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Short-term efficacy and safety of bicompartmental versus total knee arthroplasty for medial tibiofemoral and patellofemoral osteoarthritis: a propensity score-matched study

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Abstract

Objective

This study aimed to compare the 1-year clinical outcomes and early safety profiles of bicompartmental knee arthroplasty (BKA) versus total knee arthroplasty (TKA) in patients with combined medial tibiofemoral and symptomatic patellofemoral osteoarthritis.

Methods

This retrospective observational study enrolled patients who underwent BKA or TKA between January 2024 and September 2025. A 1:1 propensity score matching (PSM) was performed to balance baseline confounders including age, sex, body mass index, operative side, Kellgren-Lawrence grade, preoperative range of motion (ROM), preoperative visual analogue scale (VAS), Knee Society Score (KSS) and Western Ontario and McMaster Universities Osteoarthritis (WOMAC) index. Perioperative parameters, visual analogue scale (VAS), KSS, WOMAC index, ROM and 1-year postoperative complications were compared between groups. Standardized mean difference (SMD) was used to assess baseline balance.

Results

Before PSM, 62 BKA patients and 335 TKA patients were screened; 53 patients remained in each group after matching. The BKA group demonstrated significantly shorter operative duration and shorter hospital stay than the TKA group ($P < 0.05$). No intergroup differences were observed in intraoperative blood loss or the incidence of impaired wound healing ($P > 0.05$). At 1 month postoperatively, the BKA group achieved lower VAS scores and WOMAC index as well as superior KSS scores compared with TKA ($P < 0.05$). No significant inter-group differences were observed in ROM at any postoperative time-point. However, the between-group differences in VAS, KSS, WOMAC disappeared at 6 and 12 months.No significant differences in postoperative complications were identified within 1 year between the two cohorts.

Conclusion

BKA is associated with faster perioperative recovery and superior early functional improvement for patients with combined medial tibiofemoral and patellofemoral osteoarthritis, while mid-term functional outcomes and 1-year safety are comparable to TKA. The benefits of BKA are mainly confined to the early postoperative rehabilitation window. BKA and TKA represent complementary surgical options rather than simple alternatives when surgical indications are strictly selected.

Introduction

Knee osteoarthritis is a prevalent musculoskeletal disorder among the middle-aged and elderly population, with its incidence rising year by year[1]. Medial tibiofemoral compartment degeneration represents the most common pathological pattern. Approximately 20%-25% of patients develop clinically significant patellofemoral degeneration, while the lateral compartment and anterior cruciate ligament (ACL) remain intact[2, 3]. Total knee arthroplasty (TKA) serves as the conventional therapeutic option for this patient population. Nevertheless, TKA sacrifices the native cruciate ligaments and cartilage of unaffected compartments, and some patients fail to achieve satisfactory postoperative outcomes regarding proprioception, anterior knee pain and range of motion[4].In recent years, unicompartmental knee arthroplasty (UKA) yields superior function and range of motion compared with TKA for isolated medial compartment osteoarthritis, whereas patellofemoral arthroplasty (PFA) achieves acceptable clinical results in patients with isolated patellofemoral osteoarthritis[5, 6].Combined bicompartmental knee arthroplasty (BKA), integrating UKA and PFA, can theoretically address pathological lesions in both the medial tibiofemoral and patellofemoral compartments simultaneously, while preserving the lateral compartment, ACL and near-physiological knee kinematics. This technique has gained increasing clinical application[7].

However, most existing comparative evidence between BKA and TKA originates from small-scale and unmatched follow-up studies. Evidence from propensity score-matched (PSM) studies evaluating both 1-year postoperative functional outcomes and early safety profiles remains scarce. Furthermore, it remains unclear whether BKA confers distinct early functional benefits and whether its risks of early complications and revision are acceptable. This exploratory study hypothesized that, after balancing baseline confounders via PSM, differences in postoperative functional outcomes and early safety would exist between BKA and TKA, and such differences may be predominantly observed in the early postoperative period. Therefore, this study aimed to compare the 1-year clinical efficacy and early safety of BKA versus TKA for patients with combined medial tibiofemoral and patellofemoral osteoarthritis, to provide clinical references for patient selection.

Materials and methods

General Data

Inclusion criteria: (1) Patients aged 55–80 years; Kellgren-Lawrence grade ≥ medial tibiofemoral osteoarthritis combined with patellofemoral osteoarthritis, with failure of conservative treatment. (2) Intact lateral tibiofemoral compartment and functional anterior cruciate ligament (ACL). (3) Varus deformity ≤ 15°with passive correctability. (4) Completion of 1-year postoperative follow-up.

Exclusion criteria: (1) Concomitant lateral compartment osteoarthritis. (2) ACL insufficiency or flexion contracture > 15°. (3) Body mass index (BMI) > 30 kg/m². (4) Previous knee surgery or combined bone defects. (5) Incomplete follow-up of less than 1 year or missing clinical data.

Patients were screened according to the above inclusion and exclusion criteria. A total of 335 patients who underwent TKA and 62 patients who underwent BKA at Shanghai Guanghua Hospital of Integrated Traditional Chinese and Western Medicine between January 2024 and September 2025 were retrospectively enrolled. Final follow-up evaluation and data extraction were completed in October 2026 to ensure all enrolled patients achieved at least 12-month postoperative follow-up.To balance baseline characteristics and reduce potential confounding bias, 1:1 propensity score matching (PSM) was performed. The matching covariates included age, sex, BMI, operative side, Kellgren-Lawrence grade, preoperative range of motion (ROM), preoperative visual analogue scale (VAS), Knee Society Score (KSS), and Western Ontario and McMaster Universities Osteoarthritis (WOMAC) Index. After PSM, 106 patients were finally included for statistical analysis, with 53 patients in the BKA group and 53 in the TKA group. This study protocol was approved by the Ethics Committee of Shanghai Guanghua Hospital of Integrated Traditional Chinese and Western Medicine.

Operative procedure

All surgeries were performed by senior attending surgeons in the Department of Joint Surgery of our hospital. Patients meeting the inclusion criteria underwent either bicompartmental knee arthroplasty (BKA) or posterior cruciate-retaining total knee arthroplasty (CR-TKA). For BKA, the Simple Kinrest unicompartmental knee system combined with the Mei-FOA patellofemoral system (Double Medical Technology Co., Ltd., Xiamen, China) was used. The LEGION CR total knee system (Smith & Nephew, Memphis, TN, USA) was used for CR-TKA. Combined intravenous-inhalation anesthesia was administered, and patients were placed in the supine position. Prophylactic antibiotics were given preoperatively. The affected limb was disinfected and draped. An anteromedial knee incision was made for BKA patients, and layered dissection was performed to expose the joint cavity. Intraoperative exploration confirmed intact cartilage of the lateral tibiofemoral compartment and satisfactory structure and tension of the anterior cruciate ligament (ACL). Hyperplastic synovium, osteophytes and remnants of the medial meniscus were debrided. Unicompartmental knee arthroplasty was performed first. Extramedullary referencing was adopted for tibial osteotomy, and intramedullary referencing was used for osteotomy of the medial femoral condyle. The bone surfaces were trimmed, and flexion-extension gaps were balanced. Patellofemoral arthroplasty was carried out subsequently. Patellar osteophytes were excised, followed by sequential osteotomy of the femoral trochlea and patella. Trial prostheses were inserted, and passive knee flexion and extension were performed to assess joint gaps, prosthesis fit, patellar tracking and lower-limb alignment. After removal of the trial components, the bone bed was irrigated with pulsatile lavage. The medial unicompartmental and patellofemoral prostheses were fixed with bone cement, and excess cement within the joint was thoroughly cleared. The incision was closed layer by layer, followed by compressive dressing. Operative techniques for TKA have been described in previously published literature[8]. A standardized postoperative rehabilitation protocol was implemented for both groups.

Outcome measures

Perioperative data were recorded, including operative duration, intraoperative blood loss, postoperative wound healing disorders, and perioperative complications such as deep vein thrombosis of the lower extremities and surgical site infection. The visual analogue scale (VAS), Knee Society Score (KSS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), postoperative range of motion (ROM), and 1-year postoperative complications (including infection, knee stiffness, and prosthetic loosening) were adopted for outcome assessment.

Statistical analysis

Statistical analyses were performed using Stata 17.0. To mitigate selection bias in this retrospective observational study, 1:1 propensity-score matching (PSM) was implemented. The propensity-score model included the following covariates: age, sex, body mass index (BMI), operative side, Kellgren-Lawrence grade, preoperative range of motion (ROM), preoperative visual analogue scale (VAS), preoperative Knee Society Score (KSS), and WOMAC index. The caliper width was set at 0.2. The absolute value of the standardized mean difference (|SMD|) was applied to evaluate baseline covariate balance, with |SMD| < 0.1 defined as acceptable balance. The Shapiro-Wilk test was used to assess the normality of continuous variables. Normally distributed continuous variables were reported as mean±standard deviation and compared using the independent samples t-test. Categorical variables were presented as n (%) and compared using Fisher's exact test.Non-normally distributed data were presented as median (interquartile range) [M (P25, P75)] and analysed via the Mann-Whitney U test. A two-sided $P < 0.05$ was considered statistically significant.

Bias control

Data extraction was performed independently by two researchers, and discrepancies were resolved by a third investigator. Radiographic Kellgren-Lawrence grading was assessed by two independent senior orthopedic surgeons, and the intraclass correlation coefficient was calculated to evaluate inter-observer reliability. The assessors were aware of group allocation; this limitation will be addressed in the Limitations section. We applied 1:1 PSM to balance baseline confounders between groups, thereby mitigating selection bias arising from differences in surgical indication between the BKA and TKA groups. Nevertheless, PSM can only balance covariates included in the model and cannot eliminate residual bias caused by unmeasured confounders. Therefore, the interpretation of our results should be undertaken with caution.

Results

Patient enrollment and baseline characteristics

A total of 397 patients meeting the inclusion criteria were screened during the study period. Among them, 62 patients in the BKA group and 335 patients in the TKA group were enrolled for propensity score matching. After matching, 53 patients remained in the BKA group and 53 in the TKA group. Before matching, the standardized mean differences (SMDs) of age, BMI, Kellgren-Lawrence grade, preoperative

ROM, WOMAC index and KSS knee score were all > 0.1, indicating an imbalanced baseline between the two groups. After PSM, each group contained 53 patients. Mild residual imbalance was observed for BMI (|SMD| = 0.109) and preoperative KSS knee score (|SMD| = 0.102), with |SMD| values between 0.1 and 0.2. The absolute SMD values for the remaining covariates were less than 0.1. Baseline characteristics were largely balanced between the two groups despite minor residual imbalances (Table 1).

Table 1
Baseline characteristics of patients in the two groups before and after propensity score matching

Variable	**Before matching**			**After matching**		
	BKA Group(n = 62)	**TKA Group(n = 335)**	**|SMD|**	**BKA Group(n = 53)**	**TKA Group(n = 53)**	**|SMD|**
Age	63.63 ± 7.19	65.88 ± 6.95	0.317	64.34 ± 7.15	64.87 ± 7.04	0.074
Gender			0.008			0.038
Male	28	159		23	24	
Female	34	176		30	29	
BMI	26.13 ± 2.65	27.02 ± 3.16	0.304	26.24 ± 2.78	25.93 ± 2.83	0.109
Surgical side			0.094			
Left	30	184		26	24	
Right	32	151		27	29	
Kellgren-Lawrence			0.974			0.041
III	45	98		36	37	
IV	17	237		17	16	
Preoperative ROM(°)	117.18 ± 12.19	112.45 ± 13.28	0.369	117.23 ± 11.73	116.60 ± 13.54	0.049
VAS Score	7.02 ± 1.29	7.09 ± 1.25	0.106	7.09 ± 1.13	7.17 ± 1.31	0.062
WOMAC index	42.50 ± 9.64	47.84 ± 10.39	0.530	43.70 ± 9.30	44.19 ± 10.19	0.050
KSS Knee Score	45.84 ± 10.57	41.09 ± 10.42	0.450	44.51 ± 10.54	43.45 ± 9.99	0.102
Intraoperative findings and perioperative complications						

The operative duration was 73.14 ± 12.07 min in the BKA group and 80.28 ± 13.15 min in the TKA group. All patients received routine postoperative care and standardized rehabilitation protocols. Impaired

wound healing was noted in one patient in the BKA group and two patients in the TKA group; all wounds recovered after serial dressing changes.No other postoperative complications, such as infection, deep-vein thrombosis, knee stiffness or prosthetic loosening, were observed in the remaining patients(Table 2).All patients completed uneventful surgery and had a minimum of 12 months of postoperative follow-up.Representative cases with intraoperative images are shown in Figs. 1 and 2.

Table 2
Comparison of perioperative parameters between the two patient groups

Surgical Time (min)	**BKA Group (n = 53)**	**TKA Group(n = 53)**	**P Value**
	73.14 ± 12.07	**80.28 ± 13.15**	**0.004***
Blood Loss (ml)	54.87 ± 26.11	64.21 ± 31.36	0.095
Hospital Stay (days)	8.92 ± 2.16	10.95 ± 2.38	0.001*
Poor wound healing,n(%)	1(1.89%)	2(3.77%)	1.000
* $P < 0.05$			

Follow-up results

This study compared the clinical follow-up outcomes of patients in the BKA group and the TKA group at 1, 6, and 12 months postoperatively (Tables 3–6). In terms of pain relief, the VAS scores of both groups remained at low levels during the postoperative period. The BKA group presented lower VAS scores than the TKA group at 1 month postoperatively ($P < 0.05$), while no statistically significant intergroup differences in VAS scores were found at 6 and 12 months postoperatively ($P > 0.05$). These findings indicate that both surgical modalities can effectively treat knee osteoarthritis and achieve satisfactory pain relief, and BKA provided better early-stage postoperative pain control. In terms of knee function and symptom improvement, KSS and WOMAC scores improved markedly over follow-up in both groups. At the 1-month postoperative follow-up, the BKA group exhibited significantly higher KSS scores and lower WOMAC index values compared with the TKA group ($P < 0.05$), demonstrating that BKA confers advantages in early postoperative knee functional recovery and symptom relief. However, at 6 and 12 months postoperatively, there were no significant between-group differences in KSS and WOMAC index ($P > 0.05$), suggesting comparable mid-to-long-term functional outcomes between the two procedures. For range of motion (ROM), knee mobility recovered well in both groups during postoperative rehabilitation. No significant intergroup differences in ROM were identified at any of the 1-, 6-, or 12-month postoperative time points ($P > 0.05$), showing that BKA and TKA yield equivalent effects in improving knee range of motion.The dynamic changes in VAS, KSS, WOMAC, and ROM scores over time for both groups are visualized in Fig. 3.

Table 3
Comparison of VAS Score After Surgery Between Two Patient Groups

Group	n	1 Month Postoperative	6 Months Postoperative	12 Months Postoperative
BKA Group	53	2 (1, 3)	1 (1,1)	1 (0,1)
TKA Group	53	3 (2,3)	1 (1,1)	1 (0,1)
Z		2.11	0.33	0.27
P		0.0272*	0.80	0.81

** P < 0.05.*

Table 4
Comparison of KSS Knee Score After Surgery Between Two Patient Groups

Group	n	1 Month Postoperative	6 Months Postoperative	12 Months Postoperative
BKA Group	53	81.51 ± 3.16	89.15 ± 2.27	92.55 ± 2.51
TKA Group	53	79.49 ± 4.13	89.92 ± 2.64	93.23 ± 3.55
t		2.80	1.60	1.13
P		0.0061**	0.11	0.26

*** P < 0.01.*

Table 5
Comparison of WOMAC index After Surgery Between Two Patient Groups

Group	n	1 Month Postoperative	6 Months Postoperative	12 Months Postoperative
BKA Group	53	25.30 ± 5.23	15.53 ± 4.14	9.23 ± 3.22
TKA Group	53	28.60 ± 5.84	16.77 ± 4.63	9.81 ± 3.83
t		3.04	1.44	0.84
P		0.003*	0.15	0.40

** P < 0.05.*

Table 6
Comparison of ROM After Surgery Between Two Patient Groups

Group	n	1 Month Postoperative	6 Months Postoperative	12 Months Postoperative
BKA Group	53	118.33 ± 8.74	122.41 ± 6.83	124.23 ± 5.62
TKA Group	53	115.62 ± 9.21	121.72 ± 7.14	123.44 ± 6.13
t		1.54	0.52	0.69
P		0.13	0.61	0.49

Discussion

Controversy still exists regarding the optimal surgical strategy for patients with medial tibiofemoral osteoarthritis combined with symptomatic patellofemoral osteoarthritis. As a technically mature procedure with reliable clinical outcomes, TKA has been widely adopted for this patient population. Nevertheless, it is associated with drawbacks including substantial surgical trauma and considerable bone stock loss[9]. UKA provides the benefits of minimal invasiveness, rapid recovery, preserved cruciate ligaments and superior postoperative proprioception. However, for patients with bicompartmental osteoarthritis accompanied by symptomatic patellofemoral disease, isolated UKA cannot adequately address patellofemoral lesions. Previous studies have indicated that residual patellofemoral symptoms constitute an important risk factor for unsatisfactory postoperative outcomes and even surgical failure[10, 11]. Although some investigators have argued that the severity of preoperative patellofemoral degeneration may not affect short-term clinical results, current evidence is insufficient to support isolated UKA as the first-line treatment for patients with concomitant patellofemoral degeneration[12, 13].

Bicompartmental knee arthroplasty (BKA),defined as combined medial unicompartmental knee arthroplasty and patellofemoral arthroplasty,has gained increasing clinical acceptance for bicompartmental knee osteoarthritis.It enables simultaneous management of lesions in the medial tibiofemoral and patellofemoral compartments while preserving the lateral compartment and native cruciate ligaments, which facilitates rapid postoperative rehabilitation and exercise[14, 15].In the present study, the BKA group had a significantly shorter operative duration than the TKA group ($P < 0.05$), as well as a significantly shorter length of hospital stay ($P < 0.05$). No significant between-group differences were identified in intraoperative blood loss or the incidence of impaired wound healing.These findings demonstrate the less invasive nature of BKA compared with TKA.At 1 month postoperatively, the BKA group achieved lower VAS and WOMAC index scores and higher KSS scores relative to the TKA group ($P < 0.05$). This observation indicates superior early pain relief and knee functional recovery in patients receiving BKA.Such differences may be attributed to the preservation of native knee anatomy by BKA, with reduced bone resection and soft-tissue dissection. This approach better maintains physiological knee kinematics.Less surgical tissue injury attenuates early postoperative inflammatory response and

painful stimuli, improves patients'subjective tolerance and willingness to participate in rehabilitation, and thereby promotes early postoperative functional exercise[16].

In the present study, the early functional superiority of BKA attenuated progressively at 6 and 12 months postoperatively, with no significant inter-group differences detected in VAS, KSS, WOMAC and range of motion (ROM). Although patients treated with TKA may attain comparable mid-term pain relief, knee function and range of motion following rehabilitation, this observation does not undermine the clinical value of the early benefits conferred by BKA. For candidates undergoing knee arthroplasty, perioperative pain management and early functional restoration are closely correlated with hospital length of stay, early mobilization capacity, fall risk and rehabilitation compliance[17, 18].The superior 1-month outcomes in the BKA group, manifested as lower VAS and WOMAC scores alongside higher KSS values, may enable earlier independent ambulation, structured rehabilitation and recovery of activities of daily living. These advantages conform to the core tenets of enhanced recovery after surgery (ERAS), namely early mobilization, accelerated rehabilitation and timely discharge. Accordingly,the clinical benefits of BKA are predominantly restricted to the early postoperative rehabilitation phase and facilitate physical and psychological recovery, rather than conferring definitive superiority in long-term endpoints[19].For properly selected patients, BKA offers a viable and more streamlined pathway for enhanced recovery.

From a surgical-strategy standpoint, BKA represents a joint-preserving arthroplasty procedure. It addresses degenerative lesions confined to the medial tibiofemoral and patellofemoral compartments while maximally preserving lateral compartment cartilage and native cruciate ligaments, thereby better recapitulating physiological knee biomechanics[20].Nonetheless, BKA carries stringent inclusion criteria and places high requirements on preoperative radiographic evaluation and intraoperative decision-making. Preoperatively, symptoms and degenerative changes must be confirmed to be limited exclusively to the medial tibiofemoral and patellofemoral compartments;severe coronal malalignment and ligament insufficiency should be ruled out.Intraoperative assessment of anterior cruciate ligament integrity, lateral compartment cartilage status and the magnitude of patellofemoral degenerative wear is mandatory.Misjudgment at any stage may precipitate residual postoperative pain or progression of osteoarthritis in unresurfaced compartments[21, 22].In contrast,TKA possesses broader indications and can be applied to complex osteoarthritic knees featuring tricompartmental disease,concomitant ligamentous injury or elevated BMI,serving as a well-established gold-standard procedure[23].Therefore, BKA and TKA should not be viewed as simple substitutes for one another. Instead, they constitute complementary therapeutic strategies for distinct patient cohorts under rigorous indication screening.

Limitations

This study has several inherent limitations. First, it was a single-center retrospective propensity score-matched investigation with a follow-up duration limited to 12 months. Mid-and long-term implant survivorship data were unavailable; therefore, the long-term prosthesis survival rate could not be evaluated. Second, BKA remains a relatively uncommon arthroplasty technique associated with a steep

learning curve. Surgeon experience and strict adherence to surgical indications may directly influence postoperative outcomes. Third, outcome assessors were not blinded to group allocation during data collection and radiographic evaluation, which might introduce potential assessment bias. Our findings regarding early-phase pain relief should therefore be interpreted with caution. Fourth, Propensity-score matching was used to balance measured baseline covariates between groups. Nevertheless, PSM can only adjust for covariates included in the matching model and cannot eliminate confounding derived from unmeasured variables, which may result in residual bias. Additionally, the analytical strategy treating matched participants as independent samples is widely adopted in PSM studies, though it cannot fully exploit information from one-to-one matched pairs. Furthermore, the sample size and number of adverse events in this cohort were relatively small, which may lead to insufficient statistical power for some subgroup comparisons. Hence, the present findings should be interpreted cautiously. Future studies with larger sample sizes incorporating additional endpoints such as rehabilitation compliance and radiographic prosthetic parameters are warranted to achieve more comprehensive assessments.

Declarations

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None.

Author contributions

X.Y.W. was responsible for paper writing, research design, and most of the statistical analyses. B.Q.C. and H.Y.D. were involved in data collection and analytical interpretation. Y.M.L. was involved in the conception and design of the study. L.B.X. participated in research conceptual design and manuscript revision. S.T.S. was involved in data collection and interpretation of analytical results. All the authors approved the final version of the manuscript for publication.

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Availability of data and materials

Related data sets generated during this study are available on request from the corresponding author upon reasonable request.

Ethics approval, consent to participate

This retrospective study was approved by the Ethics Committee of Shanghai Guanghua Hospital of Integrated Traditional Chinese and Western Medicine (approval number: 2026-K-82, approval date: 24 July 2026). All procedures performed in this study were in accordance with the ethical standards of the responsible committee and with the WMA Declaration of Helsinki.

Competing interests

All the authors state that there is no conflict of interest.

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Figures

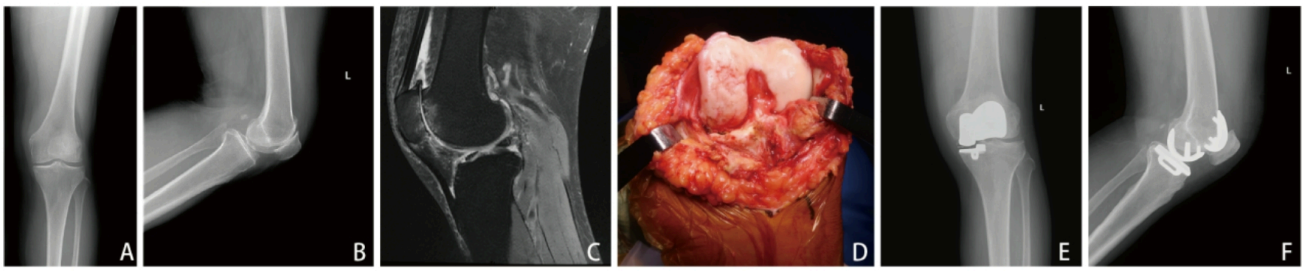


Figure 1

A 71-year-old female with a 5-year history of knee osteoarthritis. Preoperative imaging demonstrated degenerative changes of the medial compartment and patellofemoral joint. Intraoperative exploration revealed an intact and well-preserved anterior cruciate ligament (ACL). Therefore, bicompartmental knee arthroplasty (BKA) was performed. A-B: Preoperative anteroposterior and lateral radiographs of the knee; C: Preoperative sagittal MRI of the knee; D: Intraoperative exploration findings; E-F: Postoperative follow-up radiographs.

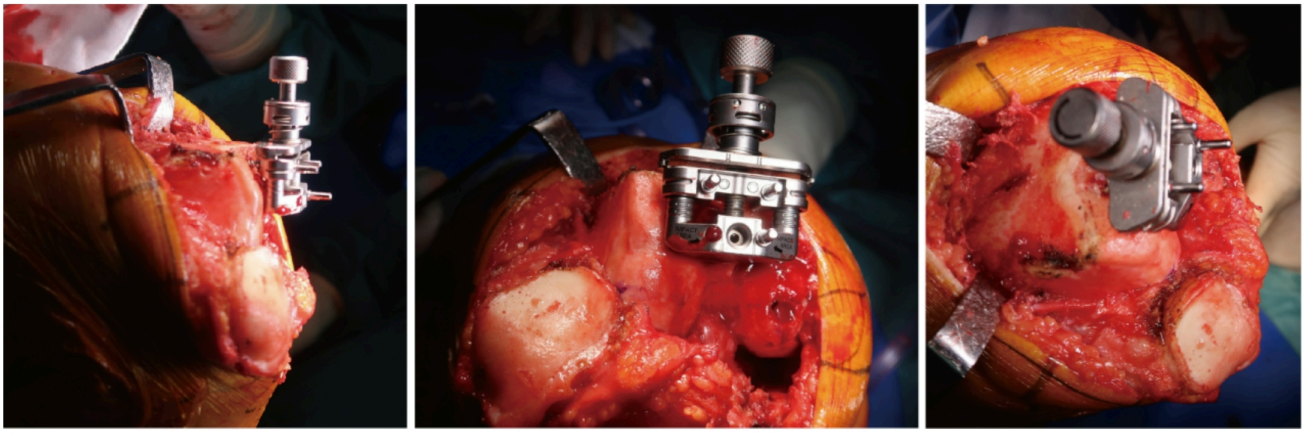


Figure 2

Patellofemoral cutting block used for precise bone resection during patellofemoral arthroplasty.

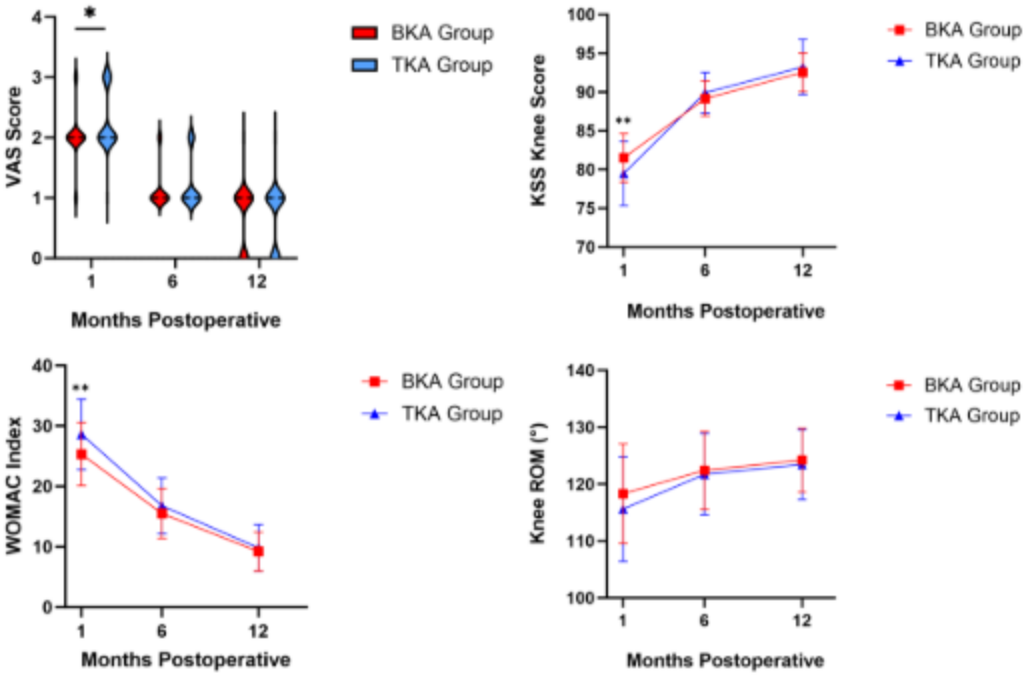


Figure 3

*Changes in VAS, KSS, WOMAC and knee ROM at 1, 6, and 12 months postoperatively in two groups. * P < 0.05, ** P < 0.01.*