Introduction: Total joint arthroplasty surgeons are frequently faced with a patient who presents with a cementless acetabular shell securely fixed to the pelvis, but with a failed polyethylene liner. Performing a complete acetabular revision or simply replacing the original liner may not be possible or advisable. The surgeon’s best option may be to leave the fixed shell in place and cement a replacement liner into the shell. Given that surgeons are actively employing this technique in patients, laboratory work is clearly necessary to help determine the best construct that can be created with this technique. The purpose of the present study was to expand upon earlier studies,1-5 and determine which surgeon-controlled variables would lead to the strongest mechanical construct when cementing a polyethylene liner into a fixed acetabular shell. The specific objectives of the study were to determine the contributions of liner texturing, shell texturing, and cement mantle thickness, to the overall mechanical strength of the construct. Methods: The contributions of the shell/cement and cement/liner interfaces to the cemented liner construct were evaluated using torsional and lever-out tests. Yield strength and maximum strength were determined. Experimental groups studied included: 1) smooth vs. textured liners, 2) unscored vs. scored acetabular shells, with and without holes, and 3) cement mantle thickness. Four different shells and five different liners (DePuy) were used to evaluate these variables (Fig. 1), with n = 5.

The acetabular shells were potted with dental acrylic to simulate cementing at the shell/cement interface, with two exceptions (polished, no hole, unscored shell). The acetabular shells were potted with dental acrylic to simulate cementing at the shell/cement interface, with two exceptions (polished, no hole, unscored shell). Nine experimental groups were tested in torsion (Fig. 2a). The specimens were cured at 37°C for four to five days before testing.

Nine experimental groups were tested in torsion (Fig. 2a). The liners were rigidly fixed to the actuator of the MTS machine, using twelve small circumferentially spaced screws. An x-y stage allowed free horizontal motion of the potted shell. An axial load of 70 kg (686.5 N) was applied to the liner. The liner was then rotated about its symmetry axis (Z; Fig. 2a) at 1°/sec until failure occurred.

Eight experimental groups were tested in lever-out (Fig. 2b). The liners were attached to a gripping ring, using twelve small circumferentially spaced screws. A lever arm was screwed into the center of the liner bearing surface, and a retaining nut was screwed to the level of the ring. A low melting point bismuth alloy was then poured into the liner. Lever-out torque was applied by means of a cylindrical platen eccentrically contacting the lever arm. The platen was lowered by the MTS machine at a liner rotation of 1°/sec until failure occurred.

One-way ANOVA and the Tukey-Welsch multiple comparison procedure were used to determine which shell/liner combinations were significantly different from one another (α = 0.05).

Results:

Discussion: Liner texturing, shell texturing, and cement mantle thickness affected the torsional and lever-out strength of the cemented liner constructs. Visible failure occurred only at the cement/liner interface, with two exceptions (polished, no hole, unscored shell).

Effect of liner texturing (Fig. 3a,b): The most important variable for the surgeon to control is liner texturing. In almost every cemented liner combination tested, failure occurred at the cement/liner interface. Textured liners had higher strengths than untextured liners, especially when the texturing features were oriented so as to oppose the applied loading. These results suggest that surgeons should texture the liners with a series of orthogonal grooves prior to cementing it in place.

Effect of shell texturing: Shell texturing, in any form, prevented failure at the shell/cement interface. As long as the shell had holes or was scored, visible failure occurred only at the cement/liner interface. This suggests that the practice of intraoperatively scoring the acetabular shell is unnecessary, provided the shell has existing texturing. Avoiding scoring of the shell prevents the creation of metal particulate debris (a likely source of 3rd body wear) during the scoring process.

Effect of cement mantle thickness (Fig. 3c): The thinner (2mm) cement mantle provided much greater construct strength in lever-out, and somewhat less construct strength under torsion, but statistical significance was not achieved for any measure. A thicker cement mantle can assure adequate liner positioning and at least minimal cement mantle thickness throughout the construct. A thinner cement mantle means a thicker liner, resulting in more polyethylene being available for wear and for any necessary liner scoring.4 However, a thin cement mantle could lead to the liner bottoming out within the shell.

Conclusions: A surgeon should ensure that both the shell and the liner are textured, as interdigitation of cement with the shell and liner is crucial to the mechanical strength of this construct. Given the importance of liner texturing and the potential for weakening a liner by “over-texturing” it with a high speed burr, the authors recommend that manufacturers consider producing polyethylene liners specifically designed for cementing into a shell.

Acknowledgements: DePuy Orthopaedics Inc., Warsaw, IN, donated all implants, and provided financial support for this study. Howmedica, Inc., Rutherford, NJ, donated the bone cement.


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49th Annual Meeting of the Orthopaedic Research Society
Poster #1367