J Shoulder Elbow Surg (2015) 24, 364-368

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

The effect of fracture comminution on the reliability and accuracy of radial head sizing

Irfan Abdulla, MD, G. Daniel G. Langohr, MASc, Michael Gladwell, MD, Celine Yeung, BSc, Kenneth J. Faber, MD, MHPE, FRCSC, Graham J.W. King, MD, MSc, FRCSC, George S. Athwal, MD, FRCSC*

Biomechanics Laboratory, Roth|McFarlane Hand and Upper Limb Center, St. Joseph's Health Care, University of Western Ontario, London, ON, Canada

Background: Radial head implant sizing can be based on the maximum head diameter (D-MAX), the minimum head diameter (D-MIN), or the articular dish diameter (D-DISH). The purpose of this study was to assess the reliability of the different radial head sizing techniques and to investigate the effect of radial head fracture comminution on measurement accuracy.

Methods: Ten observers measured 11 cadaveric radial heads with 3 radial head features (D-MAX, D-MIN, and D-DISH diameter). Radial heads were then fractured into 2, 3, and 4 parts, and the measurements were repeated. Variability was assessed by intraclass correlation. The measurements were compared with the intact state to assess the effect of radial head fracture comminution on sizing accuracy.

Results: D-MAX and D-MIN measurements were the most reliable among all observers (intraclass correlation coefficients, 0.980, 0.973). The D-DISH measurement was less reliable (intraclass correlation coefficient, 0.643). Radial head comminution did not significantly affect the reliability of any measurement ($P > .2$). Fracture comminution, however, significantly affected measurement accuracy with D-MAX and D-DISH. With fracture comminution, D-MAX underestimated radial head diameter (-0.4 ± 0.3 mm; $P < .001$), whereas D-DISH overestimated diameter ($+0.5 \pm 0.4$ mm; $P < .001$). Comminution did not significantly affect D-MIN (-0.1 ± 0.3 mm; $P = .13$).

Discussion: The D-MAX and D-MIN measurements were more reliable than D-DISH for diameter sizing of intact and comminuted radial heads. Overall, increasing comminution did not significantly affect measurement reliability. However, the accuracy of the D-MIN technique was least affected by comminution, suggesting that D-MIN should be used in selecting the diameter of a radial head implant.

Level of evidence: Basic Science, Anatomy, Imaging.

Keywords: Radial head implant sizing; radial head replacement; radial head fracture; radial head measurement reliability; radial head measurement technique

Institutional Review Board approval was not required (Basic Science Study).

*Reprint requests: George S. Athwal, MD, FRCSC, Roth|McFarlane Hand and Upper Limb Center, St. Joseph's Health Care, University of Western Ontario, 268 Grosvenor Street, London, ON, Canada, N6A 4L6.

E-mail address: gathwal@uwo.ca (G.S. Athwal).

Radial head fractures account for 2% to 5% of all fractures in the adult population. They are the most common fracture of the elbow, accounting for approximately 33% of all elbow injuries.[5,7,9,10,12] The complexity of the radial head fracture and its associated soft tissue injuries

1058-2746/$ - see front matter © 2015 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2014.10.026

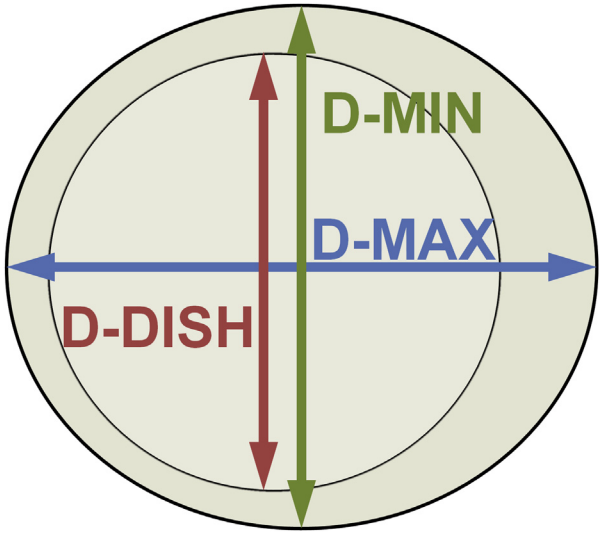

Figure 1 Image of a representative radial head with the maximum outer diameter (D-MAX), minimum outer diameter (D-MIN), and radial dish diameter (D-DISH) measurements identified.

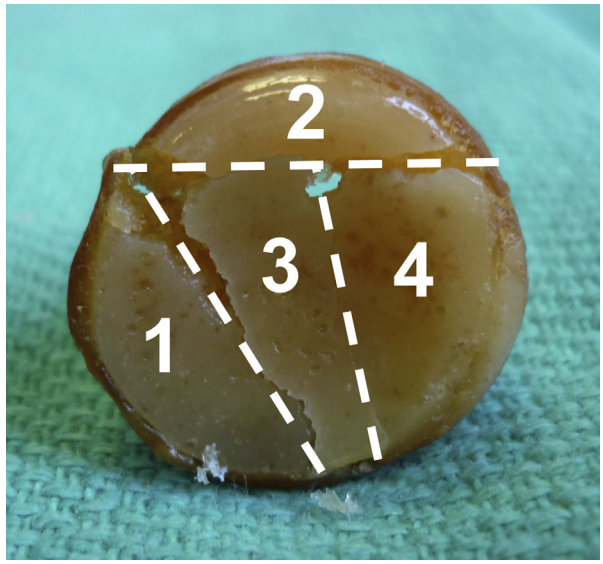

Figure 2 Photograph showing typical 4-part radial head fracture obtained through the use of the custom osteotome fracture method with fracture planes identified by *dashed lines*.

guide treatment. Surgical treatment options include open reduction and internal fixation, radial head excision, and radial head arthroplasty. Radial head arthroplasty is often the treatment of choice for comminuted displaced radial head fractures associated with instability. The failure to appropriately size the radial head prosthesis (and, in particular, oversizing of the radial head) leads to an alteration in joint architecture and mechanics that results in restricted elbow motion, capitellar erosion, pain, and early-onset osteoarthritis.[4,6,8,11,13] To prevent overlengthening or ''overstuffing'' of the implant, a number of techniques have been described to size the height of the radial head.[2,3,6,8] None of these studies, however, have reported on techniques to reliably choose the correct radial head diameter.

Implant size is commonly determined by measuring the reassembled radial head fracture fragments. Radial head implant sizing can be based on a variety of radial head features: the maximum radial head outer diameter (D-MAX), the minimum radial head outer diameter (D-MIN), and the diameter of the articular dish (D-DISH) (Fig. 1). To our knowledge, there is only one study that has evaluated the reliability of measuring D-MAX, D-MIN, and D-DISH of the excised native nonfractured radial head.[1] There are no studies that have investigated the effect of fracture comminution on radial head measurement accuracy.

The purposes of this basic science study were (1) to determine the reliability of measuring D-MAX, D-MIN, and D-DISH of the native radial head; (2) to determine if fracture comminution affected the reliability of these measurements; and (3) to investigate the effect of fracture comminution on radial head measurement accuracy. We hypothesized that use of D-MAX, D-MIN, and D-DISH would be equally reliable in measuring both the native and comminuted radial heads, whereas progressively increasing fracture comminution would decrease measurement accuracy.

Materials and methods

Radial head measurement and fracture technique

Eleven intact cadaveric radial heads, from 5 male and 6 female donors (mean age, 85 ± 7 years), were thawed and denuded of all soft tissues. Ten observers—3 upper extremity orthopedic surgeons (G.S.A., K.J.F., and G.J.W.K.), 4 upper extremity clinical fellows, and 3 senior orthopedic surgical residents—were asked to measure the intact radial heads with digital vernier calipers (Digimatic CD-6; Mitutoyo, Tokyo, Japan). Each observer was asked to measure each radial head by 3 different techniques: the maximum outer diameter (D-MAX), the minimum outer diameter (D-MIN), and the radial dish diameter (D-DISH) as described in Figure 1. All radial heads were then fractured with an osteotome into 2 parts, and all observers repeated the measurement process in a blinded manner. This same process was then repeated for 3- and 4-part fractures (Fig. 2).

Outcome variables and statistical methods

The measurements of the fractured radial heads were then compared with the value obtained for each respective intact state to calculate the difference in measurement as fracture comminution increased. Interobserver reliability was calculated by the intraclass correlation coefficient (ICC). A 3-way (measurement type, number of fractures, observer) repeated-measures analysis of variance was performed for all the measured radial head diameters. Pairwise comparisons and analyses of interaction effects were performed for significant effects ($P < .05$).