The Combined Effect of Tibiofemoral Conformity & Tibial Base Design on Initial Stability of Cementless TKA

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1. Introduction

- Initial fixation of cementless tibial baseplates is critical to long-term bony ingrowth
  - Key factors: bone quality, surgical technique, baseplate fixation features, and loading of the tray via the articulating surfaces
- Increased sagittal conformity between the insert and femur improves knee stability[1], but affects on tibial micromotion is unclear (Fig. 1)
- **Goal:** characterize the affect of tibiofemoral conformity, knee kinematics, and fixation features on tibial micromotion (Fig. 2)

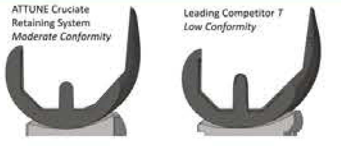


Figure 1: Examples of low and high conformity tibiofemoral articulations from commercially available knee systems

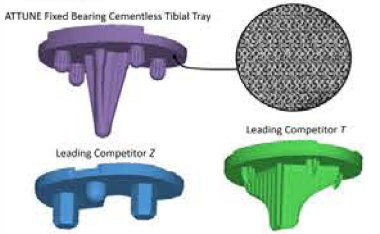


Figure 2: Tray fixation features for three different commercially available cementless tibial trays

2. Methods

- Tibial Sawbones™ were implanted with three contemporary cementless tibial tray designs
  - Loaded via their respective femurs and inserts in an AMTI VIVO™
  - Gait, stair descent, and deep knee bend cycles [2-4]
  - Micromotions between the tray and bone were measured using Digital Image Correlation
- A finite-element (FE) model of the experiment was validated using results from the testing[2]
  - Isolated effects of tray fixation features from articular conformity by virtually exchanging the articulating features of the highest and lowest conformity designs and predicting the resulting micromotion.

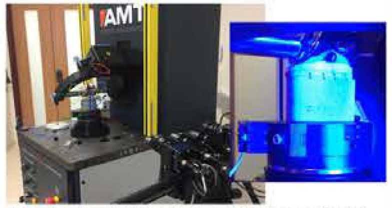


Figure 3: Experimental setup, including synthetic bone construct mounted in the VIVO with DIC

Figure 4: Synthetic foam bone construct in the VIVO (left) and the associated FE model (right)

3. Results

- Largest tibial micromotions were observed during stair descent and gait, following a consistent pattern.
- Increased micromotion correlated with lower conformity and higher condylar translations.

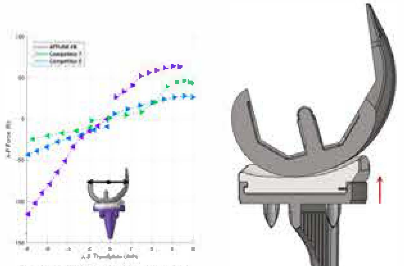


Figure 5: A-P laxity of implant articulation at full extension and 30° Flexion

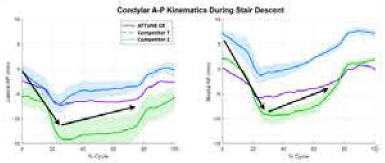


Figure 6: Femoral Condylar A-P kinematics while descending stairs

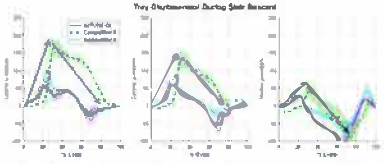


Figure 7: Tray-bone displacement measured across the anterior aspect of the tibial tray during stair descent

3. Results (Cont.)

- Lowest conformity design had highest condylar translations during Gait and Stair Descent
  - Gait: 6.0mm (Attune) to 11.7mm (Competitor *T*)
  - Stair Descent : 6.6mm (Attune) compared to 11.7mm (Competitor *T*)
- Lowest conformity design had highest micromotions during Gait and Stair Descent
  - Gait: 101.4μm (Attune) to 146.5μm (Competitor *T*)
  - Stair Descent : 126.7μm (Attune) compared to 160.5μm (Competitor *T*)

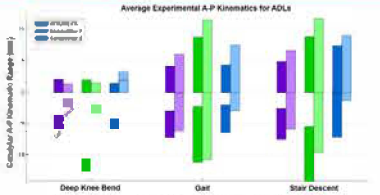


Figure 8: A-P range of condylar kinematics during activities of daily living

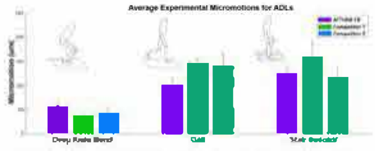
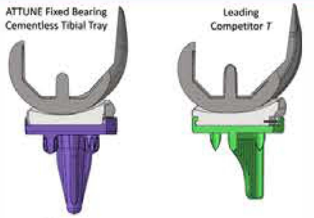
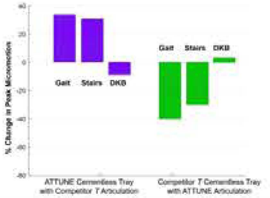


Figure 7: Average experimental micromotion (max-min) for activities of daily living

4. Discussion

- Experimental evidence suggests that articulation conformity is major driver of micromotion, but what about tray design factors?
- In FE model, swapped articulating surfaces:
  - For ATTUNE® Knee, swapping with a low conformity design increased micromotion over 30% for gait and stair descent[5]
  - For Competitor T, swapping with a high conformity design reduced micromotion between 30% - 40%[5]





5. Conclusion

- Limitations:
  - Experimental model did not have ligamentous or muscular constraint, which may improve stability (but loading does)
  - Foam bone has different mechanical properties than real bone
  - Initial fixation is a good predictor of long-term survivorship, but clinical studies and RSA evaluation still necessary to understand clinical performance
- Conclusion: Cementless tibial tray designs with optimized fixation features and moderately increased levels of tibial-femoral conformity can reduce A-P translations during activities of daily living, thus reducing micromotion and improving initial stability of cementless tibial trays.

References:
1) Clary CW, Fitzpatrick CK, Maletsky LP, Rullkoetter PJ. [illegible] J Biomech. 2013 Apr 26;46(7):1351-7.
2) Navacchia A, Clary CW, Wilson HJ, Behnam YA, Rullkoetter PJ. [illegible] J Biomech. 2018 [illegible]
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