Perioperative Differences in Conventional and Computer-Assisted Surgery in Bilateral Total Knee Arthroplasty

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Abstract

Performing bilateral total knee arthroplasties (bTKAs), sequential or staged, is a topic of debate among surgeons. To our knowledge, no studies have compared computer-assisted surgery (CAS) and conventional (CON) procedures for sequential bTKAs.

We retrospectively reviewed 124 (62 CAS, 62 CON) sequential bTKAs. CAS-bTKAs required significantly fewer blood transfusions ($P = .001$) and had significantly better postoperative day 1 (POD-1) hemoglobin (Hgb) levels ($P = .001$) and POD-2 Hgb levels ($P = .01$). Mean total blood transfusion units were 0.9 for the CAS group and 1.7 for the CON group. Postoperative range of motion, tourniquet time, length of stay, number of readmissions, and number of reoperations were not significantly different ($P > .05$). The statistically significant differences between the groups may have resulted from violation of the femoral intramedullary canal during the CON technique.

Performing bilateral total knee arthroplasties (bTKAs), sequential or staged, is a topic of debate among surgeons.[1-9] Computer-assisted surgery (CAS) using navigation for TKA is another area of disagreement with respect to complication rates, cost-effectiveness, and potential benefits (eg, fewer outliers, improved longevity) over conventional (CON) surgical techniques.[10-21]

Benefits of less rehabilitation and reduced overall cost have been shown for bTKAs over staged unilateral total knee arthroplasty (uTKA).[1] Perioperative complications in the acute hospital setting have had mixed results. Some small to medium-size retrospective and prospective studies have found minimal or no difference in complication rates or functional outcomes between bTKAs and uTKA.[1-3] However, there is some agreement that, in patients older than 70 years, bTKAs increase the risk for complications,[4-6] especially cardiovascular events and confusion or postoperative delirium. In a large database review, Memtsoudis and colleagues[5] found that, compared with primary uTKA, bTKAs had a 1.3 times higher rate of procedure-related complications and 2 times the mortality rate.

Several studies have also reported significantly higher risk for pulmonary embolism (PE), overall mortality, and cardiovascular complications with bTKAs.[7-9] Most of this literature points to use of intramedullary femoral cutting guides as the main contributing factor for increased systemic complications caused by a higher rate of marrow and fat emboli. This higher emboli rate has been measured systemically in experimental studies.[22,23]

CAS-TKA is still a topic of debate among surgeons. Proponents of CAS systems point to studies that demonstrate significant reductions in blood loss and transfusion,[17,19-21] length of stay,[12] and cardiac complications[12]; increased bone-cut precision[11,13,14,16]; and fewer emboli.[24,25] They attribute the latter benefit to the ability of CAS systems to make accurate bone cuts without intramedullary canal penetration. There is also a potential but unproven cost benefit to CAS over the long term, based on the theory that more accurate alignment reduces the need for subsequent revisions.[26]

Critics of CAS point to longer operative and tourniquet times, averaging 15 minutes more than CON-TKA.[11,15,18] Other studies critical of CAS have found longer operating time, higher cost, unique complications (eg, pin-site complications), lack of improvement in short- and long-term subjective pain scores and functional outcomes, and lack of evidence with respect to reducing revision rates.[10]

No studies have compared the clinical outcomes and complications of sequential CAS-bTKAs versus sequential bTKAs performed with conventional cutting guides. We analyzed those outcomes and complications and thereby examined the

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role of CAS in bTKAs. We hypothesized that avoiding intramedullary femoral canal cutting guides and using CAS for sequential bTKAs would significantly reduce blood loss and number of transfusions.

Materials and Methods

The power calculation showed that a minimum of 21 patients in each group would provide 80% power to detect a difference of 1 point (±1 SD) for blood loss for a significance level of .05. To account for the differences in transfusion rates, we reviewed a retrospective cohort study of 124 (62 CAS, 62 CON) sequential bTKAs performed between 2006 and 2012. Mean follow-up was 3.7 years. We defined *sequential bilateral* as performing both TKAs under the same anesthesia but completing the first replacement and then preparing and draping for the second replacement using new instrumentation. Patients were matched on age, sex, body mass index (BMI), Charlson Comorbidity Index (CCI), and American Society of Anesthesiologists (ASA) classification.

One surgeon performed all CON surgeries, and another performed all CAS surgeries. These joint reconstruction fellowship–trained surgeons perform a high volume of TKAs. All TKAs had a midline incision, medial parapatellar arthrotomy, patella resurfacing, and component cementation done at the same institution, and all TKA patients underwent the same postoperative rehabilitation. Drains were placed during surgery in all CAS patients but not in CON patients. All CAS cases used an imageless system with intraoperative registration. For all CON patients, autograft bone was used to plug the intramedullary hole in the femur. For both groups, a closed-box-design femoral component was used primarily. Tranexemic acid (TXA) was not used in any cases. When signs or symptoms were present and laboratory analysis revealed an Hgb level of less than 8.0 g/dL, transfusions were ordered.

The data were analyzed with descriptive statistics: Pearson χ^2 test or Fisher exact test for categorical variables, independent samples *t* test for continuous variables, and Poisson regression test for total number of complications. All analyses were performed with SPSS for Windows version 20.0 (SPSS, Chicago, Illinois), and a 2-tailed *P* level of .05 was considered statistically significant.

Results

Mean (SD) results were as follows: age, 65.2 (8.71) years; BMI, 31.8 (6.88); CCI, 3.29 (1.66); and ASA classification, 2.2 (.46). Male:female ratio was 1:2. Patient characteristics were broken down by treatment group (**Table**). No significant differences were found between groups with respect to age, sex, BMI, CCI, ASA classification, or preoperative Hgb level (all *P*s > .05), and there was no significant difference in preoperative mechanical alignment or range of motion (ROM) of the knees (all *P*s > .05).

Mean preoperative Hgb levels were 12.7 g/dL (CAS) and 12.4 g/dL (CON). Compared with the CON group, the CAS group had significantly better postoperative day 1 (POD-1) Hgb levels (10.3 g/dL vs 9.4 g/dL; *P* < .001) and POD-2 Hgb levels (9.59 g/dL vs 9.13 g/dL; *P* = .01) and fewer blood transfusions (0.9 vs 1.7; *P* < .001) (**Table**).

Table. Comparison of Demographics and Clinical Outcomes

	Group[a]		
Variable	CON (n = 62)	CAS (n = 62)	*P*
Sex, n (%)			.26
Male	24 (38.7)	18 (29)	
Female	38 (61.3)	44 (71)	
Age, y	65.47 (8.55)	64.98 (8.92)	.7
BMI, kg/m^2	32.91 (7.55)	30.78 (6.01)	.09
ASA class	2.26 (0.48)	2.21 (0.45)	.82
CCI	3.29 (1.55)	3.29 (1.78)	1.00
Hemoglobin, g/dL			
Preoperative	12.44 (1.34)	12.66 (1.12)	.33
Postoperative day 1	9.38 (1.02)	10.29 (1.15)	< .001
Postoperative day 2	9.13 (0.95)	9.59 (0.94)	< .01
Total PRBC transfusions	1.74 (1.01)	.89 (0.99)	< .001
Length of hospital stay, d	3.24 (0.78)	3.39 (0.61)	.25
n (%)			
Patients with complications	23 (37.1)	14 (22.6%)	.08
Total complications	35	22	.09
Patients with:			
1 complication	12 (19.4)	7 (11.3)	
2 complications	10 (16.1)	6 (9.7)	
3 complications	1 (1.6)	1 (1.6)	
Reoperation	3 (4.8)	2 (3.2)	.65

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CON, conventional; CAS, computer-assisted surgery; CCI, Charlson Comorbidity Index; PRBC, packed red blood cells.

[a]Data are means (SDs), except where noted.

In this study, our broad definition of complications included all perioperative difficulties encountered and did not differentiate between major and minor complications. No statistically significant differences were found between the groups for number of patients with complications (23 CON vs 14 CAS; *P* = .08) or total number of complications (35 CON vs 22 CAS; odds ratio, .464; 95% confidence interval, –.998 to .069; *P* = .09).

The CON group had 35 complications (23 patients): 7 knees with arthrofibrosis (2 patients bilateral), 6 venous thromboemboli (VTEs) in lower extremities (1 patient bilateral soleal vein, 1 patient bilateral peroneal vein), 4 urinary retention, 4 lethargy, 2 altered mental status (AMS), 2 confusion, 1 dizziness, 1 vasovagal syncope, 1 PE, 1 respiratory insufficiency, 1 knee instability, 1 bilateral prosthetic joint infection, 1 superficial cellulitis, 1 ileus, 1 hematoma, and 1 decubitus ulcer. The CAS group had 22 complications (14 patients): 6 knees with arthrofibrosis (2 patients bilateral), 5 VTEs in lower extremities (1 distal to knee), 3 superficial cellulitis, 2 PEs, 1 patella fracture, 1 renal insufficiency, 1 pneumonia, 1 heel ulcer, 1 stitch abscess, and 1 urinary retention.

We noted further that 7 CON patients (11%) had lethargy, AMS, presyncope, or syncope during postoperative hospitalization, but no CAS patient did.

Three CON patients and 2 CAS patients underwent procedures after their index surgeries. Two patients in each group had bilateral knee arthrofibrosis and had bilateral manipulations or arthroscopic lysis of adhesions and manipulation performed on an outpatient basis. One CON patient had bilateral infection with coagulase-negative staphylococcus and was successfully treated with open irrigation and debridement and liner exchange, and then intravenous antibiotics for 6 weeks. Other outcomes, including Hgb levels after POD-3, length of stay, postoperative ROM and alignment, readmissions, and reoperations, were not significantly different with numbers available between the 2 groups (all Ps > .05).

Discussion

Compared with sequential CON-bTKAs, sequential CAS-bTKAs had higher Hgb levels on POD-1 and POD-2 and fewer blood transfusions. Previous studies have also found reduced total blood loss[17,19-21] and lower transfusion rates[21] using CAS for uTKA. These differences are theorized to result from cannulation of the femoral canal while placing an intramedullary guide during CON-TKA causing increased bleeding. Emboli from cannulation of the femur may have resulted in the increased incidence of AMS and lethargy but did not increase incidence of PE in the CON group in our study. We did not specifically screen for emboli in this study and therefore cannot specifically conclude that they factored into our results. Symptomatic postoperative anemia also likely had a role in the increased amount of lethargy and syncope in the CON-TKA cohort.

The literature is mixed on whether CAS for TKA reduces the number of emboli. Kim and colleagues[27] sequentially evaluated arterial and right atrial blood before and after violating the femur and tibia medullary canals during CON- and CAS-TKA. No significant difference in fat or bone marrow emboli was noted. Similarly, no significant difference in fat embolism size, amount of atrium filled by emboli, and duration of embolic shower was found by O'Connor and colleagues[28] when they evaluated patients with transesophageal echocardiography of the right atrium after tourniquet deflation in both CAS-TKA and CON-TKA. Conversely, 2 studies showed differences in emboli. Kalairajah and colleagues[24] used noninvasive transcranial Doppler to evaluate cranial emboli and found a significantly higher number of emboli in the CON group than in the CAS group. They reported that almost all the emboli seen occurred during or after cannulation of the femur or insertion of the trial prosthesis. However, they found no significant difference in mental test scores between the groups. In another study, by Ooi and colleagues,[25] degree, duration, and size of embolic shower were evaluated using transesophageal echocardiography comparing CON and CAS. The authors found a significant decrease in the size of the emboli as well as improved pulse oximeter saturation and heart rates for the CAS group.

Thirty percent (37/124) of all patients in this study had at least 1 major or minor complication. Although that rate seems elevated, some studies[8,9,29,30] have reported a higher risk for complications with simultaneous bTKAs. On review of our patients' comorbidities, ASA classification (2.2) and CCI (3.29) were high. All adult surgical patients with an ASA classification of 2 have a 1.64 times increased risk for major postoperative complications compared with those with an ASA classification of 1.[31] Similarly, patients admitted for uTKA with a CCI of 2 or higher are 2.1 times more likely to have a complication during hospitalization than are patients with a lower CCI.[32] These factors likely attribute for our complication rate. The CON group in our study included 7 patients with AMS, lethargy, presyncope, or syncope during their hospital stay, versus none in the CAS group. Haytmanek and colleagues,[33] studying cognition in CON- and CAS-uTKA, administered a Folstein Mini-Mental Status Exam (MMSE) before surgery and serially after surgery in the hospital and 6 months after surgery. They found no differences between groups with respect to MMSE scores at any point, narcotic pain medicine use, or need for oxygen supplementation. The difference between their and

Compared with sequential CON-bTKAs, sequential CAS-bTKAs had higher hemoglobin levels on POD-1 and POD-2 and fewer blood transfusions. Previous studies have also found reduced total blood loss and lower transfusion rates using CAS for uTKA.

our study results could be caused by the compounding effect of bTKAs instead of uTKA.

Similar to other studies, we found no differences in component survivorship between the 2 groups. Several studies have evaluated and compared patients who had sequential or staged bTKAs using a CON technique on one side and CAS on the other. In 2 of those studies, no differences were found in alignment, ROM, or Knee Society Scores between the groups.[18,34] In another study comparing CON and CAS within the same patient with varus alignment, the authors found significant differences in alignment after surgery in the CAS group only when preoperative varus was more than 20°.[35] Zhang and colleagues[36] found a significant difference in mechanical alignment with improvement for the CAS group versus the CON group when done in the same patient, but no difference in

Hospital for Special Surgery Scores. Finally, multiple studies with 5-year or longer follow-up have compared clinical outcomes, ROM, and implant survival and failed to show improvement in CAS-TKA despite better mechanical alignment.[37-40]

At the time of our study, neither of our surgeons used TXA. A meta-analysis of level I and II evidence studies showed that intra-articular injection of TXA reduced total blood loss, drainage loss, and the transfusion rate without increasing the incidence of complications.[41] Similarly, Karam and colleagues[42] studied intravenous TXA use specifically in simultaneous bTKAs and found statistically significant reductions in blood loss and the transfusion rate without any VTEs in either group within 90 days after surgery.

Our study has several limitations, which should be considered when interpreting its findings. It is a retrospective analysis with small cohort sizes and short follow-up. It also had 2 different surgeons performing the operations—which introduces variability. Randomization of the techniques between the 2 surgeons would have created less potential for bias. This study did not control for all variables contributing to blood loss. More CON patients donated blood before surgery, but preoperative Hgb levels were not significantly different. On the contrary, all CAS-TKAs had drains placed, but no drains were placed in CON-TKAs. Use of drains in TKA has been shown to increase postoperative blood transfusion rates (relative risk, 1.5).[43] Despite this increased risk, in our study the transfusion rate was higher for CON-TKAs. Therefore, the difference in transfusion rates may actually be higher than found in our study. In addition, to better assess differences in postoperative mentation between groups, validated testing (MMSE) should be used.

Conclusion

In this study, we found a significant difference in early perioperative outcomes between CON and CAS groups. To our knowledge, this study is the first to compare CON and CAS for sequential bTKAs. Multiple studies have compared CON and CAS for uTKA and reported mixed results regarding differences in outcomes. During bTKAs, CAS improved POD-1 and POD-2 Hgb levels and reduced the transfusion rate. Prospective studies—with more patients, longer follow-up, and a single surgeon performing both CON and CAS surgeries—are required to further evaluate differences between the 2 techniques for sequential bTKAs regarding clinical outcomes and benefits.

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This paper will be judged for the Resident Writer's Award.