

Research Article

Assessment of Functional Outcome after Total Knee Replacement: A Prospective Observational Study

Dr. Amit B patil¹, Dr. Rellu Sarath chandra^{2*}, Dr. Ayush Sharma³

¹Senior resident, Dept of orthopaedics, Mandya institute of medical sciences, Mandya.

^{2*}Senior resident, Dept of Orthopaedics, Guntur Medical college, Guntur.

³Senior Resident, Department of Orthopaedics, Jawaharlal Nehru Medical College, Belagavi, KLE Academy of Higher Education and Research (KAHER), Belagavi, Karnataka, India.

Corresponding Author: Dr. Rellu Sarath chandra

Senior resident, Dept of Orthopaedics, Guntur Medical College, Guntur.

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ABSTRACT

Background: Total knee arthroplasty (TKA) is an established surgical intervention for advanced symptomatic knee osteoarthritis when conservative treatment fails to provide adequate pain relief and functional restoration. Although implant survivorship remains an important measure of surgical success, contemporary assessment increasingly emphasizes patient function, pain, mobility, and ability to perform activities of daily living. The present study assessed the temporal pattern and magnitude of functional recovery following primary total knee replacement.

Methods: A prospective observational study was conducted among 100 adults undergoing primary unilateral TKA for advanced knee osteoarthritis. Patients were evaluated preoperatively and at 6 weeks, 3 months, and 6 months postoperatively. Functional outcome was assessed using the Knee Society Knee Score (KSS-Knee), Knee Society Function Score (KSS-Function), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), visual analogue scale (VAS) for pain, and knee range of motion (ROM). Longitudinal changes were analyzed using paired and repeated-measures statistical testing, and multivariable logistic regression was used to identify determinants of high functional status at 6 months.

Results: Mean age was 65.8 ± 7.3 years, and 68% of participants were women. KSS-Knee improved from 41.8 ± 11.5 preoperatively to 84.6 ± 9.8 at 6 months, while KSS-Function increased from 38.6 ± 14.2 to 79.2 ± 15.1 (both $p < 0.001$). WOMAC decreased from 61.3 ± 11.9 to 22.6 ± 10.5 , and VAS pain decreased from 7.4 ± 1.1 to 2.0 ± 1.2 ($p < 0.001$). Mean knee flexion increased from $92.4^\circ \pm 12.1^\circ$ to $111.8^\circ \pm 9.6^\circ$. Higher preoperative functional status and greater flexion at 6 weeks independently favored high 6-month function, whereas advanced age and multiple comorbidities were associated with less favorable recovery. Overall satisfaction was 88%.

Conclusion: Primary TKA produced substantial improvements in pain, knee-specific function, mobility, and activities of daily living, with the greatest recovery occurring during the first 3 months and continued improvement through 6 months. Early functional assessment may assist in identifying patients requiring intensified rehabilitation.

Keywords: Total Knee Arthroplasty, Total Knee Replacement, Functional Outcome, Knee Society Score, WOMAC, Osteoarthritis, Rehabilitation.

INTRODUCTION

Knee osteoarthritis (OA) is among the most prevalent causes of chronic musculoskeletal pain, disability, impaired mobility, and loss of independence in middle-aged and older adults. Its clinical manifestations arise from complex pathological alterations involving articular cartilage, subchondral bone, synovium, menisci, ligaments, periarticular musculature, and nociceptive pathways rather than isolated cartilage degeneration. Increasing longevity, obesity, previous joint injury, and population-level demographic transitions have contributed substantially to the growing burden of symptomatic knee OA. Advanced disease

compromises walking, stair climbing, transfers, occupational participation, and health-related quality of life and may ultimately remain symptomatic despite exercise, weight optimization, pharmacological therapy, and intra-articular interventions [1,2].

Total knee arthroplasty has consequently become a definitive reconstructive procedure for patients with severe symptomatic knee arthritis who remain substantially limited despite appropriate nonoperative management. TKA replaces damaged articular surfaces, corrects deformity, improves mechanical stability, and provides substantial pain relief in appropriately selected patients.

Nevertheless, successful arthroplasty should not be judged exclusively according to radiographic alignment or implant survival. Restoration of meaningful physical function and participation in daily activities is central to the patient's perception of surgical success [3].

Functional assessment following TKA is intrinsically multidimensional. The original Knee Society Clinical Rating System separated knee-specific parameters from walking and stair-climbing ability, thereby reducing the influence of systemic comorbidity on assessment of the reconstructed joint [4]. The WOMAC subsequently provided a validated patient-reported assessment of pain, stiffness, and physical function in hip and knee OA [5], whereas the Oxford Knee Score was developed specifically to capture patient perceptions following knee replacement [6]. The contemporary Knee Society scoring system further incorporated symptoms, function, expectations, satisfaction, and patient-relevant activities, reflecting the evolution from surgeon-centered assessment toward comprehensive patient-centered outcome measurement [7].

Interpretation of postoperative improvement also requires distinction between statistical significance and clinically meaningful recovery. Research evaluating minimal clinically important differences for Knee Society scores has demonstrated that relatively modest score changes may represent clinically perceptible benefit, whereas considerably larger improvements correspond to substantial clinical benefit [8]. Accordingly, serial assessment across multiple postoperative intervals provides greater clinical information than a single endpoint.

Despite the generally favorable results of TKA, postoperative recovery varies appreciably among patients. Baseline disability, comorbidity burden, muscular strength, psychological characteristics, expectations, early postoperative mobility, and rehabilitation may modify recovery. The present study therefore aimed to assess functional outcome after primary total knee replacement using complementary clinician- and patient-reported measures, characterize the trajectory of recovery during the first 6 postoperative months, and explore factors associated with superior functional restoration.

MATERIALS AND METHODS

Study Design and Setting

A prospective observational study was conducted among adult patients undergoing primary unilateral total knee arthroplasty for advanced symptomatic knee osteoarthritis. Eligible patients were consecutively screened and enrolled according to the predefined inclusion and exclusion criteria. Clinical and functional assessments were performed preoperatively and subsequently at 6 weeks, 3 months, and 6 months after surgery.

Study Participants

Patients aged 50 years or older with radiographically advanced primary knee osteoarthritis, persistent pain and functional limitation despite adequate conservative treatment, and a planned primary unilateral TKA were included. Participants were required to be independently ambulatory or ambulatory with a walking aid before surgery and capable of completing the study outcome assessments. Patients undergoing revision TKA, simultaneous bilateral arthroplasty, arthroplasty for acute trauma or malignant disease, or surgery for active joint infection were excluded. Patients with severe neurological disorders substantially interfering with gait, uncontrolled systemic illness precluding standardized rehabilitation, or incomplete follow-up assessments were also excluded.

A consecutive cohort of 100 patients who fulfilled the eligibility criteria and completed the scheduled postoperative assessment constituted the analytical sample.

Preoperative Assessment

Demographic information, affected side, body mass index (BMI), symptom duration, relevant comorbidities, American Society of Anesthesiologists physical-status classification, and radiographic severity were documented preoperatively. Standard weight-bearing anteroposterior, lateral, and patellofemoral radiographs were obtained as clinically indicated.

Baseline knee function was evaluated with the Knee Society Knee Score and Knee Society Function Score. Patient-reported pain, stiffness, and activity limitation were documented with the WOMAC. Pain intensity was recorded on a 10-cm VAS ranging from 0, representing no pain, to 10, representing the worst imaginable pain. Active knee flexion and fixed flexion deformity were measured using a standard universal goniometer.

Surgical Procedure and Postoperative Rehabilitation

All patients underwent primary TKA using standardized institutional principles. Surgery was performed under appropriate regional or general anesthesia with prophylactic antimicrobial therapy and venous-thromboembolism prevention according to institutional protocols. Bone preparation, soft-tissue balancing, component positioning, cementation when applicable, and patellar management were undertaken according to the operating surgeon's routine technique.

Postoperative rehabilitation was initiated early. Quadriceps activation, ankle-pump exercises, active-assisted knee mobilization, progressive flexion-extension exercises, transfers, and assisted ambulation were started according to clinical stability. Weight bearing was advanced as tolerated unless otherwise contraindicated. Following discharge, patients continued a structured physiotherapy program emphasizing progressive ROM, quadriceps strengthening, gait normalization, balance, and functional activities.

Outcome Assessment

The primary outcomes were changes in KSS-Knee and KSS-Function from the preoperative evaluation to 6 months. Secondary outcomes comprised WOMAC total score, VAS pain, knee flexion, fixed flexion deformity, temporal recovery across 6-week, 3-month, and 6-month assessments, complications, and patient-reported satisfaction.

Higher KSS values represented superior knee condition or function, whereas higher WOMAC values represented greater symptom and functional burden. A KSS-Function score of ≥ 80 at 6 months was used as a study-specific threshold indicating high postoperative functional status for exploratory predictor analysis.

Complications occurring during the follow-up period were documented. Patient satisfaction at the 6-month assessment was recorded using a direct global question regarding satisfaction with the overall surgical outcome.

Statistical Analysis

Continuous variables were summarized as mean $\pm$ standard deviation when approximately normally distributed and as median with interquartile range when appropriate. Categorical variables were expressed as frequencies and percentages. Preoperative and postoperative continuous measurements were compared using paired-

samples *t* tests or corresponding nonparametric methods when distributional assumptions were not satisfied.

Changes across repeated assessment intervals were evaluated using repeated-measures analysis with appropriate post-hoc comparisons. Categorical variables were analyzed using chi-square or Fisher's exact testing. Multivariable logistic regression was used to examine independent associations with high functional status at 6 months. Candidate variables included age, BMI, baseline KSS-Function, comorbidity burden, and knee flexion at 6 weeks. Adjusted odds ratios (aORs) were reported with 95% confidence intervals. A two-sided *p* value < 0.05 was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee of [insert institution] under approval number [insert number]. Written informed consent was obtained from all participants before enrollment. Patient information was anonymized during data analysis, and the study was conducted in accordance with applicable ethical principles for biomedical research involving human participants.

RESULTS

A total of 100 patients undergoing primary unilateral TKA completed the 6-month functional assessment. Their mean age was 65.8 ± 7.3 years, with the majority between 60 and 70 years of age. Women constituted 68% of the cohort. Mean BMI was 28.4 ± 3.7 kg/m². Advanced radiographic degeneration predominated, with 66% having Kellgren-Lawrence grade IV disease. Hypertension and diabetes mellitus were the most frequent medical comorbidities. Baseline findings therefore reflected a typical population undergoing arthroplasty for advanced degenerative knee disease.

Marked improvement occurred across all major functional domains. Mean KSS-Knee increased by 42.8 points, from 41.8 ± 11.5 before surgery to 84.6 ± 9.8 at 6 months, while KSS-Function increased by 40.6 points. WOMAC demonstrated a corresponding reduction in symptom and disability burden, falling by 38.7 points. Mean VAS pain decreased by 5.4 points. Knee flexion improved by approximately 19°, while the mean fixed flexion deficit declined substantially. All major

preoperative-to-6-month comparisons were statistically significant at $p < 0.001$. Recovery was progressive rather than instantaneous. The largest proportional gains in KSS and WOMAC occurred between surgery and the 3-month assessment, followed by additional improvement between 3 and 6 months. At 6 months, 62% attained a KSS-Function score ≥ 80 , and 88% described

themselves as satisfied with the overall result. Two patients developed superficial wound complications that resolved with treatment, one developed symptomatic venous thrombosis, and three required intensified treatment for postoperative stiffness; no deep periprosthetic infection or revision arthroplasty occurred during the study interval.

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population (N=100)

Characteristic	Value
Age, years	65.8 $\pm$ 7.3
Female sex	68 (68%)
Male sex	32 (32%)
BMI, kg/m ²	28.4 $\pm$ 3.7
Right knee	54 (54%)
Left knee	46 (46%)
Duration of symptoms, years	6.2 $\pm$ 3.1
Kellgren-Lawrence grade III	34 (34%)
Kellgren-Lawrence grade IV	66 (66%)
Hypertension	47 (47%)
Diabetes mellitus	24 (24%)
ASA grade I	14 (14%)
ASA grade II	67 (67%)
ASA grade III	19 (19%)

The cohort predominantly consisted of older adults with advanced degenerative knee disease and a moderate burden of systemic comorbidity. Approximately two-thirds were women and two-thirds demonstrated Kellgren-Lawrence grade IV osteoarthritis, indicating substantial structural disease at the time of

arthroplasty. The mean BMI was within the overweight range. Hypertension and diabetes were common, reflecting the multimorbidity frequently encountered among TKA candidates and emphasizing the relevance of assessing function independently from radiographic or implant-related outcomes.

Table 2. Comparison of Preoperative and 6-Month Clinical and Functional Outcomes

Outcome	Preoperative	6 months	Mean change	p-value
KSS-Knee	41.8 $\pm$ 11.5	84.6 $\pm$ 9.8	+42.8	<0.001
KSS-Function	38.6 $\pm$ 14.2	79.2 $\pm$ 15.1	+40.6	<0.001
WOMAC total	61.3 $\pm$ 11.9	22.6 $\pm$ 10.5	-38.7	<0.001
VAS pain	7.4 $\pm$ 1.1	2.0 $\pm$ 1.2	-5.4	<0.001
Knee flexion, degrees	92.4 $\pm$ 12.1	111.8 $\pm$ 9.6	+19.4	<0.001
Extension deficit, degrees	8.2 $\pm$ 5.4	1.9 $\pm$ 2.8	-6.3	<0.001

Total knee replacement was associated with substantial and statistically robust improvement across clinician-assessed, patient-reported, and objective functional parameters. The magnitude of improvement in both KSS components considerably exceeded thresholds generally regarded as clinically meaningful. Simultaneous reductions in

WOMAC and VAS scores demonstrated that improvement extended beyond mechanical knee function to perceived pain and disability. Increased flexion and reduced extension deficit further supported meaningful restoration of joint mobility during the first six postoperative months.

Table 3. Temporal trajectory of functional recovery following TKA

Outcome	Preoperative	6 weeks	3 months	6 months	Overall p-value
KSS-Knee	41.8	65.4	77.9	84.6	<0.001

KSS-Function	38.6	53.2	68.5	79.2	<0.001
WOMAC total	61.3	44.8	30.7	22.6	<0.001
VAS pain	7.4	4.3	2.8	2.0	<0.001
Knee flexion, degrees	92.4	98.6	106.5	111.8	<0.001

Serial assessment demonstrated a continuous recovery trajectory rather than an isolated early postoperative response. The steepest gains in knee score, pain relief, and patient-reported function occurred within the first three months, corresponding to the period of intensive rehabilitation and resolution of acute postoperative inflammation. Nevertheless,

clinically relevant gains remained evident between three and six months, particularly in functional score and flexion. These findings support continued structured rehabilitation beyond the immediate postoperative period rather than assuming recovery has plateaued after early wound healing.

Table 4. Multivariable Predictors of High Functional Status at 6 Months

Predictor	Adjusted odds ratio	95% CI	p-value
Preoperative KSS-Function, per 10-point increase	1.52	1.11-2.08	0.009
Age, per 10-year increase	0.69	0.48-0.98	0.038
BMI, per 5-kg/m ² increase	0.81	0.58-1.14	0.230
≥2 medical comorbidities	0.54	0.31-0.94	0.029
Six-week flexion, per 10° increase	1.44	1.05-1.98	0.024

Better preoperative functional capacity and greater knee flexion achieved during early rehabilitation independently increased the probability of attaining high functional status at six months. Conversely, increasing age and multimorbidity were associated with a lower likelihood of reaching the predefined functional

threshold. BMI was not independently predictive after adjustment for competing clinical variables. These results suggest that postoperative outcome reflects the interaction of baseline reserve and early recovery rather than the technical success of arthroplasty alone.

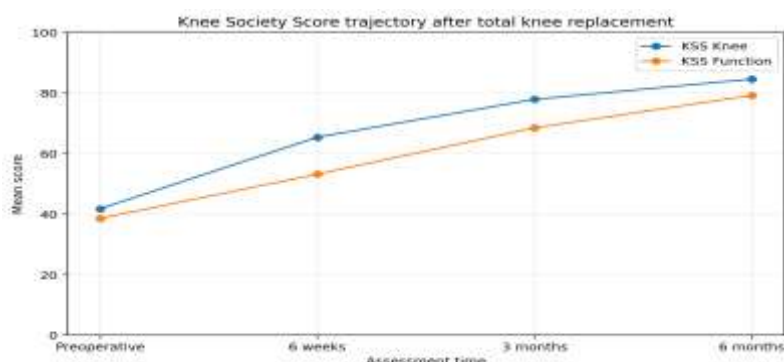


Figure 1. Temporal Improvement in Knee Society Knee and Function Scores after Total Knee Replacement

Both Knee Society domains demonstrated pronounced postoperative improvement, although the knee-specific score increased more rapidly than the functional component during early follow-up. This divergence is clinically plausible because relief of joint pain, correction of deformity, and local knee recovery may precede restoration of

endurance, stair climbing, confidence, and unrestricted community mobility. Continued gains in KSS-Function through six months emphasize that patient-level recovery extends beyond local healing and depends on progressive rehabilitation and reacquisition of functional capacity.

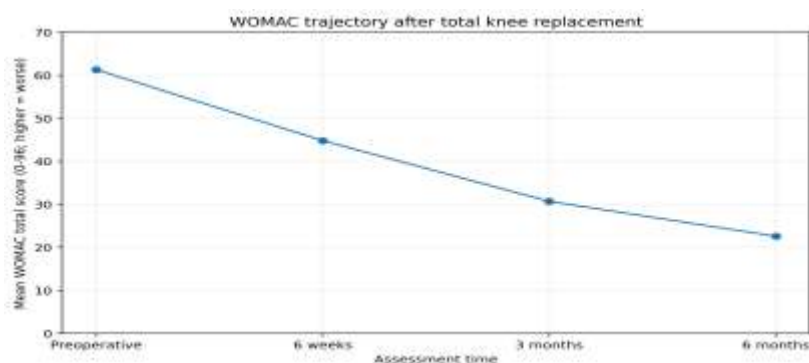


Figure 2. Reduction in Mean WOMAC Total Score During the First Six Months after Total Knee Replacement

WOMAC scores declined progressively at every postoperative assessment, indicating sustained improvement in the combined burden of pain, stiffness, and activity limitation. The greatest absolute reduction occurred during the initial three postoperative months, but improvement continued thereafter. The trajectory complements the Knee Society findings by demonstrating that objective and clinician-based recovery was accompanied by a meaningful change in the patient's own perception of symptoms and everyday function, supporting multidimensional evaluation of arthroplasty outcomes.

DISCUSSION

The present assessment demonstrated substantial improvement in knee-specific function, mobility, pain, and patient-reported disability following primary TKA. The approximate 40-point gains observed in both Knee Society domains were not merely statistically significant but were well beyond published estimates of clinically important improvement. Lizaur-Utrilla et al. reported MCID estimates of approximately 9 points for KSS-Knee and 10 points for KSS-Function using ROC analysis, with considerably larger changes corresponding to substantial clinical benefit [8]. The magnitude of recovery observed in the present cohort therefore represented a clinically important transition rather than a small numerical improvement.

The association between baseline function and subsequent postoperative capacity was consistent with Jones et al., who prospectively evaluated 276 TKA recipients and identified baseline function, walking ability, walking-aid use, and comorbidity as determinants of six-month function [9]. Lingard et al., in an international prospective cohort of 860 patients, similarly demonstrated that poor baseline scores, greater comorbidity, and

poorer mental health predicted inferior WOMAC and physical-function outcomes at one and two years [10]. Judge et al. subsequently evaluated 1,991 primary knee replacements and likewise found baseline pain/function and psychosocial characteristics to be important determinants of postoperative status [13].

The importance of early postoperative recovery was supported by Crosbie et al., who observed that functional status at eight weeks predicted six-month walking and perceived function more effectively than measurements obtained at two weeks [12]. Ferreira et al. similarly demonstrated that preoperative physical performance and early knee mobility contributed meaningfully to later function, with walking capacity, TUG performance, muscular strength, and age providing predictive information beyond questionnaires alone [18]. These observations support the present association between greater six-week flexion and higher six-month functional status. Not all predictors reported in the literature have been consistent. Crosbie et al. observed superior functional outcomes among patients with lower BMI [12], whereas Judge et al. concluded that BMI was not a clinically important independent predictor after accounting for other factors [13]. The present multivariable model was closer to the latter finding. Likewise, Winemaker et al. showed that severely stiff knees achieved large improvements after TKA and that preoperative stiffness did not necessarily prevent substantial improvement, although final ROM remained influenced by baseline limitation [15]. Thus, restricted mobility should be interpreted as a modifiable functional challenge rather than an absolute predictor of poor arthroplasty benefit.

Psychological and expectation-related factors are increasingly recognized as equally

relevant. Wyld et al. demonstrated that preoperative self-efficacy independently predicted one-year functional ability [14]. Bourne et al., among 1,703 primary TKAs, reported that unmet expectations were among the strongest predictors of dissatisfaction [11]. Kiran et al. showed that postoperative Oxford Knee Score thresholds associated with satisfaction varied according to baseline severity and patient characteristics [16], while Kahlenberg et al. concluded in a systematic review that postoperative function and pain relief were major determinants of satisfaction [17].

More recent evidence reinforces this patient-centered interpretation. Singh et al. reported satisfaction in approximately 90% of a contemporary cohort, with satisfied patients demonstrating greater improvement in patient-reported functional outcomes [19]. Selph et al. found 87.5% satisfaction and demonstrated that patients frequently expected improvements greater than those actually achieved; larger expectation-outcome discrepancies were associated with dissatisfaction [20]. The 88% satisfaction rate in the present cohort therefore corresponds closely with contemporary experience and highlights the importance of realistic preoperative counseling.

Several limitations should be acknowledged. A single-center design would limit external generalizability, six months would not capture late functional change or implant survival, and patient-reported instruments remain influenced by pain perception, psychosocial state, and comorbidity. Objective tests of walking endurance and quadriceps strength could provide additional information. Future multicenter studies should incorporate longer follow-up, performance-based testing, contemporary PROMs, expectation assessment, and clinically meaningful response thresholds to develop individualized recovery prediction models.

CONCLUSION

Total knee replacement produced substantial improvement in pain, knee-specific clinical status, range of motion, and patient-reported physical function, with the most rapid recovery occurring during the first three postoperative months and further gains continuing to six months. Better preoperative functional capacity and greater early postoperative flexion were associated with superior later function, whereas advanced age and

multimorbidity moderated recovery. These findings emphasize that successful TKA should be evaluated using multidimensional functional outcomes rather than implant-related measures alone. Structured serial assessment can identify patients with delayed recovery, support individualized rehabilitation, improve expectation management, and provide a more patient-centered definition of surgical success.

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