Tibial Component Overhang Greater than 2 mm Should Be Avoided in Unicompartmental Knee Replacements: An In Vitro Robotic Study

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INTRODUCTION:
Tibial implant overhang has been identified as a possible problem in unicompartmental knee replacements (UKR) and to some degree in total knee replacements (TKR). The idea of an optimally placed tibial implant is that the implant would be well supported by the cortical rim of the proximal tibia without overhanging. Overhang on the medial side can cause irritation of soft tissues and medial collateral ligament (MCL) impingement which may lead to chronic pain and possibly even damage the MCL. The surgeon must determine the most appropriate size of the component without the risk of overhanging or subsidence. Knowledge is very limited as to the amount of tibial component overhang and its resulting effects on the MCL. To our knowledge there are no in-vitro studies investigating the association of tibial component overhang and MCL impingement. We conducted an in-vitro robotic study to quantify the load changes in the human MCL during passive flexion-extension (PFE) with different amounts of overhang and to define a safe overhang limit. We also investigated the relationship between flexion angle and load changes in the MCL. We hypothesize that there will be a statistically significant effect of tibial component overhang on the MCL load. It is also hypothesized that load changes in MCL at different flexion angles will be significant.

METHODS:
Six fresh frozen human cadaveric knees were used in this study. First, fracture plates were implanted onto the femur and tibia of each specimen. Then, an instrumented spatial linkage (ISL) consisting of six rotational encoders was attached to these plates through surgical posts. A passive flexion-extension (PFE) motion was applied manually to each joint and recorded using the ISL. The joint was then mounted on a 6-degree-of-freedom parallel robot, with the tibia fixed to a rigid fixture, while the femur was affixed to the robot end-effector and therefore had the capability to move. All the tissues including the muscles, the cruciate ligaments, the meniscus, and the collateral ligaments except MCL were removed. Then, a coordinate measuring machine was used to reference each end of the ISL with respect to the robot coordinate system. The recorded PFE motion was converted into the motion of femur relative to the tibia and reproduced using the robot-ISL system.

The PFE motion was then repeated for 30 cycles by the robot while the loads in MCL were recorded simultaneously using a force/torque sensor. Using the coordinate measuring machine, 2 mm, 4 mm and 6 mm overhang placements were marked on the tibia and the tibial component was successively implanted in the respective positions. For each overhang, the PFE was repeated for 30 cycles again and MCL loads recorded.

RESULTS:
Figure 1 demonstrates the MCL load during passive flexion-extension at different overhang values for one of the joints tested and Figure 2 illustrates the average MCL load for six joints tested in this study at different overhang values.

A two-way ANOVA was performed to detect statistically significant effects of overhang and joint flexion angle on MCL load. There was no statistically significant load changes in the MCL with 2 mm overhang (P=0.15). However, there were statistically significant differences in MCL loads with 4 mm and 6 mm overhang placements (P=0.036 and P=0.045, respectively). The loads were almost doubled from 2 mm to 4 mm of overhang. The peak baseline (no overhang) MCL loads were found at 90 degrees of flexion in three joints, and in extension in the remaining three, depending on the PFE recorded for each specific joint. This trend was followed even with the overhang. There was no statistically significant effect of joint flexion angle on the MCL load (P=0.262).

DISCUSSION:
Tibial components are available in incremental sizes. In all UKR and TKR systems, undersizing the tibial tray will transfer loads through weak cancellous bone rather than the stronger cortical bone. In this case, using larger implants with an overhang of less than 2 mm will avoid the risk of tibial component subsidence. This is the first biomechanical study to investigate the relationship between tibial component overhang and corresponding MCL loads. The results of this study indicate that there is a statistically significant effect of 4 mm and 6 mm tibial component overhang on the MCL load. Therefore we accept our first hypothesis. In contrast, there was not a significant effect of flexion angle on the MCL load. So, we reject our second hypothesis. Our study findings support the previously published retrospective clinical study (1) that indicates no change in UKR outcome scores with tibial implant overhang less than 3 mm. We recommend from our study that if the component overhang is greater than 2 mm in a symptomatic patient, revision of the tibial component should be considered.

SIGNIFICANCE:
Surgeons must decide on the most appropriate size of the tibial component during unicompartmental knee replacements, without the risk of overhanging or subsidence. The present study will be the first of its kind to provide insights into this decision.

REFERENCES: