Long-Term Performance of a Thin Acetabular Shell with a Cemented Insert in a Simulated Revision Condition of the Acetabulum-An In-Vitro Test Model

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INTRODUCTION
Revision total hip replacements are likely to have higher complication rates than primary procedures due to the poor quality of the original bone. This may be constrained to achieve adequate fixation strength to prevent future “aseptic loosening” [1]. A thin, slightly flexible, acetabular component with a three dimensional, titanium foam in-growth surface has been developed to compensate for inferior bone quality and decreased contact area between the host bone and implant by better distributing loads across the remaining acetabulum in a revision situation. This is assumed to result in more uniform bone apposition to the implant by minimizing stress concentrations at the implant/bone contact points that may be associated with a thicker, stiffer acetabular component, resulting in improved implant performance.[2] To assemble the liner to the shell, the use of PMMA bone cement is recommended at the interface between the polyethylene insert and the acetabular shell as a locking mechanism configuration may not be ideal due to the flexibility in the shell [3].

The purpose of this study was to quantify the mechanical integrity of a thin acetabular shell with a cemented liner in a laboratory bench-top total hip revision condition. Two-point loading in an unsupported cavity was created in a polyurethane foam block to mimic the contact of the anterior and posterior columns in an acetabulum with superior and inferior defects. This simulates the deformation in an acetabular shell when loaded anatomically [4]. The application has been extended to evaluate the fatigue performance of the Titanium metal foam Revision Non-Modular Shell Sequentially Cross Linked PE All-Poly Inserts and its influence on liner fixation.

RESULTS:
All three size constructs ran out at 10 x 10^6 cycles of compression fatigue loading. There was no visible or physical evidence of loosening at the shell/cement or liner/cement interface as well as no shell fracture or coating delamination. Additionally, the constructs were x-rayed and there was no evidence of screw or shell fracture. Construct X-rays were taken before the start of the test, at the end of 3.5 million cycles and at the end of 10 x 10^6 cycles to monitor the liner shell attachment activity within the acetabulum.

The average axial push-out load of the 54mm, 62mm, and 72mm Sequentially Cross Linked All-Poly Inserts was 928.4 ± 162.4 lb, 867.3 ± 225.3 lb, and 1558.1 ± 190.0 lb respectively. These distance forces are significantly higher (p-value is less than 0.0001 in all cases using a student’s t-test) than a load of 103 ± 19.8 lb.[6] published for the Omnifit liner. A majority of recorded peak loads occurred when the push-out pin punctured the liner. Therefore, the locking strength of Sequentially Cross Linked All-Poly Inserts cemented in Titanium metal foam Revision Non-Modular Acetabular Shells is significantly greater than the locking strength of liners in Omnifit shells which are clinically known as successful devices.

DISCUSSION:
The thin acetabular shell design is expected to deform when implanted, therefore the extent to which the shell deforms will not allow for use of a conventional shell/liner locking mechanism. A cavity was created in a foam block representing a compromised acetabulum, with a superior defect and partial rim contact was used to support the shell/liner assemblies during cyclic fatigue testing. The Titanium metal foam Revision Non-Modular Acetabular Shells and cemented Sequentially Cross Linked All-Poly Inserts withstand fatigue loading at 1200 lb/in a clinically relevant acetabular defect model for 10x10^6 cycles without failure. Additionally, results of this test determined that the axial push-out distraction load of the Sequentially Cross Linked All-Poly Inserts is significantly greater than currently marketed devices with a locking mechanism and successful clinical history.

REFERENCES:
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