The Effect of Peg vs. Keel Fixation on Micromotion of Cementless Tibial Baseplates

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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 full keel and two 0.5 inch diameter cylindrical pegs.

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.

Four medium samples each of the 2-peg and keel baseplates (Figure 1) were mounted to a foam construct, and spheres attached to their medial, lateral, anterior, and posterior rims. LVDTs were then mounted on the foam constructs and arranged to measure compression/liftoff motion at each sphere. 16 mm PS inserts were mounted to the baseplates according to surgical protocol. 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 2-peg device to be substantially larger than the keel device. The nature of the motion for the 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 device demonstrates primarily compression at the posterior, medial, and lateral locations, signifying subsidence of the device into the bone. Differences in liftoff motions are significant between designs at the medial location, and near significant at the posterior and lateral locations.

DISCUSSION:
The findings of this study indicate that baseplates with dual peg fixation are susceptible to rocking motions, whereas those with full keel fixation mainly subside into the bone. In terms of long term stability, the liftoff motion created during rocking 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 full keel 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.1,4

REFERENCES:

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