Radiocapitellar Joint Contact Pressures Following Radial Head Arthroplasty

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Purpose To determine the radial head arthroplasty length that best replicates the native radiocapitellar contact pressure.

Methods Eight cadaveric elbows (4 matched pairs) with an average age of 73 years were tested. All specimens were ligamentously stable and without visible cartilage wear. Radiocapitellar contact pressures were digitally analyzed during simulated joint loading at 0°, 45°, and 90° of elbow flexion and neutral rotation in the intact specimens and after ligament-preserving radial head arthroplasty at -2 mm, 0 mm, and +2 mm of the native length. The results were analyzed using 1-way analysis of variance and post hoc Tukey pairwise comparison tests.

Results Paired analysis demonstrated significantly decreased mean contact pressures when comparing the native versus the minus 2 groups. Significantly decreased maximum contact pressures were also noted between the native and the minus 2 groups. Examining the mean contact pressures showed no significant difference between the native and the zero group and the native and the plus 2 groups. As for the maximum contact pressures, there was also no significant difference between the native and the zero group and the native and the plus 2 group.

Conclusions Up to 2 mm of overlengthening may be tolerated under simulated loading conditions without significantly increasing contact pressures of the radiocapitellar joint. Surgeons can use this knowledge along with radiographic parameters and intraoperative examination of elbow stability to gauge the appropriate size of the radial head implant to be used in order to decrease the risk of overstuffing the joint and minimizing radiocapitellar chondral wear. *(J Hand Surg Am. 2014;39(8):1566−1571. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Prognostic IV.

Key words Arthroplasty, biomechanical analysis, contact pressure, radial head, radiocapitellar joint.

Fractures of the radial head account for 33% of all elbow fractures.[1] Surgical options for displaced fractures include open reduction and internal fixation, radial head resection, and radial head arthroplasty. The radial head is important for valgus and longitudinal stability of the elbow.[2] Although internal fixation of these fractures is the preferred treatment, other surgical options must be considered to restore the biomechanical properties of the elbow joint when internal fixation is not possible.[3]

Treatment options for radial head fractures not amenable to internal fixation include radial head resection or radial head arthroplasty, each of which is associated with complications. Radial head resection should only be considered in the absence of injury to the triangular fibrocartilage complex, interosseous membrane, and ulnar collateral ligament of the elbow to minimize the risk of longitudinal radius-ulna instability or valgus elbow instability.[2,4] Radial head arthroplasty is recommended for irreparable radial head

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fractures with associated ligamentous injury to maintain stability to the forearm and elbow. However, an implanted radial head prosthesis must restore the anatomical characteristics of the original joint to achieve the closest resemblance of the native joint's biomechanics. Overstuffing the radial head causing malalignment of the radiocapitellar joint and lateral gapping of the ulnohumeral joint can create increased pressures or altered kinematics that can ultimately result in hyaline cartilage erosion, synovitis, and osteoarthritis.[5–7]

Several studies have examined the biomechanics of radial head arthroplasty on elbow joint kinematics. They show that ulnar collateral ligament injuries increase the varus-valgus laxity and radiocapitellar contact pressures in a valgus stressed position.[6–8] The goal of this study was to demonstrate whether or not the length of the radial head replacement has to match the native length removed or whether the radiocapitellar joint can tolerate small errors in placement of the radial head replacement. We hypothesized that native radiocapitellar contact pressures would not significantly increase if using a radial head prosthesis that approximated the length of the resected radial head.

MATERIALS AND METHODS

Eight fresh-frozen cadaveric upper extremities (4 matched pairs) were used. All of the cadaveric specimens were males whose average age was 72 years (range, 68–75 y). The specimens were stored at -20°C until thawed at room temperature for 24 hours prior to dissection. There were no macroscopic abnormalities, including any cartilage degeneration, in the specimens at the time of experimentation. All specimens also demonstrated normal passive flexion and extension as well as intact collateral ligaments with stability to varus and valgus stresses.

The radiocapitellar joint was approached anteriorly between the brachioradialis and the pronator teres to preserve the integrity of the collateral ligaments. A transverse anterior capsulotomy was established to allow insertion of the pressure sensor into the radiocapitellar joint, and pressure measurements were made prior to radial head osteotomy and implant insertion. We exposed the radial neck distal to the radiocapitellar joint and transected the radial neck beginning with a fine osteotome and finishing with a narrow oscillating saw. The location of the osteotomy relative to the proximal aspect of the radial head corresponded to the length of the trial component using the zero offset radial head and standard-sized stem up to the collar that abuts the cortex of the radius. This value was measured using a vernier caliper. This allowed the native length of the proximal radius to be reproduced with the implant; we denoted this the zero group. The diameter of the radial head implant chosen was based on the size that best matched the resected native head. A modular, monopolar radial head (Wright Medical Inc., Arlington, TN) was inserted using the manufacturer's recommended technique. Stainless steel trial implants were inserted, and a set screw was placed at the head-neck junction to prevent toggle. The same implant-loading protocol was repeated using the offset radial head components of -2 mm (minus 2 group) and +2 mm (plus 2 group). After sensor insertion into the radiocapitellar joint, the anterior capsulotomy was sutured.

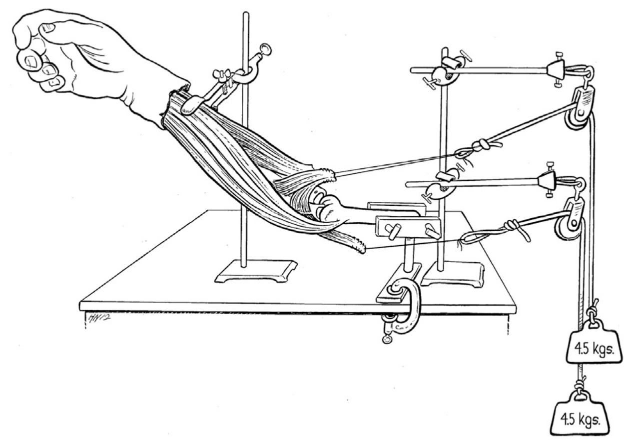

FIGURE 1: Representation of the experimental setup. Joint forces are simulated by hanging weights from sutures placed into the elbow flexors (biceps and brachialis) and extensor (triceps).

The biceps, brachialis, and triceps tendons were identified, and a heavy Krakow stitch was placed into each of these tendons. The humerus was then stripped of soft tissue and mounted onto a custom jig with the wrist in neutral rotation (Fig. 1). The biceps and brachialis tendons were loaded with a single 4.5-kg weight, and the triceps was loaded with another 4.5-kg weight representing approximately 10% of maximal physiological load of these muscles based on similar validated elbow joint-loading protocols.[2,9,10]

Radiocapitellar joint pressure measurements were obtained using the Tekscan I-Scan pressure measurement system 6900 model sensor (Tekscan Inc., South Boston, MA). The sensors were calibrated prior to each measurement, and measurements were obtained using the TekScan software. All specimens were tested in neutral rotation at 0°, 45°, and 90° of elbow flexion. Measurements were taken during a 5-second loading period and were repeated 3 times to