Reliability of Radiographic Imaging Characteristics for Osteochondritis Dissecans of the Capitellum

The ROCKET Group*†

Investigation performed at the Hartford Hospital's Bone and Joint Institute, Hartford, Connecticut, USA

Background: A primary challenge in the treatment of capitellar osteochondritis dissecans (OCD) is accurate imaging assessment. Radiographic classification consensus is not available in the current literature, and correlation of radiographs with lesion stability and resultant best treatment is lacking.

Purpose: To determine the inter- and intrarater reliability of the presence or absence and common radiographic characteristics of capitellar OCD lesions.

Study Design: Cohort study (Diagnosis); Level of evidence, 3.

Methods: Anteroposterior, lateral, and oblique radiographs for 29 cases were reviewed by 7 orthopaedic surgeons. Images were assessed for elbow anthropometry and morphology, OCD presence, lesion characteristics, the presence of progeny bone and progeny features, and radial head abnormalities. Intra- and interrater reliability was assessed using Fleiss and Cohen kappa for nominal variables and intraclass correlation coefficients (ICCs) for continuous variables.

Results: Surgeons demonstrated substantial to excellent inter- and intrarater reliability when assessing elbow characteristics: anthropometric (interrater ICC, 0.94-0.99; intrarater ICC, 0.82-0.96) and morphologic (Fleiss, 0.61-0.76; Cohen, 0.68). When the OCD lesion was assessed, fair to moderate interrater agreement was found for classifying the absence or presence of a lesion (Fleiss, 0.28-0.46) and the location of the OCD (Fleiss, 0.24-0.52), poor agreement for assessing the contour of the lesion (Fleiss, 0.00-0.09), and excellent agreement for measuring the size of the lesion (ICC, 0.82-0.94). Poor to fair interrater agreement was found for radial head abnormalities (Fleiss, 0.00-0.27). Progeny bone visualization and fragmentation demonstrated moderate interrater agreement (Fleiss, 0.43-0.47) where displacement of the bone demonstrated poor interrater agreement (Fleiss, 0.11-0.16). Intrarater agreement for OCD lesion characteristics, progeny bone visualization, and progeny bone features was moderate to excellent.

Conclusion: Given only the fair to moderate agreement among raters for identifying OCD on radiographs, this imaging modality may not serve as a dependable screening tool in isolation. Additional imaging should be obtained if the clinical presentation suggests capitellar OCD and a definitive diagnosis is not possible with radiographs. However, clinicians can reliability measure the size of radiographically apparent OCD, suggesting that radiographs may serve as an appropriate imaging modality for follow-up care.

Keywords: elbow; capitellum; osteochondritis dissecans; radiography

"Osteochondritis dissecans is a focal, idiopathic alteration of subchondral bone with risk for instability and disruption of adjacent articular cartilage that may result in premature osteoarthritis."[12] Considered a rare disease, OCDs of the capitellum occur in 2.2 per 100,000 individuals aged 6 to 19 years.[21] Temporary loss of the vascularization of the capitellum or other portion of the distal humerus[36-38,41] combined with repetitive microtrauma is believed to be the cause for an OCD.[3,6,18,26,28] Overhead athletes—particularly those between the ages of 12 and 19 years who are engaged in baseball and gymnastics—are at a 21.7-times increased odds ratio of developing a capitellar OCD. Genetic factors are also thought to play a role in the etiology of OCD,[32] as well as necrosis,[1] ischemia,[15] and repetitive trauma[13]; however, the ultimate cause in each case is typically unknown.

Clinically, a patient with capitellar OCD presents with pain, swelling, and tenderness at the elbow joint[22,23,36] and, in advanced cases, with stiffness and locking if loose bodies are present.[37] The condition is characterized by osseous collapse, resorption, sequestrum formation, as well as articular cartilage fissuring and delamination.[11,23] Treatment options depend on several factors: patient age; size, location, and stability of the lesion; and severity of symptoms.[4,8,11,17,23,26,34] Typically, young patients with small and stable lesions can be successfully treated

The American Journal of Sports Medicine
1–8
DOI: 10.1177/03635465221130452

nonoperatively.[7,17,23,25,31,36,44] Advanced OCD lesions have shown the potential to result in premature osteoarthritis and severe elbow dysfunction, often resulting in a decrease in the ability to be involved in athletic activities.[2,27,30,37,39] Treatment of these advanced lesions is usually surgical with results varying according to the severity and location of the lesion at the time of the surgery.

One of the biggest challenges in the treatment of capitellar OCDs is their identification and classification. Radiographs are used in the initial evaluation of young active individuals with elbow pain, and capitellar OCD lesions are routinely identified in this way, especially when more advanced lesions are present.[19,29,36] In these cases, when more advanced lesions are present, the radiograph can be used to not only identify the lesion but also directly help make treatment decisions. Ultrasonography can additionally be used to evaluate OCD lesions, but performing the ultrasound and interpreting the results are technique- and operator-dependent.[46] Computed tomography may be utilized to assess the subchondral bone and identify osseous fragmentation and the location of fragments within the joint.[34,41] Magnetic resonance imaging (MRI) is the most widely used advanced imaging technique when assessing an OCD lesion. MRI allows assessment of the chondral surface as well as the subchondral interface. This interface is commonly where the OCD lesion itself separates from the native capitellum in more advanced cases. Further, MRI assessment of fluid signal or displacement through interposed fibrous tissue at the progeny and native parent interface allows for determination of lesion stability and therefore may guide treatment.[4,5,7,10,22,35]

Currently radiographs are obtained as an initial step in evaluation for most individuals presenting with elbow pain. In addition, follow-up radiographs are often obtained after an OCD diagnosis has been made and treatment has been initiated. The exact predictive ability of the pre- or posttreatment radiographs is impossible to determine unless they are consistent as well as reliable. Despite increased clinical interest and attention in the literature, there is a lack of radiograph standardization and, consequently, a lack of consensus on radiographically based treatment. Although supplemental views including the 45° flexed view, or Takahara view, have been advocated to improve the diagnostic capability of radiographs, the reliability and prognostic value for treatment remain unclear in the initial evaluation.[24,36] Saper et al[33] found that when an OCD lesion was known to exist, the 45° flexion radiograph was the most reliable radiograph. Similarly, Satake et al[34] noted that when an unstable OCD was present, the 45° flexion view was highly sensitive. By assessing the reliability of radiographic elbow characteristics, OCD identification and lesion grading could elucidate the clinical value of radiographs as screening tools. Therefore, the purpose of this study was to determine the intra- and interrater reliability of capitellar OCD lesion characteristics and elbow morphology as assessed by standard radiographic views.

METHODS

This study was a prospective assessment of retrospectively collected radiographs designed to assess the inter- and intrarater reliability of common diagnostic criteria of capitellum OCD lesions. Institutional review board approval was obtained before the initiation of this study. Patients of both sexes, between 10 and 30 years of age, who sought care for the elbow from 2 large tertiary hospitals and had radiographs obtained at the time of their initial evaluation were identified through chart review. After the collection of the radiographs to be reviewed, they were deidentified; therefore, the sex of the patient for each set of radiographs was not recorded. Patients were sorted into 2 groups based on diagnosis: patients with capitellar OCD and patients with other diagnoses, such as ligamentous injuries, medial physeal separation, and pain, with no radiographic findings. In total, deidentified radiographs from 29 patients (15 OCD elbows and 14 control elbows) were obtained and used for this study. Of the 29 patients, 20 had open physes as denoted by the treating physicians at the tertiary hospitals. Each patient had 2 elbow radiographs for review—an anteroposterior (AP) view and a lateral view—and 23 patients had an oblique view. All radiographs were uploaded into REDCap using the electronic data capture tool.[16] REDCap also served as the data collection and management system for this study.

Seven surgeons were recruited from the ROCKET Elbow OCD Research Group and the PRiSM Elbow Research Interest Group (Pediatric Research in Sports Medicine). All surgeons were fellowship-trained, board-certified orthopaedic surgeons. Surgeons were not affiliated with either of the institutions that supplied the radiographs. Surgeons were provided with an instructional PowerPoint presentation that gave an overview on how to navigate the data collection platform and standard language for measuring OCD lesion characteristics. Surgeons

*Address correspondence to Carl Nissen, MD, PRISM and the Bone and Joint Institute at Hartford Hospital, 31 Seymour St, Hartford, CT 06106, USA (email: carlwnissen@gmail.com).

†All authors are listed in the Authors section at the end of this article.

Submitted December 15, 2021; accepted August 16, 2022.

One or more of the authors has declared the following potential conflict of interest or source of funding: This study was performed with support from Ossur Inc. T.G. has received research support from AlloSource and Arthrex, and support for education from Arthrex and Liberty Surgical; he is an associate editor for *AJSM*. T.L. has received royalties from Sawbones Inc. C.U. has received speaking fees from Arthrex and hospitality payments from Smith & Nephew. E.W. has received hospitality payments from Legacy Ortho. P.W. has received support for education from Arthrex and Pylant Medical. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

logged into REDCap to view radiographs and complete questions related to general elbow variables, OCD lesion characteristics, and progeny bone features. Surgeons completed 2 rounds of reviews, with the second review occurring a month after the initial review. Cases were presented in a random order for each surgeon. No time limit was imposed on the surgeons for completion of their review. On average (mean ± SD), surgeons took 17 ± 14 days to complete the first round of reviews and 8 ± 8 days to complete the second review.

Measurements

Surgeons were asked to make the following assessments and measures.

General Elbow Variables. Physeal patency was assessed with surgeons classifying the elbow physes and apophyses as open, closing, or closed. Morphologic measurements included the width of the distal humerus and radial head on the AP view and the length of the capitellum and radial head on the lateral view in millimeters (Figure 1). Radial head abnormalities were graded as follows: subluxated in comparison with the capitellum, sclerotic, rounded/beveled, fragmented, or cystic.

OCD Lesion. Surgeons were asked to determine the presence and appearance of a capitellar OCD lesion (absent, present and stable, or present and unstable) after viewing all films for each case. Surgeons determined the location by selecting the zone that contained the majority of the lesion on the AP view (medial, central, lateral, uncontained), lateral view (anterior, central, posterior), and oblique view (central, lateral, uncontained) (Figure 2). The width and depth of the lesion were measured on the AP and lateral views. Surgeons were asked to assess the contour of the lesion, defined as the shape of the articular edge of the lesion, as concave, linear, or convex. Visualization of a progeny bone was assessed, as well as the characteristics of the bone (fragmented, displaced, neither), size of the bone, boundary (distinct, indistinct) and radiodensity (more dense, same density, less dense) of the progeny bone center and rim as compared with the parent bone.

Statistical Analysis

Intra- and interrater reliability was evaluated for the presence of a capitellar OCD and other clinical characteristics. For categorical variables—presence of OCD lesion, lesion location, lesion contour, progeny bone (if applicable), progeny characteristics (if applicable), and radial head abnormalities—Cohen kappa measures were used to determine the intrarater reliability and Fleiss kappa to determine interrater reliability. Intraclass correlations coefficients (ICCs), using 2-way random modeling, were used to calculate the inter- and intrarater reliability for continuous variables (distal humeral width, capitellar width, radial head width, and OCD lesion width and depth). For continuous variables, summary statistics were provided on the mean and range of each measurement. All measurements are reported in millimeters. All interrater results were described with 95% CIs

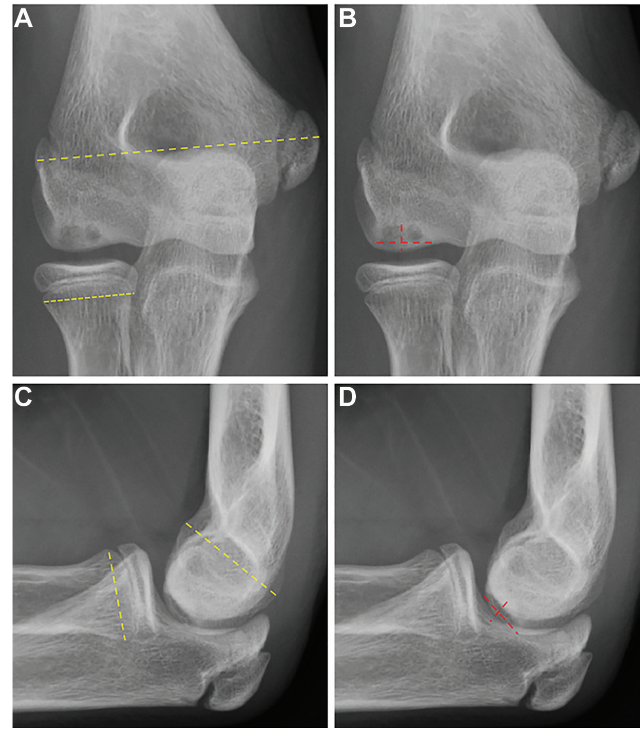

Figure 1. Elbow and lesion measurements. (A) Anteroposterior view: the distal humerus was measured by drawing a line along the longest transepicondylar distance. The width of the radial head was measured by the longest epiphyseal distance parallel to the physis. (B) Anteroposterior view: the depth of the lesion was measured using a perpendicular line to the deepest width of the lesion. (C) Lateral view: the length of the capitellum was the deepest measurement parallel to the physis. The width of the radial head was measured from the anterior-to-posterior cortices of the bone, parallel to the physis. (D) Lateral view: depth of the lesion was measured with a line perpendicular to the width of the lesion where the deepest measurement was found.

and all intraraters results with the range of ICC values. Interpretation of the data was based on guidelines for kappa suggested by the Landis and Koch criteria of the magnitude of the reliability coefficient: 0.0 to 0.2, poor; 0.21 to 0.4, fair; 0.41 to 0.6, moderate; 0.61 to 0.8, substantial; 0.81 to 1.0, excellent agreement. All analyses were performed with SPSS (Version 21.0; IBM Corp).

RESULTS

Elbow Anthropometric Qualities

The mean anthropometric measurements for the distal humerus, capitellum, and radial head on the AP and lateral views showed excellent agreement for inter- and intrarater reliability (Table 1). Determination of growth plate maturity also yielded substantial inter- and intrarater reliability.

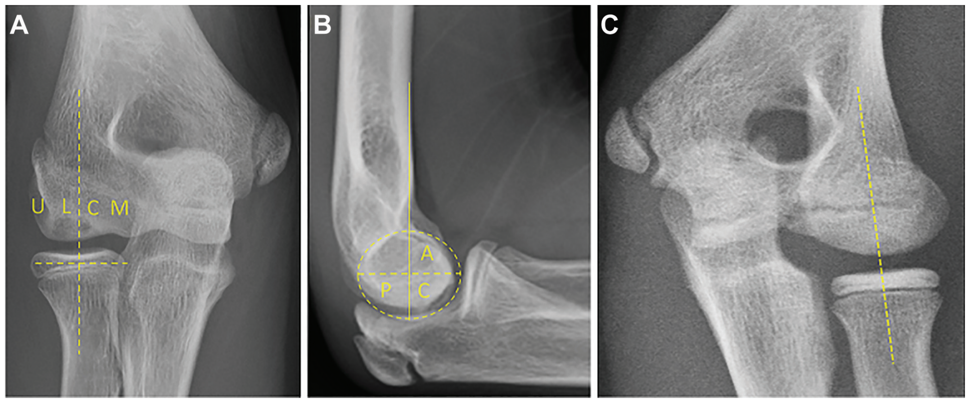

Figure 2. Lesion location. Surgeons were instructed to choose the zone containing the majority of the lesion. (A) Anteroposterior view: surgeons drew a line parallel to the surface of the radial head in a medial-to-lateral direction. Then, a second line was drawn perpendicular to this line, intersecting the midpoint of the radial head. This divided the capitellum into 4 zones: medial (*M*), medial to the lateral trochlear ridge; central (*C*), medial to the perpendicular line through the radial head; lateral (*L*), lateral to the perpendicular line through the radial head but contained within the lateral cortical margin; and uncontained (*U*), lesion extends lateral to the lateral cortical margin of the capitellum. (B) Lateral view: surgeons drew a line as an extension of the anterior humeral cortex that extended through the capitellum, and then a second transcapitellar line that was perpendicular to the first line. This divided the capitellum into 3 zones: anterior (*A*), central (*C*), and posterior (*P*). (C) Oblique view: surgeons drew a line through the capitellum to bisect the radial head. This created 3 zones: central, lesion located medial to the vertical line; lateral, lesion located lateral to the vertical line; and uncontained, lesion located lateral to the vertical line with no bone between the lateral edge of the lesion and the lateral wall of the capitellum.

TABLE 1
Inter- and Intrarater Reliability for Elbow Anthropometric Qualities

	Round 1		Round 2		
	Measurement[b] (Range)	Interrater ICC[a] (95% CI)	Measurement[b] (Range)	Interrater ICC[a] (95% CI)	Intrarater ICC[a] (Range)
AP view					
Distal humerus	57.6 (56.8-58.1)	0.99 (0.99-0.99)	58.1 (57.7-58.7)	0.99 (0.98-0.99)	0.96 (0.81-0.99)
Radial head	21.1 (20.6-21.4)	0.99 (0.98-0.99)	21.3 (21.0-21.6)	0.98 (0.97-0.99)	0.94 (0.76-0.99)
Lateral view					
Capitellum	21.3 (20.6-22.4)	0.95 (0.92-0.97)	21.8 (21.2-23.3)	0.94 (0.91-0.97)	0.82 (0.54-0.93)
Radial head	21.7 (21.1-22.0)	0.98 (0.98-0.99)	21.8 (21.4-22.1)	0.98 (0.96-0.98)	0.95 (0.82-0.98)

[a]Magnitude of the reliability coefficient agreement: poor, 0.0-0.2; fair, 0.21-0.4; moderate, 0.41-0.6; substantial, 0.61-0.8; excellent, 0.81-1.0. AP, anteroposterior; ICC, intraclass correlation coefficient.
[b]Measurement: mean results of surgeons' measurement on the length of each bony structure. Measurements provided in mm.

OCD Lesion Characteristics

Each OCD lesion and it's characteristics (presence, lesion location, lesion contour) can be found in Table 2. The presence and appearance of an OCD (absent, present and stable, or present and unstable) demonstrated substantial intrarater reliability and fair to moderate interrater reliability. Intrarater reliability showed moderate agreement for lesion location on all views as compared with fair agreement for interrater reliability. When the contour of the lesion was assessed, moderate intrarater agreement was found when compared with poor agreement for interrater reliability. Measuring the width and depth of the OCD lesion on the AP and lateral views yielded excellent reliability (Table 3).

Progeny Bone Features

Visualization of progeny bone demonstrated moderate to substantial agreement (Table 4). When the attributes of the progeny bone were assessed, surgeons showed poor to moderate agreement for fragmentation and displacement.

Radial Head Characteristics

Of the 6 characteristics assessed for radial head changes, all characteristics yielded poor interrater agreement on both rounds. Intrarater reliability calculation could not be performed as there were too few values.

TABLE 2
Inter- and Intrarater Reliability for OCD Lesion Characteristics[a]

	Interrater Fleiss Kappa (95% CI)		
	Round 1	Round 2	Intrarater Cohen Kappa (Range)
Presence and appearance	0.28 (0.22 to 0.33)	0.46 (0.40 to 0.52)	0.65 (0.42 to 0.77)
Lesion location			
AP	0.26 (0.19 to 0.33)	0.36 (0.30 to 0.42)	0.60 (0.40 to 0.85)
Lateral	0.24 (0.17 to 0.31)	0.34 (0.27 to 0.41)	0.57 (0.30 to 0.74)
Oblique	0.52 (0.44 to 0.59)	0.34 (0.27 to 0.40)	0.59 (0.15 to 0.86)
Contour	0.09 (0.01 to 0.17)	0.00 (–0.08 to 0.06)	0.50 (0.00 to 1.00)

[a]Magnitude of the reliability coefficient agreement: poor, 0.0-0.2; fair, 0.21-0.4; moderate, 0.41-0.6; substantial, 0.61-0.8; excellent, 0.81-1.0. AP, anteroposterior; OCD, osteochondritis dissecans.

TABLE 3
Inter- and Intrarater Reliability for OCD Lesion Anthropometric Qualities[a]

	Round 1		Round 2		
OCD Size	Measurement[b] (Range)	Interrater ICC[a] (95% CI)	Measurement[b] (Range)	Interrater ICC[a] (95% CI)	Intrarater ICC[a] (Range)
AP view					
Width	11.3 (9.3-12.2)	0.86 (0.74-0.94)	10.9 (9.0-12.7)	0.83 (0.69-0.92)	0.74 (0.58-0.94)
Depth	6.4 (5.4-7.2)	0.91 (0.84-0.96)	6.1 (5.2-7.3)	0.89 (0.80-0.95)	0.83 (0.55-0.91)
Lateral view					
Width	11.1 (9.8-12.3)	0.94 (0.88-0.97)	10.7 (8.4-12.4)	0.82 (0.64-0.93)	0.74 (0.53-0.91)
Depth	4.6 (4.3-5.3)	0.93 (0.87-0.97)	4.7 (4.0-5.5)	0.92 (0.83-0.97)	0.79 (0.50-0.99)

[a]Magnitude of the reliability coefficient agreement: poor, 0.0-0.2; fair, 0.21-0.4; moderate, 0.41-0.6; substantial, 0.61-0.8; excellent, 0.81-1.0. AP, anteroposterior; ICC, intraclass correlation coefficient; OCD, osteochondritis dissecans.
[b]Measurement: mean results of surgeons' measurement on the size of the OCD lesion. Measurements provided in mm.

TABLE 4
Inter- and Intrarater Reliability for Progeny Bone Attributes[a]

	Interrater Fleiss Kappa (95% CI)		
	Round 1	Round 2	Intrarater Cohen Kappa (Range)
Visibility of progeny bone	0.46 (0.36-0.56)	0.44 (0.35-0.54)	0.68 (0.38-1.0)
Progeny bone attributes			
Fragmented	0.47 (0.39-0.55)	0.43 (0.35-0.51)	0.66 (0.51-0.78)
Displaced	0.11 (0.37-0.19)	0.16 (0.08-0.23)	0.50 (0.03-1.0)

[a]Magnitude of the reliability coefficient agreement: poor, 0.0-0.2; fair, 0.21-0.4; moderate, 0.41-0.6; substantial, 0.61-0.8; excellent, 0.81-1.0.

DISCUSSION

The goal of this study was to assess the level of agreement of observations between and within surgeons for determination of the presence and appearance of capitellar OCD, progeny bone characteristics, radial head abnormalities, and elbow anthropometric features. The interrater reliability was excellent for 7 features (distal humeral width, capitellar width, radial head width, and OCD width and depth on the AP and lateral views), substantial for 1 feature (physeal patency), fair to moderate for 6 features (presence and appearance of OCD; location of OCD on AP, lateral and oblique views; progeny bone visualization and fragmentation), and poor for 5 features (radial head changes [subluxation, sclerosis, cystic changes], lesion contour, and progeny bone displacement). When compared with interrater results, intrarater reliability demonstrated the same or better agreement for all features.

Our study suggests that radiographs may not be a viable screening tool in isolation. These findings support the results of similar studies that have shown low interrater agreement on the presence and appearance of an OCD on plain radiographs.[9,43] In a review of 22 cases, Claessen et al[9] demonstrated poor to fair interrater agreement among surgeons when using radiographs to determine the stage of a capitellar OCD based on 4 classification systems. The ROCK group (Research in Osteochondritis of the Knee) established that radiographic evaluations of OCDs in the knee can provide reliable diagnostic information.[43] However, these findings illustrate the differences between the bony architecture of the knee and elbow. Within the United States, there are standard images when evaluating a patient presenting with elbow pain, including those with a suspected OCD. A specialized AP view with the elbow in 45° of flexion, known as a Takahara view, was recently shown to improve the diagnostic accuracy of radiographs with substantial interrater agreement.[33] Yet, isolated radiographs may not be reliable for diagnosis or assessment of a stability-based treatment plan. Our findings indicate poor to moderate reliability of surgeons to make assessments of lesion severity or stability on plain radiographs. The current results suggest that further imaging, such as MRI, may be required for accurate diagnosis and assessment of stability-based treatment when the patient's history and physical examination are suggestive of capitellar OCD.

Plain radiographs do serve a function in the initial evaluation of elbow OCD lesions and during follow-up of care in specific situations. Some authors have determined that radiographs have a utility in certain situations in making treatment decisions.[40] Using AP and lateral radiographs, Funakoshi et al[14] reported that patients with a larger radial head, as determined by a radial head-to-neck ratio, had a lower chance of spontaneous healing. A recent study demonstrated the prognostic value of measuring the size of the lesion in comparison with the capitellum.[45] In addition, the use of radiographs in follow-up care is helpful. In a multicenter study conducted by the ROCK group, using plain radiographs to clinically evaluate the healing of knee OCDs after definitive treatment yielded excellent interrater reliability.[42] The measurement of these anthropomorphic structures on radiographs is supported with excellent reliability among surgeons and over multiple ratings in our study. Our findings reveal similar results to those of Wall et al,[43] who found excellent inter- and intrareliability for measuring OCD knee lesion size on radiographs. We believe that when an elbow OCD is visible on radiograph, follow-up care can be directed based on radiographs. This situation needs to be further studied and confirmed.

There is emerging interest in concomitant radial head changes and their association with capitellar OCDs. In an observation study of capitellar OCDs by Wu et al,[45] 5% of radial heads had cystic changes, 12% were blunted, and 15% were subluxated. The authors commented that these changes were commonly found with advanced-stage OCDs. Chronic radial head subluxation has been associated with capitellar OCDs, with a recent single-center study reporting that 33% of patients with an OCD had chronic subluxation of the radial head.[20] Unfortunately, our study demonstrated poor agreement among surgeons on the identification of these radial head changes. This may be because of the lack of fluid and edema visualization on plain radiographs that are visible on MRI scans. Intuitively, plain radiographs should be ideal for visualizing subluxation, sclerosis, rounded/blunted, and fragmented radial head changes. Improper positioning during radiography and overlap of bony structures may impair visualization of the entire radial head. Further work is necessary to elucidate the involvement of the radial head in the natural evolution of capitellar OCDs and the more effective method to visualize and document these changes.

There are limitations to this study to consider in interpreting the results. First, images were collected retrospectively at 2 institutions, which may have resulted in slight variations among imaging techniques and limited the ability to analyze views not included in standard order sets (ie, Takahara view). Should radiographs be utilized for the diagnosis and management of capitellar OCD, then a standardization of radiographs will be needed. Second, radiographs were viewed through the REDCap platform as a JPEG image rather than through a picture archiving and communication system. This may have resulted in different visualization features between the imaging formats. Third, surgeons were not provided with a clinical scenario when evaluating each case. The combination of the patient's history and clinical presentation can influence the clinical suspicion of a capitellar OCD. Fourth, as the sex of the patients was not recorded per institutional review board requirement, we were unable to analyze the effect, if any, that sex would have on radiograph interpretation. Finally, all surgeons were fellowship-trained orthopaedic surgeons who have extensive experience treating patients with capitellar OCDs. Therefore, the generalizability to all orthopaedic surgeons who may encounter this pathology will need to be evaluated. Future work should assess the reliability of radiographic features among musculoskeletal radiologists, primary care providers, and pediatricians, as well as general orthopaedic surgeons.

The use of radiographs as a screening tool in the identification of a capitellar OCD may yield fair to moderate agreement among treating providers and substantial agreement within a treating provider but may be unreliable in assessing changes of the radial head. As a result, the use of radiographs as screening tools may not be appropriate or may need refining during the assessment of capitellar OCD. Future work should evaluate the sensitivity and specificity of a standardized radiograph order set that includes specialized views and the use of other imaging modalities, such as ultrasound.

This study provides a depiction of the problem with utilizing and relying on radiographs alone in the care of patients with capitellar OCD. To improve the utility of radiographs, further work is needed to describe and explain how to review elbow radiographs in these cases. At this point, however, even though radiographs are appropriate as an initial screening tool, they should be followed by additional imaging when a capitellar OCD is known to be present or when the suspicion of its presence is high.

AUTHORS

The ROCKET Group; Carl Nissen, MD (PRiSM Sports Medicine, Hartford, Connecticut, USA; Hartford Hospital's Bone and Joint Institute, Hartford, Connecticut, USA); Deborah C. Bohn, MD (University of Minnesota, Minneapolis, Minnesota, USA); Allison

Crepeau, MD (Connecticut Children's Medical Center, Hartford, Connecticut, USA); Eric Edmonds, MD (Rady Children's Hospital, San Diego, California, USA; University of California San Diego, San Diego, California, USA); Theodore Ganley, MD (Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA); Regina Kostyun, MSEd, ATC (Hartford Hospital's Bone and Joint Institute, Hartford, Connecticut, USA); J. Todd R. Lawrence, MD, PhD (Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA); J. Lee Pace, MD (Children's Health Andrews Institute for Orthopaedics and Sports Medicine, Plano, Texas, USA); Paul Saluan, MD (Cleveland Clinic, Cleveland, Ohio, USA); Carlos Uquillas, MD (Cedars Sinai Kerlan-Jobe Institute, Los Angeles, California, USA); Eric Wall, MD (Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA); Philip L. Wilson, MD (Scottish Rite for Children Sports Medicine, Frisco, Texas, USA; University of Texas Southwestern Medical Center, Dallas, Texas, USA); and Donald S. Bae, MD (Boston Children's Hospital, Boston, Massachusetts, USA).

ACKNOWLEDGMENT

The authors thank Emily Shearier, PhD, and Ryan Smith, MD, for their assistance with the administrative aspects of this study.

ORCID iD

Carl Nissen https://orcid.org/0000-0002-7727-622X

REFERENCES

1. Barrie HJ. Hypertrophy and laminar calcification of cartilage in loose bodies as probable evidence of an ossification abnormality. *J Pathol*. 1980;132(2):161-168. doi:10.1002/path.1711320206
2. Bauer M, Jonsson K, Josefsson P, Lindén 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. doi:10.1177/03635465980260040801
4. Bohndorf K. Osteochondritis (osteochondrosis) dissecans: a review and new MRI classification. *Eur Radiol*. 1998;8(1):103-112. doi:10.1007/s003300050348
5. Bojanić I, Ivković A, Borić I. Arthroscopy and microfracture technique in the treatment of osteochondritis dissecans of the humeral capitellum: report of three adolescent gymnasts. *Knee Surg Sports Traumatol Arthrosc*. 2006;14(5):491-496. doi:10.1007/s00167-005-0693-y
6. Byrd JWT, Jones KS. Arthroscopic surgery for isolated capitellar osteochondritis dissecans in adolescent baseball players. *Am J Sports Med*. 2002;30(4):474-478.
7. Cahill BR, Phillips MR, Navarro R. The results of conservative management of juvenile osteochondritis dissecans using joint scintigraphy. *Am J Sports Med*. 1989;17(5):601-606. doi:10.1177/036354658901700502
8. Churchill RW, Munoz J, Ahmad CS. Osteochondritis dissecans of the elbow. *Curr Rev Musculoskelet Med*. 2016;9(2):232-239. doi:10.1007/s12178-016-9342-y
9. Claessen FMAP, van den Ende KIM, Doornberg JN, et al. Osteochondritis dissecans of the humeral capitellum: reliability of four classification systems using radiographs and computed tomography. *J Shoulder Elbow Surg*. 2015;24(10):1613-1618. doi:10.1016/j.jse.2015.03.029
10. Dipaola JD, Nelson DW, Colville MR. Characterizing osteochondral lesions by magnetic resonance imaging. *Arthroscopy*. 1991;7(1):101-104. doi:10.1016/0749-8063(91)90087-E
11. Edmonds EW, Polousky J. A review of knowledge in osteochondritis dissecans: 123 years of minimal evolution from König to the ROCK study group. *Clin Orthop Relat Res*. 2013;471(4):1118-1126. doi:10.1007/s11999-012-2290-y
12. Edmonds EW, Shea KG. Osteochondritis dissecans: editorial comment. *Clin Orthop Relat Res*. 2013;471(4):1105-1106. doi:10.1007/s11999-013-2837-6
13. Fairbank HAT. Osteo-chondritis dissecans. *Br J Surg*. 1933;21(81):67-82. doi:10.1002/bjs.1800218108
14. Funakoshi T, Furushima K, Miyamoto A. Predictors of unsuccessful nonoperative management of capitellar osteochondritis dissecans. *Am J Sports Med*. 2019;47(11):2691-2698. doi:10.1177/0363546519863349
15. Green WT, Banks HH. Osteochondritis dissecans in children. *J Bone Joint Surg Am*. 1953;35(1):26-47.
16. Harris PA, Taylor R, Minor BL, et al. The REDCap Consortium: building an international community of software platform partners. *J Biomed Inform*. 2019;95:103208. doi:10.1016/j.jbi.2019.103208
17. Iwasaki N, Kamishima T, Kato H, Funakoshi T, Minami A. A retrospective evaluation of magnetic resonance imaging effectiveness on capitellar osteochondritis dissecans among overhead athletes. *Am J Sports Med*. 2012;40(3):624-630. doi:10.1177/0363546511429258
18. 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. doi:10.1177/0363546506286343
19. Iwase T, Ikata T. Baseball elbow of young players. *Tokushima J Exp Med*. 1985;32(1):57-64.
20. Jarrett DY, Walters MM, Kleinman PK. Prevalence of capitellar osteochondritis dissecans in children with chronic radial head subluxation and dislocation. *AJR Am J Roentgenol*. 2016;206(6):1329-1334. doi:10.2214/AJR.15.15513
21. Kessler JI, Jacobs JC, Cannamela PC, Weiss JM, Shea KG. Demographics and epidemiology of osteochondritis dissecans of the elbow among children and adolescents. *Orthop J Sports Med*. 2018;6(12):2325967118815846. doi:10.1177/2325967118815846
22. 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. doi:10.2214/AJR.04.1570
23. Kohyama S, Ogawa T, Mamizuka N, Hara Y, Yamazaki M. A magnetic resonance imaging–based staging system for osteochondritis dissecans of the elbow: a validation study against the International Cartilage Repair Society Classification. *Orthop J Sports Med*. 2018;6(9):2325967118794620. doi:10.1177/2325967118794620
24. Maruyama M, Takahara M, Satake H. Diagnosis and treatment of osteochondritis dissecans of the humeral capitellum. *J Orthop Sci*. 2018;23(2):213-219. doi:10.1016/j.jos.2017.11.013
25. Matsuura T, Hashimoto Y, Nishino K, Nishida Y, Takahashi S, Shimada N. Comparison of clinical and radiographic outcomes between central and lateral lesions after osteochondral autograft transplantation for osteochondritis dissecans of the humeral capitellum. *Am J Sports Med*. 2017;45(14):3331-3339. doi:10.1177/0363546517730358
26. Matsuura T, Kashiwaguchi S, Iwase T, Takeda Y, Yasui N. Conservative treatment for osteochondrosis of the humeral capitellum. *Am J Sports Med*. 2008;36(5):868-872. doi:10.1177/0363546507312168
27. McManama GB, Micheli LJ, Berry MV, Sohn RS. The surgical treatment of osteochondritis of the capitellum. *Am J Sports Med*. 1985;13(1):11-21. doi:10.1177/036354658501300103
28. Mihara K, Tsutsui H, Nishinaka N, Yamaguchi K. Nonoperative treatment for osteochondritis dissecans of the capitellum. *Am J Sports Med*. 2009;37(2):298-304. doi:10.1177/0363546508324970
29. Minami M, Nakashita K, Ishii S, et al. Twenty-five cases of osteochondritis dissecans of the elbow. *Rinsho Seikei Geka*. 1979;14(8):805-810.
30. Mitsunaga MM, Adishian DA, Bianco AJ. Osteochondritis dissecans of the capitellum. *J Trauma*. 1982;22(1):53-55.

31. Pill SG, Ganley TJ, Milam A, Lou JE, Meyer JS, Flynn JM. Role of magnetic resonance imaging and clinical criteria in predicting successful nonoperative treatment of osteochondritis dissecans in children. *J Pediatr Orthop*. 2003;23(1):102-108. doi:10.1097/00004694-200301000-00021
32. Ruchelsman DE, Hall MP, Youm T. Osteochondritis dissecans of the capitellum: current concepts. *J Am Acad Orthop Surg*. 2010;18(9): 557-567.
33. Saper MG, Bompadre V, Schmale GA, Menashe S, Burton M, Nagle K. Association between 45° flexion anteroposterior elbow radiographs and diagnostic accuracy of capitellum osteochondritis dissecans. *Am J Sports Med*. 2021;49(10):2778-2782. doi:10.1177/0363 5465211027178
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. doi:10.1007/s11999-012-2462-9
35. Singer KM, Roy SP. Osteochondrosis of the humeral capitellum. *Am J Sports Med*. 1984;12(5):351-360. doi:10.1177/036354658401 200503
36. 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. doi:10.2106/00004623-200706000-00007
37. 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.
38. Takahara M, Ogino T, Takagi M, Tsuchida H, Orui H, Nambu T. Natural progression of osteochondritis dissecans of the humeral capitellum: initial observations. *Radiology*. 2000;216(1):207-212. doi: 10.1148/radiology.216.1.r00jl29207
39. Tivnon MC, Anzel SH, Waugh TR. Surgical management of osteochondritis dissecans of the capitellum. *Am J Sports Med*. 1976;4(3):121-128. doi:10.1177/036354657600400305
40. van Bergen CJ, van den Ende KI, Ten Brinke B, Eygendaal D. Osteochondritis dissecans of the capitellum in adolescents. *World J Orthop*. 2016;7(2):102-108. doi:10.5312/wjo.v7.i2.102
41. van Den Ende KIM, Mcintosh AL, Adams JE, Steinmann SP. Osteochondritis dissecans of the capitellum: a review of the literature and a distal ulnar portal. *Arthroscopy*. 2011;27(1):122-128. doi:10.1016/j.arthro.2010.08.008
42. Wall EJ, Milewski MD, Carey JL, et al. The reliability of assessing radiographic healing of osteochondritis dissecans of the knee. *Am J Sports Med*. 2017;45(6):1370-1375. doi:10.1177/0363546517698933
43. Wall EJ, Polousky JD, Shea KG, et al. Novel radiographic feature classification of knee osteochondritis dissecans: a multicenter reliability study. *Am J Sports Med*. 2015;43(2):303-309. doi:10.1177/0363546514566600
44. Wall EJ, Vourazeris J, Myer GD, et al. The healing potential of stable juvenile osteochondritis dissecans knee lesions. *J Bone Joint Surg Am*. 2008;90(12):2655-2664. doi:10.2106/JBJS.G.01103
45. Wu M, Eisenberg K, Williams K, Bae DS. Radial head changes in osteochondritis dissecans of the humeral capitellum. *Orthop J Sports Med*. 2018;6(4):2325967118769059. doi:10.1177/2325967118769059
46. Yang T-H, Lee Y-Y, Huang C-C, et al. Effectiveness of ultrasonography screening and risk factor analysis of capitellar osteochondritis dissecans in adolescent baseball players. *J Shoulder Elbow Surg*. 2018;27(11):2038-2044. doi:10.1016/j.jse.2018.07.018