A NOVEL TECHNIQUE FOR MICROMOTION MEASUREMENT OF UNICOMPARTMENTAL TIBIAL TRAYS FOR DESIGN COMPARISONS

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Statement of Purpose: The study of micromotion for orthopaedic devices is an important predictor for the survival of orthopaedic devices. Several studies have used an approach based on LVDTs for the measurement of micromotion in 6 degrees of freedom[1]. This approach, while relevant, can be susceptible to error due to the fixation of measurement instrumentation to the tested medium. LVDTs can move at a level that is larger than the measured test parameters at a micrometer level. We are proposing a new testing protocol that can be used to compare tibial tray keel designs.

Methods: The test was conducted on an MTS machine (Eden Prairie, MN) with polyurethane foam capable of simulating the bone structure and mechanical properties (Sawbones Worldwide, Vashon Island, WA). The block was clamped to the MTS machine surface as shown in Figure 1.

An adjustable testing head was used to first push a needle end effector into the sawbone, and then a cylindrical peg of the same diameter was inserted to the same hole. A secondary location was also loaded with the peg giving distinct force measurements (Figure 2).

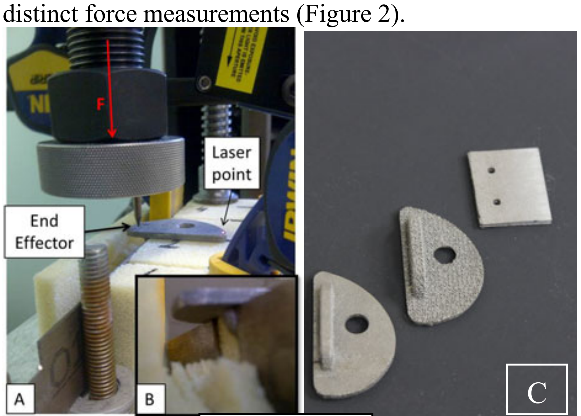

Figure 1

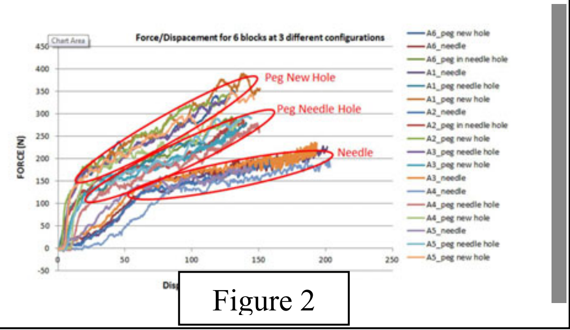

Figure 2

Data from the blocks show that for a given block, the hole created by the needle still provides an increased reactionary friction force to the peg, and hence demonstrates the bone-like hoop stress required to test the various implant designs for micromotion under loading.

The implant is expected to compress the surrounding prep walls while maintaining the hoop stress.

A slot was cut along the sawbone material as shown on Figure 1A. The implant's posterior section was allowed to overhang the foam so the loading would create a maximum moment arm with minimum resistance. A metal shim with slots was placed along the cut to provide room for the keel design of the implant while supporting the bottom of the implant for the moment fulcrum without creating foam compression (Figure 1B). The posterior edge of the implant was loaded with a needle and the anterior most point of the implant was measured by a laser displacement sensor (MTI Instruments, Albany, NY) capable of 1 micrometer resolution measurements.

A simple keel design was chosen to compare the micromotion of solid titanium versus a porous high friction titanium structure. Both designs were dimensionally equivalent and were inserted into the sawbone using a prep punch with uniform interference fit of 1.3mm (Figure 1C). Implants were inserted in the sawbone by the MTS machine loaded directly over the center of the keel to prevent loosening of the implant due to compression of material walls caused by moments generated. Both designs were inserted at a rate of 5 mm/min. The micromotion test was conducted at 0.5mm/min to eliminate error and to minimize the likelihood of introducing dynamic responses within the system.

Results:

The insertion forces and the liftoff forces for the solid and porous titanium keel designs are shown below. The liftoff force is recorded at a displacement of 0.1mm. Both the insertion and liftoff forces show distinct differences for the different materials that were tested.

		Insertion Force (N)		Liftoff Force (N)	
Description	Samples	Average	Standard Deviation	Average	Standard Deviation
Solid Keel	6	242.25	17.40	75.79	13.70
Porous Keel	4	306.25	101.17	42.36	14.32

Conclusions:

The test method is an effective way of distinguishing between different tibial tray keel design proposals and is useful for determining the best design giving the trade-off of insertion force to liftoff force, which is important for a cementless orthopaedic implant concept.

References:

1.Amer et al. Initial Mechanical Stability of Cementless Highly-Porous Titanium Tibial Components. Proceedings of the IMAC. 2009 Orlando, Florida.