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Disparate Postoperative Results in the First and Second Knees on Simultaneous Bilateral Total Knee Arthroplasty

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ABSTRACT

We hypothesized that the circumstances of the two consecutive operations of a simultaneous bilateral total knee arthroplasty (TKA) are different, and could lead to different outcomes of overlapping bilateral TKAs. Both knees of 420 subjects were evaluated in the current study. In the second TKA, there were more incidence rates of outlier in mechanical femoro-tibial angle (16.2% vs. 9.0%), more blood loss (735 vs. 656 mL), and longer operation time (61, 58 minutes respectively), as compared to the first TKA, while no significant differences in clinical outcomes. In conclusion, there were no significant differences in the clinical outcomes even though few distinct outcomes due to different circumstances of the surgery. Awareness of these findings can help the continued success of bilateral TKA in an increasing patient population.

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A large proportion of patients with osteoarthritis of the knee, present with bilateral symptoms at the outpatient department [1]. A simultaneous total knee arthroplasty (TKA) procedure is available for such patients [2] and has several advantages. Simultaneous surgery decreases the required duration of hospital stay as well as the number of hospital admissions, with concomitant decreased absence from work, at an overall less cost to the patient [3,4]. Furthermore, anesthesia during a simultaneous surgery minimizes the complications from multiple episodes of anesthesia [5,6], and period of total rehabilitation is expected to be shorter than a staged approach [7,8].

The first operation in a simultaneous surgery may provide information to the surgeon to determine component size, soft tissue balancing, and estimate gap size for the second operation. Capeci et al indicated a difference in component asymmetry, during bilateral TKA, although bilateral gonarthrosis is frequently symmetric in appearance and deformity [9]. Furthermore, the second team usually conducts an operation in a confined space on the contralateral side during closure for the first operation, which can disturb cooperation during the second operation and may lead to more intra-operative surgical errors.

We hypothesized that bilateral TKAs performed simultaneously would have different postoperative results due to disparate situations. We therefore addressed the following research questions to determine whether there would be differences in short-term clinical outcomes, radiographic results, and implanted component size between the two sides. We sought to: (1) determine whether there was a difference in the incidence and characteristics of outliers for postoperative whole limb mechanical axis angle outside the acceptable range of 180 ± 3° and component alignment angle outside the acceptable range of 90 ± 3°; (2) determine differences in clinical results including operation time, blood loss, and clinical outcome scales obtained from patient questionnaires (the American Knee Society [10], Western Ontario McMaster University Osteoarthritis Index [WOMAC] scales [11]), range of motion (ROM) and incidence of peri-operative surgical complications between bilateral TKAs performed simultaneously; and (3) determine how well femoral and tibial component sizes coincided, the correlation in component symmetry, and which factors were correlated with the asymmetry, in bilateral simultaneous TKA.

Materials and Methods

A retrospective review of 451 consecutive patients, who underwent simultaneous bilateral TKA between January 2011 and April 2012, was conducted. We excluded patients whose radiographic records were incomplete for analysis (n = 39), those with unilateral posttraumatic arthritis (n = 2), those whose knee was operated, using a constrained prosthesis due to severe bony defects in the proximal tibia (n = 7), and those patients who had follow-up data for a minimum of 1 year. After these exclusions, 420 patients were eligible for inclusion. The data were reviewed for demographic characteristics. A preoperative assessment was done according to Kellgren–Lawrence (K-L) classification for gonarthrosis [12]; 384 patients were included in K-L grade IV, 35 in grade III, and 1, who was diagnosed with osteonecrosis, in grade II. There was no significant

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side-to-side difference of preoperative K-L grade (3.9 ± 0.3 in each side respectively, $P = 1.000$) (Table 2) and ROM (122.4 ± 17.9 in right side, 122.9 ± 16.3 in "left" side, $P = 0.663$) (Table 3). There were 427 females and 24 males with a mean age of 69 years (standard deviation: 6.4 years, range: 55–85 years). The average body mass index (BMI) was 27.4 kg/m^2 (standard deviation: 3.2, range: 19–39) (Table 1). The current study obtained institutional review board approval from our institution (Samsung Medical Center, 2014-01-137) and informed consent was obtained from all participants.

The same surgical technique and rehabilitation protocol were used for both knees of all patients. All surgeries were performed by a single senior surgeon (one of the authors) using Insall's anteromedial approach with a tourniquet [13]. Bilateral TKAs were performed with the senior surgeon conducting the main procedure (from skin incision to implantation of prosthesis). The surgeon first operated on the right side just by implantation, then he switched to the contralateral "left" knee with a second team. The similar main procedure was progressed to the second knee during closure of right side.

All closures were done by the same assistant *i.e.* the first author's fellow. Ritter et al reported overlapped procedures reduced approximately twenty minutes in tourniquet elevation time between the two sides [14]. During the "left" side procedures, the operative team on right side did not provide any assistance to the other side. For this reason, the second operative team, with one operator and two assistants on the "left" side was confined to a restricted area. An extramedullary alignment system for both the femur and tibial guide system was used in all patients [15]. We determined the coronal and sagittal femoral resection planes using a customized graduated ruler for targeting the accurate location of femoral head center [16] the palpable anatomical landmark [17], reported previously. An extramedullary tibial guide with a perpendicular cut to the tibial anatomical axis, was used for the tibial cut [15,18]. Femoral components were sized to optimally match femoral anatomy and create balanced flexion and extension gaps with anterior referencing techniques. Tibial component sizing was performed to maximize coverage of the resected surface and maintain proper component rotation.

Two deep-flex designed total knee prostheses (LOSPA, Corentec, Inc. South Korea; Scorpio Non-Restrictive Geometry (NRG), Stryker, NJ, USA) were used. Two prostheses were used bimonthly during our study and each patient had bilateral surgeries with the same prosthesis. 233 patients underwent bilateral TKAs using Scorpio NRG, and 187 patients using LOSPA. Different versions were available designed to be compatible with the geometry of the femur and tibia implant size. All the components were cemented with Simplex P (Howmedica, Rutherford, NJ) bone cement, and all the patellae were resurfaced with an all polyethylene dome-shaped component, implanted with bone cement. Drains were put on both sides. The skin was closed using a metal stapler, and an elastic compression dressing was then applied. The drain on the right side was clamped during completion of the "left"-side operation. Drains were removed simultaneously the second day after surgery. The total volume of each drain was then recorded separately. A tourniquet was used for all surgical procedures, and the tourniquet was released only after skin closure. Tranexamic acid (0.1 mg/kg body weight) was used for all patients except those with a history of myocardial infarct or stroke. Tranexamic acid was administered via intravenous route just before surgery on both sides in all cases. All patients received a first-generation cephalosporin as antibiotic prophylaxis until postoperative day 3. Continuous passive motion exercises were started on postoperative day 1. Ambulation was allowed on postoperative day 2, after drainage removal. Thereafter, active and passive joint exercises were allowed within a comfortable range of motion (ROM).

Table 1
Demographic Data for the Study Population.

Parameters	Frequencies
Number of patients	420
Age (years)	69.2 ± 6.4 (50–89)
Body mass index (kg/m^2)	27.4 ± 3.2 (19–39)
Sex (number of patients)	
Male	23 (5.5%)
Female	397 (94.5%)
Diagnosis (number of patients)	
Osteoarthritis	413
Rheumatoid arthritis	5
Osteonecrosis	2
General/regional anesthesia	17/429
Kellgren–Lawrence classifications (2/3/4)	1/35/384
Used prosthesis (number of patients)†	
Scorpio NRG®	233
LOSPA®	187

* Values are mean ± standard deviation, with range in parentheses.
† Each patient was taken bilateral TKAs simultaneously with same company's prosthesis.

Clinical Evaluation

Clinical information was prospectively collected by an independent investigator. Parameters compared between the bilateral sides included postoperative blood loss, operation time (tourniquet time), implanted femoral and tibial component size, and peri-operative surgical complications. Blood loss was determined by the total volume of blood *via* a drain for 24 hours postoperatively. Tourniquet time was recorded at deflation after the dressing was applied. ROM recorded in all patients at 1 month preoperatively and 1 year postoperatively, was measured using a goniometer, with the patient in a supine position. Clinical outcome scores were measured using the Knee Society Knee and Function scores (KSKS and KSFS) [10] and WOMAC score [11,19] preoperatively and at 1 year after surgery. A peri-operative surgical complication was defined as a significant problem related to surgery that occurred within 3 months postoperatively. These included deep infection requiring a revision operation, patellar or quadriceps tendon rupture, peri-prosthetic fracture, or peroneal nerve palsy. The difference in the incidence rate of complications was compared between the sides.

Radiographic Evaluation

One of the authors (BHL) screened all full-length radiographs before analysis for excessive rotation of the limb or improper exposure, which would make the radiograph unsuitable for analysis. To determine excessive rotation of the limb on radiographs, the appearance of the lesser trochanter and the fibular head profile was used as landmarks. Radiographs that showed one of these two profiles in excess, were interpreted as malrotation of the limb, and those limbs were excluded from the study. Angles measured on full-length hip-to-ankle radiographs are reportedly reliable [20]. Hence, the radiographic assessment was done using preoperative and postoperative full-length standing hip-to-ankle and standing AP and lateral radiographs. The radiographs taken preoperatively and at one-year follow-up were used for analysis in this study. All digital radiographic images were analyzed using a picture archiving and communication system (General Electric, Milwaukee, WI, USA). The degree of preoperative and postoperative knee deformity or HKA angle was determined on the standing full-length radiographs as the angle between the mechanical axis of the femur (center of the femoral head to the center of the knee) and the mechanical axis of the tibia (center of the knee to the center of the ankle plafond). There was no significant side-to-side difference in preoperative alignment (10.3 ± 6.3° in the first TKA, right side, 10.7 ± 6.4° in the second TKA, "left" side) (Table 2). Postoperatively, coronal alignment of femoral and tibial components was measured using their respective mechanical axes on full-length radiographs. Two independent investigators (KYK, NRL) drew these angles on

Table 2
Outlier Rates of Preoperative and Postoperative Mechanical Femoro-Tibial Axis Angle and Femoral and Tibial Component Alignment in Bilateral Total Knee Arthroplasty.

Parameters*	1st Knee (Mean ± SD)	2nd Knee (Mean ± SD)	*P* Value
Preoperative MFTA	10.3 ± 6.3	10.7 ± 6.4	0.230
Preoperative K-L classification	3.9 ± 0.3	3.9 ± 0.3	1.000
Postoperative MFTA	1.1 ± 1.8 (−7 to 9)	1.9 ± 1.9 (−3 to 13)	
Outliers for postoperative MFTA[$]	9.0 %	16.1 %	0.003
Femoral component coronal angle	89.8 ± 2.0 (83–95)	88.4 ± 2.4 (78–93)	
Outliers for femoral component angle[#]	10.1 %	12.6 %	0.346
Tibial component coronal angle	90.3 ± 1.4 (86–95)	90.2 ± 1.5 (86–95)	
Outliers for tibial component angle[#]	8.3 %	7.8 %	0.861

MFTA, mechanical femoro-tibial axis angle; SD, standard deviation K-L: Kellgren-Lawrence.
P-value was calculated by McNemar's test.
* Values are mean ± SD, with range in parentheses.
$ Postoperative MFTA outside the conventional ±3° range from a neutral alignment of 180° was considered outliers for limb alignment.
# Components outside the conventional ±3° range from a neutral alignment of 90°in the coronal plane were considered outliers for component alignment.

preoperative and postoperative full length radiographs and compared the values between the sides. Intraclass correlation coefficients (ICC) were used to identify the degree of agreement within a rater or between raters.

Two independent observers measured coronal alignment of the component. Hence, the ICC about intra-observer variability was 0.86, and ICC about inter-observer variability was 0.84. There was good or excellent inter-observer agreement in all of the measurements performed.

Statistical Analysis

Patient data and the preoperative and postoperative radiographic alignment data are expressed as mean and standard deviation [21]. Differences between the first and second TKA were determined by McNemar's test for binary variables and the Wilcoxon signed-rank test for continuous variables. We investigated the association between influential factors for the difference between the first and second TKA in a binary outcome that was defined as the incidence rate of postoperative coronal limb alignment outliers (> ± 3°) and surgical complications, respectively. The influential factors were regarded as demographic factors (sex, age, and body mass index), and preoperative clinical conditions (ROM and mechanical tibio-femoral angle). We determined the significance of the association using GEE (Generalized Estimating Equations) in univariate and multivariate analyses.

The weighted kappa was used to assess the reliability of the symmetry rate in component size. Component asymmetry rates for the femur and tibia were compared between the two prostheses types using the chi-square test with Bonferroni's correction. The incidence rates in which smaller sized components were inserted in the femur and tibia during the second TKA were estimated with 95% confidence intervals and compared with 0.5 using the binomial test with Bonferroni's correction. Results were considered significant at a *P*-value < 0.05. All statistical analyses were performed using SAS ver. 9.3 (SAS Institute, Cary, NC, USA).

Results

Radiographic Results

The second TKA had significantly more postoperative coronal limb alignment outliers. However, no significant differences were observed in outlier rates of the femoral and tibial component angle ($P = 0.346$ and 0.861, respectively) (Table 2). In the first TKA, 10.1% incidence rate of outliers in the femoral component angle and 8.3% in the tibial component angle, while 12.6% incidence rate of outliers in femoral component angle, and 7.8% in tibial component were observed in the second TKA. However, a greater incidence (16.1%) of outliers during postoperative coronal limb alignment (> ± 3°) were identified in the second TKA than those in the first TKA (9.0%) ($P = 0.003$), and the mean coronal alignment values were 1.1° for the first TKA, vs. 1.9° in the second TKA (Table 2). Univariate analysis for the association of outlier rates in the second TKA relative to the first and influential factors, revealed a significance for severity of the preoperative deformity (pre-op. coronal limb alignment, $P = 0.002$) from the GEE analysis. After adjusting for other factors, significance was found for severity of the preoperative deformity (pre-op mechanical femoro-tibial angle, $P = 0.006$) and decreased ROM ($P = 0.042$) from the GEE analysis (Table 4). Figures for the log odds (logit) of the outliers and severity of preoperative deformity were displayed to identify these results in a multivariate analysis. After adjusting for other factors, the logit of the outlier for the first knee decreased with severity of the preoperative deformity, while the logit for the second knee increased (Fig. 1). The severity of preoperative deformity decreased ROM similarly.

Clinical Results

Clinical Outcomes and Surgical Complications

The second TKA did not have identical clinical outcomes as the first TKA, including operation time, blood loss, clinical outcome scale scores (KSKS). The second TKA was longer (61 minutes) than that of the contralateral side (58 minutes) ($P < 0.001$). Mean total blood loss *via* the drain for the first TKA was significantly less than that for the second TKA (656 vs. 735 mL, $P < 0.001$). At the 1 year follow-up, neither knee showed a difference in ROM before or after surgery ($P = 0.663$, 1.000 respectively). The mean preoperative flexion angles of the knees were 122° and 123° in order, and postoperative flexion angle improved equally to 129° and 127°, respectively. No significant differences in postoperative KSFS or total WOMAC scores

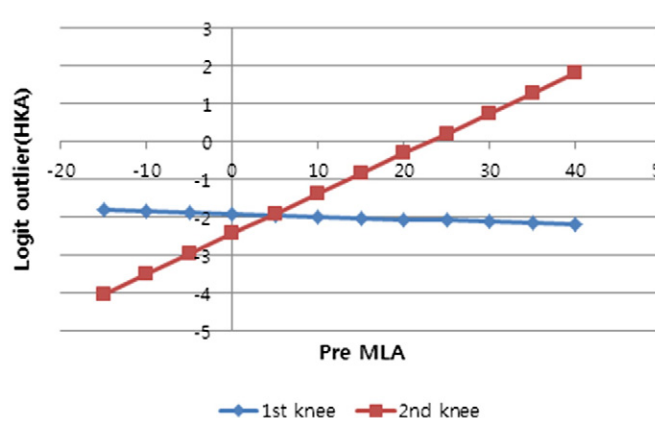

Fig. 1. Log odds (logit) of outliers increase along with the severity of preoperative deformity and the inclination is more in the second knee than in the first knee (x axis: preoperative mechanical limb axis angle (MLA)).

Table 3
Comparison of the First and Second Total Knee Arthroplasty Procedures.

Parameters	1st Knee (Mean ± SD)	2nd Knee (Mean ± SD)	*P* Value
Tourniquet time (minutes)	58.2 ± 12.4	60.5 ± 10.3	<0.001
Postoperative drained blood amount (mL)	656 ± 420	735 ± 434	<0.001
Postoperative			
KSKS	86.5 ± 13.1	83.8 ± 13.2	<0.001
KSFS	69.8 ± 23.7	69.7 ± 23.7	0.316
Total WOMAC scores	23.8 ± 13.5	23.8 ± 13.4	0.717
Range of motion			
Preoperative	122.4 ± 17.9	122.9 ± 16.3	0.663†
Postoperative	125.5 ± 12.2	125.3 ± 11.9	1.000†
Incidence rate of surgical complications	1.2%	2.4%	0.166*

SD, standard deviation; KSKS, Knee Society Knee Score; KSFS, Knee Society Function Score; WOMAC, Western Ontario and McMaster Universities Index.
Postoperative data were checked at the outpatient department 1 year postoperatively. *P*-value was calculated by Wilcoxon signed-rank test.
† Wilcoxon signed rank test with Bonferroni's correction and
* McNemar's test.

were observed between the sides ($P = 0.316$, 1.000 respectively); however, a significant difference in postoperative KSKS score was observed ($P < 0.001$). The mean postoperative KSFS and total WOMAC scores improved equally to 70 and 24, 1-year after surgery, whereas the KSKS score improved to 86.5 and 83.8 in the first and second TKA respectively ($P < 0.001$).

We identified more peri-operative surgical complications during the second TKA than those during the first. Among 15 surgical complications, 5 (1.2%) occurred after the first TKA and 10 (2.4%) were identified after the second TKA. One deep infection, one distal femoral condylar fracture, one peri-patellar fracture, one quadriceps tendon rupture, and one peroneal nerve palsy were observed during the first TKA, and two deep infections, 2 peri-patellar fractures, 1 patellar subluxation, 2 patellar tendon ruptures, 2 peroneal nerve palsies, and 1 massive hemarthrosis occurred after the second TKA. However no differences were observed between the sides ($P = 0.166$) (Table 3). In univariate and multivariate analyses, no significant factors were related to the difference between the first and second TKAs or the TKA complication incidences.

Component Symmetry

Component size symmetry in bilateral TKA showed high coincidences. Weighted kappa ratios (0.900 in femur and 0.867 in tibia) were identified (weighted kappa >0.75: excellent reliability, $0.4 \leq \kappa \leq 0.75$: good reliability, <0.4: marginal reliability). There was an 89.1% femoral component symmetry rate and an 86.9% tibial component symmetry rate in the 420 bilateral TKAs. Asymmetric implanted femoral and tibial components differed by one size in all instances. The incidence of component asymmetry was not correlated with differently sized prosthesis types (femur: 12%, 10% $P = 0.871$ tibia: 14%. 11% $P = 0.620$ in Scorpio NRG, LOSPA respectively).

Discussion

Simultaneous bilateral TKA has several advantages including shorter hospital stay, rehabilitation and disability times, and lower hospital costs [22]. Proponents of simultaneous bilateral TKA argue that the surgery carries no more risk for postoperative complications than that of unilateral TKA [23–25] and that there is no difference in component alignment between simultaneous bilateral TKA and unilateral TKA [26]. Furthermore, the first operation can provide information and aid the surgeon conducting the later contralateral side operation. In another study, bilateral procedures were not overlapped, and performed separately [26]. There has been no prior study of comparison between both sides, especially performed overlapped, with two teams and one operator. We anticipated that several factors including the surgeon's fatigue and restricted operation field during the second operation could affect postoperative results. Therefore, we determined whether there were differences in postoperative radiological and clinical results including surgical complications, between bilateral TKA. We also determined whether there were any correlations between the knees.

Radiographic Results

We hypothesized that it was possible for angular differences to occur during coronal alignment of limbs and components placed during bilateral TKA and single TKA. Therefore, we addressed the differences and characteristics of alignment, a reported advantage to prosthesis survival [27]. There were more incidences outside the conventionally acceptable range of 180 ± 3° during postoperative coronal limb alignment of the second operated knee than those for the first (9.0% in the first TKA, 16.1% in the second TKA) ($P = 0.003$). In contrast, no significant differences were observed in the incidence rates of coronal component placement angles. In the first operated knee, there were 10.1% of outlier rates in femoral component coronal angle (mean 89.8°), and 8.3% of outlier rates in tibial component coronal angle (mean 90.3°); and there were 12.6% of outlier rates in femoral component coronal angle (mean 88.4°), and 7.8% of outlier rates in tibial component coronal angle (mean 90.2°) in the second operated knee (Table 2).

We interpreted the meaning of 3 radiographic results: (1) the later operation had more chances for poor postoperative alignment results (2) but, this difference was not caused by errors during bone cuts and inadequate component positioning, but by a medio-lateral soft tissue imbalance in knee extension, which may have caused the mechanical axis to deviate under weight-bearing conditions. (3) The soft tissue balance technique is complex and based on a surgeon's expertise and subjective assessment [28]. Thus, the surgeon's performance in the confined space of the contralateral knee could affect the accuracy of soft tissue balancing and deformity correction during the second TKA. The multivariate analysis also showed that the severity of preoperative various deformity and stiffness (lower ROM) were related to an increased incidence of outliers for the postoperative coronal limb alignment angle ($P = 0.006$, 0.042 respectively). That is, technical difficulties during ligament balancing procedures might affect the radiographic results on either side of one patient. BMI, age, and gender did not significantly affect postoperative results (Table 4). Actually,

Table 4
The Association of Influential Factors for the Difference Between the First and Second Total Knee Arthroplasty Procedures in the Binary Outcome.

Parameters	MFTA		Surgical Complication	
	Univariate (*P*)	Multivariate (*P*)	Univariate (*P*)	Multivariate (*P*)
BMI	0.659	0.527	0.053	0.051
Pre-op MFTA	**0.002**	**0.001**	0.189	0.358
Pre-op ROM	0.548	**0.042**	0.275	0.435

MFTA, mechanical femorotibial axis; ROM, range of motion; BMI, body mass index.
P-values derived from GEE analysis.
Values < 0.05 are displayed in bold.

Mullaji et al reported that 43% of limbs had malalignment of the mechanical axis despite having well-positioned femoral and tibial components. Deviation of mechanical axis under weight-bearing conditions may result from mediolateral soft tissue imbalance on knee extension [28]. In our study, we did not observe x-ray findings such as condylar lift-off, however we supposed that mediolateral soft tissue balancing might have affected the alignment of the limb mechanical axis.

Our study had 3 limitations: (1) we focused on the coronal plane alignment of limbs and components after TKA, and did not analyze these in the sagittal and axial planes. Although the coronal plane has been the focus of most studies on limb and component alignment, both the sagittal and axial planes may be equally important for long-term implant survival and functioning after TKA. (2) We defined outliers as those outside the $\pm 3°$ range from 180° for the limb mechanical axis and outside the $\pm 3°$ range from 90° for component alignment based on previous studies using these ranges. However, we are fully cognizant of the fact that these are arbitrary ranges and there is inconclusive evidence to support their use [29]. (3) It is possible that other surgeons may obtain the same results for bilateral TKAs performed simultaneously, when these two operations are not overlapped by a single surgeon, as at our institute. Additionally, in contrast with most surgeons' techniques of implementing femoral alignment with an intramedullary guide system and tibial alignment with extramedullary guide system, extramedullary techniques in both bones might likely be more dependent on assist techniques.

Clinical Results and Surgical Complications

The second TKA required more time than the contralateral side. However, the difference was not clinically meaningful (about a 2 minute difference between sides). Others have reported that the surgeon's experience and case volume were related to operative time [30]. In our study, all operations were performed by a single, high volume (>10,000 cases) surgeon with a well-trained adaptive team, which decreased the operation time gap between the sides. In other words, we assumed that the performance of a skilled team and a high volume surgeon might lessen the difference in operation time for a simultaneous bilateral TKA. However, we did not carry out more intensive study on factors affecting operation time. Further investigation in a comparative controlled study is required.

In our study, the mean total blood loss *via* the drain in the second TKA was about 70 mL more than the first TKA. This result corroborated a previous report that blood loss was greater for the second knee by a mean of 323 mL [31]. Several parameters are related to bleeding tendency after TKA, including technical skill, operation time, hemostasis technique, tourniquet type, timing of tourniquet release, and preoperative factors such as gender [32,33]. We proposed 4 possible explanations for this result. Firstly, a lack of meticulous hemostasis due to surgeon's fatigue could have affected the result. Secondly, a longer operation time could have increased blood loss after surgery. Thirdly, "the hemovac tamponade effect" could have influenced the result. Several authors have reported that clamping the drain after the operation can decrease drained blood loss due to the tamponade effect [33]. We clamped the drain for the first TKA after finishing the second TKA and the drains for both sides were set to negative pressures at the end of the second operation; thus, "the hemovac tamponade effect in the overlapping gap" may have reduced bleeding tendency after the first operation. Fourthly, the difference may have resulted from different times of administration to effect of tranexamic acid, administered just before surgery on both sides. However, the total blood volume *via* the drain did not represent the real total blood loss during TKA.

As described above, although several parameters such as the rate of mechanical limb axis outliers and component asymmetry were different bilaterally, there were no significant differences on the KSFS or total WOMAC scores following bilateral TKA ($P = 0.316$, 0.717).

The KSKS score for the second TKA group was significantly lower than that of the contralateral side (first TKA: 86.5 vs. second TKA: 83.8), but we thought that the difference of the knee scores mainly stemmed from the difference in alignment assessment since it affected the subscale of the scoring systems. Although we endeavored every effort to obtain knee scores separately, it was highly challenging. We postulated it was because the functional status of one knee would affect the other [34]. Additionally, patients would not be able to distinguish differences on each side as the KSFS score was based on walking distance, stair-climbing, and the use of walking assistance devices [35]. The same may have occurred with the WOMAC scores, which were mainly composed of functional scores. Briefly, although we endeavored every effort to get knee scores separately, we admit that it was with great difficulty.

Careful attention to detail during TKA, including intraoperative vigilance, judicious use of force when inserting implants, and meticulous technical execution of the procedure is beneficial for minimizing the risk of subsequent peri-prosthetic fractures and is related with surgical complications [36]. However, the surgeon's fatigue resulting from the first operation and restricted space for the second operation may negatively influence these factors during simultaneous bilateral TKA. Contrary to our hypothesis, we could not identify a significant difference in surgical complication incidences after the second TKA (2.4% for second TKA vs. 1.2% for second TKA, $P = 0.166$).

Component Symmetry

Determining femoral component size is dependent on several factors, including rotation [37], surgeon experience [38], surgical technique [39], prosthesis type [9], distal cutting level, and gap size. Similarly, tibial component size is also dependent on proximal tibial bony geometry, bone cutting level, and compatibility with the femoral component. We showed excellent coincidence reliability of the femoral and tibial component size for simultaneous bilateral TKA ($\kappa = 0.900$, 0.867 respectively) but did not show any relationship between component asymmetry and prosthesis type, unlike a previous study [9]. Our result agreed with results from previous studies in which the incidence of component symmetry was very high [9].

In conclusion, although there were few distinct outcomes due to different circumstances of the surgery, there were no significant differences in the clinical outcome. Awareness of these findings can help the continued success of bilateral TKA in an increasing patient population.

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