Is Pie-Crusting as Safe as the Traditional Technique of Medial Collateral Ligament Release for Correction of Varus Deformity in TKR?

Meneghini RM; Daluga AT; Sturgis L; Lieberman JR

INTRODUCTION:
Recently, some have advocated a pie-crusting technique to release the medial collateral ligament (MCL) for correction of varus deformity during total knee replacement (TKR). Despite the established and accepted use of this technique on the lateral aspect of the knee in TKR, a pie-crusting technique has not been clinically or biomechanically validated on the medial side of the knee. This study compared the biomechanical characteristics of the MCL released with pie-crusting compared to a traditional technique.

METHODS: A median parapatellar arthrotomy and tibial and femoral bone cuts were performed on fresh frozen cadaver specimens. In five knees the superficial MCL was released at the joint line with the pie-crusting technique. In the contralateral knee, a traditional MCL release was performed as popularized by Insall by elevating the anterior MCL fibers from the tibia. Along with a control group of unreleased ligaments, each MCL was isolated and subjected to cyclic mechanical loading to failure.

Mechanical testing was performed using an MTS 858 Mini Bionix II using a 5KN load cell. A custom-made mount was affixed to the testing machine so that the PVC pipe could be secured in place. The MCL was held in place by a ligament clamp along with the portion where the ligament began to taper, leaving a rectangular section of MCL visible (Figure 1). Three measurements of the ligament width and thickness were taken at the joint line, at the clamp, and at the center of the ligament using digital calipers. The average of these three cross-sectional area measurements was used later during the data analysis process. The specimens then underwent preconditioning by cyclic loading between 0-2 mm of elongation at 10 mm/min for a total of ten cycles, followed by tensile loading of 10 mm/min until failure of the ligament occurred, based on an established protocol (Figure 2). The failure mode was documented qualitatively using digital photography. The MTS software was set to record values of force, displacement, and time at 20Hz during testing.

Stress-Strain curve data was then calculated based on the cross-sectional area of the ligament in each specimen as determined with digital calipers. The maximum force applied to each ligament before failure, load to 2mm, 3mm, maximum displacement, and interface stiffness were determined and used in an analysis of variance (ANOVA) calculation. An ANOVA test and paired t-tests were used to verify if any statistical significance could be found between the three groups, with a null hypothesis of zero. Further analysis was performed taking into account the age, sex, and failure mode of the ligament.

RESULTS: Interface Stiffness. The interface stiffness used in this analysis was found at the most linear points of the data graph between the clinically relevant sections between 2mm-5mm of elongation. The interface stiffness calculations were used to evaluate the amount of resistances each MCL technique presented for unit of displacement. The mean interface stiffness for the control MCL group equaled 75.94 ± 28.99, which as expected was found to be greater than the mean values of 52.38 ± 24.11 and 36.63 ± 8.80 for the traditional and piecrusting techniques, respectively (Figure 3). ANOVA analysis revealed there was near statistical difference between the interface stiffness exhibited by the 3 test groups (P = .0599). Further evaluation of the individual groups showed that the piecrusting and traditional groups had no discernable difference between them, and the control and traditional had similar results with student t-test (P = 0.114 and P = 0.120 respectively). A statistical significance was however observed in a t-test between the control and the piecrusting group (P = 0.0396).

Force. The mean force for the experimental groups was found at 3mm of elongation for its significance to clinical use. The force that was found had similar results to that of the interface stiffness with an ANOVA result (P = 0.0623), which again showed a lack of complete statistical significance. The mean values of the control, traditional, and piecrusting force values at 3mm were 164.55 ± 68.61, 99.62 ± 57.58, and 69.14 ± 32.14 respectively (Figure 4). When compared to each other separately with a student t-test, the comparison showed that the traditional and piecrusting as well as traditional and control did not have a statistical difference. The piecrusting and the control, however, did again show a difference between the two groups (P = 0.0312).

CONCLUSIONS: Although no statistical difference in the mechanical strength was observed between the MCL release technique groups, their characteristic failure modes are different. Unlike the traditional MCL release method, pie-crusting is likely technique dependent since failure occurs within the ligament itself. Due to the critical importance of the MCL in knee stability, further research is warranted and caution should be utilized before employing a pie-crusting technique for MCL release in TKR.