Impact of Ligament Balancing Workflow on Implant Position and Coronal Plane Alignment of the Knee in Total Knee Arthroplasty

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INTRODUCTION:

Robotic TKA enables the acquisition of ligament balance data at various stages in the surgical workflow to inform implant planning. This study evaluates the impact of ligament balance acquisition before versus after the tibial resection on implant positioning and coronal plane alignment of the knee (CPAK) classification in robotic TKA.

METHODS:

A single-surgeon single-institution series of 382 primary posterior-cruciate sacrificing TKAs using a digital ligament tensioner was reviewed. The first 194 cases assessed gaps after tibial and before femoral resections (mid-resection group, Figure 1a) in an inverse-kinematic alignment (iKA) workflow (Figure 1b). The subsequent 188 cases assessed gaps before any bone resections (pre-resection group, Figure 1c) in a femur-first kinematic alignment (KA) workflow (Figure 1d). During final trialing, the digital ligament tensioner was used to assess final joint gaps from the medial and lateral compartments. Mediolateral balance was calculated as medial minus lateral gaps.

Native and postoperative medial proximal tibial angle (MPTA), lateral distal femoral angle (LDFA), and final mediolateral balance were compared using Wilcoxon rank-sum tests. CPAK phenotype distributions were compared using chi-square tests.

RESULTS:

Native MPTA was different between pre-resection and mid-resection (87.0±1.2° vs. 88.3±1.5°, $p<0.001$) while LDFA was similar (88.1±1.7° vs. 88.3±1.7°, $p=0.429$). Postoperative measurements differed between pre-resection and mid-resection for both MPTA and LDFA ($p<0.001$). The pre-resection group had greater preoperative to postoperative change in MPTA (-0.4±1.5° vs 0±0.8°, $p<0.001$) and smaller change in LDFA (1.5±1.5° vs. 2.7±1.7°, $p<0.001$), joint line orientation (1.1±2.4° vs 2.7±2°, $p<0.001$), and arithmetic hip-knee-ankle (-2±1.9° vs -2.6±1.7°, $p<0.001$) (Figure 2). The pre-resection group had more patients whose CPAK phenotype didn't change postoperatively (35% vs 17%, $p<0.001$). Final mediolateral balance was significantly different only at 90°, however the difference in means was within 0.6 mm between groups throughout flexion (Figure 3).

DISCUSSION AND CONCLUSION: While both techniques achieved similar balance, a pre-resection ligament balancing workflow that prioritized femoral anatomy better restored native CPAK than an inverse-kinematic alignment workflow that balanced the femur off an anatomic tibial resection. A robotic pre-resection balancing workflow targeting kinematic alignment may also avoid the pitfalls associated with traditional KA, where balance is assessed only after resections.

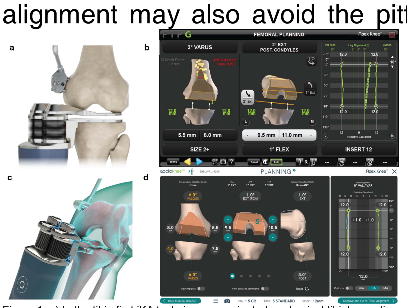


Figure 1: a) In the tibia first iKA technique, a navigated anatomical tibial resection was performed between 5° varus and 1° valgus, and then the ligament tensioner was inserted and gaps were acquired throughout flexion. b) Femoral implant planning was then performed to achieve equal gaps in extension and flexion within 1.5mm. c) In the pre-resection KA technique, the ligament tensioner was inserted prior to any resection and gaps were acquired. d) combined femoral and tibial planning was performed while prioritizing femoral anatomy restoration and gap balance within 1.5mm throughout flexion. The ACL and PCL were removed prior to the ligament balance acquisition in both techniques.

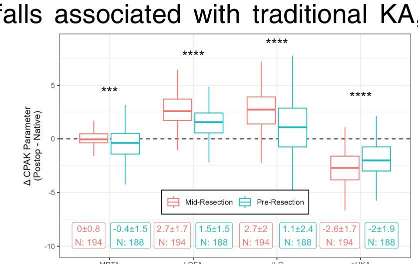
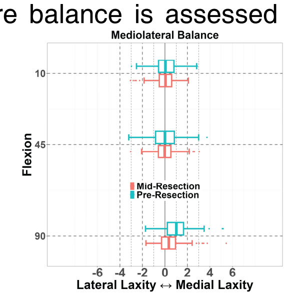


Figure 2: Comparing the change in CPAK parameters from preop to postop between Mid-Resection and Pre-Resection workflows.



Flexion	Mid-Resection	Pre-resection	p
10°	0.1±1.1	0.0±0.9	0.520
45°	0.0±1.2	0.0±1.0	0.902
90°	1.0±1.1	0.4±1.1	**<0.001**

Figure 3: Comparing the final mediolateral balance between Mid-Resection and Pre-Resection workflows.