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Comparative study of simultaneous and staged bilateral total knee arthroplasty: is age a key factor in surgical outcomes?

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Abstract

Background The present study aimed to compare the outcomes of simultaneous bilateral total knee arthroplasty (simBTKA) and staged bilateral total knee arthroplasty (stgBTKA) across different age groups, with a specific focus on patients under and over 65 years old.

Methods A retrospective cohort study design was employed to analyze the medical records of patients who underwent simBTKA or stgBTKA between August 2018 and May 2023. Patients were categorized into 4 groups based on age and surgical approach. Various outcome measures including knee extension strength, patient-reported outcome measures (PROMs), length of stay (LOS), operating room time (ORT), and complication rates were evaluated.

Results The study included a total of 162 patients, with 48 patients in the simBTKA group and 114 patients in the stgBTKA group. Across all age groups, simBTKA resulted in a significantly shorter LOS and ORT than stgBTKA ($p < 0.05$). However, there were no significant differences in PROMs or in knee extension strength between the two surgical approaches. The complication rates were comparable between the groups, with no reported deaths within one year after surgery.

Conclusion Compared with stgBTKA, simBTKA demonstrated superior efficacy in terms of reduced hospitalization duration and ORT, irrespective of age. Both surgical approaches yielded comparable clinical outcomes and complication rates across all age groups. Overall, the findings suggest that simBTKA is a viable option for appropriately selected patients, offering outcomes comparable to those of stgBTKA, with the added benefit of reduced hospitalization time and operating room utilization.

Keywords Bilateral total knee arthroplasty, Simultaneous surgery, Staged surgery, PROMs

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Introduction

Simultaneous bilateral total knee arthroplasty (simBTKA) is a procedure that is the subject of significant debate due to its implications and potential drawbacks. Studies have highlighted its advantages, such as shorter surgical duration, cost-effectiveness, and increased patient satisfaction [1, 2], with outcomes similar to those of staged bilateral total knee arthroplasty (stgBTKA) [3, 4]. Simultaneous surgery may be preferred when recovery after the first procedure is hindered by severe stiffness and deformity in the opposite knee [5]. Moreover, sequential procedures may increase the risk of complications, especially for those susceptible to challenges such as prolonged recovery and increased infection rates [6]. Nonetheless, there are potential hazards associated with postoperative complications, including inadequate blood loss control and prevention of venous thrombosis [7].

SimBTKA is uncommon, representing only 2 to 7% of all TKAs [8]. The majority of individuals with knee osteoarthritis (OA) experience symptoms in both knees [9]. This indicates that older individuals commonly have knee issues in both knees, which makes them appropriate candidates for BTKA. The demand for and accessibility of simBTKA are anticipated to increase in parallel with the aging population due to factors such as the increasing prevalence of knee OA and advancements in surgical techniques.

Although the American Academy of Orthopedic Surgeons guidelines suggest simBTKA for patients younger than 70 years or those with a score of 1 or 2 on the American Society of Anesthesiologists (ASA) scale [10], there is a lack of consensus about the safety and effectiveness of simBTKA in elderly individuals. Previous studies have examined the outcomes of simBTKA surgery across different age groups [11]. However, none of these studies have directly compared the outcomes of simBTKA surgery and stgBTKA surgery in relation to age. Furthermore, the clinical outcomes did not include a comparison of the Forgotten Joint Score-12 (FJS-12 score), a scoring system that assesses joint perception, and knee extension strength (the chair-rise test) based on age. We compared prosthesis perception, clinical outcomes, knee extension strength, and one-year mortality between patients over and under 65 years of age who underwent either simBTKA or stgBTKA. We hypothesized that the results would be comparable regardless of whether the patients received simBTKA or stgBTKA.

The current study aimed to assess the outcomes of simBTKA and stgBTKA by examining factors such as knee extension strength, patient-reported outcome measures (PROMs) such as the Oxford Knee Score (OKS) and the Short-Form-12 (SF-12), prosthesis perception, and complications in patients aged younger and older than 65 years at the one-year after surgery.

Materials and methods

Study design and patients

The present study employed a retrospective cohort design, utilizing patient medical records duly authorized by the local ethics council and meticulously adhering to the ethical guidelines outlined in the Helsinki Principles. Prior to surgical interventions, all participants provided informed consent.

The study involved participants who received either simBTKA or stgBTKA at one facility from August 2018 to May 2023, utilizing a minimum follow-up period of one year. The current research was conducted on 4 distinct groups, consisting of patients < 65 years who received either simBTKA or stgBTKA and patients ≥ 65 years who underwent either simBTKA or stgBTKA. All patients in the stgBTKA cohort underwent a second operation at least 3 months after the first operation. Prior to considering simBTKA, we evaluated individuals with advanced knee OA who expressed a willingness to undergo the simBTKA procedure. Patients whose medical history, preoperative data, and general health status suggested that simBTKA was inappropriate or who rejected simBTKA were considered to have stgBTKA. The selection criteria for simBTKA at our institution did not consider age. Individuals with cognitive impairment, psychological illnesses, and a history of alcohol or drug addiction or balance disorders were not included in the study. Additional criteria for excluding individuals from the simBTKA group included ischemic heart disease, left ventricular ejection fraction < 40%, body mass index > 40, hemoglobin < 11 g/dl, severe chronic renal disease, and severe chronic obstructive pulmonary disease [12]. Similar exclusion criteria were used for the patients in the stgBTKA group. Moreover, the exclusion criteria for both groups included patients who were either unable to be contacted or who did not participate in the functional score evaluations conducted in the first year after surgery.

Patients underwent a comprehensive screening before being admitted to the hospital, which included assessments such as blood tests, electrocardiograms, chest imaging, hematologic evaluation, anesthesiology consultation, and evaluation of the ASA score [13]. We ensured that during the preoperative anesthesia preparation phase, each patient's hemoglobin level was greater than 11 g/dL. This was a standard measure to ensure adequate hemoglobin levels before surgery. Postoperatively, blood transfusions were considered if a patient's hemoglobin level dropped below 8 g/dL. To determine the total impact of comorbidities, the Charlson Comorbidity Index (CCI) was used [14].

Surgical procedure and follow-up

Anesthesia was administered either by spinal or general procedures. Every patient underwent a cemented TKA (Genesis II, Smith & Nephew, London, UK) either with either a cruciate retaining (CR) or posterior-stabilized (PS) design. The same prosthetic design was implanted into both knees of each patient in the simBTKA group. Patello-femoral resurfacing was not performed in any of the patients. All surgical procedures were performed by senior surgeons. Both of the knees were operated on consecutively under a single anesthetic by the same surgeon for simBTKA. The surgeries were conducted using the same surgical techniques, which included the application of a tourniquet, a conventional medial parapatellar arthrotomy, and the use of cemented implants. Before the surgery, the patient received antibiotic prophylaxis with either cefazolin or clindamycin. From the moment a patient entered the operating room until they left, the total amount of time they spent in the room was recorded as operating room time (ORT) [12]. Tranexamic acid (TXA) was intravenously infused gradually for 30 min before the surgical operation. The dose of the application was determined to be 15 mg/kg of TXA. An additional dose of TXA was administered 15 min before releasing the tourniquet.

All patients received the same postoperative treatment, which included pain relief, physical rehabilitation allowing them to bear full weight immediately, and standard chemoprophylaxis for deep vein thrombosis (DVT) prevention. This typically included low molecular weight heparin (LMWH), continued for a specified duration postoperatively. Additionally, mechanical prophylaxis with sequential compression devices (SCDs) was used, and early mobilization was encouraged to further reduce DVT risk. Every patient underwent regular follow-up, which included a standardized clinical and radiological evaluation during the first year.

Outcome measures

Assessment of knee extensor mechanism function

An evaluation of extensor mechanism function was conducted using the chair-rise test at 6 months and one year after surgery. The participants were seated on a chair that was 40 cm in height. They were then instructed to stand up from the chair without any assistance while keeping their arms crossed over their chests [15]. Each participant was allowed up to three attempts to stand up from the chair. One element of the chair-rise test was assessed using a simple yes or no response: specifically, whether the participant could rise from the chair without using their arms for support. Participants were categorized as either “able” or “unable” to perform this action based on their performance. This binary assessment was used to evaluate the basic functional capacity of the participants.

Assessment of patient-reported outcome measures

One year following the surgery, the OKS, FJS-12, and SF-12 scores were evaluated via in-person and telephone interviews to determine the functional results. The OKS provides a comprehensive 12-question PROM that effectively assesses both pain and function. This tool is widely used due to its easy administration, strong validity and reliability, and excellent patient adherence, even when administered in remote locations [16, 17]. The OKS was rated on a scale from 0 to 48 [17], with <27 being considered poor, 27–33 being considered fair, 34–41 being considered good, and >41 being considered outstanding, based on the Kalairajah categorization [18].

The FJS-12 is a PROM consisting of 12 items that evaluates the patient’s awareness of the constructed joint during different activities of everyday life. Indeed, it signifies the highest point of joint replacements when patients no longer perceive their artificial joint and experience it as if it were a natural joint. The FJS-12 has been extensively validated in several different languages and has been extensively utilized in both clinical practice and research [19].

The SF-12 is a PROM that assesses quality of life. The assessment comprises a total of 12 questions and yields scores for both the physical and mental aspects of well-being, referred to by the names physical component summary (PCS) and mental component summary (MCS). Both the SF-12 PCS and the MCS have a scale that spans from zero (the least level of function) to 100% (the maximum level of function). Studies have demonstrated that the OKS and SF-12 are the most efficient knee-specific and general assessment tools in terms of their ability to correctly evaluate many aspects of knee health, including validity, reliability, and responsiveness [20].

Statistics

The statistical analyses in the study were conducted using the IBM SPSS Statistics 22 (IBM SPSS, Turkey) software. The normality of the parameters was assessed using the Shapiro-Wilk test. Descriptive statistical methods such as the mean, standard deviation, and frequency were employed. Student’s t test was used for comparing quantitative data, while the Mann-Whitney U test was used for comparing parameters that did not exhibit a normal distribution between two groups. The chi-square test, Fisher’s exact test, Fisher Freeman Halton test, and continuity (Yates) correction were used for the comparison of qualitative data. The significance was assessed at a level of $p<0.05$.

Using G*Power software, we conducted a power analysis and found that, given an effect size of **0.31** and a standard deviation of 20.6, the minimum total sample size for Power:0.80 and α:0.05 was n:105.

Results

The present study included 4 different groups, and patients aged < 65 years with simBTKA were classified as Group A (n=25); patients aged ≥ 65 years with simBTKA were classified as Group B (n=23); patients aged < 65 years with stgBTKA were classified as Group C (n=39); and patients aged ≥ 65 years with stgBTKA were classified as Group D (n=75). All four groups experienced no complications during surgery, and there were no reported deaths within one year after the operation. We encountered two cases of DVT in the staged BTKA group, one in the < 65 years group and the other in the ≥ 65 years group, both occurring during the second knee surgery. No DVT cases were observed in the simBTKA group. These patients were managed with therapeutic anticoagulation, using LMWH or oral anticoagulants, and were closely monitored with adjustments made as needed. Table 1 presents the study's demographic data.

The LOS and ORT values of the simBTKA group were determined to be significantly shorter than those of the stgBTKA group (p=0.000; p < 0.05) (Table 2).

Mann Whitney U Test *p < 0.05

A comparison of the simBTKA group based on age revealed that patients under 65 years of age had considerably shorter LOSs and fewer ORTs than did those aged 65 years and older (p=0.000; p < 0.05). However, there was no significant difference between the groups in terms of PROMs (p=0.618, p=0.868, p=0.941, p=0.248, p > 0.05) (Table 3).

Table 1 Demographics of the patients

		Min-Max	Mean ± SD (median)
Age		51–88	67,2 ± 7,34 **(67)**
Body mass index (BMI)		25–32	27,81 ± 1,24 **(28)**
Follow-up (months)		**12–28**	**18,5 ± 3,2 (18)**
Length of stay (LOS) (day) *(median)*		4–10	7,81 ± 1,75 (9)
Operation room time (minutes) *(median)*		110–205	154,6 ± 24,63 (165)
Forgotten joint score (FJS) postop 1-year		89–95	91,88 ± 1,61 (92)
Oxford knee score (OKS) postop 1-year		36–44	40,07 ± 1,72 (40)
Short form-12 Physical Component Summary (SF-12 PCS)		52,5–57,8	55,39 ± 1,77 (55,9)
Short form-12 Mental Component Summary (SF-12 MCS)		52,2–61,6	57,03 ± 3 (57,7)
		n	**%**
Total number of the population		**162**	**100**
Group A	**< 65-Sim BTKA**	25	15,4
Group B	**≥ 65-Sim BTKA**	23	14,2
Group C	**< 65-Stg BTKA**	39	24,1
Group D	**≥ 65-Stg BTKA**	75	46,3
Gender	**Male**	25	15,4
	Female	137	84,6
Surgery Type	**Sim BTKA**	48	29,6
	Stg BTKA	114	70,4
American Society of Anesthesiologists (ASA) Score	**1**	11	6,8
	2	140	86,4
	3	11	6,8
Charlson Comorbidity Index (CCI)	**3**	59	36,4
	4	91	56,2
	5	12	7,4
Post-op Local Complications	**No**	158	97,5
	Hematoma	2	1,2
	Superficial Infection	2	1,2
Post-op Systemic complications	**No**	157	96,9
	DVT	2	1,2
	Pulmonary complications	1	0,6
	Urologic complications	2	1,2
The necessity of transfusion	**No**	156	96,3
	Yes	6	3,7
6-months postop Chair-rise test	**Unable**	7	4,3
	Able	155	95,7
One-year postop Chair-rise test	**Able**	162	100

Table 2 Evaluation of length of stay and operation time parameters according to surgery type

	Simultaneous BTKA	Staged BTKA	P
	(Min-Max)-(Mean ± SD (median))	(Min-Max)-(Mean ± SD (median))	
Length of stay(LOS)(day)	(4–9)-(5,33 ± 0,78 (5))	(7–10)-(8,86 ± 0,61 (9))	**0,000***
Operation room time (minutes)	(110–140)-(119,17 ± 8,08 (115))	(155–205)-(169,52 ± 8,92 (170))	**0,000***

Table 3 Examination of study variables between groups of individuals under 65 years old and those 65 years and older who underwent simBTKA

		< 65 Sim BTKA	≥ 65 Sim BTKA	P
		(Min-Max)-(Mean ± SD)	(Min-Max)-(Mean ± SD)	
Age		(51–64) -(59,72 ± 3,61) **(57)**	(65–81) -(69,78 ± 4,64) **(69)**	[1]**0,000***
Body mass index (BMI)		(25–29) -(27,28 ± 1,06) **(27)**	(26–29) -(27,65 ± 0,83) **(27)**	[1]**0,186**
American Society of Anesthesiologists (ASA) Score *(median)*		(1–2) -(1,72 ± 0,46 (2))	(2–3) -(2,04 ± 0,21 (2))	[2]**0,005***
Charlson comorbidity index (CCI) *(median)*		(3–4) -(3,52 ± 0,51 (4))	(3–5) -(3,83 ± 0,58 (4))	[2]**0,620**
Length of stay (LOS) (day) *(median)*		(4–6) -(5,24 ± 0,6 (5))	(4–9) -(5,43 ± 0,95 (5))	[2]**0,000***
Operation room time (minutes) *(median)*		(110–135) -(118,4 ± 8,98 (115))	(110–140) -(120 ± 7,07 (120))	[2]**0,000***
Forgotten joint score (FJS) postop 1-year *(median)*		(89–95) -(92,12 ± 2,03 (92))	(89–94) -(91,87 ± 1,33 (92))	[2]**0,618**
Oxford knee score (OKS) postop 1-year *(median)*		(38–43) -(40,28 ± 1,57 (40))	(38–43) -(39,91 ± 1,56 (40))	[2]**0,868**
Short form-12 Physical Component Summary (SF-12 PCS) *(median)*		(52,5–57,8)-(55,45 ± 1,6 (56,1))	(52,7–57,6)-(55,46 ± 1,81 (56,5))	[2]**0,941**
Short form-12 Mental Component Summary (SF-12 MCS) *(median)*		(52,2–60,7)-(57,5 ± 2,89 (57,8))	(52,4–61,6)-(57,27 ± 3,04 (57,8))	[2]**0,248**
		n (%)	**n (%)**	
Gender	**Male**	6 (24)	4 (17,4)	[3]**0,419**
	Female	19 (76)	19 (82,6)	
Post-op Local Complications	**No**	25 (100)	21 (91,3)	**0,224**
	Hematoma	0 (0)	1 (4,3)	
	Superficial Infection	0 (0)	1 (4,3)	
Post-op Systemic complications	**No**	24 (96)	23 (100)	[3]**0,521**
	Pulmonary complications	1 (4)	0 (0)	
The necessity of transfusion	**No**	24 (96)	22 (95,7)	[3]**0,734**
	Yes	1 (4)	1 (4,3)	
6-months postop Chair-rise test	**Unable**	0 (0)	1 (4,3)	[3]**0,479**
	Able	25 (100)	22 (95,7)	
One-year postop Chair-rise test	**Able**	25 (100)	23 (100)	-

[1]*Student t Test* → [2]*Mann Whitney U Test* → [3]*Fisher's Exact Test* → [4]*Fisher Freeman Halton Test* *$p<$**0.05**

There were no notable differences in the LOS or ORT or in any of the PROMs assessed in the study, when comparing patients who underwent stgBTKA based on age (under and over 65 years) ($p=0.078$, $p=0.772$, $p=0.740$, $p=0.711$, $p=0.916$, $p=0.337$, $p>0.05$) (Table 4).

A comparison of patients aged 65 years and older who underwent stgBTKA or simBTKA revealed that patients in the simBTKA group had significantly shorter LOSs and lower ORTs ($p=0.000$; $p<0.05$). However, no significant difference was found in any other parameter ($p=0.922$, $p=0.814$, $p=0.980$, $p=0.365$, $p>0.05$) (Table 5).

When examining patients under 65 years of age who received stgBTKA or simBTKA, it was found that the simBTKA group had a notably shorter LOS and ORT ($p=0.000$; $p<0.05$). Furthermore, our research revealed a preference for stgBTKA among female patients and a preference for simBTKA among male patients under 65 years of age ($p=0.034$, $p<0.05$). Nevertheless, there were no notable differences observed in any other parameter ($p=0.494$, $p=0.716$, $p=0.761$, $p=0.527$, $p>0.05$) (Table 6).

Discussion

The current study stands out for its thorough analysis of simBTKA and stgBTKA patients across different age groups. It also includes a comprehensive evaluation of postoperative PROMs (OKS, FJS, and SF-12) and knee extension strength. The primary result of the current research was that, compared to stgBTKA, simBTKA resulted in a shorter LOS and fewer ORTs across all age groups. Furthermore, an evaluation of the most frequently used PROMs in the literature revealed no significant difference between simBTKA and stgBTKA across all age groups. Moreover, the assessment of extension strength at 6 months and one year after surgery showed

Table 4 Examination of study variables between groups of individuals under 65 years old and those 65 years and older who underwent stgBTKA

		< 65 Staged BTKA	≥ 65 Staged BTKA	*P*
		(Min-Max)-(Mean ± SD)	**(Min-Max)-(Mean ± SD)**	
Age		(53–64) -(60,13 ± 3,09) **(60)**	(65–88) -(72,57 ± 5,02) **(72)**	[1]**0,000***
Body mass index (BMI)		(26–32) -(27,95 ± 1,49) **(28)**	(26–32) -(27,97 ± 1,23) **(28)**	[1]**0,929**
American Society of Anesthesiologists (ASA) score$_{(median)}$		(1–3) -(1,92 ± 0,35 (2))	(2–3) -(2,12 ± 0,33 (2))	[2]**0,005***
Charlson comorbidty index (CCI)$_{(median)}$		(3–5) -(3,59 ± 0,55 (4))	(3–5) -(3,8 ± 0,64 (4))	[2]**0,101**
Length of stay (LOS) (day)$_{(median)}$		(8–10) -(9 ± 0,56 (9))	(7–10) -(8,79 ± 0,62 (9))	[2]**0,078**
Operation room time (minutes)$_{(median)}$		(155–190) -(168,59 ± 6,97 (170))	(155–205) -(170 ± 9,8 (170))	[2]**0,772**
Forgotten joint score (FJS) postop 1-year$_{(median)}$		(89–95) -(91,74 ± 1,68 (92))	(89–95) -(91,88 ± 1,52 (92))	[2]**0,740**
Oxford knee score (OKS) postop 1-year$_{(median)}$		(37–43) -(40,13 ± 1,64 (40))	(36–44) -(40,01 ± 1,88 (40))	[2]**0,711**
Short form-12 Physical Component Summary (SF-12 PCS)$_{(median)}$		(52,5–57,8) -(55,44 ± 1,84 (56,1))	(52,5–57,8) -(55,32 ± 1,8 (55,7))	[2]**0,916**
Short form-12 Mental Component Summary (SF-12 MCS)$_{(median)}$		(52,2–61,6) -(57,24 ± 2,87 (57,8))	(52,2–61,6) -(56,68 ± 3,11 (57,5))	[2]**0,337**
		n (%)	**n (%)**	
Gender	**Male**	2 (5,1)	13 (17,3)	[3]**0,124**
	Female	37 (94,9)	62 (82,7)	
Post-op Local Complications	**No**	38 (97,4)	74 (98,7)	[4]**0,569**
	Hematoma	0 (0)	1 (1,3)	
	Superficial Infection	1 (2,6)	0 (0)	
Post-op Systemic complications	**No**	36 (92,3)	74 (98,7)	[4]**0,218**
	DVT	1 (2,6)	1 (1,3)	
	Urologic complications	2 (5,1)	0 (0)	
The necessity of transfusion	**No**	38 (97,4)	72 (96)	[6]**0,577**
	Yes	1 (2,6)	3 (4)	
6-months postop Chair-rise test	**Unable**	0 (0)	6 (8)	[6]**0,076**
	Able	39 (100)	69 (92)	
One-year postop Chair-rise test	**Able**	39 (100)	75 (100)	-

[1]*Student t Test* → [2]*Mann Whitney U Test* → [3]*Continuity (Yates) Correction* → [4]*Fisher Freeman Halton Test*

[5]*Chi-square Test* → [6]*Fisher's Exact Test* **p* < 0.05

no significant difference between the simBTKA and stgBTKA groups.

The duration of ORT in the simBTKA group was shorter than that in the combined duration of staged surgery group. Previous research comparing the duration of surgery between simBTKA and stgBTKA has yielded varying findings. Although Hart et al. [21] reported that patients who underwent simBTKA had a longer surgical time, Ashkenazi et al. [22] reported a shorter surgical time for simBTKA. In a recent study, Franceschetti et al. [12] reported that simBTKA surgeries had a shorter ORT than stgBTKA surgeries, based on the total time in the operating room rather than the surgical time, as in the present study. To provide a more significant measure of efficiency, the current research considered not only the effective surgical time, which is defined as the interval between surgical incision and the outer layer closure but also the total period that passed through the operating theatre from the moment the patient entered until the moment they left. This full-time measurement offers a more significant evaluation of process efficiency [12]. The current study revealed that patients who underwent simBTKA experienced a nearly quarterly reduction in hospitalization duration compared to those who underwent stgBTKA. The majority of prior research on the issue [22–24] has also shown a shorter stay in the hospitals with simBTKA, which further supports the cost viability of the treatment. The shorter LOS and ORT associated with simBTKA can be attributed to several factors. Firstly, simBTKA requires only one anesthesia and recovery period, which reduces the overall perioperative workload. This consolidation minimizes the cumulative effects of anesthesia, pain management, and postoperative care required for recovery, ultimately reducing the LOS. Secondly, by performing both knee replacements in a single session, there is no need for a second hospital admission, reducing the overall hospitalization time. Thirdly, from a surgical perspective, performing two procedures

Table 5 The assessment of parameters in patients aged 65 years and older undergoing simBTKA or stgBTKA procedures

		≥65-simBTKA	≥65-stgBTKA	*P*
		(Min-Max)-(Mean ± SD)	**(Min-Max)-(Mean ± SD)**	
Age		(65–81) -(69,78 ± 4,64) **(69)**	(65–88) -(72,57 ± 5,02) **(72)**	[1]**0,020***
BMI		(26–29) -(27,65 ± 0,83) **(27)**	(26–32) -(27,97 ± 1,23) **(28)**	[1]**0,245**
American Society of Anesthesiologists (ASA) Score$_{(medyan)}$		(2–3) -(2,04 ± 0,21 (2))	(2–3) -(2,12 ± 0,33 (2))	[2]**0,291**
Charlson Comorbidity Index (CCI)$_{(median)}$		(3–5) -(3,83 ± 0,58 (4))	(3–5) -(3,8 ± 0,64 (4))	[2]**0,808**
Length of stay(LOS)(day)$_{(median)}$		(4–9) -(5,43 ± 0,95 (5))	(7–10) -(8,79 ± 0,62 (9))	[2]**0,000***
Operation room time (minutes)$_{(median)}$		(110–140) -(120 ± 7,07 (120))	(155–205) -(170 ± 9,8 (170))	[2]**0,000***
Forgotten Joınt score (FJS) postop 1-year$_{(median)}$		(89–94) -(91,87 ± 1,33 (92))	(89–95) -(91,88 ± 1,52 (92))	[2]**0,922**
Oxford Knee Score (OKS) postop 1-year$_{(median)}$		(38–43) -(39,91 ± 1,56 (40))	(36–44) -(40,01 ± 1,88 (40))	[2]**0,814**
Short Form-12 Physical Component Summary (SF-12 PCS)$_{(median)}$		(52,7–57,6) -(55,46 ± 1,81 (56,5))	(52,5–57,8) -(55,32 ± 1,8 (55,7))	[2]**0,980**
Short Form-12 Mental Component Summary (SF-12 MCS)$_{(median)}$		(52,4–61,6) -(57,27 ± 3,04 (57,8))	(52,2–61,6) -(56,68 ± 3,11 (57,5))	[2]**0,365**
		n (%)	**n (%)**	
Gender	**Male**	4 (17,4)	13 (17,3)	[3]**0,607**
	Female	19 (82,6)	62 (82,7)	
Post-op Local Complications	**No**	21 (91,3)	74 (98,7)	[4]**0,136**
	Hematoma	1 (4,3)	1 (1,3)	
	Superficial Infection	1 (4,3)	0 (0)	
Post-op Systemic complications	**No**	23 (100)	74 (98,7)	[3]**0,765**
	DVT	0 (0)	1 (1,3)	
The necessity of transfusion	**No**	22 (95,7)	72 (96)	[3]**0,664**
	Yes	1 (4,3)	3 (4)	
6-months postop Chair-rise test	**Unable**	1 (4,3)	6 (8)	[3]**0,478**
	Able	22 (95,7)	69 (92)	
One-year postop Chair-rise test	**Able**	23 (100)	75 (100)	-

[1]*Student t Test* → [2]*Mann Whitney U Test* → [3]*Fisher's Exact Test* → [4]*Fisher Freeman Halton Test* *p < **0.05**

consecutively allows for more efficient use of resources and ORT, as there is only one setup and takedown. These process efficiencies collectively contribute to the shorter ORT and LOS observed in simBTKA patients. Therefore, selecting appropriate candidates who can tolerate a more extended initial procedure without increased risks is crucial to maximizing these benefits.

The variation in mortality rates across investigations highlights the complex nature of the decision-making process. Tsay et al. [25] and Chua et al. [26] conducted distinct studies that reported elevated mortality rates in simBTKA patients. However, some studies, such as the one by Lindberg-Larsen et al. [27], suggest that simBTKA did not result in any deaths. This finding is consistent with our own data and implies that there may be certain patient groups or surgical situations in which simBTKA may be considered a safe choice.

A thorough examination of previous simBTKA studies revealed that the orthopedic benefits of simBTKA are particularly evident in selected patient populations [5]. Any remaining discussion will revolve around medical and anesthetic contraindications. At our facility, only individuals who do not have any signs of cardiac or pulmonary illness, who have ASA scores of 1 or 2, and who have bilateral OA that significantly impairs their mobility are considered suitable candidates for simBTKA. For these carefully selected patients, simBTKA offers several orthopedic benefits, such as reduced overall recovery time, faster rehabilitation due to a single surgical event, and a potentially lower risk of complications associated with multiple anesthesia exposures. The ability to address both knees in a single procedure also minimizes the psychological and physical burden on the patient, allowing for quicker return to daily activities and improved overall quality of life. Furthermore, the shorter total hospitalization time and fewer rehabilitation sessions make it a cost-effective choice. The current study revealed that the average age of patients in the simBTKA group was significantly lower than that of patients in the stgBTKA group when analyzing patients older than 65 years. We emphasize the importance of carefully selecting suitable candidates for simBTKA in patients over 65 years of age, given the increased incidence of cardiopulmonary disease with age. Therefore, while simBTKA can provide clear orthopedic benefits such as efficient use of healthcare resources and enhanced patient satisfaction, it

Table 6 The assessment of parameters in patients aged under 65 years undergoing simBTKA or stgBTKA procedures

		< 65 simultaneous BTKA	< 65 staged BTKA	*p*
		(Min-Max)-(Mean ± SD)	(Min-Max)-(Mean ± SD)	
Age		(51–64) -(59,72 ± 3,61) **(57)**	(53–64) -(60,13 ± 3,09) **(60)**	[1]**0,631**
BMI		(25–29) -(27,28 ± 1,06) **(27)**	(26–32) -(27,95 ± 1,49) **(28)**	[1]**0,056**
American Society of Anesthesiologists (ASA) Score$_{(median)}$		(1–2) -(1,72 ± 0,46 (2))	(1–3) -(1,92 ± 0,35 (2))	[2]**0,055**
Charlson Comorbidity Index (CCI)$_{(median)}$		(3–4) -(3,52 ± 0,51 (4))	(3–5) -(3,59 ± 0,55 (4))	[2]**0,658**
Length of stay(LOS)(day)$_{(median)}$		(4–6) -(5,24 ± 0,6 (5))	(8–10) -(9 ± 0,56 (9))	[2]**0,000***
Operation room time (minutes)$_{(median)}$		(110–135) -(118,4 ± 8,98 (115))	(155–190) -(168,59 ± 6,97 (170))	[2]**0,000***
Forgotten Joınt score (FJS) postop 1-year$_{(median)}$		(89–95) -(92,12 ± 2,03 (92))	(89–95) -(91,74 ± 1,68 (92))	[2]**0,494**
Oxford Knee Score (OKS) postop 1-year$_{(median)}$		(38–43) -(40,28 ± 1,57 (40))	(37–43) -(40,13 ± 1,64 (40))	[2]**0,716**
Short Form-12 Physical Component Summary (SF-12 PCS)$_{(median)}$		(52,5–57,8) -(55,45 ± 1,6 (56,1))	(52,5–57,8) -(55,44 ± 1,84 (56,1))	[2]**0,761**
Short Form-12 Mental Component Summary (SF-12 MCS)$_{(median)}$		(52,2–60,7) -(57,5 ± 2,89 (57,8))	(52,2–61,6) -(57,24 ± 2,87 (57,8))	[2]**0,527**
		n (%)	**n (%)**	
Gender	**Male**	6 (24)	2 (5,1)	[3]**0,034***
	Female	19 (76)	37 (94,9)	
Post-op Local Complications	**No**	25 (100)	38 (97,4)	[3]**0,609**
	Superficial Infection	0 (0)	1 (2,6)	
Post-op Systemic complications	**No**	24 (96)	36 (92,3)	[4]**0,458**
	DVT	0 (0)	1 (2,6)	
	Pulmonary complications	1 (4)	0 (0)	
	Urologic complications	0 (0)	2 (5,1)	
The necessity of transfusion	**No**	24 (96)	38 (97,4)	[3]**0,632**
	Yes	1 (4)	1 (2,6)	
6-months postop Chair-rise test	**Able**	25 (100)	39 (100)	-
One-year postop Chair-rise test	**Able**	25 (100)	39 (100)	-

[1]*Student t Test* → [2]*Mann Whitney U Test* → [3]*Fisher's Exact Test* → [4]*Fisher Freeman Halton Test* *p < 0.05

may not be suitable for all patients, especially those with higher anesthetic or surgical risks.

Latifi et al. [28] reported that there was no significant difference between the simBTKA group and the unilateral TKA cohort in terms of functional results or knee consciousness at 2 to 4 years after surgery, which is consistent with the findings of the present investigation. The present investigation assessed OKS and FJS-12 scores, similar to the study conducted by Latifi et al. However, the present study had one-year follow-up period following surgery, while Latifi et al. had a longer follow-up time. With the implementation of simBTKA, Bagsby et al. [29] showed a statistically significant improvement in postoperative functional results, including an increase in the overall range of motion. Husted et al. [30] compared 150 simBTKA patients and 271 unilateral TKA patients and found that the outcomes after three months and two years were comparable in the simBTKA group in terms of satisfaction, range of motion, discomfort, use of walking assistance, and capacity to work and perform daily activities, which aligns with the findings of the present research. However, the prior research did not utilize a verified PROM, as employed in the current study. Franceschetti et al. [12] conducted a study that compared patients with simBTKA and stgBTKA in terms of FJS-12 scores, mortality, and satisfaction. The outcomes in both groups were found to be comparable, consistent with the findings of the present investigation.

No research assessing the extensor mechanism between the simBTKA and stgBTKA groups was found in the literature. In the research of Bakırhan et al. [31], 98% of the participants who underwent simBTKA surgery achieved success in the chair with the CR prosthesis, and 100% of the participants who underwent surgery with the PS prosthesis achieved success in the first year after the surgery. Mahoney et al. [15] conducted a study that revealed that 94% of patients who underwent BTKA were able to independently rise from a chair one year after surgery. Researchers conducted another study using the CR design on patients who had undergone BTKA. The study revealed that all 40 individuals were able to independently rise from a chair at 6 months after surgery [32]. These results are consistent with our research findings. In the present study, we used the chair-rise test, and all patients in each group demonstrated a 100% ability to rise from the chair at both the 6th month and the first year. There was no significant difference between the four groups in terms of extension strength at 6 months or one year after the surgery.

Limitations and strengths

There are several drawbacks to the current study that warrant discussion. First, our study has a retrospective and nonrandomized design, which is known to have certain limitations. This could introduce selection bias, potentially impacting the internal validity of the outcomes. To address this, future research should consider prospective, randomized controlled trials to provide more robust evidence. Second, the decision about whether to send the patients home or to a rehabilitation institution was not based on any standardized criterion. This variability could affect the stated duration of hospitalization and may misrepresent the patients' clinical status. Future studies should implement standardized discharge criteria and rehabilitation protocols to ensure consistency and improve accuracy. However, because this restriction has an equal influence on both groups, it is improbable that it would compromise the accuracy of the ensuing findings. Third, it is important to note that we derived our findings from a limited group of carefully selected individuals who underwent surgery at a specialized center that regularly performs TKA procedures. While this enhances the study's internal validity, it may limit the generalizability of the results. Future research should aim to include a more diverse patient population across multiple centers to validate the findings. An important aspect of the current study is its analysis of the simBTKA and stgBTKA groups based on age, which allows for a more comprehensive understanding of the findings. It is also one of the rare studies that comparatively evaluated postoperative extension strength after simBTKA and stgBTKA surgeries. Another notable aspect of the study is its analysis of specific PROMs, which focus on patients' psychological well-being, awareness of the constructed joint, and overall quality of life.

Conclusions

In summary, compared with stgBTKA, simBTKA demonstrated superior outcomes in terms of reduced LOS and decreased ORT across all age categories. Furthermore, no significant difference was found between simBTKA and stgBTKA across all age groups after examining the most commonly used PROMs in the literature. We believe that the significance of preoperative comorbid conditions outweighs the age of the patient when considering them for the simBTKA procedure. Patient selection is the primary determinant of postoperative morbidity and mortality.

Author contributions

All authors made substantive intellectual contributions in this study to qualify as authors. MY designed this study. MY, HY, MK and FG drafted the manuscript, performed data analysis, and was responsible for manuscript preparation. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Written informed consent was obtained from the participants. Ethical approval was obtained from the research ethics committee of Fırat University (approval number: 2024/06–19).

Consent for publication

Written informed consent for publication of person images was obtained from the participants.

Competing interests

The authors declare no competing interests.

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