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The Patient's Perception Does Not Differ Following Subvastus and Medial Parapatellar Approaches in Total Knee Arthroplasty: A Simultaneous Bilateral Randomized Study

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ABSTRACT

This simultaneous bilateral randomized study investigated whether patients would perceive the difference between the subvastus approach (SVA) and the medial parapatellar approach (MPA) after total knee arthroplasty (TKA). In 50 patients scheduled to undergo same-day bilateral TKA, one knee was randomly assigned to SVA and the other to MPA. Patient-reported measures (pain, Western Ontario McMaster University Osteoarthritis Index score, and side preference) and physician-assessed measures (isokinetic muscle strength, range of motion, and Knee Society score) were compared. No differences were observed in the patient-reported measures and physician-assessed measures, with the exception of greater quadriceps strength at postoperative 1 week in knees that underwent SVA. Patients receiving contemporary perioperative management after same-day bilateral TKA do not perceive any difference between knees that underwent SVA or MPA.

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The use of total knee arthroplasty (TKA) has increased substantially over the past few decades, with the projected demand for TKA estimated to increase rapidly in the future [1–4]. With this escalation in use, concerns about a growing socioeconomic burden on the health care society are emerging [5]. Various strategies to improve postoperative recovery have been established, which might serve to reduce the cost of TKAs. Recently, as the length of time spent in hospital has been shortened by TKAs performed on an outpatient basis [6–8], the emphasis has been on a faster recovery during the early postoperative period. Although advances in pain management are well documented to be a major factor in the improvement of postoperative recovery after TKA, a modification of the surgical approach may also play a part. The subvastus approach (SVA), which has numerous theoretical advantages over the traditional medial parapatellar approach (MPA) during the early postoperative period, may be a reasonable surgical approach within this context. However, although some previous studies have reported that SVA provided a superior postoperative outcome compared with MPA [9–16], other studies reported no difference between the 2 surgical approaches [17–23]. Therefore, the question of whether SVA is more appropriate for a contemporary postoperative management protocol after TKA remains controversial.

Recently, patient-reported outcome measures (PROMs) such as patient satisfaction and quality of life (QoL) are becoming increasingly accepted as an essential part of the assessment of the postoperative outcome after TKA [24–26]. However, as most previous studies have tended to focus on physician-assessed objective outcomes such as the maximal muscle strength, it is unclear whether any difference in surgical approach affects the PROMs. A comparison between knees that underwent different surgical approaches in a single patient might be the best method of assessing the difference between these approaches. However, only a few simultaneous randomized bilateral trials relating to different surgical approaches have been undertaken [12,22,27–29] and have provided contradictory results regarding patients' side preference between a recent study [28] and those published in the 1990s [12,27]. Therefore, whether patients prefer SVA or MPA remains to be determined.

Thus, this prospective simultaneous bilateral randomized study was performed to determine whether patients perceive the difference between knees in terms of PROMs and whether SVA has any advantages over MPA in terms of physician-assessed objective outcomes in patients receiving contemporary perioperative management after same-day bilateral TKA.

Patients and Methods

This study included 56 patients scheduled to undergo same-day bilateral TKAs between March 2013 and March 2014. After obtaining approval from our institutional review board, we randomly assigned one

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knee to undergo SVA and the other knee to MPA for each patient. Eligible patients included those younger than 75 years, with an American Society of Anesthesiologists score of 1 or 2, and who were scheduled for same-day bilateral TKA for primary osteoarthritis. Exclusion criteria included patients who had postoperative complications such as periprosthetic infection, periprosthetic fracture, or venous thromboembolism that could potentially affect the postoperative outcomes. Patients who declined to participate in this trial or who were unable to provide informed consent were also excluded. Of the 56 patients enrolled in this study, 5 were subsequently excluded: 3 patients for a diagnosis other than osteoarthritis (2 rheumatoid arthritis and 1 post-traumatic arthritis) and 2 patients (4 knees) because they declined to participate. Thus, 51 patients in total were recruited. One knee was randomly assigned to the SVA group, which underwent the SVA, and the contralateral knee was assigned to the MPA group, which underwent the MPA. A computer-generated randomization table, permuted into blocks of 4 and 6, was used to randomly assign patients to either the SVA group or the MPA group. Allocation was assigned at the commencement of surgery by a scrub nurse who was not involved in patient recruitment for this trial. The patients and an independent investigator who prospectively collected the clinical information were unaware of group assignments until the final data analyses were complete. One patient (2 knees) was excluded because she could not complete the same-day bilateral TKA due to intraoperative atrial fibrillation after one side of the TKA. Consequently, 50 patients (100 knees) were included in the final analyses (Fig. 1). Of these 50 patients, 47 were female and 3 were male. The mean age was 65 years, ranging from 56 to 75 years, and the mean body mass index was 26.8 kg/m^2, ranging from 19.0 to 39.7 kg/m^2. Final outcome adjudications were completed in April 2015.

We performed an a priori power analysis based on the results of a previous study [30] to determine whether our sample size had sufficient statistical power, using the 2-sided hypothesis test at an α level of .05 and a power of 80%. Thirty-nine knees in each group were required to detect a 2-point visual analog scale (VAS) difference in pain level, which we considered to be clinically significant for the following reasons. First, the pain levels assessed after same-day bilateral TKA were 3 to 5 points on a 0- to 10-point VAS in our clinical practice [30,31], and a previous study reported that it considered a 50% reduction in the VAS pain score to be clinically meaningful [32]. Second, the mean satisfactory postoperative VAS pain score has been reported to be around 2 VAS points [33]. To allow for exclusions and dropouts, we enrolled 50 patients in the current trial.

All operations were performed by a single surgeon (one of the authors) in patients under general anesthesia in a standard fashion. A posterior-stabilized prosthesis (LOSPA; Corentec, Seoul, Korea) was implanted in all patients. The patella was not resurfaced, and cement fixation was used for all components in all cases. An intramedullary alignment system was used for the femoral cuts and an extramedullary system was used for the tibial cut. A pneumatic tourniquet that inflated to 300 mm Hg was applied. Meticulous bleeding control was performed after deflation of the tourniquet. An intra-articular suction catheter was inserted and removed within 48 hours after the operation. The surgical approach for TKA was performed using either SVA or MPA. An identical anteromedial skin incision from 2 finger breadths above the patella to the tibial tuberosity was used in both groups to maintain blindness. In SVA, the medial margin of the vastus medialis muscle was identified and retracted. A curvilinear medial arthrotomy was made beginning in the medial suprapatellar pouch through the midpatellar insertion of the vastus medialis and ending at the tibial tuberosity [34]. In MPA, the extensor mechanism was incised along the most medial aspect of the quadriceps tendon with 3 mm of medial margin, opening the musculotendinous junction of the vastus medialis and leaving the

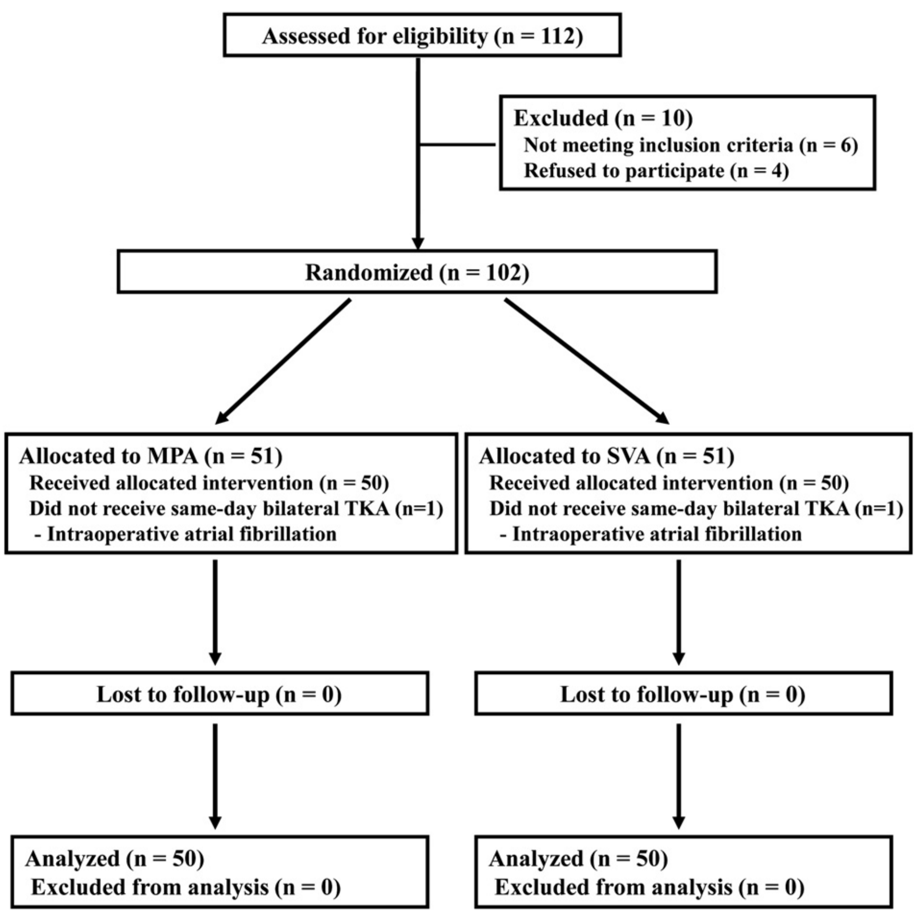

Fig. 1. A flow diagram shows the study design.

quadriceps tendon completely intact, beginning 2 finger breadths above the patella and ending at the tibial tuberosity [35]. After arthrotomy, the patella was displaced laterally without eversion with the knee in full extension and the knee was slowly flexed in all patients.

All patients received the same anesthetic and multimodal perioperative management protocol. Two hours before surgery, multimodal oral analgesic drugs (200 mg celecoxib and 150 mg pregabalin) were administered for preemptive analgesia on a call basis. All patients received 1.0 g cefazolin as an antimicrobial prophylaxis, and general anesthesia was administered by a single anesthesiologist. To exclude the confounding factors affecting postoperative pain after TKA, additional pain relieving modalities such as peripheral nerve block or periarticular injection were not performed in this study. Postoperatively, all patients received intravenous patient-controlled analgesia, which was programmed to deliver 1 mL of a 100-mL solution containing 2000 μg fentanyl when patients depressed a button. A 10-minute lockout period without basal flow was in place. The intravenous patient-controlled analgesia was typically discontinued on the fourth postoperative day. When patients resumed oral intake, 10 mg oxycodon, 200 mg celecoxib, 37.5 mg tramadol, and 650 mg acetaminophen were administered every 12 hours. An intramuscular injection of diclofenac (75 mg) was used as an acute analgesic when a patient reported severe pain greater than level 6 on a 0- to 10-point VAS. All patients received 40 mg of enoxaparin (Clexane; Sanofi Aventis, Paris, France) subcutaneously for thromboprophylaxis. This treatment was started 12 hours before the operation and continued for 10 days. All patients wore graduated compression stockings for 4 weeks after the operation. Beginning the day after surgery, patients were allowed to walk using a frame and began gradually increasing range-of-motion (ROM) exercises in bed. All patients were admitted for a period of 10 days and followed up at 6 weeks, 3 and 6 months, and 1 year postoperatively.

The primary outcome variable was pain level, whereas the secondary outcome variables were the Western Ontario McMaster University Osteoarthritis Index (WOMAC) score, patients' side preference, isometric quadriceps muscle strength, ROM, outcomes related to patellar tracking (patellar displacement and tilt angle, incidence of lateral retinacular release), the Knee Society scores (KSS), the duration of operation, hemovac drainage volume, and the incidence of wound complications.

A clinical investigator (one of the authors) who was blinded to the group assignments assessed all of the prospectively collected data. Pain level, WOMAC score, and patients' side preference were recorded to evaluate the differences in PROMs. Pain levels preoperatively, and at postoperative 1 day, 3 days, 7 days, 6 weeks, 3 and 6 months, and 1 year were estimated using a VAS that ranged from 0 (no pain) to 10 (worst imaginable pain). The WOMAC scores were assessed by the patient preoperatively and at 6 weeks, 3 and 6 months, and 1 year postoperatively. Patients' side preference was evaluated by selection of the one preferential side between knees, based on satisfaction and physical function performance at 1 week and 1 year postoperatively. The duration of operation, hemovac drainage volume, isometric quadriceps muscle strength, ROM, outcomes related patellar tracking, the KSS, and the incidence of wound complications were recorded to evaluate the physician-assessed objective measures. At postoperative week 1, the peak torque for the quadriceps muscle was measured by a single blinded rehabilitation physician. Patients were positioned in an isokinetic dynamometer (Primus RS; BTE Technologies, Englewood, CO) for maximal isometric contraction. With the knee positioned at 60° of flexion, a set of 2 maximal isometric quadriceps contractions (4 seconds each) were performed at each measurement time point. The highest peak force was calculated by multiplying the averaged data from the 2 trials, which was then normalized by body mass (Nm/kg). The ROM was calculated by subtracting the degree of flexion contracture from the degree of maximum flexion using a standard 38-cm goniometer, with the patient lying in the supine position, preoperatively, and postoperatively at 6 weeks, 3 and 6 months, and 1 year. A Merchant view was obtained with the knee at 45° of flexion to measure the patellar tilt and displacement at every follow-up visit. The patellar tilt angle was determined to be the angle between the patellar and the anterior flange of the femoral component, and the patellar displacement was the distance from the middle of the patella to the middle of the patellofemoral groove of the femoral component [35,36]. We calculated the difference in patellar tilt and displacement between the preoperative assessment and that 1 year after the TKA and compared these values between the groups. The incidence of lateral retinacular release was also compared. The KSSs were assessed by a blinded clinical investigator (one of the authors) preoperatively and at postoperative 6 weeks, 3 and 6 months, and 1 year. The duration of tourniquet time and hemovac drainage volume were also assessed, and the incidence of wound complications including periprosthetic joint infection and inadequate wound healing (including delayed wound healing or wound dehiscence) were evaluated at each follow-up visit.

We compared the primary and secondary outcomes between the SVA and MPA groups. Continuous variables were analyzed using Student t test or the Wilcoxon signed-rank test. The χ^2 or Fisher exact test was used to determine the statistical significance of differences in the categorical variables. Statistical analyses were performed using SPSS for Windows (version 21.0; SPSS Inc, Chicago, IL).

Results

Patients did not perceive differences between knees that underwent TKAs using different surgical approaches in terms of pain level and physical function performance. The mean pain VAS scores were similar in both knees during the entire study period, including 1, 3, and 7 days postoperatively ($P > .1$ in all comparisons; Fig. 2) and 6 weeks, 3 and 6 months, and 1 year postoperatively ($P > .1$ in all comparisons). In addition, no between-group differences were observed in the physical performance based on the WOMAC scores at each time point ($P > .1$ in all comparisons; Table 1).

Patients' side preference had not been affected by either surgical approach or measurement periods. At postoperative 1 week, 20 (40%) of 50 patients preferred the MPA side, 9 patients (18%) reported no preference, and 21 patients (42%) preferred the SVA side ($P = .976$). In addition, 21 patients (42%) preferred the MPA side, 11 patients (22%) had no preference, and 18 patients (36%) preferred the SVA side ($P = .795$) at 1 year postoperatively (Table 2). However, 17 (4 in MPA, 6 in no preference, 7 in SVA) of 50 patients (34%) changed their initial preferential side at 1 year after TKA.

Subvastus approach did not have any advantage over MPA in terms of the physician-assessed objective measures, with the exception of more rapid recovery in the maximal extensor muscle strength at postoperative 1 week. The maximal isometric quadriceps contraction in

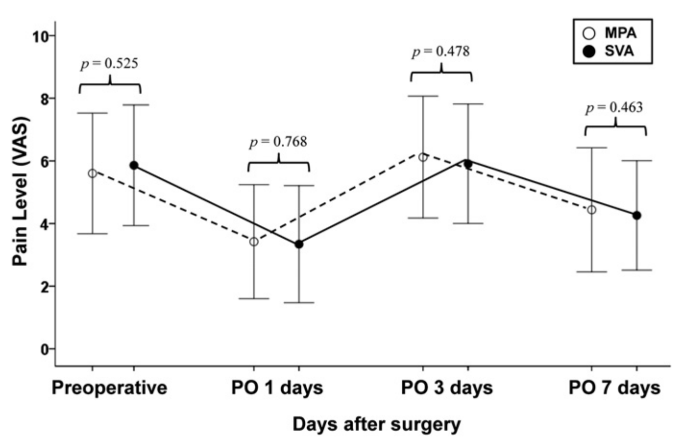

Fig. 2. The pain levels according to the VAS during the first 7 days after surgery are shown. No between-group differences were observed during the entire study period. Error bars represent 1 SD. PO, postoperative hour.

Table 1
Pain Level and WOMAC Scores in the Medial Parapatellar and SVA Groups.

	Pain Level (VAS)			WOMAC Score		
	MPA	SVA	Significance	MPA	SVA	Significance
Preoperative	5.6	5.9	.525	92	93	.965
Postop 6 wk	3.4	3.0	.226	30	32	.852
Postop 3 mo	2.2	2.7	.174	19	22	.414
Postop 6 mo	2.0	2.2	.773	13	14	.670
Postop 1 y	1.4	1.7	.430	9	11	.287

Data are presented as means. Postop, postoperative.

SVA was found to be stronger than that of MPA (1.05 Nm/kg in MPA vs 1.42 Nm/kg in SVA, $P = .014$), but no group differences in the maximal hamstring contraction ($P = .310$) and Hamstring/Quadriceps ratio ($P = .073$) were observed at 1 week postoperatively. In addition, no differences were reported in tourniquet time, hemovac drain volume, ROM, patellar tracking, KSS, and the incidence of wound complications ($P > .1$ in all comparisons; Table 3).

Discussion

There has been a recent emphasis on a faster recovery time during the early postoperative period. Although SVA, which has multiple theoretical advantages over MPA during the early postoperative period, seems to be more appropriate in this context, the question of whether SVA is actually superior to MPA remains controversial. In addition, previous simultaneous bilateral randomized studies reported contradictory results regarding whether the patient prefers SVA or MPA. Thus, we aimed to determine whether a modification of the surgical approach is necessary to provide the additional benefits of a rapid recovery in terms of objective and subjective outcome measures. This study sought to determine whether patients perceived the differences between knees in terms of the PROMs and whether SVA had any advantages over MPA in terms of physician-assessed objective outcomes.

We found that patients do not perceive any difference between knees which had undergone either SVA or MPA for TKA, and that patients' side preference is not affected by the surgical approach. In this study, no between-group differences in pain level and WOMAC scores were observed, and a similar proportion of patients preferred each surgical approach at both 1 week and 1 year postoperatively. In addition, a substantial proportion of patients did not perceive any difference between knees either during the early postoperative period (18%) or at 1 year postoperatively (22%). Moreover, patients were also observed to change their initial side preference at 1 year after TKA (34%). The results of this study are in agreement with recent reports of a similar pain level, QoL, and clinical outcomes between SVA and MPA [18,19,21–23,28,37,38], and comparable side preference between knees in patients after same-day bilateral TKA [22]. However, these findings do not concur with previous simultaneous bilateral randomized studies that were published in the 1990s, reporting superior pain relief and functional performances in SVA compared with MPA, and a higher preference in SVA [12,27] (Table 4). The findings of this study, together with those of the previous studies, suggest that superior pain relief and functional performance results instead from recent substantial advances in the perioperative management protocol, especially in pain management, and therefore, the PROMs can be increased based on pain relief and physical performance. Thus, patients do not perceive the differences between the knees that might have been perceived by patients undergoing TKA a few decades ago.

Table 2
Patients' Side Preferences at Postoperative 1 Week and 1 Year.

Side Preference		Postoperative 1 wk MPA	Same	SVA	Total	Significance
Postoperative 1 y	MPA	16 (32)	3 (6)	2 (4)	21 (42)	.795
	Same	3 (6)	3 (6)	5 (10)	11 (22)	
	SVA	1 (2)	3 (6)	14 (28)	18 (36)	
Total		20 (40)	9 (18)	21 (42)	50 (100)	
Significance		.976				

Data are presented as numbers of patients (percentage).

Table 3
Physician-Assessed Objective Measures in the Medial Parapatellar and SVA Groups.[a]

	MPA (n = 50)	SVA (n = 50)	Significance
Operation-related outcomes			
Tourniquet time (min)	41.2	41.8	.577
Hemovac drainage volume (mL)	472	495	.719
Function-related outcomes			
Isometric muscle strength test			
Flexion (Nm/kg)	1.14	1.25	.310
Extension (Nm/kg)	1.05	1.42	.014
F/E ratio	1.4	1.1	.073
ROM (°)			
Preoperative	115	115	.978
Postop 6 wk	111	114	.538
Postop 3 mo	120	120	.928
Postop 6 mo	126	125	.940
Postop 1 y	129	124	.543
Patellar tracking			
Lateral retinacular release[b]	0 (0)	0 (0)	–
Changes of patellar tilt (°)[c]	2.9	2.0	.437
Changes of displacement (mm)[c]	0.8	0.9	.817
KSS			
Preoperative	119	119	.933
Postop 6 wk	123	125	.937
Postop 3 mo	153	151	.804
Postop 6 mo	166	166	.838
Postop 1 y	189	180	.226
Complication			
Incidence of complication[b]	2 (4)	0 (0)	.495

F/E, flexion/extension; Postop, postoperative.
[a] Data are presented as means.
[b] Data are presented as numbers of patients (percentage).
[c] Data are differences in a given value between postoperative 1 year and preoperative.

Subvastus approach does not have any significant advantage over MPA in terms of physician-assessed objective measures, with the exception of more rapid recovery of the maximal quadriceps muscle strength during the early postoperative period. In this study, although the isometric quadriceps muscle peak contraction with SVA was stronger than that with MPA at 1 week postoperatively, no between-group differences were observed in the ROM, patellar tracking, and KSS at any assessment time point. These findings concur with multiple previous reports that SVA does not have an advantage over MPA, with the exception of more rapid recovery of the quadriceps maximal strength during the early postoperative period [17–23,28,37,38]. Meanwhile, previous studies of the recovery of quadriceps muscle strength after TKA reported that the quadriceps muscle strength following MPA was recovered as much as that following SVA within 2 to 3 months after surgery [19,21,22], and became even stronger than SVA at 1 year after TKA [28]. The data from this study, together with those of previous studies, suggest that the only benefit from SVA was more rapid recovery of the extensor muscle strength, which was limited to the first 3 months after TKA. On this basis, it seems unnecessary for surgeons to modify the surgical approach to improve physician-assessed objective outcomes.

More rapid recovery of the quadriceps muscle strength during the early postoperative period does not affect either the patients' side preference or the physical performance after TKA. In this study, although the maximal isometric quadriceps strength with SVA was higher than MPA at 1 week postoperatively, no between-group differences in patients' side preference and WOMAC score were noted. These findings are in agreement with previous reports that patients' side preference was not associated with maximal quadriceps muscle strength [22] and that the surgical approach was beneficial only to the maximal muscle

Table 4
Summary of Previous Simultaneous Bilateral Randomized Trials on the Comparison of Outcomes Between Medial Parapatellar and Quadriceps-Sparing Surgical Approaches.

Author (year)	n	Side Preferences	Pain Level (VAS)	ROM	Muscle Strength
Current study (2015)	50 SD BTKA	1 wk—no difference (P = .976; 21 SVA vs 20 MPA vs 9 same) 1 y—no difference (P = .795; 18 SVA vs 21 MPA vs 11 same)	No difference (1 d, 3 d, 7 d, 6 wk, 3 mo, 6 mo, 1 y)	No difference (6 wk, 3 mo, 6 mo, 1 y)	SVA > MPA at 1 wk
Heekin and Fokin (2014) [28]	40 St BTKA	Not presented	Not presented	No difference	MVA > MPA until 3 mo No difference thereafter
Nestor et al. (2010) [22]	27 SD BTKA	1 d—No difference 2 d—MVA > MPA (swelling, pain, weak) 3 d—no difference 3 wk—MVA > MPA (stiffness) 6 wk—no difference 12 wk—no difference	No difference (1 d, 2 d, 3 d, 3 wk, 6 wk, 12 wk)	No difference (1 d, 2 d, 3 wk, 6 wk, 12 wk) except 3 d	MVA > MPA until 3 wk No difference thereafter
Dalury and Jiranek (1999) [27]	24 SD BTKA	17 MVA vs 2 MPA vs 5 same	1 d—MVA 4.7 vs 7.0 MPA 2 d—MVA 2.9 vs 5.8 MPA 3 d—MVA 2.1 vs 4.5 MPA	No difference	MVA > MPA until 6 wk No difference thereafter
Faure et al. (1993) [12]	14 SD BTKA 6 SD BUKA	9 SVA vs 2 MPA vs 9 Same	Not presented	No difference	SVA > MPA until 1 M No difference thereafter

SD BTKA, same-day bilateral TKA; St BTKA, staged bilateral TKA; SD BUKA, same-day bilateral unicompartmental knee arthroplasty; MVA, midvastus approach.

strength, but of no benefit for functional performance [39]. The results of this study, together with those of previous studies, suggest that the maximal contraction strength assessed by isokinetic dynamometer may not reflect either patient satisfaction or the real physical performance. During the early postoperative period, patients may be more concerned with performing daily activities, rather than demonstrating the maximal quadriceps muscle strength. It is well documented that patients and physicians do not always agree on ratings of QoL improvements after surgery [24]. Thus, the difference in the maximal quadriceps strength seems to have little influence on rapid recovery after TKA, and the measurement of functional performance during the early postoperative period after TKA should include more detailed muscle strength measures that reflect real daily activity performance, rather than the maximal strength that caused pain during the evaluation.

This study has several limitations. First, because we evaluated only Korean patients, the demographic characteristics, lifestyle, and the length of hospital stay of this study population should be noted before extrapolating to other populations. Some salient differences should be highlighted, such as the predominance of females among patients undergoing knee arthroplasty [1,2,40], and more frequent squatting and kneeling in daily activities in the Korean population [41,42]. In addition, although most patients who underwent TKA are admitted for 1 to 3 days in the United States, all patients in this study were admitted for 10 days after surgery, which is the usual practice in our medical system. Because the length of hospital stay after TKA would be influenced by the overall health care system in each country, it can widely vary among countries. Thus, these findings may not be widely generalizable because demographics, lifestyle, and perioperative management may affect the clinical outcomes that were assessed in this study. Second, although all patients received a current preemptive multimodal pain management measure, we did not include additional pain-relieving modalities such as peripheral nerve block and periarticular injection because we wanted to avoid the confounding factors that might have affected pain relief after TKA. We anticipated that the addition of these modalities would make it more difficult for the patient to perceive the differences between the 2 approaches. However, this should be considered before extrapolating our findings to other postoperative pain management protocols. Third, we measured isokinetic muscle strength only at 1 week postoperatively. However, it is clearly documented that the differences in the maximal quadriceps muscle strength between SVA and MPA become comparable 3 months after TKA. Despite these limitations, this simultaneous randomized bilateral trial provides valuable information as to the PROMs and preference between SVA and MPA in patients receiving a contemporary postoperative management protocol.

Conclusion

This study demonstrates that patients undergoing same-day bilateral TKA do not perceive any difference between knees that had undergone either MPA or SVA. These results suggest that a surgeon should select the exposure based on his/her expertise and experience with the knowledge that both exposure options are associated with similar patient-reported outcomes.

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