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Outcomes of Bilateral Simultaneous Primary Total Knee Arthroplasty with Tibial Stems or Revision Implants

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ABSTRACT

Background: Total knee arthroplasty (TKA) is effective for alleviating pain and restoring function in end-stage arthritis. Simultaneous bilateral TKA (simBTKA) offers benefits such as a single anesthetic, lower costs, and enhanced joint rehabilitation.

Objective: This study aimed to assess the outcomes of simBTKA using patient-specific templating (PST) in patients with unilateral tibial stem or revision implants.

Patients and Methods: Data were prospectively collected through the Egyptian Community Arthroplasty Registry. The study included 120 patients with severe bilateral osteoarthritis who underwent simBTKA with PST. Exclusion criteria included unicompartmental, revision, and bilateral knee replacements without tibial stems. Knee Society Score (KSS) and range of motion (ROM) outcomes were compared between groups using Student's t-test.

Results: The cohort was predominantly female (75%) with a mean age of 65.1 years. There was a significant age difference between the groups (P = 0.026), but no differences in preoperative varus (P = 0.085) or fixed flexion deformities (P = 0.185). No mortality was recorded. Improvement in KSS (P = 0.711) and ROM (P = 0.270) was comparable between groups. Complications were reported in seven patients, with the most severe being a superficial infection requiring debridement and polyethylene exchange.

Conclusion: Tibial stems or revision implants in simBTKA result in satisfactory improvements in KSS and ROM, further supporting the advantages of simBTKA, particularly with PST or similar patient-specific instrumentation.

Keywords: Bilateral simultaneous total knee arthroplasty; simBTKA; Tibial stems; Revision implants.

INTRODUCTION

Knee osteoarthritis is one of the major medical concerns as it influences the walkability and workability of the affected individuals. The incidence of osteoarthritis is variable; however, it was reported to be affecting 48% of the worldwide population [1].

Total knee arthroplasty (TKA) is the standard treatment for end-stage knee osteoarthritis that can manifest with bone loss, ligamentous laxity, leg length discrepancy, bilateral shortening, and limb disfigurement [2]. TKA has also consistently been reported to be the most successful means of relieving pain and restoring function in end-stage arthritis as implant survival after TKA is reported to be around 95% at 15 years and 82% at 25 years [3].

Noteworthy is that patients with end-stage arthritic knees often present with symptoms affecting both joints, warranting a bilateral TKA (BTKA). BTKA can be performed in one operation (simultaneous, TKA simBTKA) or two unilateral TKA (UTKA) operations (staged, TKA staBTKA). SimBTKA has the advantages of a single exposure to anesthesia, less hospitalization duration, easier rehabilitation, and lower cost as compared to staBTKA [4-7].

Contrastingly, staBTKA has lower rates of morbidity and mortality, which can be related to the increased intraoperative time in simBTKA [5,8]. Similarly, performing UTKA may be associated with better outcomes than any BTKA [9].

However, in the developing world (low-and-middle-income countries or LMICs), patients usually present very late when bilateral deformities become well-established [10,11]. These patients are in a deadlock and are usually deprived of the privilege of UTKA as the other arthritic side is still deformed. Moreover, the time difference between the two UTKAs may pose a higher risk for those patients as a postponement of less than 30-90 days is associated with higher systemic complications (such as pulmonary embolism), and more than 90 days are associated with a higher risk of local complications (like, leg length discrepancy and prosthetic wear and tear) [12]. Therefore, there is a need for minimally invasive simBTKA for these patients who usually have multiple comorbidities, such as old age, obesity, diabetes mellitus, hypertension, heart disease, and renal malfunction.

One option to reduce perioperative morbidity and mortality of BTKA is the use of patient-specific instrumentation or templating (PSI or PST, respectively) as surgeons might be able to combat the high rates of complications of simBTKA because PSI/PST eliminate the use of intramedullary guides and reduce the operative time, bleeding, and risk of complications such as fat embolism or infection [13-16].

Moreover, PSI/PST may be more favorable in patients with bilateral severe deformity as this technique aids in retaining near-normal angles, reducing surgical complications, and enhancing the quality of life [5,14,17-20].

And because in our setting (Egypt), patients with knee osteoarthritis typically present late, they usually have bilateral severe arthritis with deformities. Moreover, severe osteoporosis and obesity are common associations in our population [10,11]. Hence, simBTKA may be more appropriate because of bilateral affection and to correct bilateral deformities in one go. The use of

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a revision implant or tibial stem may be required in these patients.

To the extent of our knowledge, no study has reported the use of PSI or its equivalent, PST, using tibial stems or revision implants in simBTKA in the presence of severe deformities. Therefore, this work aims to evaluate the outcomes of simBTKA using PST in patients who had tibial stem or revision implants on one side. The two main objectives of the study are to evaluate the knee function following simBTKA using the Knee Society Score (KSS) and to report the complications that may arise in our sample. Our hypothesis is derived from the fact that various complications such as deep venous thrombosis, pulmonary embolism, and fat embolism may arise from a complex operation, which is simBTKA with one side having previous tibial stem or revision implant.

PATIENTS AND METHODS

Study design

This is a prospective cross-sectional study that was conducted in the Orthopedic Department at the Faculty of Medicine, October 6 University. The reporting of this study was checked against the Strengthening the Reporting of Observational Studies in Epidemiology – The Cross-sectional Version [21].

Participants

We included 120 patients with severe bilateral osteoarthritis. Participants were recruited using the consecutive sampling technique.

Inclusion criteria included adult patients aged above 18 years who had severe knee osteoarthritis confirmed clinically and radiologically, and all patients should have had simBTKA using tibial stems or revision implants.

Exclusion criteria included unicompartmental knee arthroplasty, revision knee arthroplasty, simBTKA using a primary prosthesis with no stem, and patients who had UTKA. All patients were recruited from the Egyptian Community Arthroplasty Register (ECAR) [22].

History taking and clinical examination were properly done for all patients to ensure that they were eligible to receive TKA.

Data collection

The data collected included basic demographics (like age in years, sex, weight in Kg, and height in cm), preoperative data (such as preoperative functional hip score), and postoperative data (for instance, postoperative functional hip score). All patients have undergone weight-bearing X-rays of both hips using the anteroposterior and lateral views.

All patients have undergone weight-bearing X-rays of both knees using the anteroposterior and lateral views. A scanogram of the knee was also done to evaluate the extent of joint damage. An example is presented in figure 1.

And because all patients were operated on using the patient-specific instrumentation (PSI) variant called patient-specific templating (PST), a preoperative knee CT scan was required.

Postoperative care

All the patients had rehabilitation immediately after surgery for stiffness prevention. The spinal epidural anesthesia was given for two days after surgery for pain management. All patients stayed at the hospital for two or three days postoperatively. All patients were discharged and prescribed antibiotics and anti-coagulants for prophylaxis for two weeks and were scheduled for a follow-up appointment at the clinic after six weeks and then after six months. All patients were in good condition at the follow-up and reported no complications.

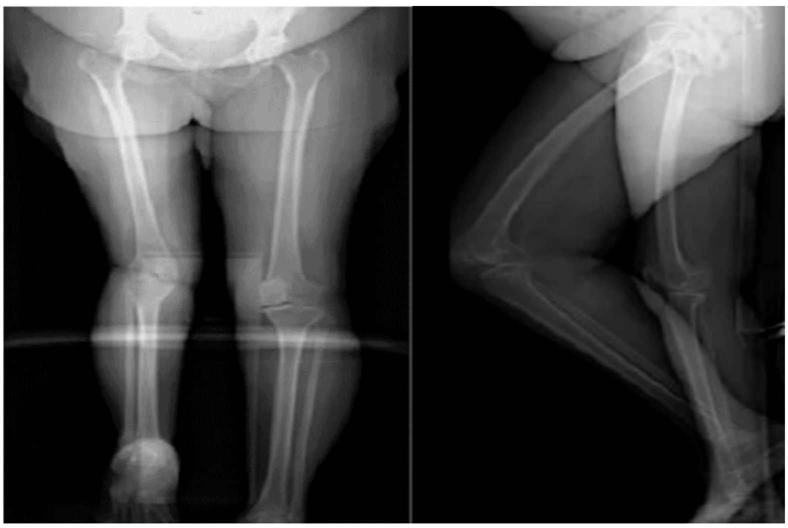

Figure 1. An example of the anteroposterior and lateral scanogram.

Outcome variables

The outcomes of this study were the Knee Society Score (KSS), range of motion (ROM) of the knee joint, varus knee deformity, and fixed flexion knee deformity.

Ethical considerations:

The study was done after being accepted by the Ethical Committee of the October 6 University Hospital. All patients provided written informed consents prior to their enrolment. The consent form explicitly outlined their agreement to participate in the study and for the publication of data, ensuring protection of their confidentiality and privacy. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The statistical analysis of the acquired data was conducted using the Statistical Package for the Social Sciences (SPSS) version 20 by IBM for Windows. We defined numbers and percentages for qualitative data. The Chi-Square test was employed to compare categorical variables. To check if quantitative data was normal, the Kolmogorov-Smirnov test was used. The mean, standard deviation (SD), and range were used to present qualitative data, which were compared by independent t-test in case of comparing the 2 groups, while a paired t-test was utilized to compare preoperative and postoperative variables in the same group. A statistically significant difference between the two groups was indicated by a p-value of less than 0.05.

RESULTS

After applying the inclusion/exclusion criteria to our population, we were able to identify a total of 120 patients that could be included. Three-quarters of the included participants were females (N=90) while the rest (N=30) were males. Nearly half of the sample (57%) had a previous unilateral tibial stem, and the other half (43%) had a previous unilateral implant.

There was a statistically significant difference between the ages of the implant and tibial stem groups. There were no statistically significant differences between the implant and tibial stem groups regarding the angle of varus and fixed flexion deformities (Table 1). Regardless of the degree of deformity, all cases had no postoperative deformity except for one case that had residual varus deformity (Figure 2).

Table 1. Comparison of the basic characteristics of the two studied groups.

	Total (N=120)	**Implant group (N=68)**	**Tibial stem group (N=52)**	**P-value**
Age (years)				
Mean (SD)	65.1 (7.5)	63.7 (6.8)	66.8 (8.1)	0.026*
Range	50.0, 80.0	50.0, 77.0	52.0, 80.0	
Varus deformity degree				
Mean (SD)	13.8 (6.1)	14.1 (5.7)	15.2 (6.2)	0.085
Range	0, 35.0	0, 30.0	0, 35.0	
Fixed flexion deformity degree				
Mean (SD)	12.0 (7.1)	11.3 (7.0)	13.0 (7.1)	0.185
Range	0, 35.0	0, 35.0	0, 30.0	

*: Significant, SD: Standard deviation.

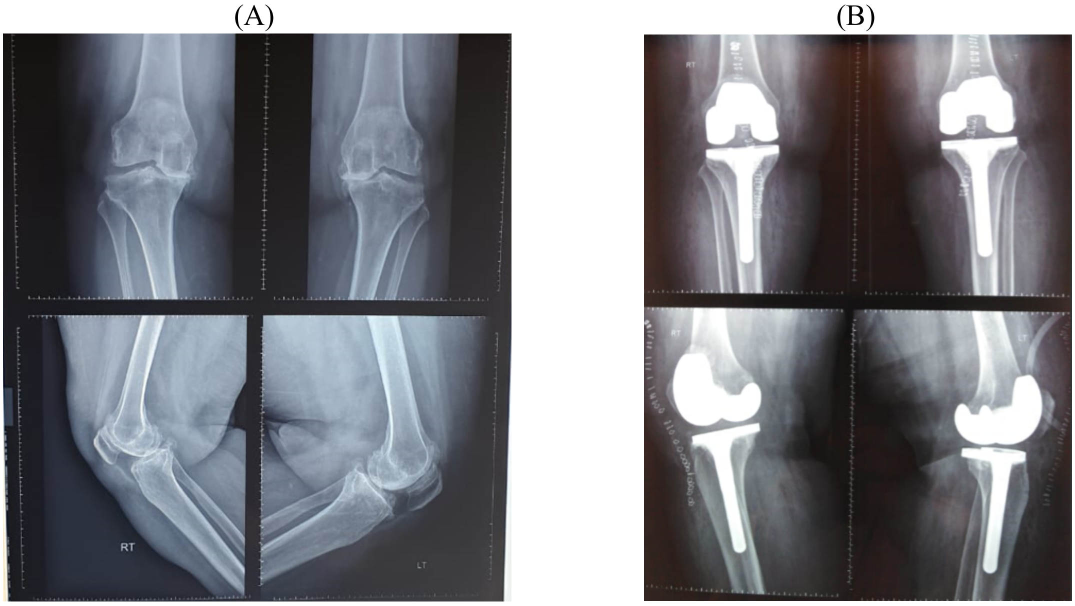

Figure 2. Preoperative (A) and postoperative (B) radiographs of one of the patients who had severe varus deformity.

All participants had improved KSS from 32.2 (SD=10.1) preoperatively to 98.0 (SD=2.2) postoperatively. There were no statistically significant differences between the tibial stem or implant groups in the preoperative, postoperative, or improvement values. Similarly, all participants had improved ROM with no differences between the two groups (Table 2).

Table 2. Comparison of the preoperative, postoperative, and improvement values of the Knee Society Score (KSS) and range of motion (ROM) of the two studied groups.

	Total (N=120)	**Implant group (N=68)**	**Tibial stem group (N=52)**	**P-value**
Preoperative KSS				
Mean (SD)	32.2 (10.1)	33.2 (9.7)	30.9 (10.6)	0.237
Range	14.0, 50.0	14.0, 50.0	15.0, 49.0	
Postoperative KSS				
Mean (SD)	98.0 (2.2)	98.2 (2.1)	97.8 (2.3)	0.235
Range	92.0, 100	93.0, 100	92.0, 100	
KSS improvement				
Mean (SD)	65.8 (10.2)	65.1 (9.7)	66.8 (11.0)	0.711
Range	44.0, 84.0	49.0, 84.0	44.0, 82.0	
Preoperative ROM				
Mean (SD)	78 (18)	80 (16)	76 (21)	0.237
Range	35, 120	45, 120	35, 120	
Postoperative ROM				
Mean (SD)	117 (12)	119 (12)	116 (11)	0.191
Range	85, 140	95, 140	85, 130	
ROM improvement				
Mean (SD)	39 (18)	39 (16)	40 (22)	0.270
Range	5, 85	5, 70	5, 85	

SD: Standard deviation, ROM: Range of motion, KSS: Knee Society Score.

Only seven patients (two males and five females) experienced complications. One had a periprosthetic fracture two months after surgery, and it was managed with screws and plate fixation. The second patient had twisted her knee and tilted the tibial component, which was managed conservatively. The third patient had a right lower limb deep venous thrombosis (DVT) that resolved without further complications. The fourth patient was readmitted for severe anemia (<8 mg/dL) two weeks after surgery, and she received two units of packed RBCs. This patient also reported dissatisfaction because she had residual varus deformity. The fifth patient fell in the bathroom two days after surgery, ruptured her patellar tendon, and got it repaired. The sixth patient had aseptic loosening. The last patient had a superficial infection and had debridement and polyethylene exchange (Table 3).

Table 3. The frequency of complications in the studied groups.

	Implant group (N=68)	**Tibial stem group (N=52)**
Aseptic loosening	1	0
DVT	0	1
Patellar tendon rupture after a fall in the bathroom	0	1
Periprosthetic fracture	1	0
Residual varus deformity	1	0
Superficial infection	0	1
Severe anemia requiring transfusion	1	0
Tilting of the tibial component	1	0
Total	5 (7%)	3 (6%)

DVT: Deep venous thrombosis.

DISCUSSION

In this study, we aimed to measure the outcomes of using tibial stems or revision implants in patients undergoing simBTKA using PST. All 120 patients had significant increases in KSS and ROM with no differences between the two groups. We reported no implant failure in the first two years and only one major complication requiring revision surgery.

The success rate of knee arthroplasty depends on many factors, including patient selection, implant design, preoperative condition of the joint, surgical technique, incidence of complications, and rehabilitation [23]. Controversy exists on the applicability of simBTKA due to variable outcomes related to postoperative complications. Several reports showed that this procedure has similar outcomes to single-sided or staBTKA but with higher complication rates such as fat embolism, mortality, infection, bleeding, and DVT [24]. Other studies have documented that despite the younger age and lower comorbidity burden of patients undergoing simBTKA, the rate of complications and early mortality was higher than UTKA, which could be described as a result of the increased tourniquet time and the higher risk of developing fat embolism syndrome [8].

Ritter *et al.* have found that the 30-day mortality rate of BTKA performed 3–12 months apart was 0.29%–0.36% compared to 6 weeks apart (0.48%). In the same study, the mortality rate for simBTKA was 0.99% (significantly higher) [25]. **Memtsoudis *et al.*** found that staBTKA done a few days apart during the same hospitalization does not affect the mortality rate but may increase the risk for perioperative complications. However, the authors were unable to compare the outcomes of patients who had two TKAs performed during different hospitalizations [26]. **Bohm *et al.***, comparingly, concluded that UTKA is safer than simBTKA and staBTKA. Even when the simBTKA group was younger and had no fewer comorbidities than the two other groups, the former received more blood transfusions and suffered more from in-hospital mortality [9]. In a smaller sample size of 115, UTKA was superior to simBTKA regarding functional outcomes [27].

On the other hand, simBTKA was found to have the advantages of a single hospital stay and exposure to anesthesia, shorter accumulated operative time and rehabilitation period, lower rate of blood loss, and more cost reduction [28,29]. **Chen *et al.*** reported that the mean cumulative operating time and length of hospital stay were both shorter with simBTKA by 22.5 minutes (P < 0.001) and three days (P < 0.001), respectively, compared to staBTKA [8]. **Spicer *et al.*** compared simBTKA to UTKA; both done with conventional technique. The results indicated that simBTKA was safer depending on the surgeon's experience, hospital setup, paramedical staff collaboration, and ready access to postoperative rehabilitation [30]. In 2019, **Liu *et al.*** published their systematic review and meta-analysis that included 18 studies comparing 73617 to 61838 participants in the simBTKA and staBTKA groups respectively. The results of this study were non-inferiority of simBTKA to staBTKA. Moreover, they encouraged choosing which procedure to do under the different circumstances present with each case [5].

Computer-assisted surgery (CAS) may even offer more satisfying results in this matter. In 2013, staBTKA using CAS was reported to have a longer operative time than conventional UTKA. Furthermore, there were no differences regarding the Knee Society Score, postoperative anatomical alignment, mechanical axis, or tibial angle [31]. Another study reported the same outcomes but with less blood loss in favor of the CAS group [32]. However, **Zhang *et al.*** conducted a randomized controlled study on patients undergoing simBTKA and found that navigation provided coronal alignment of 3° from the mechanical axis, which is significantly better than conventional TKA [33].

In the current study, the authors used PSI for simBTKA, where there is no perforation of the intra-medullary canals to reduce the risk of complications. The preoperative presentation with flexion deformity masked the degree of valgus that was revealed intraoperatively after correcting the flexion deformity. For educational reasons, the surgeon used the extra-medullary guide of the conventional instrumentation system in some cases to compare and double-check the positioning of the tibial PSI cutting block. However, femoral or tibial intramedullary guides were never used. In the authors' view, simBTKA using PSI is a minimally invasive surgery that is capable of correcting both deformities at the same onset. It is good for patients with severe intra-/extra-articular deformities and high bleeding tendencies, together with those seeking shorter rehabilitation [34]. Moreover, PSI seems more advantageous for eliminating intramedullary guides and the potential perforation of the intramedullary canal as well as the more accurate planning.

The limitations of this study are the relatively small sample size. However, we argue that it is hard to find patients with severe deformities and comorbidities. Another limitation is the significant difference in the number of males compared to females, which means that future studies should aim for a more balanced gender representation. Moreover, the relatively small sample size and the unequal gender representation hinder the ability to adjust for confounders. Therefore, future studies need to ensure that they adjust for confounders using the appropriate regression models. There is also no control group. The use of different implants is another variable. These limitations need to be considered before making any conclusions. More comparative studies, systematic reviews, and meta-analyses are needed to determine whether PSI improves outcomes in simBTKA and staBTKA.

CONCLUSION

This study showed that doing simBTKA with a bilateral tibial stem or using a revision implant on one side is a practical option if PST is utilized. The complication rates in such cases are comparable to those reported in the literature. Having said that, the authors do not recommend the use of bilateral revision implants while doing simBTKA. This is because entering the femoral and tibial medullary canals on both sides poses an extremely high risk of fat embolism that could be fatal. The use of PST in this study eliminated the violation of the conventional intramedullary guides, thus reducing the risk of fat embolism.

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