Influence Of The Individual Components Of The Main Medial Knee Structures On Valgus And Rotatory Stability In Total Knee Arthroplasty

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Introduction: Many factors can influence post-operative kinematics after total knee arthroplasty (TKA). These factors include intraoperative surgical conditions such as ligament release or quantity of bone resection as well as differences in implant design. Release of the medial collateral ligament (MCL) is commonly performed to allow correction of varus knee. Precise biomechanical knowledge of the individual components of the MCL is critical for proper MCL release during TKA. The purpose of this study was to define the influences of the deep medial collateral ligament (dMCL) and the posterior oblique ligament (POL), two of the three main components comprising the MCL, on valgus and rotatory stability in TKA.

Methods: This study used six fresh-frozen cadaveric knees with intact cruciate ligaments. All TKA procedures were performed by the same surgeon using CR-TKA (Vanguard: Biomet, Inc, Warsaw, Ind) with a CT-free navigation system (Knee 2.6.0: BrainLab, Germany). A standard medial parapatellar approach was performed, and the navigation system was registered. Each knee was tested at 0°, 20°, 30°, 60°, and 90° of flexion. One sequential sectioning sequence was performed on each knee, beginning with femoral arthroplasty only (S1), and thereafter sequentially, medial half tibial resection with spacer (S2), ACL cut (S3), tibial arthroplasty (S4), release of the dMCL (S5), and finally, release of the POL (S6). The same examiner applied all external loads of 10 N-m valgus and 5 N-m internal and external rotation torques at each flexion angle and for each cut state. Two-way analysis of variance was performed to compare each ligament's angular displacement to valgus loads and internal and external rotation torques for each flexion angle for each sectioned state. Paired t tests were used to determine changes between femoral arthroplasty and all cut states for each tested load at each tested flexion angle. A significant difference was determined to be present for P < .05.

Results: There were no significant differences in medial gaps at any sequential step or any tested angle of flexion under valgus loads even after release of the dMCL and the POL compared with those at S1. Internal rotation angles significantly increased after medial half tibial resection with spacer, compared with those after S1, at 0° (P < .05), 20° (P < .05), and 30° (P < .05). Moreover, release of the POL under internal rotation torque resulted in significantly increased internal rotation, compared with that at S1, at 90° of knee flexion (P < .01). External rotation angles under external rotation torque significantly increased after the ACL cut compared with those at S1 at 0° (P < .05), and after tibial arthroplasty, significant increase in external rotation angles compared with those at S1 was observed at 60° (P < .01). Thereafter, significant increase in external rotation angles was seen, at 0° (P < .05), 30° (P < .05) and 90° (P < .01) after release of the dMCL compared with S1, and significant increase after release of the POL at 30°(P < .05), 60° (P < .01) and 90° (P < .05) compared to S1. Total rotation angles significantly increased after release of the dMCL compared with S1 at 20° (P < .05), 30° (P < .05) and 90° (P < .01), and release of the POL resulted in significantly increased total rotation angles, compared with S1 at 20° (P < .05), 30° (P < .05), 60° (P < .01) and 90° (P < .01). There were significant increases in total rotation angles, compared with the previous state, after release of the dMCL at 0° (P < .05), 30° (P < .05) and 90° (P < .05), and after release of the POL at 20° (P < .05). Rotational angles had correlation with the size of medial gap at 0° (P < .05), 20° (P < .01) and 90° (P < .01).

Discussion: Unicompartmental knee arthroplasty (UKA) leads to a greater increase in relief of pain, and improvement in physical function compared with TKA (1). Biomechanical studies have confirmed that tibial axial rotation and femoral rollback after UKA more closely recapitulate normal knee kinematics than those after TKA (2). No soft tissue involving the medial collateral ligament is released in UKA. Previous studies have demonstrated that the medial knee structures have important primary and secondary roles in providing stability against abnormal valgus motion and external and internal rotation in the knee (3). In this study, while increases of medial gap size were not clearly recognized with the release of the dMCL, significant increases of rotatory instability were seen on release of the dMCL. In addition, rotatory instability further increased after release of the POL. Moreover, as medial gap size increased, rotatory instability got correlatively worse. From this study we concluded that retaining of the medial knee structures preserves the valgus and rotatory stability of the knee. Accordingly, to devise a surgical approach of retaining the dMCL and POL has a possibility to improve the outcome after primary TKA.

Significance: From this study we concluded that retaining of the medial knee structures preserves the valgus and rotatory stability of the knee.

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Figure 1. Medial gap. No significant differences.
Figure 2. Total rotation. *a: Significant differences compared with after femoral arthroplasty. *b: Significant differences compared with the previous sequential state.
Figure 3. Correlation between the medial gap and the total rotation angle at 20° of knee flexion.