

Analyzing the Effect of Posterior Tibial Tilt in Medial UKA on Kinematics and Kinetics Using Mathematical Modeling

*Bradley Meccia - University of Tennessee Knoxville - Knoxville, USA
 Seth Coomer - University of Tennessee in Knoxville - Knoxville, USA
 Michael LaCour - University of Tennessee - Knoxville, USA
 Richard Komistek - The University of Tennessee - Knoxville, USA

*Email: allenbrad3@gmail.com

Introduction: When performing unilateral knee arthroplasty (UKA), the posterior tilt of the tibial component is commonly matched to the anatomical slope of the medial plateau, creating a postoperative geometry comparable to the native geometry. This is believed to produce native-like kinematics. Therefore, this study will analyze the effect of posterior tibial tilt (PTT) of the medial tibial component in UKA using mathematical modeling.

Methods: A previously developed and validated mathematical model of the human knee was expanded from only including total knee arthroplasty (TKA) to include UKA. In the mathematical model, a subject underwent virtual UKA reproducing this subject's native PTT of 8°. The virtual surgery was redone with PTT values ranging from 0° to 14° in 2° increments (reported PTTs ranges from 0° to 15°). For each alignment, a simulated deep knee bend was analyzed.

Results: Changing the PTT had minimal effect on the resulting kinematics. The medial condyle anteroposterior (MAP) position started at approximately -5 mm (negative numbers denote posterior positioning) and translated posteriorly to approximately -15 mm for all simulations (Figure 1). The lateral condyle anteroposterior (LAP) position started at approximately -7 mm and rolled posteriorly to -15 mm at maximum flexion. The LAP and MAP had approximately 2 mm of variation for the different PTT with more tilt resulting in more posterior positioning. The external rotation angles at full extension ranged from 0.1° to -3.3° with more PTT having more external rotation and were 7.0° at maximum flexion for all PTT. Peak quadriceps and patella ligament forces were similar for all simulations with maximum forces of approximately 3.7 times body weight (xBW) and 2.0 xBW, respectively (Figure 2). The peak tibiofemoral forces ranged from 3.5 xBW to 4.0 xBW with more PTT resulting in less force. Lateral collateral ligament forces peaked at 0.45 xBW for all simulations. Peak medial collateral ligament forces ranged from 0.30 xBW to 0.55 xBW with more PTT resulting in lower forces (Figure 3). Peak ACL and PCL forces ranged from 0.40 to 0.60 xBW and 0.70 to 1.20 xBW, respectively. More PTT resulted in less PCL force and more ACL force.

Discussion: Based on these results, PTT has minimal effect of the kinematics with almost no effect on LAP or MAP and only a small effect on the initial axial rotation. However, ligament forces are heavily affected by the PTT with the MCL and PCL increasing by almost 100% when comparing the 0° PTT simulation to the 14° simulation. This increase in forces was partially offset by a decrease in ACL forces. Overall, this resulted in slightly higher tibiofemoral forces for the 0° PTT simulation. In conclusion, selecting the correct PTT is an exercise in ligament balancing which may not affect kinematics but could still affect patient satisfaction. Care must be taken not to cause any ligaments to be excessively tight in mid or late flexion. Continued research may lead to the ability to customize PTT based on preoperative templating and patient specific geometries to achieve a desired ligament force profile.

Figures

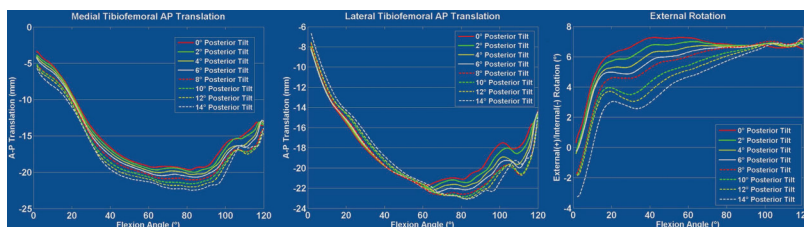


Figure 1

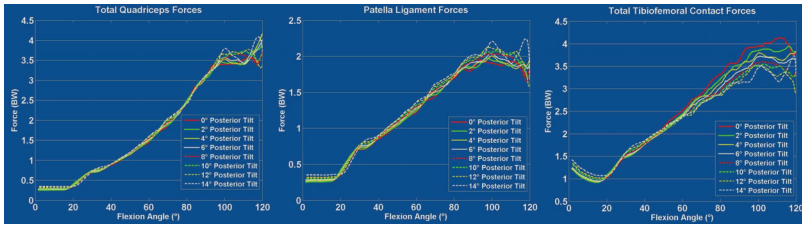


Figure 2

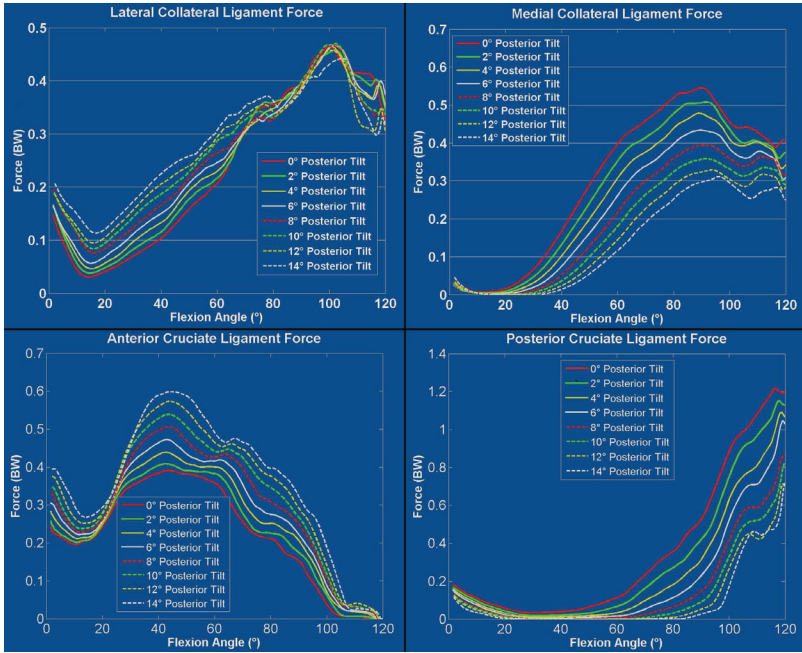


Figure 3