Introduction

It is estimated that there will be over 12,000 total shoulder replacements implanted worldwide this year. In the best of cases, the survivorship of these devices has improved to be over 90% at 7 years. However, even in these cases, there are radiographic indications that the long term success of these devices will be limited due to wear and damage to the ultra high molecular weight polyethylene (UHMWPE) glenoid components. Similar to the tibial insert in total knee replacements, the glenoid is subjected to both rolling & sliding motions of a metal counterface. Additionally, the compressive loads on the glenoid component have been estimated to be as high as 2800N under ‘normal’ use conditions. In contrast to tibial inserts, UHMWPE glenoid components are typically less than 6 mm in thickness. In metal backed glenoid devices, the polyethylene thickness is often < 3 mm. Kinematically, the humeral head movement is constrained by the height of the walls of the glenoid while contact stresses are managed by altering the conformity of the glenoid relative to the humerus. The effects of these parameters on the nature of polyethylene damage have not previously been described. Although total shoulder replacements have been in use for over 25 years, there have been no reports describing the nature and extent of the wear and damage to the UHMWPE glenoid components. An analysis of retrieved glenoid components should provide some indication of how large the issue of polyethylene wear and damage in total shoulder replacements will be.

We report here on the determination of damage types and severity for 38 retrieved glenoid components.

Materials and Methods

All 38 glenoid components retrieved at one institution between 1992 and 2000 were included in this study. There were several glenoid designs evaluated. Design differences included overall shapes of the glenoids, the presence of metal backings of different designs and different fixation pegs and keels. Due to the differences in revision indications and the relatively few numbers of each specific design features, no attempt was made to correlate damage with design. Most of the glenoid components were cemented. The minimum polyethylene thickness was 3 mm. For each component, the main mode of surface damage was visually determined and the severity of the damage was assessed as being significant or insignificant. Significant wear and damage were indicated when over 80% of the surface of the glenoid was damaged or if over 25% of the component was worn away.

Results

The results are summarized in the table below. Abrasion, burnishing, and pitting were the main modes of surface damage. There were 2 incidences of fracture. 17 of the 38 components showed significant wear and damage. Abrasion was the main mode of damage in 10 of these 17 components. Abrasion was characterized by clear removal of polyethylene and the creation of a roughened, matte finished surface. In 9 of these cases, the humeral component had completely worn through the glenoid. There were virtually no signs of delamination in these components. An example of severe glenoid damage is provided in the figure.

<table>
<thead>
<tr>
<th>N</th>
<th>Severe Damage</th>
<th>Worn Through</th>
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<td>38</td>
<td>17 (45%)</td>
<td>9 (24%)</td>
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Discussion

The polyethylene in the glenoid is subjected to a similar environment as the tibial inserts in total knee replacements. The total shoulder has a relatively nonconforming geometry of the humeral head and glenoid, and the peak stress generated under conditions of normal living can exceed the polyethylene yield strength. There are both rotation and translation during shoulder articulation that could produce a crossing wear pattern. The crossing path wear pattern would be expected to provide higher wear rates. Additionally, the maximum thickness of the UHMWPE in these components was generally 6 mm, which is significantly lower than the 8 mm recommended minimum thickness for tibial inserts. Many of the glenoid components were found to have only 3 mm of UHMWPE.

There was significant UHMWPE wear and damage found in 45% of these components. For those components that were severely worn, abrasion, burnishing, pitting and fracture were the most predominant damage modes. These findings are consistent with high stress, high wear conditions in components.

These results clearly indicate polyethylene wear and damage can be expected to be a key factor in limiting the long term survivorship of total shoulder replacements. Based on these results, polyethylene damage and wear in total shoulder replacements may even be higher than that found for either total hip or knee replacements.

References

1. Wallace, et. al., JBJS 81A, 510, 1999

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