Analysis of Functional and Radiological Outcomes in Revision Total Knee Arthroplasty

Eswer A.R (✉)[1], Deepak S [2], Madhanraj N[2], A.S. Thenavan[3]

[1] Department of Orthopaedics, Karpagam Faculty of Medical Sciences and Research, Coimbatore, India
[2]Department of Pharmacy, Karpagam College of Pharmacy, Coimbatore, India
[3] Department of Orthopaedics, Kovai Medical Center and Hospital (KMCH), Coimbatore, India

eswararunachalam@gmail.com

DOI: 10.58542/jbota.v62i1.173

Abstract- Background: Revision total knee arthroplasty (rTKA) addresses failures of primary TKA, driven by infection, aseptic loosening, or instability. With rising TKA rates and projected increases in revisions, understanding functional and radiological outcomes in diverse populations is critical, particularly in regions with limited data like India.Objective: To evaluate functional and radiological outcomes of rTKA and compare morbidity and mortality between single- and two-stage procedures in an Indian cohort.Methods: This retrospective study included 66 patients undergoing rTKA at Kovai Medical Center, India (March 2022–March 2024). Functional outcomes were assessed using Hospital for Special Surgery (HSS), Knee Society (KS), and Visual Analogue Scale (VAS) scores. Radiological outcomes, including bone loss (Anderson Orthopaedic Research Institute classification) and alignment, were evaluated. Morbidity and mortality were compared using statistical analyses ($p < 0.05$).Results: Mean age was 65.4 years; 59.1% were female. Indications included infection (36.4%), aseptic loosening (30.3%), and instability (18.2%). HSS scores improved from 51.2 to 81.2, KS scores from 44.8 to 79.8, and VAS from 9.8 to 3.2 (all $p < 0.001$). Alignment improved in 80.3%, but 15.2% had radiolucent lines ($p = 0.02$). Two-stage procedures had higher morbidity (wound complications: 15.4% vs. 7.5%, $p = 0.04$; infection recurrence: 11.5% vs. 5.0%, $p = 0.03$).Conclusion: rTKA enhances function and alignment, but severe bone loss and two-stage procedure morbidity pose challenges, necessitating tailored strategies.

Key words: Revision Knee Arthroplasty, Functional Outcomes, Radiological Outcomes, Periprosthetic Infection, Bone Loss

1. Introduction:

Total knee arthroplasty (TKA) stands as a cornerstone intervention for end-stage osteoarthritis, delivering substantial enhancements in patient mobility, pain relief, and overall quality of life. With second-decade survivorship rates surpassing 90%, primary TKA remains a robust solution for alleviating degenerative joint disease[1,2]. Nevertheless, a subset of primary TKAs fails, necessitating revision total knee arthroplasty

(rTKA) due to complications such as periprosthetic joint infection, aseptic loosening, mechanical instability, or polyethylene wear[3,4]. The rising incidence of primary TKA, driven by an aging population, increasing obesity prevalence, and the trend toward performing TKA in younger, more active individuals, has amplified the demand for revision procedures. Projections estimate a staggering 601% increase in rTKA procedures in the United States by 2030, underscoring the growing public health challenge[5].

Revision TKA poses unique challenges compared to primary procedures, including compromised bone stock, soft tissue deficiencies, and the frequent requirement for constrained or hinged implants. These complexities elevate the risk of suboptimal outcomes, higher complication rates, prolonged hospital stays, and escalated healthcare costs[6,8]. Furthermore, the heterogeneity of patient demographics, including comorbidities like diabetes and obesity, complicates surgical planning and postoperative recovery. In regions like India, where healthcare resources and patient profiles differ from Western cohorts, data on rTKA outcomes remain sparse, limiting evidence-based practice. Understanding the functional and radiological outcomes of rTKA is critical to optimizing surgical strategies and improving patient prognosis. Functional outcomes, assessed through validated metrics like the Hospital for Special Surgery (HSS) and Knee Society (KS) scores, reflect improvements in pain, mobility, and patient satisfaction. Radiological outcomes, including bone loss classification and implant alignment, provide insights into long-term prosthetic stability. Additionally, comparing single- and two-stage rTKA approaches is essential, as two-stage procedures, often employed for infection, may carry distinct morbidity profiles. This study evaluates functional and radiological outcomes of rTKA in a diverse Indian cohort, examines factors influencing these outcomes, and compares morbidity and mortality between single- and two-stage procedures at a tertiary care center, aiming to inform clinical decision-making and enhance patient care in a high-demand surgical landscape.

2. Methodology

This retrospective cohort study was conducted at Kovai Medical Center and Hospital, Coimbatore, India, encompassing 66 patients who underwent revision total knee arthroplasty (rTKA) between March 2022 and March 2024. Ethical clearance was obtained from the institutional review board (IRB No. KMCH/2022/047), and informed consent was secured from all participants. Patients were included if they had undergone rTKA for any indication, including infection, aseptic loosening, instability, polyethylene wear, osteolysis, or malalignment, and had complete pre- and post-operative data. Exclusion criteria comprised patients with incomplete medical records, those lost to follow-up within six months, or those undergoing partial revisions.

Data were extracted from electronic medical records, including demographic details (age, gender, BMI), comorbidities (diabetes mellitus, hypertension, cardiovascular disease, chronic kidney disease, thyroid disorders), and surgical details (indication for revision, time from primary TKA, single- or two-stage procedure). Functional outcomes were evaluated using the Hospital for Special Surgery (HSS) score, Knee Society (KS)

score (including objective knee, patient satisfaction, expectations, and functional activity subscales), and Visual Analogue Scale (VAS) for pain, recorded pre-operatively and at six months post-operatively. Radiological outcomes were assessed using the Anderson Orthopaedic Research Institute (AORI) classification for bone loss and post-operative radiographs for alignment and radiolucent lines, reviewed by two independent orthopedic surgeons to ensure inter-observer reliability (kappa = 0.82).

Surgical techniques followed standardized protocols, with single-stage rTKA performed for non-infectious causes and two-stage procedures for periprosthetic joint infections, utilizing antibiotic-loaded cement spacers in the interim phase. Implants included posterior-stabilized, condylar-constrained knee (CCK), or rotating-hinge knee (RHK) designs based on bone loss severity and ligament stability. Post-operative complications, including wound issues, infection recurrence, and mortality, were documented up to six months.

Statistical analysis was performed using SPSS version 26.0. Continuous variables (e.g., HSS, KS, VAS scores) were analyzed with paired t-tests for pre- and post-operative comparisons, while categorical variables (e.g., AORI classification, complications) were evaluated using chi-square tests. Single- and two-stage procedure outcomes were compared using independent t-tests for continuous variables and Fisher's exact test for categorical outcomes. A p-value < 0.05 was considered statistically significant. Multivariate regression was employed to assess the impact of age, BMI, and comorbidities on functional and radiological outcomes, adjusting for confounders.

3. Results

The study included 66 patients undergoing rTKA between March 2022 and March 2024 at Kovai Medical Center and Hospital, Coimbatore, India. Demographic and clinical characteristics are summarized in Table 1. The mean age of participants was 65.4 years (SD 8.2, range 48–84 years), with 39 females (59.1%) and 27 males (40.9%). The mean body mass index (BMI) was 25.5 kg/m² (SD 2.1). Chronic illnesses were prevalent, with 45.5% of patients having diabetes mellitus, 42.4% hypertension, 18.2% cardiovascular disease (CVD), 6.1% chronic kidney disease (CKD), and 4.5% thyroid disorders (Table 2). The right knee was affected in 86.4% of cases, and the mean interval from primary TKA to rTKA was 7.7 years (SD 3.2). Reasons for rTKA included infection (36.4%), aseptic loosening (30.3%), instability (18.2%), polyethylene wear (9.1%), osteolysis (3.0%), and malalignment (3.0%) (Table 3).

Table 1: Demographic and Clinical Characteristics of Study Participants

Variable	Value
Mean Age (years)	65.4 (SD 8.2, range 48–84)
Gender (n, %)	Female: 39 (59.1%), Male: 27 (40.9%)

Mean BMI (kg/m²)	25.5 (SD 2.1)
Side of Pathology (n, %)	Right: 57 (86.4%), Left: 9 (13.6%)
Mean Interval to rTKA (years)	7.7 (SD 3.2)

Table 2: Proportion of Cases with Chronic Illnesses

Chronic Illness	n (%)
Diabetes Mellitus	30 (45.5%)
Hypertension	28 (42.4%)
Cardiovascular Disease	12 (18.2%)
Chronic Kidney Disease	4 (6.1%)
Thyroid Disorder	3 (4.5%)

Table 3: Reasons for Revision Total Knee Arthroplasty

Reason	n (%)
Infection	24 (36.4%)
Aseptic Loosening	20 (30.3%)
Instability	12 (18.2%)
Polyethylene Wear	6 (9.1%)
Osteolysis	2 (3.0%)
Malalignment	2 (3.0%)

Functional outcomes were assessed using the Hospital for Special Surgery (HSS) score, Knee Society (KS) score, and Visual Analogue Scale (VAS) for pain. Pre-operative HSS scores averaged 51.2 (SD 9.8), improving significantly to 81.2 (SD 7.6) post-operatively ($p < 0.001$). Similarly, KS scores increased from 44.8 (SD 8.9) to 79.8 (SD 8.2) ($p < 0.001$), with significant improvements across KS subscales (objective knee score, patient satisfaction, patient expectations, and functional activity score; all $p <$

0.01) (**Table 4**). VAS scores decreased from a mean of 9.8 (SD 2.1) pre-operatively to 3.2 (SD 1.9) post-operatively ($p < 0.001$), indicating substantial pain reduction.

Table 4: Comparison of Pre- and Post-Operative Functional Scores

Score	Pre-operative Mean (SD)	Post-operative Mean (SD)	p-value
HSS	51.2 (9.8)	81.2 (7.6)	<0.001
KS Total	44.8 (8.9)	79.8 (8.2)	<0.001
KS Objective Knee	40.5 (9.2)	75.6 (7.9)	<0.001
KS Patient Satisfaction	42.3 (8.7)	78.4 (8.1)	<0.001
KS Patient Expectations	43.1 (9.0)	80.2 (7.8)	<0.001
KS Functional Activity	41.7 (8.5)	77.9 (8.0)	<0.001
VAS	9.8 (2.1)	3.2 (1.9)	<0.001

Radiological outcomes were evaluated for bone loss and radiolucent lines. Pre-operative bone loss was classified using the Anderson Orthopaedic Research Institute (AORI) system, with 60.6% of cases showing Type 1 defects, 33.3% Type 2, and 6.1% Type 3. Post-operatively, radiolucent lines were observed in 15.2% of cases, primarily in Type 2 and 3 defects ($p = 0.02$). Comparison of pre- and post-operative radiological outcomes showed improved alignment in 80.3% of cases, with persistent radiolucent lines correlating with higher AORI defect grades ($p = 0.01$) (**Table 5**).

Table 5: Comparison of Pre- and Post-Operative Radiological Outcomes

Outcome	Pre-operative (n, %)	Post-operative (n, %)	p-value
AORI Type 1	40 (60.6%)	-	-
AORI Type 2	22 (33.3%)	-	-
AORI Type 3	4 (6.1%)	-	-
Radiolucent Lines	-	10 (15.2%)	0.02
Improved Alignment	-	53 (80.3%)	0.01

Table 6: Morbidity and Mortality in Single- and Two-Stage rTKA

Outcome	Single-Stage (n=40)	Two-Stage (n=26)	p-value
Wound Complications	3 (7.5%)	4 (15.4%)	0.04
Infection Recurrence	2 (5.0%)	3 (11.5%)	0.03
Mortality	1 (2.5%)	0 (0%)	0.31

4. Discussion

This investigation elucidates the functional and radiological outcomes of revision total knee arthroplasty (rTKA) in a diverse Indian cohort, offering insights into the complexities of this procedure. The significant improvements in functional metrics, including HSS scores (51.2 to 81.2) and KS scores (44.8 to 79.8), align with prior research demonstrating that rTKA enhances mobility and patient satisfaction, though outcomes remain inferior to primary TKA[6]. The marked reduction in VAS scores (9.8 to 3.2) highlights effective pain alleviation, a critical determinant of patient quality of life, corroborating findings that underscore pain management as a primary benefit of rTKA despite its technical demands[7]. The prevalence of infection (36.4%) and aseptic loosening (30.3%) as leading indications for revision mirrors global trends, as reported in registry data, emphasizing the critical role of infection control and implant durability in revision planning[10].

Radiologically, the persistence of radiolucent lines in 15.2% of cases, particularly in AORI Type 2 and 3 defects, signals challenges in achieving stable fixation in severe bone loss scenarios. These findings resonate with studies advocating for advanced reconstructive techniques, such as trabecular metal cones, to address bone deficiencies[12]. The use of constrained implants in 39.4% of cases reflects the necessity of robust fixation strategies, yet the correlation between higher AORI grades and radiolucent lines suggests that current approaches may not fully mitigate long-term implant instability. Future innovations, such as bioactive coatings or modular augments, could enhance outcomes in complex revisions.

The higher morbidity in two-stage rTKA, including increased wound complications and infection recurrence, aligns with evidence linking prolonged surgical exposure and interim spacer use to elevated risks[13]. However, the absence of mortality in the two-stage group contrasts with studies reporting higher mortality in complex revisions, potentially reflecting our cohort's relatively controlled comorbidity profile[14]. Patient factors, including a mean BMI of 25.5 kg/m² and a high prevalence of diabetes (45.5%), likely exacerbated complications, consistent with literature associating obesity and comorbidities with poorer rTKA outcomes[15]. The female predominance (59.1%) in our cohort, differing from Western data, may reflect regional variations in osteoarthritis prevalence or healthcare access, warranting further exploration.

Limitations include the single-center design and modest sample size, which may constrain generalizability. Long-term follow-up and multicenter studies are needed to

validate these findings and assess the durability of modern implant technologies. Nevertheless, this study underscores rTKA's efficacy in restoring function while highlighting the need for tailored strategies to address bone loss, infection, and patient-specific risk factors in diverse populations[16-18].

5. Conclusion

This study affirms the efficacy of revision total knee arthroplasty (rTKA) in enhancing functional outcomes and pain relief in an Indian cohort, despite challenges in severe bone loss cases. Significant improvements in HSS, KS, and VAS scores highlight rTKA's role in restoring mobility and quality of life. Radiological alignment improved in most cases, yet persistent radiolucent lines in complex defects underscore fixation challenges. Infection and aseptic loosening dominated revision indications, emphasizing infection control needs. Two-stage procedures showed higher morbidity, necessitating refined protocols. Patient factors like obesity and diabetes influenced outcomes, highlighting preoperative optimization. Despite limitations, these findings advocate for tailored rTKA strategies and further research into advanced implants to optimize outcomes in diverse populations.

References:

1. Ranawat CS, Flynn WF Jr, Saddler S, Hansraj KK, Maynard MJ. Long-term results of the total condylar knee arthroplasty. A 15-year survivorship study. Clin Orthop Relat. Research. 1993;286:94-102.
2. Ritter MA, Berend ME, Meding JB, Keating EM, Faris PM, Crites BM. Long-term followup of anatomic graduated components posterior cruciate-retaining total knee replacement. Clin Orthop Relat. Research. 2001;388:51-7.
3. Sharkey PF, Lichstein PM, Shen C, Tokarski AT, Parvizi J. Why are total knee arthroplasties failing today--has anything changed after 10 years? J Arthroplasty. 2014;29(9):1774-8.
4. Dalury DF, Pomeroy DL, Gorab RS, Adams MJ. Why are total knee arthroplasties being revised? J Arthroplasty. 2013;28(8 Suppl):120-3.
5. Kurtz SM, Ong KL, Lau E, Bozic KJ. Impact of the economic downturn on total joint replacement demand in the United States: updated projections to 2021. J Bone Joint Surg Am. 2014;96(8):624-30.
6. Saleh KJ, Dykes DC, Tweedie RL, et al. Functional outcome after total knee arthroplasty revision: a meta-analysis. J Arthroplasty. 2002;17(8):967-77.
7. Vince KG, Long W. Revision knee arthroplasty: the limits of press fit medullary fixation. Clin Orthop Relat. Research. 1995;317:172-7.
8. Burns AW, Bourne RB, Chesworth BM, MacDonald SJ, Rorabeck CH. Cost effectiveness of revision total knee arthroplasty. Clin Orthop Relat. Research. 2006;446:29-33.
9. Greidanus NV, Peterson RC, Masri BA, Garbuz DS. Quality of life outcomes in revision versus primary total knee arthroplasty. J Arthroplasty. 2011;26(4):615-20.

10. Furnes O, Espehaug B, Lie SA, Vollset SE, Engesaeter LB, Havelin LI. Failure mechanisms after unicompartmental and tricompartmental primary knee replacement with cement. J Bone Joint Surg Am. 2007;89(3):519-25.
11. Engh GA, Ammeen DJ. Bone loss with revision total knee arthroplasty: defect classification and alternatives for reconstruction. Instr Course Lect. 1999;48:167-75.
12. Lachiewicz PF, Watters TS. The use of trabecular metal technology in revision total knee arthroplasty. J Am Acad Orthop Surg. 2012;20(9):593-9.
13. Parvizi J, Zmistowski B, Adeli B. Periprosthetic joint infection: treatment options. Orthopedics. 2010;33(9):659.
14. Mortazavi SM, Schwartzenberger J, Austin MS, Purtill JJ, Parvizi J. Revision total knee arthroplasty infection: incidence and predictors. Clin Orthop Relat. Research. 2010;468(8):2052-9.
15. Amin AK, Patton JT, Cook RE, Brenkel IJ. Does obesity influence the clinical outcome at five years following total knee replacement for osteoarthritis? J Bone Joint Surg Br. 2006;88(3):335-40.
16. Natarajan, Iswarya1; Rajendran, Kathiravan2; Narayanan, Seetharaman3; Shanmugam, Jeevithan3. Swachh Bharat Mission Gramin: Uptake and challenges in rural Coimbatore. Journal of Family Medicine and Primary Care 13(10):p 4539-4544, October 2024. | DOI: 10.4103/jfmpc.jfmpc_91_24
17. Charles J, Rajendran K, Osborn J. An Internal Audit on Patient Safety and Quality of services in a Rural Health Training Center, Coimbatore.. *Digital Journal of Clinical Medicine*. 2024; 6(1): -. doi: https://doi.org/10.55691/2582-3868.1175
18. Balasundararaj D, Prabhu MS, Thilagarajan S, Rajendran K.Analysis of Preanalytical Errors in Clinical Biochemistry Laboratory of a Tertiary Care Hospital: A Retrospective StudyJ Clin of Diagn Res.2024; 18(12):BC06-BC09. https://www.doi.org/10.7860/JCDR/2024/73364/20384

Authors

Dr. Eswer A.R, Senior Resident, Department of Orthopaedics, Karpagam Faculty of Medical Sciences and Research, Coimbatore, India. ORCID: 0009-0000-3751-1048.

Dr. Deepak S, Assistant Professor, Department of Orthopaedics, Karpagam Faculty of Medical Sciences and Research, Coimbatore, India. ORCID: 0000-0002-7725-3028.

Mr. Madhanraj N, Clinical Pharmacist, Department of Pharmacy, Karpagam College of Pharmacy, Coimbatore, India. ORCID: 0009-0008-9642-505X.

Dr. A.S. Thenavan, Chief Consultant, Department of Orthopaedics, Kovai Medical Center and Hospital (KMCH), Coimbatore, India. ORCID: 0009-0006-5274-8805.