Effect of Sequential Medial Soft Tissue Release on Knee Joint Balance in Total Knee Arthroplasty

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Introduction: Obtaining soft tissue balancing in extension and flexion is one of the important objectives in total knee arthroplasty with varus medial OA. Indications for soft tissue release and techniques of measuring balancing are still controversial because the optimal distraction force of the tensor/balancer to check the joint gap distance and angle has not been defined. Further, the position of the patella (everted or reduced) varies among surgeons and this effect on knee balancing is not known. In this study, the effect of each step of medial soft tissue release on joint gap was assessed at different distraction forces with the patella everted or reduced.

Methods: Five fresh frozen normal cadaver lower extremities with intact hip joints were selected. In each cadaver specimen, after the capsule was opened, the proximal tibia was cut perpendicular to the tibial shaft. Then, anterior cruciate ligament was cut, and deep MCL ligament was released. This condition was called “the baseline”. Joint gap distance and angle were measured at full extension, 30°, 60°, 90°, 120° flexion and in full flexion (approximately 144°). These measurements were initially made using a standard tensor/balancer with the patella everted. Next, measurements were made using an offset tensor/balancer which permits joint gap distraction with the patella reduced. Three levels of torque (10, 20, and 30 inch-pounds) were applied to the standard tensor/balancer through the specialized torque wrench, which resulted in net distraction force at the joint gap of 21, 41, and 62 pounds respectively. To apply similar magnitudes of distraction force at the joint gap with the offset tensor/balancer, 18, 35, and 52 inch-pounds of torque, respectively, were needed. After the “baseline” measurement, the posterior cruciate ligament (PCL), medial collateral ligament (MCL) superficial fibres, pes anserinus (PES), and semi-membranosus (Semi-Mem) were sequentially released, and joint gap distance and angle measured with the standard and offset tensor/balancer after each release.

Results: Joint gap distance: With the PCL intact, the offset balancer generated greater gap distance that the standard balancer at similar distraction forces (Fig. 1). At 90° flexion and 41lbs of distraction, the average gap distance measured with the offset and standard balancer was 3.8mm and 0.8mm respectively (p<0.01). After the PCL was released, at 90° flexion and 41lbs of distraction, the average gap distance with offset and standard balancers was 4.2mm and 1.2mm, respectively (p<0.01) (Fig. 2). None of the releases changed the joint gap distance significantly in extension. However, the effect of soft tissue release on joint gap was significant at higher knee flexion. The average joint gaps after releasing the superficial MCL fibres, pes anserinus, and semi-membranosus with standard and offset balancers at 41lbs of distraction at 90° flexion were 4.8mm and 2.6mm, 2.6mm and 1.7mm, and 2.6mm and 2.0mm respectively (Fig. 2). Although the effect was larger with the standard balancer, no significant differences were found between balancers in full extension and at 90° flexion at the three levels of distraction force at each of the steps of medial release. Joint gap angle: With the PCL intact, offset balancer generated more varus (wider joint gap laterally than medially) than the standard balancer (Fig. 1). At 90° flexion and 41lbs of distraction, the average gap angle with offset and standard balancer were 2.7° varus and 0.1° valgus respectively (p<0.05). After PCL cut, at 90° flexion and 41lbs of distraction, the average gap angle with offset and standard balancer were 3.2° varus and 1.5° valgus respectively (p<0.05) (Fig. 3). None of the releases changed the joint gap angle significantly in extension. However, over the range of flexion, the joint gap angle tilted into more valgus after each step of soft tissue releases. The average effect of release of MCL superficial fibres, pes anserinus, and semi-membranosus with standard and offset balancers with 41lbs of distraction on the joint gap angle at 90° flexion was 1.3° and 2.3°, 2.3° and 1.8°, and 2.1° and 3.2°, respectively (Fig. 3). No significant difference was found between balancers in full extension and at 90° flexion at the three levels of distraction force, over the sequential steps of the medial release.

Discussion: We assessed the effect of two different types of tensor/balancers with the patella everted or reduced, over the entire range of flexion, at three joint gap distraction forces. In extension, even though all medial soft tissues were released, the joint gap distance and angles did not change significantly. This indicates that release of soft-tissues from the underlying bone maintains the soft-tissue sleeves around the knee joint and preserves stability in extension. It’s important that surgeons appreciate the differences in distraction force generated by balancing instruments with respect to the applied torque. We had to
apply approximately 1.8 times greater torque with the offset balancer to generate the same distraction force as the standard balancer. There were significant differences in joint gap distance and angle at different distraction forces in flexion. This indicates that the knee can be “balanced” at one level of distraction force but may not be balanced at a different distraction force. At 90° flexion the “baseline” joint gap distance was greater and the joint gap angle was in more varus with the offset balancer. However, over each step of sequential medial soft tissue releases, no significant differences were found between two balancers. These results indicate that patella position during balance is likely to affect knee balance measurement with the PCL intact but not after the PCL has been released.

**Significance:** The differences in the joint gap distance and angle generated by the standard balancer with the patella everted and the offset balancer with the patella reduced were analyzed. The quantitative effects of various medial soft-tissue releases on the joint gap over the full range of flexion can be used to guide the total knee arthroplasty surgeon during the process of knee balancing.

**Acknowledgments:**

**References:**
Fig. 1 Joint gap angle and distance with PCL
Fig. 2 Change of joint gap distance
Fig. 3 Change of joint gap angle