



Are unilateral or staged bilateral total knee arthroplasty really safer than simultaneously bilateral TKA, or is it a myth?

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The purpose is to evaluate feasibility of simultaneous TKA in comparison with staged and unilateral procedures.

Number of patients included: 72 simultaneous bilateral, 61 staged bilateral and 222 unilateral TKAs were included.

The mean age in the simultaneous group was lower than the other groups. Heart failure as comorbidity was observed less in the simultaneous TKA group than the other two groups. There was no significant difference between simultaneous and staged groups with respect to postoperative WOMAC and SF36 scores. Rates of thrombotic complications and mortality were not different. There was no significant difference in terms of wound healing, periprosthetic infection and TKA revision rates.

Younger age and heart failure as a comorbidity were found to be decisive in the selection of simultaneous procedure. Thus, in the case of advanced bilateral knee osteoarthritis, simultaneous bilateral TKA should be performed after a proper preoperative risk assessment when there is a medical rationale, or the patient's personal preference. In the light of aforementioned conditions, hesitancy about simultaneous TKA seems unnecessary.

Keywords : knee arthroplasty, simultaneous, staged, unilateral, bilateral.

INTRODUCTION

Approximately two thirds of knee osteoarthritis affects joints bilaterally, and bilateral TKA

operation is performed either simultaneously or in a staged manner (11). Simultaneous bilateral TKA is preferred by a remarkable number of orthopaedic surgeons (5,15,18,25). There are some advantages of the simultaneous procedure: it requires only one anaesthetic session, and it offers a faster recovery time than the sum of two individual operations. Moreover, it has been recently reported that mortality and complication rates of the simultaneous procedure are decreasing (5,16,27,32,40). However, mortality and complication rates of the staged and unilateral procedures are reported to be lower than those of the simultaneous procedure by many studies (11,12,15,19,21,23,26,28,31,36). Therefore, the safety of simultaneous bilateral TKA is under debate; and patient selection for the simultaneous procedure is essential (18,26,30,39). In fact, there are valid reasons for preferring simultaneous bilateral TKA. In the case of bilateral advanced knee deformities, postoperative mobilization will be

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difficult if the staged procedure is preferred; and if the second TKA operation is performed after a long period, early implant loosening in the previous knee may occur (30). For patients and their relatives, the staged procedure means that they have to make time for two separate operations, and that they have to go through the painful postoperative period again and become distanced from work (26). Besides, it has been reported in many studies that simultaneous bilateral TKA is cost effective when compared with the staged procedure (12,17,18,25,21,29,35).

The objective of the current study was to evaluate feasibility of simultaneous TKA in comparison with staged and unilateral procedures.

PATIENTS AND METHODS

Simultaneous bilateral, staged bilateral and unilateral TKAs performed between January 2009 and October 2013 were evaluated. Patients who had preoperative ligament instability, or prior major surgical treatment of fractures including knee joint, and patients with inflammatory arthritis were excluded. After the exclusion criteria were applied, the study group consisted of 434 patients. In October 2015, these patients were recalled. 49 patients dropped out of the follow-up program due to change of address. We checked whether these patients were alive or dead from population registry administration using their identification numbers. There was no death among these patients in the first postoperative year. Patients who had staged operations longer than one-year period were excluded. There were 72 patients (19 males, 53 females) in the simultaneous, 61 patients (17 males, 44 females) in the staged and 222 patients (60 males, 162 females) in the unilateral group in the present study. The method of patient inclusion is described in Figure 1.

All the patients who underwent TKA were suffering from advanced stage knee osteoarthritis unresponsive to conservative treatment methods. These patients had been feeling permanent pain for at least a year until the operation. Demographic features and body mass index (BMI) of all study participants were recorded. Additionally, pain, skeletal deformities, knee range of motion (ROM),

contractures and functional status were also evaluated in accordance with Knee Society score and WOMAC. Radiographies were evaluated using the Ahlbäck grading system (1) and patients who underwent TKA were assessed to be grade 3 or over. All the patients were assessed in terms of comorbidity. Consultations were performed in collaboration with the relevant departments. ASA score was used for risk assessment. Operations assessed to be ASA 4 were cancelled, and they were treated in consultation with the relevant departments. In case the risk was lessened, operation was considered. Antibiotic prophylaxis was performed with Cefazolin 1 gr IV 2 hours before the operation.

Anaesthesia methods were evaluated for each group (Table 1). As posterior cruciate retaining prosthesis, Apex CR Knee (OMNI life science, East Taunton, USA) was used. As posterior stabilized prosthesis, Hipokrat 2000 PS (Hipokrat, Izmir, Turkey) was used. Tourniquets were used in all operations and inflated one after the other in the simultaneous procedure. Surgical exposure was performed via midline incision and midvastus approach for all knees. Patellar resurfacing was not performed. All prostheses were performed using cemented implants.

Table I. — Anaesthesia methods

	Spinal block	Combined spinal epidural block	General anaesthesia
Simultaneous group (n=72)	10 (%14)	45 (%63)	16 (%22)
Staged group (n=122)	78 (%64)	32(%26)	10 (%8)

Postoperative complications, the quantity of RBC transfusion, and hospitalization period were calculated by sum of two procedures in the staged procedure. RBC transfusion was performed if the hemoglobin value was below 8 g/dl. If symptoms of anemia were found in hemoglobin values (8 to 10 g/dl), RBC transfusion was performed. Ankle pump exercise and ice therapy were started immediately on the postoperative day. Passive knee exercises with CPM, isometric quadriceps

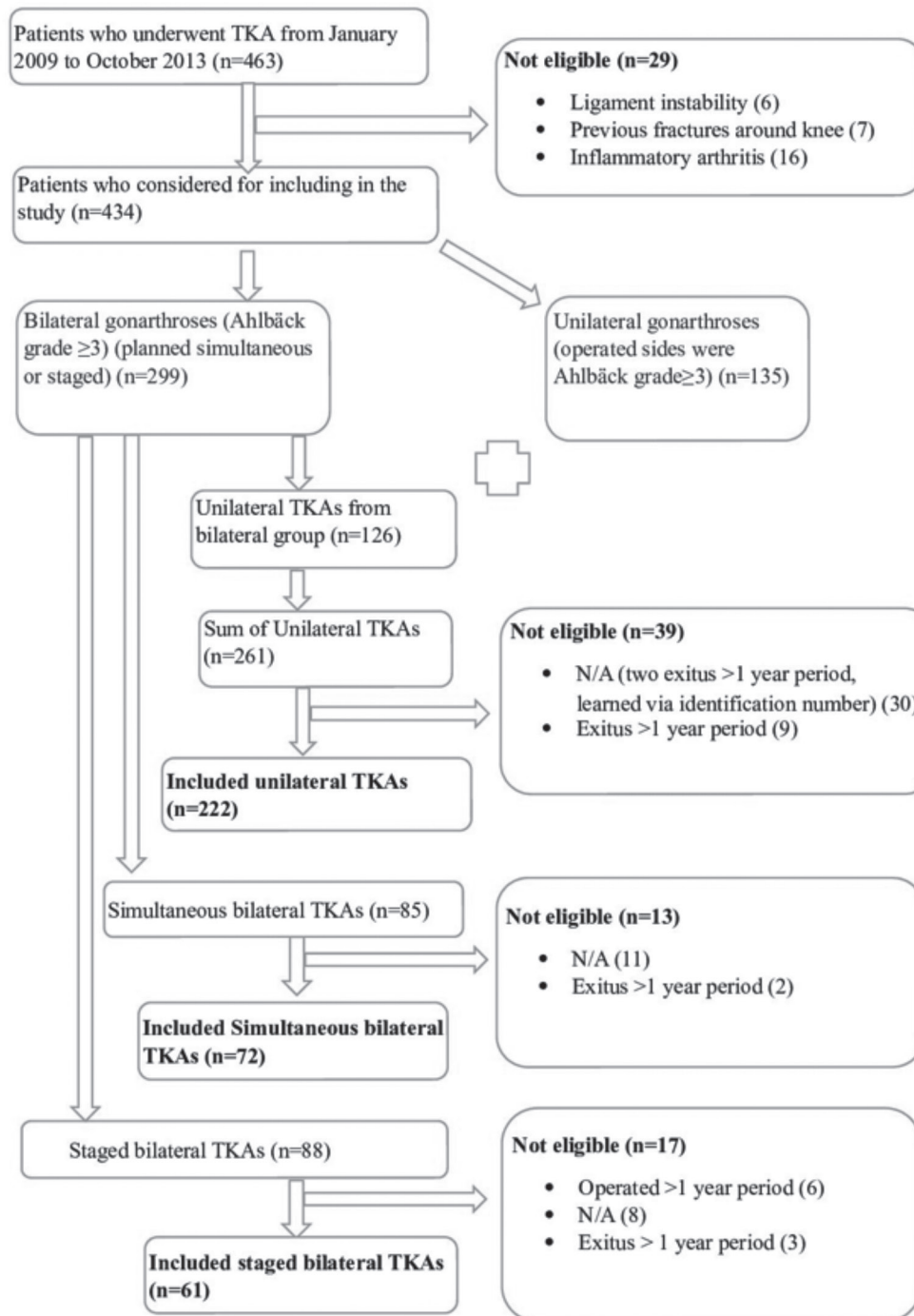


Fig. 1.— The method of patient inclusion. TKA; Total Knee Arthroplasty, “N/A; not available” was used for unavailable patients due to change of addresses.

exercises, straight leg raise exercises were started on the first postoperative day. After sitting on the bed and bedside, patients were mobilized using a

walker in the afternoon on the first postoperative day. Low molecular weight heparin was used for thromboembolism prophylaxis in the same manner

for each groups. 40 mg/0.4 ml enoxaparin sodium (clexane 4000 anti-Xa/ 0.4ml pre-filled syringes, Sanofi Aventis) was given subcutaneously 12 hours after the operation and continued once a day for 3 weeks; morbid obese patients were given 60 mg/0.6 ml enoxaparin sodium (clexane 6000 anti-Xa/ 0.6 ml pre-filled syringes, Sanofi Aventis). These patients were followed at the outpatient clinic in the first postoperative month, third month, sixth month, the first year and annually. There were at least 45 days between the two operations of staged procedure. The minimum follow-up time was 24 months for all patients except those who died during the follow-up and those who underwent a revision TKA (in the 15th month in simultaneous group and in the 10th and 19th months in the staged group).

Simultaneous and staged groups were evaluated using WOMAC (37) and Knee Society Score (14) as a disease specific scale preoperatively and at the last postoperative follow-up visits. These two groups were evaluated using The Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System at the final follow-up visit (8). SF 36 survey was performed as a generic measure at the final follow-up visit (9).

Radiographic assessment was performed via orthoroentgenograms, Rosenberg views, standard antero-posterior and lateral views. In addition, the merchant views were obtained in the final follow-up visit. AP femoral angle (α), AP tibial angle (β), Lateral femoral angle (γ), Lateral tibial angle (δ), Valgus angle and patellar tilt were evaluated at the last control. The following were considered to be a marker of loosening: a radiolucent line thicker than 2 mm around the entire circumference of the prosthesis, collapse of the component, or a newly developing alignment deformity when compared with previous radiograph (2).

Statistical analyses were performed using SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY). Kolmogorov-Smirnov Test was used to assess whether the data were normally distributed or not. Wilcoxon signed-rank test was used to compare KSS and WOMAC scores between the dependent groups. Mann-Whitney U Test was used to compare KSS and WOMAC score between

the independent groups. Simultaneous, staged and unilateral groups were compared in terms of age, BMI, ASA score and follow-up time using Kruskal-Wallis non-parametric variance analysis. Comorbid diseases, postoperative complications and mortalities were compared using Pearson's Chi-square if the expected count was >5 , and Two-Sample Kolmogorov-Smirnov Test if the expected count was <5 . Anaesthesia methods was compared using Pearson's Chi-square Test. A p-value of <0.05 was considered to be statistically significant.

RESULTS

Mean age was 65.41 ± 5.9 in the simultaneous group, 69.07 ± 6.57 in the staged group and 67.3 ± 6.5 in the unilateral group. Mean age in the simultaneous group was lower than the other two groups ($p = 0.009$). There was no statistically significant difference in terms of BMI, ASA score and follow up time (Table II). When the three groups were evaluated in terms of comorbid diseases, heart failure was observed less in the simultaneous group than in the other groups ($p = 0,04$) (Table III). Quantity of red blood cell (RBC) transfusion was 1.6 ± 0.78 (1-4) units in the simultaneous group and 0.72 ± 0.71 (0-3) in the staged group, ($p < 0.001$). Postoperative length of stay in hospital was 7.1 ± 1.73 (5-17) days and 10.6 ± 2.0 (8-19) days in the simultaneous and staged groups, respectively ($p < 0.001$).

When simultaneous and staged groups were compared in terms of the intra-group Knee Society and WOMAC scores, there were statistically significant differences between the preoperative and postoperative scores in each group. Mean postoperative Knee Society score was 84.1 ± 7.6 and 83.4 ± 6.3 points in the simultaneous group and the staged group, respectively. ($p = 0.02$) In preoperative assessment, the mean WOMAC functional scale score was 59.6 ± 3.6 and 58.5 ± 3.0 points in the simultaneous group and the staged group respectively ($p = 0.02$). There was no difference in terms of the postoperative WOMAC functional scale between the two groups. No statistical differences were found in knee society functional score, the WOMAC pain score and the

Table II. — Comparison of three groups in terms of age, BMI, ASA score and follow up time

	Age	BMI	ASA score	Follow up time
Simultaneous group (n=72)	65.41 ± 5.9 (51-79)	31.87 ± 3.9	median:2 (1-3) mean:2.3 ± 0.5	58.6 ± 136 (15-84)
Staged group (n=61)	69.07 ± 6.57 (54-83)	32.09 ± 3.8	median :3(1-3) mean:2.5 ± 0.6	55.8 ± 15.0(24-83)
Unilateral group (n=222)	67.3 ± 6.5 (54-85)	32.56 ± 2.52	median:2(1-3) mean:2.4 ± 0.6	57.17 ± 12.8(10-84)
p	0.009	0.287	0.279	0.360

BMI; body mass index, ASA; American Society of Anaesthesiologists.

Table III. — Distribution of comorbid diseases in three groups

	Simultaneous group (n=72)	Staged group (n=61)	Unilateral group (n=222)	P
Hypertension	37 (51%)	34 (56%)	109 (49%)	0.65
Diabetes mellitus	19 (26%)	20 (33%)	63 (28%)	0.71
Heart failure	6 (8%)	15 (24%)	36 (16%)	0.04
Coronary artery disease	2 (3%)	5 (8%)	16 (7%)	0.89
Cerebrovascular disease	-	3 (5%)	7 (3%)	0.79
Parkinson	1 (1%)	2 (3%)	9 (4%)	0.99
Hyperthyroidism	1 (1%)	-	3 (1%)	1.00
Hypothyroidism	4 (5%)	3 (5%)	15 (7%)	1.00
Chronic renal failure	-	2 (3%)	4 (2%)	0.96

Table IV. — Comparison of KSS and Womac scores in simultaneous and staged bilateral TKA

	KSS1	KSS2	KSSF1	KSSF2	WP1	WP2	WS1	WS2	WPh1	WPh2
Simultaneous (n=71)	29.5 ± 7.2	84.1 ± 7.6	28.8 ± 10.3	83.6 ± 7.9	17.7 ± 1.7	4.6 ± 2.4	4.3 ± 1.4	2.8 ± 0.9	59.6 ± 3.6	22.2 ± 6.8
Staged (n=60)	28.7 ± 7.4	83.4 ± 6.3	29.3 ± 8.5	82.3 ± 10.1	17.8 ± 1.6	4.5 ± 2.6	4.4 ± 1.5	2.9 ± 0.9	58.5 ± 3.0	21.6 ± 8.0
P	0.24	0.02	0.89	0.55	0.45	0.53	0.73	0.32	0.02	0.41

KSS1; preoperative Knee Society Score, KSS2; knee society score at the last follow up visit, KSSF1; preoperative Knee Society Functional Score, KSSF2; Knee Society Functional Score at the last follow up visit, Knee society Scores of 80 to 100 were rated as excellent, 70 to 79 good, 60 to 69 fair, and less than 60 poor.

WP1; preoperative Womac Pain score, WP2; Womac Pain Score at the last follow up visit, WS1; Preoperative Womac Stiffness score, WS2; Womac Stiffness Score at the last control follow up visit, WPh1; Preoperative Womac Physical function score, WPh2; Womac physical function Score at the last follow up visit. The WOMAC index (37) is a disease specific measure and includes 24 questions. These questions were grouped into three subscales; namely, pain (20 points), stiffness (8 points), and physical function (68 points). Higher scores demonstrate poor results.

WOMAC stiffness score in the preoperative and the postoperative assessments of the simultaneous and staged groups (Table IV). There were no differences with respect to all SF 36 subscales between the two groups (Table V).

According to the American Knee Society Radiographic evaluation system, AP tibial angle (β) was $88.2 \pm 1.77^\circ$ and $87.7 \pm 1.7^\circ$ in the simultaneous and staged groups, respectively ($p = 0.03$). Lateral femoral angle (γ) was $3.91 \pm 1.76^\circ$ and $3.34 \pm 1.58^\circ$ in the simultaneous and staged groups, respectively ($p = 0.004$). There were no differences in terms of AP femoral angle (α) and valgus angle between the groups (Table VI). There were no significant radiographic signs of implant loosening at the last follow up visit.

for two months in the intensive care unit. One patient in the unilateral group died in the second month due to myocardial infarction. There was no difference in terms of thrombotic complications (Table VII).

Irrigation and debridement were performed on one patient in the simultaneous group, one patient in the staged group and two patients in the unilateral group due to increasing erythrocyte sedimentation rate and C-reactive protein levels in patients with infection symptoms. These patients also underwent polyethylene insert exchange. One patient in the simultaneous group and two patients in the unilateral group underwent a revision TKA due to periprosthetic infection. There were no differences with respect to haematoma and

Table VI. — Comparison of simultaneous and staged groups according to American Knee Society Radiographic evaluation system

	AP femoral angle (α)	AP tibial angle (β)	Lateral femoral angle (γ)	Lateral tibial angle (δ)	Valgus angle	Patellar tilt (lateral)
Simultaneous (n=142)	94.45±2.27	88.2±1.77	3.91±1.76	87.41±1.47	2.79±2.22	3.88±3.10
Staged (n= 120)	94.18±2.12	87.7±1.7	3.34±1.58	87.12±1.35	2.44±2.23	4.13±3.34
P	0.35	0.03	0.004	0.06	0.24	0.15

AP; anteroposterior

Table VII. — Thrombotic complications and mortality

	Simultaneous (n:72)	Staged (n:61)	Unilateral (n:222)	P
PTE	2 (2F)	1 (F)	3(2F,1M)	1.00
DVT	3(2F,1M)	2(2 F)	4(2F,2M)	0.92
First year mortality	1 (MI), (M), at 6th month	1 CVH (F), at 5th month	1(MI) (F), at 45th day	0.96

During hospitalization period, pulmonary thromboembolism (PTE) was observed in two patients in the simultaneous group, one patient in the staged group and three patients in the unilateral group. These patients were followed at intensive care unit and treated successfully. One patient in the simultaneous group died in the sixth postoperative month due to acute myocardial infarction. There was one death in the staged group in the first year due to cerebrovascular hemorrhage. This patient was hospitalized in the intensive care unit in the third month, and she died after being hospitalized

periprosthetic infection occurrences (Table VIII).

According to the Knee society functional score, the rate of excellent results (80-100 points) was 124/142 (87%) in the simultaneous group and 104/120 (86%) in the staged group, good results (70-79 points) 9/142 (6%) in the simultaneous group and 8/120 (7%) in the staged group, medium results (60-69 points) 7/142 (5%) in the simultaneous group and 6/120 (5%) in the staged group, poor results (< 60) 2/142 (1%) in the simultaneous and 2/120 (2%) in the staged group. One patient with poor results in the simultaneous

Table VIII. — Comparison of groups with respect to complications of wound healing and TKA revision rates

	Simultaneous (n:142)	Staged (n:120)	Unilateral (n:221)	p
Hematoma	8 (7F,1M)	7 (5F,2M)	18(14F,4M)	0.57
Superficial infection	7 (5F,1M)	9 (6F, 3M)	13(11F,2M)	0.68
Irrigation and debridement, polyethylene insert exchanging due to periprosthetic infection	1 (F) (4 th month)	1 (1M) (2 nd month)	2 (2F) (2 nd , 3 rd months)	1.00
Revision due to periprosthetic infection	1 (15 th month) (1 F)	-	2 (10 th ,19 th months) (1F,1M)	0.85
Revision due to aseptic loosening	1 (43 rd month) (M)	2(38 th ,70 th months) (2F)	4(53 rd ,54 th ,79 th ,82 nd months) (3F,1M)	0.74

F; female, M; male

group underwent a two-staged revision TKA (after antibiotic cement spacer procedure and intravenous antibiotic treatment) in the 15th month. Another patient with poor results in the simultaneous group underwent a revision TKA in the 43th month due to aseptic loosening. Two patients with poor results in the staged group underwent revision TKA in the 38th and 70th months due to aseptic loosening. There were 4 patients in the unilateral group who underwent revision TKA due to aseptic loosening (Table VIII).

For the patients who could not comply with performing exercises on their own, consultation from physical therapy unit was needed at a rate of 12/72 (17%) in the simultaneous group and 13/61 (21%) in the staged group ($p = 0.49$).

Intervals of two operations in the staged group were as follows: 16 patients in 1.5-3 months, 26 patients in 3-6 months, 19 patients in 6-12 months. With respect to anaesthesia methods, spinal epidural block was performed at a rate of 63% and 26% in the simultaneous and staged groups respectively (Table 1).

DISCUSSION

Nearly one third of all TKA operations necessitate bilateral total knee arthroplasty (13). It is suggested that simultaneous bilateral TKA has a higher risk of cardiovascular and thrombotic complications and increased mortality. Moreover, its blood transfusion requirement is higher than that of unilateral procedures (5,26). Therefore, there is a

tendency to select younger and healthier patients for simultaneous bilateral TKA (5,26). Recent studies reported that if patient selection is performed thoroughly with careful risk assessment, and the simultaneous procedure is carried out via proper prophylaxis and care, simultaneous bilateral TKA becomes safer even for older patients (5,26,38). In the present study, the mean age of the simultaneous group was found to be lower than those of the staged and unilateral groups.

That being said, in most of the cases there is almost equal advanced stage osteoarthritis in both knees radiographically. The clinical condition of patients does not represent equal symptoms for each knee. Thus, the unilateral or the staged bilateral procedure could be preferred. Occasionally in the case of advanced stage knee deformities, the staged procedure may not be suitable since postoperative mobilization would be grueling, and adverse force on the operated side may cause early loosening (5). In the current study in accordance with the patient's preference, the simultaneous procedure was selected for the participant patients who had advanced bilateral knee deformities without high operation risk account.

Evaluation of comorbidities is substantial for risk assessment. In previous studies, heart failure and pulmonary hypertension were found to significantly increase the risk of postoperative complications (5,26). Comorbidity indices were used in some studies (4,6,18,26,19). Poultsides et al. (26) reported no difference between the simultaneous and staged bilateral TKA in terms of comorbidity. J. Liu et al.

(19) found less comorbidities in the simultaneous group than the staged group. In the present study, only heart failure was observed to be significantly less in the simultaneous group than in the staged and unilateral groups. L.I. Suleiman et al. (36) reported no difference between simultaneous and unilateral groups in terms of ASA scores. Although in the current study the median of ASA score was 3 in the staged group and 2 in the other groups, there was no statistically significant difference between the three groups in terms of ASA scores.

As for complications related to anaesthesia, simultaneous procedure is advantageous, since only one anesthetic session is required. In the present study, regional anaesthesia with combined spinal block and epidural catheterization was preferred with a rate of 63% and 26% in the simultaneous and the staged group respectively due to longer operation time of the simultaneous procedure. A. Hart et al. (11) reported that general anaesthesia had been preferred more in the simultaneous group than in the unilateral group. Choi et al. (5) reported 98% of simultaneous bilateral TKA were performed under general anaesthesia. In the present study, the rate of simultaneous bilateral TKA under general anaesthesia was 22%.

It has been reported that the necessity of postoperative RBC transfusion was higher in the simultaneous group than in the staged group (5,11). Ekinici et al. (7) reported 3.3 ± 0.91 and 2.3 ± 0.69 units of RBC transfusion in the simultaneous and the unilateral group, respectively. In the present study, the necessity of postoperative RBC transfusion was 1.6 ± 0.78 (1-4) and 0.72 ± 0.71 (0-3) units in the simultaneous and staged groups, respectively ($p < 0.05$).

Cardiopulmonary monitorization is more important in the simultaneous procedure due to higher rates of metabolic devastation and fluid-electrolyte imbalance (26). It has been reported that although postoperative length of hospitalization is longer in the simultaneous procedure in comparison with the unilateral procedure. However, it is, in fact, shorter when the sum of two individual hospitalizations of staged procedure is taken into account (7). Ekinici et al. (7) reported that lengths of postoperative hospitalization were 7.5 ± 1.84 (5-16)

days and 6.1 ± 1.24 (4-13) days in the simultaneous and the unilateral group, respectively. Linn et al. (18) reported the length of postoperative hospitalization was 12 days (9-15) and 15 days (12-18) in the simultaneous and the staged group, respectively. In the current study, the length of postoperative hospitalization time was 7.1 ± 1.73 (5-17) days and 10.6 ± 2.0 (8-19) days in the simultaneous and the staged group, respectively ($p < 0.001$).

It has been reported that the necessity of a physical therapy and rehabilitation program increased in the simultaneous group (11). In the present study there was no difference between the simultaneous and staged groups with respect to the need of physical therapy and rehabilitation for patients who could not perform exercises on their own. There was statistically significant, but clinically marginal difference in terms of preoperative WOMAC functional score and postoperative KSS (Table 4). There was no difference in terms of other disease specific and generic measures. Besides, according to American Knee Society evaluation criteria, there was small difference in AP tibial angles (β) and lateral femoral angles (γ). However, radiographic results of both the simultaneous and staged groups were in line with literature (7,8,10).

The most commonly reported major complications after simultaneous bilateral TKA were deep vein thrombosis, pulmonary thromboembolism, cardiovascular complication and mortality (12,15,20-22,25-28,33,40). Reportedly, the incidence of postoperative complications is related to patient selection (5,18,19). The rate of pulmonary thromboembolism is reported to range from 0% to 5.6% in literature (25). In the current study, the incidence of pulmonary thromboembolism is 2.7%, 1.7% and 1.4% in the simultaneous group, the staged group and the unilateral group, respectively ($p = 1.00$). Although it would not be proper to compare simultaneous and unilateral procedure in terms of postoperative complications, this comparison was made in a remarkable number of studies (5,7,11,15,19,24,36). In many studies it is emphasized that the incidence of postoperative complications was higher in the simultaneous procedure than in the staged and unilateral procedures (12,21,24,28,36). However, there are also some studies with findings

that display no difference with respect to the postoperative complications (15,20,26,27,40). In the present study there was no difference with regard to postoperative complications between three groups. J. Lui et al. (19) reported that staged operations with short intervals, particularly less than seven days are not suggested due to high complication and mortality risk. In the current study the staged procedure was performed with an interval of at least 45 days.

Early postoperative mortality of simultaneous bilateral TKA is reported at a rate that ranges from 0.3% to 1% in literature. Stefansdottir et al. (34) reported that postoperative thirty days mortality of the simultaneous procedure was 3.77 times more than the unilateral procedure and 7.53 times more than the staged procedure after operation of second knee. They suggested that one by one application is safe. Additionally, some meta-analysis reported that mortality rates for the first 30 postoperative days and for one-year are relatively higher in the simultaneous procedure when compared with the staged and unilateral procedures (12,13,28). On the other hand, there are some other studies with great series that present no increased risk of mortality after the simultaneous procedure (3,22,26,36). In the present study there was no difference in terms of mortality between the three groups.

There were limitations to this study. Although many studies reported that the simultaneous procedure is cost effective in comparison with staged procedures, in the current study an accurate cost effectiveness analysis could not be done because during the study period, the Turkish Social Security Institution was undergoing a process of reorganizations in order to provide healthcare services with a more attentive and economical approach. However, it can be argued that the simultaneous procedure is more advantageous than the staged procedure when the following points are taken into consideration: (i) shorter hospitalization in the simultaneous bilateral TKA group, (ii) no difference in postoperative rehabilitation need and complication rate between the simultaneous and staged groups, (iii) the cost of the simultaneous bilateral TKA package in Turkey is approximately 25% cheaper than two individual unilateral

procedures. In order to clarify whether there is a difference between the safety and cost of the simultaneous and staged procedures or not, further prospective randomized studies are needed.

CONCLUSIONS

Younger age as a demographic feature and heart failure as a comorbid condition were found to be decisive in the selection of the simultaneous procedure. Radiographic, generic and disease specific evaluations displayed no clinically significant difference between the simultaneous and the staged groups postoperatively. In addition, complication rates and mortality did not differ between the three groups. Thus, simultaneous bilateral TKA seems to be an advantageous operation method in the case of advanced bilateral knee osteoarthritis when there is a medical rationale, or the patient's personal preference. However, a thorough preoperative risk assessment needs to be carried out first. Consequently, taking into consideration of the aforementioned conditions, hesitancy about simultaneous bilateral TKA seems unnecessary.

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Authors contributions:

Each author has made substantial intellectual contributions to this multicenter research. All authors read and approved the final manuscript. Ethics committee approval, patients signed informed consent to publish the data.

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