THE EFFECT OF METALLIC RADIAL HEAD ARTHROPLASTY ON RADIOCAPITELLAR JOINT CONTACT AREA

*Liew, V S (A-Lawson Health Research Institute); *Cooper, I C; *Ferreira, L M; *Johnson, J A; +*King, G JW (A-Lawson Health Research Institute) 
+Hand & Upper Limb Centre, Lawson Health Research Institute, St. Joseph's Health Care London, Division of Orthopaedic Surgery, London, CANADA. 519-646-6011, Fax: 519-646-6049, gking@uwo.ca

INTRODUCTION
Radial head fractures are the most common fractures of the elbow. Treatment options include non-operative management, open reduction and internal fixation, radial head excision, and in the case of a non-reconstructible fracture with associated elbow and/or forearm instability, radial head arthroplasty. 1,2,4 Although silicone implants were the preferred option for arthroplasty in the past, associated well-known complications 3 have led to an increasing use of metal implants. The utilization of metal prostheses raises important questions regarding the effect of the implant and implant sizing on contact mechanics. The purposes of this study were to quantify the contact area of the radiocapitellar joint before and after metallic radial head arthroplasty and to determine the effect of implant size on joint contact area. Our hypotheses were that radiocapitellar joint contact area would decrease after metallic radial head arthroplasty and that implant size would influence contact area.

METHODS
The distal humerus and proximal radius were resected from eight fresh, frozen upper extremities, dissected of all soft tissue, and potted in bone cement. A custom-made apparatus was used that allowed the joint to be reproducibly tested at different flexion angles. Reprosil® (DENTSPLY International Inc. - Milford, DE)- a silicone-based dental impression material- was used to make casts of the radiocapitellar joint. After application of the casting material to the radial head, the joint was loaded with 100N of compressive force. Testing was performed at 60, 90, and 120 degrees of flexion in neutral rotation. This protocol was followed for the intact radial head, then subsequently with an undersized metal (cobalt-chrome) implant, an optimally sized implant, and an oversized implant (Evolve®, Wright Medical - Arlington, TN). The undersized and oversized implants were 2 mm smaller and larger in diameter than the optimally sized implant, respectively. SigmaScan® (SPSS Science - Chicago, IL) was utilized to calculate joint contact area from the casts. In order to evaluate the reproducibility of the casting method, five casts of the radiocapitellar joint were made for a randomly chosen condition. The contact area of each cast was then calculated and compared. To verify the repeatability of the SigmaScan® measurement technique, five different individuals calculated the contact area from the same cast five times.

RESULTS
Contact area decreased significantly after metallic radial head arthroplasty, regardless of implant size (Fig. 1, p<0.001). On further analysis of implant size, we found a significant decrease in contact area as implant size increased (Fig. 1, p<0.05). Overall, there was a small but significant decrease in joint contact area at larger flexion angles (Fig. 2, p<0.04). Regarding the reproducibility of the casting method, less than 6% variability was found. The interobserver variability of the measurement technique was found to be less than 1%.

DISCUSSION
Harrington 4 has reported on the medium-term outcomes of titanium radial head arthroplasty, with good to excellent results in 75% of subjects. As such, the reduction in contact area (and hence the increase in contact pressure) that occurs with a metal arthroplasty may be inconsequential with regard to joint cartilage wear. While there have been reports on radiocapitellar joint contact patterns of the native articulation, 5, 6 this study is the first investigation quantifying the contact area of the reconstructed radiocapitellar joint. We found that optimally sized metallic radial head arthroplasty decreased radiocapitellar joint contact area by an average of 68% relative to the native radial head. The two major factors affecting joint contact area are stiffness (or modulus) and conformity. The disparity in modulus between joint cartilage and the metal implant may help to explain the decrease in contact area noted after arthroplasty. The difference in conformity (as represented by the radius of curvature) between the native radial head and the metal implant may also offer an explanation for this decrease.

With respect to the effect of implant size, we found that contact area increases slightly when a smaller implant size is used. This is, in all probability, due to the increased conformity that occurs. These findings suggest that selection of implant size to maximize contact area may not be efficacious and likely will not have a significant effect on joint cartilage wear. Future work in this field should include dynamic measurements of contact mechanics, quantification of pressure parameters, and in-situ testing with soft-tissue constraints of the joint kept intact.

REFERENCES

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