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Quantitative measurement of radial head fracture location

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Background: The most common location of a displaced fracture of part of the radial head is often described as the anterior lateral aspect of the radial head with the forearm in neutral position, based on observation rather than precise measurements. The purpose of our study was to measure the exact location of fractures involving part of the radial head using quantitative 3-dimensional computed tomography (CT).
Materials and methods: We measured the fracture lines with respect to the biceps tuberosity in 24 patients with a displaced articular fracture of part of the radial head (Mason type 2). Two observers preformed each measurement twice. Reliability was measured using the concordance correlation coefficient according to Lin.
Results: The average start of the fracture was 97° (standard deviation [SD]) 48.3°; range 31°-254°) clockwise from the biceps tuberosity, the average end of the fracture was 241.6° (SD, 61.0; range 19°-330°), and the average fracture subtends was 170° (SD, 32.8°; range 99°-252°). The fracture was through the anterolateral quadrant of the radial head in 22 of the 24 patients and through the posteromedial quadrant in 2 patients.
Conclusion: This quantitative analysis of CT scans of displaced articular fractures of part of the radial head (Mason type 2) confirms that the most common location is the anterolateral quadrant with the forearm in neutral rotation. Given the important role of the radial head in elbow stability, more accurate characterization of incomplete radial head fractures may improve our understanding of treatment and outcome of these fractures.
Level of evidence: Basic Science Study, Anatomic Study, Imaging.

Keywords: Computed tomography; fractures; location; quantitative; radial head

Previous observations have suggested that the most common location of a fracture of part of the radial head (Mason type 2) is the anterolateral quadrant of the radial head with the forearm in neutral position, but this is based on observation rather than data.[13] To our knowledge, quantitative measurements of radial head fracture location have not previously been performed. Quantitative evaluation requires both a standardized imaging modality and an accurate method of determining the axial position of the fracture with respect to a constant anatomic landmark.

Previous investigators have examined the anatomy of the radial head. Gorden et al[3] demonstrated using cadavers that although the anterolateral quadrant of the radial head did not articulate with the lesser sigmoid notch, the bone

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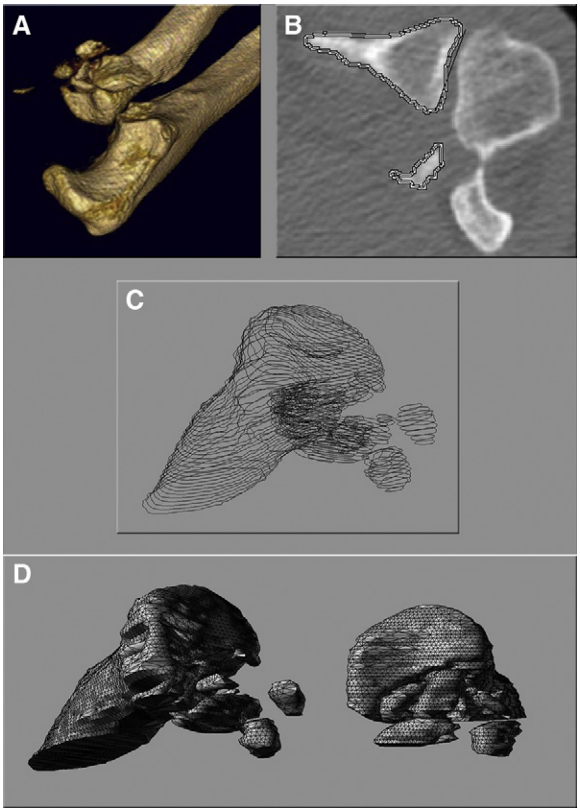

Figure 1 Steps to make a three-dimensional (3D) model: (**A**) 3D reconstructions of displaced fractures of part of the radial head (Mason type 2); (**B**) points represent the outer border of the radial bone; (**C**) wire model represents the outer border of the radial bone; and (**D**) final 3D model of Mason type 2 fracture.

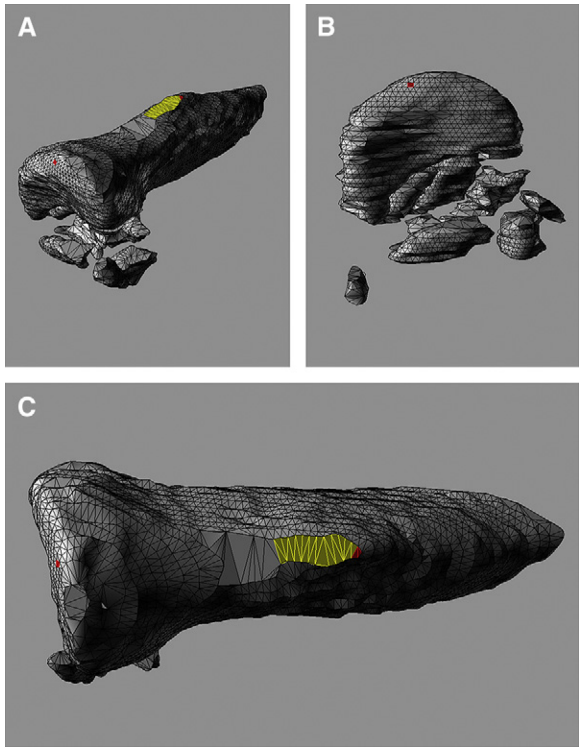

Figure 2 Screen shots are shown of radial head models within Rhinoceros software. (**A, C**) The ridge of the biceps tuberosity (*yellow*) is identified by turning the model. The center of ridge is marked (*red point*), and the marked point is projected to the edge of proximal articular surface. (**B**) Top view of articular surface of radial head.

strength was comparable to the other quadrants. Smith et al[12] and Caputo et al[1] studied the nonarticular part of the radial head to determine where implants might be best applied. Quantitative characterization of incomplete radial head fractures may help with pretreatment planning and improve the long-term outcome of these fractures.

Materials and methods

Patient selection

Informed patient consent for this retrospective study was waived. A search of billing records between 2002 and 2008 identified 72 patients who had a computed tomography (CT) scans of a fracture of the radial head. For adequate 3-dimensional (3D) modeling, the CT scans needed to have a slice thickness of between 0.62 and 1.25 mm; this was the case in 46 patients.

Our analysis included 26 displaced articular fractures of part of the radial head (Mason type 2). The other 20 patients were excluded because the fracture was not displaced or involved the entire head. Two patients were excluded because the biceps tuberosity (our landmark for fracture location) was not clearly visible on the CT scan. The 24 remaining patients (13 men, 11 women) were an average age of 46 years (range, 22-71 years). The right elbow was injured in 8 and the left elbow in 16.

Modeling technique

For reliable measurement of the axial position of the fracture on the radial head articular surface, the quantitative 3D CT (Q3DCT) modeling technique established by Guitton et al[4] was used to create 3D models of the radial head. Q3DCT is performed using software manipulation of CT scans. Details of the technique have been presented previously[4] (Fig. 1).

Quantitative assessment

The created 3D models were used to measure the start and end points of the fracture on the radial head. We chose the biceps tuberosity on the radius as the "zero-axis" and divided the proximal articular surface into a clock face of 360°, with the clockwise direction designated as the positive axis.

We identified the most prominent point in the center of the biceps tuberositas within the Rhinoceros 3D modeling tool (McNeel, Seattle, WA, USA). By turning the model, we were able to mark a corresponding point, orthogonal to the plane of this surface, on the edge of the articular surface of the radius (Fig. 2, *A* and *C*). Facing the proximal articular surface of the radius, it was now possible to see the corresponding point of the biceps