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ORIGINAL ARTICLE

Osteochondritis dissecans of the capitellum: lesion size and pattern analysis using quantitative 3-dimensional computed tomography and mapping technique

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Background: The goals of this study were to evaluate the reliability of a quantitative 3-dimensional computed tomography (Q3DCT) technique for measurement of the capitellar osteochondritis dissecans (OCD) surface area, to analyze OCD distribution using a mapping technique, and to investigate associations between Q3DCT lesion quantification and demographic characteristics and/or clinical examination findings.
Methods: We identified patients with capitellar OCD who presented to our orthopedic sports medicine practice between January 2001 and January 2016 and who had undergone a preoperative computed tomography scan (slice thickness ≤1.25 mm). A total of 17 patients with a median age of 15 years (range, 12-23 years) were included in this study. Three-dimensional polygon models were reconstructed after osseous structures were marked in 3 planes. Surface areas of the OCD lesion as well as the capitellum were measured. Observer agreement was assessed with the intraclass correlation coefficient (ICC). Heat maps were created to visualize OCD distribution.
Results: Measurements of the OCD surface area showed almost perfect intraobserver agreement (ICC, 0.99; confidence interval [CI], 0.98-0.99) and interobserver agreement (ICC, 0.93; CI, 0.86-0.97). Measurements of the capitellar surface area also showed almost perfect intraobserver agreement (ICC, 0.97;CI, 0.91-0.99) and interobserver agreement (ICC, 0.86; CI, 0.46-0.96). The median OCD surface area was 101 mm^2 (range, 49-217 mm^2). On the basis of OCD heat mapping, the posterolateral zone of the capitellum was most frequently affected. OCDs in which the lateral wall was involved were associated with larger lesion size ($P = .041$), longer duration of symptoms ($P = .030$), and worse elbow extension ($P = .013$).

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Conclusions: The ability to quantify the capitellar OCD surface area and lesion location in a reliable manner using Q3DCT and a mapping technique should be considered when detailed knowledge of lesion size and location is desired.
Level of evidence: Basic Science; Anatomy Study; Imaging
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Keywords: Osteochondritis dissecans; capitellum; elbow; 3-dimensional; computed tomography; mapping

Surgical decision making in patients with osteochondritis dissecans (OCD) of the capitellum may be influenced by multiple factors, including severity of symptoms, lesion size,[21,34] lesion location,[12,31,32] stability,[34] capitellar physis status,[34] and patients' activity goals. For example, in patients with early OCD in the setting of an open capitellar growth plate, nonoperative treatment with activity modification would likely be recommended.[18,22] For advanced OCDs in the setting of an intact lateral capitellar wall, arthroscopic debridement with or without marrow stimulation procedures[14,24,28] or fixation may lead to satisfactory outcomes.[35,37] Newer techniques such as osteochondral autologous transplantation may be indicated in some of the advanced OCD cases as the primary procedure and may be used as a salvage procedure if primary treatment has failed in the high-demand athlete.[9,16,17,26] This approach is also advocated in large lesions (diameter >10 mm,[21] >50% capitellar surface area involvement[34]) and in lesions in which the lateral capitellar wall is involved.[12,31,32]

To guide treatment and predict prognosis, various imaging studies including radiography,[30,34] ultrasound,[11,19] computed tomography (CT),[30] and magnetic resonance imaging (MRI)[7,8,30] have been used as diagnostic modalities to evaluate OCD lesions with limited interobserver reliability.[4] State-of-the-art quantitative 3-dimensional computed tomography (Q3DCT)[6,15,36] and heat-mapping techniques offer a more detailed understanding of elbow fracture patterns and morphology.[1,5,20,25] Because lesion size and location play a pivotal role in surgical decision making, we investigated the feasibility of using Q3DCT and heat-mapping techniques in the evaluation of capitellar OCD lesions.

The purpose of this study was to investigate whether Q3DCT and heat-mapping techniques are reliable techniques to assess lesion size and location in patients with OCD of the capitellum. The goals of this study were to (1) evaluate intraobserver and interobserver reliability of a Q3DCT technique for measurement of the OCD surface area as well as the entire capitellum, (2) analyze OCD distribution using Q3DCT and a heat-mapping technique, and (3) investigate associations between Q3DCT lesion quantification and demographic characteristics and/or clinical examination findings.

Materials and methods

Subjects

A search of our retrospective patient database was performed to identify patients with a CT scan of capitellar OCD who presented to our orthopedic sports medicine practice between January 2001 and January 2016. The search resulted in 20 patients. The inclusion criteria were (1) patients with capitellar OCD confirmed at the time of surgery and (2) a preoperative CT scan with a slice thickness of 1.25 mm or thinner. The exclusion criteria were (1) OCDs accompanied by a post-traumatic deformity of the distal humerus, (2) scans with intra-articular injection of contrast, and (3) scans of insufficient quality. We excluded 3 scans because of low quality of images and artifacts, which resulted in 17 patients with adequate CT scans for 3-dimensional (3D) modeling.

There were 14 male and 3 female patients with a median age of 15 years (interquartile range [IQR], 14-16 years; range, 12-23 years). Baseball was the primary sport in 10 patients (56%), gymnastics in 2 (12%), and basketball in 2 (12%). The remainder of patients participated in lacrosse, karate, or soccer. A detailed summary of patient demographic characteristics and clinical examination findings is provided in Table I.

Quantification using 3D CT

The original Digital Imaging and Communications in Medicine (DICOM) files were obtained via the picture archiving and communication system database. The DICOM files were then loaded into 3D Slicer (Boston, MA, USA), a software platform for the analysis and visualization of medical images and for research in image-guided therapy. By use of this software, osseous structures were manually marked in the axial, coronal, and sagittal planes using a threshold of 250 Hounsfield units with a region growing algorithm and corrected segmentation, under the supervision of the senior author (L.S.O). Then, 3D polygon models were reconstructed (Fig. 1).[15,36]

Subsequently, the 3D models were imported into Rhinoceros (Robert McNeel & Associates, Seattle, WA, USA) for measurements. In Rhinoceros, after removal of any loose bodies and surface irregularities, the OCD surface area and capitellar surface area were marked on the 3D model and then measured using the area command (Fig. 2).[15,36] The articular portion of the capitellum was defined as the surface area surrounded by the anterior, posterior, and lateral capitellar edge and the indentation that separates the capitellum and trochlea. Measurements were independently performed by 2 authors not involved in patient care at 2 different time points with an interval of 2 weeks to assess intraobserver and interobserver agreement of Q3DCT quantification.

Lesion mapping using 3D CT

All 3D models were graphically superimposed onto a standard template of an intact right capitellum with the use of MATLAB (The MathWorks, Natick, MA, USA).[1,5,25] Rotation and normalization were guided by aligning specific landmarks of the distal humerus (medial and lateral epicondyles), as well as the anterior and posterior capitellar

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