The Effect Of Prosthetic Radial Head Geometry On Radiocapitellar Joint Contact Area And Pressure

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Introduction: Mid- to long-term results are being reported for radial head prostheses. Concern has arisen about capitellar erosions or arthritic changes, which have been reported in 33% to 70% of patients. Various etiologies are being considered, including initial trauma to the articular surface, joint overstuffing, material properties of the implant, and prosthesis capitellar shape mismatch. A previous report(1) explored the effects of prosthesis shape on isolated radiocapitellar contact profiles. They documented significant differences in contact area and pressure between a circular and an elliptical design. Our aims were to utilize a more ‘intact’ cadaveric model for evaluation and to test a greater variety of radial head designs. We hypothesized radiocapitellar contact pressures would be elevated with nonanatomic (circular) prostheses over those mimicking native anatomy, and such pressures would be related to the depth and contour of the articular dish as well as to the pattern of prosthetic articulation against the lateral trochlear ridge.

Methods: Four commercially available and two prototype modular radial head designs were implanted into cadaveric specimens, which were then loaded in neutral and extension with a custom testing apparatus while measuring contact areas and pressures using Tekscan (South Boston, MA) technology. These included: (1) the Anatomic Radial Head (ARH - Acumed, Hillsboro, OR), (2) a modified ARH Prototype #1, and (3) a modified ARH Prototype #2; (4) the circular Evolve Radial Head (Wright Medical Technology, Arlington, TN), (5) the circular Radial Head System (RHS - Tornier SA, Saint-Ismier, France), and (6) the circular rHead (Small Bone Innovations, Morrisville, PA). Contact pressures were reported in MPa ± standard error.

Results: ARH Prototype #2 had similar radiocapitellar contact areas as the native radial head, but the contact areas were significantly decreased (P < .05) for all other designs. The reduction in contact areas were: ARH Prototype #1 - 20%; ARH - 25%; Evolve - 30%; RHS - 50%; and rHead - 55% (Figure 1). As with the contact areas, the mean radiocapitellar contact pressures for ARH Prototype #2 were not significantly different than those for the intact radial head. However, all other prostheses showed elevated contact pressures. Compared to the intact radial head they were increased significantly (P < .05) by: 25% with Prototype #1; 40% with ARH; 70% with Evolve; 130% with RHS; and 180% with the rHead prosthesis (Figure 2). Peak contact pressures were also measured, and were significantly elevated with all prostheses (P < .05). They were 2.9 ± 0.14 MPa with the native radial head; 4.2 ± 0.70 with Prototype #2; 4.4 ± 0.76 with Prototype #1; 4.4 ± 0.78 with ARH; 6.9 ± 0.78 with Evolve; 7.5 ± 0.78 with RHS; and 8.6 ± 1.2 with the rHead prosthesis (Figure 3).
ARH and ARH prototype designs are more likely to contact the lateral trochlear ridge than circular prostheses (28/30 vs 11/30, $P < .0001$), and less likely for that contact to be above the 5 MPa threshold (7/28 vs 8/11, $P < .005$).

**Discussion:** Current commercially available radial head prostheses demonstrated reduced radiocapitellar contact and elevated contact pressures during compressive loading. These were significantly greater with symmetrical circular prostheses than with asymmetric elliptical designs. The depth of the articular dish had a significant effect on contact area and pressure. Contact with the lateral trochlear ridge, and its adjacent sulcus, as well as the presence of elevated pressures there, were highly dependent on prosthetic geometry.

**Significance:** The prosthesis that best mimicked natural anatomy was the ARH Prototype #2, which was designed to articulate with the capitellum, the lateral trochlear ridge and the sulcus between them.

**Mean Radiocapitellar Contact Areas**

![Bar chart showing mean radiocapitellar contact areas with error bars and letters indicating significant differences.](chart.png)

*Figure 1:* Radiocapitellar contact areas (mean ± standard error of mean). The columns with differing lowercase letters are significantly different from each other ($P < .05$).
Figure 2: Radiocapitellar contact pressures (mean ± standard error of mean). The columns with differing lowercase letters are significantly different from each other ($P \leq .05$).

Radial Head Pressure Maps

Intact

Anatomic®

ARH Proto #1

ARH Proto #2

Evolve®

rHead®

RIIS®

Figure 3: Sample pressure maps showing distribution for varying design. Green regions indicate areas with pressures above 5 MPa. Yellow indicates pressures above 7 MPa, Orange above 8 MPa and Red above 10 MPa.
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