GAP BALANCING PRECISION IN ROBOTIC-ASSISTED TOTAL KNEE ARTHROPLASTY

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Introduction: Soft tissue balance is associated with patient satisfaction and implant survivorship in total knee arthroplasty (TKA). Robotic-assisted gap-balancing methods aim to achieve greater consistency in balance, through gap-based planning of implants and bone resections. This study evaluated the efficacy of a novel robotic-assisted gap-balancing technique to achieve mediolateral balance throughout flexion, when using a computer-controlled ligament tensioning system to plan balance. The repeatability of knee gap assessment using dynamically controlled ligament tensioning was also assessed.

Methods: Consecutive patients undergoing robotic-assisted TKA by four surgeons using a tibia-first gap-balancing technique were retrospectively reviewed as part of a multicenter study. After resecting the tibia, a computer-controlled tensioning device was inserted into the joint and the knee was dynamically ranged from flexion to extension while the device applied constant tension to the medial and lateral sides. Femoral component alignment and position was then planned to achieve a targeted balance throughout flexion using predictive medial and lateral gap profiles. Femoral resections were then made to plan using robotic-assistance, and a femoral trial component was inserted. The computer-controlled tensioning device was then reinserted into the knee in place of the tibial trial to assess final balance. The knee was dynamically ranged through flexion while the tensioner applied 80-100N (18-22lbs) of tension medially and laterally. The degree of imbalance was then calculated as the mediolateral difference in the gap opening at 0, 10, 45, and 90 degrees of flexion and was categorized in 1 mm increments of imbalance. The repeatability of the technique to assess medial and lateral gaps was also evaluated in 24 patients by three surgeons who each performed three repeated gap measures dynamically throughout the flexion range.

Results: Final mediolateral balance throughout flexion was within 1 mm and 2 mm in 65-75% and 87-95% of cases, respectively (figure 1), with a maximum imbalance of 3.7mm measured across all knees. Gap assessment repeatability was within 0.5 mm standard deviation across surgeons, sides, and flexion angles (figure 2).

Discussion and Conclusion: Performing gap-balancing TKA with a computer-controlled ligament tensioner resulted in mediolateral balance within 2 mm in 87-95% of cases. Dynamic gap assessment under constant ligament tension demonstrated a high degree of repeatability across a range of surgeons and patients. Future studies are needed to better determine how gap balancing precision correlates with improvements in knee joint function, quality of life, and patient satisfaction.
Fig. 1. Distribution of mediolateral imbalance at 0, 10, 45, and 90 degrees of flexion.

Fig. 2. Medial and lateral gap assessment repeatability for individual surgeons and for pooled data. Error lines represent 90% confidence intervals.