Introduction:
Radial head replacement is accepted as the current standard of care for non-reconstructible radial head fractures. Stability to this joint is conferred largely by concavity compressive forces, particularly for prostheses with immobile articulating components (i.e. monopolar implants). Recent biomechanical studies have investigated the extent to which radiocapitellar stability can be restored with radial head prostheses, though have focused on comparisons between monopolar and bipolar implants(1). The monopolar implants in these studies have demonstrated mean peak subluxation forces which approximate those of native radial heads, though remain inferior to them. To our knowledge, no biomechanical investigation has been conducted comparing radiocapitellar stability between differently-shaped monopolar radial heads. Variable factors among monopolar radial heads are the radius of curvature, depth of the articulating dish, and the angulated head. Any or all of these factors may affect stability. We investigated the degree of radiocapitellar joint stability conferred by an anatomic radial head as compared to the native radial head and a non-anatomic, circular prosthesis.

Methods:
8 fresh frozen cadaveric radii were stripped of all surrounding soft tissue. The distal thirds of the humerus and radius were securely potted in aluminum tubes with polymethyl methacrylate prior to mounting them in the biomechanical testing apparatus (Figure 1). The distal humerus was fixed to a vertical slide capable of exerting a pneumatically-applied axial load. The radius was mounted on a motorized X-Y stage (DCI Design Components, Franklin, MA) which contained the 6-axis load cell (JR3 Inc, Woodland, CA) used to measure resistance to subluxation during translation. Each specimen/head combination was tested at a simulated flexion angle of 30° with axial compression loads of 50N, combined with translation in the posterior direction. The radial head was translated 6 mm in each direction at a speed of 2 mm/s, with the subluxation force during each cycle being measured at a frequency of 45 Hz. After the native radial head was tested, we implanted one of two prosthesis types: a circular (non-anatomic) design or an anatomically-shaped design. The circular implant was a bipolar prosthesis to which we affixed a custom-made metal collar that prevented tilting, effectively converting it into a monopolar implant. The data were presented as ‘mean peak subluxation force,’ representing the maximum force aligned with one direction before radiocapitellar subluxation occurred. All data are reported as the mean ± standard error of the peak subluxation force.

Results:
Although the mean peak subluxation force of the anatomic radial head (17 ± 4 N) was less than that of the native radial head (19 ± 4N), statistical analysis revealed that the difference between the two was not significant (p > 0.05). In the posterior direction, the circular implant’s peak force (6 ± 2) was significantly less than both the native and anatomic implants (p = 0.0001). Data is presented for translation in the posterior direction, although we found that the direction of subluxation tested did not significantly impact our peak force measurements. The force-displacement curves for all three variables tested displayed similar patterns. The positively-sloped curve demonstrates an increasing force required to dislocate the radiocapitellar joint, ultimately reaching a peak and descending.

Discussion:
Non-anatomic, circular radial head prostheses provide adequate radiocapitellar stability through concavity compression. Our study demonstrated that from a biomechanical perspective, a monopolar design with an anatomically-shaped radial head can offer a measure of radiocapitellar joint stability that is not significantly different from that provided by an intact, native radial head. The circular radial head, while demonstrating similar force-displacement curve properties as the native radial head, provided less radiocapitellar stability than both the native and anatomic radial heads. The likely explanation for this observation is the 1mm discrepancy in radiol dish depth (2 mm in the anatomic implant versus 1 mm in the circular implant.) The increased depth might allow for increased radiocapitellar surface contact. Another explanation may be the anatomic radial head’s asymmetrical, oval shape. Additionally, the anatomic implant’s angulated head may contribute to its capacity to resist dislocation. Unlike a native radial head, the circular implant’s head is oriented perpendicular relative to its stem.

Figure 1 – Testing apparatus

Figure 3 - Force - Displacement curves for each radial head tested.

In conclusion, an anatomically-shaped radial head can provide a degree of radiocapitellar stability that is comparable to an intact joint. This design may provide a reliable alternative to non-anatomic radial heads in cases requiring additional joint stability.

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