Cartilage Wear of Cadaveric Glenoid against Metal and Ceramic Heads

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INTRODUCTION:

While hemiarthroplasty improves shoulder functions and provides pain relief in patients, it has a high revision rate of up to 30% at 9 years after surgery [1], of which 83% of the revisions was for painful glenoid erosion. To improve hemiarthroplasty outcomes by minimizing glenoid wear, ceramic has been gaining attention as an alternative counter-bearing surface to metal because it is hard, inert, abrasion-resistant, and is not subject to gradual surface roughness changes as with metal [2]. Ceramic is also more wettable than metal, providing better joint lubrication and so, less adhesive wear on the glenoid [2]. There are limited studies evaluating implant materials on in-vitro glenoid wear during realistic joint articulation. Therefore, this study aimed to compare the in-vitro glenoid cartilage wear on metal and ceramic counterface using a shoulder wear simulator.

METHODS:

Seventeen fresh-frozen human cadaveric shoulders were assigned to the Al_2O_3 ceramic group (4 males, 4 females, age 58.3 ± 3.7 years) and the CoCr metal group (4 males, 5 females, age 61.7 ± 3.4 years). The resected glenoid and the size-matched humeral head implant were set up in a six-station shoulder wear simulator to replicate 'washing the opposite axilla,' a low-load daily activity, by applying the appropriate joint motion and loading profiles obtained from an earlier musculoskeletal modelling study. The joint was kept lubricated by filling the test cell with 500mL diluted calf serum and 15ppm anti-microbial agent. Each wear test was performed for a total of 500,000 cycles at 1.2Hz. At every interval of 125,000 cycles, the glenoid was imaged with a micro-computed tomography, then processed in software to characterize the glenoid wear by calculating the change in cartilage thickness (Figure 1). Statistical analyses were performed, with a $p \leq 0.05$ level of significance.

RESULTS:

The mean thickness of the native cartilage prior to wear testing was 2.2 ± 0.4mm for the ceramic group and 2.1 ± 0.4mm for the metal group. At the end of the wear test, the cartilage thickness decreased significantly to 1.6 ± 0.4mm ($p = 0.011$) for ceramic and 1.5 ± 0.4mm ($p = 0.0075$) for metal. The mean cartilage wear between the ceramic and metal was not significantly different through the wear test ($p > 0.05$), but when looking at the individual wear data (Figure 2), the wear for ceramic tests had a very large variation, making it more unpredictable than metal. The region with the most wear was inconsistent between the two groups (Figure 3): the wear for ceramic was highest at the inferior-anterior region and the wear for metal was highest at the superior-anterior region, although they are not significantly different to other regions ($p > 0.05$).

DISCUSSION AND CONCLUSION:

Ceramic has better tribological properties than metal, but ceramic had a less predictable glenoid cartilage wear behavior. This study did not find evidence that the use of ceramic in shoulder hemiarthroplasty with healthy cartilage is a much better alternative to conventional metal humeral head.

[1] Bartelt, R., Sperling, J. W., Schleck, C. D., and Cofield, R. H., 2011, "Shoulder Arthroplasty in Patients Aged Fifty-Five Years or Younger with Osteoarthritis," Journal of Shoulder and Elbow Surgery, 20(1), pp. 123–130.

[2] Davidson, J. A., 1993, "Characteristics of Metal and Ceramic Total Hip Bearing Surfaces and Their Effect on Long-Term Ultra High Molecular Weight Polyethylene Wear," Clinical Orthopaedics and Related Research, 294, pp. 361–378.

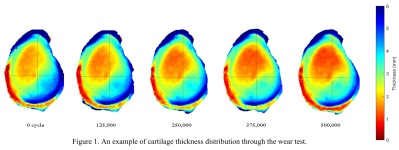

Figure 1. An example of cartilage thickness distribution through the wear test.

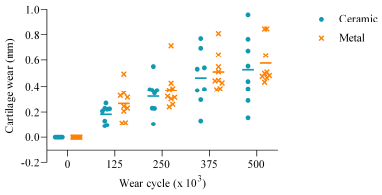

Figure 2. The individual cartilage wear (mm) through the wear test.

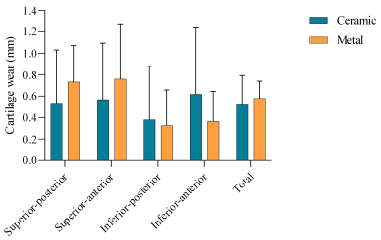

Figure 3. The cartilage wear (mm) at each glenoid surface region at the end of test.