An In-Vitro Evaluation of the Initial Stability of Cementless Pressfit Hip Stems using Injectable HA Bone Substitute
+1Schmidig, G; ²Thakore, M; ³Yanoso-Scholl, L
+1Stryker Orthopaedics, Mahwah, NJ
Gregg.schmidig@stryker.com

INTRODUCTION
Stability of a cementless press-fit total hip arthroplasty is essential for osteointegration and long-term success of the implant. Areas of non-contact between the bone and implant (gaps) may reduce the initial stability of the resulting construct. Gaps occur naturally and as a result of surgical preparation. Better initial fixation is desired to improve long term clinical results. Hydroxyapatite (HA) bone substitutes have been used in conjunction with orthopaedic implants because of their osteoinductive and osteoconductive properties as well as their biocompatibility and mechanical properties.

We proposed the use of an injectable HA bone substitute to eliminate the gaps created at the bone/implant surface. This will theoretically increase surface contact area between the implant and HA/bone and ultimately improve initial stability of the implant. This theory was tested by measuring interfacial micromotion of an orthopaedic cementless hip stem implanted into a composite femur both with and without an injectable HA bone substitute. A physiological loading profile consisting of axial and cyclic torsional loading was implemented.

METHOD
Testing was performed on titanium alloy Meridian ST Femoral Components (Stryker Orthopaedics, NJ) with a roughened ingrowth surface. The stem was modified with 1/8” holes drilled into the medial, anterior and posterior aspects of the femoral stem. The holes were positioned central to the ingrowth in the S/I direction. Synthetic composite femurs (Pacific Research Labs, WA) were used for testing. Typical surgical recommendations were followed for creating the femoral bone canal. Based on measurements taken by Wu et al., gaps were created in approximately 32% of the femoral canal [1]. The control group specimens (n=3) were tested with the gaps. The test group (n=3) had an injectable HA bone substitute pressed into the gaps by hand prior to insertion of hip stem (Figure 1, A). The femur was shortened distally to fit on the mechanical test frame (MTS, Eden Prairie, MN) and secured in a metal block at a 0˚ flexion angle and 0˚ varus/valgus angle using bone cement. Metal probes for measurement by LVDT (Linear Variable Differential Transformers) transducers were placed in the hip stem and the LVDTs were mounted to the bone via a custom frame (Figure 1, B). Three LVDTs were mounted vertically to collect superior/inferior displacement of the probes. Three additional LVDTs were mounted horizontally to collect medial/lateral displacement from the anterior and posterior probes and anterior/posterior displacement from the medial probe.

Mechanical loading included an axial compressive load ramping from 0 N to 1000 N at a rate of 200 N/s followed by ten torsional cycles oscillating between 8 N-m external torque to 6 N-m internal torque at a rate of 0.5 Hz. Calculations were used to convert the displacements measured by the LVDTs into interfacial micromotion which is defined as micromotion occurring at the bone/implant interface [2].

RESULTS
Data collected from the anterior and medial horizontal probes showed that axial compression produced greater micromotion (p<0.01) in the control group when compared to the test group (Figure 2). During torsional loading the test group had reduced motion for the anterior, medial and posterior probes (p<0.01, p<0.01, p<0.001, respectively). For both groups it was noted that there was an increase in micromotion at the medial probe when compared to the anterior and posterior probes for both axial and torsional loading. This indicated that the implant tended to tilt in the medial direction during testing.

Translational motion was calculated from data obtained from the vertical probes. Translational data was summed for axial and torsional loading. The data is shown on a logarithmic scale and the control group had significantly (p<0.01) larger total micromotion than the test group. Based on calculations, it was determined that for both axial and torsional loading, the translational component of the interfacial micromotion was significantly greater than the rotational component (p<0.001).

DISCUSSION
The purpose of this study was to determine whether the use of an injectable HA bone substitute would reduce initial micromotion of a cementless press-fit hip implant. Initial stability is important to the long-term success of an implant. It was found that the addition of the bone substitute in the gaps of the bone canal significantly reduced both translational and rotational micromotion. This stabilizing feature in conjunction with the bone inductive properties of the bone substitute can make it a valuable asset in orthopaedic implantation. The test was conducted for basic research and it does not recommend the use of this product as described. The HA bone substitute used is a bone gap filler and not meant to provide mechanical stability. Further research must be performed to determine the usefulness of the bone substitute as a grouting agent.

REFERENCES