INFLUENCE OF ACETABULAR LOCKING MECHANISM ON MICROMOTION

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INTRODUCTION

The production of wear debris from the polyethylene liner of total hip arthroplasty has been well documented. The majority of research has focused on debris from the primary articulating surface between the polyethylene liner and the femoral head classified as Mode-1 wear. However, it has been noted that the movement of the backside articulating surface between the polyethylene liner and the metal shell (Mode-4 wear) also contributes particulate debris (Guttman et al., (1994), Manley et al., (1994)).

The purpose of this study was to measure the backside micromotion associated with different numbers of locking splines in the acetabular component of a total hip arthroplasty. Our hypothesis was that a greater number of splines would reduce the motion measured between the polyethylene liner and the metal acetabular shell.

METHODS

The locking mechanism investigated was the Smith & Nephew Richards, Inc. (Memphis, TN) MicroStable® Reflection acetabular system. The passive mechanism is an interference fit of matching scalloped rims, or dove-tailed splines, between the rim of the titanium metal shell and the polyethylene liner. The number of dove-tail splines on the metal shell was varied among three groups (Fig. 1) tested that contained either the normal configuration with 0% splines removed (Group A), 30% of the splines removed (Group B), or 50% of the splines removed (Group C). A total of nine standard Reflection polyethylene liners were used to test each of the three groups (three liners per metal shell).

Figure 1: Group A, Group B, and Group C.

The acetabular cups were subjected to 8 million testing cycles using an EnduraTEC (Eden Prarie, MN) servo pneumatic testing machine. An axial load of 200-3000 N was delivered in phase with a ±2.5 N-m torsional load at 10 Hz. The components were tested in a 37°C water bath (Fig. 2).

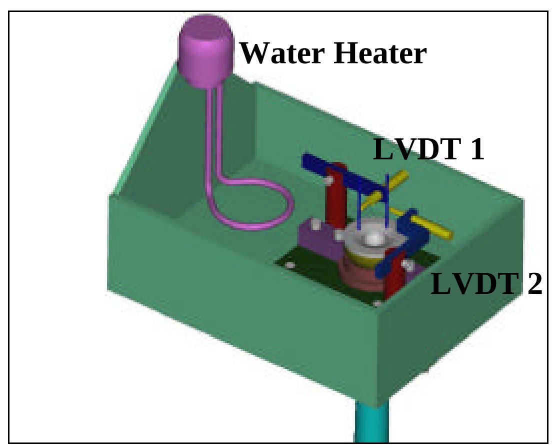

Figure 2: Schematic of LVDT placement.

The movement between the polyethylene liner and metal shell was measured using two linear variable differential transducers (LVDTs), located 90° from each other. Holes were drilled in the polyethlene liner and stainless steel pins were placed perpendicular to the liner at a constant radius from the center. The liners were gold coated before testing to observe the wear by visual and scanning electron microscopy (SEM) analysis.

One-way analysis of variance was performed to compare the motion between the three groups and a Student-Newman Keuls method for pairwise multiple comparison procedure ($p<0.05$) was performed at every 500,000 cycles.

RESULTS

The only significant difference in the measured motion between Group A and Group C was at 3 million cycles. There were multiple significant differences seen in the displacements between Group B vs. Group A and Group B vs. Group C from 4.5 million to 6 million cycles.

There was no visual evidence of burnishing, scratching, abrasions, or pitting on the backside surface of the polyethylene liners. When viewed with SEM, all of the liners showed some pitting and marking of the polyethylene surface but no areas of burnishing or polishing that would be evidence of gross wear.

DISCUSSION

In the first million cycles, we observed random increases and decreases in the motion measured by LVDT 1 and LVDT 2 (Fig. 3). This period was noted by Manley et al. (1994) as the "running in period" in which the polyethylene liner displays creep deformation. This was observed in all the groups in the first million cycles. After the running in period ended, there were little changes in the overall measured motion in the next 7 million cycles. However, the amount of motion measured in Group B, Liner #2 could be considered an outlier as its motion decreased by 3-4 microns over the final 7 million cycles. This large decreasing trend is responsible for the significant differences in measured motion observed between Group B vs. Group A and Group B vs. Group C.

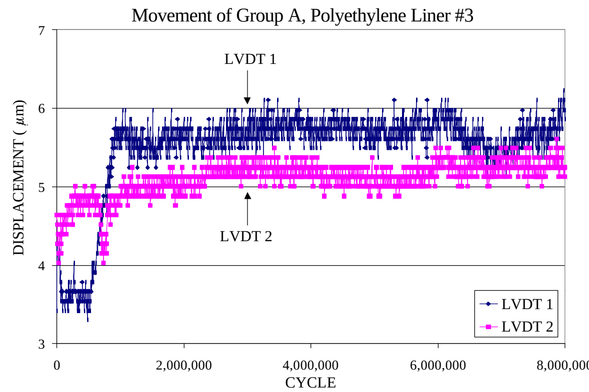

Figure 3: Example of typical motion data.

SUMMARY

This study showed that the current MicroStable® acetabular locking mechanism (Group A) creates a stable acetabular locking system. Furthermore, since the largest motion measured between the polyethylene liner and the metal shell was less than 8 microns for all the groups tested, it could be possible to use fewer locking splines.

REFERENCES

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