Biomechanical Differences between Bipolar and Monopolar Radial Head following Radial Head Arthroplasty

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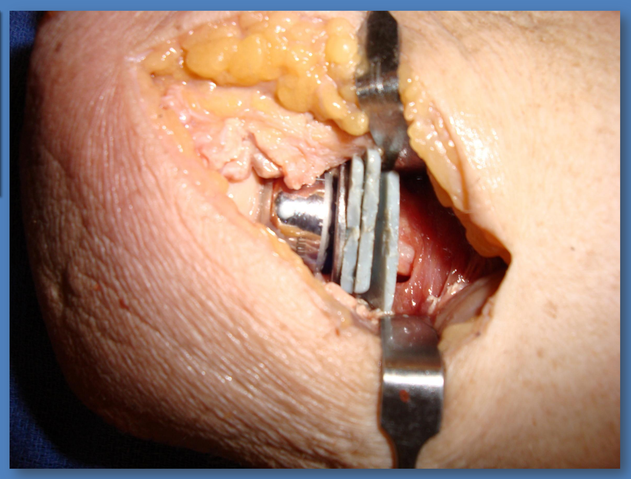
INTRODUCTION:

Radial head arthroplasty is a reliable procedure with good functional outcomes when faced with irreparable radial head fractures. Since the first attempt at arthroplasty by Speed in 1941, there have been a variety of different designs created for radial head prostheses. There has been considerable recent interest in bipolar radial head components. However, to date, there have been few biomechanical studies comparing bipolar components to their monopolar counterparts. We examine the effects of alteration of axial length of the radial head prosthesis and force conveyed at the radiocapitellar joint in a head-to-head comparison of bipolar implants to monopolar implants.

METHODS:

Sixteen fresh-frozen, sided cadaveric arms were utilized. Radial heads were resected and either a monopolar, rigid, metal radial head prosthesis (Solar, Stryker, Mahwah, NJ) was implanted or a bipolar metal prosthesis used (Katalyst, Integra, Plainsboro, NJ). Adjustments of radial head length were made in 2mm increments using radiolucent washers to create an understuffed (-2), neutral (0), and overstuffed (+2, +4) effect, see Fig. 1. Forearms were cyclically loaded in compression from 13N to 130N with the forearm in neutral. Radiocapitellar forces were measured using Tekscan (Tekscan, Inc., Boston, MA) pressure sensors with radial head length set at -2mm, 0, +2mm and +4mm and comparisons were made with the neutral (0) radial head, see Fig. 2. Multivariant ANOVA with Tukey's HSD correction was used for statistical analysis.

Figure 1 – Radial head length was controlled by applying 2 mm thick washers beneath the head, shown here with a monopolar prosthesis.



RESULTS:

Radiocapitellar forces using monopolar radial heads in arms that were understuffed (-2), neutral (0), overstuffed (+2, +4) were 24.07 +/- 9.65 N/mm^2, 30.21 +/- 9.63 N/mm^2, 37.45 +/- 13.09 N/mm^2, 46.47 +/- 9.25 N/mm^2. Radiocapitellar joint forces using bipolar radial heads in arms that were understuffed (-2), neutral (0), overstuffed (+2, +4) were 0.10 +/- 0.08 N/mm^2, 0.16 +/- 0.15 N/mm^2, 0.26 +/- 0.15 N/mm^2, 0.31 +/- 0.17 N/mm^2. There was a noticeable stepwise increase in force transmitted with progressive radial head lengthening regardless of implant design. Radiocapitellar forces were essentially 1.5 times greater with monopolar radial head overstuffing (+4) compared to neutral (0) while they essentially doubled with bipolar radial head overstuffing (+4) compared to neutral (0) ($p<0.01$).

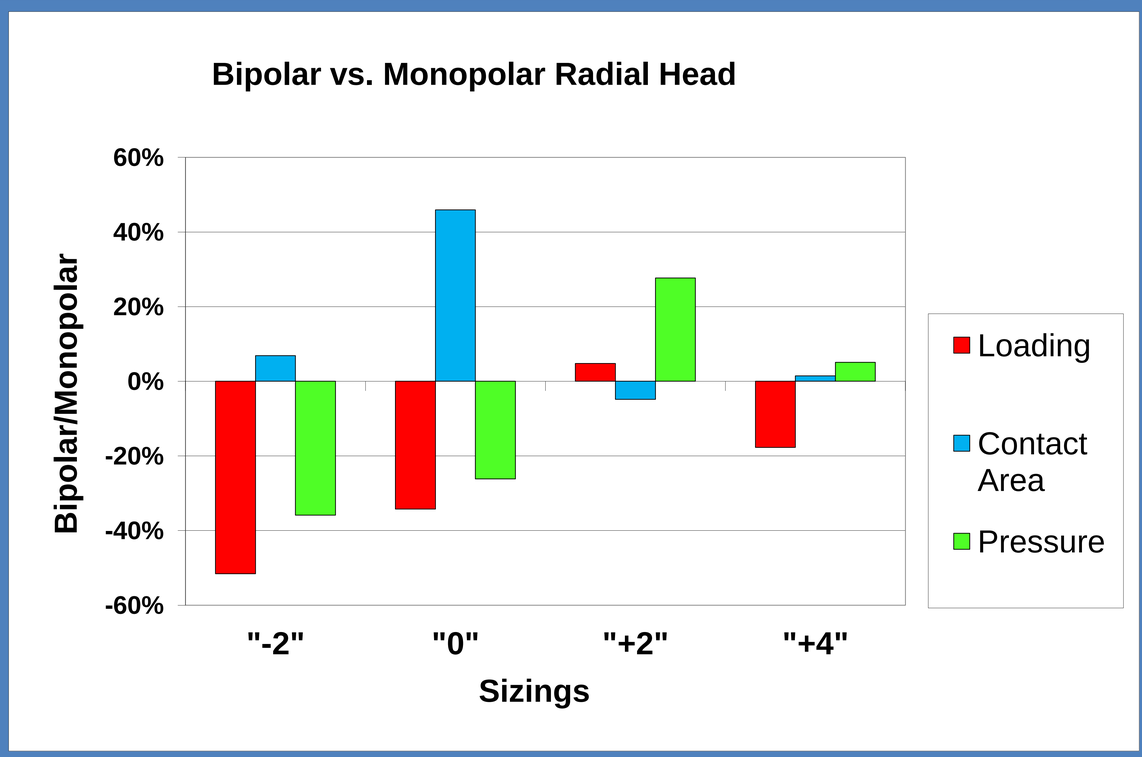


Figure 2 – The bipolar radial head transmitted less force, greater contact area and lower peak pressures than with monopolar prostheses.

DISCUSSION:

Progressive radial head lengthening regardless of implant design was associated with a stepwise increase in radiocapitellar joint force. Radiocapitellar forces where notably lower with the bipolar radial head when compared to their monopolar counterparts. This may in part be due to the bipolar design which allows for increased play at the radiocapitellar junction., see Fig. 3

Figure 3 – This radiographic image shows the potential for the bipolar radial head implant to realign to the joint under load.

SIGNIFICANCE:

Sizing and selection of the radial head implant plays a critical role in restoring native radiocapitellar loads and may prevent accelerated wear at the radiocapitellar joint after radial head arthroplasty.

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