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Clinical evaluation of usefulness and effectiveness of sitting-type continuous passive motion machines in patients with total knee arthroplasty: a dual-center randomized controlled trial

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Abstract

Background Total knee arthroplasty (TKA) is a treatment option for osteoarthritis of the knee. After undergoing TKA, patients can be treated with continuous passive motion (CPM); however, inconsistent results have been reported on the effectiveness of CPM as part of a rehabilitation strategy. This discrepancy may be due to the difference between the set-arc of CPM and real arcs of knee motion. In this randomized controlled trial, we compared the efficacy of the sitting-type CPM, which can apply a more fitted arc of motion, to that of the conventional CPM.

Methods We performed a prospective, multicenter, single-blind, three-arm, randomized controlled trial. Patients who underwent unilateral TKA were recruited and randomly allocated to three groups (151 participants; Group 1, conventional type; Group 2, mixed; and Group 3, sitting type). All participants underwent 10 days of CPM management. Passive and active ranges of motion (ROMs), pain, lower-extremity edema, patient-reported outcomes, and functional assessments were evaluated at four time points.

Results Passive and active ROMs and pain significantly improved during and after the intervention in all groups; however, no significant differences were noted between the groups. Compared with the conventional type, the sitting-type CPM devices were rated higher in participant's satisfaction questionnaires.

Conclusion The sitting-type CPM had equivalent efficacy to that of the conventional-type CPM but provided higher satisfaction to patients after TKA. Therefore, the sitting-type CPM may be a useful tool in post-TKA rehabilitation.

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Clinical trial registration This clinical trial was registered with the Clinical Research Information Service of Republic of Korea, KCT0005520, Registered on 21 October 2020, date of first enrollment at 10/11/2020 <https://cris.nih.go.kr/cris/search/detailSearch.do/21750>.

Keywords Knee osteoarthritis, Total knee arthroplasty, Continuous passive motion, Range of motion, Post-operative period

Background

Total knee arthroplasty (TKA) is a successful treatment for advanced knee osteoarthritis and is known to improve the quality of life of patients [1]. An increasing number of TKAs are performed in clinical settings and are anticipated to rise to 3.5 million per year in the United States by 2030 [2]. Between 2010 and 2018, TKAs increased by approximately 68% in Korea, and their number is expected to increase by nearly 53% by 2030 [3]. According to previous reports, 15–20% of patients experience post-operative discomfort [4, 5], possibly because of a reduced range of motion (ROM) following TKA. The ideal treatment outcome is at least 110° knee flexion, which is sufficient to provide patients with a satisfactory level of performance [6, 7]. Thus, appropriate post-operative rehabilitation is needed.

Continuous passive motion (CPM) involves an externally powered device that provides passive movement of a joint throughout a pre-set arc of motion. Several reports in the 1980s identified CPM as useful in the early phase of rehabilitation after TKAs toward ROM recovery [8, 9]. However, questions regarding the use of CPM in post-operative rehabilitation have recently emerged due to inconsistent results and unproven long-term efficacy after TKAs [10, 11].

These inconsistent data from previous reports may be due to differences between the real arc of knee motion and the set arc of motion in the CPM device. Bible et al. suggested that the discrepancies between the two parameters could be reduced by increasing the inclination angle of the bed from 30° to 60° [12]. Consequently, in post-operative rehabilitation with CPM devices, accurate fitting and setting of the genuine knee motions on the CPM machine could have an impact on the efficacy of the rehabilitation regime. Additionally, increasing bed inclination may be a useful adjustment to CPM protocols toward successful post-operative rehabilitation.

CPM devices that allow the patient to sit have been developed and are currently in use by patients (Resilion K20P, HEXAR Humancare, Korea, Fig. 1) [13]. We postulated that the position of the patient affects the effectiveness of CPM machines, and that CPM devices used by sitting patients would be more effective than traditional CPM methods. In this randomized trial, we aimed to assess the effectiveness of traditional CPM versus sitting-type CPM devices following TKA.

Methods

Research design

This was a randomized, controlled, three-arm, assessor-blinded trial that compared the efficacy of two types of CPM in the acute period after unilateral TKA in two tertiary urban hospitals. This study was approved by the Institutional Review Boards of Chungnam National University Hospital (CNUH-2020-07-028) and the Catholic University of Korea, Daejeon St. Mary Hospital (DC20DNDI0089). All the patients signed an informed consent form and the clinical trial was registered with the Clinical Research Information Service (KCT0005520, Registered on 21 October 2020, date of first enrollment at 10/11/2020, <https://cris.nih.go.kr/cris/search/detailSearch.do/21750>). The detailed protocol for this study has been previously published [14]. All participants were followed after 1-month post-operatively in orthopedic outpatient clinics. We collected the outcome data at 1- and 3-months after TKA, which differed from the published protocol. We followed the CONSORT 2010 statement guidelines (Supplementary Material 1) [15].

Participants

Patients undergoing unilateral TKA between March 2020 and August 2022 were recruited from two tertiary urban hospitals. Inclusion criteria were: (1) patients planned to undergo primary unilateral TKA due to degenerative changes; (2) age 60 years or older. Exclusion criteria were: (1) age over 90 years old; (2) surgery owing to causes other than degenerative changes; (3) previous orthopedic surgical history in the hip, knee or ankle joint; (4) previous lumbar surgery within 3 months of enrollment; (5) serious osteoporosis, cardiovascular disease, or neuromuscular disease; (6) coagulation deficits; (7) severe obesity (body mass index > 35 kg/m²); (8) patients with cognitive deficits or language problems, unable to understand the study's protocols; and (9) refusal to participate in the trial.

Patients who met the eligibility criteria were screened in the orthopedic department of the outpatient clinics and provided informed consent to participate in the study. Participants were then randomly assigned to three groups at a 1:1:1 ratio by block randomization, with a block size of 12. The three groups consisted of conventional, mixed, and sitting-type CPM groups. The participants allocated to the mixed-type CPM group were divided into two subgroups after the initial allocation.



Fig. 1 New type of continuous passive motion machines (Resilion K20P, HEXAR Humancare, Korea) which could be used by sitting patients

After randomization, the allocation of participants was confirmed by the principal study coordinator.

Interventions

Conventional-type CPM group (Group 1): patients received continuous passive movement training in lying positions; mixed-type CPM group 1 (Group 2–1): patients received continuous passive movement training in mixed positions (lying-type first, followed by sitting-type CPM); mixed-type CPM group 2 (Group 2–2): patients received continuous passive movement training in mixed positions (sitting-type first, followed by lying-type of CPM); and sitting-type CPM group (Group 3): patients received continuous passive movement training in sitting positions. The interventional program was started on post-operative day 3, the day after the removal of the surgical site drainage system. Two CPM systems were applied to the participants according to their allocated groups for two hours each day. The conventional type of CPM machine used was the RCF1121[®] (CARETECH, Gumi-si, Gyeongsangbuk-do, Korea) and the sitting-type used was the Resilion K20P[®] (Fig. 1, HEXAR Humancare, Ansan-si, Gyeonggi-do, Korea). Each participant received 10 consecutive working days of CPM treatment, according to published intervention protocols [14].

Primary outcome measurement

Passive and active ROM in the affected knee joint at supine position were the primary outcomes, measured before and after the surgery and at 1- and 3-months after the intervention. Passive and active ROM were measured using a digital inclinometer (Dualer IQ electronic dual inclinometer system; JTECH Medical, Midvale, UT, USA) by a physiotherapist blinded to the experimental group. Passive ROM was evaluated while the assessor mobilized the knee joints of the participants using a force of 2 kgf with a handheld dynamometer (MicroFET2; Hoggan Health Industries, West Jordan, UT, USA) to exclude potential bias.

Secondary outcome measurement

The numeric rating scale (NRS) was used to evaluate the participants' pain. NRS scores were measured before, during, and at the end of the intervention and at 1 and 3 months of follow-up [16]. To evaluate patient-reported outcomes, we employed modified scoring systems based on the Knee Society Score (KSS) and Western Ontario and McMaster Universities Arthritis Index (WOMAC) questionnaires [17–19]. In our study, we used the validated Korean version of the KSS [17]. Briefly, we used the total functional capacity domains in the KSS, consisting of 19 items measured from 0 to 100 points. Higher

scores indicated better performance in functional activities. Additionally, we used the validated Korean version of WOMAC [18]. Our questionnaire consisted of 24 questions in three domains (pain, stiffness, and function), with higher scores indicating greater disability. The patients were surveyed a day before the operation, end of intervention, and at the 1- and 3-months follow-up visits.

Lower limb swelling after TKA was measured using the thigh circumference, 10 cm above the superior patellar pole, and the calf circumference, 10 cm below the inferior patellar pole [20]. The timed up and go test (TUG) and 6-minute walking test (6MWT) were conducted to evaluate the functional gait ability of the participants [21, 22]. These functional parameters were measured a day before the operation, end of intervention, and at the 1- and 3-months follow-up visits.

Satisfaction questionnaires (Supplementary Material 2), which we developed, were also used at the end of the intervention by the participants in the mixed-type CPM groups. The satisfaction questionnaire consisted of two parts. Part 1 evaluated three domains (convenience, effectiveness, and satisfaction) consisting of 13 items, with each item evaluated from 0 (very dissatisfied) to 5 (very satisfied). Total scores ranged from 0 to 65. Higher scores indicated higher satisfaction ratings of the participants. Part 2 directly compared the two types of machines, requiring the selection by the participants of the preferred machine, for each item (conventional type of CPM;1, sitting type of CPM;2).

Sample size estimation

Based on a preliminary pilot study, the trial required a sample size of at least 35 participants per group with a significance level of 5% and 80% statistical power [14]. Considering an expected dropout rate of 20%, we enrolled at least 42 individuals per group.

Statistical analysis

Descriptive statistics were used to characterize the demographic and clinical variables. Data distribution was assessed using the Kolmogorov-Smirnov test. We also performed a modified intent-to-treat analysis and excluded patients who did not initially participate in the intervention because of requests before the intervention, or because medical or surgical complications had to be managed. To compare the baseline values between the groups, ANOVA or the Kruskal-Wallis test were employed. We used regression imputation methods to replace missing data. The effects of the interventions and differences between groups for secondary outcomes were examined using repeated-measures ANOVA, with one between-subject component (intervention and control) and one within-subject factor (evaluation time: baseline, end-of-intervention, 1-month, and 3-month follow-up).

Bonferroni correction was used to adjust the P-values to evaluate differences between the groups in the post-hoc analysis. Paired t-tests were performed to evaluate the scores on satisfaction questionnaires in group 2. The IBM SPSS software (version 23.0; Chicago, IL, USA) was used for statistical analysis ($P < 0.05$).

Results

Participants' characteristics

A total of 156 patients were enrolled in this study. Five patients were excluded from the analysis between surgery and intervention because of intraoperative fracture (two cases), withdrawal of consent (one case), and COVID-19 (two cases). A total of 151 patients [Group 1, 51 (14 male, 37 female); Group 2, 49 (11 male, 38 female); Group 3, 51 (13 male, 38 female)] were included in the modified intention-to-treat population. Thirty-six patients did not complete the intervention because of withdrawal of consent to participate ($n=24$), post-operative complications ($n=7$; subdural hemorrhage, $n=1$; foot drop, $n=1$; wound problem, $n=1$; delirium, $n=1$; pneumonia, $n=2$; acute kidney injury, $n=1$), or COVID-19 ($n=5$). Thus, a total of 115 participants (Group 1, $n=42$; Group 2, $n=34$; and Group 3, $n=39$) completed the intervention (Fig. 2).

Table 1 presents the baseline and clinical characteristics of the participants in each group. The mean age was 69.5 ± 6.0 , 71.6 ± 7.3 , and 71.6 ± 6.3 years in Groups 1, 2, and 3, respectively. Other characteristics, including height, weight, preoperative ROM, NRS pain score, and other patient-reported outcomes and functional assessments were not significantly different between the groups (Table 1).

ROM and pain intensity in the affected knee

Passive and active ROM significantly improved during the intervention and post-operative periods in all groups (passive ROM, $P < 0.001$; active ROM, $P < 0.001$). However, no significant differences were observed between the groups (passive ROM, $P = 0.266$; active ROM, $P = 0.461$) (Table 2). NRS-rated pain also significantly improved in all groups after the intervention and at the 3-month post-operative follow-up visit ($P < 0.001$). However, similar to ROM, there was no significant time-group interaction ($P = 0.482$) (Table 2).

Lower limb swelling after TKA

Lower limb swelling, measured in the thigh and calf of the affected limb, significantly improved in all groups (thigh circumference, $P < 0.001$; calf circumference, $P < 0.001$). However, we found no differences between the groups (thigh circumference, $P = 0.483$; calf circumference, $P = 0.486$).

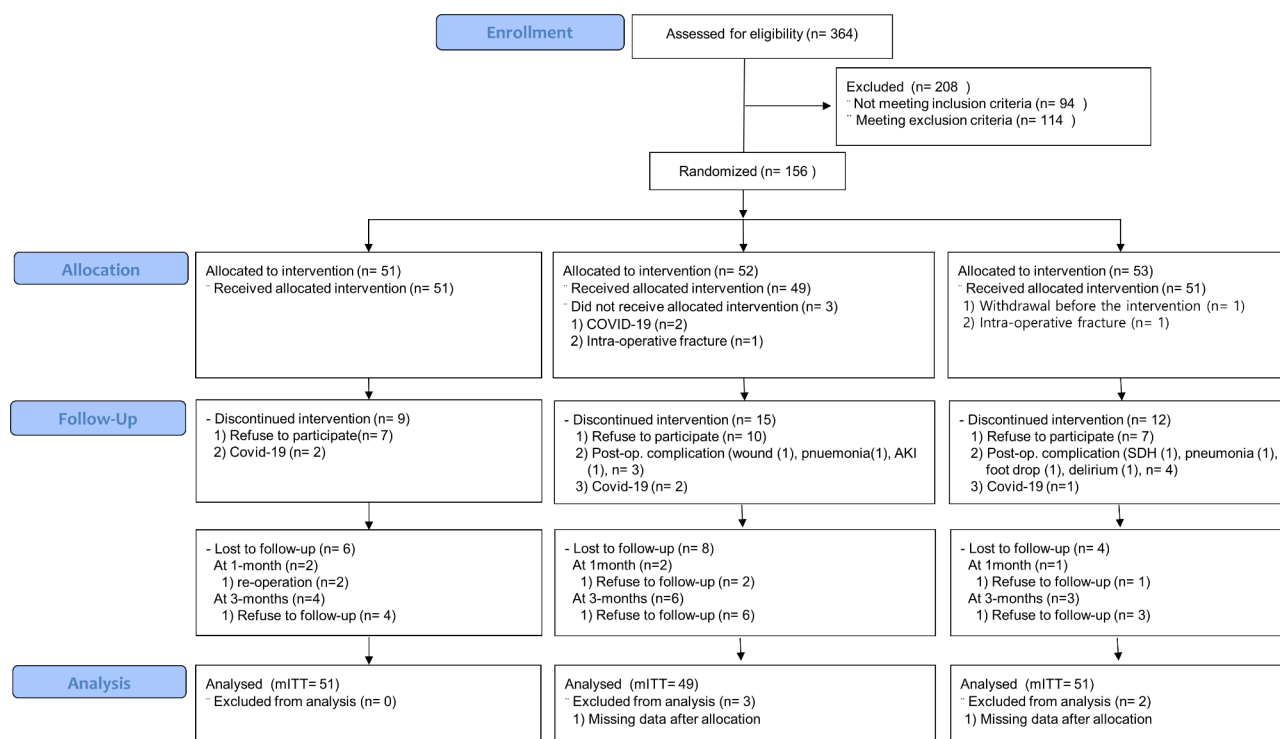


Fig. 2 CONSORT flow diagram of the study

Patient-reported outcomes

Participants reported their WOMAC and KSS scores in the pre-operative phase, immediately after the intervention, and at the 1- and 3-months post-operative visits. No significant time or group interactions were observed between the groups, when comparing the 3-months visit scores with the preoperative scores (KSS, $P=0.358$; WOMAC, $P=0.428$; Table 2).

Functional assessment

The TUG and 6MWT were performed to evaluate the participants' functional capacities. Both scores improved at the 3-months follow-up visit, in all groups, compared with the preoperative measurements. However, the differences between the groups were not statistically significant (Table 2).

Satisfaction questionnaires

Of the 34 participants who completed the interventions in Group 2, 31 participants responded to the satisfaction questionnaire (response rate, 91.2%; $n=31/34$). The mean scores for each item of the satisfaction questionnaire between the lying and sitting types of CPM machines were significantly different, favoring the sitting type in 12 items (Table 3). Only the satisfaction of the participants regarding the reduction of edema and swelling (item 11) displayed no statistical differences ($P=0.080$). The total questionnaire scores were 46.42 ± 6.37 for the conventional CPM, and 55.68 ± 4.71 for the sitting-type CPM

($P<0.001$). Overall, the preference for the sitting-type CPM over the conventional type ranged from 74.2 to 100% (Table 3).

Side effects

Only two patients each in Groups 2 and 3 complained of minor pain at the surgical site, and one patient in Group 3 reported nonspecific back pain. Overall, no reports of severe side effects requiring medical attention occurred in any of the three groups.

Discussion

In this study, we found no significant differences in the clinical outcomes between the conventional- and sitting-type CPM machines. All the participants responded well to both types of CPM device in terms of ROM, pain, patient-reported outcomes, and functional assessment. In the satisfaction questionnaires, the sitting-type CPM was highly rated by participants who experienced both types of CPM machines in terms of convenience, effectiveness, and overall satisfaction.

CPM treatment after TKA has a short-term effect of increasing active knee flexion ROM (mean difference, 2° ; 95% confidence interval, 0–5) and reducing the risk of manipulation under anesthesia. However, no clinically significant improvements in pain or function have been found following CPM treatment. Additionally, there is insufficient evidence of the moderate-to-long-term effects of CPM after TKA [11]. A systematic

Table 1 Basal demographics and clinical characteristics of study participants

Basal demographics and clinical characteristics	Lying (n=51)	Mixed (n=49)	Sitting (n=51)	P-value
Affected side	Rt:21 Lt:30	Rt:28 Lt:21	Rt:27 Lt:24	0.244
Sex	M:14 F:37	M:11 F:38	M:13 F:38	0.867
Age (years)	69.5±6.0	71.6±7.3	71.6±6.3	0.174
Height (cm)	156.0±8.7	155.9±7.1	155.7±9.5	0.986
Weight (kg)	64.7±10.2	65.4±10.0	62.8±9.7	0.395
BMI (kg/m ²)	26.6±3.5	26.9±3.7	25.9±3.0	0.314
Pre-Op PROM of affected knee (degree)	122.2±10.9	121.6±13.8	123.2±11.1	0.809 [†]
Pre-Op NRS	6.5±1.7	6.1±2.3	6.2±2.0	0.624 [†]
Pre-Op circumference (upper, cm)	37.7±3.6	37.3±3.6	37.0±3.2	0.633 [†]
Pre-Op circumference (lower, cm)	32.3±2.6	32.0±3.1	31.9±2.6	0.656
KSS	58.1±24.9	62.7±20.1	58.7±20.0	0.535 [†]
WOMAC	36.7±16.4	33.0±14.2	34.0±14.6	0.440
TUG (sec)	13.6±5.1	14.0±4.2	14.1±5.1	0.872 [†]
6MWT (m)	316.0±123.0	281.3±106.1	300.5±127.3	0.357
Affected side extensor IST (peak torque/BW)	50.5±23.4	52.3±32.1	54.7±32.6	0.776 [†]
Affected side flexor IST (peak torque/BW)	28.8±15.6	29.7±21.6	30.9±22.7	0.881
SMI (kg/m ²) [*]	6.4±1.2	6.4±1.1	6.4±1.1	0.971

BMI, Body mass index; Op, Operation; PROM, Passive range of motion; NRS, Numeric rating scale; KSS, Knee Society Score; WOMAC, Western Ontario and McMaster Universities osteoarthritis index; TUG, Timed up and go test; 6MWT, 6-minute walking test; IST, Isokinetic Strength Test; BW, Body weight; SMI, Skeletal muscle index

[†]Kruskal-Wallis test

^{*}The SMI was calculated from the measured appendicular skeletal muscle mass divided by the participant's height squared

review of CPM after TKA reported a small difference in active (mean difference, 3°; $P=0.019$) and passive knee extension at 1 week (mean difference, 3°; $P=0.031$) and 3 months (mean difference, 3°; $P=0.019$) compared with the control groups [10]. However, these reported changes are not considered clinically significant; thus, the effect of CPM training after TKA remains unclear.

However, all of the included studies in the systematic review by Yang et al., except one, compared CPM with standard care and controls, implying that CPM treatment had no additive effect on patient functional recovery following TKA and conventional physiotherapy [23]. Woland et al. compared CPM with standard physiotherapy, and reported that home CPM treatment without physiotherapy showed similar clinical outcomes to physiotherapy; additionally, the associated treatment cost was approximately half compared to that of standard care [23].

The mechanism of action underlying CPM treatment following TKA has not been fully elucidated. Data from animal experiments suggest that CPM acts by reducing intraarticular adhesions and eliminating inflammatory exudates via passive movement [24]. In this study, passive/active ROM of the affected knee, pain, and functional ability were all improved in patients who underwent TKA, regardless of the type of CPM machine used, with no significant side effects during the treatment. However, we did not observe significant differences in the outcomes between the two types of CPM machine. This observation is contradictory to previous studies showing that the passive movement angle applied during CPM treatment varies according to the patient's posture and that greater clinical effects are obtained when a larger pre-set angle is applied [12, 25]. Therefore, CPM could be beneficial because the external passive movement contributes to reducing inflammation and post-operative adhesions, rather than the applied arc of motion itself. This hypothesis supports the notion that steady movement is important in post-operative rehabilitation therapy. CPM treatment also has advantages as a potential treatment for patients with reduced treatment options, for example due to restrictions during the COVID-19 pandemic or limited resources for proper post-operative care [26, 27].

In this study, a comparison between conventional and sitting-type CPM machines showed no significant differences in ROM, pain, functional ability, or patient-reported outcomes. However, CPM in a seated position could offer several advantages compared to conventional CPM treatment in a supine position. In the sitting position, patients can use their free hands to engage in various activities during treatment, which has led to higher satisfaction ratings in patient surveys. Moreover, sitting or semi-recumbent positions could improve pulmonary function in the post-operative phase following TKR surgery. A previous systematic review recommended post-operative sitting or semi-recumbent positions, as avoiding supine or immobilized positions may improve pulmonary function in the post-operative phase [28]. Furthermore, a semi-recumbent position was also recommended to prevent hospital-acquired pneumonia [29]. Therefore, given that this new CPM method in a seated position has similar efficacy to conventional CPM in a supine position, it may not only be preferred by patients but could also support better management in the post-operative period.

Our study had several limitations. First, due to COVID-19 restrictions, many participants dropped out or were lost to follow-up. Second, the efficacy of CPM training itself was not evaluated in this trial because of the absence of negative controls, patients who did not participate in any type of physiotherapy. This absence relates

Table 2 Participants' clinical outcomes between groups

Outcome	Group	Before intervention [†]	End of intervention	Post-Op 1 month	Post-Op 3 months	P-value (Time)	P-value (Group*Time)
PROM (degree)	Lying	63.6±22.3	106.8±17.7	118.3±9.9	123.4±13.3	0.000	0.266
	Complex	60.7±23.2	109.2±15.6	120.6±10.7	120.8±9.9		
	Sitting	63.9±21.4	108.3±14.1	115.0±15.4	121.8±8.6		
AROM (degree)	Lying	55.9±24.8	101.2±18.2	112.9±10.8	117.5±9.8	0.000	0.461
	Complex	54.1±24.4	102.9±14.1	115.8±10.0	116.2±11.9		
	Sitting	56.1±22.2	100.2±15.1	109.6±15.5	115.7±10.4		
Pain (NRS)	Lying	6.7±1.4	4.4±1.4	3.0±1.6	2.0±1.1	0.000	0.482
	Complex	6.2±1.6	4.0±1.3	3.0±1.6	1.9±1.2		
	Sitting	6.7±1.7	4.7±1.3	3.0±1.5	2.3±1.7		
Thigh circumference (cm)	Lying	41.5±3.7	39.1±3.2	38.4±3.2	37.8±2.9	0.000	0.483
	Complex	41.1±4.1	39.2±4.1	38.5±3.7	38.1±3.6		
	Sitting	41.0±3.5	38.4±3.5	37.8±3.3	37.3±3.1		
Calf circumference (cm)	Lying	35.0±2.5	32.8±2.5	32.7±2.4	32.5±2.0	0.000	0.486
	Complex	34.7±3.0	33.1±3.2	32.7±2.9	32.2±2.7		
	Sitting	34.5±2.6	32.7±2.9	32.2±2.5	31.9±2.1		
KSS	Lying	58.1±24.9	40.0±26.3	65.4±15.4	72.6±15.2	0.000	0.358
	Complex	62.7±20.1	35.7±20.3	64.3±18.6	73.4±15.8		
	Sitting	58.7±20.0	33.4±23.3	61.0±18.4	65.2±23.2		
WOMAC	Lying	36.7±16.4	29.4±10.8	21.6±10.0	15.2±12.1	0.000	0.428
	Complex	33.0±14.2	28.6±11.0	20.1±10.5	15.7±10.6		
	Sitting	34.0±14.6	31.2±11.0	23.0±9.5	16.9±10.7		
TUG (sec)	Lying	13.6±5.1	14.8±5.0	12.9±5.4	11.4±4.0	0.000	0.838
	Complex	14.0±4.2	15.9±5.1	13.0±4.6	11.6±4.5		
	Sitting	14.1±5.1	15.4±4.9	12.9±4.8	11.8±4.1		
6MWT (m)	Lying	316.0±123.0	278.8±114.7	329.5±114.7	383.1±114.6	0.000	0.725
	Complex	281.3±106.1	260.3±126.8	320.5±116.1	357.6±117.2		
	Sitting	300.5±127.3	264.7±119.6	324.5±110.8	366.7±106.7		

PROM, Passive range of motion; AROM, Active range of motion, NRS, Numeric rating scale; Op, Operation., KSS, Knee Society score; WOMAC, Western Ontario and McMaster Universities osteoarthritis index; TUG, Timed up and go test; 6MWT, 6-minute walking test; Op, Operation

[†]'Before intervention' measurements for PROM, AROM, pain, and thigh and calf circumference were taken on post-operative day 3. The KSS, WOMAC, TUG, and 6MWT measurements for 'before intervention' were taken the day before the operation

to the ethical option of not using negative controls in this trial. Instead, we recruited mixed-type CPM groups to allow for comparisons in patient preference between both types of CPM machines.

Conclusion

The sitting-type of CPM had equivalent efficacy to that of the conventional-type of CPM but provided higher satisfaction to patients after TKA. Therefore, the sitting-type of CPM could be a useful tool in post-TKA rehabilitation.

Table 3 Results of participants' satisfaction questionnaires between groups

n = 31		Conventional type		Sitting Type		P-value	Preference n
Questionnaire		Mean	SD	Mean	SD		
1	Was it convenient to move from the wheelchair to another place in order to use the equipment?	3.68	0.65	4.19	0.60	0.002	28 (90.3%)
2	Was it easy to mount the equipment around the legs?	3.36	0.75	4.39	0.62	< 0.001	27 (87.1%)
3	Was the shape of the equipment suitable to be worn on the legs?	3.48	0.63	4.48	0.68	< 0.001	26 (83.9%)
4	Were there any inconveniences when tying the legs with the strings?	3.48	0.89	4.42	0.50	< 0.001	31 (100%)
5	Were there any inconveniences when removing the equipment after treatment?	3.68	0.70	4.45	0.51	< 0.001	30 (96.8%)
6	After use of the equipment, was it convenient to return to the wheelchair?	3.61	0.76	4.16	0.86	0.010	26 (83.9%)
7	Was the speed of the moving equipment satisfactory during the treatment?	3.74	0.63	4.07	0.63	0.048	24 (77.4%)
8	Did the equipment and the legs move well together in accordance without falling apart during treatment?	3.58	0.85	4.35	0.55	< 0.001	29 (93.5%)
9	Were you satisfied with the intensity of the exercise during treatment?	3.52	0.72	4.26	0.44	< 0.001	30 (96.8%)
10	Were there any uncomfortable areas, other than the legs, during treatment?	3.81	0.79	4.52	0.57	< 0.001	27 (87.1%)
11	Do you feel a decrease in edema and swelling after using this device?	3.42	0.72	3.77	0.85	0.080	23 (74.2%)
12	Do you feel that your joint range of motion has increased after using this equipment?	3.65	0.71	4.32	0.60	< 0.001	31 (100%)
13	Are you satisfied with the overall treatment using this equipment?	3.42	0.67	4.29	0.46	< 0.001	31 (100%)
Total Score		46.42	6.37	55.68	4.71	< 0.001	

†Preferred machines were selected by the participants for each item (conventional type of CPM, 1; sitting type of CPM, 2). The number of table were number of participants who reported that the sitting type of CPM were preferred over the conventional type of CPM

SD, Standard deviation

Abbreviations

6MWT	6-minute walking test
CPM	Continuous passive motion
KSS	Knee Society Score
NRS	Numeric rating scale
ROM	Range of motion
TKA	Total knee arthroplasty
TUG	Timed up and go test
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index

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Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12891-024-08062-0>.

Supplementary Material 1

Supplementary Material 2

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Author contributions

Byung Chan Lee: Formal analysis, Data curation, Writing-Original draft preparation; Chang-Won Moon: Conceptualization, Methodology, Writing-Original draft, Writing – Review & Editing; Woo Sung Choi: Methodology, Investigation, Data curation; Young Mo Kim: Conceptualization, Methodology, Resources, Writing – Review & Editing; Yong Bum Joo: Conceptualization, Methodology, Resources, Writing – Review & Editing; Da Gyo Lee: Methodology, Investigation, Data curation; Sook Joung Lee: Conceptualization, Methodology, Writing – Review & Editing, Eunseok Choi: Conceptualization, Methodology, Writing – Review & Editing, Supervision, Project administration; Jong Hun Ji: Conceptualization, Methodology, Resources, Writing – Review & Editing; Dongwhan Suh: Conceptualization, Methodology, Resources, Writing – Review & Editing, Kang Hee Cho: Conceptualization, Methodology, Writing – Review & Editing, Supervision, Project administration, Funding acquisition.

Declarations

Ethics approval and consent to participate

The ethical validity of the trial was assessed and approved by the Institutional Review Boards of Chungnam National University Hospital (CNUH-2020-07-028) and the Catholic University of Korea, Daejeon St. Mary Hospital (DC20DNDI0089). All participants provided written informed consent before the trial.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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