**Novel Method for Testing Cementless Tibial Components Using Micromotion and Impedance Vibration Analysis**

**INTRODUCTION:**

The initial mechanical stability of cementless implants is critical to achieve successful osseointegration through minimization of deleterious micromotion. Controversy exists regarding the most reliable and appropriate methodology for *in vitro* mechanical testing of implants used to guide design and performance of cementless total knee replacement. Mechanical testing methods vary within the literature, both with respect to the applied loads to simulate in vivo forces, as well as the devices used to assess the micromotion and stability. Established methodology involves the use of linear variable differential transducers (LVDT) to measure micromotion; however, LVDT’s are limited by varying specifications, mechanical quality, and difficulty constructing a test apparatus to accurately acquire data in three planes of motion.

The objective of this study was to assess whether vibration analysis methods via structural impedance measurements are capable of identifying and characterizing initial mechanical stability of cementless tibial implants. A second objective was to establish a precise and clinically relevant method of assessing initial mechanical stability and micromotion of tibial implants in 6 degrees of freedom.

**MATERIALS AND METHODS:**

The mechanical test setup and methodology utilized in this study is based on an established ASTM standard for biomechanically induced loosening of glenoid components in shoulder arthroplasty (ASTM F-2028-08). This was modified for knee arthroplasty testing based on previous studies and incorporates compressive, shear and torsional force components (Figure 1). Testing was conducted with a constant 700 N compressive force that equates to weight-bearing, and the A/P shear loads of up to 350N induced micromotion. The shear load was applied cyclically at 0.1Hz for 30 cycles by an MTS servohydraulic machine. The average maximum recoverable displacement at five locations for the 3 tested tibial component designs is reported in Figure 2. A p-value of 0.05 was considered statistically significant.

**RESULTS:**

The average maximum recoverable displacement at five locations for the 3 tested tibial component designs is reported in Figure 2. A significant difference was observed at all 5 locations between the cementless and cemented designs with the control cemented designs having less mean micromotion than the cementless designs. A significant difference between the two cementless designs in micromotion was noted only at the medial edge of the tibial component, with the four-pegged design demonstrating greater displacement.

**CONCLUSION:**

This novel mechanical test apparatus and loading scenario appears to be an accurate and clinically relevant method to assess the initial stability of cementless tibial components. This method is able to determine the difference in experimental micromotion between cemented and cementless implants, as well as being able to distinguish between cementless components of different designs. This study was also able to demonstrate that vibration analysis methods via structural impedance measurements are capable of identifying and characterizing initial mechanical stability of cementless tibial implants. Yet, due to the requirement of using a particular frequency band, the impedance may not provide as robust a test method as hypothesized. However, further research is warranted to determine if these novel methods of assessing implant micromotion and stability can improve and simplify mechanical testing of cementless implants and facilitate design of such components.