The Effect of Tibial Slope on the Biomechanics of Cruciate-Retaining TKA: a Musculoskeletal Simulation Study.

Marco A. Marra[1], Marta Strzelczak[1], Petra J.C. Heesterbeek[2], Sebastiaan van de Groes[1], Dennis W. Janssen[1], Bart F.J.M. Koopman[3], Ate B. Wymenga[2], Nico J.J. Verdonschot[1,3]

[1]Radboudumc, Nijmegen, Netherlands, [2]Sint Maartenskliniek, Nijmegen, Netherlands, [3]University of Twente, Enschede, Netherlands

Introduction

- More posterior tibial slope may reduce flexion gap tightness in cruciate-retaining total knee arthroplasty (CR-TKA) and widen the range of knee flexion.
- However, it is unknown how knee kinematics and loads during daily activities are affected by variations in tibial slope.

Objective
We studied the effect of tibial slope and surgical technique on the kinematics of the tibiofemoral contact points, quadriceps muscle forces, and patellofemoral contact forces during squat.

Materials and Methods

- Validated musculoskeletal model[1] of CR-TKA

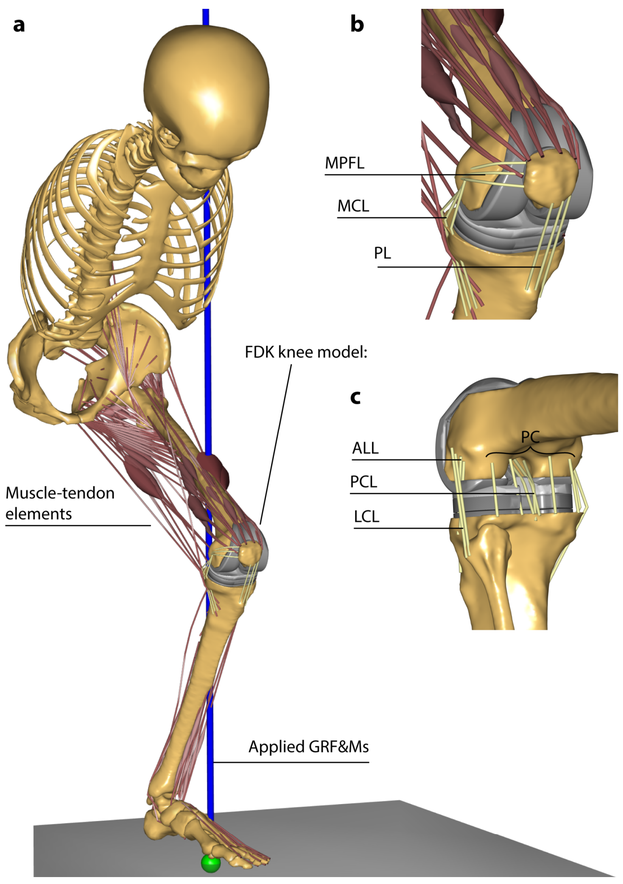


Figure 1. (a) Full-body musculoskeletal model used to simulate a squat activity using a detailed force-dependent kinematic knee model. The model is muscle actuated and takes ground reaction forces and moments (GRF&Ms) and skin marker trajectories (not shown) as input. (b) Anteromedial view showing medial patellofemoral ligament (MPFL), medial collateral ligament (MCL) and patellar ligament (PL). (c) Posterolateral view showing anterolateral ligament (ALL), posterior cruciate ligament (PCL) and lateral collateral ligament (LCL).

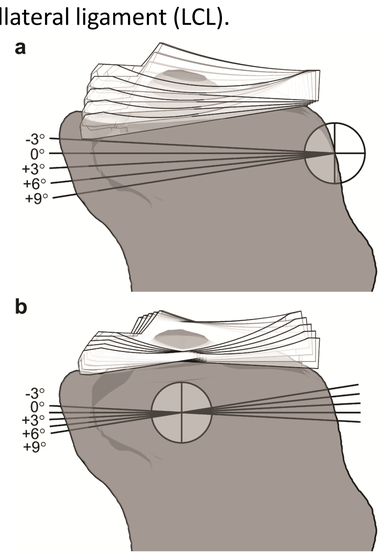
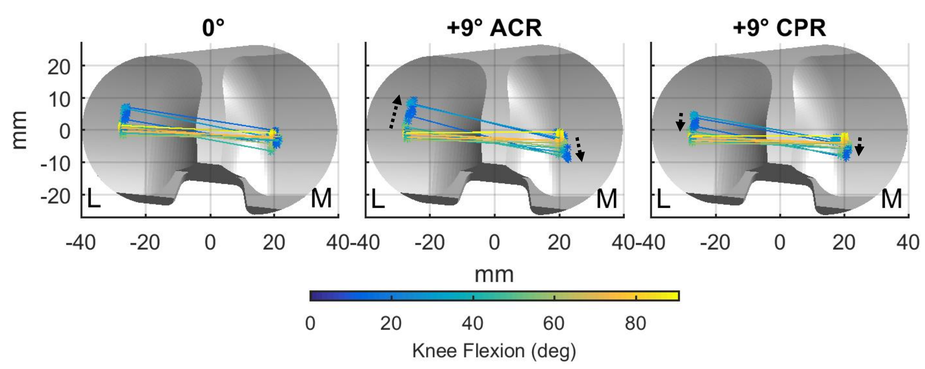


Figure 2. Variation of tibial slope using (a) anterior tibial cortex-referencing technique (ACR) and (b) center of tibial plateau-referencing technique (CPR).

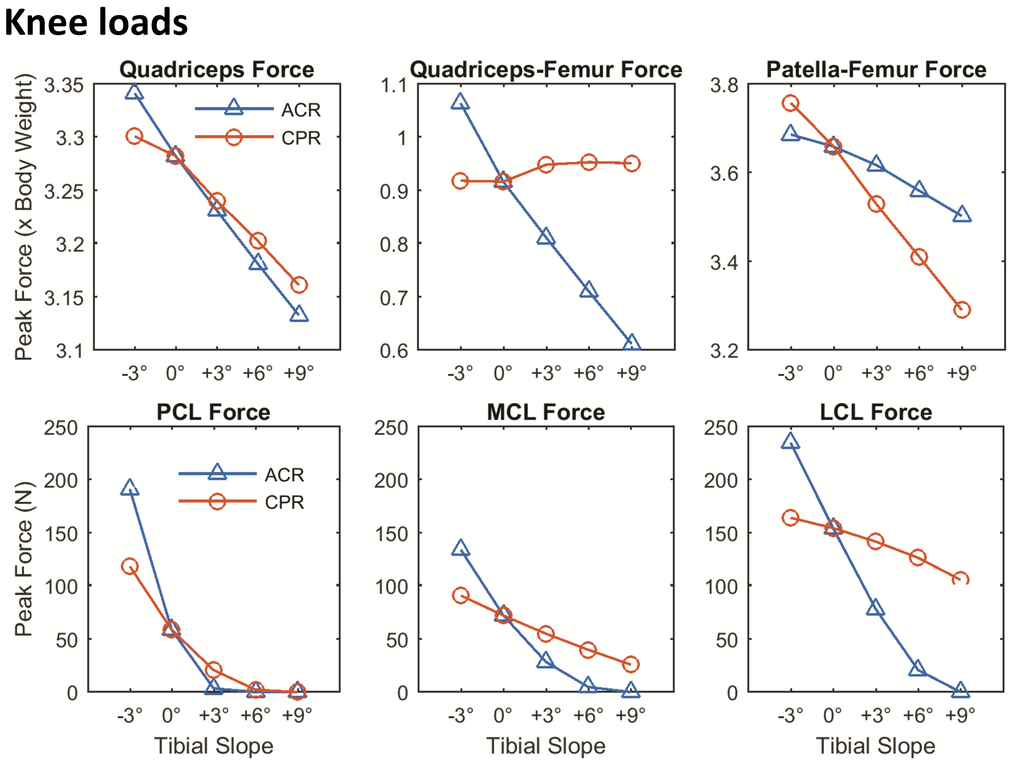
- Tibial slope variations
  - -3°, 0°, +3°, +6°, +9°
- Referencing techniques
  - anterior referencing (ACR)
  - central referencing (CPR)
- Squat simulations based on Grand Challenge[2] knee dataset

Results

Knee kinematics



Knee loads



Discussion and Conclusion

ACR technique
- kinematics more unstable with more slope, due to slackening of knee ligaments
- reduced quadriceps-femur load sharing

CPR technique
- stable kinematics with more posterior contact points with more slope
- reduction in patellofemoral contact forces

Conclusion
Tibial slope should be pre-planned and executed using the CPR technique. Surgeon should be very careful when increasing the tibial slope using the ACR technique in CR-TKA, as it may have huge effects on knee kinematics and loads in daily activities.

[1] Marra MA, Vanheule V, Fluit R, et al. 2015. A subject-specific musculoskeletal modeling framework to predict in vivo mechanics of total knee arthroplasty.J. Biomech. Eng. 137(2):20904. [2] Fregly BJ, Besier TF, Lloyd DG, et al. 2012. Grand challenge competition to predict in vivo knee loads.J. Orthop. Res. 30(4):503–13.

Marco A. Marra, MSc
Marco.Marra@radboudumc.nl

Radboudumc | Orthopaedic Research Laboratory
P.O. Box 9101, 6500 HB Nijmegen, The Netherlands

The research leading to these results has received funding from the European Research Council under the European Union's Seventh Framework Programme (FP/2007-2013) / ERC Grant Agreement n. 323091

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Established by the European Commission

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