Effect of Radial Head Malunion on Radiocapitellar Stability
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Introduction:
Treatment options for radial head fractures include nonsurgical management, radial head resection, open reduction and internal fixation, and prosthetic replacement. Conservative treatment for Mason type I fractures has demonstrated good results, while surgical management is recommended for type III and type IV fractures. There is no consensus on management of type II fractures. A biomechanical study has demonstrated the inverse relationship between the size of a partial radial head deficiency and the shear force that resists radiocapitellar subluxation. The Broberg-Morrey modification of the Mason classification describes the type I fracture as having a fragment that is displaced by 2 mm or more, and involves 30% or more of the articular surface. Non-operative treatment of these injuries can result in malunion and subsequent fragment displacement and articular degeneration. We hypothesize that a simulated minimally displaced malunion of a type II radial head fracture significantly alters radiocapitellar stability.

Methods:
8 fresh frozen cadaveric radii were stripped of all surrounding soft tissue. The distal thirds of the humerus and radius were securely potted in aluminum tubes with polymethyl methacrylate prior to mounting them in the biomechanical testing apparatus (Figure 1). The distal humerus was fixed to a vertical slide capable of exerting a pneumatically-applied axial load. The radius was mounted on a motorized X-Y stage (DCI Design Components, Franklin, MA) which contained the 6-axis load cell (JR3 Inc, Woodland, CA) used to measure resistance to subluxation during translation. Each specimen was tested at a simulated flexion angle of 10° and 30° with axial compression loads of 50 N, combined with translation in the posterior direction. The radial head was translated 6 mm in each direction at a speed of 2 mm/s, with the subluxation force during each cycle being measured at a frequency of 45 Hz. We first tested the native, intact radial head (1) (intact), then resected 30% of the radial head from the anterolateral quadrant (2) (partial resection), as determined by the anterolateral radial head diameter (Figure 2). We then used screws to fix the fragment (3) (fixed). We then removed and the re-fixed the fragment in 2 mm of depression relative to the articular surface (4) (depressed). We then simulated a 30 degree-angled fracture by resecting a wedge-shaped fragment of radial head and neck (apex proximally). This articular fragment was re-fixed after drilling new screw holes (5) (angulated). The data are presented as ‘mean peak subluxation force,’ representing the maximum force aligned with one direction (perpendicular to the fracture line) before radiocapitellar subluxation occurred. All data are reported as the mean ± standard error of the peak subluxation force.

Results:
Though each condition was tested in 10° and 30° of elbow flexion, all of the forces measured in 10° were within 2 N of their respective condition in the 30° group, so only the data for the 10° group are presented. The forces required to subluxate the joint were significantly lower after partially resecting the radial head (5 ± 1 N) than when the head was intact (21 ± 1 N) (p = 0.0001). The force increased after screw fixation of the fragment (21 ± 1 N) and was not different from the intact joint (p = 0.9). After removing and re-fixing the fragment with 2 mm of depression (depressed), the peak forces significantly decreased again (4 ± 1 N) relative to the repaired condition (p = 0.0001) and the intact condition (p = 0.0001). The forces measured after resecting a wedge from the radial head and repairing the radial head in an inferiorly angulated manner (angulated) (4 ± 2 N) were less than those in the native joint (p = 0.0001) and the fixed condition (p = 0.0001). There was no difference in the force required to subluxate the joint between the partially excised, depressed, and angulated conditions (p > 0.3).

Discussion:
Radiocapitellar stability due to concavity-compressive forces is reduced by 80% in Mason type II radial head fractures that are depressed by 2 mm or angulated by 30°. These findings carry several clinical implications, particularly for the elbow in which the radial head may be important for stability. This includes those in which the coronoid is deficient. Although the coronoid is considered a primary constraint, and the radial head a secondary constraint, the radial head takes on the role of a primary constraint when the coronoid is deficient.

Acknowledgments:

Scant biomechanical data are available regarding this type of fracture, and no consensus exists as to the indications for open reduction and internal fixation of a Mason type II fracture. Our findings corroborate another study in which multiple 20 degree wedges of radial head were sequentially removed [1]. The authors found that that the peak shear load (i.e. peak force required for subluxation in our study) decreased with each increase in wedge size between 20 and 120 degrees. Even small losses of the radial head margin compromised radiocapitellar stability. These data suggest that loss of the native joint architecture can significantly reduce the ability of the joint to withstand subluxation. We observed a significant reduction in the force required to subluxate the joint after one third of the head was depressed 2 mm or angulated 30°. Therefore, malunion and not just partial loss of the radial head can have important effects on radiocapitellar stability.

Significance: A type II radial head fracture that is depressed 2 mm or angulated 30° causes severe loss of concavity-compression stability. Anatomic repair of such displaced or angulated fractures would be important in unstable elbows.

References:

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