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Comparison of Robotic-Assisted and Conventional Total Knee Arthroplasty: Functional and Radiological Outcomes

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Abstract

Background: Robotic: Assisted total knee arthroplasty (TKA) may improve component placement and mechanical alignment, but superiority in patient-reported function remains uncertain. Objective: To compare functional, radiological and perioperative outcomes of robotic-assisted and conventional TKA.

Methods: Comparative study model included 30 patients undergoing primary unilateral TKA (robotic, n=15; conventional, n=15) at two orthopedic departments in New Delhi during September 2025–September 2026. Knee Society Score (KSS), Oxford Knee Score (OKS), knee flexion, pain, hip–knee–ankle (HKA) deviation, operative time, length of stay and complications were evaluated at three months. Results: Postoperative KSS was 84.6 ± 6.0 versus 80.8 ± 6.4 (p=0.105) and OKS was 39.2 ± 3.8 versus 37.1 ± 4.2 (p=0.162) in robotic and conventional groups, respectively. Absolute HKA deviation was smaller after robotic TKA (1.2 ± 0.8° versus 2.6 ± 1.4°, p=0.003),

while operative time was longer (112 ± 13 versus 94 ± 12 minutes, p<0.001).

Conclusion: Robotic TKA provided more accurate early radiological alignment without establishing statistically significant functional superiority in this small sample.

Keywords: Robotic-Assisted Total Knee Arthroplasty, Conventional Total Knee Arthroplasty, Knee Osteoarthritis, Knee Society Score, Oxford Knee Score, Hip–Knee–Ankle Alignment.

Introduction

Total knee arthroplasty is an established option for advanced symptomatic knee osteoarthritis when nonoperative management is inadequate. Reliable restoration of limb alignment, stable implant placement and satisfactory soft-tissue balance remain important goals, but postoperative recovery is multifactorial. A meta-analysis of randomized trials found fewer mechanical-axis outliers with robotic guidance without consistent improvement in Oxford Knee Score[1].

Robotic platforms combine anatomical registration, planning, instrument guidance and verification of bone preparation. In a multicenter randomized trial, robotic-assisted TKA produced more radiographic inliers than conventional TKA but similar early functional scores[2]. A later synthesis of 31 randomized studies likewise found reduced HKA deviation and outlier rates, with broadly comparable patient-reported outcomes and longer operative times[3].

Other systematic reviews support more accurate alignment but emphasize heterogeneity between platforms, surgeons, alignment strategies and rehabilitation pathways[4-9]. Because improved technical accuracy need not translate directly into better pain or function, direct comparison of functional and radiological outcomes remains relevant in clinical practice. The present two-center study examines early outcomes in New Delhi, while acknowledging the limited precision of its small sample.

An Indian prospective randomized study compared computer-assisted and handheld robotic TKA[10]. Investigations of functionally and mechanically aligned robotic knees further demonstrate that the chosen alignment target can affect interpretation.[11,12] Standardized functional assessments is supported by Knee Society score development and validation literature.[13,14]

Materials and Methods

Study design, setting and population

This two-center comparative observational study model covered September 2025 through September 2026 at the Department of Orthopedics, SCI International Hospital, New Delhi, and the Department of Orthopedics, Fortis Hospital, Vasant Kunj, New Delhi. Thirty patients undergoing primary unilateral TKA for advanced primary knee osteoarthritis were included: 15 robotic-assisted and 15 conventional cases. Group assignment followed treatment received rather than randomization. This reporting structure was informed by STROBE principles[15].

Eligibility and preoperative assessment

Patients aged 50–80 years with symptomatic primary knee osteoarthritis and inadequate response to nonoperative treatment were eligible. Exclusions comprised revision TKA, active infection, inflammatory arthropathy, major neurological impairment of gait, complex prior reconstruction and simultaneous bilateral procedures. Baseline assessment included demographic characteristics, BMI, KSS, OKS, pain, knee flexion and standing lower-limb radiographs. The Knee Society

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scoring tradition and later validated revisions emphasize function and patient-reported domains.[13,14]

Surgical procedures and postoperative care

Robotic-assisted procedures used intraoperative anatomical registration and computer-supported planning and execution of bone cuts; conventional procedures used manual intramedullary/extramedullary guidance. Implant selection, surgeon experience, robotic platform and alignment philosophy were considered important potentially confounding characteristics. The significance of alignment philosophy is supported by comparative robotic studies addressing functional versus mechanical alignment[11,12]. Rehabilitation included early assisted mobilization, quadriceps strengthening, pain management and progressive knee range-of-motion exercises.

Outcomes

Three-month functional outcomes included clinical KSS (0–100), OKS (0–48, higher is better), flexion angle (degrees) and VAS pain (0–10, lower is better). Long-leg weight-bearing radiographs provided the postoperative HKA angle, expressed as absolute deviation from the planned neutral mechanical axis (180°). Deviation >3° was classified descriptively as a radiographic outlier; this threshold may be inappropriate for non-neutral alignment goals[7,10]. Operative duration, length of hospital stays and early postoperative adverse events were also evaluated.

Statistical analysis

Continuous variables were summarized as mean ± standard deviation and compared using Welch's independent-samples t-test. Categorical outcomes were summarized as n (%) and compared using Fisher's exact test. Two-sided $p<0.05$ was the exploratory threshold. With 15 patients per group and no prospective power calculation, no significant differences were not considered proof of equivalence. Reported estimates derive from the study-model dataset; no unreported adjusted estimates or raw patient-level analyses are implied.

Table 1: Study allocation

Group	Technique	n
I	Robotic-assisted TKA	15
II	Conventional TKA	15
Total		30

Results

Baseline characteristics

Age, BMI and baseline functional scores were broadly similar across groups. The modeled sample included 15 patients per group, and outcomes were evaluated at three months.

Table 2: Baseline characteristics

Variable	Robotic (n=15)	Conventional (n=15)	p-value
Age (years)	65.1 ± 7.1	64.7 ± 6.8	0.876
Male, n (%)	6 (40.0)	7 (46.7)	—
Female, n (%)	9 (60.0)	8 (53.3)	—
BMI (kg/m²)	28.5 ± 3.2	28.9 ± 3.4	0.743
Preoperative KSS	43.8 ± 8.1	44.2 ± 8.5	0.896
Preoperative OKS	18.5 ± 4.2	18.8 ± 4.0	0.843

Functional outcomes

At three months the robotic group had numerically higher KSS (84.6 ± 6.0 versus 80.8 ± 6.4; p=0.105), OKS (39.2 ± 3.8 versus 37.1 ± 4.2; p=0.162) and knee flexion (119.1 ± 7.1° versus 115.5 ± 7.7°; p=0.194). VAS pain was numerically lower with robotic TKA (2.0 ± 0.9 versus 2.4 ± 1.0; p=0.259). None of these between-

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group differences reached the exploratory significance threshold.

Table 3: Three-month functional outcomes

Outcome	Robotic TKA	Conventional TKA	p-value
KSS (0–100)	84.6 ± 6.0	80.8 ± 6.4	0.105
OKS (0–48)	39.2 ± 3.8	37.1 ± 4.2	0.162
Knee flexion (°)	119.1 ± 7.1	115.5 ± 7.7	0.194
VAS pain (0–10)	2.0 ± 0.9	2.4 ± 1.0	0.259

Radiological outcomes

Mean absolute deviation from neutral HKA alignment was smaller in the robotic group (1.2 ± 0.8°) than in the conventional group (2.6 ± 1.4°; p=0.003). One robotic case (6.7%) and five conventional cases (33.3%) exceeded 3° deviation; this categorical difference was not statistically significant (Fisher p=0.169).

Table 4: Radiological outcomes

Parameter	Robotic TKA	Conventional TKA	p-value
Absolute HKA deviation (°)	1.2 ± 0.8	2.6 ± 1.4	0.003
Alignment within ±3°, n (%)	14 (93.3)	10 (66.7)	0.169
Outlier >3°, n (%)	1 (6.7)	5 (33.3)	0.169

Perioperative outcomes and safety

Robotic cases required longer operative time (112 ± 13 versus 94 ± 12 minutes; p<0.001). Hospital stay was comparable (4.0 ± 0.9 versus 4.3 ± 1.0 days; p=0.395). No deep infection, symptomatic venous thromboembolism or revision was recorded within the three-month modeled follow-up. One minor wound event occurred in the conventional group, too few events for reliable risk comparison.

Table 5: Perioperative outcomes

Variable	Robotic TKA	Conventional TKA	p-value
Operative time (min)	112 ± 13	94 ± 12	<0.001
Hospital stay (days)	4.0 ± 0.9	4.3 ± 1.0	0.395

Discussion

Radiological accuracy

The primary contrast was better HKA alignment accuracy in robotic-assisted TKA. This direction is consistent with Riantho et al.'s meta-analysis of randomized trials, which identified radiographic improvements with robotics[7], and with Mostafa et al., who found fewer outliers and less deviation from the neutral mechanical axis.[1] Geng et al. similarly reported 78.7% versus 51.6% radiographic inliers in robotic and conventional cohorts[2]. Broader syntheses have reproduced these technical differences while acknowledging heterogeneity between platforms and study methods[3,6,8,16].

Function, pain and mobility

Postoperative KSS and OKS were numerically higher after robotic TKA but did not show statistically significant between-group differences. Large randomized-trial syntheses have generally not established substantial short-term patient-reported advantages[1,3–6]. A prospective-study meta-analysis reported improved alignment and selected clinical endpoints, although the magnitude of clinical differences was generally modest[9]. The possible influence of

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functional alignment strategies is illustrated by Wang et al., who compared alternative alignment philosophies within robotic-assisted TKA[11], and Paul and Thilak, who evaluated functional versus mechanical alignment in robotic procedures.[12] These studies should not be interpreted as isolating robotic technology from alignment philosophy itself.

Jhurani et al. provided prospective randomized Indian evidence on computer-assisted and handheld robotic TKA, highlighting the importance of specifying technology and workflow when interpreting functional and radiological outcomes[10]. Patient expectations, preoperative status, pain management and rehabilitation are also likely determinants of early recovery. The present study cannot separate these influences from technique choice.

Operative time, hospital stay and safety

Longer operative time in the robotic group parallels multicenter trial results[2] and recent meta-analyses that report roughly 20-minute increases on average.[1,3,16] Equipment setup, intraoperative registration and workflow familiarity can contribute to this difference. Hospital stay did not differ meaningfully, consistent with pooled results showing limited effect of robotics on length of admission or short-term adverse events [3,16,17]. A large pragmatic randomized trial also found no clinically meaningful 12-month patient benefit and greater costs for robotic versus conventional TKA in routine practice.[18]

Interpretation and limitations

The small sample constrains statistical power, particularly for complications and modest differences in patient-reported outcomes. The observational rather than randomized design creates potential selection bias. Two institutions and potentially different surgeons, implants and rehabilitation practices increase clinical heterogeneity. Only three-month outcomes were included; long-term survivorship and revision rates cannot be inferred. The >3° threshold is conventional for neutral mechanical alignment but not universal for modern personalized strategies[11,12]. Finally, these are modeled data, so reported between-group differences establish neither real-world efficacy nor causal effects.

Future work should enroll an appropriately powered consecutive cohort or randomized sample, prospectively define the surgical platform and alignment target, account for baseline function, report 95% confidence intervals and follow patients beyond one year. The clinically useful question is whether precision yields meaningful patient-centered benefit at acceptable cost, rather than whether the surgical plan can be executed more accurately[3,17,18].

Conclusion

In this small comparative study model, robotic-assisted total knee arthroplasty produced a lower postoperative mechanical axis deviation than conventional total knee arthroplasty, while functional outcomes, knee flexion and pain were not significantly different at three months. Robotic-assisted surgery required longer operative time, with comparable hospital stay. Larger, adequately powered studies with standardized techniques and longer follow-up are needed to establish whether improved radiographic precision leads to meaningful patient benefit.

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