# Functional Knee Positioning in Robotic-Assisted Total Knee Arthroplasty: An Assessment of Coronal Alignment Strategies and Early Outcomes

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INTRODUCTION: Functional knee positioning (FKP) is a personalized approach to total knee arthroplasty (TKA) that aims to optimize ligament balancing based on carefully planned bony resections to minimize soft tissue releases with restricted kinematic alignment. The primary objective of this study was to understand surgical decision making for patients undergoing MAKO v2.0 robotic-assisted TKA using FKP, in the context of their preoperative constitutional coronal alignment and the final MAKO plan, including implant placement, gaps, and final alignment. The secondary objective was to compare early outcomes based on preoperative alignment and final MAKO plans.

METHODS: A retrospective review was performed on prospectively collected, de-identified data from all MAKO robot-assisted TKAs performed at our institution with the MAKO v2.0 software from January 2023 through August 2024. Patients were divided based on their coronal alignment into four preoperative groups (no deformity [0-1° varus/valgus], mild deformity [2-5° varus/valgus], moderate deformity [6-10° varus/valgus], severe deformity [>10° varus/valgus]) and three postoperative groups (neutral [between 0 and 1° varus], narrow-boundary preference [between 1-4° varus and up to 1° valgus], wide-boundary preference [between ≥4° varus and ≥2° valgus]). Target surgical alignment was based on surgeon preference for the degree of alignment correction and implant position. Univariate analysis and multivariate regression were used to analyze these factors as well as patient-specific characteristics and early outcome measures. Both male and female patients were included in the study with a sample size of 1,177.

RESULTS SECTION: A total of 1,177 patients (810 females) were included in the study. There was no significant difference in baseline patient characteristics based on preoperative deformity. Patients with greater preoperative deformities were more likely to receive a varus-valgus constrained bearing. Postoperative neutral alignment was less likely to be the correction goal as preoperative deformity increased; patients with worse preoperative deformities were more likely to be assigned to wide-boundary preference postoperatively. Postoperative alignment strategy did not influence early functional outcomes with regard to time to discharge, visual analog scale (VAS) pain scores, ambulation distance, or activity measure for post-acute care (AMPAC) scores.

DISCUSSION: The degree of coronal plane correction using FKP is correlated with the severity of preoperative deformity. There are no early outcome differences between patients who were placed in neutral alignment, narrow-boundary preference, or wide-boundary preference. This supports latitude in surgeon decision making with respect to boundary selection based on preoperative deformity and provides surgeons with confidence to not bring all patient back to neutral alignment. Further research is required to evaluate long-term functional outcome differences and the impact of FKP alignment boundaries on implant durability.

SIGNIFICANCE/CLINICAL RELEVANCE: This study supports the use of FKP as a reliable balancing strategy in TKA, offering a more personalized approach rather than a standardized correction goal for all patients, with similar early outcomes.

IMAGES AND TABLES:

Table 1: Preoperative and postoperative alignment distribution

| | | Preoperative deformity | | | |
|---|---|---|---|---|---|
| | | No deformity (N=233) | Mild deformity (N=641) | Moderate deformity (N=279) | Severe Deformity (N=24) |
| Post-operative alignment | Neutral post-operative alignment (n=205) | 60 (25.8) | 130 (20.3) | 15 (5.4) | 0 (0) |
| | Narrow-boundary FKP (n=628) | 146 (62.7) | 369 (57.6) | 107 (38.4) | 6 (25) |
| | Wide-boundary FKP (n=344) | 27 (11.6) | 142 (22.2) | 157 (56.3) | 18 (75) |

Table 2: Early functional outcomes

| | | Post-operative alignment | | |
|---|---|---|---|---|
| | Neutral alignment (n=205) | Narrow-boundary FKP (n=628) | Wide-boundary FKP (n=344) | p-value |
| Time to discharge (hours) | 27.4 ± 24.2 (3.0 - 143.0) | 29.2 ± 28.3 (2.0 - 218.0) | 31.6 ± 30.7 (1.0 - 233.0) | 0.394 |
| | (n=144) | 2 (n=415) | 3 (n=224) | |
| AMPAC scores at discharge | 22.9 ± 2.1 (16.0 - 24.0) | 22.7 ± 2.3 (11.0 - 24.0) | 22.7 ± 2.2 (15.0 - 24.0) | 0.58 |
| | (n=180) | 2 (n=528) | 3 (n=292) | |
| Postoperative MME at discharge | 30.4 ± 38.1 (3.8 - 270.0) | 34.4 ± 57.9 (3.8 - 865.0) | 37.8 ± 47.4 (3.8 - 315.0) | 0.142 |
| | (n=128) | 2 (n=365) | 3 (n=185) | |
| Time to 100 feet ambulation distance (hours) | 17.0 ± 17.4 (2.0 - 101.0) | 16.9 ± 16.8 (1.8 - 171.4) | 21.0 ± 21.3 (0.9 - 140.9) | 0.08 |
| | (n=178) | (n=560) | (n=309) | |
| VAS pain scores at 6 hours | 4.0 ± 2.4 (0.0 - 10.0) | 3.9 ± 2.4 (0.0 - 10.0) | 4.2 ± 2.4 (0.0 - 10.0) | 0.161 |
| | (n=83) | (n=223) | (n=133) | |
| VAS pain scores at 12 hours | 5.8 ± 2.(0.0 - 10.0) | 5.8 ± 2.(0.0 - 10.0) | 5.6 ± 2.(0.0 - 10.0) | 0.549 |
| | (n=89) | (n=277) | (n=148) | |
| VAS pain scores at 18 hours | 5.4 ± 2.(0.0 - 10.0) | 5.6 ± 2.5 (0.0 - 10.0) | 5.7 ± 2.(0.0 - 10.0) | 0.516 |
| | (n=72) | (n=194) | (n=115) | |
| VAS pain scores at 24 hours | 5.5 ± 2.(0.0 - 10.0) | 5.3 ± 2.4 (0.0 - 10.0) | 5.6 ± 2.6 (0.0 - 10.0) | 0.532 |