

## The clinical comparison of simultaneous bilateral total knee arthroplasty in treatment of osteoarthritis

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### Abstract

**Objective:** To evaluate the risk and efficacy of simultaneous bilateral total knee arthroplasty(TKA) in treatment of osteoarthritis when compared with sequential bilateral TKA and unilateral TKA. **Methods:**A retrospective analysis was performed on 162 patients who underwent TKA from 2003 to 2006. The analyses were adjusted for demographics, preexisting medical conditions, and osteoarthritis diagnosis. **Results:**Patients undergoing simultaneous bilateral TKA had significantly lower amounts of blood loss, shorter surgical time, shorter hospitalization time, less hospital charges and lower rates of perioperative complications compared with patients undergoing sequential bilateral TKA. No significant difference was found with regard to postoperative complications between the simultaneous bilateral and the unilateral TKA groups. Patient's knee range of motion and the postoperative Hospital for Special Surgery scores(HSS) were similar for the three groups. **Conclusion:**When there are adequate indications for bilateral TKA, simultaneous bilateral TKA is beneficial to patients compared with sequential bilateral or unilateral TKA.

**Key words:** total knee arthroplasty, osteoarthritis, simultaneous, sequential

### INTRODUCTION

Osteoarthritis is a frequently reported cause of long-term disability and presents with bilaterally symptomatic disease in approximately one third of cases<sup>[1]</sup>. Total knee arthroplasty(TKA) can provide reliable pain relief and consistent correction of limb alignment in patients after conservative treatment has failed<sup>[2]</sup>. The surgical options available for these patients include simultaneous arthroplasty in both knees using two surgical teams, sequential arthroplasty using one team under one anesthetic, or a staged approach using two separate anesthetics.

The benefits of doing bilateral TKA under one anesthetic as opposed to two-staged procedures include shorter time spent in the hospital, shorter time under

anesthesia, less time in physical therapy, and fewer wound infections, resulting in more cost-effective treatment<sup>[3]</sup>. In contrast, several studies have suggested that perioperative complications are concerns associated with bilateral TKA surgery under one anesthetic. For example, sequential procedures require extended anesthetic time. This has been shown to be associated with adverse perioperative events, such as a prolongation of prothrombin time<sup>[4]</sup>. However, the complication rate for simultaneous surgery using two-team compared with sequential or staged surgery was not evaluated.

The purpose of the current study was to evaluate surgical details, perioperative complications and clinical outcomes associated with patients having simultaneous bilateral TKA compared with patients having sequential bilateral or unilateral TKA.

### MATERIALS AND METHODS

#### Patients

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All patients with osteoarthritis of the knee who underwent a TKA between 2003 and 2006 were identified from hospital database, which consists of all patients completing a preoperative, intraoperative and postoperative data form. Strict inclusion criteria included clinically significant osteoarthritic changes in one or both knees and failure of conservative treatment for osteoarthritis of the knee. Strict exclusion criteria included a history of previous knee infection, trauma requiring surgery, or previous arthroplasty of the lower extremity<sup>[5]</sup>. Strict patient grouping criteria were based on demographics and preoperative comorbidities. A total of 52 patients undergoing simultaneous bilateral TKA and 48 patients undergoing sequential bilateral TKA were identified and matched from the database, and all were eligible for inclusion, exclusion and grouping criteria in the study. These bilateral TKA patients were matched with 62 patients undergoing unilateral TKA who met the established criteria according to age, sex, weight, height, body mass index and preexisting medical conditions. Patients in these three groups were assessed preoperatively by a certified anesthesiologist to determine the level of anesthetic risk as outlined by the American Society of Anesthesiologists(ASA) classification system. 12 patients in the simultaneous bilateral TKA group were class I, 35 were class II, and 5 were class III. In the sequential bilateral TKA group, 10 were class I, 34 were class II, and 4 were class III. In the unilateral TKA group, 19 were class I, 33 were class II, and 10 were class III. In the simultaneous bilateral group, the type of anesthesia used was general in 14 patients and epidural in 38. In the sequential bilateral group, the type of anesthesia used was general in 17 patients and epidural in 31. In the unilateral group, the type of anesthesia used was general in 14 patients and epidural in 48. None of these differences were statistically significant<sup>[6]</sup>. Postoperative events and functional outcomes were assessed independently and recorded. The Hospital for Special Surgery(HSS) knee score was administered independently to assess overall patient satisfaction and functional outcome of the three TKA groups<sup>[5]</sup>.

#### Operative technique and outcome measurement

Tourniquets were used on every lower extremity for hemostasis, and the inflation pressure ranged from 300 to 350 mmHg. The protocol at our institution for performing a simultaneously bilateral TKA under 1 anesthetic is to treat each total knee reconstruction using 2 surgical teams, operating at the same time, with 2 sets of instruments. In the sequentially bilateral TKA group, a separate procedure was performed sequentially using 1 surgical team under a single anesthetic. In this manner, the second knee operation can be cancelled if the

patient does not tolerate the first procedure very well. The tourniquet in the bilateral TKA group was applied and inflated simultaneously or sequentially on each lower extremity.

All patients were admitted routinely to the intensive care unit(ICU) postoperatively regardless of preoperative medical assessment or postoperative course as per institutional protocol. Patients were discharged from the ICU within 24 hours if they could stand up for a short period of time.

The postoperative physiotherapy and rehabilitation routine for the three groups of patients was identical, with hallmarks of the program being early mobilization of the patient out of bed, strengthening of quadriceps, and range of motion(ROM) exercises beginning on the first postoperative day. All patients were treated perioperatively by the same medicine group, using standardized and established treatment protocols. Patients were discharged from the hospital when they were able to walk up and down stairs with knees operated<sup>[5]</sup>.

#### Statistical analysis

The quantitative data are presented as means  $\pm$  standard errors(range). One-way analysis of variance with Duncan's multiple comparison was used to analyze the mean age, weight, height, body mass index, hemoglobin, postoperative blood loss, red blood cell (RBC) transfused postoperatively, surgical time, total hospital length of stay(LOS), total hospital charge, HSS knee score and mean ROM of patients. The chi-square test and fisher exact test were used to analyze preexisting medical conditions, postoperative complications, gender, ASA rating and the type of anesthesia used. Values of *P* less than 0.05 were considered significant.

## RESULTS

#### Demographics and preoperative morbidity

There were 44 women and 8 men in the simultaneous bilateral TKA group, 40 women and 8 men in the sequential TKA group, and 51 women and 11 men in the unilateral TKA group(Tab 1). 35 patients in the simultaneous bilateral TKA group, 29 patients in the sequential bilateral TKA group and 38 patients in the unilateral TKA group had one or more preexisting conditions(Tab 2). There was no significant difference among the three groups with respect to age, gender, weight, height, body mass index and the number and type of preexisting medical conditions.

#### Surgical parameters

The preoperative hemoglobin was equivalent in the three groups(*P* > 0.05). The postoperative hemoglobin of the sequential bilateral group was significantly reduced compared to the other two groups. The average blood loss and the volume of RBC transfused postop-

eratively were significantly higher in the bilateral TKA group. The surgical time was nearly twice as long in the sequential bilateral group compared with the unilateral group (206.8 min vs. 105.3 min;  $P < 0.01$ ). Of particu-

lar note is that in the simultaneous bilateral group, the average blood loss, the volume of RBC transfused post-operatively and the surgical time were significantly less compared to the sequential bilateral group (Tab 3).

Tab 1 Demographic Data on Patients

Demographic Variable	Simultaneous Bilateral Group (n = 52)	Sequential Bilateral Group (n = 48)	Unilateral Group (n = 62)
women(n)	44	40	51
men(n)	8	8	11
Mean age(y)(range)	64.9 ± 1.8(31-77)	66.1 ± 2.0(55-76)	65.3 ± 1.5(26-83)
Mean weight(kg)(range)	69.9 ± 2.1(50-103)	65.1 ± 4.1(50-83)	66.3 ± 1.5(41-93)
Mean height(cm)(range)	154.5 ± 1.2(140-176)	157.6 ± 1.5(144-172)	158.2 ± 1.3(149-173)
Body mass index(range)	28.4 ± 1.0(20.3-36.0)	27.1 ± 3.1(19.1-34.1)	26.3 ± 1.0(16.4-33.5)

Tab 2 Preexisting Medical Conditions

Preexisting Factors	Simultaneous Bilateral Group (n = 52)	Sequential Bilateral Group (n = 48)	Unilateral Group (n = 62)
Hypertension	13	10	12
Other cardiovascular condition §	11	10	13
Neurologic condition¶	2	3	4
Diabetes mellitus	4	3	4
Renal/genitourinary‡	1	0	0
Hyperthyroidism	2	1	1
Pulmonary condition†	2	1	2
Gastrointestinal disorder ※	3	2	4
	(35 patients)	(29 patients)	(38 patients)

§ Coronary artery disease, congestive heart failure, valvular insufficiency, arrhythmia. ¶Dementia, stroke, Parkinson's disease, seizure disorder. ‡prostatic hypertrophy, renal insufficiency, recurrent urinary tract infection. †Chronic obstructive pulmonary disease, asthma. ※ Esophageal reflux, peptic ulcer disease, hepatitis.

Tab 3 Surgical Details

Surgical Details	Simultaneous Bilateral Group (n = 52)	Sequential Bilateral Group (n = 48)	Unilateral Group (n = 62)
Preoperative hemoglobin(g/L)	126.2 ± 2.8(93-153)	124.5 ± 3.0(91-145)	126.5 ± 2.5(88-162)
Postoperative hemoglobin(g/L)	93.6 ± 2.1(70-120)	77.4 ± 2.2(66-88)**	93.3 ± 1.8(65-128)
Postoperative blood loss(ml)	503.2 ± 34.8(200-1000)***	772.7 ± 85.4(400-1400)**	230.3 ± 11.6(150-500)
RBC transfused postoperatively(U)	2.9 ± 0.4(0-12)**#	4.0 ± 0.3(0-8)**	1.6 ± 0.3(0-8)
Surgical time(min)	113.3 ± 2.5(92-150)**#	206.8 ± 7.1(183-240)**	105.3 ± 2.4(74-137)

the bilateral groups compared with the unilateral group respectively, \*\* $P < 0.01$ ; the simultaneous bilateral group compared with the sequential bilateral group, \*\* $P < 0.01$ .

## Complications

A total of 11 postoperative complications occurred in 8 patients in the simultaneous bilateral TKA group compared with 18 events in 16 patients in the sequential bilateral TKA group ( $P < 0.05$ ) and 6 events in 5 patients in the unilateral TKA group ( $P > 0.05$ ) (Tab 4). Postoperative cardiovascular complications occurred in 1 patient in the simultaneous bilateral TKA group, compared with 7 patient in the sequential bilateral TKA group ( $P < 0.05$ ) and 0 patients in the unilateral TKA group ( $P > 0.05$ ) (Tab 4). There were 3 cases of deep venous thrombosis in the simultaneous bilateral group compared to 1 case in the sequential group and none in the unilateral group, but was not significantly different.

Analysis of respiratory, genitourinary, gastrointestinal, neurologic and electrolyte imbalances did not yield any significant differences among the three groups. The wound complication rate was 6% of all patients in the simultaneous bilateral group compared with 10% in the sequential group ( $P > 0.05$ ) and 3% in the unilateral group ( $P > 0.05$ ). There were no deaths among the 162 patients at the time of their 1-year follow-up.

## Clinical outcomes

Bilateral patients have a longer overall LOS and more total hospital charges compared with unilateral patients ( $P < 0.01$ ) (Tab 5), but not twice. The simultaneous bilateral TKA group had less total charges and shorter LOS than that of the sequential bilateral TKA group.

Tab 4 Postoperative Complications

Type of Complication	Simultaneous Bilateral Group(n = 52)	Sequential Bilateral Group(n = 48)	Unilateral Group(n = 62)
Respiratory†	1	0	1
Deep venous thrombosis	3	1	0
Genitourinary‡	0	1	0
Gastrointestinal ※	1	2	2
Wound complications			
Bleeding/hemarthrosis	2	4	1
Fat liquefaction	1	1	1
Deep infection	0	0	0
Cardiovascular §	1 <sup>#</sup>	7 <sup>**</sup>	0
Electrolyte imbalances	0	1	0
Neurologic¶	2	1	1
Death(≤ 12 months)	0	0	0
Total complications	11	18	6
	(8 patients) <sup>#</sup>	(16 patients) <sup>**</sup>	(5 patients)

the bilateral groups compared with the unilateral group respectively, <sup>\*\*</sup>*P* < 0.01; the simultaneous bilateral group compared with the sequential bilateral group, <sup>#</sup>*P* < 0.05, <sup>\*\*</sup>*P* < 0.01.

†Chronic obstructive pulmonary disease, asthma. ‡Urinary Retention. ※Vomit, diarrhea. § congestive heart failure, arrhythmia. ¶hysteria, depression, hypoxic encephalopathy.

ROM of the knee at 1 year was similar among the three groups (*P* > 0.05), indicating that the bilateral procedure did not compromise the outcome (Tab 5). The three groups' HSS scores were evaluated preoperatively and at 1 year (Fig 1). A steady functional improvement in scores over 1 year was observed in all three groups.

### DISCUSSION

The bilateral TKA under one anesthetic has long been controversial<sup>[7]</sup>. Various retrospective studies have been published in support of this procedure, showing no increased morbidity or loss of effectiveness<sup>[8]</sup>. In contrast, an increased incidence of postoperative cardiac events, postoperative confusion, thromboembolic disease, and

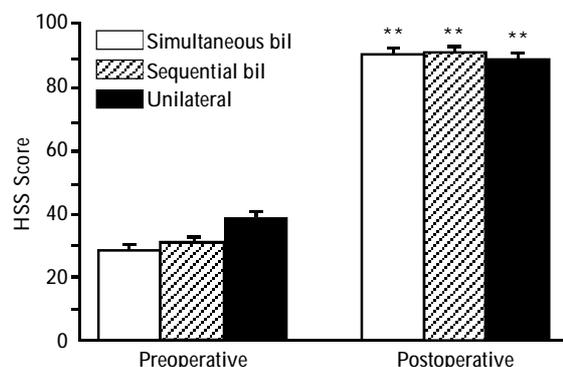


Fig 1 The change of HSS Scores after TKA in three groups. (Ordinate represented HSS Score). Compared with the preoperative scores, <sup>\*\*</sup>*P* < 0.01

Tab 5 Clinical Outcome

Relative variable	Simultaneous Bilateral Group(n = 52)	Sequential Bilateral Group(n = 48)	Unilateral Group(n = 62)
Total hospital length of stay(d)	30.9 ± 1.2(25-57) <sup>#</sup>	36.0 ± 2.5(28-67) <sup>*</sup>	28.8 ± 1.2(21-58)
Total hospital charges(Yuan)	82 500.5 ± 1 427.8(69 937-101 429) <sup>#</sup>	89 074.2 ± 2 415.8(78 329-101 929) <sup>*</sup>	48 115.2 ± 1 897.6(33 125-53 794)
Mean ROM(degree)	113.9 ± 1.8(90-140)	111.3 ± 2.6(85-130)	116.5 ± 2.0(80-140)

ROM, range of motion of the knee

the bilateral groups compared with the unilateral group respectively, <sup>\*</sup>*P* < 0.01; the simultaneous bilateral group compared with the sequential bilateral group, <sup>#</sup>*P* < 0.05.

loss of blood have all been related to bilateral TKA, especially the sequential bilateral TKA<sup>[4]</sup>. However, there is a paucity of published studies that focus on evaluating simultaneous procedures by two teams under one anesthetic. In our study, we attempted to find out whether simultaneous bilateral TKA is more or less safe compared with sequential bilateral TKA or unilateral procedure.

We found in the sequential bilateral group that patients experienced significantly greater blood loss and

usage, longer surgical time and more postoperative complications, compared with the simultaneous bilateral group and the unilateral group. Especially, the rate of postoperative cardiovascular complications was significantly higher in the sequential bilateral TKA group when compared with the unilateral TKA group or the simultaneous bilateral TKA group.

Our results are consistent with previous reports that more patients in the sequential bilateral group had complications postoperatively compared with the unilateral

group. The reason may be attributed to the differences in surgical procedures. Firstly, a longer anesthetic time and greater blood loss appear to result in an increased complication rate. Bould et al. reported blood loss greater in the second knee by an average of 323 mL in tests of sequential bilateral TKA ( $P < 0.05$ )<sup>[9]</sup>. Secondly, the frequency and time of using a tourniquet can affect vascular circulation and hemodynamic status of patients. Analysis of studies showed a prolongation of prothrombin time, activated partial thromboplastin time, and thrombin time after release of the first tourniquet<sup>[10]</sup>. Huang et al. concluded that blood pressure changes following deflation of the second tourniquet are more pronounced than those following deflation of the first tourniquet<sup>[11]</sup>. Third, it is known that free radicals, such as reactive oxygen species (ROS) which are released abruptly after deflation of an ischaemic tourniquet, cause reperfusion injuries<sup>[12]</sup>. Also, after prolonged tourniquet inflation, nerve injury results from the combined effects of ischemia and mechanical trauma<sup>[13]</sup>.

Notably, the simultaneous bilateral group experienced a significant decrease in surgical stress owing to reduced surgical time, blood loss and usage. In the bilateral group, the rate of postoperative cardiovascular complications was lower in the simultaneous bilateral TKA group when compared with the sequential group. However, some studies show that when the intramedullary alignment guide rods are inserted at relatively the same time bilaterally, the peak fat emboli load in the simultaneous bilateral TKA may be greater than in sequential bilateral TKA procedures<sup>[5]</sup>. Other studies have evidence that total knee replacement is accompanied by a hypercoagulative state with or without the use of a tourniquet, but it seems to be higher when the tourniquet is not used. In addition, tourniquet application may increase fibrinolysis<sup>[14]</sup>. Our results have shown that the rate of deep venous thrombosis in the simultaneous bilateral TKA group (6%) was higher than that (2%) in the sequential group and none in the unilateral group, but there is no significant difference. The potential negative factors of the simultaneous bilateral TKA still need to be weighed up clearly.

The range of movement achieved in the bilateral group one year after surgery was identical to the unilateral group, and consequently functional outcome was not compromised by the bilateral TKA procedure. These results are similar to those reported in another series of patients undergone TKA<sup>[15]</sup>. Our results also suggest that the total charges and LOS of the simultaneous bilateral TKA group were significantly less than that of the sequential group. It seems that simultaneous bilateral TKA is a more cost-effective treatment among the bilateral TKA groups.

All clinical outcomes were assessed independently. The treatment groups were matched according to significant prognostic variables—ex, age, weight, height, body mass index, preexisting medical conditions, etc. The HSS knee score is a popular and valid clinical assessment standard. The limitations of the current study include a retrospective design and the use of observational data, and key elements of the study design limit these biases. Another limitation of this study is that one may argue that the control group (unilateral TKA group) may be more appropriately represented if they were staged bilateral TKA. However, the main purpose of this study was to judge fully simultaneous bilateral TKA respecting its safety and efficacy, and this was not lessened by using the unilateral TKA group<sup>[16]</sup>.

Based on the results from this study and previous literature documenting patient preference, patient satisfaction, efficacy, and outcomes, we believe that when there are adequate indications for bilateral total knee replacement, simultaneous bilateral TKA is beneficial for patients because of proven excellent functional results, the opportunity for only one anesthetic risk, reduced surgical time and economic savings compared to a sequential group. However, a more complete prospective evaluation of the safety and efficacy of simultaneous bilateral TKA demands further attention.

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