



Clinical and functional recovery after primary total knee replacement for osteoarthritis: A six-month prospective observational study

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ABSTRACT

Article info:

Received: 21 Jul 2026

Accepted: 13 Sep 2026

Keywords:

Total knee replacement

Knee osteoarthritis

Oxford Knee Score

Functional outcome

Range of motion

Total knee replacement (TKR) is the standard surgical treatment for end-stage knee osteoarthritis. Understanding the pace and pattern of functional recovery helps in counselling patients and planning rehabilitation. To evaluate changes in pain, joint function, range of motion, and activities of daily living over 6 months after primary unilateral TKR. In this prospective observational study, 30 patients with primary knee osteoarthritis undergoing primary unilateral TKR were enrolled by consecutive sampling. Patients were assessed preoperatively and at 6 weeks, 3 months, and 6 months using the Oxford Knee Score (OKS), the Numerical Rating Scale (NRS) for pain, goniometric knee flexion and extension deficit, and 0–100 functional scores for walking, stair climbing, sit-to-stand, and activities of daily living (ADL). The mean age was 64.6 ± 7.6 years, and 60% of patients were female. OKS improved from 18.71 ± 3.72 to 41.47 ± 3.48 , NRS pain fell from 7.69 ± 1.09 to 1.36 ± 0.78 , knee flexion increased from 85.32° to 116.98° , and extension deficit fell from 11.98° to 0.92° (all $p < 0.001$). Walking, stair climbing, sit-to-stand, and ADL scores each improved by 47 to 51 points (all $p < 0.001$). Most recovery occurred within 3 months, with smaller gains between 3 and 6 months. At least one complication occurred in 6 patients (20.0%); knee stiffness was the most common (10.0%). Primary TKR was associated with substantial, progressive improvement in pain, function, and mobility over 6 months, with the steepest gains in the first 3 months. Complications were not uncommon and warrant attention during follow-up.

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1. Introduction

Knee replacement is one of the most commonly performed and cost-effective musculoskeletal operations, and painful knee osteoarthritis with reduced function remains its main indication [1,2]. The procedure relieves pain and improves knee function in people with advanced arthritis of the joint [2]. Demand is expected to keep rising: projections for the United States estimated that annual primary total knee arthroplasties would grow by 673% to 3.48 million procedures by 2030 [3].

Outcomes after TKR are increasingly judged from the patient's perspective rather than by implant survival alone. The Oxford Knee Score (OKS) is a 12-item patient-reported questionnaire developed specifically for TKR that is short, reliable, valid, and sensitive to clinically important change over time [4,5], and it is usually combined with objective measures such as range of motion. Although TKR is highly successful when judged by prosthesis-related outcomes, some patients continue to have painful joints; in the best-quality studies, an unfavorable long-term pain outcome was reported in about 20% of patients after knee replacement [6]. Knowing how quickly different domains recover helps surgeons and physiotherapists set realistic expectations and identify patients who deviate from the expected course.

We therefore conducted a prospective observational study to evaluate changes in pain, joint function, range of motion, and activities of daily living over 6 months after primary unilateral TKR for primary knee osteoarthritis, and to document postoperative complications.

2. Materials and Methods

2.1 Study design and setting

This prospective observational study evaluated changes in functional outcomes after primary unilateral TKR in patients with primary knee osteoarthritis over a 6-month follow-up. Patients were assessed preoperatively and at 6 weeks, 3 months, and 6 months after surgery.

2.2 Ethical considerations

The study was approved by the Institutional Ethics Committee of Satya Hospital and Maternity Centre (ECR/21/Inst/UP/2021). Written informed consent was obtained from all participants, and confidentiality was maintained throughout.

2.3 Study population and sampling

Consecutive sampling was used to recruit eligible patients undergoing primary unilateral TKR for primary knee osteoarthritis during the study period. Patients who met the eligibility criteria were enrolled after written

informed consent until the required sample size of 30 was reached. Inclusion criteria were age ≥ 18 years, primary knee osteoarthritis, primary unilateral TKR, and Willingness to provide informed consent and attend follow-up assessments. While, exclusion criteria were revision or bilateral TKR, secondary osteoarthritis or inflammatory arthritis, neurological or musculoskeletal disorders affecting functional assessment, inability to complete follow-up assessments.

2.4 Study procedure

Baseline demographic and clinical details, including age, sex, and operated knee, were recorded on a structured proforma. Preoperative functional assessments were performed before surgery. All patients underwent routine primary unilateral TKR and were reassessed at 6 weeks, 3 months, and 6 months postoperatively.

2.5 Outcome measures

OKS: A 12-item patient-reported measure of knee pain and function [5], scored from 0 to 48, with higher scores indicating better function [7]. Numerical Rating Scale (NRS): Pain intensity from 0 (no pain) to 10 (worst imaginable pain). Range of motion: Active knee flexion and extension deficit, measured in degrees with a universal goniometer.

Functional performance: Walking ability, stair climbing, sit-to-stand performance, and activities of daily living, recorded as functional scores on a 0–100 scale (higher scores indicating better function). Complications: Infection, wound problems, knee stiffness, thromboembolic events, readmission, and reoperation.

2.6 Statistical analysis

Continuous variables are expressed as mean $\pm$ standard deviation and categorical variables as frequencies and percentages.

Changes between the preoperative and 6-month assessments were analyzed with the paired t-test, or the Wilcoxon signed-rank test, when the assumptions of the paired t-test were not met. Outcomes at 6 weeks and 3 months were summarized descriptively to show the progression of recovery. A p -value < 0.05 was considered statistically significant.

3. Results

3.1 Baseline characteristics

Thirty patients with primary knee osteoarthritis underwent primary unilateral TKR and were followed for 6 months. The mean age was 64.6 ± 7.6 years. Eighteen patients (60.0%) were female and 12 (40.0%) were male. The right knee was operated on in 17 patients (56.7%) and the left in 13 (43.3%) (Table 1).

3.2 Clinical outcomes

All clinical outcomes improved progressively at each follow-up (Table 2, Figure 1). The mean OKS rose from 18.71 ± 3.72 preoperatively to 27.62 ± 4.39 at 6 weeks, 36.47 ± 4.97 at 3 months, and 41.47 ± 3.48 at 6 months, a mean gain of 22.76 points. The NRS pain score fell from 7.69 ± 1.09 to 1.36 ± 0.78 , a mean reduction of 6.33 points. Active knee flexion increased from $85.32 \pm 9.34^\circ$ to $116.98 \pm 3.90^\circ$ (mean gain 31.66°), and extension deficit decreased from $11.98 \pm 3.32^\circ$ to $0.92 \pm 0.87^\circ$ (mean reduction 11.06°). The preoperative-to-6-month change was statistically significant for all four measures ($p < 0.001$). Most of the recovery occurred within the first 3 months. Gains between 3 and 6 months were smaller (OKS +5.00 points, NRS -1.10, flexion +4.56°, extension deficit -1.15°), suggesting that recovery was beginning to plateau.

3.3 Functional outcomes

Walking ability, stair climbing, sit-to-stand

performance, and activities of daily living all improved steadily (Table 3).

Walking ability rose from 38.42 ± 6.15 to 86.53 ± 4.28 , stair climbing from 32.14 ± 7.38 to 83.41 ± 4.75 , sit-to-stand performance from 41.57 ± 6.89 to 88.92 ± 3.66 , and activities of daily living from 39.46 ± 5.76 to 87.21 ± 3.91 .

The mean gains were 48.11, 51.27, 47.35, and 47.75 points, respectively, all statistically significant ($p < 0.001$). Stair climbing had the lowest baseline score and showed the largest gain.

3.4 Postoperative complications

At least one complication occurred in 6 patients (20.0%). Knee stiffness was the most frequent ($n = 3$, 10.0%), followed by wound problems ($n = 2$, 6.7%) and readmission ($n = 2$, 6.7%).

Infection, thromboembolic events, and reoperation each occurred in one patient (3.3%) (Table 4). Some patients had more than one complication.

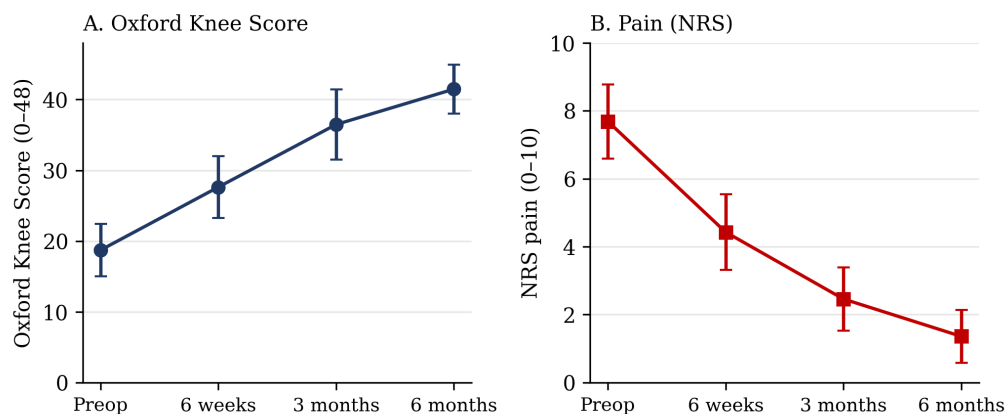


Figure 1. Oxford Knee Score (A) and NRS pain score (B) at each assessment. Points are means; error bars show ± 1 SD.

Table 1. Baseline characteristics of the study population (N = 30)

Characteristic	Frequency (n)	Percentage (%)
Age (years), mean $\pm$ SD	64.6 $\pm$ 7.6	—
Gender		
Male	12	40.0
Female	18	60.0
Operated knee		
Right	17	56.7
Left	13	43.3
Total	30	100

Table 2. Clinical outcomes over time (mean $\pm$ SD)

Outcome measure	Preoperative	6 weeks	3 months	6 months	Mean change (preop to 6 mo)	p-value*
Oxford Knee Score	18.71 $\pm$ 3.72	27.62 $\pm$ 4.39	36.47 $\pm$ 4.97	41.47 $\pm$ 3.48	+22.76	< 0.001
Pain score (NRS)	7.69 $\pm$ 1.09	4.43 $\pm$ 1.12	2.46 $\pm$ 0.93	1.36 $\pm$ 0.78	-6.33	< 0.001
Knee flexion (°)	85.32 $\pm$ 9.34	98.80 $\pm$ 6.78	112.42 $\pm$ 5.20	116.98 $\pm$ 3.90	+31.66	< 0.001
Extension deficit (°)	11.98 $\pm$ 3.32	5.46 $\pm$ 2.07	2.07 $\pm$ 1.45	0.92 $\pm$ 0.87	-11.06	< 0.001

Preoperative vs. 6-month values (paired t-test/Wilcoxon signed-rank test). The 6-week and 3-month values are descriptive. NRS, Numerical Rating Scale

Table 3. Functional parameters over time (mean $\pm$ SD, 0–100 scale)

Functional parameter	Preoperative	6 weeks	3 months	6 months	Mean change (preop to 6 mo)	p-value*
Walking ability	38.42 $\pm$ 6.15	56.81 $\pm$ 5.92	76.24 $\pm$ 5.11	86.53 $\pm$ 4.28	+48.11	< 0.001
Stair climbing	32.14 $\pm$ 7.38	51.35 $\pm$ 6.77	71.92 $\pm$ 5.46	83.41 $\pm$ 4.75	+51.27	< 0.001
Sit-to-stand	41.57 $\pm$ 6.89	60.18 $\pm$ 6.05	79.43 $\pm$ 4.79	88.92 $\pm$ 3.66	+47.35	< 0.001
Activities of daily living	39.46 $\pm$ 5.76	58.09 $\pm$ 5.37	77.75 $\pm$ 4.58	87.21 $\pm$ 3.91	+47.75	< 0.001

Preoperative vs. 6-month values. The 6-week and 3-month values are descriptive.

Table 4. Postoperative complications (N = 30)

Complication	Frequency (n)	Percentage (%)
Infection	1	3.3
Wound problems	2	6.7
Knee stiffness	3	10.0
Thromboembolic events	1	3.3
Readmission	2	6.7
Reoperation	1	3.3
Patients with ≥ 1 complication	6	20.0

4. Discussion

The present prospective study demonstrates substantial improvement in pain, patient-reported knee function, range of motion, mobility, and activities of daily living during the first 6 months following primary unilateral TKR for osteoarthritis. The most pronounced improvements occurred during the first 3 months, followed by more modest gains between 3 and 6 months. This pattern is clinically relevant because recovery after TKR is not instantaneous; rather, different dimensions of pain relief, joint mobility, and functional independence improve progressively during the postoperative period. The magnitude of improvement observed in the present study supports the established role of TKR as an effective intervention for symptomatic end-stage knee osteoarthritis [1,8].

OKS increased by 22.76 points, from 18.71 preoperatively to 41.47 at 6 months. This change is substantially greater than the approximately 4-point minimal detectable change reported for the OKS, indicating that the observed improvement was considerably greater than expected measurement variability [9]. The 6-month postoperative score in the present study was also within the range reported in large observational datasets evaluating patient-reported outcomes after knee arthroplasty, although direct comparisons should be interpreted cautiously because postoperative scores are influenced by patient characteristics, baseline severity, healthcare setting, and rehabilitation practices [10]. The substantial reduction in NRS pain from 7.69 to 1.36 further indicates that improvement was not restricted to perceived functional capacity but was accompanied by marked symptomatic relief.

An important finding was the temporal distribution of recovery. By 3 months, the mean OKS had already increased to 36.47, while pain had decreased to 2.46 and knee flexion had reached 112.42°. The subsequent improvement to 6 months was smaller, with an additional 5-point increase in OKS and approximately 4.6° improvement in flexion. This suggests that the early

postoperative period represents a particularly important phase of functional rehabilitation. Nevertheless, recovery should not be considered complete at 3 months. Evidence from larger cohorts indicates that clinically meaningful improvement can continue after 6 months, and some patients demonstrate further changes between 6 and 12 months [11]. Therefore, the apparent plateau observed in the present study should be interpreted as a slowing of recovery rather than definitive stabilization of long-term outcome.

The improvement in objective knee motion provides additional support for the patient-reported findings. Mean flexion increased by 31.66°, while the extension deficit decreased by 11.06°, approaching full extension by 6 months. These changes are particularly relevant to everyday activities because adequate flexion and extension contribute to walking, stair negotiation, transfers, and other functional tasks. The parallel improvement in walking, stair climbing, sit-to-stand performance, and activities of daily living suggests that the gains in joint motion and pain relief translated into broader functional recovery. However, because the 0–100 functional measures used in this study were recorded scores rather than a named validated instrument, these findings should be interpreted primarily as supportive functional observations rather than as formally validated patient-reported outcomes [7,9].

The complication findings also warrant consideration. Six of 30 participants experienced at least one postoperative complication, corresponding to 20.0%, with stiffness being the most frequent individual complication. The observed rate should not be interpreted as a general estimate of the complication risk following primary TKR because several patients experienced more than one event, the sample was small, and the study was not designed or powered to estimate complication incidence precisely. Large systematic evidence indicates that serious adverse events and readmission after primary TKR are generally considerably lower than the overall event rate observed in this study, although definitions and follow-up periods

vary substantially between studies [12]. The relatively frequent occurrence of stiffness in the present study nevertheless highlights the importance of monitoring postoperative range of motion. Published systematic reviews have identified multiple potential contributors to postoperative stiffness, including preoperative limitation of motion, surgical factors, obesity, and biological or patient-related factors [13,14].

The findings have practical implications for postoperative counselling and rehabilitation. Patients can be informed that substantial improvements in pain and function may occur during the first several months following TKR, while additional recovery may continue thereafter. The concurrent improvement in patient-reported outcomes and objective range of motion supports the use of multidimensional follow-up rather than reliance on a single outcome measure. In particular, early identification of persistent pain or restricted motion may allow clinicians to investigate potentially modifiable causes and intensify rehabilitation when appropriate. This is relevant because postoperative stiffness can adversely affect function and may require additional intervention in selected patients [13,15].

The prospective design, consecutive recruitment, complete follow-up, and combination of the validated OKS, pain assessment, goniometric measurements, and functional observations are important strengths of this study. Nevertheless, several limitations restrict interpretation. The sample consisted of only 30 patients from a single center, limiting statistical precision and generalizability. The absence of a control or comparison group prevents definitive attribution of all observed changes to the surgical intervention. Potential confounding factors, including body mass index, comorbidities, implant characteristics, and rehabilitation protocols, were not examined. The 0–100 functional scores were recorded scores rather than a named, validated instrument, and their reliability should be interpreted with caution. Finally, follow-up was limited to 6 months, preventing assessment of longer-term functional courses, persistent pain, patient satisfaction, implant-related outcomes, and revision.

Primary unilateral TKR in patients with knee osteoarthritis was associated with substantial improvement in pain, patient-reported knee function, range of motion, mobility, and activities of daily living over 6 months. The greatest gains were observed during the first 3 months, followed by a slower rate of improvement through 6 months.

The findings support the value of monitoring both subjective and objective recovery during postoperative follow-up, particularly during the early rehabilitation period. Although complications were observed in 20% of participants, the small single-center sample and overlapping events preclude generalization of this proportion to broader TKR populations. Larger prospective multicenter studies with validated functional instruments, longitudinal statistical analyses, and longer follow-up are warranted to characterize

recovery trajectories and identify patient- and treatment-related factors associated with favorable or delayed recovery.

Declaration of artificial intelligence (AI) in the writing process

The authors declare whether AI or AI-assisted technologies were used during the preparation of this manuscript. If used, AI tools were employed solely to improve language quality, grammar, readability, and organizational structure. The authors carefully reviewed and edited all AI-generated content and take full responsibility for the accuracy, integrity, and originality of the final manuscript. No AI tool was used to generate, analyze, or interpret scientific data or images, or to draw scientific conclusions. The use of AI-assisted technologies complies with current publication ethics recommendations and journal policies.

Authors' contributions

Investigation, data collection, draft preparation: MA, AG. Conceptualization, project leader, funding, validation, draft preparation, final revision and editing: AKA. All authors have read and approved the final version of the manuscript.

Conflict of interest

No potential conflict of interest was reported by the authors.

Ethical declarations

The study was approved by the Institutional Ethics Committee of Satya Hospital and Maternity Centre. Written informed consent was obtained from all participants, and confidentiality was maintained throughout.

Financial support

Self-funded.

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