

Do Alignment Strategies Affect Outcomes in Robotic-Assisted Total Knee Arthroplasty (TKA)? A study of Mechanical vs. Kinematic Approaches

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INTRODUCTION: Robotic-assisted TKA is gaining widespread adoption, yet the optimal alignment strategy remains a topic of ongoing debate. While robotic technology offers enhanced precision in bone resections and soft tissue balancing, its clinical benefit to patients remains uncertain. Given the increased cost, learning curve, and limited long-term data, it is important to evaluate its value in real-world practice. This study prospectively compared patient reported outcomes among three groups: conventional TKA with mechanical alignment, robotic-assisted mechanical alignment TKA, and robotic-assisted kinematic alignment TKA.

METHODS:

This is a preliminary report from a single center, single-surgeon, prospective randomized study of patients aged 50-80 undergoing total knee arthroplasty (TKA). Patients with end-stage arthritis and minimal coronal and sagittal plane deformities were included. Patients were computer randomized into one of three parallel groups: conventional TKA with mechanical alignment, robotic TKA with mechanical alignment, or robotic assisted TKA with kinematic alignment.

Outcome measures were collected at 2 weeks, 6 weeks, 6 months, and 1 year postoperatively. At each follow-up, patients completed the Visual Analog Scale (VAS) for pain, Knee Osteoarthritis Outcome Score (KOOS-JR), Forgotten Joint Score (FJS), PROMIS Physical Function, and PROMIS Pain Interference assessments. Additionally, operative time and range of motion (flexion and extension) were collected. Range of motion was assessed at follow-up intervals of 6 weeks, 6 months, and 1 year postoperatively. This preliminary analysis includes 18 randomized subjects per group. Statistical comparisons between groups were performed using one-way ANOVA, with a significance level of $p < 0.05$.

RESULTS:

Table 1 presents average VAS Pain Scores (0-100) at each postoperative time point, with no significant differences observed between groups. Table 2 displays the mean PROMIS Pain Interference T-scores across all follow-up periods; again, there were no significant differences between groups.

Table 3 demonstrates the mean PROMIS Physical Function T-scores. At the 1 year follow-up, the robotic assisted mechanically aligned group demonstrated a significantly higher Physical Function score compared to the other two groups ($p=0.0453$).

Table 4 shows the Forgotten Joint Scores (FJS). At the 6 week follow-up, the non-robotic mechanically aligned knee group (Control) had significantly higher FJS score than both robotic-assisted groups ($p=0.0084$).

Operative time was significantly longer for the non-robotic mechanically aligned group versus the robotic assisted mechanically aligned group ($p=0.0083$). There were no statistically significant differences in range of motion for any of the groups at any of the three time points.

DISCUSSION AND CONCLUSION:

This study contributes adds to the growing body of literature on patient-reported outcomes in total knee arthroplasty. In this prospective, randomized trial, patients in the robotic-assisted mechanically aligned group demonstrated significantly higher PROMIS Physical Function scores at 1 year follow-up compared to both the non-robotic mechanically aligned and robotic-assisted kinematically aligned groups. Interestingly, at 6 weeks postoperatively, the non-robotic mechanically aligned group reported significantly higher Forgotten Joint Score than the robotic-assisted groups. These findings highlight the temporal differences in functional patient reported metrics across TKA alignment strategies with and without robotic-assistance.

VAS Pain	Ctrl	1-Mechanical	2-Kinematic	ANOVA P-value
Baseline (Avg)	41.125 SD= 30.79	42.61 SD= 29.72	41 SD= 27.39	0.9819
2 weeks	32.88 SD= 18.97	32.41 SD= 19.74	40.73 SD= 24.97	0.4605
6 weeks	23.93 SD= 20.94	17.22 SD= 16.83	27.77 SD= 21.67	0.2827
6 months	14.76 SD= 20.81	9.19 SD= 10.08	16.68 SD= 17.58	0.4374
1 year	10.23 SD= 17.95	4.76 SD= 6.22	9.41 SD= 13.53	0.4486

Pain Interference T-score	Ctrl	1-Mechanical	2-Kinematic	ANOVA P-value
Baseline (Avg)	61.71 SD= 5.73	61.78 SD= 4.66	61.62 SD= 4.76	0.9908
2 weeks	58.17 SD= 5.24	58.41 SD= 5.62	58.46 SD= 5.58	0.8866
6 weeks	53.4 SD= 7.29	56.48 SD= 5.90	56.83 SD= 5.0	0.1920
6 months	50.09 SD= 6.46	48.76 SD= 7.17	52.16 SD= 5.84	0.3099
1 year	49.85 SD= 6.93	44.57 SD= 6.83	48.79 SD= 6.74	0.0684

Physical Function	Ctrl	1-Mechanical	2-Kinematic	ANOVA P-value
Baseline (Avg)	38.44 SD= 6.71	37.74 SD= 3.87	38.76 SD= 5.33	0.6392
2 weeks	38.26 SD= 6.00	33.74 SD= 8.04	33.08 SD= 5.77	0.1851
6 weeks	41.64 SD= 5.84	40.33 SD= 6.89	40.88 SD= 3.99	0.6774
6 months	46.02 SD= 6.12	47.38 SD= 5.44	46.36 SD= 5.61	0.7407
1 year	46.72 SD= 7.02	51.72 SD= 7.41	46.49 SD= 5.32	0.0453*

FJS Score	Ctrl	1-Mechanical	2-Kinematic	ANOVA P-value
Baseline (Avg)	35.66 SD= 22.38	34.00 SD= 21.11	27.33 SD= 19.39	0.6368
2 weeks	41.19 SD= 21.42	26.95 SD= 15.12	26.70 SD= 23.11	0.0084**
6 weeks	65.51 SD= 24.23	62.25 SD= 23.50	51.39 SD= 21.56	0.1702
1 year	64.94 SD= 20.47	66.57 SD= 25.17	59.39 SD= 22.50	0.4337