

Optimizing Medial Soft-Tissue Release During Total Knee Arthroplasty with Algorithmic Pie-Crusting Approach

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INTRODUCTION: Soft tissue balance on both sides of the knee is essential during total knee arthroplasty (TKA). The pie-crusting technique was proposed for releasing the tight lateral structures in patients with fixed valgus deformities. While an algorithmic approach to lateral pie-crusting has been studied, there is paucity of studies quantifying the effect of pie-crusting on the medial gap. The present aim was to determine the effects of this technique using a customized grid and 18-gauge needle for Medial Collateral Ligament (MCL) release.

METHODS: The study was approved by the Institutional Review Board. Seven frozen cadaver knees were dissected, isolating the femur and tibia, while preserving the MCL intact. Bone cuts were made as would be performed during TKA. The specimens were preloaded with a tensile load of 2-5 Newtons (N) until the desired stretch was achieved (**Figure 1**). An 80N load was applied, but due to minimal displacement, the load was increased to 120N. A 12-hole grid with 4mm x 3mm spacing between holes was devised, covering the entire surface area of the MCL (**Figure 2**). Starting from the tibial plateau to above the midpoint of the MCL, data were collected after every 2 perforations and repeated 3 times for each measurement. The collected measurements were averaged, and a regression analysis was conducted.

RESULTS SECTION: Mean medial femorotibial (MFT) space before pie-crusting was 6.018 ± 1.4 mm and the mean stiffness was 32.15 ± 9.44 N/mm. After 12 perforations, the MFT increased to 7.078 ± 1.414 and the mean stiffness decreased to 26.57 ± 6.15 N/mm. **Figure 3** shows the linear increase in MCL deformation and the linear decrease in MCL stiffness with progressive pie-crusting. These values were statistically significant ($p = 0.00955$; $p = 0.00803$). There was no MCL failure.

DISCUSSION: The variations observed in MCL stiffness and displacement exhibit a direct correlation with the number of holes employed during the pie crusting technique. These findings can contribute to the development of a precise tool to be utilized for effective MCL gap balancing. There are some limitations to this study, including the small sample size of 7 cadaveric knees. Although this is a small sample size in comparison to clinical trials, small samples are relatively common in biomechanical studies. Our study also utilized cadaveric knees with unknown pre-existing alignment, thus they may not be an accurate model of the asymmetric soft tissue tightness seen in valgus and varus deformed knees. This makes it difficult to discern the effectiveness of MCL pie-crusting in patients with true varus deformities. Additionally, the dynamic stabilizers of the knee were not intact during testing. These include the iliotibial band, popliteus tendon, and lateral head of the gastrocnemius. Ultimately, this decreases the generalizability of our results to patients with intact soft tissue structures surrounding the knee. Still, this study demonstrates the safety and efficacy of our algorithmic pie-crusting technique employing a customized grid. The technique avoids specific complications such as over-release or mechanical instability. This approach mitigates both concerns through the utilization of an 18-gauge needle and a pre-formed grid.

SIGNIFICANCE/CLINICAL RELEVANCE: The safety, simplicity, and high success rate inherent in the needle pie-crusting technique validate its routine application for addressing varus deformities in patients undergoing TKA.

IMAGES AND TABLES:



Fig. 1 Experimental set-up

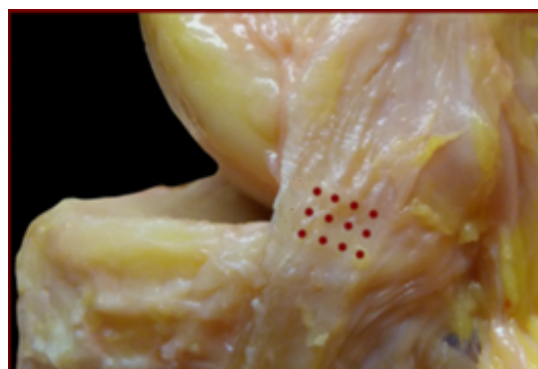


Fig. 2 Algorithmic Grid on Cadaveric MCL Specimen

