The Effect of Fixation Design on Micromotion of Cementless Tibial Baseplates
+Bhimji, S; 1Alipit, V.  
+Stryker Orthopaedics, Mahwah, NJ  
safia.bhimji@stryker.com

INTRODUCTION:
Initial implant stability is crucial to cementless knee replacement success, however the optimal design remains elusive. Previous biomechanical studies have aimed at quantifying initial stability using simplified loading scenarios. The objective of this study was to use a physiological relevant methodology which incorporates torsion, shear and compression forces to evaluate tibial components with two different fixation features: A monoblock baseplate featuring two 16 mm long hexagonal pegs, and a modular design featuring a keel with four 9 mm long cruciform pegs surrounding it.

METHODS:
A test model previously published by the authors was used in this study.1 A dual density polyurethane foam construct was developed to simulate the proximal tibia. The construct consists of an inner core of 12.5 pcf open cell foam to simulate cancellous bone, and an outer rim of 40 pcf closed cell foam to simulate cortical bone.

Two medium samples each of baseplate (Figure 1) were mounted to a foam construct, and spheres attached to their medial, lateral, anterior, and posterior rims. LVDTs were then mounted to the foam constructs and arranged to measure compression/liftoff motion at each sphere. 16 mm PS inserts were mounted to the modular baseplate according to surgical protocol (the monoblock design featured a 17 mm PS insert). Each construct was then rigidly clamped to a servohydraulic test machine (Figure 2). A loading profile representing a stair descent activity, adapted from Benson, et al.,2 was applied to the constructs (Figure 3). All loads were applied to the baseplate through reactions of a PS femoral component articulating on the insert at a 72 deg flexion angle. Compressive loads, anterior/ posterior loads, and internal/ external torques were varied as a function of the gait cycle. This loading profile is ideal as it represents a relatively high load activity that applies high shear forces to the tibial component at a low compressive load (at ~60% gait cycle).

The profile also involves reverse loading, which could be a cause of baseplate loosening in-vivo. Average compression and liftoff at each LVDT were calculated throughout the test, and averaged across samples. Comparisons between designs were made via an unpaired t-test with α=0.05.

RESULTS:
Figures 4 – 7 show the average compressive and liftoff motions at the anterior, posterior, medial, and lateral spheres, respectively, for each design tested. Results reveal the total motion of the hex peg device to be substantially larger than the keel with pegs device. The nature of the motion for the hex peg device is comprised of both compression and liftoff at all locations, signifying a rocking motion in the sagittal and frontal planes throughout the load cycle. Contrarily, the keel with pegs devise demonstrates significantly less liftoff at the posterior, medial, and lateral locations, signifying more subsidence of the device into the bone.

DISCUSSION:
The findings of this study indicate that baseplates with dual hex peg fixation are susceptible to larger amounts of liftoff than those with a keel and four surrounding pegs. In terms of long term stability, liftoff motion is more likely to inhibit bone ingrowth than pure subsidence due to the physical separation of the baseplate from the bone. It is therefore concluded that baseplates featuring a keel with four pegs will experience better initial and long term stability than those featuring only peg fixation. The successful use of cementless keel devices documented in the literature support this finding.3-6

SIGNIFICANCE:
This study applies clinically relevant loading to evaluate the initial fixation of two types of baseplates. Optimal initial fixation is crucial to bone ingrowth and ultimate long-term stability.

REFERENCES: