



Research Article

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Unilateral vs. simultaneous bilateral cruciate-retaining total knee arthroplasty: Mid-term clinical, functional, and radiological outcomes

Göksel Gültekin Şahiner¹, Bedirhan Albayrak^{2,*}, Zafer Orhan³

¹Department of Orthopaedics and Traumatology, Büyük Anadolu Private Hospital, Samsun, Türkiye

²Department of Orthopaedics and Traumatology, Samsun Training and Research Hospital, Samsun, Türkiye

³Department of Orthopaedics and Traumatology, Başakşehir Çam and Sakura City Hospital, University of Health Sciences, İstanbul, Türkiye

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Abstract

This study aimed to evaluate the clinical, functional, and prosthesis survival outcomes of patients who underwent cruciate-retaining total knee arthroplasty (TKA) at a single center by a single surgeon, with a minimum follow-up of 13 months. Additionally, the influence of comorbidities and cold sensitivity on mid-term outcomes was investigated. A total of 41 patients (50 knees) who underwent TKA for varus-aligned gonarthrosis were retrospectively analyzed. Clinical and functional outcomes were assessed using WOMAC, Clinical and Functional American Knee Society Scores (C-AKSS, F-AKSS), SF-12 MCS and PCS, and radiological evaluation was performed using the KSRES scoring system. Patients were grouped based on surgery type (unilateral vs. bilateral), etiology, prosthesis brand, total valgus angle (TVA), and presence of cold sensitivity. Comparative statistical analyses were conducted among subgroups. Bilateral TKA was associated with significantly higher erythrocyte transfusion requirements ($p = 0.003$), worse WOMAC ($p = 0.032$), SF-12 MCS ($p = 0.045$), and KSRES scores ($p = 0.029$) compared to unilateral TKA. No significant differences were found between implant brands in terms of clinical or radiological outcomes ($p > 0.05$). Subgroup comparisons based on TVA categories showed no statistically significant differences ($p > 0.05$). Patients with cold sensitivity had significantly worse WOMAC ($p = 0.041$) and SF-12 MCS ($p = 0.048$) scores. Diabetes mellitus or coronary artery disease did not significantly affect KSRES or functional scores ($p > 0.05$). Cruciate-retaining TKA is a safe and effective procedure. However, simultaneous bilateral TKA may lead to inferior mid-term outcomes and increased transfusion needs. Based on our findings, unilateral TKA may be more favorable in routine practice, particularly in patients without strong bilateral indications.

Keywords: knee replacement arthroplasty, knee osteoarthritis, knee prosthesis

1. Introduction

Total knee arthroplasty (TKA) is a well-established surgical intervention for relieving pain and improving joint function in patients with degenerative knee diseases, especially when conservative treatments such as anti-inflammatory drugs, physical therapy, intra-articular injections, arthroscopic debridement, and high tibial osteotomy fail to provide adequate relief (1). Since the introduction of modern prosthesis designs in the 1970s, early complications such as infection, loosening, and metallosis have significantly decreased, leading to widespread adoption of the procedure.

While primary osteoarthritis (OA) is the most common indication for TKA, other etiologies such as post-traumatic OA, post-septic arthritis, and OA secondary to rheumatologic conditions also necessitate surgical treatment in advanced stages (2, 3). The initial treatments for these underlying conditions are generally managed by the respective specialty physicians; however, when it comes to treating knee OA,

orthopedic surgeons play a central role. As the disease progresses to moderate or advanced stages, TKA often becomes the only viable option. Comparing factors such as perioperative morbidity and intraoperative complexity across different etiologies in the literature allows for the development of optimal preoperative, intraoperative, and postoperative management algorithms, facilitating better surgical planning and patient outcomes (4, 5).

Another ongoing debate in TKA is whether the procedure should be performed bilaterally in a single session or in separate sessions (6). Some studies have compared patients undergoing unilateral and bilateral TKA in terms of functional outcomes and the incidence of intraoperative or postoperative complications (7, 8). Furthermore, recent studies have emphasized the impact of patient-related factors—such as psychological distress, comorbidities, and cold sensitivity—on postoperative outcomes. However, there is limited evidence

*Correspondence: bedirhanalbayrak.5595@gmail.com

examining how cold sensitivity, a potentially underrecognized sensory phenomenon, influences mid-term functional recovery following TKA.

The present study aims to compare the clinical, functional, and prosthesis survival outcomes of patients who underwent unilateral versus bilateral cruciate-retaining TKA, and to investigate whether the presence of self-reported cold sensitivity is associated with worse patient-reported outcome scores. We hypothesize that bilateral TKA results in inferior functional outcomes and that cold sensitivity negatively affects postoperative recovery.

2. Materials and Methods

This retrospective study included patients who underwent total knee arthroplasty (TKA) at our clinic and had a minimum follow-up duration of 13 months. Inclusion criteria were patients with predominantly medial compartment gonarthrosis in varus alignment. Those with valgus alignment or lateral compartment predominance were excluded.

Demographic data, comorbidities, and surgical details (e.g., unilateral vs. bilateral procedure, implant brand, operative time, number of erythrocyte blood transfusions, and length of hospital stay) were recorded. Postoperative complications were documented. Radiological assessments were performed using the Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System (KSRES). Clinical and functional evaluations were performed at the final follow-up using the American Knee Society Score (C-AKSS and F-AKSS), the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the Short Form-12 (SF-12) questionnaire, including both physical (PCS) and mental (MCS) component summaries.

2.1. Assessment of Cold Sensitivity

Cold sensitivity was assessed at the final follow-up using a standardized direct question: *“Do you experience discomfort or pain in your operated knee(s) when exposed to cold environments or during temperature drops?”* Patients who responded “yes” were categorized as cold sensitivity positive. This self-reported binary classification method has been used in previous orthopedic outcome studies and provides a reproducible means of identifying cold-sensitive individuals, although it is not based on a validated quantitative scale.

2.2. Surgical Technique and Postoperative Care

All TKAs were performed by the same surgical team using a standard medial parapatellar approach under tourniquet control. Intravenous prophylactic antibiotics (1 g cefazolin and 80 mg gentamicin) were administered preoperatively. Postoperative antibiotic prophylaxis (3×1 g cefazolin, 2×80 mg gentamicin) was continued until discharge. Drains were used routinely and removed once drainage was <100 cc. Dressings were changed every 48 hours. Mobilization began on postoperative day 1, and active/passive range of motion exercises were initiated on day 2. Patients were discharged with oral cephalexin (3×1 g/day) until day 14. Follow-ups were

conducted at postoperative week 2, and months 1, 3, 6, and 12. Final assessments included clinical, functional, and radiological evaluation.

2.3. Radiological Measurements

The KSRES was used to evaluate prosthesis alignment. Anteroposterior and lateral radiographs were used to measure component alignment angles (Alpha, Beta, Gamma, Delta) and to calculate the Total Valgus Angle (TVA). Measurements were performed using standard anatomical landmarks and validated angular definitions.



Fig. 1. 74/F patients had primer osteoarthritis, preoperative and last postoperative AP and lateral X-rays. Preoperative X-ray shows isolated medial arthrosis. Postoperative KSRES score was 0.

2.4. Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics version 26. Normality of continuous variables was assessed using the Shapiro–Wilk test. For normally distributed data, comparisons between two groups were made using the Student's *t*-test; otherwise, the Mann–Whitney *U* test was applied. Categorical variables were compared using the Chi-square or Fisher's exact test where appropriate. Subgroup comparisons (e.g., based on implant brand, TVA classification, etiology, cold sensitivity) were also conducted. For comparisons among three or more independent groups, one-way ANOVA was used for normally distributed data, and the Kruskal–Wallis test was employed for non-parametric data. Categorical variables were compared using the Chi-square or Fisher's exact test as appropriate. No adjustment for multiple comparisons was applied. A *p*-value of <0.05 was considered statistically significant.

3. Results

A total of 41 patients (33 females and 8 males) who underwent posterior cruciate ligament (PCL)-retaining total knee arthroplasty (TKA) were included, encompassing 50 knees.

The mean age was 63.3 years (range: 46–90), and the average follow-up duration was 26.75 months (range: 13–56). Of these, 9 patients underwent bilateral TKA while 32 had unilateral procedures. The number of patients aged >65 was 26, and 15 were aged ≤65.

When clinical and functional outcomes were compared between the unilateral and bilateral groups, statistically significant differences were observed in several key parameters. The bilateral group demonstrated significantly worse WOMAC, Functional AKSS (F-AKSS), Clinical AKSS (C-AKSS), and SF-12 Mental and Physical Component Scores (SF-12 MCS and PCS). Additionally, this group had a higher frequency of cold sensitivity complaints, received more erythrocyte blood transfusions (EBTs), and had longer hospital stays ($p < 0.05$ for all comparisons). These results suggest that bilateral TKA may be associated with less favorable mid-term outcomes (see Table 1 for summary statistics).

Table 1. Parameters Evaluated According to Surgery Type (Unilateral/Bilateral Involvement)

<i>Surgery Type</i>	Unilateral (n:32)	Bilateral (n:9)	p value
WOMAC	30.1±6.4	33.3±6.1	0.032*
F-AKSS	88.9±15.6	76.6±15.3	0.003*
C-AKSS	90.2±8.2	78.3±14	<0.001*
SF-12 MCS	54.4±1.5	52.2±2.5	0.001*
SF-12 PCS	49.6±4	46.8±2.6	0.011*
KSRES	1(0-6)	2.3(0-6)	0.029*
EBT count	0.3(0-2)	2.1(0-4)	<0.001*
Cold sensitivity	15(%47)	16(%89)	<0.001*
Length of hospital stay	4.6±2.4	6.5±4.5	<0.001*

Table 2. Parameters evaluated according to the etiology of gonarthrosis

<i>Etiology of Gonarthrosis</i>	Primary(n:38)	PTOA(n:9)	RAOA(n:3)	p value
WOMAC	31.6±6	26.5±2.7	41.3±8	0.005*
CAKSS	84.4±12.2	95.6±5.8	76.3±7.5	0.001*
FAKSS	83.1±16.1	97.2±6.6	63.3±14.4	0.001*
SF-12 MCS	53.5±2.4	51.3±1.9	52±1.7	0.040*
SF-12 PCS	48.6±3.5	45.8±1.4	43.6±1.1	0.006*
KSRES	1.7(0-6)	0.2(0-2)	3(0-5)	0.055
EBT count	1.1(0-3)	0	1.6(1-2)	0.004*
Cold sensitivity	26(38)	3(9)	2(3)	0.144
Length of hospital stay	5.4±1.8	5±2.3	5	0.143

Table 3. Parameters evaluated according to TVA

<i>Total Valgus Angle (TVA)</i>	TVA negative(n:28)	TVA zero(n:12)	TVA positive(10)	p value
WOMAC	30.8±5.4	32.6±9	30.8±6.1	0.714
CAKSS	86.2±12.3	81.7±13.4	90.4±8.2	0.207
FAKSS	85.7±13.9	76.6±21.9	90.5±13.4	0.261
SF-12 MCS	52.7±2.5	53.6±2.4	53.2±1.9	0.510
SF-12 PCS	47.8±3.4	49.1±4.1	46.4±1.9	0.254
KSRES	1.4(0-6)	2(0-6)	1.2(0-6)	0.604
EBT count	0.9(0-3)	1.1(0-3)	0.8(0-2)	0.780
Cold sensitivity	18(28)	7(12)	6(10)	0.927

Although all patients demonstrated total valgus angles (TVA) within the accepted physiological range on

Subgroup analysis based on implant brand revealed no statistically significant differences in any of the measured clinical, functional, or radiological parameters, including WOMAC, AKSS, SF-12, KSRES scores, EBT counts, or hospital stay durations. However, it should be noted that some subgroups (e.g., Biomed, $n = 4$; Wright, $n = 5$) had very small sample sizes, limiting the statistical power and reliability of these comparisons.

Patients were also classified by gonarthrosis etiology into primary osteoarthritis (OA), post-traumatic OA (PTOA), and rheumatoid arthritis-associated OA (RAOA). While no differences were observed in KSRES scores, cold sensitivity, weight change, or hospital stay, the groups differed significantly in functional outcomes. Patients with RAOA exhibited worse scores in WOMAC, F-AKSS, C-AKSS, and both SF-12 components compared to other etiologies ($p < 0.05$; Table 2). Again, some etiological subgroups (e.g., RAOA) consisted of relatively few cases, and the results should be interpreted with caution.

Although all patients demonstrated total valgus angles (TVA) within the accepted physiological range on radiographic evaluation, they were categorized into three TVA subgroups: negative, neutral, and positive. No statistically significant differences were found in any clinical, functional, or radiological outcome between these TVA groups (Table 3), suggesting that minor angular deviations within the normal range may not impact outcomes in the short- to mid-term.

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significant differences were found in any clinical, functional, or radiological outcome between these TVA groups (Table 3), suggesting that minor angular deviations within the normal range may not impact outcomes in the short- to mid-term.

Out of 41 patients, 23 (56.1%) reported cold sensitivity at the final follow-up. Patients in the cold-sensitive group had significantly worse WOMAC and SF-12 MCS scores compared to those without cold sensitivity ($p < 0.05$). However, other outcome measures—including AKSS, SF-12 PCS, KSRES scores, weight change, EBT, and hospital stay—did not differ significantly between the two groups (Table 4).

Table 4. Parameters evaluated according to the presence of cold sensitivity

<i>Cold Sensitivity</i>	Yes(n:23)	No(n:18)	p value
WOMAC	32.9±5.1	28.6±7.7	<0.001*
F-AKSS	83.3±13.8	86.3±20.3	0.106
C-AKSS	86±6.8	86±17.8	0.095
SF-12 MCS	52.2±2.3	53.5±2.3	0.049*
SF-12 PCS	46.2±2.7	48.9±3.4	0.006
KSRES	1.8(0-6)	1(0-6)	0.115
EBT count	1.1(0-3)	0.6(0-3)	p: 0.070
Length of hospital stay	5.3±1.3	5.3±2.5	p: 0.080

Finally, comorbidity-based subgroup analyses revealed no significant differences in KSRES scores between patients with and without diabetes mellitus (DM), or between those with and without coronary artery disease (CAD). These findings indicate that such systemic comorbidities did not have a notable effect on radiological implant outcomes within the scope of this study.

4. Discussion

Total knee arthroplasty (TKA) remains the primary and most effective surgical option for patients with advanced-stage gonarthrosis, offering satisfactory outcomes with various implant designs. Numerous studies have attempted to answer whether TKA should be performed unilaterally or bilaterally in a single session. Additionally, questions remain regarding which prosthesis brand is most effective, the impact of component alignment on functional outcomes, and how the etiology of gonarthrosis affects clinical results.

TKA is most commonly performed for primary osteoarthritis, post-traumatic osteoarthritis, and rheumatoid arthritis (2, 3). Beyond these, it is also indicated for degenerative and destructive joint diseases such as septic arthritis, psoriatic arthritis, pigmented villonodular synovitis, tuberculous arthritis, systemic lupus erythematosus, osteonecrosis, and gout (4). Absolute contraindications for TKA include active infection, sepsis, a stable and painless arthrodesis, and irreparable damage to the extensor mechanism (4). In our study, 30 patients were operated on due to primary osteoarthritis, 9 due to post-traumatic osteoarthritis, and 2 due to rheumatoid arthritis.

Brockman et al. reported a higher complication rate in patients with post-traumatic osteoarthritis (PTOA) compared to those with primary osteoarthritis (3). The younger age of PTOA patients and the technical complexity of surgery may contribute to differing outcomes. Conversely, patients with primary OA tend to be older and present more comorbidities, leading to greater anesthetic risk (5). In our study, patients were categorized etiologically into primary OA, PTOA, and RAOA groups. The PTOA group demonstrated more favorable clinical and functional outcomes, although the small sample size in RAOA cases limits generalizability.

Studies have shown that patients undergoing simultaneous bilateral TKA may require more blood transfusions, have longer hospital stays, increased referrals to rehabilitation, and higher rates of cardiac complications and even mortality, compared to those undergoing staged procedures (9). Complication rates are particularly elevated in patients with pulmonary disease or increased body mass index (7). However, a study by Bullock reported only a slight increase in complications in the bilateral group, suggesting that the decision should be based on patient preference. (6). Boyer et al. found improved prosthesis survival in simultaneous bilateral TKAs (8). In our study, bilateral TKA was associated with a significantly higher number of erythrocyte transfusions, longer hospital stays, and lower functional outcome scores compared to unilateral TKA. While these findings suggest that unilateral TKA may be more favorable in terms of mid-term outcomes, conclusions should be interpreted cautiously due to the retrospective nature and limited sample size of the study.

Previous studies evaluating TKA implant brands using KOOS, LEAS, and SF-12 found no significant differences in outcomes between different prosthesis types (10). In a UK-based study comparing PFC Sigma, AGC Biomet, Nexgen, Genesis 2, and Triathlon brands, Nexgen was found to be the most cost-effective (11). Similarly, in our cohort, no statistically significant differences were observed between implant brands regarding radiological or functional parameters, including KSRES scores. These findings align with the literature and support the idea that clinical performance is comparable across standard implants, although economic disparities in procurement should be addressed at the policy level. Nonetheless, the small sample sizes in certain implant subgroups (e.g., Biomed, Wright) limit the strength of this conclusion.

A total valgus angle (TVA) exceeding 6 degrees has been associated with worse clinical and functional outcomes (12). However, some studies have not found such a relationship (13). All our patients had TVA values within the normal range (-3° to $+3^\circ$), and no statistically significant outcome differences were observed among TVA-based subgroups. These findings support the idea that small angular deviations within the physiological range may not have a measurable impact on short- to mid-term outcomes.

In a study by King et al., patients with high-symptom knee OA demonstrated increased sensitivity to thermal, blunt, mechanical, and cold stimuli, without a corresponding difference in endogenous pain inhibition, suggesting central sensitization or altered pain modulation mechanisms (14). In our cohort, 23 of 41 patients reported cold sensitivity. These patients had significantly worse WOMAC and SF-12 MCS scores. Although the exact pathophysiological basis remains unclear, increased central sensitivity and diminished descending inhibitory control may explain the observed differences. This highlights the importance of incorporating sensory symptomatology into patient-centered outcome assessments.

Previous literature presents conflicting results regarding diabetes mellitus (DM) and its impact on TKA outcomes. (15). Some studies report no effect on function, while others indicate increased revision and complication rates (16-18). In our study, the presence of DM or coronary artery disease (CAD) did not significantly influence KSRES or functional scores. However, the low number of patients in these subgroups precludes firm conclusions.

The literature suggests that patients with cardiovascular disease undergoing TKA have higher perioperative complication and mortality risks. Preoperative cardiology consultations are recommended, especially in elderly patients, to reduce adverse outcomes (19). In our study, 5 patients had a history of coronary artery disease. No statistically significant differences in functional outcomes or KSRES scores were observed, but larger sample sizes are needed to draw more definitive conclusions.

This study has several limitations. The retrospective design inherently carries a risk of selection bias, and there was no randomized control group. Implant brand assignment was not randomized and may reflect institutional availability rather than clinical preference. Cold sensitivity was assessed using a self-reported, non-validated question, limiting objectivity. Subgroup analyses, particularly those involving implant types, gonarthrosis etiology, and comorbidities, were constrained by small sample sizes. Thus, while our findings provide valuable clinical insight, they should be interpreted with caution and confirmed through prospective, large-scale, controlled studies.

Cruciate-retaining total knee arthroplasty (TKA) is a safe and effective surgical intervention with satisfactory clinical and functional outcomes and acceptable implant survival rates. Achieving optimal postoperative radiological alignment remains an important contributor to favorable outcomes. In this single-center study performed by a single surgeon, patients who underwent simultaneous bilateral TKA exhibited comparatively poorer functional and clinical results, along with a higher need for perioperative erythrocyte blood transfusions. While simultaneous bilateral TKA can be safely performed with appropriate patient selection and preoperative optimization, our findings suggest that unilateral TKA may be

more favorable in terms of mid-term outcomes. Further large-scale, prospective studies are warranted to validate these observations and guide clinical decision-making.

Conflict of interest

All authors declare that they have no conflict of interest.

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Authors' contributions

Concept: G.G.Ş., B.A., Z.O., Design: G.G.Ş., B.A., Z.O., Data Collection or Processing: G.G.Ş., Analysis or Interpretation: G.G.Ş., B.A., Literature Search: G.G.Ş., Writing: G.G.Ş.

Ethical statement

This study is the thesis work of Göksel Gültekin Şahiner. It was conducted with the approval of the Local Ethics Committee of Düzce University Faculty of Medicine. This study was conducted in compliance with the Helsinki Declaration as revised in 2013.

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