Rim Loading Wear for Total Shoulder Applications

Andre Freligh, Jeffrey Hassebrock[1], Joshua Bingham, Julian Nowak, Jason Agusto Longaray[2], Kevin Abbruzzese, Sally Liarno[3]
[1]Mayo Clinic, [2]Stryker Othopaedics, [3]Stryker

INTRODUCTION: Shoulder arthroplasty is the third most popular joint replacement procedure worldwide, with survivorship rates surpassing 90% at 10 years.[3,4,10] Like arthroplasty procedures in other major joints, total shoulder arthroplasty (TSA) is associated with complications related to fixation and instability, as well as loosening and wear, which is a concern specific to UHMWPE glenoids.[2,5,6,8,13] Survivorship analysis has demonstrated that revision surgery for UHMWPE wear occurs at a higher rate than in hip and knee arthroplasty constructs. Findings from retrievals indicate rim loading to be the most prevalent among wear damage modes.[1,2,8,11] Therefore, the objective of this study was to compare polyethylene wear between TSA glenoid #1 (highly crosslinked polyethylene) and TSA glenoid #2 (UHMWPE) under rim loading conditions.

METHODS:

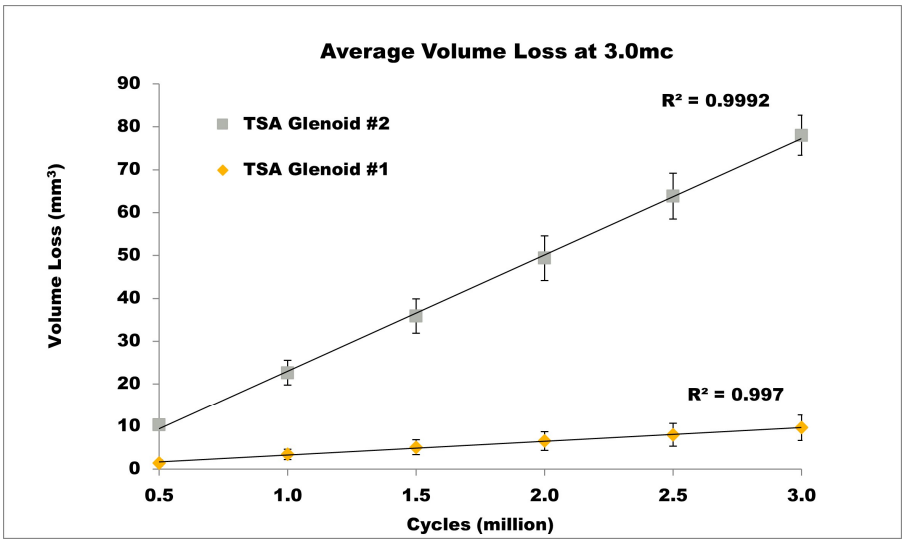
Five (n=5) TSA glenoid #2 implants were evaluated in this study. All TSA glenoid #2 implants were pegged UHMWPE glenoids. The implants were press-fit into stainless steel fixtures. Cobalt chromium humeral heads articulated against the glenoid implants. An MTS knee joint simulator was used for testing. The loading and kinematics used in this study were derived from Wirth et al.[7] for the glenohumeral joint to simulate a high load event, such as raising from a chair. A constant load of 756N (1x body weight) was applied, which is similar to the load described in ASTM F1378-18e1 and ASTM F2028-17.[14,17] Rolling motion was accomplished with abduction/adduction and translation. Sliding and forward elevation together were used to produce rim loading and account for cross-shear near the anterior and posterior sides of the glenoid. Testing was run at a frequency of 1.0Hz. The lubricant used was Alpha Calf serum. Gravimetric measurements of the polyethylene implant, and serum replacement occurred every 0.5 million cycles (mc) for a total of 3.0mc. The TSA glenoid #2 implant's (n=5) cumulative volume loss and wear rate was then compared to the TSA glenoid #1 implant's (n=6) cumulative volume loss and wear rate, which were evaluated in a previous investigation using the same test methodology.[7]

RESULTS:

The average wear rate for the TSA glenoid #2 (UHMWPE) was 27.2 ± 1.5 mm^3 per mc. Cumulative volume loss was 78.0 ± 4.7 mm^3 (R^2= 0.999) after 3mc of testing. Visual inspection of glenoid surfaces showed wear scars in areas of load contact including polishing, striations and scratches showing net wear or deformation. No evidence of fracture or delamination of the material was observed. Wear performance data was compared to a previous investigation (Mummert et al.[7]) that followed the same test method (Figure 1). Mummert et al.[7] found the wear rate for the glenoid bearing surface for TSA glenoid #1 (highly crosslinked polyethylene) offering to be 3.5 ± 0.9 mm^3 per million cycles, with a cumulative volume loss of 9.68 ± 3.0 mm^3 (R^2 = 0.997) after 3mc of testing.[7] Significant differences were determined between the wear rate of TSA glenoid #1 (highly crosslinked polyethylene) and TSA glenoid #2 (UHMWPE) when compared with a 2-sample t-test ($p<0.05$).

DISCUSSION AND CONCLUSION:

The shoulder joint is often described as a non-weight bearing joint and traditionally wear was thought to be an unlikely occurrence. However, rim wear and progressive wearing of the polyethylene glenoid has been observed clinically.[8,11] Our wear results for the design and material evaluated in this study are lower than the reported values in other investigations on shoulder wear.[2,7,9,12,13] It is important to note that superior wear performance of highly crosslinked polyethylene should be expected based on legacy evaluations.[15,16] In conclusion, TSA glenoid #1 (highly crosslinked polyethylene) exhibited significantly lower wear ($p<0.05$) when compared to TSA glenoid #2 (UHMWPE) utilizing a test method that simulated rim loading for total shoulder applications.


Average Volume Loss at 3.0mc
Volume Loss (mm³)
90
80
70
60
50
40
30
20
10
0
TSA Glenoid #2
TSA Glenoid #1
R² = 0.9992
R² = 0.997
0.5
1.0
1.5
2.0
2.5
3.0
Cycles (million)