Does Capsular Repair Technique Affect Laxity in TKA?

Erik L. Woodard¹, Casey T. Hebert¹, John L. Williams, PhD², Norfleet Thompson¹, William M. Mihalko, MD PhD¹,³.
¹University of Tennessee Health Science Center, Memphis, TN, USA, ²University of Memphis, Memphis, TN, USA, ³Campbell Clinic Orthopaedics, Memphis, TN, USA.

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Introduction: During every total knee arthroplasty (TKA) surgery, an arthrotomy, or incision, is made vertically along the medial side of the knee joint capsule in order to gain access to the joint. After surgery, it is important to correctly repair this arthrotomy to seal the joint capsule. Surgeons attempt to close the arthrotomy with the medial and lateral edges anatomically approximated. However, if no visible landmarks are made prior to incision, there is a risk that anatomical approximation may not be attained. If the edges of the arthrotomy are shifted in relation to each other and sutured together, this may affect laxity and stability compared to an anatomical approximation, leading to a decline in patient outcomes and satisfaction. The goal of this study was to compare the biomechanical changes in knee stiffness by comparing cadaveric TKA knees before and after a medial parapatellar arthrotomy. The arthrotomy was repaired with an anatomic (neutral) approximation and with the medial side shifted upward and downward. Changes in rotational and varus/valgus laxity were noted and compared to the normal knee before arthrotomy was performed. We hypothesize that repairing the knee joint capsule with a deviation from anatomical approximation will produce changes in laxity compared to the anatomical approximation.

Methods: The specimens utilized in this study were total knee replacement fresh cadaveric specimens of donors who had previously undergone a total knee replacement (Medical Education and Research Institute (Memphis, TN) and Restore Life USA (Johnson City, TN)). IRB approval was obtained to perform the study. Ten knee specimens (3 Left, 7 Right) were retrieved and all skin, subcutaneous tissue and muscle was removed, while carefully retaining all aspects of the knee capsule and surrounding ligaments. The femur and tibia were cut transversely 180mm superior and inferior to the knee joint line, respectively. Each specimen had the femur and tibia potted using urethane epoxy in a coupling that allowed it to be mounted into a custom knee testing machine (Little Rock, AR). Specimens were then mounted with the tibia mounted vertically in the machine, and the femoral coupling was locked in a neutral position. During normal conditions and after each arthrotomy repair, specimens were tested with the tibia at full extension and at 30, 60, and 90 degrees of flexion in relation to the femur. An upward vertical force of 30 N was placed under the tibia to maintain joint contact during all tests. At each flexion angle, a 1.5Nm internal and external rotational torque was applied about the tibial axis while the femur was fixed and the tibia was free to rotate about the joint center in the coronal plane. A 10 Nm varus and valgus torque was also applied to the tibia, while internal-external rotation was unconstrained. A fellowship trained, board-certified orthopedic surgeon then made a small horizontal incision with a number 10 scalpel blade on the medial side of the joint to vent any pressure inside the capsule. Then, a parapatellar incision was made on the medial side of the joint to gain access into the knee capsule. The previous horizontal incision was used to provide a landmark to align the two edges of the arthrotomy and facilitate anatomic approximation during the repair. The arthrotomy was closed using #0 sutures with an anatomic or “neutral” alignment. Sutures were cut and the repair was repeated, shifting the medial side of the capsule upward by 5mm in relation to the lateral side. The technique was repeated once more, this time shifting the medial capsule 5mm downward. The deflection in degrees at ±10Nm varus and valgus torque in the coronal plane referenced from normal neutral position was recorded to determine the varus and valgus laxity for each test. Likewise, the deflection in degrees at ±1.5Nm internal and external torque in the transverse plane referenced from the normal neutral position was recorded to determine rotational laxity. A Wilcoxon signed rank test with a Holms-Sidak correction was used to determine if any statistically significant changes existed between arthrotomy repair tests, and a paired t-test was used to compare normal laxity to joint capsule. All statistical analyses were performed using SPSS version 21.0 (IBM-SPSS, Armonk, New York) software. A p-value less than 0.05 was considered significant at the 95% confidence level.

Results: Venting the joint capsule consistently increased laxity in all tests, most notably increasing valgus laxity by 1 degree (figure 1) and varus laxity by 1.9 degrees at 90 degrees of flexion (figure 2). All surgical techniques increased varus and valgus laxity in flexion. Greater laxity changes occurred in flexion than extension for all tests. All capsule repairs except neutral repair decreased rotational laxity in flexion, with an upward or downward shift of the medial limb of the arthrotomy decreasing internal rotational laxity by 1.8 and 1.3 degrees over neutral repair, respectively (figure 3).

Discussion: Small changes were measured in the stiffness after venting the capsule and during non-anatomical repairs of the capsule. None of the repairs were able to re-approximate normal joint stiffness in varus or valgus movement in flexion, indicating the importance of intracapsular pressure in maintaining stability. The anterior joint capsule is expected to be under greater strain in flexion, leading to the observed decrease in rotational laxity after arthrotomy repair due to increased tightening of the anterior capsule after closure. Compared to venting the capsule, arthrotomy repair stiffened the capsule under rotational
load while having little effect on varus or valgus laxity. This is expected, since shifting the capsule affects the transverse plane and not collateral structures which would modify laxity in the coronal plane. These results stress the fact that the capsule can be measurably tightened during arthrotomy repair, especially with regard to tibial rotation. These changes in stiffness may impact post-operative rehabilitation and range of motion. Limits of this study include a small sample size (n = 10).

**Significance:** Knowledge of how these surgical techniques affect capsule stiffness in flexion and extension emphasizes the importance of anatomical approximation when repairing the joint capsule after surgery.

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**Figure 1:** Graph of valgus laxity changes in the coronal plane after venting the joint capsule and performing variations in arthrotomy repair. Bars represent averages of differences from normal for 10 specimens. Error bars are standard errors of the mean (SEM) for each average. Positive values are an increase in laxity and a decrease in capsule stiffness. Negative values are a decrease in laxity and increase in capsular stiffness.

**Figure 2:** Graph of varus laxity changes in the coronal plane after venting the joint capsule and performing variations in arthrotomy repair. Bars represent averages of differences from normal for 10 specimens. Error bars are standard errors of the mean (SEM) for each average. Positive values are an increase in laxity and a decrease in capsule stiffness. Negative values are a decrease in laxity and increase in capsular stiffness.

* Difference from normal
**Internal Rotational Laxity Changes**

![Graph showing internal laxity changes with flexion angle and rotation](image)

*Figure 3: Graph of internal laxity changes in the transverse plane after venting the joint capsule and performing variations in arthroscopy repair. Bars represent averages of differences from normal for 10 specimens. Error bars are standard errors of the mean (SEM) for each average. Positive values are an increase in laxity and a decrease in capsule stiffness. Negative values are a decrease in laxity and increase in capsular stiffness.*

+ Difference from downward shift

**External Rotational Laxity Changes**

![Graph showing external laxity changes with flexion angle and rotation](image)

*Figure 4: Graph of external laxity changes in the transverse plane after venting the joint capsule and performing variations in arthroscopy repair. Bars represent averages of differences from normal for 10 specimens. Error bars are standard errors of the mean (SEM) for each average. Positive values are an increase in laxity and a decrease in capsule stiffness. Negative values are a decrease in laxity and increase in capsular stiffness.*