

Evaluation of Lateral Compartment Laxity in Flexion and Extension During Robotic Assisted Total Knee Arthroplasty for Varus Knees

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INTRODUCTION: Soft tissue balance plays a critical role in achieving optimal outcomes following Total Knee Arthroplasty (TKA). Robotic-assisted TKA (RA-TKA) provides an opportunity for intraoperative assessment of compartmental gaps with high precision. In varus knees, asymmetrical gap behavior between extension and flexion poses challenges in achieving balanced kinematics, particularly due to differential tension in the posterolateral structures. The present study investigates the variation in lateral-medial gap differences between full extension and full flexion in varus knees undergoing RA-TKA and its implication on femoral component rotation.

METHODS: This prospective study analyzed the first 50 consecutive patients undergoing RA-TKA for primary knee osteoarthritis with varus deformity. Sample size estimation (n=46) was based on detecting a 15% difference in lateral-medial gaps between flexion and extension with $\alpha = 0.05$, $\beta = 0.20$, and power = 80%. Patients with valgus alignment or inflammatory arthritis were excluded. All surgeries were performed using a robotic platform with intraoperative tensor sensors. After proximal tibial resection, an independent observer recorded the medial and lateral compartmental gaps in both full extension and full flexion using the Accubalance graph. The femoral component was externally rotated (up to 7°) as needed to balance excessive posterolateral laxity in flexion. The study started with null hypothesis i.e. no difference exists between flexion and extension as regards the lateral - medial laxity difference.

RESULTS:

There was a statistically significant increase in the lateral-medial gap difference in flexion compared to extension. The mean difference in full extension was 2.64 ± 0.72 mm, whereas in full flexion it increased to 4.66 ± 1.06 mm ($p < 0.0001$). This suggests greater lateral compartment laxity in flexion in varus knees undergoing RA-TKA.

Table: Mean Difference Between Lateral and Medial Gaps in Extension and Flexion.

Figure: Intraoperative lateral compartment laxity in flexion and extension

DISCUSSION AND CONCLUSION:

This study rejects the null hypothesis by demonstrating a significantly greater lateral-medial gap differential in flexion compared to extension in varus knees undergoing RA-TKA. This finding highlights the presence of increased posterolateral laxity during flexion, likely due to the attenuation of lateral soft tissue structures in arthritic varus deformities. Such differential laxity, if not adequately addressed, may lead to suboptimal femoral component positioning, mid-flexion instability, or uneven polyethylene loading.

By utilizing robotic-assisted tools and intraoperative sensor feedback, surgeons can quantitatively assess compartmental gaps and make precise femoral rotational adjustments to balance the flexion gap. In this study, up to 7° of external rotation was applied intraoperatively to equalize the posteromedial and posterolateral compartments, illustrating how real-time data can guide individualized component positioning.

The results underscore the value of robotic technology not only in achieving accurate bone cuts but also in fine-tuning soft tissue balance in a reproducible, objective manner. These insights support the concept of kinematically driven balancing over traditional measured resection techniques, particularly in varus knees. In clinical practice, incorporating these findings could enhance joint stability, patient satisfaction, and long-term implant survivorship in RA-TKA.

	Extension(±SD)	Flexion(±SD)	P value
Difference between lateral and Medial Gap	2.64 (± 0.72)	4.66 (± 1.06)	< 0.0001