# Is Simultaneous Bilateral Total Knee Arthroplasty (BTKA) as Safe as Staged BTKA?

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**Abstract**

Simultaneous bilateral total knee arthroplasty (BTKA) is often performed to treat patients with disabling arthritis of both knees. Its use compared with staged procedures remains controversial.

In a retrospective study, we compared 371 patients who had simultaneous BTKA with 67 patients who had staged (<6 months apart) BTKA. The staged procedures fall within the crucial postoperative period when increased morbidity and mortality would more likely be present. Primary outcomes were perioperative complications, length of stay, and transfusion requirements. Complications included respiratory arrest, pulmonary embolism, and deep surgical-site infection.

Overall, there was no significant difference in complication rates between the 2 cohorts ($P = .97$). Mean transfusion rate was higher for the simultaneous BTKA group ($P = .042$). Study limitations included the retrospective design and the relatively small sample, given the low incidence of complications.

In the United States, osteoarthritis is the most common cause of knee pain and one of the leading causes of disability.[1] Total knee arthroplasty (TKA) is an effective treatment for end-stage osteoarthritis of the knee.[2] Whether patients with severe, debilitating bilateral disease should undergo simultaneous bilateral TKA (BTKA) or staged BTKA (2 separate procedures during separate hospital admissions) continues to be debated. The relative risks and benefits of simultaneous BTKA relative to staged BTKA or unilateral TKA are controversial.[3-6] Proponents of simultaneous BTKA have argued that this surgery results in shorter hospital length of stay (LOS) and higher patient satisfaction without increased risk of perioperative complications,[7-9] and opponents have argued that it leads to increased perioperative mortality and complications and should not be performed routinely.[10,11]

The safety of simultaneous BTKA cannot necessarily be extrapolated from data on unilateral TKA. Authors have argued that the complication rate for simultaneous BTKA is not comparable to the rate for unilateral TKA but instead is double the rate.[12] Although a doubled rate may more closely approximate the true risk of simultaneous BTKA, it still does not account for the increased surgical impact of 2 procedures (vs 1 procedure) on a patient. In this regard, comparing simultaneous and staged BTKA provides a more accurate assessment of risk, as long as the interval between surgeries is not excessive. The major stress experienced during TKA

### *Take-Home Points*

- Complication rates did not statistically significantly differ between simultaneous and staged TKA.
- Length of stay of 2 TKA admissions was greater than 1 BTKA admission.
- Transfusion requirements were greater in BTKA.
- Avoid bilateral procedures in ASA 3 patients.
- Develop institutional protocols for BTKA with multidisciplinary input.

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affects the cardiovascular, pulmonary, and musculoskeletal systems, and full recovery may take up to 6 months.[13-15] Outcome studies have found significant improvement in validated measures of function and pain up to but not past 6 months.[13,15] Furthermore, a large study comparing American Society of Anesthesiologists (ASA) scores with morbidity and mortality rates recorded in the New Zealand Total Joint Database established 6 months as a best approximation of postoperative mortality and morbidity risk.[14] Given these data, we propose that the most accurate analysis of postoperative morbidity and mortality would be a comparison of simultaneous BTKA with BTKA staged <6 months apart. The staged procedures fall within the crucial postoperative period when increased morbidity and mortality would more likely be present. A between-surgeries interval >6 months would effectively separate the 2 procedures, rendering their risks not truly representative.

We retrospectively analyzed all simultaneous BTKA and staged BTKA (<6 months apart) surgeries performed at our orthopedic specialty hospital between 2005 and 2009. We hypothesized there would be no significant difference in perioperative morbidity or mortality between the groups.

Table 1. **Characteristics of Patients in Simultaneous and Staged Cohorts**

| | Cohort | | | |
|---|---|---|---|---|
| | Simultaneous | | Staged | |
| **Characteristic** | **n** | **%** | **n** | **%** |
| Age, y ($P$ = .105) | | | | |
| <50 | 21 | 5.7 | 5 | 7.5 |
| 50-64 | 186 | 50.1 | 36 | 53.7 |
| 65-74 | 119 | 32.1 | 14 | 20.9 |
| ≥75 | 45 | 12.1 | 12 | 17.9 |
| Total | 371 | | 67 | |
| Sex ($P$ = .359) | | | | |
| Male | 112 | 30.2 | 24 | 35.8 |
| Female | 259 | 69.8 | 43 | 64.2 |
| BMI, kg/m$^2$ ($P$ = .739) | | | | |
| <25 | 34 | 9.2 | 9 | 13.4 |
| 25-30 | 97 | 26.1 | 16 | 23.9 |
| 31-40 | 169 | 45.6 | 28 | 41.8 |
| ≥40 | 71 | 19.1 | 14 | 20.9 |
| ASA score ($P$ = .527) | | | | |
| 1 | 9 | 2.4 | 1 | 1.5 |
| 2 | 236 | 64.0 | 41 | 62.1 |
| 3 | 124 | 33.6 | 24 | 36.4 |
| Comorbidity ($P$ = .283) | | | | |
| DM | 45 | 12.1 | 12 | 17.9 |
| CAD | 11 | 2.9 | 3 | 4.5 |
| Both DM and CAD | 8 | 2.1 | 3 | 4.5 |

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CAD, coronary artery disease; DM, diabetes mellitus.

## Methods and Materials

Our institution's Institutional Review Board approved this study. All patients who underwent either simultaneous BTKA or staged BTKA (<6 months apart) at a single orthopedic specialty hospital between 2005 and 2009 were retrospectively identified. Twenty-five surgeons performed the procedures. Which procedure to perform (simultaneous or staged) was decided by the attending surgeon in consultation with an anesthesiologist. Preoperative medical diagnostic testing was determined by the internist, who provided medical clearance, and was subject to review by the anesthesiologist. A patient was excluded from simultaneous BTKA only if the medical or anesthesiology consultant deemed the patient too high risk for bilateral procedures. Revision TKAs were excluded from the study.

Implant, approach, tourniquet use, and TKA technique were selected by the individual surgeons. Strategies for the simultaneous procedures were (1) single surgeon, single team, sequential, start second knee after closure of first, and (2) single surgeon, single team, sequential, start second knee after implantation of first but before closure. The decision to proceed with the second knee was confirmed in consultation with the anesthesiologist after implantation and deflation of the tourniquet on the first knee.

Individual electronic patient charts were reviewed for information on demographics, comorbidities, anesthesia type, antibiotics, and postoperative venous thromboembolism prophylaxis. Demographic variables included age, sex, height, weight, and body mass index (BMI). Comorbidities recorded were diabetes mellitus, coronary artery disease, prior myocardial infarction, stroke, and endocrinopathies. In addition, available ASA scores were recorded. The primary outcome was perioperative complications, defined as any complications that occurred within 6 months after surgery. These included death, pulmonary embolism (PE), and deep surgical-site infections (SSIs). Secondary outcome measures were LOS, discharge location (rehabilitation or home), and blood transfusion requirements.

The 2 groups (simultaneous BTKA, staged BTKA) were compared using Student $t$ test for continuous variables and $\chi^2$ test for categorical variables. Subgroup analysis was performed to

Table 2. **Operative Data of Patients in Simultaneous and Staged Cohorts**

| | Cohort | | | |
|---|---|---|---|---|
| | Simultaneous | | Staged | |
| **Operative Data** | **n** | **%** | **n** | **%** |
| Anesthesia ($P$ = .167) | | | | |
| Spinal | 313 | 84.4 | 121 | 90.3 |
| General | 36 | 9.7 | 8 | 6.0 |
| Antibiotics ($P$ = .288) | | | | |
| Cefazolin | 314 | 84.6 | 120 | 90.0 |
| Clindamycin | 51 | 13.7 | 12 | 9.0 |
| Vancomycin | 6 | 1.6 | 0 | 0.0 |
| Anticoagulation ($P$ = .223) | | | | |
| Enoxaparin | 124 | 33.4 | 51 | 38.1 |
| Warfarin | 32 | 8.6 | 22 | 16.4 |
| Fondaparinux | 73 | 19.7 | 25 | 18.7 |
| Aspirin | 47 | 11.1 | 10 | 7.5 |
| Combination – warfarin[a] | 19 | 5.1 | 6 | 4.5 |
| Combination + warfarin[a] | 75 | 20.2 | 19 | 14.2 |

[a]Combination includes one or more of the following: enoxaparin, warfarin, fondaparinux, and aspirin.

Table 3. **Results of Patients in Simultaneous and Staged Cohorts**

| | Cohort | | |
|---|---|---|---|
| **Result** | **Simultaneous** | **Staged** | ***P*** |
| Complication | 13 | 1 | .97 |
| Pulmonary embolism | 7 | 0 | |
| Deep surgical-site infection | 5 | 1 | |
| Respiratory arrest | 1 | 0 | |
| Transfusion, mean units | 1.39 | 0.66 | .042 |
| Length of stay, mean days | 4.94 | 8.93 | .0001 |
| Discharge to rehabilitation | | | |
| n | 344 | 68 | .0001 |
| % | 92.7 | 50.7 | |

compare healthier patients (ASA score 1 or 2) with patients who had more severe comorbidities (ASA score 3). Statistical significance was set at $P < .05$.

## Results

Between 2005 and 2009, 371 patients had simultaneous BTKA, and 67 had staged BTKA (134 procedures) <6 months apart (**Table 1**). Mean recovery interval between staged procedures was 4.3 months (range, 2-6 months). Mean age was 63.9 years (range, 44-88 years) for the simultaneous BTKA patients and 63.1 years (range, 35-81 years) for the staged BTKA patients ($P$ = .105). Both groups had proportionately more female patients (69.8% in the simultaneous BTKA group, 64.2% in the staged BTKA group), but there was no sex difference between the groups ($P$ = .359). There were 71 (19.1%) morbidly obese patients (body mass index [BMI], ≥40 kg/m$^2$) in the simultaneous group and 14 (20.9%) in the staged group ($P$ = .739). The groups had statistically similar proportions of diabetes mellitus and coronary artery disease ($P$ = .283).

Most surgeries (84.4% simultaneous, 90.3% staged) were performed with the patient under spinal anesthesia, and there was a trend ($P$ = .167) toward more frequent use of general anesthesia in the simultaneous group relative to the staged group (**Table 2**). Intraoperative antibiotics were given in all cases, and there were no significant differences in antibiotic type between the groups. Postoperative chemical venous thromboembolism prophylaxis was administered to all patients, depending on surgeon preference, and there were no significant differences between the groups.

The 2 cohorts' perioperative complication rates were not statistically significantly different ($P$ = .97) (**Table 3**). The simultaneous BTKA group had 13 complications: 7 PEs (1.9%), 5 deep SSIs (1.08%), and 1 respiratory arrest (0.27%). The staged BTKA group had only 1 complication, a deep SSI (0.75%). There were no significant differences in rates of individual complications (deep vein thrombosis, PE, SSI; $P$ = .697) or intensive care unit admission ($P$ = .312). Mean number of transfusion units was 1.39 for simultaneous BTKA and 0.66 for both staged TKAs combined ($P$ = .042). Mean aggregated LOS for both procedures in the staged BTKA was 8.93 days per patient, and mean LOS for simultaneous BTKA was 4.94 days per patient, significantly shorter ($P$ = .0001). The percentage of postoperative discharges from hospital to an inpatient acute rehabilitation center was significantly higher ($P$ = .0001) in the simultaneous BTKA group (92.7%) than in the staged BTKA group (50.7%).

There was no statistically significant difference ($P$ = .398) in occurrence of postoperative complications between the 2 cohorts compared on ASA scores, and the difference between patients with ASA score 1 or 2 and those with ASA score 3 was not statistically significant ($P$ = .200) (**Table 4**). There was a trend ($P$ = .161) toward more complications in 85 patients with BMI of ≥40 kg/m$^2$ (morbidly obese), of whom 5 (5.9%) had a complication, than in 9 patients (2.6%) with BMI of <40 kg/m$^2$, but the difference was not statistically significant because of the sample size.

## Discussion

Although there was no significant difference in postoperative complication rates within 6 months after surgery between the simultaneous and staged BTKA groups, the incidence of complications in the simultaneous group was notable. The disproportionate size of the 2 comparison groups limited the power of our study to analyze individual perioperative complications. This study may be underpowered to detect differences in complications occurring relatively infrequently, which may explain why the difference in number of complications (13 in simultaneous group, 1 in staged group) did not achieve statistical significance ($\beta = 0.89$). Post hoc power analysis showed 956 patients would be needed in each group to adequately power for such small complication rates. However, our results are consistent with those of other studies.[13-15] The 1.9% PE rate in our simultaneous BTKA group does not vary from the average PE rate for TKA in the literature and is actually lower than the PE rate in a previous study at our institution.[16] Fat embolism traditionally is considered more of a concern in bilateral cases than in unilateral cases. Although fat embolism surely is inherent to the physiologic alterations caused by TKA, we did not find clinically significant fat embolism in either cohort.

Similarly, the 1.08% rate of deep SSIs is within the range for postoperative TKA infections at our institution and others.[17] Our staged BTKA group's complication rate, 0.75% (1 SSI), was slightly lower than expected. However, 0.75% is in keeping with institutional norms (typical rate, ~1%). We would have expected a nonzero rate for venous thromboembolism, and perhaps such a rate would have come with an inclusion period longer than 6 months. Last, the death in the simultaneous BTKA group was not an outlier, given the published rate of mortality after elective total joint surgery.[18]

The characteristics of our simultaneous and staged BTKA groups were very similar (Table 1), though the larger number of staged-group patients with diabetes mellitus and coronary artery disease may represent selection bias. Nevertheless, the proportions of patients with each of 3 ASA scores were similar. It is also important to note that, in this context, a high percentage of patients in each group (33.6% simultaneous, 37.5% staged) received ASA score 3 from the anesthesiologist ($P > .05$). This may be an important factor in explaining the larger though not statistically significant number of complications in the simultaneous group (13) relative to the staged group (1). We therefore consider

Table 4. **Postoperative Complications of Simultaneous and Staged BTKA by ASA Scores ($P = .398$)**

| | | Complication | | |
|---|---|---|---|---|
| **BTKA** | **ASA Score** | **No** | **Yes** | **Total** |
| Simultaneous | 1 | 9 | 0 | 9 |
| | 2 | 229 | 7 | 236 |
| | 3 | 118 | 6 | 124 |
| | Total | 356 | 13 | 369 |
| Staged | 1 | 1 | 0 | 1 |
| | 2 | 41 | 0 | 41 |
| | 3 | 23 | 1 | 24 |
| | Total | 65 | 1 | 66 |
| Total | 1 | 10 | 0 | 10 |
| | 2 | 270 | 7 | 277 |
| | 3 | 141 | 7 | 148 |
| | Total | 421 | 14 | 435 |

Abbreviations: ASA, American Society of Anesthesiologists; BTKA, bilateral total knee arthroplasty.

Table 5. **Exclusion Criteria for Simultaneous Bilateral Total Knee Arthroplasty**

| |
|---|
| Age >75 years |
| American Society of Anesthesiologists score 3 or 4 |
| Ischemic heart disease (positive stress test) |
| On aggressive anticoagulation or clopidogrel |
| Poor ventricular function (left ventricular ejection fraction <50%) |
| Oxygen-dependent pulmonary disease |
| Renal insufficiency or end-stage renal disease (creatinine level >1.6 mg/dL) |
| Steroid-dependent asthma or chronic obstructive pulmonary disease |
| Pulmonary hypertension (pulmonary arterial pressure >45 mm Hg) |
| Morbid obesity (body mass index ≥40 kg/m$^2$) |
| Chronic liver disease (Child-Pugh class B or worse) |
| Cerebral vascular disease |
| Obstructive sleep apnea (proved on sleep study, untreated) or STOP/BANG score >5 |
| Insulin-dependent diabetes mellitus (blood glucose level >180 mg/dL) |
| History of deep vein thrombosis or pulmonary embolism |
| History of congestive heart failure |
| Hemoglobin level <11 g/dL or Jehovah's Witness |

Abbreviation: STOP/BANG, snoring, tired, observed, pressure/body mass index, age, neck size, gender (risk stratification score for sleep apnea).

ASA score 3 to be a contraindication to a bilateral procedure, and for simultaneous BTKA we have developed a set of exclusion criteria that include ASA score 3 or 4 (**Table 5**). These criteria reflect input from our surgeons, anesthesiologist, and medical specialists, as well as the data presented here.

Other authors have studied the safety of simultaneous vs staged BTKA and drawn conflicting conclusions.[11,19-21] Walmsley and colleagues[21] found no differences in 90-day mortality between 3 groups: patients with simultaneous BTKA, patients with BTKA staged within 5 years, and patients with unilateral TKA. Stefánsdóttir and colleagues[11] found that, compared with simultaneous BTKA, BTKA staged within 1 year had a lower 30-day mortality rate. Meehan and colleagues[20] compared simultaneous BTKA with BTKA staged within 1 year and found a lower risk of infection and device malfunction and a higher risk of adverse cardiovascular outcomes in the simultaneous group. A recent meta-analysis found that, compared with staged BTKA, simultaneous BTKA had a higher risk of perioperative complications.[19] A systematic review of retrospective studies found simultaneous BTKA had higher rates of mortality, PE, and transfusion and lower rates of deep SSI and revision.[22] A survey of Medicare data found higher 90-day mortality and myocardial infarction rates for simultaneous BTKA but no difference in infection and revision rates.[23] Clearly, there is no consensus as to whether simultaneous BTKA carries higher risks relative to staged BTKA.

The amount of blood transfused in our simultaneous BTKA group was more than double that in the 2 staged TKAs combined. It is intuitive that the blood loss in 2 concurrent TKAs is always more than in 1 TKA, but the clinical relevance of this fact is unknown. Transfusions have potential complications, and this risk needs to be addressed in the preoperative discussion.

LOS for simultaneous BTKA was on average 4 days shorter than the combined LOS (2 hospitalizations) for staged BTKA. This shorter LOS has been shown to provide the healthcare system with a cost savings.[8] However, not considered in the equation is the difference in cost of rehabilitations, 2 vs 1. In the present study, 92.7% of simultaneous BTKA patients and only 50.7% of staged BTKA patients were discharged to an inpatient acute rehabilitation unit. Interestingly, the majority of the staged patients who went to inpatient rehabilitation did so after the second surgery. At our institution at the time of this study, simultaneous BTKA patients, and staged BTKA patients with the second surgery completed, were more likely than unilateral TKA patients to qualify for inpatient acute rehabilitation. Staged BTKA patients' higher cost for 2 rehabilitations, rather than 1, adds to the cost savings realized with simultaneous BTKA. In the context of an episode-based payment system, the cost of posthospital rehabilitation enters the overall cost equation and may lead to an increase in the number of simultaneous BTKAs being performed.

## Conclusion

In this study, the incidence of postoperative complications was higher for simultaneous BTKA than for staged BTKA performed <6 months apart, but the difference was not significantly different. There were significant differences in LOS and blood transfusion rates between the groups, as expected. At present, only patients with ASA score 1 or 2 are considered for simultaneous BTKA at our institution. Patients with ASA score 3 or higher are not eligible.

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