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Long-duration immediate postoperative knee flexion positioning results in better functional outcomes after total knee arthroplasty

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Abstract. – OBJECTIVE: This study aimed to evaluate the effects of affected knee flexion for 24 *vs*. 72 hours on blood loss, pain, range of motion, and functional outcomes after total knee arthroplasty.

PATIENTS AND METHODS: The present study included 46 participants with a mean age of 64.33 ± 6.70 years. The affected knee of the first 23 participants, based on the order of operations, was positioned at 70° flexion for 24 hours, and the knee of the next 23 participants was positioned at 70° flexion for 72 hours. Participants were evaluated before the operation and on postoperative day 3 and week 6. Pain, edema, range of motion, time up and go test scores, and Western Ontario McMaster Universities Arthritis Index scores, hemoglobin, and hematocrit were measured before the operation and on postoperative at day 3 and week 6.

RESULTS: We found that the calculated blood loss was 575.07 ± 282.44 and 578.39 ± 297.11 mL in patients who underwent short- and long-duration flexion positioning, respectively (p = 0.921). The active flexion angles at postoperative week 6 were 83.61° ± 22.03° and 105.91° ± 13.06° in the short- and long-duration flexion groups, respectively ($p < 0.01$). Furthermore, the Western Ontario and McMaster Universities Arthritis Index scores at postoperative week 6 were 35.52 ± 24.71 and 17.17 ± 15.37 in the short- and long-duration flexion groups, respectively ($p < 0.01$).

CONCLUSIONS: Long-duration flexion positioning after total knee arthroplasty may lead to better middle-term flexion range of motion and physical function scores than short-duration flexion positioning.

Key Words:
Flexion, Osteoarthritis, Pain, Rehabilitation, Surgery.

Introduction

Total knee arthroplasty (TKA) is the most commonly used treatment option for intermediate-to-end-stage knee osteoarthritis (OA)[1]. At present, the increasing prevalence of knee OA has led to an increase in the use of TKA. Notably, the number of primary TKA procedures in the United States is expected to increase to 85% (i.e., 1.26 million procedures) by 2030[2]. However, many factors, such as preoperative and postoperative care[3], timing of surgery[4], sociocultural factors[5] and comorbidities[6], have been reported to affect functional recovery and quality of life of patients after TKA. Among the rehabilitation practices after surgery, postoperative immediate positioning protocols are known to affect TKA outcomes[3].

Postoperative immediate flexion positioning protocols (PIFPP) have some advantages over postoperative immediate extension positioning protocols (PIEPP). For example, it has been reported that PIFPP reduces total blood loss[7-10], occult bleeding[11], blood transfusion[9], need for painkillers[7,] and edema[11,12]; shortens hospital stay[8,9] and provides a greater range of motion (ROM) of flexion[10] in the early period compared with PIEPP. However, to the best of our knowledge, extension ROM has not been reported in the relevant literature, and further studies are needed to investigate the effects of PIFPP on extension ROM[3]. Notably, PIFPPs used in studies investigating the effect of positioning included different flexion angles, and there is no consensus on the positioning angle to date[7-11]. Although a flexion angle of > 30° was recommended in a previous meta-analysis[13], differences in the outcomes of PIFPP with small and large flexion angles compared to those of PIEPP

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remain unknown. Another important variable that may affect the outcomes of PIFPP is the positioning time, which has not been fully elucidated to date. Although there is some evidence that protocols of > 24 hours may be effective[13], to the best of our knowledge, no study has focused on positioning duration. Hence, further studies investigating the potential differences between PIFPPs of different durations and those between PIFPPs and PIEPPs may contribute to the relevant literature.

Therefore, we hypothesized that better functional results would be obtained by facilitating a joint range of motion with long-duration PIFPP after TKA compared to short-duration PIFPP. The present study aimed to compare the effects of two PIFPPs with a flexion angle of 70° and a positioning time of 24 *vs*. 72 hours on blood loss, pain, ROM of flexion, ROM of extension, and functional outcomes.

Patients and Methods

Overall, 46 patients (mean age, 64.33 ± 6.78 years) who underwent TKA for primary knee OA were included in this study. The number of participants was determined according to the pre-study sample size calculation using the values of the postoperative knee flexion angle reported by Li et al[12]. Accordingly, at least 42 participants, including at least 21 participants in each group, had to be included in the study (effect size = 0.80, alpha = 0.05, 1-beta = 0.80 and actual power = 0.81). Considering the possible dropouts, we decided to include 50 participants in the present study. Notably, four participants dropped out of the study, and finally, 46 participants (39 women, 7 men) were included in the study. Reasons for the exclusion of individuals from the study were fracture of the drain tube during removal and an additional surgical intervention (n = 1), failure to obtain follow-up data (n = 2), and bilateral TKA (n = 1). Inclusion criteria were as follows: individuals who underwent TKA for stage III or IV degenerative knee OA and those who were fluent in Turkish. In contrast, patients with rheumatoid arthritis, post-traumatic knee OA, hemostatic diseases and history of thromboembolism, neuromuscular diseases, and metabolic bone diseases were excluded from the study. Informed consent was obtained from participants at the beginning of the study. The cohort was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology statement[14]. This study was approved by the local ethics committee (date: 02/03/2022, approval number: 2022/20-169) and followed the Helsinki Declaration.

Participants underwent unilateral cemented TKA and were operated by the same surgeon. Moreover, the same type of posterior stabilized implant was used in all participants (Vega System, B. Braun AG, Melsungen Germany). A tourniquet was used during surgery, and spinal anesthesia was used during all operations. All participants underwent flexion in accordance with the same postoperative hospital care protocol. First-generation cephalosporin was intravenously administered preoperatively as a single dose for prophylaxis. Moreover, low-molecular-weight heparin and early mobilization were used for thromboprophylaxis. Further, the drainage tube was removed 24 hours after surgery. Participants and their caregivers were taught a set of knee ROM and quadriceps exercises before surgery and encouraged to perform them after surgery. Further, the participants were allowed to walk with partial weight bearing 24 hours after surgery. The affected limb was positioned at 70° flexion at all times, except when the wound care and exercises were being performed. The first 25 operated participants were included in the short-duration flexion group (SDG) and their affected knees were positioned at 70° flexion for 24 hours. The next 25 participants were included in the long-duration flexion group (LDG), and their affected knees were positioned at 70° flexion for 72 hours. Notably, flexion positioning was performed using custom-made hinged knee braces (Ortholand, Beyaz Grup Sağlık Ürünleri İmalat San. Tic. Ltd. Şti., Ankara, Turkey) (Figure 1).

Figure 1. Knee position.

Surgical blood loss was calculated based on the criteria described by Nadler et al[15] and Gross[16], and it was referred to as calculated blood loss (CBL). The hematocrit and hemoglobin values measured routinely preoperatively and on the 3rd postoperative day were used for this calculation.

Notably, pain intensity during rest and activity, active and passive flexion ROM, active and passive extension ROM and knee circumference were measured before surgery, before discharge (postoperative day 3) and at postoperative week 6. Moreover, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and time up and go (TUG) scores were recorded preoperatively and at postoperative week 6. The pain was measured by scoring participant responses on a numeric scale ranging from 0, 'I have no pain' to 10, 'I have unbearable pain.' Moreover, pain intensity was recorded both at rest and during activity[17]. The knee circumference was determined by measuring the circumference with a tape measure from the upper pole of the patella and recorded in centimetres[10]. Furthermore, knee flexion and extension ranges of motion were measured using a universal goniometer (Baseline® Plastic Goniometer - HiRes™ 360 Degree Head - 12-inch arms, NY, USA) and recorded in degrees. Notably, knee flexion was measured in the supine position, whereas knee extension was measured in a sitting position. The participant was asked to bend or straighten the knee in the desired direction of movement (flexion and extension). The ROM measured at the last point that could be actively reached was recorded as active ROM, whereas the ROM measured at the last point after the active limit of motion that could be passively reached by the researcher was recorded as passive ROM[18]. WOMAC was designed to assess pain, stiffness, and limitations in activities of daily living owing to OA. The scale comprises 24 questions, including 5, 2, and 17 questions for assessing pain, stiffness, and 17 limitations in activities of daily living, respectively. The questions are scored between 0 and 4 (0: none, 1: mildly severe, 2: moderately severe, 3: severe, and 4: very severe) according to the presence and severity of the complaint. Lower scores indicate that the severity of complaints and limitations is low. In the present study, the WOMAC questionnaire was completed by participants in the presence of the researcher[19]. For the TUG test, the participant sat on a chair at a height where their feet touched the floor, and they placed their arms on the armrests of the chair. For this test, the participant was instructed to stand up, walk back from a pre-marked point 3 meters away from the chair, walk back, and sit on the chair. Moreover, they were asked to complete the test at their own pace and as fast as possible. The test was initiated with the start command of the researcher and terminated with the participant sitting on the chair. The time between the beginning and end of the test was measured using a stopwatch, and the measured duration was recorded. Further, the test was repeated three times. The rest period between the repetitions was 2 minutes. The best of the three recorded times was considered as the test score[20]. Moreover, complications were noted.

Statistical Analysis

SPSS version 20 (IBM Corp., Armonk, NY, USA) program was used for data analysis. The conformity of the data to normal distribution was determined using visual measures (histogram and qq graphs), analytical methods (Shapiro-Wilk test), and coefficients of skewness and kurtosis. Continuous variables were expressed as mean ± standard deviation values, whereas categorical variables were expressed as number (n) and percentage (%). Notably, the significance of the difference between the two means tests was used to compare the data that met the assumptions of parametric testing. The statistical significance level was set at $p < 0.05$.

Results

There was no difference between the two patient groups in terms of demographic characteristics and preoperative hemoglobin and hematocrit values (Table I).

Blood loss of the SDG on postoperative day 3 was 575.07 ± 282.44 mL, whereas that of the LDG was 578.39 ± 297.11 mL ($p > 0.05$). The hemoglobin and hematocrit values on postoperative day 3 were similar between the two groups ($p > 0.05$) (Figure 2).

The preoperative pain, ROM, and functional scores of SDG and LDG were similar ($p > 0.05$). LDG had larger active and passive flexion angles and smaller active and passive extension angles than SDG before discharge. Moreover, the active flexion angle, passive flexion angle, and TUG score measured at postoperative week

Table I. Demographic characteristics, preoperative hemoglobin and hematocrit values.

	SDG (mean ± standard deviation)	LDG (mean ± standard deviation)	p^t
Age (year)	65.57 ± 6.80	63.09 ± 6.67	0.22
Height (m)	1.60 ± 0.082	1.63 ± 0.72	0.25
Weight (kg)	85.91 ± 16.61	87.39 ± 12.49	0.74
BMI (kg/m^2)	33.49 ± 6.06	33.03 ± 4.89	0.78
Hb (g/L)	13.94 ± 1.16	13.89 ± 1.84	0.902
Hct (%)	41.75 ± 4.74	42.48 ± 4.95	0.594

BMI: body mass index, Hb: hemoglobin, Hct: hematocrit, SDG: short duration postoperative immediate flexion position group, LDG: long duration postoperative immediate flexion, p^t: *t*-test.

6 were larger in LDG than in SDG, whereas the WOMAC total and physical function scores were smaller in LDG than in SDG ($p < 0.05$, Table II).

In SDG, the rest visual analogue scale (VAS), activity VAS, active flexion ROM, passive flexion ROM, and WOMAC scores were smaller at postoperative week 6 than preoperatively. In LDG, the rest VAS, activity VAS, and WOMAC scores were smaller at postoperative week 6 than preoperatively ($p < 0.05$) (Table III).

No complications, such as delayed wound healing, infection, or deep vein thrombosis, were observed in any participant.

Discussion

The present study aimed to compare the effects of short- *vs.* long-duration PIFPPs on CBL, pain, joint ROM, and physical function after TKA. With the use of long-duration PIFPP, a greater flexion angle and a smaller extension angle was achieved before discharge. In patients who underwent long-duration PIFPP, the flexion ROM, TUG, and WOMAC total and physical function scores at postoperative week 6 were better than those in patients who underwent short-duration PIFPP.

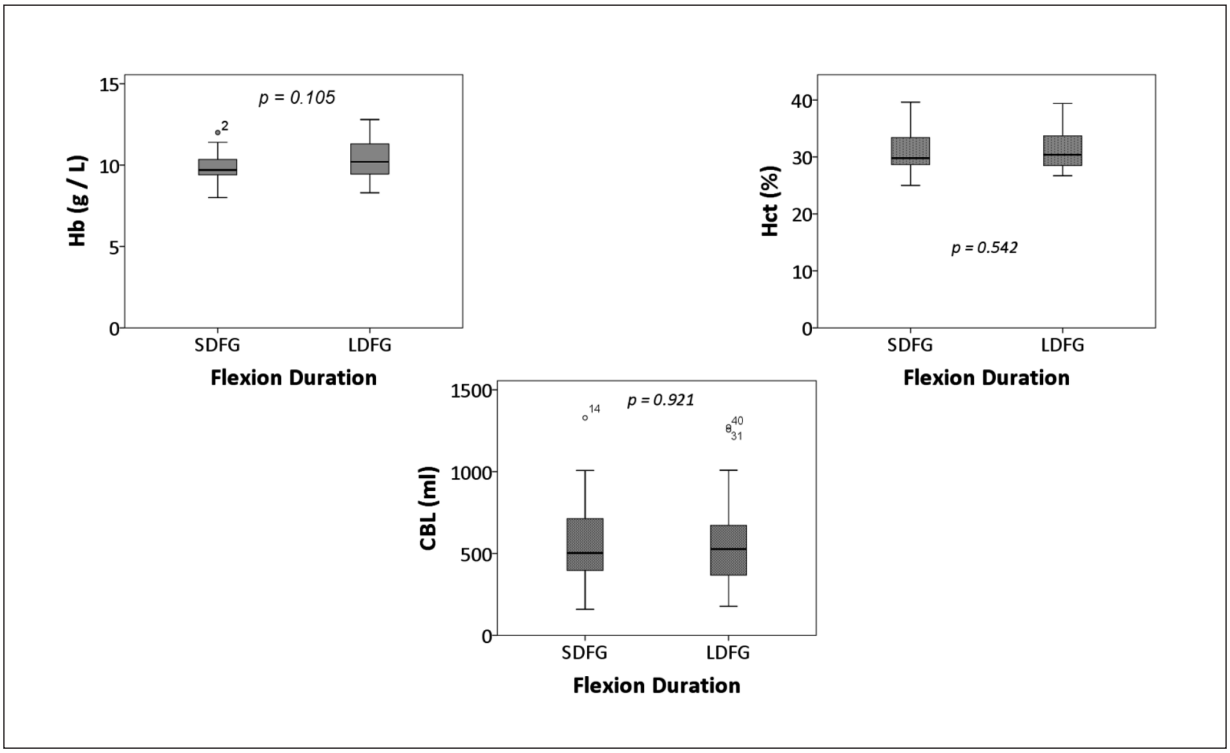

Figure 2. Comparison of hemoglobin, hematocrit and calculated blood loss on postoperative day 3 of groups.

Table II. Intergroup analysis.

Parameter	Preoperative			Postoperative day 3			Postoperative week 6		
	SDG	LDG	p^t	SDG	LDG	p^t	SDG	LDG	p^t
Rest VAS	3.91 ± 3.29	4.21 ± 2.89	0.74	2.44 ± 2.27	2.09 ± 2.43	0.57	2.04 ± 2.42	1.78 ± 2.15	0.70
Activity VAS	9.35 ± 0.93	9.30 ± 1.36	0.90	4.48 ± 2.43	3.55 ± 2.37	0.16	2.57 ± 2.33	2.57 ± 2.31	1.00
Circumference measurement (cm)	46.35 ± 4.35	43.83 ± 4.43	0.06	49.39 ± 5.02	47.98 ± 4.41	0.30	47.80 ± 5.04	45.24 ± 4.58	0.08
Active flexion (°)	98.22 ± 13.29	104.17 ± 1,857	0.22	38.78 ± 12.44	78.64 ± 13.57	**< 0.01**	83.61 ± 22.03	105.91 ± 13.06	**< 0.01**
Passive flexion (°)	112.87 ± 12.51	112.61 ± 16.34	0.95	49.82 ± 11.92	89.36 ± 14.21	**< 0.01**	92.17 ± 21.44	113.22 ± 13.41	**< 0.01**
Active extension (°)	-8.22 ± 6.50	-5.522 ± 5.83	0.15	-8.48 ± 4.67	-11.91 ± 6.35	**0.04**	-9.78 ± 7.28	-9.087 ± 8.62	0.77
Passive extension (°)	-2.57 ± 4.68	-1.870 ± 5.92	0.66	-3.91 ± 4.01	-7.36 ± 6.37	**0.03**	-3.09 ± 5.75	-3.57 ± 5.62	0.78
TUG (sec)	16.46 ± 5.36	13.62 ± 4.64	0.06				17.11 ± 4.73	13.18 ± 4.13	**< 0.01**
Womac total score	68.39 ± 12.73	60.91 ± 18.95	0.12				35.52 ± 24.71	17.17 ± 15.37	**< 0.01**
Womac pain score	14.60 ± 3.83	13.17 ± 4.09	0.23				5.83 ± 5.77	3.61 ± 3.65	0.13
Womac stiffness score	4.96 ± 2.40	4.78 ± 2.37	0.81				2.78 ± 2.68	1.65 ± 1.85	0.10
Womac function score	48.83 ± 9.90	42.96 ± 13.97	0.11				26.91 ± 19.42	11.91 ± 11.38	**< 0.01**

SDG: short duration postoperative immediate flexion position group, LDG: long duration postoperative immediate flexion position group, VAS: visual analog scale, TUG: time up and go, p^t: *t*-test.

Table III. Intragroup analysis.

Parameter	SDG			LDG		
	Preoperative	Postoperative week 6	p^t	Preoperative	Postoperative week 6	p^t
Rest VAS	3.91 ± 3.29	2.04 ± 2.42	**0.017**	4.21 ± 2.89	1.78 ± 2.15	**0.004**
Activity VAS	9.35 ± 0.93	2.57 ± 2.33	**< 0.01**	9.30 ± 1.36	2.57 ± 2.31	**< 0.01**
Circumference measurement (cm)	46.35 ± 4.35	47.80 ± 5.04	**0.002**	43.83 ± 4.43	45.24 ± 4.58	**0.007**
Active flexion (°)	98.22 ± 13.29	83.61 ± 22.03	**< 0.01**	104.17 ± 1,857	105.91 ± 13.06	0.58
Passive flexion (°)	112.87 ± 12.51	92.17 ± 21.44	**< 0.01**	112.61 ± 16.34	113.22 ± 13.41	0.27
Active extension (°)	-8.22 ± 6.50	-9.78 ± 7.28	0.394	-5.522 ± 5.83	-9.087 ± 8.62	0.17
Passive extension (°)	-2.57 ± 4.68	-3.09 ± 5.75	0.84	-1.870 ± 5.92	-3.57 ± 5.62	0.35
TUG (sec)	16.46 ± 5.36	17.11 ± 4.73	0.64	13.62 ± 4.64	13.18 ± 4.13	0.69
Womac total score	68.39 ± 12.73	35.52 ± 24.71	**< 0.01**	60.91 ± 18.95	17.17 ± 15.37	**< 0.01**
Womac pain score	14.60 ± 3.83	5.83 ± 5.77	**< 0.01**	13.17 ± 4.09	3.61 ± 3.65	**< 0.01**
Womac stiffness score	4.96 ± 2.40	2.78 ± 2.68	**0.007**	4.78 ± 2.37	1.65 ± 1.85	**< 0.01**
Womac function score	48.83 ± 9.90	26.91 ± 19.42	**< 0.01**	42.96 ± 13.97	11.91 ± 11.38	**< 0.01**

SDG: short duration postoperative immediate flexion position group, LDG: long duration postoperative immediate flexion position group, VAS: visual analog scale, TUG: time up and go, p^t: *t*-test.

According to the results of the present study, postoperative flexion time had no effect on CBL. During the theoretical preparation of the study, we hypothesized that a flexion duration of 24 or 72 hours would not affect CBL, and our results confirmed this hypothesis. To date, studies in the relevant literature have provided strong evidence that PIFPPs are more effective in reducing CBL caused by TKA than PIEPPs[13]. Furthermore, it has been reported that the outcomes of low and high flexion angle PIFPPs do not differ in terms of CBL and that moderate flexion angles may be preferred as they are well tolerated[3]. However, to the best of our knowledge, no study has reported the effect of the duration variable of PIFPPs on CBL; therefore, the results of the present study may make a novel contribution to the relevant literature.

In the present study, a better flexion ROM was obtained in the mid-term (6 weeks) with long-duration PIFPP compared to that with short-duration PIFPP. The better flexion angle before discharge in long-duration PIFPP may have led to a better flexion angle in the mid-term. Knee flexion ROM is considered one of the important indicators of recovery after TKA[21]. Postoperative immediate joint positioning protocols are effective in improving knee flexion ROM. After TKA, compared to PIEPPs, PIFPPs may help achieve better flexion ROM in the early (first week) and mid-term postoperative period[10-12]. However, two questions are important in this context. The first question is for how long should the flexion positioning be performed. To the best of our knowledge, no study has directly investigated the effect of different durations in PIFPPs on early-, mid- and long-term flexion ROM. However, in the meta-analysis by Wang et al[13], it was reported that the duration should be ≥ 24 hours for a greater flexion ROM in the early period (1 week). The second question is whether PIFPPs with different flexion angles increase the ROM. In the relevant literature, some study[22] results provide a reasonable answer to this question and report that the positioning of the affected knee at different flexion angles does not affect flexion ROM. However, because these studies examining the effectiveness of different degrees of flexion did not compare the results of the flexion group *vs.* extension group, a definitive conclusion on the subject is not possible, and further research is needed.

According to the results of the present study, active and passive extension ranges of motion were smaller in the early period (day 3) in patients who underwent PIFPP. This result may be attributed to pain, edema, and quadriceps inhibition[23-25]. In the intermediate period (week 6), there was no difference in active and passive extension ROM with short- and long-term PIFPPs. However, the active extension ranges of motion measured in the mid-term in both groups were smaller than the preoperative active extension, and this was particularly evident with prolonged PIFPPs. We believe that insufficient quadriceps strength may have led to the loss of

active extension[26]. To the best of our knowledge, no PIFPP study has reported extension ROM in the literature[3]; therefore, the relevant result of the present study increases its uniqueness value. This is because extensor lag after TKA is one of the most important complications leading to functional limitation[25] and because PIFPP has a high potential to cause extensor lag due to its nature[3]. To the best of our knowledge, only one study, i.e., the study by De Fine et al[22], has compared the number of patients who developed fixed flexion deformity in the early period (1 week). They classified patients who underwent TKA into two groups and positioned the affected knees at 30° and 70° flexion, respectively, for 48 hours and reported that the number of patients with fixed flexion deformity was not different between the two groups at week 1.

In the present study, patients who underwent long-duration PIFPP had higher WOMAC physical function and TUG scores in week 6 postoperatively. This may be attributed to the fact that the improvements in flexion ROM were greater in those who underwent long-duration PIFPP. TKA is known to provide great improvements in the physical function of patients[27], and the amount of improvement in physical function is affected by postoperative rehabilitation[28]. To the best of our knowledge, this is the first study to investigate the effect of PIFPPs on mid-term functional outcomes after TKA. The results suggest that the duration of PIFPP affects mid-term functional outcomes. However, further studies are required to investigate whether PIFPP is more effective than PIEPP in terms of mid-term functional outcomes.

Some important clinical implications that can be drawn from the current study are as follows. Compared with short-duration PIFPPs, long-duration PIFPPs may help physicians achieve better flexion angles and functional outcomes in the mid-term after TKA. Although it is not statistically significant, the fact that mid-term active extension limitation is higher in long-term PIFPP than in short-term PIFPP suggests that prolonged knee flexion after TKA may increase quadriceps inhibition and weakness. As far as we know, the effect of PIFPP on quadriceps activation and strength after TKA has not been investigated before, and the short-, mid- and long-term effect of PIFPP on quadriceps activation and strength should be investigated in the future. However, it has long been known that quadriceps inhibition after TKA causes quadriceps weakness and atrophy[29]. There is evidence to suggest that quadriceps weakness may persist for periods of 3 months to 3 years after TKA[30,31]. In addition, preoperative quadriceps strength is one of the determinants of knee function healing after TKA, and preoperative quadriceps strengthening exercises are effective in the improvement of postoperative quadriceps strength[32,33]. For these reasons, when using PIFPP for long durations, more and careful emphasis should be placed on quadriceps activation and strengthening exercises both before and after surgery.

Limitations

This study has some limitations. Although participants and caregivers were encouraged and informed to maintain the postoperative position, there may have been intermittent PIFPP compliance issues that were beyond our control. Another limitation of the study is the degree of compliance of the patients to the recommended exercises after discharge. Finally, the fact that some patients neglected prescribed ROM and quadriceps strengthening exercises may have influenced the results of some measured variables.

Conclusions

Long-duration (72 hours) PIFPP provides better mid-term flexion ROM and physical function than short-duration (24 hours) PIFPP. However, PIFPPs may increase the tendency to lose active extension motion. Therefore, if PIFPP is to be used, emphasis should be placed on quadriceps activation and strengthening exercises.

Authors' Contributions

Conceptualization: MZG, SA, TA; methodology: SA, MZG; validation: TA; investigation: SA, MZG; data curation: MZG, SA; writing - original draft: SA; writing - review and editing: TA, MZG; visualization: TA, MZG; supervision: SA.

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Conflict of Interest
We have no conflicts of interest associated with this publication.

Informed Consent
All participants signed a written informed consent.

Ethics Approval
The research was carried out by following the Declaration of Helsinki and received ethical compliance according to the decision numbered 2022/20-169 and dated 02/03/2022 from the Health Sciences Scientific Research Ethics Committee of Necmettin Erbakan University.

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