arm
M93.821	ICD-10	Other specified osteochondropathies, right upper arm
M93.822	ICD-10	Other specified osteochondropathies, left upper arm
M93.829	ICD-10	Other specified osteochondropathies, unspecified upper arm
M93.83	ICD-10	Other specified osteochondropathies of forearm
M93.831	ICD-10	Other specified osteochondropathies, right forearm
M93.832	ICD-10	Other specified osteochondropathies, left forearm
M93.839	ICD-10	Other specified osteochondropathies, unspecified forearm
M93.92	ICD-10	Osteochondropathy, unspecified of upper arm
M93.921	ICD-10	Osteochondropathy, unspecified, right upper arm
M93.922	ICD-10	Osteochondropathy, unspecified, left upper arm
M93.929	ICD-10	Osteochondropathy, unspecified, unspecified upper arm
M93.93	ICD-10	Osteochondropathy, unspecified of forearm
M93.931	ICD-10	Osteochondropathy, unspecified, right forearm
M93.932	ICD-10	Osteochondropathy, unspecified, left forearm
M93.939	ICD-10	Osteochondropathy, unspecified, unspecified forearm
732.3	ICD-9	Juvenile osteochondrosis of upper extremity
29830	CPT	Arthroscopy, elbow, diagnostic with or without synovial biopsy (separate procedure)
29834	CPT	Arthroscopy, elbow, surgical; with removal of loose body or foreign body
29835	CPT	Arthroscopy, elbow, surgical; synovectomy, partial
29836	CPT	Arthroscopy, elbow, surgical; synovectomy, complete
29837	CPT	Arthroscopy, elbow, surgical; debridement, limited
29838	CPT	Arthroscopy, elbow, surgical; debridement, extensive
29999	CPT	Unlisted procedure, arthroscopy
24999	CPT	Unlisted procedure, humerus or elbow

CPT, Current Procedural Terminology; ICD-9, *International Classification of Diseases, Ninth Revision*; ICD-10, *International Classification of Diseases, Tenth Revision*.