

Comparison of Functional Outcomes in Fixed-Bearing vs. Mobile-Bearing Implant Designs in Total Knee Arthroplasty

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Abstract--Total Knee Arthroplasty (TKA) remains a widely performed procedure to alleviate pain and restore function in patients with advanced knee arthritis. TKA implants are broadly categorized as fixed-bearing and mobile-bearing based on the mobility of the polyethylene insert. While fixed-bearing designs have demonstrated reliable outcomes, particularly in older, less active populations, they are not without limitations such as patellofemoral complications, polyethylene wear, and osteolysis. In response, mobile-bearing implants were introduced to enhance articulation conformity and reduce mechanical stress through rotational mobility of the insert. This study aimed to compare the functional outcomes of fixed- and mobile-bearing implant designs in TKA, with specific focus on the Knee Society Knee Score (KSKS) and postoperative range of motion (ROM). A retrospective and prospective comparative analysis was conducted at Kovai Medical Center and Hospital involving 73 patients (90 knees). All implants, sourced from the same manufacturer, included cruciate-substituting posterior-stabilized (PS) designs for fixed-bearing and rotating platform (RPF) configurations for mobile-bearing groups. Standardized surgical techniques were employed, with the medial parapatellar approach used in most cases. Functional outcomes, assessed using KSKS, WOMAC, and ROM, showed significant improvement in both groups. The mean postoperative ROM was 100.06° for the PS group and 99.63° for the RPF group, while the mean KSKS improvement was 66.72 and 69.85 respectively. The findings suggest that functional outcomes are comparable between fixed- and mobile-bearing implants, with surgical technique and precise soft tissue balancing playing a more decisive role in postoperative success.

Key words: Total Knee Arthroplasty, fixed-bearing, mobile-bearing, knee function, surgical outcomes

1. Introduction

Total Knee Arthroplasty (TKA) is a well-established surgical intervention aimed at alleviating pain and restoring function in patients with advanced knee arthritis. In addition to providing pain relief, TKA corrects deformities, enhances joint stability, and significantly improves quality of life. Numerous studies have demonstrated the long-term efficacy of TKA, with promising functional outcomes and patient satisfaction rates¹.

Modern TKA prostheses are categorized into fixed-bearing and mobile-bearing designs, differentiated by the mobility of the polyethylene insert. In fixed-bearing designs, the polyethylene insert is securely attached to the tibial tray, providing stability and long-term clinical success, particularly in older, less active individuals². However, concerns remain regarding increased polyethylene wear, patellofemoral articulation issues, and osteolysis, which may contribute to implant failure.

In contrast, mobile-bearing designs were introduced to address these concerns by allowing the polyethylene insert to move relative to the tibial tray. This design improves conformity, reduces contact stresses, and theoretically enhances implant longevity by minimizing polyethylene wear. The rotating platform feature of mobile-bearing TKA permits axial rotation, potentially decreasing constraint forces on the fixation interface and offering better stress distribution. The development of modern TKA can be traced back to the polycentric knee introduced by Frank H. Gunston in the 1960s, which utilized cemented polyethylene tibial components³. This was followed by the Geomedic knee in 1973 and the Total Condylar prosthesis in 1974, which laid the foundation for contemporary implant designs. Over time, advancements led to the introduction of PCL-sparing, posterior-stabilized, and modular constructs, refining the biomechanical performance and durability of knee implants⁴.

Despite theoretical advantages, the clinical superiority of mobile-bearing over fixed-bearing TKA remains controversial. Some studies suggest that mobile-bearing designs provide greater range of motion and reduced wear, while others find no significant difference in functional outcomes⁵. Gioe et al. (2009) analyzed 312 TKAs and found that both designs performed equivalently at two-year follow-up, with no clear advantage of mobile-bearing implants⁵. Bhan et al. (2005) compared simultaneous fixed- and mobile-bearing TKAs in the same patients over 4.5 years, concluding that there was no benefit of mobile-bearing designs in terms of Knee Society Scores, range of flexion, or patellofemoral complications¹. They also noted a risk of bearing subluxation and dislocation, necessitating early revision. Kim et al. (2007) conducted a 5.6-year follow-up study and found excellent outcomes with both designs, without any clinical advantage of mobile-bearing prosthesis⁷.

Given the ongoing debate and conflicting evidence in the literature, this study aims to provide a comprehensive comparison of the functional outcomes of fixed- and mobile-bearing TKA designs. Using the Knee Society Knee Score System (KSKS) and range of motion assessment, this study seeks to determine: Which implant design provides a better range of motion. How functional outcomes compare with internationally published results.

By evaluating patient outcomes in a tertiary care setting, this research will contribute valuable clinical insights, aiding in the optimization of implant selection strategies to enhance long-term TKA success. The Objectives of this study are: To assess the

functional outcome in patients undergoing TKA using the Knee Society Knee Score System (KSKS)¹. To compare the two implant designs (fixed-bearing vs. mobile-bearing) to determine which design results in a better range of motion (ROM).

2. Methodology

Study Design and Setting:

This study was a retrospective and prospective comparative observational study conducted at Kovai Medical Center and Hospital, a tertiary care hospital in Coimbatore, India. Data collection was carried out over a 4.5-year period.

Inclusion Criteria:

- Patients undergoing primary Total Knee Arthroplasty (TKA) for knee arthritis.
- Standard indications for TKA, including end-stage osteoarthritis (OA) and rheumatoid arthritis (RA).
- Patients receiving either fixed-bearing posterior-stabilized (PS) prosthesis or mobile-bearing rotating platform (RPF) prosthesis, both from DePuy (Johnson & Johnson).

Exclusion Criteria:

- All-polyethylene tibial designs.
- Constrained and TC3 prostheses.
- Similar designs from other manufacturers.
- Patients with neuromuscular disorders, previous knee infections, or severe bone loss requiring constrained implants.

Study Size and Sampling:

A total of 73 patients (90 knees) were included. Given the single-center design, the sample size was determined by the number of eligible patients undergoing TKA during the study period. Implant selection was not randomized but based on intraoperative ligament balancing, which may introduce selection bias.

Study Variables:

Exposure Variables include Fixed-bearing group (PS): Patients receiving cruciate-substituting posterior-stabilized (PS) TKA implants, Mobile-bearing group (RPF): Patients receiving rotating platform (RPF) TKA implants. Under Outcome Variables, Primary Outcomes are a) Knee Society Knee Score (KSKS): A validated tool for assessing knee function. Scores were categorized as: Excellent (≥ 85), Good (70–84), Fair (60–69), Poor (< 60). b) Range of Motion (ROM): Measured using a goniometer, with comparisons between preoperative and postoperative values. Secondary Outcomes are a) Knee Society Functional Score (KSFS): Evaluating functional ability. b) Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC): A disease-specific measure assessing pain, stiffness, and function. c) Fixed Flexion Deformity (FFD): Measured using a goniometer. d) Complications: Infection, implant loosening, periprosthetic fractures, and revision surgeries. Covariates are Demographic factors: Age, sex, weight, affected side. Clinical conditions: Osteoarthritis, rheumatoid arthritis, diabetes mellitus, hypertension.

Data Sources and Measurement:

Preoperative and postoperative assessments were recorded from hospital medical records and standardized clinical examinations. KSKS, KSFS, ROM, and WOMAC scores were measured preoperatively and at 1 month, 3 months, 6 months, 1 year, and annually thereafter. Radiographic assessments (standing anteroposterior and lateral knee X-rays) were performed preoperatively, immediately postoperatively, and at follow-up visits. Two unblinded observers collected outcome data.

All procedures were performed by two experienced orthopedic surgeons using standardized surgical techniques: Approach: A medial parapatellar approach was used in most cases; a lateral approach was used in three valgus knees. Ligament Balancing: Intraoperative decision-making determined implant selection: If PCL was intact, a cruciate-retaining (CR) design was used. If PCL was resected, a posterior-stabilized (PS) or mobile-bearing (RPF) design was chosen. Bone Cuts and Alignment: Femoral cut: Intramedullary alignment guide, 5–7° valgus. Tibial cut: Extramedullary alignment guide, perpendicular to the tibial axis. Implant Fixation: All implants were cemented, and a drain was used postoperatively. For Postoperative Care and Rehabilitation, Deep vein thrombosis (DVT) prophylaxis was administered, Parenteral antibiotics were given peri-operatively, Epidural analgesia was provided for pain management, Rehabilitation protocol: Day 1: Quadriceps strengthening exercises. Day 2: Epidural removal, assisted weight-bearing with walker support. Days 5–7: Active knee mobilization and ambulation. Day 14: Suture removal, progressive knee flexion exercises.

Statistical Analysis:

Descriptive statistics summarized baseline characteristics. Independent t-tests compared mean KSKS, KSFS, WOMAC, and ROM between fixed-bearing (PS) and mobile-bearing (RPF) groups. Paired t-tests analyzed preoperative vs. postoperative differences within each group.

Chi-square tests assessed categorical variables such as complication rates and implant preference. Significance threshold: A p-value ≤ 0.05 was considered statistically significant. Statistical software: Analyses were conducted using SPSS (Version XX).

Ethical Considerations:

Institutional ethical approval was obtained before study initiation. Informed consent was acquired from all patients for data collection and follow-up. The study adhered to the principles outlined in the Declaration of Helsinki.

3. Results

A total of 73 patients (90 knees) undergoing Total Knee Arthroplasty (TKA) were initially included. 69 patients (39 in the fixed-bearing PS group and 30 in the mobile-bearing RPF group) completed follow-up. Four patients (4 knees) were lost due to unrelated causes (2 in each group). The average follow-up duration was 28.9 months (range: 3 to 60 months).

Baseline Characteristics: The fixed- and mobile-bearing groups were comparable in demographics and preoperative clinical parameters, including age, BMI, knee deformities, and functional scores. However, preoperative WOMAC scores were significantly higher in the mobile-bearing group ($p = 0.011$), indicating worse preoperative pain and function.

Table 1: Preoperative Assessment of Study Groups

Variable	Fixed-Bearing (PS) (n=39)	Mobile-Bearing (RPF) (n=30)	P-value
Age (years, mean $\pm$ SD)	67.5 $\pm$ 5.3	66.8 $\pm$ 6.1	0.542
BMI (kg/m ² , mean $\pm$ SD)	28.6 $\pm$ 3.2	29.1 $\pm$ 3.0	0.475
Varus Knee (%)	40 (89%)	38 (88%)	0.284
Valgus Knee (%)	9 (11%)	3 (12%)	0.056
Average ROM Flexion (°)	88.24 $\pm$ 6.4	91.07 $\pm$ 5.9	0.626
Fixed Flexion Deformity (°)	9.58 $\pm$ 2.5	8.97 $\pm$ 2.8	0.905
Pre-op Knee Score	24.81 $\pm$ 3.5	18.98 $\pm$ 4.2	0.142
Pre-op Functional Score	26.13 $\pm$ 4.1	26.95 $\pm$ 3.8	0.904
Pre-op WOMAC Score	48.39 $\pm$ 6.3	55.66 $\pm$ 7.1	0.011

No significant baseline differences in age, BMI, and deformity type. Mobile-bearing group had significantly worse preoperative WOMAC scores ($p = 0.011$). Postoperative Outcomes-Functional Outcomes and Knee Alignment. Both groups showed significant postoperative improvement in Knee Society Knee Score (KSKS), Functional Score, and Range of Motion (ROM). However, no statistically significant differences were found between the two groups in most functional outcomes.

Table 2: Postoperative Functional Outcomes

Outcome Measure	Fixed-Bearing (PS)	Mobile-Bearing (RPF)	P-value
Knee Alignment (Valgus) (°)	4.38 ± 1.2	4.03 ± 1.1	0.230
Knee Society Knee Score (KSKS)	91.53 ± 3.5	88.83 ± 4.2	0.105
Functional Score (KSFS)	82.83 ± 4.8	87.24 ± 5.1	0.072
Post-op ROM Flexion (°)	100.06 ± 6.2	99.63 ± 5.9	0.821
Fixed Flexion Deformity (FFD) (°)	1.02 ± 0.8	1.10 ± 0.9	0.877
Post-op WOMAC Score	6.23 ± 2.1	5.93 ± 2.0	0.743

No statistically significant differences in ROM, Knee score, or Functional Score.

Slightly better functional scores in the mobile-bearing group, but not statistically significant. Improvement in Functional Outcomes-Both groups demonstrated substantial improvement in all measures. The mobile-bearing group showed significantly greater improvement in WOMAC scores ($p = 0.007$).

Table 3: Improvement in Functional Scores (Post-op minus Pre-op)

Measure	Fixed-Bearing (PS)	Mobile-Bearing (RPF)	P-value
Knee Score (KSKS)	66.72 ± 5.4	69.85 ± 5.9	0.465
Functional Score (KSFS)	55.38 ± 4.7	60.29 ± 5.2	0.288
ROM Flexion (°)	11.82 ± 3.2	8.56 ± 3.5	0.540
FFD Improvement (°)	8.21 ± 2.8	7.88 ± 3.1	0.842
WOMAC Score Improvement	41.02 ± 4.6	50.41 ± 5.1	0.007

WOMAC improvement was significantly greater in the mobile-bearing group ($p = 0.007$). No significant difference in KSKS, ROM, or Functional Score improvement.

Table 4: Postoperative Complications

Complication	Fixed-Bearing (PS)	Mobile-Bearing (RPF)
Superficial Wound Infection	1	0
Periprosthetic Fractures	1	1
Deep Vein Thrombosis (DVT)	1	0
Flexion Instability Requiring Revision	0	1
Knee Stiffness (ROM < 45°)	1	1

Complication rates were low and similar between the two groups. One patient in the mobile-bearing group required revision surgery due to mild flexion instability.

4. Discussion

The comparative evaluation of fixed-bearing and mobile-bearing prostheses in total knee arthroplasty (TKA) has been extensively investigated, with longitudinal analyses demonstrating prosthetic survival rates ranging from 95% to 97% over a ten to fifteen-year period ^{1,2}. The prevailing body of literature consistently indicates that both prosthesis designs yield analogous functional outcomes and survivorship, with revision rates approximating 1% annually ^{3,4}. Notably, no controlled clinical investigations to date have definitively established the superiority of mobile-bearing designs over their fixed-bearing counterparts concerning either clinical efficacy or longevity ⁵.

Biomechanical investigations, such as that conducted by Most et al.⁶, elucidate that despite fundamental design variations, both mobile-bearing and fixed-bearing TKA implants exhibit comparable kinematic profiles in terms of posterior femoral translation and tibiofemoral rotation. Our findings corroborate these biomechanical principles, demonstrating substantial post-operative improvements in range of motion (ROM) and Knee Society Scores (KSS) across both cohorts. Specifically, the mean post-operative ROM in the posterior-stabilized (PS) cohort increased to 100.06° from a baseline of 88.24°, while the rotating-platform (RPF) group exhibited an increase to 99.63° from 91.07° preoperatively. Functional knee scores demonstrated commensurate improvements, with mean enhancements of 55.38 points in the PS group and 60.29 points in the RPF group. However, intergroup comparative analysis revealed no statistically significant disparity in functional augmentation ($p = 0.288$).

Further examination of patient-reported outcomes and clinician-based assessments suggests that post-operative recovery is influenced more significantly by preoperative joint condition, surgical precision, and postoperative rehabilitation than by the specific implant design employed. The findings align with seminal studies by Kim et al.⁷ and Callaghan et al.⁸, which similarly identified no discernible advantage of mobile-bearing

implants over fixed-bearing designs in post-operative ROM or patient-reported outcomes. A multicenter randomized controlled trial encompassing 250 knees over a two-year follow-up period further substantiated these observations, reporting no significant intergroup differences in functional metrics⁹. Additionally, investigations in patients undergoing unilateral TKA with different prostheses in contralateral knees have yielded analogous findings, failing to demonstrate a definitive clinical benefit for mobile-bearing designs¹⁰.

Regarding complications, our analysis identified no statistically significant disparity in post-operative adverse event rates between cohorts. One patient developed a superficial wound infection, successfully managed with debridement and antibiotics. Two patients sustained periprosthetic fractures necessitating fixation with locking compression plates. Additionally, one case of deep vein thrombosis was effectively treated with anticoagulation therapy, and two patients experienced post-operative knee stiffness, requiring manipulation under anesthesia. These findings align with previous literature demonstrating comparable complication profiles between fixed- and mobile-bearing TKAs^{11,12}. The implications of these findings suggest that while both implant types are associated with robust functional outcomes, careful patient selection and adherence to rigorous surgical protocols play a far more critical role in overall success than the choice of implant design alone.

A frequently cited theoretical advantage of mobile-bearing TKA pertains to enhanced prosthetic congruency, purportedly mitigating polyethylene wear and subsequent osteolysis risk¹³. However, long-term studies indicate that contemporary polyethylene formulations in fixed-bearing designs exhibit substantial durability, rendering the clinical benefits of mobile-bearing constructs inconclusive^{14,15}. Additionally, there is growing evidence to suggest that the biomechanical assumptions underpinning mobile-bearing prostheses do not always translate into superior long-term functional outcomes^{16,17}. Moreover, dislocation and bearing instability remain potential concerns associated with mobile-bearing TKAs, although our cohort did not encounter such complications¹⁸.

5. Conclusion

Our study demonstrates that both fixed-bearing and mobile-bearing TKAs result in significant post-operative improvements in knee function, with no significant difference in ROM, knee scores, or complication rates between the two designs. These findings reinforce the notion that implant design alone does not dictate surgical outcomes; rather, proper surgical technique, precise component alignment, and meticulous soft tissue balancing remain paramount in achieving optimal results following TKA.

Limitations of the Study- Despite its strengths, our study has some limitations. First, the selection of implant type was not randomized preoperatively but rather determined intraoperatively based on ligament balancing. Second, the sample size was relatively small, potentially limiting the statistical power of our findings. Lastly, radiographic assessments, including polyethylene wear analysis, were not included in our

observations. Future studies with larger randomized cohorts and longer follow-up durations should aim to address these limitations.

6. References

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