# Implant Choice Impacts Initial Tibial Component Micromotion in Total Ankle Replacement: A Biomechanical Analysis

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INTRODUCTION: Despite advancements in technique and design, total ankle replacements (TARs) remain at risk of early mechanical failure and revision. Prior clinical studies have demonstrated that implants with more robust tibial fixation – i.e., stemmed designs – are associated with lower risk of early aseptic failure. One hypothesis is that more robust fixation accommodates loads more effectively, resulting in less micromotion at the bone-implant interface and resulting in improved osseointegration. Our aim was to compare the micromotion of the tibial component between two fixation features using a cadaveric robotic gait simulator. We hypothesized that stemmed tibial implants would have less micromotion than low-profile tibial implants with peg fixation throughout the stance phase of gait.

METHODS: Five cadaveric matched pairs (5 males, age: 46±14 years) were used for the study. Specimens underwent computed tomography (CT) scans to generate patient-specific instrumentation (PSI) and alignment guides, and then underwent either low-profile peg or stemmed TAR in a randomized order. Post-TAR, gait was simulated using a validated six-degree-of-freedom robot, which operates by rotating a force plate around a stationary tibia. A digital image correlation camera system captured the relative motion of the tibial bone and the implant via surface reflective markers during the gait simulations. Implant micromotion throughout gait was calculated by performing rigid body transformations on segmented geometries of the tibia and implant obtained from post-gait simulation CT scans. Peak micromotion was defined as the maximum nodal displacement on the implant surface considering each time point in stance. A paired t-test was used to compare the peak micromotion of stemmed and low-profile implants between matched pairs.

RESULTS: All TARs were implanted according to the PSI plans without complications. Alignment was assessed and confirmed with postoperative imaging. Mean peak micromotion was significantly greater in the low-profile implants compared to the stemmed implants (382±156 μm vs. 240±158 μm, P=0.00392). Peak micromotion was greater in the low-profile implant in each specimen pair, with an average increase of 59% compared to the stemmed implant (P=0.008). In the low-profile implants, peak micromotion occurred at the posterior aspect of the tibial component, consistent with a rocking motion in the sagittal plane. Meanwhile, micromotion was evenly distributed throughout the stemmed implant, and was directed superiorly into the tibial bone.

DISCUSSION AND CONCLUSION: In this study, we found significant differences in time-zero tibial component micromotion between stemmed and low-profile peg fixation implants. Low-profile implants consistently produced greater peak micromotion compared to stemmed implants. The location of peak micromotion implies that stemmed implants were further compressed into bone superiorly, whereas the low-profile implants demonstrated a rocking motion. Our data support the hypothesis that higher early mechanical failures in low-profile tibial implants, especially those associated with subsidence in the sagittal plane, may be due to excessive early micromotion.

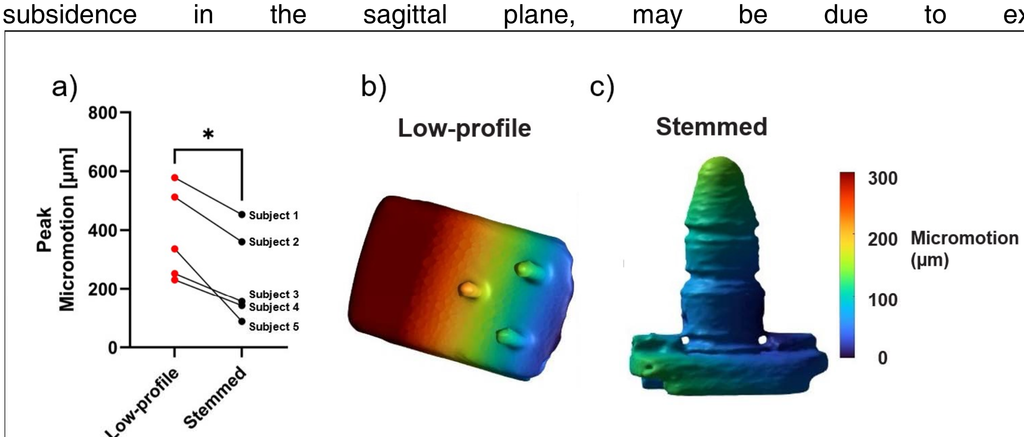


Figure 1: (a) Peak micromotion values for each matched pair for low-profile and stemmed implant designs. (b-) An example of the three-dimensional mesh deviation analysis for low-profile (b) and stemmed (c) implants. The color gradient is indicative of the micromotion of the implant relative to its initial position at a specific time point in stance.