Finite element analysis of the tibial component stem orientation in revision total knee replacement

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Background: Finite element (FE) models are frequently used in biomechanics to predict the behaviour of new implant designs. To increase the stability after severe bone loss tibial components with long stems are used in revision total knee replacements (TKR). A clinically reported complication after revision surgery is the occurrence of pain in the stem-end region. The aim of this analysis was the development of a validated FE-model of a fully cemented implant and to evaluate the effect of different tibial stem orientations.

Methods: A scanned 4th generation synthetic left tibia (Sawbones) was used to develop the FE-model with a virtually implanted fully cemented tibial component. The 500 N load was applied with medial:lateral compartment distributions of 60:40 and 80:20. Different stem positons were simulated by modifying the resection surface angle posterior to the tibias shaft axis. The results were compared with an experimental study which used strain gauges on Sawbones tibias with an implanted tibial TKR component. The locations of the experimental strain gauges were modelled in the FE study.

Results: Similar patterns and magnitudes of the predicted and experimentally measured strains were observed which validated the FE-model. An increase of strain at the most distal gauge locations were measured with the stem-end in contact to the posterior cortical bone. More uniform strain distributions were observed with the stem aligned to the intramedullary canal axis. The load distribution of 80:20 shifts the strains to tensile laterally and a large increase of compressive strain in the medial distal tibia.

Conclusions: A contributory factor of the clinically reported stem-end pain is possibly the direct effect of contact of the tibial stem-end to the posterior region of the cortical bone. The increased load to the medial tibial compartment is more critical for the development of pain.

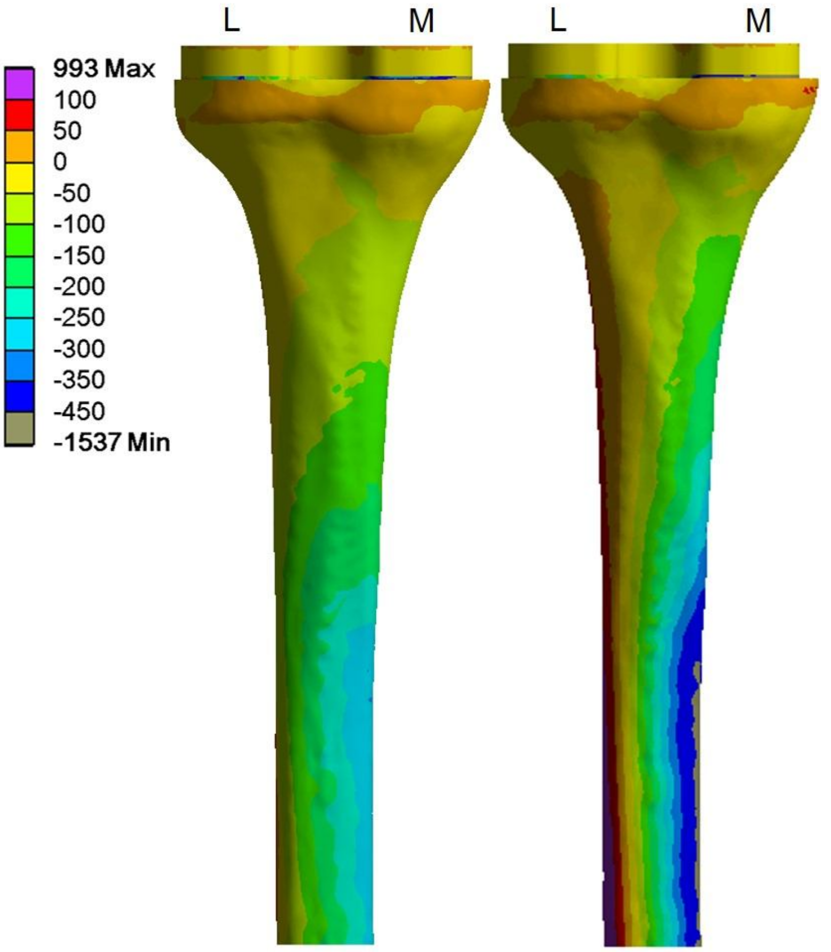

Figure 1: Posterior view of the normal microstrain to the global y-axis with a medial:lateral load distribution of 60:40 (left) 80:20 (right).