

Press-fit Tibial Tray Micromotion is Similar during Loading in High Flexion Between Manual and Robotic-Assisted Total Knee Arthroplasty

Ana Figueroa¹, Ayobami Ogunsola^{1,2}, Michael Marinier¹, Marc Brouillette¹, Jessica Goetz¹, Jacob Elkins¹

¹University of Iowa, Iowa City, IA, ²Wake Forest University, Winston-Salem, NC
anavictoria-figueroa@uiowa.edu

Disclosures: Ana Figueroa (N), Ayobami Ogunsola (N), Michael Marinier (N), Marc Brouillette (N), Jessica Goetz (N), Jacob Elkins (5; Research Support (DePuy Synthes), Research Support (IronMind). 8; Editor (Journal of Arthroplasty).

INTRODUCTION: Robot assisted TKAs (rTKA) are becoming more prevalent when compared to manual TKAs (mTKA) [1]. Most comparative studies between the two focus on factors such as revision rates [2], implant positioning [3], and patient satisfaction [4]. However, another key factor in the success of a TKA is overall stability of the tibial implant. The role of initial implant stability is perhaps even more critical in the setting of modern press-fit components. The objective of this study was to determine differences in the motion of the posterior edge of the press-fit tibial component relative to the tibia when the surgery was performed with and without the use of a surgical robot.

METHODS: 10 fresh-frozen lower-body (pelvis to toe-tips) cadaveric specimens were implanted with an Attune press-fit Cruciate Retaining Knee System (DePuy Synthes, Warsaw, IN). One side of each specimen was randomized to undergo a mTKA and the contralateral underwent rTKA. A traditional gap-balancing technique was used for the mTKAs, and a VELYS Robotic-Assisted Solution (DePuy Synthes, Warsaw, IN) was used for the rTKAs. After surgical implantation, all tibias were harvested, soft tissues and the fibula were removed, and the bones embedded in polymethylmethacrylate bone cement up to 3 cm distal to the tibial cut, for mechanical testing. A custom Delrin® insert was manufactured, which permitted loading scenarios on the tibial tray similar to those seen during weight-bearing deep flexion. The custom insert was loaded with a ball-end, two-pronged, simulated femoral component mounted on an MTS actuator (MTS Inc. Eden Prairie, MN). Specimens were first axially loaded with 250 N to seat the implants into the tibia, replicating initial post-operative, protected weightbearing standing. Specimens were then fixed with the tibia at a 60° angle from vertical and cyclically loaded for 10 cycles from 10 N to 600 N to represent stair climbing. Displacement of the posterior edge of the implant relative to the tibia was measured using a digital image correlation system (ARAMIS, GOM, Braunschweig, Germany). Displacement was quantified relative to the tibia in a local coordinate system orthogonal to the plane created by the proximal surface of the tibial component (Figure 1). Average displacement within a given loading cycle and maximum displacement of the implant under load were calculated independently for the medial and lateral sides of the implant. Within-cycle displacement differences were compared using Students' t-tests, and repeated-measures (medial/lateral), two-way ANOVA with Fisher's LSD pairwise comparisons were used to determine the statistical significance of differences in maximum displacement during cyclic testing ($p < 0.05$).

RESULTS: Data from $n=2$ mTKA specimens was not available due to a software failure during data capture ($n=1$) and to a tibia fracture during testing ($n=1$). Within-cycle (between 10 N and 600 N) implant displacement for rTKAs averaged 0.32 ± 0.18 mm, and mTKAs had an average of 0.20 ± 0.11 mm of displacement, which was significantly different ($p = 0.018$), but of a negligible magnitude. Maximum displacement on the lateral side of the implant averaged 1.07 ± 0.60 mm for mTKA and 1.38 ± 0.86 mm for rTKA. Similarly, maximum implant displacement on the medial side averaged 1.00 ± 0.56 mm for mTKA and 1.30 ± 0.80 mm for rTKA. There were no significant differences between surgery types nor laterality (Figure 2); between lateral manual and robot ($p = 0.365$), between medial robot and manual ($p = 0.381$), manual surgery type between laterality ($p = 0.497$) and robotic surgery type between laterality ($p = 0.386$).

DISCUSSION: This study determined that there was no significant difference in press-fit tibial implant motion between rTKAs and mTKAs when loaded in high flexion. The wide variation in implant displacement data for both rTKA and mTKA and could be the result of large variation among cadaveric specimens regarding bone structure and density. Slight variation in displacement between the medial and lateral sides of the implant may be the result of the orientation of the tibial implant relative to the digital image correlation cameras, as well as slight overhang of the implant relative to the posterolateral tibial cortex.

SIGNIFICANCE/CLINICAL RELEVANCE: Both manual and robotic-assisted press-fit TKAs performed similarly regarding tibial implant motion during the extreme weight-bearing conditions of deep flexion loading. The degree of tibial tray unsupported by cortical bone should be minimized to reduce incidence of early implant motion and possible loosening.

REFERENCES: [1] Siebert, W., et al. *The Knee*. 2002. [2] Sione AO., et al., *Arthroplasty Today*, 6(4), 2020. [3] Song EK., et al., *Clin Orthop Relat Res.*, 471(1), 2013. [4] Khlopas A, et al., *J Knee Surg*, 33(07), 2020.

ACKNOWLEDGEMENTS: The authors would acknowledge DePuy Synthes and the Roy and Linda Crowninshield Fund for Biomechanics Research for supporting this work. They would also like to thank Ryan Bailey for assistance with cadaveric surgery and Victoria Tappa and Caleb McCabe for assistance coordinating specimens and equipment for this study.

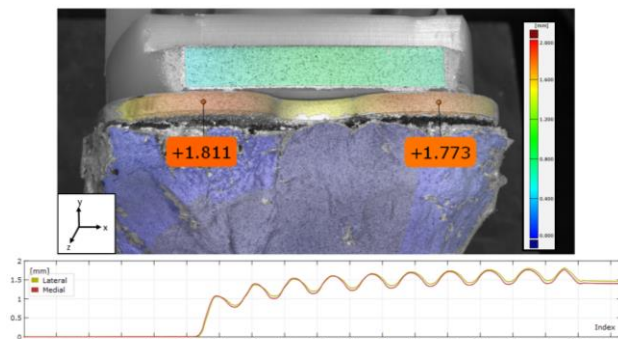


Figure 1. Digital image correlation analysis was conducted for each specimen to track the displacement (mm) of the posterior-most edge of the tibial implant relative to the tibia which was set to be a rigid reference frame (blue). Implant displacements are shown in both heat map and graph form.

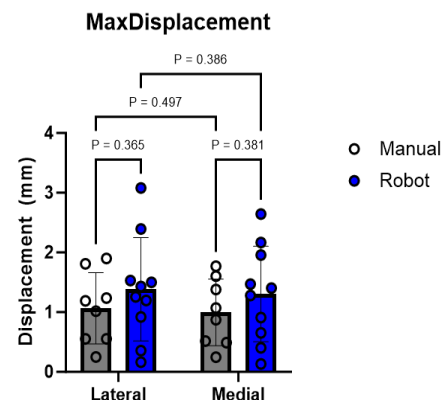


Figure 2. Maximum displacement of the posterior tibial implant edge relative to the tibia.