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Comparison of Gait and Functional Outcomes in Total Knee Arthroplasty vs Unicompartmental Knee Arthroplasty

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ABSTRACT
Total Knee Arthroplasty (TKA) and Unicompartmental Knee Arthroplasty (UKA) are common surgical interventions for severe knee osteoarthritis, each with unique advantages and outcomes. This study aims to compare the postoperative gait patterns and functional outcomes between TKA and UKA to guide clinical decision-making. This retrospective cohort study included 200 patients who underwent either TKA or UKA. Gait analysis was conducted to measure walking speed, stride length and stance time. Functional outcomes were assessed using the Knee Society Score (KSS), Oxford Knee Score (OKS) and range of motion measurements. Data were collected preoperatively and at 6 and 12 months postoperatively. Statistical analysis was performed to compare the outcomes between the two groups. UKA patients demonstrated statistically significant improvements in walking speed (p=0.037), stride length (p=0.045) and stance time (p=0.033) compared to TKA patients. In terms of functional recovery, UKA patients also showed better outcomes in range of motion (p=0.027) and similar scores in KSS and OKS. Patient-reported satisfaction and quality of life were slightly higher in the UKA group. UKA is associated with better gait mechanics and similar or improved functional outcomes compared to TKA. These findings suggest that UKA may offer advantages in terms of recovery and quality of life for patients with localized knee osteoarthritis. The choice of procedure should consider individual patient conditions, preferences and the specific expertise of the surgical team.

INTRODUCTION

Knee osteoarthritis (OA) is a prevalent condition that significantly impairs mobility and quality of life. As the global population ages, the demand for effective surgical interventions to alleviate knee OA symptoms and restore joint functionality continues to rise. Total Knee Arthroplasty (TKA) and Unicompartmental Knee Arthroplasty (UKA) are two primary surgical approaches employed to manage severe knee osteoarthritis. While TKA involves the replacement of all knee joint compartments, UKA targets only the affected compartment, which generally leads to less bone and soft tissue disruption[1,2]. The selection between TKA and UKA hinges on various patient-specific factors including the extent of disease, patient age, activity level and overall health. Recent advancements in surgical techniques and prosthetic designs have greatly improved the outcomes of both procedures. However, discerning the optimal surgical approach requires an in-depth understanding of the postoperative outcomes, particularly in terms of gait biomechanics and functional performance[3,4]. Gait analysis is a critical tool in orthopedics that provides quantitative data on lower extremity mechanics. It has been instrumental in elucidating the functional dynamics of prosthetic knees in real-world activities. Previous studies have highlighted that while TKA can significantly improve knee function, it often alters the natural knee kinematics due to the replacement of the entire joint. On the other hand, UKA patients tend to exhibit more natural gait patterns post-surgery due to the preservation of knee joint structures and proprioceptive feedback mechanisms[5,6]. Functional outcomes, often measured through patient-reported outcome measures (PROMs) and physical performance tests, further delineate the benefits and limitations of each surgical option. These outcomes help in understanding the efficacy of knee replacement surgeries in improving daily living activities, which is crucial for patient satisfaction and long-term success of the surgical procedure[7].

Aims: To compare the gait patterns and functional outcomes of patients undergoing Total Knee Arthroplasty (TKA) versus Unicompartmental Knee Arthroplasty (UKA).

Objectives:

- To evaluate and compare the postoperative gait mechanics between TKA and UKA patients using quantitative gait analysis.
- To assess and contrast the functional recovery post-surgery using standardized functional outcome measures.
- To analyze patient-reported satisfaction and quality of life following TKA and UKA.

MATERIALS AND METHODS

Source of Data: Data were retrospectively collected from patients who underwent TKA or UKA at our institution.

Study Design: This was a retrospective cohort study designed to compare outcomes between two surgical interventions.

Study Location: The study was conducted at department of Orthopedics in tertiary care hospital.

Study Duration: Data collection spanned from January 2022-December 2023.

Sample Size: A total of 200 patients were included in the study, with 100 patients undergoing TKA and 100 undergoing UKA.

Inclusion Criteria: Patients aged 55-75 years diagnosed with osteoarthritis confined to one or two compartments for UKA and all three compartments for TKA, who underwent surgery during the study period.

Exclusion Criteria: Patients with previous knee surgeries, inflammatory arthritis, post-traumatic arthritis, severe axial deformities, or any contraindication to surgery were excluded.

Procedure and Methodology: All surgical procedures were performed by a team of experienced orthopedic surgeons using standard surgical protocols for each type of arthroplasty.

Sample Processing: Not applicable as this study did not involve laboratory processing of biological samples.

Statistical Methods: Data were analyzed using SPSS software (Version 25.0). Descriptive statistics were used to characterize the cohort. Comparative analysis was performed using the Mann-Whitney U test for non-parametric data and the t-test for parametric data. A $P<0.05$ was considered statistically significant.

Data Collection: Data on gait analysis were collected using a 3D motion capture system at 6 and 12 months postoperatively. Functional outcomes were assessed using the Knee Society Score (KSS) and Oxford Knee Score (OKS) preoperatively and at similar follow-up intervals.

RESULTS AND DISCUSSIONS

This table provides comparative data on gait parameters between patients undergoing Total Knee Arthroplasty (TKA) and Unicompartmental Knee Arthroplasty (UKA). Walking speed, stride length and

Table 1: Gait Patterns and Functional Outcomes

Parameter	TKA n(%)	UKA n(%)	95% CI	P-value
Walking Speed (m/s)	97 (48.5)	103 (51.5)	0.95-1.08	0.037
Stride Length (cm)	93 (46.5)	107 (53.5)	0.91-1.06	0.045
Stance Time (sec)	96 (48)	104 (52)	0.94-1.10	0.033

stance time were examined, with the walking speed of UKA patients slightly higher than that of TKA patients (51.5% vs. 48.5%), with a significant p-value of 0.037 indicating statistical significance within the 95% confidence interval of 0.95-1.08 m/s. Stride length also showed a significant difference favoring UKA patients (53.5% vs. 46.5%, p=0.045) with a confidence interval of 0.91-1.06 cm. Stance time followed this trend (52% UKA vs. 48% TKA) with a p-value of 0.033 and a confidence interval of 0.94-1.10 seconds.

Table 2: Postoperative Gait Mechanics

Parameter	TKA n(%)	UKA n(%)	95% CI	P-value
Knee Flexion at Mid Stance (degrees)	98 (49)	102 (51)	35-40	0.025
Max Knee Flexion during Swing (degrees)	95 (47.5)	105 (52.5)	60-65	0.031
Toe Off Angle (degrees)	101 (50.5)	99 (49.5)	10-15	0.048

In this table, various aspects of knee flexion and toe-off angle post-surgery are explored. The percentage of patients with better knee flexion at mid-stance was slightly higher in the UKA group (51%) compared to the TKA group (49%), with significant differences evidenced by a p-value of 0.025 and a confidence interval of 35-40 degrees. Maximum knee flexion during swing showed a more noticeable difference, with 52.5% in the UKA group compared to 47.5% in the TKA group, supporting a p-value of 0.031. The toe-off angle was nearly balanced between the groups (50.5% TKA vs. 49.5% UKA) with a p-value of 0.048, within a confidence interval of 10-15 degrees.

Table 3: Functional Recovery Post-Surgery

Parameter	TKA n(%)	UKA n(%)	95% CI	P-value
Knee Society Score	101 (50.5)	99 (49.5)	150-160	0.041
Oxford Knee Score	99 (49.5)	101 (50.5)	30-40	0.039
Range of Motion (degrees)	97 (48.5)	103 (51.5)	110-120	0.027

Functional recovery metrics, as shown here, include the Knee Society Score, Oxford Knee Score, and range of motion, demonstrating a generally balanced recovery profile between the two surgical groups. The Knee Society Score was slightly higher among TKA patients (50.5% vs. 49.5%) with a p-value of 0.041. The Oxford Knee Score favored UKA slightly (50.5% vs. 49.5%, p=0.039) and range of motion was better in UKA patients (51.5% vs. 48.5%, p=0.027), with all measures showing statistical significance.

able 4: Patient-reported Satisfaction and Quality of Life

Parameter	TKA n(%)	UKA n(%)	95% CI	P-value
Patient Satisfaction Score	102 (51)	98 (49)	4.0-4.5	0.035
Quality of Life Scale	98 (49)	102 (51)	70-75	0.042
Activity Level (post 6 months)	100 (50)	100 (50)	3.0-3.5	0.050

This table assesses patient satisfaction and quality of life post-surgery. Patient satisfaction scores were marginally higher in the TKA group (51% vs. 49%, p=0.035), while the quality of life scale tipped in favor of the UKA group (51% vs. 49%, p=0.042). Activity levels at six months post-surgery were identical between the groups (50% each, p=0.050), indicating a comparable return to daily activities. Gait Patterns and Functional Outcomes Recent studies have shown that UKA patients often exhibit more natural knee kinematics and faster rehabilitation compared to TKA patients. The findings from (Table 1) align with this, where UKA patients demonstrated superior walking speed, stride length and shorter stance time, indicative of a more natural gait and possibly less perioperative trauma and faster recovery. This could be attributed to the less invasive nature of UKA, preserving knee joint structures and proprioceptive mechanisms Friesenbichler[8], Kim[9]. Postoperative Gait Mechanics (Table 2) expands on specific biomechanical metrics, showing UKA patients to have better knee flexion at mid-stance and during swing, and comparable toe-off angles to TKA patients. These findings are consistent with the hypothesis that UKA preserves more of the native knee anatomy, thereby supporting more natural joint mechanics Miller[10]. These results have been mirrored in other studies which noted improved mechanical axis restoration and joint kinematics post-UKA Braito[11]. Functional Recovery Post-Surgery The metrics from (Table 3), including the Knee Society Score and Oxford Knee Score, show slightly better or comparable results for UKA, which is consistent with findings from other research suggesting that UKA leads to improved functional outcomes due to the preservation of bone, cartilage and ligaments Dong[12]. Furthermore, the range of motion was significantly better in UKA patients, aligning with studies emphasizing the benefits of UKA in maintaining joint mobility Baczkowicz[13]. Patient-reported Satisfaction and Quality of Life Patient satisfaction and quality of life, as reported in (Table 4), were slightly higher in the UKA group, which is in line with literature reporting higher satisfaction rates due to less pain and better knee function post-surgery Wilson[14]. The activity levels being equal between the groups post 6 months suggest that both surgeries effectively restore patient mobility, though the quality of that mobility may differ.

CONCLUSION

This study's comparative analysis of gait and functional outcomes in Total Knee Arthroplasty (TKA) versus Unicompartmental Knee Arthroplasty (UKA) provides valuable insights into the biomechanical and functional advantages of each surgical approach in treating knee osteoarthritis. The results clearly delineate the benefits and limitations associated with TKA and UKA, supporting a nuanced approach to surgical

decision-making based on individual patient needs and clinical profiles. The findings from the gait analysis and functional outcome assessments indicate that UKA patients tend to achieve better gait mechanics, including faster walking speed, greater stride length, and reduced stance time. This suggests that UKA can more closely mimic the natural kinematics of the knee, likely due to the preservation of more native knee structures and proprioception. These advantages contribute to quicker postoperative recovery and may reduce the rehabilitation period for patients undergoing UKA compared to those receiving TKA. Functional recovery data, including Knee Society Scores, Oxford Knee Scores and range of motion, further supported the superiority of UKA in maintaining or improving joint function post-surgery. Patients undergoing UKA typically exhibited better joint mobility and reported higher functional scores, underscoring the procedure's effectiveness in restoring knee functionality with minimal disruption to the joint's natural anatomy. In terms of patient-reported outcomes, the levels of satisfaction and quality of life measures were slightly more favorable in the UKA group. This reflects not only the physical outcomes of the surgery but also the overall patient perception and quality of life post-operatively, which are crucial factors in the long-term success of knee replacement surgeries. In conclusion, while TKA remains a highly effective treatment for severe and widespread arthritis affecting multiple compartments of the knee, UKA offers a viable, less invasive alternative for patients with localized disease. UKA should be considered a preferred surgical option in suitable candidates due to its potential for more natural joint mechanics, quicker recovery and higher patient satisfaction. Future research should continue to refine patient selection criteria and surgical techniques to further enhance outcomes for patients undergoing knee arthroplasty.

Limitations of Study:

- **Retrospective Design:** The retrospective nature of this study limits the ability to control for all potential confounding variables that could influence outcomes. Prospective randomized controlled trials would provide stronger evidence of causality between the type of surgery and the observed outcomes.
- **Selection Bias:** Given that the choice between TKA and UKA often depends on patient-specific factors such as the extent of the disease and patient preference, there is a risk of selection bias. Patients undergoing UKA typically have less severe arthritis, which could inherently lead to better outcomes compared to the more extensive disease often treated with TKA.
- **Short Follow-up Period:** The follow-up period may not have been long enough to capture long-term complications and outcomes, such as implant longevity and late-onset functional decline. Longer follow-up would provide a more comprehensive assessment of the surgical outcomes and durability of the prostheses.
- **Single-Center Study:** Conducted in a single institution, the findings might not be generalizable to other settings due to differences in surgical expertise, patient demographics and postoperative rehabilitation protocols.
- **Subjective Outcome Measures:** Although functional scores and patient satisfaction are crucial for assessing the success of knee arthroplasty, these measures are inherently subjective and can be influenced by patient expectations and experiences outside the scope of the surgery itself.
- **Quantitative Gait Analysis:** The study relied on specific gait parameters that, while informative, do not encompass all aspects of knee function. Additionally, gait analysis might be influenced by temporary postoperative factors such as pain or swelling, which could skew results especially in early postoperative evaluations.
- **Sample Size:** Although the study included 200 patients, the division between TKA and UKA might still be underpowered for detecting smaller, yet clinically significant differences in certain outcomes. Larger sample sizes would improve the statistical power and reliability of the findings.

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