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Fractures of the coronoid: morphology based upon computer tomography scanning

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Hypothesis/Background: Coronoid fractures have traditionally been described by the Regan-Morrey classification system, based upon lateral plain film radiographs. However, use of computer tomography (CT) scans to determine fracture morphology, define associated injuries, and make treatment plans is now commonplace. In addition, it is increasingly recognized that classification systems based upon plain film imaging studies may not be adequate to describe complex fracture patterns. The purpose of the present investigation was to review CT scans obtained for elbow trauma to describe coronoid fracture morphology and determine inter- and intra-observer reliability.

Methods: CT scans performed for elbow trauma over a 2-year period were examined to identify coronoid fractures, and recurring patterns were sought. After patterns were identified, the scans were reviewed by 3 observers to determine inter- and intra-observer reliability.

Results: Of 373 CT scans, 52 identified coronoid fractures were appropriate for review. Five common patterns were identified, including a tip type, mid-transverse type, basal type, anteromedial oblique fractures, and an anterolateral oblique type fracture that has not been well described previously. Inter- and intra-observer reliability ranged from good to very good in this series.

Discussion/Conclusion: In this series, we describe anatomic patterns by which coronoid fractures break. Five common patterns were noted: a ''tip'' type fracture seen in 29% of the cases; a ''mid-transverse'' type fracture (24%); a ''basal'' type fracture (23); and 2 ''oblique'' type fracture patterns (24%), including an ''anteromedial'' type fracture (17%) and an ''anterolateral'' type (7%). There was a high rate of intra- and inter-observer reliability between and within 3 observers.

Level of evidence: Level III, Diagnostic Study.

Keywords: Coronoid; coronoid fracture; coronoid process; classification system; elbow; elbow trauma; elbow fracture

The understanding of complex traumatic injuries of the elbow has improved over time, resulting in a higher rate of satisfactory outcomes following such injuries.[1,2,25,26,30-32] This is likely related to outcomes series documenting treatment and status of these injuries, and also due in large part to a better understanding of the implications of fracture

IRB: Committee: Mayo Clinic Institutional Review Board/Approved Study Number (1574-05).

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patterns upon stability from biomechanical studies as well as improvement in both technology and access to axial imaging.[4,6,8,10-12,15-19,21,29,34] For several decades, our understanding of coronoid fractures and the implication of these fractures upon stability of the elbow has been largely based upon a classification system according to findings on lateral plain film radiographs.[31] At our institution, Regan and Morrey[31] described findings in 37 fractures and developed a simple classification system based upon the lateral x-ray view. Type I fractures involve the tip of the coronoid, type II fractures represent a fracture of <50% of the height of the coronoid, and type III fractures involve >50% of the coronoid.[31] More recently, we investigated treatment and outcomes in 103 fractures of the coronoid, and continued to find the Regan-Morrey classification useful as a broad index of injury severity and prognosis.[2] However, with widespread use and availability of computer tomography (CT) scanning and 2- (2D) and 3-dimensional (3D) reconstructions, it is now readily possible to routinely image and describe more subtle fracture patterns based upon CT scanning. As such, it is increasingly recognized that classification systems based upon plain film imaging studies may not be adequate to describe complex fracture patterns, and that CT scanning can improve the inter-observer reliability of classifications.[9,16,23,33,36] In this series, we reviewed all coronoid fractures with CT scans with 2- and 3D imaging reconstructions obtained for indications of elbow trauma, and identified patterns by which coronoid process fractures occur. The specific goal was to describe these more complex fractures and the inter- and intra-observer reliability based on CT imaging.

Materials and methods

Following Institutional Review Board approval, over a 2-year period (January 2004-2006), all CT scans identifying a coronoid fracture were reviewed to describe the fracture pattern. This period was chosen because it represented the time period at which CT scans and 3D reconstructions became routine in the evaluation of these injuries about the elbow at the study institution. The study institution represented a facility with Level One Trauma center designation. Fractures that represented chronic or subacute (>4 weeks old) injuries or nonunions, or injuries previously treated, were excluded. Imaging studies that were of poor quality or deemed to be inadequate or incomplete were excluded. Thus 52 CT scans were available for review. Scans were reviewed by initially assessing the 3D reconstructions. The coronoid fracture lines were localized and their orientations and extent were recorded from the joint (humerus) subtraction views. Once a description of these injuries was complete, the 2D images were used to confirm fracture morphology. The initial evaluation of coronoid fracture morphology was performed without consideration of any current classification systems. Patterns of coronoid fracture were noted and repeatedly observed to include 5 major pattern types.

Subsequently, the CT scans were then reviewed independently and classified into 1 of these 5 patterns by the following 3 observers: a dual fellowship trained surgeon (S.P.S.) who had completed separate shoulder and elbow and hand fellowships; a fellowship trained hand surgeon (J.E.A.); and a fellowship trained shoulder and elbow surgeon (J.S.S.). A second review was undertaken 3 months later by each observer to determine intra-observer reliability.

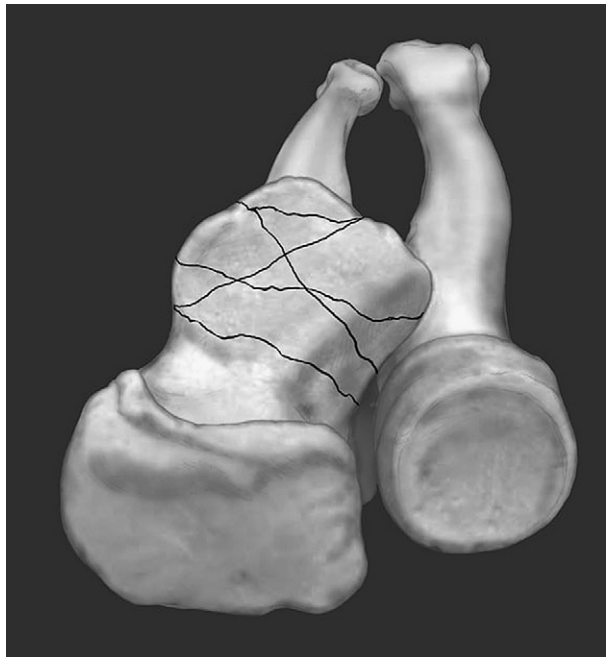

Figure 1 Schematic drawing of coronoid fracture patterns observed in this series.

Statistical methods

Statistical analysis to assess intra- and inter-observer reliability was performed with an unweighted kappa statistic, as the fractures were considered as nonordinal categories. Statistical analysis was performed using JMP software (version 6; SAS Institute Inc., Cary, NC, USA).

Results

A total of 373 CT scans were performed for elbow trauma, elbow fracture, or elbow dislocation during this noted time period. Of these CT scans, 55 identified an acute coronoid fracture, of which 52 had images appropriate and amenable for review and thus included in the study; 3 scans were excluded, as they were of inadequate quality to provide meaningful data about the fracture pattern.

As the scans were reviewed and recurring patterns were noted, 5 such patterns were identified (Figs. 1-6). Although these patterns were identified without specific regard to existing classification systems, we did identify fractures as previously described, according to the Regan-Morrey classification, as well as that of a more recently described system by O'Driscoll et al.[28,31] As the Regan-Morrey