DEPENDENCE OF TOTAL ANKLE TIBIAL BASEPLATE STABILITY UPON DEVICE FIXATION FEATURES

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Introduction

- Success of uncemented total ankle replacement (TAR) is linked to initial implant stability.
- Bone-implant micromotions <20-50 µm promote bone ingrowth, while those >150 µm promote fibrous tissue ingrowth.[1,2]
- Tibial implant design fixation features play a critical role in determining early stability.
- Fixation is supplemented with retention of bone sidewalls and interference fit.
- This study reports early findings on how different TAR tibial component designs affect implant-bone micromotions.

Objective

Investigate how TAR tibial component fixation design features influence implant-bone interface micromotion.

Methods

- Finite element analysis (FEA) was used to evaluate implant-bone micromotion for tibial component of TAR implant designs.
- Three tibial component designs virtually implanted into computer models of a patient with end-stage ankle arthritis.
- Designs 1 and 2 are commercially available products with differing baseplate shapes. Design 3 is a generalized model of a common design strategy.

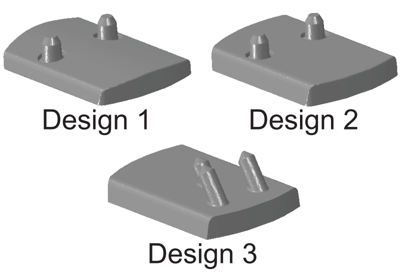

Figure 1: Tibial components of TAR implants

- Patient selected for having healthy bone.
- Tibia models generated from CT, with bone properties assigned from CT Hounsfield units to allow modeling of plastic deformation (i.e., compaction) of bone with interference fit.[3]
- All tibial implants modeled as titanium alloy material.
- Two fixation cases modeled (Figure 2):
  1) No sidewalls + line-to-line fit
  2) Retained sidewalls + 50 µm interference fit

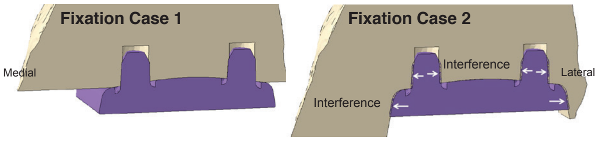

Figure 2: Fixation Cases Considered (1) No sidewalls + line-to-line and (2) Sidewalls retained + 50 µm interference fit

- Fixation Case 1 targeted analysis of implant fixation features, while Fixation Case 2 evaluated role of fixation features in clinically meaningful implantation.
- FEA performed using body weight-scaled kinetic profiles representing the stance phase of gait.[4]
- Press-fit simulated prior to gait for interference fit cases.
- Micromotions defined as displacement difference between bone-implant closest nodal pairs.

Results

- For no sidewalls + line-to-line fit fixation case, micromotions observed were relatively large, especially at the beginning and end of the stance phase of gait (Figure 3).
- Micromotions observed were largest for Design 1, 2, then 3, with peak values of 223 µm, 160 µm, and 46 µm, respectively.
- Design 1 and Design 2 performed similarly, with notable differences at early and late stance where more micromotion was observed in Design 1, with the only effective design difference being the arced baseplate.

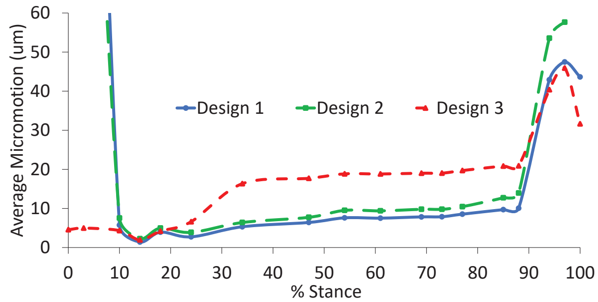

Figure 3: Micromotion during stance no sidewalls+line-to-line fit

- For sidewalls + 50 µm interference fit fixation case, micromotions observed were substantially smaller for all implant designs, especially in early and late stance (Figure 4).

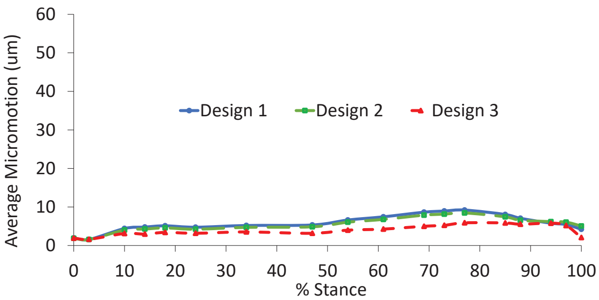

Figure 4: Micromotion during stance Sidewalls+50µm press-fit

- Design 3 less susceptible to proximally directed forces and out of plane moments prevailing in early stance when modeled without sidewalls or interference fit.
- Design 3 micromotions remained below the 50 µm threshold throughout stance for both Fixation Case 1 and Fixation Case 2.
- All designs performed similarly in Fixation Case 2, with average micromotions for all implant designs below 10 µm.

Discussion

- Findings suggest that the unique fixation design features of TAR tibial components play a role in initial implant stability.
- Differences in micromotion between implant designs are also explainable by analyzing design features and loads in the ankle at a given point in the gait cycle, further suggesting a relationship between fixation and design feature.
- Differences between implant designs largely disappeared when tibia sidewalls and interference fit were introduced.
- Findings suggest that in relatively healthy bone, proper cementless fixation may play a more important role than the specific implant design fixation features, given the nearly identical micromotion behavior of the three different designs when modeled with retained sidewalls and interference fit.

Significance

- This study presents new insights on the relative initial stability afforded by TAR fixation features across designs.
- Furthermore, this study suggests how the design fixation features of the specific implants perform nearly identically when implanted with an interference fit.

Acknowledgements

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Paragon 28

References

[1] Jasty et al. (1997), *J Bone Joint Surg* 79(5):707-14.
[2] Jasty et al. (1997), *J Arthroplasty* 12(1):106-13.
[3] Bayraktar et al. (2004), *J Biomech* 37(1):27-35.
[4] Quevedo Gonzalez et al. (2021) *J Orthop Res* 39(1):94-102.

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