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Fracture mapping of displaced partial articular fractures of the radial head

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Background: Recognition of patterns of traumatic elbow instability helps anticipate specific fracture characteristics and associated injuries. The objective of this study was to assess the association of fracture line distribution and location of displaced partial articular radial head fractures with specific patterns of traumatic elbow instability using fracture mapping techniques.

Methods: Fracture line distribution and location of 66 acute displaced partial articular radial head fractures were identified using quantitative 3-dimensional computed tomography reconstructions that allowed reduction of fracture fragments and a standardized method to divide the radial head into quadrants with forearm in neutral position. Based on qualitative and quantitative assessment of fracture maps, the association between fracture characteristics of displaced partial articular radial head fractures and specific elbow fracture patterns was determined.

Results: In partial articular radial head fractures, the highest fracture line intensity was located in the anterolateral quadrant near the center of the radial head. Fracture location corresponded with fracture line distribution; most fractures involved the anterolateral quadrant (n = 65; 98%), whereas parts of the posteromedial quadrant were involved in a minority of the fractures (n = 10; 15%). The association of fracture line distribution and location with overall fracture patterns of the elbow, as depicted on fracture maps, was not statistically significant.

Conclusion: Fracture maps demonstrated no association between fracture line distribution and location of displaced partial articular fractures of the radial head and overall specific patterns of traumatic elbow instability, suggesting a common fracture mechanism that involves the anterolateral part of the radial head in most patients.

The work was performed at the Hand and Upper Extremity Service, Department of Orthopedic Surgery, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, USA, and the Department of Orthopedic Surgery, Academic Medical Center, University of Amsterdam, Amsterdam, The Netherlands.

The Institutional Review Board of our institution approved this study under protocol #2009P001019/MGH.

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Fracture mapping, as initially described by Cole et al,[1,6] enables evaluation of fracture characteristics, such as location and frequency, that help identify specific fracture patterns by superimposing fracture lines, zones of comminution, and articular involvement from a large number of fractures. Using a modification of this technique,[24,26] fracture line distribution and location were related to specific injury patterns for coronoid fractures.[24]

Recognition of patterns of traumatic elbow instability helps anticipate specific fracture coronoid and olecranon characteristics (eg, location and articular involvement) and associated injuries.[7-10,12,23,28,33,34] Fracture mapping and quantitative 3-dimensional computed tomography (Q3DCT) analysis of coronoid and olecranon fractures have identified specific shapes, sizes, and orientations of fracture fragments according to pattern of traumatic elbow instability.[21,24,25] It is not clear if specific patterns of traumatic elbow instability are associated with specific locations and sizes of displaced partial articular fractures of the radial head.

Based on qualitative and quantitative assessment of fracture maps, we tested the null hypothesis that there is no difference in fracture line distribution (ie, fracture line entries and exits) and location of displaced partial articular radial head fractures between specific patterns of traumatic elbow instability (isolated radial head fracture, radial head fracture with posterior dislocation, terrible triad injury, and posterior olecranon fracture-dislocation).

Materials and methods

Patients

At 2 level I trauma centers, the administrative databases were searched using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (codes 813.0x and 813.1x for fractures of upper end of radius and ulna) and *Current Procedural Terminology* (codes 24586-24685, including elbow dislocations, Monteggia type of fractures, radial and ulnar fractures) for patients with a radial head fracture between July 2001 and January 2014. The search identified 769 patients with a radial head fracture. Inclusion criteria were (1) age of 18 years or older, (2) acute displaced partial articular fracture of the radial head (Mason type 2), and (3) complete radiographic assessment including anteroposterior and lateral radiographs and a computed tomography (CT) scan displaying the complete fracture. Displaced partial articular radial head fractures were defined as Broberg and Morrey modified Mason type 2 fractures (more than 2 mm of displacement, involving only a part of radial head).[2] Anteroposterior and lateral radiographs, CT scans, and surgical reports were evaluated by 2 authors (J.J.M. and D.R.) to establish the diagnosis. A total of 69 patients met the inclusion criteria. The exclusion criterion was artifacts on CT images that interfered with the 3-dimensional (3D) reconstruction of the proximal radius, including the radial head, fracture fragments, and the radial tuberosity. Three patients were excluded. The remaining 66 patients were analyzed in this study. Of these patients, the mean age was 49 years (range, 19-79). There were 38 (58%) men and 28 (42%) women, most of whom received operative treatment (83%). The most common injury was a terrible triad fracture-dislocation (47%; Table I).

Table I Patient characteristics

	All patients (N = 66)
Age, mean (SD), years	49 (15)
Sex, n (%)	
Men	38 (58)
Women	28 (42)
Side of injury, n (%)	
Right	39 (59)
Left	27 (41)
Treatment, n (%)	
Operative	55 (83)
Nonoperative	11 (17)
Injury patterns, n (%)	
Isolated radial head fracture	8 (12)
Radial head fracture with posterior dislocation	3 (4.6)
Terrible triad injury	31 (47)
Varus posteromedial rotational instability	1 (1.5)
Posterior olecranon fracture-dislocation	12 (18)
Posterior Monteggia with dislocation of the elbow	2 (3.0)
Essex-Lopresti injury	1 (1.5)
Unique pattern	8 (12)

Fracture mapping

According to the mapping technique as described by Cole et al[1,6] and modified by our group,[24,26] fracture line distribution and location, which was defined as the anatomic area of articular involvement, were determined using Q3DCT techniques. Q3DCT techniques allow the study of shapes, sizes, displacement, and orientations of bone structures.[3,15,21,25] To create Q3DCT reconstructions, Digital Imaging and Communications in Medicine files of the selected CT scans were retrieved and loaded in Slicer (3D Slicer, Boston, MA, USA). Slicer is a software program used for visualization and analysis of medical images. In Slicer, bone structures, including fracture fragments and the radial tuberosity of the proximal radius, were marked manually in axial, sagittal, and coronal planes using Edit Selected Label Map options available in this program. Subsequently, 3D polygon mesh reconstructions were built.