Demographics and Epidemiology of Osteochondritis Dissecans of the Elbow Among Children and Adolescents

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Background: Osteochondritis dissecans (OCD) of the elbow is a disorder of subchondral bone and articular cartilage, of which the incidence among children is not clearly known.

Purpose: To assess the demographics and epidemiology of OCD of the elbow among children.

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

Methods: A retrospective chart review of an integrated health system for the years 2007 through 2011 was performed for patients with elbow OCD aged 2 to 19 years. Lesion location, laterality, and all patient demographics were recorded. OCD incidence was determined for the group as a whole as well as by sex and age group (2-5, 6-11, 12-19 years). Patient differences based on age, sex, and ethnicity were analyzed, and multivariable logistic regression models were used to assess the risk of elbow OCD by group.

Results: A total of 37 patients with 40 OCD lesions fit the inclusion criteria. No lesion was found among 2- to 5-year-olds. A majority of lesions (n = 39, 97.5%) were in the capitellum, and 1 (2.5%) was in the trochlea. Twenty-five patients (67.6%) had right-sided lesions; 9 (24.3%), left-sided; and 3 (8.1%), bilateral. The incidence of elbow OCD for patients aged 6 to 19 years was 2.2 per 100,000 overall and 3.8 and 0.6 per 100,000 for males and females, respectively. The majority of OCD cases were seen in those aged 12 to 19 years, with an incidence of 3.4 per 100,000 versus 0.38 among 6- to 11-year-olds. Multivariable logistic regression analysis revealed a 21.7-times increased odds ratio of elbow OCD among patients aged 12 to 19 years versus 6 to 11 years, and males had a 6.8-times greater odds ratio of elbow OCD than females ($P < .0001$ for both). Based on race and ethnicity, non-Hispanic whites had the highest incidence of elbow OCD as compared with all other ethnic groups.

Conclusion: In this population-based cohort study of pediatric elbow OCD, males had almost 7 times the risk of elbow OCD as compared with females, and 12- to 19-year-olds had nearly 22 times the risk of elbow OCD versus 6- to 11-year-olds. In keeping with many prior studies, the majority of patients had right-sided lesions.

Keywords: osteochondritis dissecans; OCD; elbow; epidemiology; pediatric

Franz Konig[18] first described osteochondritis dissecans (OCD) in 1888. Incidence studies on OCD were performed by Linden[23] for OCD of the knee and by Kessler et al[14,15] on OCD of the knee and ankle. Anecdotally, elbow OCD is thought to be associated with overuse among young athletes, such as those in overhead throwing sports and gymnastics, and treatment often includes reducing stresses placed on the joint by restricting participation to allow healing. However, there are no true incidence studies on OCD of the elbow or any epidemiologic studies of this disease in a closed, self-contained population. Thus, the purpose of the present study was to evaluate the demographics and epidemiology of elbow OCD in an extremely large population-based cohort of children and adolescents in Southern California.

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METHODS

All patients aged 2 to 19 years from the entire database of patients enrolled as members of Kaiser Permanente Southern California from January 2007 until August 2011 (N = 1,068,215) were assessed per the methods described by Kessler et al[14,15] for OCD of the knee and ankle. From this population, we retrospectively reviewed the electronic health records of inpatient, outpatient, and emergency department encounters for the first occurrence of an International Classification of Diseases, Ninth Revision (ICD-9) code for elbow OCD. The ICD-9 codes used to identify patients with OCD of the elbow included 732.3, 732.7, 732.9, and 733.9. Inclusion criteria included isolated OCD lesions of the elbow among patients aged 2 to 19 years at the time of diagnosis. Exclusion criteria included osteochondral fractures, Panner disease, and all other intra-articular cartilaginous, ligamentous, or bony injuries. Radiographs were reviewed by a

TABLE 1
Demographics of Patients Included in the Elbow OCD Modeling[a]

	Total (N = 1,068,215)	No Elbow OCD (n = 1,068,178)	Elbow OCD (n = 37)	*P* Value
Ethnicity				<.0001
Non-Hispanic white	234,772 (22)	234,750 (22)	22 (59.5)	
Black	91,638 (8.6)	91,635 (8.6)	3 (8.1)	
Hispanic	492,598 (46.1)	492,589 (46.1)	9 (24.3)	
Asian/Pacific Islander	70,023 (6.6)	70,020 (6.6)	1 (2.7)	
Other	179,184 (16.8)	179,182 (16.8)	2 (5.4)	
Age, y				<.0001
Mean ± SD	11.0 ± 3.85	11.0 ± 3.85	13.8 ± 2.00	
Median	11.0	11.0	14.0	
Q1, Q3	7.0, 14.0	7.0, 14.0	13.0, 15.0	
Range	6.0-18.0	6.0-18.0	7.0-18.0	
Age group, y				<.0001
6-11	593,178 (55.5)	593,176 (55.5)	2 (5.4)	
12-19	475,037 (44.5)	475,002 (44.5)	35 (94.6)	
Sex				<.0001
Missing	22 (0.0)	22 (0.0)	0 (0.0)	
Female	533,743 (50)	533,738 (50)	5 (13.5)	
Male	534,450 (50)	534,418 (50)	32 (86.5)	
Age + sex combined				<.0001
Female 6-11	290,523 (27.2)	290,522 (27.2)	1 (2.7)	
Female 12-19	243,220 (22.8)	243,216 (22.8)	4 (10.8)	
Male 6-11	302,647 (28.3)	302,646 (28.3)	1 (2.7)	
Male 12-19	231,803 (21.7)	231,772 (21.7)	31 (83.8)	

[a]Values are presented as n (%) unless noted otherwise. *P* value based on *t* test for continuous variables and Mantel-Haenszel chi-square for categorical variables. OCD, osteochondritis dissecans; Q1, Q3, interquartile range.

fellowship-trained pediatric orthopaedic surgeon (J.M.W.) to ensure that a true OCD lesion existed. All cases of OCD identified on radiographs were confirmed with magnetic resonance imaging (MRI). It was also noted whether patients had radiographs of the contralateral elbow within 1 year before or after the diagnosis of OCD. Diagnosis of OCD was confirmed per findings of focal subchondral lucency and edema versus more diffuse necrotic lesions among younger patients, characteristic of Panner disease. Ultimately, 37 patients were found to fit the inclusion and exclusion criteria.

Patient age at diagnosis, sex, race and ethnicity, joint involvement, side involved, and specific location within the elbow were included as variables. Specific locations included the capitellum and trochlea. Age at diagnosis was obtained from enrollment records and was categorized as 2 to 5, 6 to 11, or 12 to 19 years to reflect preschool, elementary school, and middle/high school, and race/ethnicity was documented in the same manner as prior OCD epidemiology studies[14,15] (Table 1). Incidence data were calculated only for the year 2010 because (1) the transition of all Kaiser Southern California hospitals and clinics to a fully integrated electronic coding system (Current Procedural Terminology and ICD-9) was incomplete until the end of 2009 and (2) only a portion of the year 2011 was used to identify patients. All information on patient participation in competitive sports was recorded, including whether there had been an antecedent injury or trauma noted by the patient or parents prior to the onset of OCD. The specific type of trauma was recorded, as was the specific type of competitive sport.

The distribution and frequency of elbow OCD and joint location were calculated, and chi-square tests were performed to determine differences by age and sex. The associations between elbow OCD and race/ethnicity, age, and sex were assessed with multivariable logistic regression models to estimate odds ratios (ORs) and 95% CIs. An alpha level of 0.05 was used to determine statistical significance, and SAS Enterprise Guide (v 4.2; SAS Institute) was used for all analyses.

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Ethical approval for this study was obtained from a subcommittee of the Kaiser Permanente Southern California Institutional Review Board.

TABLE 2
Demographics for Patients With Elbow Osteochondritis Dissecans[a]

	Male (n = 32)	Female (n = 5)	Total (N = 37)
Age, y			
Mean ± SD	13.9 ± 1.59	13.0 ± 3.94	13.8 ± 2.00
Median	14.0	13.0	14.0
Q1, Q3	13.0, 14.5	12.0, 16.0	13.0, 15.0
Range	11.0-18.0	7.0-17.0	7.0-18.0
Side, n (%)			
Right only	23 (71.9)	2 (40)	25 (67.6)
Left only	8 (25.0)	1 (20)	9 (24.3)
Bilateral	1 (3.1)	2 (40)	3 (8.1)

[a]Q1, Q3, interquartile range.

TABLE 3
Location of Elbow Osteochondritis Dissecans by Sex and Age Group

	Sex, n (%)		Age Group, n (%)		
Location	Male (n = 33)	Female (n = 7)	6-11 y (n = 3)	12-19 y (n = 37)	Total (N = 40)
Capitellum	33 (100)	6 (85.7)	2 (66.7)	37 (100)	39 (97.5)
Humeral trochlea	0 (0)	1 (14.3)	1 (33.3)	0 (0)	1 (2.5)

RESULTS

No patients aged ≤5 years were found to have elbow OCD, and only 1 patient <10 years of age was diagnosed with elbow OCD. A total of 37 patients were found to have elbow OCD, and patient demographics are summarized in Tables 1 and 2. There were 32 male and 5 female patients, for a male:female ratio of 6.4:1. Overall, 25 (67.6%) patients had right-sided lesions; 9 (24.3%), left-sided (Table 2); and 3, bilateral (8.1%). Radiographs of the contralateral elbow within 1 year of diagnosis were available in 70% of the patients, and they demonstrated no evidence of contralateral OCD. There were 12.3 times as many OCD lesions in the 12- to 19-year-old group as in the 6- to 11-year-old group, with 37 and 3 lesions, respectively. The male:female ratio differed significantly between age groups, with 86.5% and 33.3% elbow OCD among males in the older and younger age groups, respectively ($P < .01$). The mean ± SD and median ages of disease onset for the entire group were 13.8 ± 2.0 and 14.0 years, respectively. Most lesions involved the capitellum (97.5%), with 1 involving the trochlea (2.5%) (Table 3). The location within the elbow did not differ significantly by sex, but logistic regression analysis demonstrated a significantly higher proportion of capitellar lesions in the older group versus the younger ($P = .03$).

In the analysis of sports participation and association of trauma, 31 of 37 patients were documented to participate in competitive sports (Table 4). The most common competitive sports were baseball and football, with 25% participating in baseball only, 25% in football only, and 6.25% in both. Only 10 patients (27.5% of all elbows) with OCD initially presented after having had an injury to the elbow in the prior weeks or months, after which the parents claimed the pain in the elbow began. Of note, among all 35 patients with unilateral elbow OCD, radiographs were performed because of ongoing pain. For 2 of the 3 patients with bilateral OCD, however, the findings on 1 side were purely incidental in an asymptomatic elbow. One of these 2 patients with incidentally found OCD was a competitive gymnast, whereas the second did not document participation in competitive sports.

TABLE 4
Patient-Reported Competitive Sports Participation[a]

Sport	Patients, n
Baseball	11
Football	10
Basketball	3
Biking	3
Gymnastics	2
Volleyball	1
Water polo	1
Softball	1
Judo	1
Tennis	1

[a]Two patients played both football and baseball; 1 patient played both football and basketball.

In the incidence analysis, the incidence of elbow OCD for patients aged 6 to 19 years was 2.2 per 100,000 overall (Table 5). The incidence for males was >6 times that of females, at 3.8 and 0.6 per 100,000, respectively. The older group represented the majority of elbow OCD, with an incidence of 3.4 per 100,000 among 12- to 19-year-olds versus 0.38 among 6- to 11-year-olds. Older males had the highest incidence of disease, at 6.2 per 100,000.

Logistic regression analysis further confirmed the univariate analysis. The OR of having elbow OCD was 21.7 times greater for patients aged 12 to 19 years compared with patients aged 6 to 11 years ($P < .0001$; 95% CI, 5.2-90.3) (Table 6). In addition, the odds of a male having elbow OCD was 6.8 times greater than that of females ($P < .0001$; 95% CI, 2.6-17.4). Consistent with this, older males had the highest risk of OCD, with ORs of 39.0 and 37.1 as compared with 6- to 11-year-old males and females, respectively ($P = .0003$ and $.0004$; 95% CI, 5.3-285.8 and 5.1-272.1). The OR was also higher for older males versus older females (OR, 8.2; $P < .0001$; 95% CI, 2.9-23.3).

In the OR analysis done by race and ethnicity, the risk of elbow OCD was greatest for non-Hispanic whites, who had 4.4 and 9.4 times the risk of elbow OCD as compared with Hispanics ($P = .0002$; 95% CI, 2.0-9.6) and those with unknown/other ethnicity ($P = .003$; 95% CI, 2.2-39.8), respectively. The risk for non-Hispanic whites trended toward being greater than that for Asians and blacks but did not reach statistical significance ($P = .09$ for both) (Table 6). Incidence analysis by ethnicity confirmed the highest incidence for non-Hispanic whites, at 7.4 per 100,000 (Table 7).

TABLE 5
Incidence Rates for Osteochondritis Dissecans of the Elbow by Age for 2010

	Incidence			Incidence Population			Incidence Rates (per 100,000)		
Age Group, y	Female	Male	Total	Female	Male	Total	Female	Male	Total
6-11	1	0	1	129,175	135,611	264,786	0.8	0.0	0.4
12-19	1	13	14	203,038	209,426	412,464	0.5	6.2	3.4
6-19	2	13	15	332,213	345,037	677,250	0.6	3.8	2.2

TABLE 6
Multiple Logistic Regression Models for Elbow Osteochondritis Dissecans

Contrast[a]	Odds Ratio (95% CI)	*P* Value[b]
White vs		
Asian	5.62 (0.76-41.67)	.09
Black	2.80 (0.84-9.37)	.09
Hispanic	4.41 (2.03-9.58)	.0002
Other	9.35 (2.20-39.77)	.003
Black vs		
Hispanic	1.57 (0.43-5.81)	.50
Asian	2.00 (0.21-19.26)	.55
Asian vs Hispanic	0.79 (0.10-6.20)	.82
12-19 males vs		
6-11 males	39.00 (5.32-285.8)	.0003
6-11 females	37.13 (5.07-272.1)	.0004
12-19 females	8.24 (2.91-23.34)	<.0001
6-11 males vs 6-11 females	0.95 (0.06-15.22)	.97
12-19 vs 6-11	21.70 (5.21-90.29)	<.0001
Males vs females	6.76 (2.64-17.36)	<.0001

[a]Age groups are indicated by year range: 6-11 and 12-19.
[b]*P* value indicates the significance of the effect in predicting elbow osteochondritis dissecans.

DISCUSSION

Takahara et al[40] provided the largest study on OCD of the elbow, reporting on 106 patients. Their study was a retrospective review to assess treatment outcomes, which found that patients with open capitellar growth plates healed completely with rest. The Takahara et al[40] study, however, included a mixture of children and adults. In addition, this and all other studies of elbow OCD failed to assess the incidence of disease or demographics in a self-contained population.

The present study found a lower incidence of elbow OCD as compared with the incidences of knee OCD in the studies of Linden[23] and Kessler et al[14] and ankle OCD in the study by Kessler et al.[15] In terms of sex, prior literature on elbow OCD among children and adults has demonstrated a predilection toward males.[¶] The present epidemiology study clearly confirms this finding, with a 6.4:1 male:female ratio and a 6.8-times greater OR of disease among males. In terms of age of presentation, the majority of studies have shown that elbow OCD among children usually occurs at ≥10 years.[#] The present study unequivocally confirms that older children have the higher frequency of the disease, with a nearly 22-times increased risk of OCD among 12- to 19-year-olds versus 6- to 11-year-olds.

Prior studies on laterality have indicated that OCD tends to affect the right elbow more frequently.[**] Our study also demonstrates this right-side dominance, with just over two-thirds of patients having right elbow OCD, with a relatively low incidence of bilateral disease. We assume that the right-sided dominance is due to the fact that the majority of the population is right-handed. In terms of location of elbow OCD, the literature has consistently shown that lesions are usually in the capitellum.[††] Our epidemiologic study supports this, with 97.5% of the sample having capitellar lesions and only 2.5% (1 patient) having a trochlear location. In addition, our study supports the findings of many prior studies on elbow OCD suggesting that these injuries tend to occur among patients who participate in competitive sports,[‡‡] although rarely is the OCD related to an actual acute injury. We suspect that development of elbow OCD may be related to the repetitive microtrauma produced during activities such as gymnastics or overhead throwing (baseball and football). The adolescent-male, dominant-sided predilection for elbow OCD could then be explained by increased participation in competitive sports during an important stage in joint development.

Little is known about the association between race/ethnicity and OCD of the elbow. The present study sheds light on the risk of elbow OCD by ethnicity and, to our knowledge, is the first to do so. The logistic regression analysis demonstrated that, as with ankle OCD,[15] non-Hispanic whites have a higher risk of disease as compared with all other races/ethnicities, although it is important to note that this risk did not reach statistical significance when compared with Asians, blacks, and Hispanics individually. The increased risk of elbow OCD among whites was confirmed by the incidence analysis.

Our study has a number of weaknesses. Similar to our prior studies on ankle[15] and knee OCD,[14] the incidence data were obtained only from 2010, while the demographic/epidemiological data were obtained from January 2007 to August 2011 (for reasons cited previously). True

[¶]References 1-4, 8, 12, 13, 16, 21, 26, 27, 32-34, 36, 37, 41, 42, 45.

[#]References 1-5, 9-13, 16, 17, 20-22, 24-26, 28-30, 32-46, 48-50.
[**]References 2-5, 12, 13, 22, 24, 26, 28, 30, 32, 36, 45, 48, 50.
[††]References 1-4, 12, 13, 16, 22, 24, 26-28, 30, 32-34, 36, 37, 41, 42, 45, 48, 50.
[‡‡]References 2-7, 9, 13, 19, 25, 31, 37, 45, 47.

TABLE 7
Incidence Rates for Elbow Osteochondritis Dissecans by Ethnicity for 2010

	Incidence			Incidence Population			Incidence Rates (per 100,000)		
Ethnicity	Female	Male	Total	Female	Male	Total	Female	Male	Total
Non-Hispanic white	2	8	10	66,183	69,175	135,359	3.0	11.6	7.4
Black	0	1	1	28,417	28,581	56,999	0.0	3.5	1.8
Hispanic	1	4	5	143,608	147,194	290,802	0.7	2.7	1.7

incidence may be underestimated, as some lesions may remain asymptomatic and go undiagnosed. Other weaknesses include the retrospective nature of the study and the fact that in the multivariable logistic regression modeling by ethnicity/race, socioeconomic status, and sports participation measures were not assessed as potential confounders. In addition, our population demographics may not be representative of other populations, and the small numbers of certain ethnic groups in our study may limit the extrapolations that can be made.

CONCLUSION

The present study represents the first and only true incidence and epidemiologic study of OCD of the elbow among patients aged $\leq$19 years. Similar to our prior study of knee OCD[14] and in contrast to our study of ankle OCD,[15] males were found to have an increased incidence of disease and a significantly increased risk of elbow OCD as compared with females. However, similar to both these studies, teenagers had a markedly increased risk of disease versus younger patients. In addition, this study demonstrates that, as with ankle OCD, non-Hispanic whites have the highest incidence of elbow OCD.

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REFERENCES

1. Ansah P, Vogt S, Ueblacker P, Martinek V, Woertler K, Imhoff AB. Osteochondral transplantation to treat osteochondral lesions in the elbow. *J Bone Joint Surg Am*. 2007;89(10):2188-2194.
2. Bauer M, Jonsson K, Josefsson PO, Linden B. Osteochondritis dissecans of the elbow: a long-term follow-up study. *Clin Orthop Relat Res*. 1992;(284):156-160.
3. Baumgarten TE, Andrews JR, Satterwhite YE. The arthroscopic classification and treatment of osteochondritis dissecans of the capitellum. *Am J Sports Med*. 1998;26(4):520-523.
4. Bojanic I, Smoljanovic T, Dokuzovic S. Osteochondritis dissecans of the elbow: excellent results in teenage athletes treated by arthroscopic debridement and microfracture. *Croat Med J*. 2012;53(1):40-47.
5. Byrd JW, Jones KS. Arthroscopic surgery for isolated capitellar osteochondritis dissecans in adolescent baseball players: minimum three-year follow-up. *Am J Sports Med*. 2002;30(4):474-478.
6. de Graaff F, Krijnen MR, Poolman RW, Willems WJ. Arthroscopic surgery in athletes with osteochondritis dissecans of the elbow. *Arthroscopy*. 2011;27(7):986-993.
7. Hennrikus WP, Miller PE, Micheli LJ, Waters PM, Bae DS. Internal fixation of unstable in situ osteochondritis dissecans lesions of the capitellum. *J Pediatr Orthop*. 2015;35(5):467-473.
8. Holland P, Davies AM, Cassar-Pullicino VN. Computed tomographic arthrography in the assessment of osteochondritis dissecans of the elbow. *Clin Radiol*. 1994;49(4):231-235.
9. Iwasaki N, Kato H, Ishikawa J, Masuko T, Funakoshi T, Minami A. Autologous osteochondral mosaicplasty for osteochondritis dissecans of the elbow in teenage athletes. *J Bone Joint Surg Am*. 2009;91(10):2359-2366.
10. Iwasaki N, Kato H, Ishikawa J, Saitoh S, Minami A. Autologous osteochondral mosaicplasty for capitellar osteochondritis dissecans in teenaged patients. *Am J Sports Med*. 2006;34(8):1233-1239.
11. Iwasaki N, Kato H, Kamishima T, Minami A. Sequential alterations in magnetic resonance imaging findings after autologous osteochondral mosaicplasty for young athletes with osteochondritis dissecans of the humeral capitellum. *Am J Sports Med*. 2009;37(12):2349-2354.
12. Jans LB, Ditchfield M, Anna G, Jaremko JL, Verstraete KL. MR imaging findings and MR criteria for instability in osteochondritis dissecans of the elbow in children. *Eur J Radiol*. 2012;81(6):1306-1310.
13. Jones KJ, Wiesel BB, Sankar WN, Ganley TJ. Arthroscopic management of osteochondritis dissecans of the capitellum: mid-term results in adolescent athletes. *J Pediatr Orthop*. 2010;30(1):8-13.
14. Kessler JI, Nikizad H, Shea KG, Jacobs JC Jr, 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. Kessler JI, Weiss JM, Nikizad H, et al. Osteochondritis dissecans of the ankle in children and adolescents: demographics and epidemiology. *Am J Sports Med*. 2014;42(9):2165-2171.
16. Kijowski R, De Smet AA. MRI findings of osteochondritis dissecans of the capitellum with surgical correlation. *AJR Am J Roentgenol*. 2005;185(6):1453-1459.
17. Kiyoshige Y, Takagi M, Yuasa K, Hamasaki M. Closed-wedge osteotomy for osteochondritis dissecans of the capitellum: a 7- to 12-year follow-up. *Am J Sports Med*. 2000;28(4):534-537.
18. Konig F. Ueber freie Korper in den Glenken. *Zeiteschr Chir*. 1888;27:90-109.
19. Kosaka M, Nakase J, Takahashi R, et al. Outcomes and failure factors in surgical treatment for osteochondritis dissecans of the capitellum. *J Pediatr Orthop*. 2013;33(7):719-724.
20. Krijnen MR, Lim L, Willems WJ. Arthroscopic treatment of osteochondritis dissecans of the capitellum: report of 5 female athletes. *Arthroscopy*. 2003;19(2):210-214.
21. Kusumi T, Ishibashi Y, Tsuda E, et al. Osteochondritis dissecans of the elbow: histopathological assessment of the articular cartilage and subchondral bone with emphasis on their damage and repair. *Pathol Int*. 2006;56(10):604-612.
22. Kuwahata Y, Inoue G. Osteochondritis dissecans of the elbow managed by Herbert screw fixation. *Orthopedics*. 1998;21(4):449-451.
23. Linden B. The incidence of osteochondritis dissecans in the condyles of the femur. *Acta Orthop Scand*. 1976;47(6):664-667.

24. McManama GB Jr, Micheli LJ, Berry MV, Sohn RS. The surgical treatment of osteochondritis of the capitellum. *Am J Sports Med*. 1985; 13(1):11-21.
25. Mihara K, Suzuki K, Makiuchi D, Nishinaka N, Yamaguchi K, Tsutsui H. Surgical treatment for osteochondritis dissecans of the humeral capitellum. *J Shoulder Elbow Surg*. 2010;19(1):31-37.
26. Mitsunaga MM, Adishian DA, Bianco AJ Jr. Osteochondritis dissecans of the capitellum. *J Trauma*. 1982;22(1):53-55.
27. Miyake J, Masatomi T. Arthroscopic debridement of the humeral capitellum for osteochondritis dissecans: radiographic and clinical outcomes. *J Hand Surg Am*. 2011;36(8):1333-1338.
28. Nishimura A, Morita A, Fukuda A, Kato K, Sudo A. Functional recovery of the donor knee after autologous osteochondral transplantation for capitellar osteochondritis dissecans. *Am J Sports Med*. 2011;39(4): 838-842.
29. Oka Y, Ohta K, Fukuda H. Bone-peg grafting for osteochondritis dissecans of the elbow. *Int Orthop*. 1999;23(1):53-57.
30. Ovesen J, Olsen BS, Johannsen HV. The clinical outcomes of mosaicplasty in the treatment of osteochondritis dissecans of the distal humeral capitellum of young athletes. *J Shoulder Elbow Surg*. 2011; 20(5):813-818.
31. Rahusen FT, Brinkman JM, Eygendaal D. Results of arthroscopic debridement for osteochondritis dissecans of the elbow. *Br J Sports Med*. 2006;40(12):966-969.
32. Roberts N, Hughes R. Osteochondritis dissecans of the elbow joint; a clinical study. *J Bone Joint Surg Br*. 1950;32(3):348-360.
33. Ruch DS, Cory JW, Poehling GG. The arthroscopic management of osteochondritis dissecans of the adolescent elbow. *Arthroscopy*. 1998;14(8):797-803.
34. Satake H, Takahara M, Harada M, Maruyama M. Preoperative imaging criteria for unstable osteochondritis dissecans of the capitellum. *Clin Orthop Relat Res*. 2013;471(4):1137-1143.
35. Sato K, Nakamura T, Toyama Y, Ikegami H. Costal osteochondral grafts for osteochondritis dissecans of the capitulum humeri. *Tech Hand Up Extrem Surg*. 2008;12(2):85-91.
36. Schoch B, Wolf BR. Osteochondritis dissecans of the capitellum: minimum 1-year follow-up after arthroscopic debridement. *Arthroscopy*. 2010;26(11):1469-1473.
37. Shi LL, Bae DS, Kocher MS, Micheli LJ, Waters PM. Contained versus uncontained lesions in juvenile elbow osteochondritis dissecans. *J Pediatr Orthop*. 2012;32(3):221-225.
38. Shimada K, Tanaka H, Matsumoto T, et al. Cylindrical costal osteochondral autograft for reconstruction of large defects of the capitellum due to osteochondritis dissecans. *J Bone Joint Surg Am*. 2012; 94(11):992-1002.
39. Shimada K, Yoshida T, Nakata K, Hamada M, Akita S. Reconstruction with an osteochondral autograft for advanced osteochondritis dissecans of the elbow. *Clin Orthop Relat Res*. 2005;(435):140-147.
40. Takahara M, Mura N, Sasaki J, Harada M, Ogino T. Classification, treatment, and outcome of osteochondritis dissecans of the humeral capitellum. *J Bone Joint Surg Am*. 2007;89(6):1205-1214.
41. Takahara M, Ogino T, Fukushima S, Tsuchida H, Kaneda K. Nonoperative treatment of osteochondritis dissecans of the humeral capitellum. *Am J Sports Med*. 1999;27(6):728-732.
42. Takahara M, Ogino T, Sasaki I, Kato H, Minami A, Kaneda K. Long term outcome of osteochondritis dissecans of the humeral capitellum. *Clin Orthop Relat Res*. 1999;(363):108-115.
43. Takahara M, Ogino T, Tsuchida H, Takagi M, Kashiwa H, Nambu T. Sonographic assessment of osteochondritis dissecans of the humeral capitellum. *AJR Am J Roentgenol*. 2000;174(2):411-415.
44. Takeda H, Watarai K, Matsushita T, Saito T, Terashima Y. A surgical treatment for unstable osteochondritis dissecans lesions of the humeral capitellum in adolescent baseball players. *Am J Sports Med*. 2002;30(5):713-717.
45. Tis JE, Edmonds EW, Bastrom T, Chambers HG. Short-term results of arthroscopic treatment of osteochondritis dissecans in skeletally immature patients. *J Pediatr Orthop*. 2012;32(3):226-231.
46. Tivnon MC, Anzel SH, Waugh TR. Surgical management of osteochondritis dissecans of the capitellum. *Am J Sports Med*. 1976;4(3): 121-128.
47. Vezeridis AM, Bae DS. Evaluation of knee donor and elbow recipient sites for osteochondral autologous transplantation surgery in capitellar osteochondritis dissecans. *Am J Sports Med*. 2016;44(2):511-520.
48. Woodward AH, Bianco AJ Jr. Osteochondritis dissecans of the elbow. *Clin Orthop Relat Res*. 1975;(110):35-41.
49. Wulf CA, Stone RM, Giveans MR, Lervick GN. Magnetic resonance imaging after arthroscopic microfracture of capitellar osteochondritis dissecans. *Am J Sports Med*. 2012;40(11):2549-2556.
50. Yamamoto Y, Ishibashi Y, Tsuda E, Sato H, Toh S. Osteochondral autograft transplantation for osteochondritis dissecans of the elbow in juvenile baseball players: minimum 2-year follow-up. *Am J Sports Med*. 2006;34(5):714-720.