CT Sagittal Image Evaluation for Osteochondritis Dissecans of the Elbow Correlates with Clinical Outcomes of Arthroscopic Debridement in Adolescent Baseball Players

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Abstract

Objectives: To investigate the relationship between size and location of osteochondral defects in capitellar osteochondritis dissecans (OCD) measured on coronal and sagittal reconstructed computed tomography (CT) images and the clinical outcomes of arthroscopic debridement in adolescent baseball players.

Methods: Retrospective study of clinical outcomes of arthroscopic debridement for capitellar OCD in adolescent baseball players with at least 24 months of follow-up after surgery between 2008 and 2020. Outcome measures were determined using the Timmerman–Andrews score at the latest follow-up. On a preoperative reconstructed CT coronal image, defect size (%) was described as the length of the defect relative to the length of the capitellum. On a preoperative reconstructed CT sagittal image, the superior and inferior angles (degrees) were used to describe the location of the defect. Defect angle (degrees) was used to describe the size of the defect on the sagittal plane. Spearman's rank correlation coefficient was used to examine the relationship between the Timmerman–Andrews score and each of the following parameters: defect size, superior and inferior angles, and defect angle, and also the relationship between each sub-score and the parameters. Significance was established at $p < 0.05$.

Results: Twenty-nine players (mean age, 14 [range, 11-16] years) underwent arthroscopic

debridement. 5 were pitchers, 6 were catchers, 13 were infielders, and 5 were outfielders. Mean follow-up duration was 26 (range, 24-66) months. Timmerman–Andrews score at the latest follow-up was 188 (range, 165-200) points. Mean defect size was 44.64% (range, 22.60%-68.21%). Mean superior angle was 91.82 (range, 69.80-110.90) degrees, mean inferior angle was 22.41 (range, -32.53-55.33) degrees, and mean defect angle was 69.41 (range, 47.40-135.04) degrees. Timmerman–Andrews score was positively correlated with the inferior angle ($r=0.494$, $p<0.01$) and negatively correlated with the defect angle ($r= -0.431$, $p=0.020$). For each sub-score considered, pain and sagittal arc of motion were positively correlated with the inferior angle ($r=0.467$, $p=0.011$, $r=0.387$, $p=0.038$), and flexion contracture was negatively correlated with the defect angle ($r=-0.398$, $p=0.033$).

Conclusion: Posterior or large osteochondral defects of the humeral capitellum on preoperative reconstructed CT sagittal images were associated with poor outcomes of arthroscopic debridement for capitellar OCD in adolescent baseball players.

Level of evidence: Level IV, Case series.

What are the new findings

・In arthroscopic debridement for capitellar OCD, posterior defects of the humeral capitellum on preoperative reconstructed CT sagittal images were more likely to cause postoperative pain and restrict the sagittal arc of motion.

・Large osteochondral defects on the sagittal images were more likely to correlate with postoperative flexion contracture.

・Defect size on coronal images and anterior defects of the humeral capitellum on sagittal images showed no correlation with clinical outcomes.

Introduction

Capitellar osteochondritis dissecans (OCD) tends to affect young athletes, especially baseball players. There is general agreement that capitellar OCD can result from repetitive loading to an area of the humerus with poor blood flow. [1, 2] Compressive and shear forces are thought to cause noninflammatory degeneration of the subchondral bone. Conservative treatment is recommended for early-stage OCD, such as immediate cessation of throwing and batting. [3, 4] Surgical indications include persistent symptoms recalcitrant to nonoperative treatment, symptomatic loose bodies, and displacement or detachment of fragments. [2, 4] Several surgical treatments have been reported, including arthroscopic debridement and loose body removal, [5-9] fragment fixation, [10] bone peg fixation, [11, 12] and osteochondral autologous transplantation. [13-16]

The surgical approach for capitellar OCD is determined from the findings of imaging studies that evaluate the size of the lesion, [17, 18] presence of loose bodies, [4, 5] involvement of the lateral wall, [5, 19] and stability of the lesion. [2, 20] Arthroscopic debridement tends to be performed when the osteochondral defect is small and unstable, and good results have been reported. [21, 22] More recently, favorable results of arthroscopic debridement have also been reported for large defects. [5, 7, 23] This difference in reported results may be the variety of imaging modalities, such as plain radiography, computed tomography (CT), and magnetic resonance imaging (MRI), and the inconsistent evaluation of the lesion.

Previous studies have comprehensively evaluated the size of capitellar OCD defects in both the coronal and sagittal planes and discussed its association with clinical outcomes, [5, 7, 21, 23] but few have focused on the location of the defect in the sagittal plane. Thus, prognostic factors for arthroscopic debridement remain controversial. The purpose of this imaging study using reconstructed CT images was to investigate the relationship of defect size and location, determined in the sagittal plane, with clinical outcomes.

Methods

This study was a retrospective evaluation of the clinical outcomes of arthroscopic debridement for capitellar OCD in adolescent baseball players seen at a single institution between 2008 and 2020. Patients were included in the study if they had undergone arthroscopic debridement and loose body removal for capitellar OCD and were followed up for more than 24 months after surgery. Patients were excluded if they were aged >19 years, had undergone previous elbow surgery or other treatment such as other cartilage restoration procedures, or had previous trauma to the elbow. Indications for arthroscopic debridement were no improvement after at least 6 months of nonoperative treatment (including the immediate cessation of throwing and batting), severe locking or catching phenomenon with evidence of unstable fragments in the elbow.

Operative Technique

General anesthesia or axillary block was administered, and the patient was placed in the supine position. Two 2.9-mm arthroscopes of 30° and 70° were used. Arthroscopic debridement for capitellar OCD require 2 anterior portals (superomedial and anterolateral) and 2 posterior portals (direct lateral and posterolateral). Loose bodies were removed using a grasper. All unstable cartilage of the capitellar lesion was removed using a grasper and shaver in tandem to create a stable bed. A ringed curette was coupled to create a stable, perpendicular rim of healthy surrounding cartilage. The inflow was then turned off to verify the efflux of blood and marrow in the lesion bed. If sclerotic changes in the lesion bed were observed, the bed was drilled with a Kirschner wire. The inflow was then turned off to verify the efflux of blood and marrow in each drill hole. [23]

Postoperative Rehabilitation

Splinting was recommended for the first 7 to 10 days postoperatively. Physical therapy was then started and the patient was instructed in full active and active assisted range of motion (ROM) in all planes (flexion, extension, pronation, and supination). No continuous passive

motion devices were used. Patients were instructed to avoid any activity that placed stress on the articular surface for the first 3 months postoperatively, such as throwing or other activities that would exert valgus force on the lateral articular surface in compression. A throwing program was typically initiated 3 months later, anticipating a usual return to participation in baseball at 4 to 5 months. [23]

Clinical Evaluation

Patients were evaluated at the latest follow-up in the clinic by the same orthopaedic surgeon (T.M.). They were examined for presence of pain, inflammation (effusion), and ROM (flexion, extension, pronation, and supination). ROM was measured in degrees using a handheld goniometer. Outcome measures were determined using the postoperative Timmerman–Andrews score, [24] which evaluates both subjective and objective criteria.

Radiographic Assessment

CT scans of the affected elbow were obtained before surgical treatment. On a preoperative reconstructed CT coronal image in a plane at 45 degrees to the brachial axis, the defect size (%) was defined as the length of the defect relative to the length of the capitellum. On a preoperative reconstructed CT sagittal image, the location of the defect was determined in relation to the superior and inferior angles (degrees), which are defined as shown in Fig. 1. The defect angle (degrees) was used to describe the size of the defect in the sagittal plane and was defined as the inferior angle subtracted from the superior angle (Fig. 1).

All scans were analyzed by the same orthopaedic surgeon (K.Y.). Intraclass correlation coefficients were used to evaluate the intraexaminer reproducibility of measurements of the defect size and defect angle.

Statistical Analysis

Spearman's rank correlation coefficient was used to examine the relationship between the Timmerman–Andrews score and each of the following parameters: defect size, superior and inferior angles, and defect angle, and also the relationship between each sub-score and the

parameters. Correlation was considered significant at $p < 0.05$. Statistical analysis was performed using SPSS version 23 (IBM Corporation, Armonk, NY, USA).

Results

In total, 56 baseball players aged 11 to 16 years underwent operative treatment for capitellar OCD between 2008 and 2020 at a single institution. Forty-five of these patients underwent arthroscopic debridement with or without drilling and loose body removal, 8 underwent osteochondral autologous transplantation, 2 underwent fragment fixation, and 1 underwent microfracture. Sixteen of the 45 players could no longer be contacted, leaving 29 patients (64.4%) who had been followed up for a minimum of 24 months for analysis. Of these, 5 were pitchers, 6 were catchers, 13 were infielders, and 5 were outfielders. All were male, with a mean age of 14 (range, 11-16) years at the time of surgery. Surgical management was conducted or supervised by an experienced orthopedic surgeon (M.T.). Mean duration of clinical follow-up was 26 (range, 24-66) months. The lesion was in the dominant arm in all patients (28 right and 1 left). The clinical data for the 29 patients are summarized in Table 1.

No postoperative complications were observed during the study period, such as hemarthrosis, infection, or persistent nerve injury. Preoperatively, all patients played competitive baseball at the high or junior high school level and presented with a history of difficulty in throwing.

Twenty of the 29 patients (69.0%) reported no elbow pain at the latest follow-up. Nine patients (31.0%) experienced pain; 7 occasional pain and 2 pain with moderate activity. None presented with swelling. One patient reported instances of locking or catching after surgery. Flexion contracture was <5 degrees in 16 patients and 5-15 degrees in 13 patients. One patient had a < 30% decrease in ROM for pronation and supination. Sagittal arc of motion was >130 degrees in 14 patients, 120-130 degrees in 12 patients, and 110-119 degrees in 3 patients. The postoperative score-based assessment was excellent for 24 patients and good for 5 patients at the latest follow-up.

CT scans of the affected elbow were obtained at 24±22 days preoperatively. The mean inter-rater intraclass correlation coefficient for defect size was 0.85 (range, 0.68-0.93) and that for defect angle was 0.88 (range, 0.75-0.95) (K.Y. and J.I.). On preoperative CT coronal images, the mean defect size was 44.64% (range, 22.60%-68.21%). On preoperative CT sagittal images, the mean superior angle was 91.82 (range, 69.80-110.90) degrees, mean inferior angle was 22.41 (range, -32.53-55.33) degrees, and mean defect angle was 69.41 (range, 47.40-135.04) degrees.

Tables 2-5 summarize the relationship between CT image measurement and clinical outcome. Timmerman–Andrews score at the latest follow-up was 188 (range, 165-200) points. Timmerman–Andrews score was not correlated with defect size (r_s = -0.229, p = 0.231) or superior angle (r_s = -0.016, p = 0.934), but was positively correlated with inferior angle (r_s = 0.494, $p < 0.01$) and negatively correlated with defect angle (r_s = -0.431, p = 0.020). For each sub-score considered, pain and sagittal arc of motion were positively correlated with inferior angle (r_s = 0.467, p = 0.011, r_s =0.387, p = 0.038), and flexion contracture was negatively correlated with the defect angle (r_s =-0.398, p = 0.033). None of sub-scores were correlated with defect size or the superior angle.

Discussion

This study reports on the relationship between size and location of osteochondral defects measured by reconstructed CT coronal and sagittal images and the Timmerman–Andrews score in 29 baseball players with capitellar OCD. The most important finding of this study was that, at an average follow-up of 26 months, posterior or large defects in the sagittal plane were correlated with poor outcomes of arthroscopic debridement. In addition, the size of the defect in the coronal plane and an anterior defect in the sagittal plane were not correlated with the clinical results.

Several studies have evaluated the overall defect size in the coronal and sagittal planes.

Takahara et al. [21] measured the defect on plain radiographs in 39 patients who underwent open surgery, with an average follow-up of 12.6 years. They reported poor results in 7 of 7 patients with large lesions and 6 of 25 patients with small or moderate lesions, suggesting larger defects are associated with poorer postoperative outcomes. However, other studies have reported no relationship between size and postoperative outcomes; Matsuura et al. [23] reported on 23 baseball players who underwent arthroscopic debridement with or without drilling, with an average follow-up of 12.6 years, and evaluated the defect with plain radiography. They found no significant association between defect size and Timmerman–Andrews score, and fielders had a high return-to-play rate. Bexkens et al. [5] evaluated lesions by CT and MRI and found no difference in patient satisfaction in 77 patients who underwent arthroscopic surgery. Lewine et al. [7] measured lesion size by MRI and found no difference in clinical outcomes in 21 patients who underwent arthroscopic surgery. This variance in the reported results could be due to the imaging modality used to assess the defect and the measurement method used. To examine the relationship between defects and clinical outcomes, it is necessary to exactly measure the size and location of the defects in imaging studies.

Imaging modalities to evaluate lesions include plain radiography, CT, and MRI. Using plain radiography, Michael et al. [25] demonstrated a sensitivity for capitellar OCD of 85.1% in conventional AP and 73.2% in conventional lateral views, with corresponding substantial (κ = 0.65) and moderate (κ = 0.60) inter-rater reliability. It indicated that the defect measurement from lateral view was inaccurate. Muller et al. [26] measured the size of capitellar OCD lesions by plain radiography, CT, and MRI, and found CT and MRI superior to plain radiography. In addition, MRI tended to overestimate defects on T1-weighted images and underestimate defects on T2-weighted images, with osteochondral defects better confirmed by CT. Thus, CT has afforded more detailed information about these defects.

Previous studies have comprehensively measured capitellar OCD defects in the coronal and sagittal planes. [5, 7, 21, 23] , but the location of the defects was not examined. Furthermore,

to gain a more detailed understanding of the relationship between defects and clinical outcomes, it would be beneficial to measure defects in the coronal and sagittal planes separately. In the coronal plane, the size of the defect did not correlate with either the subjective or objective criteria of the Timmerman–Andrews score. Ueda et al. [9] measured the capitellar OCD defects of 38 athletes in the coronal plane on CT and found that although there was no difference in functional scores by size at a mean follow-up of 8 years, those with larger defects had lower patient satisfaction. Their study included 7 gymnasts who were prone to heavy loading on the elbow, which may have made a difference in the results. It is also controversial whether involvement of the lateral wall is also a factor in poor postoperative outcomes. [7, 19, 27] In other words, in the coronal plane, not only the size of the defect but also involvement of the lateral wall may influence clinical outcomes. Comprehensively evaluating both factors could prove useful. In the sagittal plane, our study showed that the size and location of the defect influenced clinical outcomes. Thus, location as well as size of the lesion should be considered in treatment planning.

CT is useful for accurately evaluating the defect in the sagittal plane, but it comes at the cost of a higher radiation dose. CT has a radiation dose of approximately 0.21 mSv (with the arm above the head), [28] compared with 0.01 mSv for plain radiography [29] and no exposure with MRI. The dose of elbow CT is about 7% of the average background radiation exposure for an individual (3 mSv/y). [30] We believe that the advantages of CT for capitellar OCD in adolescent baseball players exceed the disadvantages of moderate radiation doses. The detailed location and size of the defect in the sagittal plane obtained from CT can play an important role in surgical planning and preparation.

In the surgical treatment of capitellar OCD, osteochondral autologous transplantation tends to be performed on larger defects. [15, 31-33] The results of our study suggest that less invasive arthroscopic debridement with technically straightforward procedures, with minimal complications, may yield good results, depending on the location and size of the defect in the

preoperative CT sagittal plane.

This study has some limitations. First, preoperative evaluation of elbow function could have been more comprehensive and meant that we could not fully compare preoperative with postoperative elbow function. Second, this is a small case series with no long-term follow-up. Studies with greater numbers of patients over longer follow-up periods are warranted. Third, postoperative imaging findings were not evaluated. Progression of osteoarthritis is a long-term concern after surgical treatment, and the clinical significance of these findings and postoperative results needs to be clarified in future studies.

Conclusion

In arthroscopic debridement for capitellar OCD, posterior defects of the humeral capitellum on preoperative reconstructed CT sagittal images were more likely to be associated with postoperative pain and to restrict the sagittal arc of motion. Large osteochondral defects on preoperative reconstructed CT sagittal images were more likely to be associated with postoperative flexion contracture. These findings on preoperative reconstructed CT sagittal images were associated with poor outcomes of arthroscopic debridement for capitellar OCD in adolescent baseball players.

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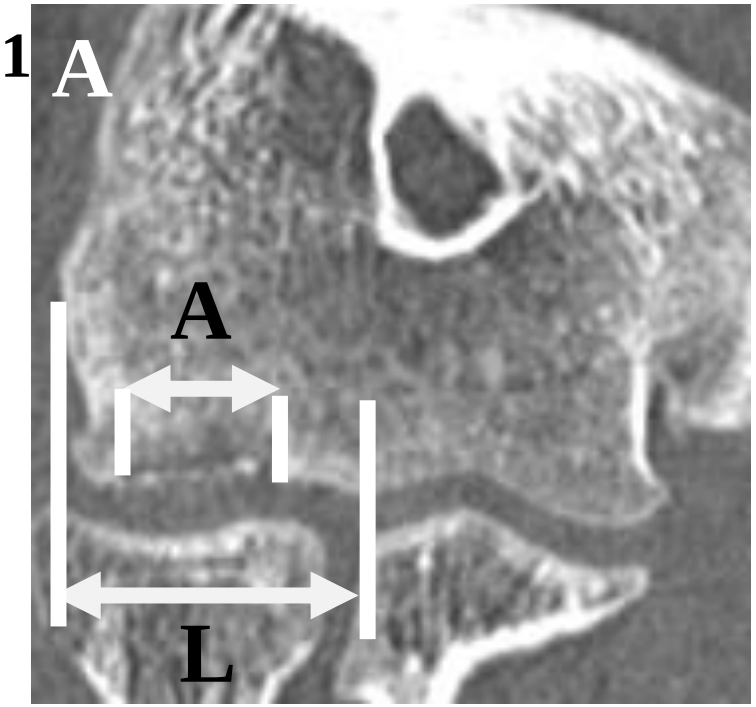
Fig.1



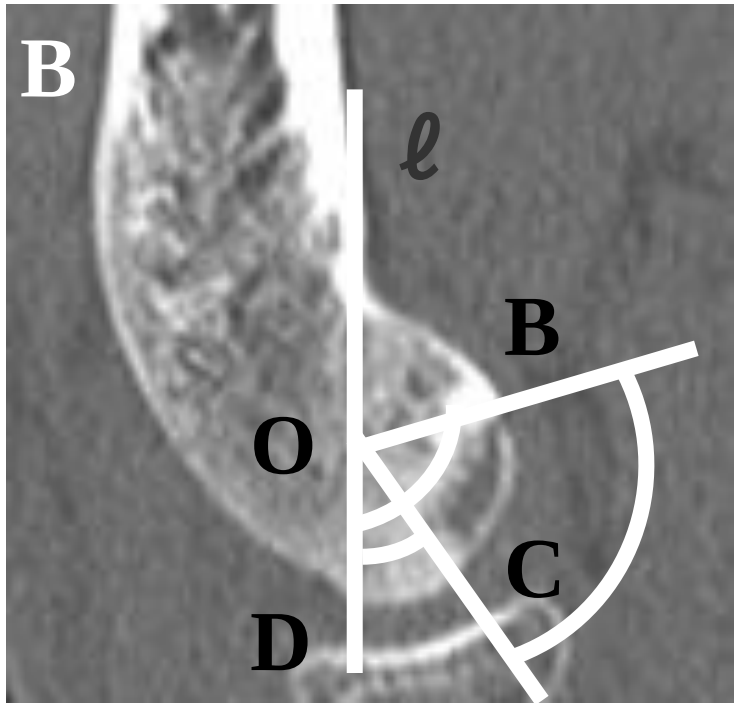


Table1. Measurements of capitellar osteochondritis dissecans defects in 29 adolescent baseball players who underwent arthroscopic debridement

Patient	Age at surgery, y	Position before surgery	Defect size	Inferior angle	Superior angle	Defect angle	Pain Final	Flex. contracture	Sagittal arc	Timmerman–Andrews score Final
1	11	Catcher	38.81	17.68	69.80	52.12	Occasional	< 5	120－130	185
2	11	Infielder	62.61	-3.73	105.35	109.08	None	< 5	> 130	200
3	12	Infielder	53.92	14.44	110.90	96.46	Occasional	< 5	110-119	165
4	12	Catcher	52.76	-4.21	91.16	95.37	Occasional	< 5	110-119	170
5	12	Catcher	38.41	-32.53	102.51	135.04	Moderate activity	5-15	120－130	170
6	12	Infielder	49.34	46.08	102.38	56.30	None	< 5	> 130	200
7	12	Pitcher	43.00	55.33	103.77	48.44	None	< 5	> 130	200
8	13	Pitcher	41.06	21.69	84.25	62.56	None	< 5	120－130	190
9	13	Outfielder	48.23	23.80	91.63	67.83	None	5-15	> 130	195
10	13	Catcher	43.27	51.32	107.05	55.73	None	< 5	> 130	195
11	13	Infielder	53.30	21.61	94.28	72.67	None	5-15	> 130	195
12	13	Infielder	49.10	23.21	101.30	78.09	Moderate activity	5-15	120－130	170
13	13	Infielder	38.32	22.56	74.17	51.61	None	< 5	> 130	200
14	14	Pitcher	46.68	22.91	83.12	60.21	None	5-15	120－130	185
15	14	Pitcher	50.14	16.48	77.68	61.20	Occasional	5-15	120－130	180
16	14	Catcher	42.44	25.21	91.56	66.35	None	< 5	> 130	200
17	14	Outfielder	54.03	35.16	96.15	60.99	None	5-15	120－130	185
18	14	Infielder	68.21	20.65	91.44	70.79	Occasional	5-15	120－130	180
19	14	Outfielder	35.72	32.75	93.83	61.08	None	5-15	120－130	185
20	14	Infielder	22.95	18.66	72.43	53.77	Occasional	< 5	> 130	195
21	14	Infielder	35.44	26.20	95.99	69.79	None	< 5	> 130	200
22	14	Infielder	44.36	29.46	86.22	56.76	Occasional	< 5	> 130	195
23	14	Infielder	57.96	18.96	104.23	85.27	None	5-15	110-119	175
24	15	Pitcher	36.32	41.67	108.75	67.08	None	< 5	> 130	200
25	15	Infielder	57.06	-18.77	71.64	90.41	None	5-15	> 130	195
26	15	Infielder	40.35	16.08	88.08	72.00	None	5-15	120－130	185
27	15	Outfielder	40.74	32.03	79.43	47.40	None	< 5	> 130	200
28	16	Catcher	27.52	22.13	88.36	66.23	None	5-15	120－130	180
29	16	Outfielder	22.60	53.13	95.44	42.31	None	< 5	120－130	190

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Table 2. Correlation between Defect size and Timmerman–Andrews score

Timmerman–Andrews score	Defect size	
	r_s	*p*
Subjective		
Pain	-0.115	0.553
Swelling	-	-
Locking/ catching	-0.203	0.290
Activities	-0.217	0.259
Objective		
Flexion contracture	-0.298	0.116
Pronation/ supination	0.271	0.155
Sagittal arc	-0.164	0.395
Total score	-0.229	0.231

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Table 3. Correlation between Superior angle and Timmerman–Andrews score

Timmerman–Andrews score	Superior angle	
	r_s	*p*
Subjective		
Pain	0.117	0.544
Swelling	-	-
Locking/ catching	-0.316	0.095
Activities	-0.311	0.100
Objective		
Flexion contracture	0.083	0.669
Pronation/ supination	0.090	0.641
Sagittal arc	-0.043	0.823
Total score	-0.016	0.934

Table 4. Correlation between Inferior angle and Timmerman–Andrews score

Timmerman–Andrews score	Inferior angle	
	r_s	*p*
Subjective		
Pain	**0.467**	**0.011**
Swelling	-	-
Locking/ catching	0.226	0.239
Activities	0.135	0.484
Objective		
Flexion contracture	0.282	0.139
Pronation/ supination	0.023	0.907
Sagittal arc	**0.387**	**0.038**
Total score	**0.494**	**<0.01**

Table 5. Correlation between Defect angle and Timmerman–Andrews score

Timmerman–Andrews score	Defect angle	
	r_s	*p*
Subjective		
Pain	-0.249	0.193
Swelling	-	-
Locking/ catching	-0.271	0.155
Activities	-0.203	0.291
Objective		
Flexion contracture	**-0.398**	**0.033**
Pronation/ supination	0.000	1.000
Sagittal arc	-0.315	0.096
Total score	**-0.431**	**0.020**

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Fig. 1

Computed tomography in (A) the coronal plane at 45 degrees to the brachial axis and in (B) the sagittal plane of the right elbow showing the osteochondral defect in the capitellum. (A) Defect size (%) = A/L × 100, where A = length (mm) of the osteochondral defect and L = length (mm) of the capitellum. (B) Superior angle (degrees) is ∠BOD, inferior angle (degrees) is ∠COD, and defect angle (degrees) is ∠BOC, where B and C are the upper and lower end of the osteochondral defect, O is the center of the capitellum, and D is the intersection of ℓ and the subchondral bone. ℓ = line passing the center of the capitellum and parallel to the humeral shaft.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1 ✓	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
	✓	(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2 ✓	Explain the scientific background and rationale for the investigation being reported
Objectives	3 ✓	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4 ✓	Present key elements of study design early in the paper
Setting	5 ✓	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 ✓	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7 ✓	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8* ✓	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 ✓	Describe any efforts to address potential sources of bias
Study size	10 ✓	Explain how the study size was arrived at
Quantitative variables	11 ✓	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 ✓	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*✓	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*✓	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*✓	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16✓	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17✓	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18✓	Summarise key results with reference to study objectives
Limitations	19✓	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20✓	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21✓	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22✓	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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