Fatigue Resistance of Ceramic Liners to the Physiological Loading Under Conditions of Impingement

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INTRODUCTION:

Improper positioning of the acetabular shell during surgery may create the impingement situation between the femoral implant's neck and the liner. Previous study evaluated the effect of impact loading on the ceramic liner and found that the impacts up to 12,000N can be tolerated by the liner for up to 20 occurences[1]. However to our knowledge no study has been conducted on the longevity of the ceramic liner if the impingement with the stem occurs repeatedly during daily activities. Determining if this impingement is detrimental to the longevity of the ceramic liner and/or femoral neck may be an important factor in ceramic on ceramic hip articulation. Since ceramic is harder than titanium the forceful contact of two components will result in transferring titanium debris to the ceramic surface. Prolonged exposure to contact under loading may lead to notching of the femoral neck and even breakage of the stem.

The objective of this study is to determine the endurance of the ceramic liner when subjected to a repeated contact with the femoral stem neck under the physiological loading. In addition, the study will evaluate the effect on the titanium neck in terms of notching and metal transfer.

METHODS

Group 1, 28mm ID ceramic liner (CeramTec, Plochingen, Germany) was assembled into the titanium shell (LINEAGE® Wright Medical Technology, Arlington, TN) according to the surgical technique. A 28mm diameter ceramic femoral head was assembled onto the titanium stem (BRIDGE®, Wright Medical Technology, Arlington, TN). The assembled shell was positioned with respect to the stem in a way that left the rim of the liner in contact with the femoral neck. Both shell and the stem were rigidly fixed in the fixtures and placed into the testing machine. A cyclic compressive load of 2300 N (517 lbs) was applied for 5 million cycles. The test was interrupted periodically to examine the liner and the femoral neck for any signs of wear and fractures. The test was repeated with two other identical assemblies.

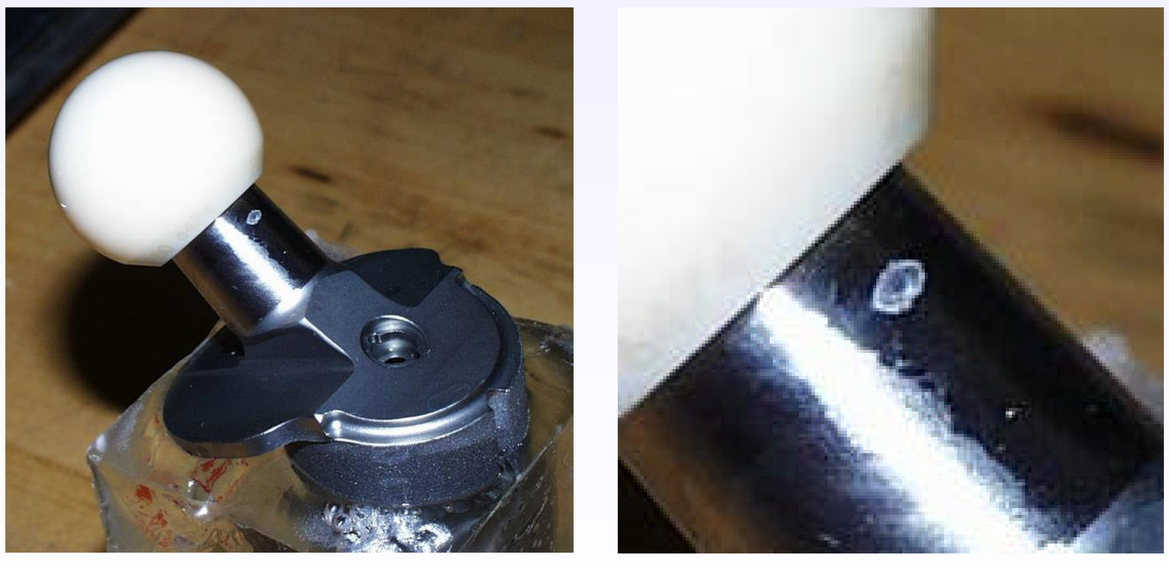
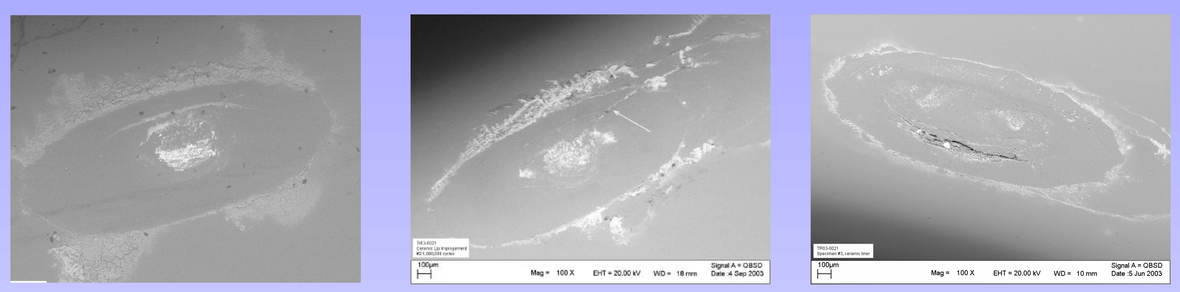


Figure 1: Appearance of neck after 5 million cycles

Figure 2: Appearance of liner after 5 million cycles

Figure 3: Results of cyclic loading(SEM @100x magnification)



500,000 cycles **1 million cycles** **5 million cycles**

RESULTS

All three assemblies withstood the cyclic loading regime without any visible signs of fractures or wear of ceramic liners. Femoral necks appeared burnished in the areas of contact, and some notching was observed. An SEM examination of contact area of the ceramic liners revealed a polished surface with titanium debris. One liner exhibited the initiation of the micro-fractures after 1 million cycles, the other two liner exhibited similar pattern after 2 million cycles. At five million cycles none of the liners exhibited fracture propagation.

DISCUSSION AND CONCLUSION

Lip impingement of the ceramic liners with the femoral necks is not likely to result in the ceramic fractures even if subjected to the repeated loading regime.

REFERENCES

1. Maher SA, Lipman JD, Gilchrist MD, Curley LJ, Wright TM: Mechanical Performance of Ceramic Acetabular Liners Under Conditions of Impingement, ORS 2003.