Performance Characteristics of an Alumina Ceramic Liner-Titanium Shell Locking Mechanism

Irina Timmerman, M.S. and Stephen Murphy, M.D.***

** Center for Computer Assisted and Reconstructive Surgery, New England Baptist Hospital, Tufts University School of Medicine and Harvard Medical School, Boston, MA*

*** Wright Medical Technology, Inc. Arlington, TN, USA*

INTRODUCTION:

While two-piece acetabular components became a standard in total hip arthroplasty, locking mechanisms for polyethylene liners vary greatly between the implant manufacturers[1]. In order to compare the integrity of liner-shell locking mechanisms, several standard tests were designed[1,2]. Most polyethylene liners feature locking mechanisms of the tongue and groove type, and rely on plastic deformation for proper assembly and locking into the shell. By contrast, hard bearings use taper connections for fixation. The current study tests the locking strength of a current alumina ceramic bearing-titanium shell junction and compares these results to those of traditional polyethylene bearing-titanium shell junctions.

METHODS:

Push Out Test

Twelve alumina oxide liners (Ceramtec, Plochingen, Germany) were assembled into titanium shells featuring an 18-degree tapered internal geometry (Wright Medical Technology, Arlington, TN). Six of the assemblies were subjected to the static push out test described by Trandonsky *et al*. Another six assemblies were subjected to the cyclic loading regime of 2,000 cycles with 1800N load and then subjected to the static push out test. Results are summarized in Table 1.

Lever Out Test

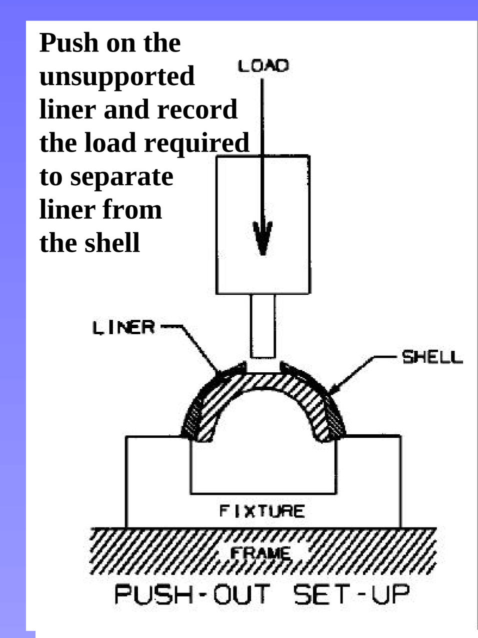
Six liner-shell assemblies were subjected to a lever out test described by Trandonsky, et al and another six liner-shell assemblies were subjected to the same cyclic loading regimen described above and then subjected to lever out testing. The results are summarized in Table 2. All reported lever out values represent either failure of the fixture or failure of the lever arm. In no case did the insert actually "lever out" of the titanium shell.

Torsional Test

For torsional testing twelve ceramic liners were assembled into titanium shells, which were, in turn, glued into stainless steel cylindrical fixtures. Cobalt chrome femoral heads were glued to the inside of the ceramic liners. Femoral heads were assembled onto titanium tapered spigots representing femoral stem tapers. The spigots and cylindrical fixtures were firmly fixed in the test machine, and were subjected to torsional load until failure. Six of the assemblies were subjected to the cyclical fatigue regimen described above prior to conducting the torsional test. Results of the torsional test are summarized in Table 3. None of these test specimens actually failed at the liner-shell interface, but rather, either between the stem taper and femoral head (2 cases) or at the shell/fixture interface. All of these specimens demonstrated adhesive failure of the test assembly before failure at the liner-shell interface could be achieved.

Table 1
Static and Post Fatigue Push Out Force

Specimen	*Mean Push Out Force (std. dev.), N*
Static	10,998 (2,220)
Post-Fatigue	13,633 (2,458)



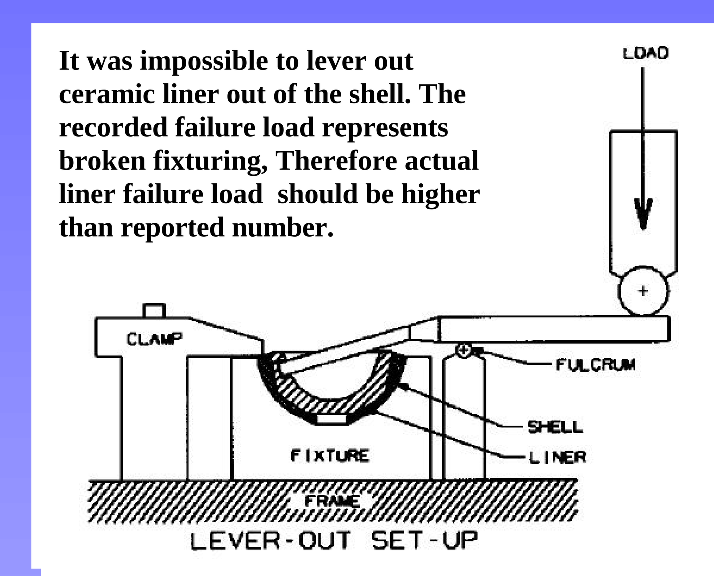


Table 2
Static and Post Fatigue Lever Out Torque

Specimen	*Mean Lever Out Torque (std. dev.), N-m*
Static	337.5 (87.3)
Post-Fatigue	337.5 (90.1)

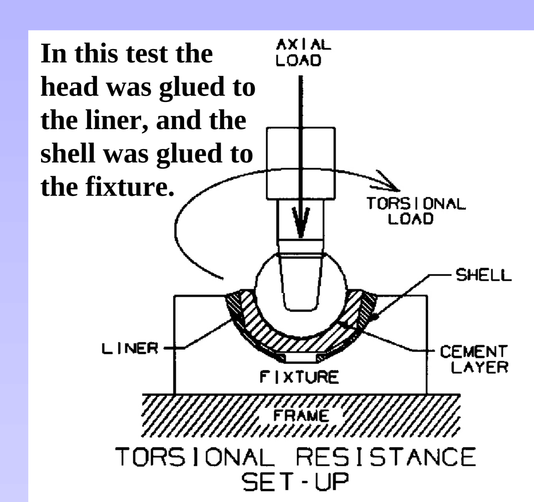


Table 3
Static and Post Fatigue Torsional Separation

Specimen	Mean Torque (std. dev.), N-m
Static	121.8 (26.4)
Post-Fatigue	150.8 (17.5)

DISCUSSION AND CONCLUSION:

Review of three contemporary acetabular designs with the cross-linked polyethylene inserts revealed that the CONVERGE™ (Centerpulse, Switzerland) had the highest push out value of 3336 N (750 lbs.), and the Duraloc® with the locking mechanism supplemented by a wire capture (Depuy Orthopaedics) had the highest lever out value at 79 N-m (700 in-lbs.)[3]. By comparison, the alumina oxide liner had 3-4 times higher push out resistance, and a minimum of 1.5 times higher lever out resistance. The current study demonstrates that the alumina ceramic-titanium locking mechanism studied is more secure than polyethylene-titanium locking mechanisms.

REFERENCES

1. Trandonsky, Postak. Froimson, Greenwald: A Comparison of the Disassociation Strength of Modular Acetabular Components, Clinical Orthopedics and Related Research, 1993.
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