Femoral Stem Subsidence After Impaction Bone Grafting: A Comparison of Morselized Bone Allograft Versus Synthetic Bone Graft Substitutes

1 Bruneau, P; 1Meyers, K; 1Johnstone, S; 1Wright, T; 1Padgett, D
1Hospital for Special Surgery, New York, NY
+meyersk@hss.edu

Introduction
The objective of impaction bone grafting of the proximal femur in revision total hip arthroplasty is to restore bone stock with the use of morselized bone allograft (MBG) while providing a stable femoral construct to allow early ambulation. Femoral stem subsidence has been reported to be as high as 50% and is a potential cause of failure in femoral impaction allografting. Furthermore, the use of allograft tissue carries the risk of infection, and as revision arthroplasty becomes more prevalent, an eventual shortage of allograft bone may develop. Others have examined the effect of adding synthetic graft materials to MBG, but have not considered using alternate materials exclusively. The purpose of this study was to determine the rates of subsidence between morselized bone allograft, Hydroxyapatite (HA) and β Tricalcium Phosphate (TCP).

Methods
Eighteen synthetic femurs were used for testing. The femoral necks were cut in a standardized fashion and the same defect was were created in each proximal femurs. The femurs were then randomized before being impacted with either MBG, HA, or TCP followed by the insertion of a cemented, double-tapered, polished stem. Photo-reflective markers were placed on the implant, the femoral shaft, and pins that were placed into the cement mantle as it was curing. The implanted femurs were potted, mounted on a servohydraulic load frame in 12° of varus, and loads were applied to the femoral head for 5000 cycles from 440N to 4000N. A bearing plate was inserted between the load cell and the femoral specimen to reduce friction. A Qualisys motion tracking system was utilized to record data in three dimensions at defined intervals, and the change in position at maximum load from 0 to 5000 cycles was calculated as total stem subsidence at 5000 cycles. Stem subsidence was defined as the relative motion of the implant markers with respect to the femoral markers in the axial direction (Y-axis). Overall motion in the axial (Y-axis) direction was determined using the displacement data from the load frame. This was then compared to the implant subsidence calculated from the marker data.

Statistical analysis was performed utilizing the Kruskal – Wallis one way ANOVA on ranks with a significant P value set for (p ≤ 0.05).

Results
The mean change in displacement relative to the load frame in the MBG group was 0.65mm. The mean change in load frame displacement in the TCP group was 0.49mm and in the HA group 0.46mm. No significant difference was found among the three groups (p=0.502), though the power of the performed test with alpha = 0.05 was 0.05.

The average stem subsidence in microns measured in the global Y direction utilizing the Qualisys motion tracking system was 406µ in the MBG group versus -21µ in the HA and -13µ in the TCP groups. A significant difference existed between the MBG group and the synthetic bone graft substitute groups (p ≤ 0.05); however, no difference was found between the two synthetic bone graft substitutes. The power for this test was 0.05.

Discussion
Femoral stem subsidence in the synthetic bone groups did not exceed subsidence in the morselized bone graft group. These findings suggest that Hydroxyapatite and β Tricalcium Phosphate can provide enough mechnical stability when impacted compared with that provided by Morselized Bone Graft, even under severe cyclic loading. Of course, further investigation is needed to determine the biological reactions to using only synthetic bone graft instead of morselized bone. The results also highlight the need to track individual bodies rather than relying on the overall motion of the construct. While the power was too low to show a significant difference in overall motion, it was adequate to determine a significant difference in subsidence between groups when using the marker data.

Acknowledgements
The authors would like to thank the Clark and Kirby Foundations for providing partial support for this study.