PCL retaining TKA Significantly Effects Kinematics and PCL Tension

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Introduction:
The purpose of TKR is to improve knee function to allow individuals to perform daily activities. Posterior cruciate retaining TKA is commonly used as a means of preserving anatomical femoral rollback and improving knee flexion. However, clinical and fluoroscopic studies have shown that the flexion achieved following PCL retaining arthroplasty is highly variable, even in designs intended to allow high flexion. Although the causes of this loss of motion are multi-factorial, one possible factor is loss of the normal anatomic relationship between the bundles of the PCL and the prosthetic components. Thus, the purpose of this study is to delineate the effect PCL length has on knee kinematics during a functional high-flexion activity after TKR.

Materials and Methods:
In this study, six (3 right, 3 left) intact human cadaver specimens were thawed and stripped of all soft tissue preserving the ligaments, tendons, and the extensor mechanism. Using the CT scans of each specimen, computer models were generated in three-dimensional computer software (RapidForm). The same six specimens then underwent PCL-retaining TKA with NexGen implants and the kinematic experiment was repeated.

The origins and insertions of the antero-lateral (AL) and posteromedial (PM) bundles of the PCL were located on each specimen specific knee reconstruction using the locations described by Race et al. The centers of the femoral origins of the AL and PM bundles were defined by points displaced by 7mm along the 10:20 direction (AL) and 7mm in the 8:30 direction (PM) respectively. Similarly, the tibial insertion centers were measured 7mm for AL and 3mm for PM in a posterior-anterior direction along the posterior end of the anatomical tibial axis.

The length of each bundle of the PCL was calculated as the distance from each origin to each insertion at flexion angles of 0°, 15°, 30°, 60°, 90°, 120°, 135° and 150°. Statistical comparisons were made between the implant and intact AL and PM bundle lengths. Additionally, the joint lines of the implant specimens relative to the intact were determined using three-dimensional computer software.

Femoral lateral translation and tibial rotation as a function of flexion angle were quantified using the displacement of a vector connecting the medial and lateral epicondyles. All measurements were reported with respect to the knee at full extension.

Using kinematic observations from Li et al., the kinematic pattern of motion of each specimen was classified as "normal" or "paradoxical". Normal posterior translation of the medial condyle was expected to be minimal in full extension, constant through 30-90°, and peak at full flexion (150°). The tibial rotation before TKR should increase externally with flexion and not exhibit paradoxical rotation.

Results:
Of the six specimens, three exhibited paradoxical rotation at lower flexion as well as decreased posterior displacement of the lateral condyle. The remaining three specimens displayed the normal pattern of knee motion with flexion without paradoxical translation or rotation.

Femoral Lateral Translation

Discussion
The longer AL and PM bundle lengths in implants with normal kinematics from 135-150° correspond with more external rotation from 0-30° as well as significantly less internal tibial rotation from 60-150° compared to the intact knee (p<0.05). Conversely, specimens with abnormal kinematics after TKR showed paradoxical rotation form 0-30° as well as significantly less internal tibial rotation from 60-150° compared to the intact knee (p<0.05). In knees displaying normal kinematic patterns after TKR, elongation of the PM bundle of the PCL was greater than observed in the intact knee at all flexion angles. PCL strain was highest at 135° and significantly elevated from 90-150° (p<0.05). Similar changes were seen with the AL bundle, though in these cases elongation values were only significantly larger than normal at 135° and 150°. In specimens displaying paradoxical kinematics, elongation of the PCL was higher than in the intact knee from 30-150° for the PM bundle, and from 60-150° for the AL bundle, though less than knees with normal motion.

References