Submitted: 07 May, 2024 Accepted: 24 September, 2024 Online Published: 26 March, 2025 DOI:10.22514/sv.2025.045

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ORIGINAL RESEARCH

Effects of pericapsular nerve group block on patients under spinal anesthesia for total hip arthroplasty: a randomized, controlled, double-blind study

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Abstract

Background: This study aimed to evaluate the Pericapsular Nerve Group (PENG) Block applied for anesthesia in total hip arthroplasty (THA) surgery regarding its effects on postoperative pain, opioid requirement and early mobilization. **Methods**: This prospective, randomized, controlled study was included a total of 60 patients who underwent THA under spinal anesthesia. The patients were divided into two groups: those receiving the PENG block and others not receiving the PENG block. The primary outcome was assessing postoperative pain with Visual analogue scales (VAS). Secondary outcomes included postoperative adverse effects, hip joint range of motion, mobilisation, total opioid requirement and length of hospital stay. **Results**: In the PENG group, the VAS score at the 12th, 24th and 48th hours after the procedure, total opioid requirement, and the time to mobilization were significantly lower than those in the control group ($p < 0.01$). In the PENG group, the time to additional analgesic administration was significantly longer, and the hip joint range of motion was significantly higher compared to the control group ($p < 0.01$). There was no significant difference between the groups regarding the length of hospital stay ($p > 0.05$). **Conclusions**: Our study indicated a decrease in postoperative pain and total opioid consumption in patients undergoing PENG block application. It was observed that these patients had a later requirement for initial additional analgesia and greater hip joint range of motion, and they required a shorter time for mobilization. It has been concluded that the PENG block could be an effective and safe analgesic method as a significant part of multimodal analgesia in postoperative pain control in THA surgery. **Clinical Trial Registration**: NCT06183528.

Keywords

Anaesthesia; Arthroplasty; Hip surgery; Postoperative pain; Pericapsular nerve group block

1. Introduction

Total hip arthroplasty (THA) is a commonly performed major surgery associated with moderate to severe pain in the postoperative period. Inadequate postoperative pain control has been associated with delayed rehabilitation, impaired functional recovery, and decreased patient satisfaction after surgery [1–3].

Systemic analgesic administration, intra-articular injection, neuraxial, and peripheral nerve block combinations are used during the perioperative period for pain control. Among these, intra-articular local injections of anesthetics have been shown to play a potential role in providing analgesia after THA [4–6]. The incidence of opioid prescribing following THA can be as high as 89.7% [7, 8].

Recent studies have suggested a multimodal analgesia approach to reduce adverse effects and dependence on opioid-based medications in THA [9, 10]. Regional anesthesia is an important component of this multimodal approach. Commonly used regional anesthesia techniques include femoral nerve block, lumbar plexus block, or fascia iliaca block. The major disadvantage of these commonly used regional techniques for THA is that they are partially effective in reducing pain; they often cause weakness in motor abilities and delay mobilization [11, 12].

Giron *et al*. [13] first described the PENG block in 2018. Ultrasonography-guided PENG block involves blocking the femoral, obturator, and accessory obturator nerve branches, which provide sensory innervation to the anterior of the hip joint capsule [14]. It has been used as an alternative method for preoperative pain management in patients with hip fracturs [12, 15]. PENG block applied prior to surgery has been found beneficial in managing postoperative pain in THA [16–18]. Randomized controlled trials investigating the efficacy

of PENG have reported improvements in analgesia while preserving motor function and the strength of the quadriceps muscle, enabling postoperative mobilization, and enhancing the quality of recovery [12, 16, 19]. However, there is insufficient evidence in the literature supporting the use of the PENG block [20]. This technique is not mentioned in the current postoperative pain management guidelines for THA (procedure-specific postoperative pain management) [21].

This study aimed to evaluate the Pericapsular Nerve Group (PENG) Block applied for anesthesia in total hip arthroplasty (THA) surgery regarding its effects on postoperative pain, opioid requirement and early mobilization.

The primary outcome was assessing postoperative pain with VAS. Secondary outcomes included postoperative adverse effects, hip joint range of motion, mobilisation, total opioid requirement and length of hospital stay.

2. Methods

2.1 Design and setting

This study was conducted as a prospective, randomized, controlled, double-blind study between February 2023 and October 2023 at Umraniye Training and Research Hospital Department of Anesthesiology and Reanimation with the Ethics Committee's approval number B.10.1.TKH.4.34.H.GP.0.01/251 dated 11 August 2022 in accordance with the Helsinki Declaration, the regulation on patient rights, and ethical principles. Patients were asked to read the consent form, and the participants provided verbal and written consent for participating in the study.

The study included a total of 60 patients aged from 40 to 85 years of age undergoing posterior approach THA surgery. The patients were randomly divided into two groups using a closed envelope method: one receiving PENG block (n = 30) and the other not receiving PENG block (n = 30). Inclusion criteria required an American Society of Anesthesiologists physical status classification of 1, 2 or 3 and a body mass index <35 kg/m^2. Patients with diagnosed with cognitive impairment (*e.g.*, Alzheimer's, dementia, delirium), local infection of the puncture site, allergy to local anesthetics, coagulopathy, patients on opioid therapy for coxarthrosis and who did not give consent were excluded.

2.2 Interventions

Before transfer to the operating room, all patients received sedation with intravenous (iv) midazolam 0.03 mg/kg before the surgery. Patients were monitored for electrocardiogram (EKG), noninvasive artery pressure, oxygen saturation (SaO_2) and temperature. Spinal anesthesia was preferred as the main anesthesia technique. When the patient was in a sitting position, 15 mg of 0.5% heavy bupivacaine was injected into the L2–L3 or L3–L4 interspace using a 27G Whitacre needle. After spinal anesthesia, before the surgical incision, ultrasound (USG) (GE, Wauwatosa, WI, USA, LOGIQ P5, 149678SU5) was performed on the PENG group in the supine position using a 2–5 MHz, low-frequency curved probe placed transversely on the medial aspect of the anterior inferior iliac spine (AIIS). The medial tip of the probe was rotated approximately 45° counterclockwise to align with the superior pubic ramus. A 100 mm block needle (Pajunk, SonoPlex II) was placed in the fascial plane between the psoas tendon and the pubic ramus for the blockage of the femoral, obturator, and accessory obturator nerves, providing sensory innervation to the anterior hip capsule, and 20 mL of 0.5% bupivacaine was injected using an in-plane technique (Fig. 1). The operation was started after the block was achieved.

In the group that did not receive a block, the surgery was started without any intervention following spinal anesthesia.

At the end of surgery, 10 mL of 0.5% bupivacaine + 10 mL of 2% lidocaine was infiltrated into the surgical incision line by the surgical team for all patients. Additionally, at the end of the surgery, both groups received Patient controlled analgesia (PCA) with tramadol 50 mg iv loading dose followed by a basal rate of 5–10 mg/hour (20 mg bolus dose + 30 minute lockout time) and iv paracetamol 10 mg/kg every 8 hours. Surgery was performed by the same surgical team for all patients. For patients with a VAS score of $\geq$4, tramadol 0.5 mg/kg was added as an additional analgesic opioid. All patients were

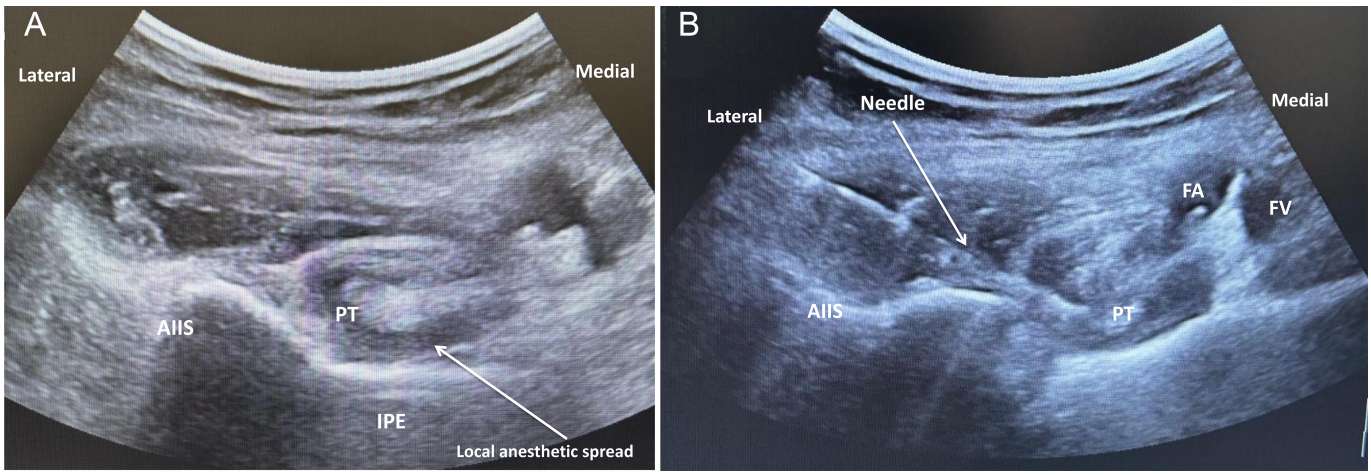

FIGURE 1. PENG block ultrasound image. (A) Before 20 mL of 0.5% bupivacaine injection; (B) After 20 mL of 0.5% bupivacaine injection. AIIS: anterior inferior iliac spine; PT: psoas tendon; IPE: iliopubic eminence; FA: femoral artery; FV: femoral vein.

transferred to the orthopedics ward, where a physiotherapist blinded to the patient groups measured hip flexion angle with a goniometer and helped patients with mobilization.

VAS were adopted for evaluating patients' pain level, they were numbered by drawing a line between 0 (no pain) and 10 (most severe pain). The pain level was marked numerically on the line.

2.3 Measurements

Before the surgery, age, weight, height, body mass index (BMI), gender, ASA score, and co-morbidities were recorded. Surgical duration was also recorded. Perioperative heart rate (HR) and mean arterial pressure (MAP) were recorded at the baseline (T_0), 30th minutes after spinal anesthesia (T_1), end of surgery (T_2) and 30th minutes in the recovery room (T_3).

Recorded data included all patients' VAS scores at the recovery unit at minute 30th and at the 12th, 24th and 48th hours in the postoperative period, the time to the first additional analgesic administration postoperatively, the total opioid dose administered, hip joint range of motion at the 24th hour, the time to first mobilization, the length of hospital stay, and possible adverse events (*e.g.*, motor block, nausea, vomiting, anaphylaxis, nerve injury).

All patients were operated on by the same surgical team. Tramadol 0.5 mg/kg was added as an additional analgesic opioid to patients with VAS $\geq$4 and received regular subcutaneous injection of enoxaparin. The dose of enoxaparin sodium is 40 mg given by subcutaneously once a day given initially 12 hours prior to surgery and provided that hemostasis has been established, the initial dose given 12 to 24 hours after surgery.

"First mobilization time" is; after the first 12 hours of end of the surgery; the time to be able to take at least three steps with the help of a walker was defined as the first postoperative mobilization time and was recorded.

2.4 Statistical analyses

We used the descriptive statistics of mean, standard deviation, median, minimum, maximum, frequency and ratio. The Kolmogorov-Smirnov test was used to measure the distribution of the variables. The independent sample *t*-test and the Mann-Whitney U test were employed to analyze quantitative independent data. The Chi-square test was used to analyze independent qualitative data. Statistical Package for Social Sciences (SPSS, ver. 28, IBM Corp., Armonk, NY, USA) was used for calculations, and all *p*-values were considered significant at a level of < 0.05.

2.5 Power analysis

In the power analysis was conducted using the G*Power (v3.1.9) program (Faul, Erdfelder, Lang, & Buchner, Mannheim, BW, Germany) to determine the sample size. Assuming an effect size ($d = 0.254$) as determined by Cohen, it was found that a sample size of at least 30 for the control group and at least 30 for the study group would be needed to achieve a power of 80%.

3. Results

A total of 62 patients were enrolled in the study. One patient in the PENG group was excluded due to postoperative dislocation of the hip prosthesis, and one patient in the non-PENG group was excluded because of being older than 85 years of age. As a result, data belonging to 60 patients was analyzed in the study (Fig. 2).

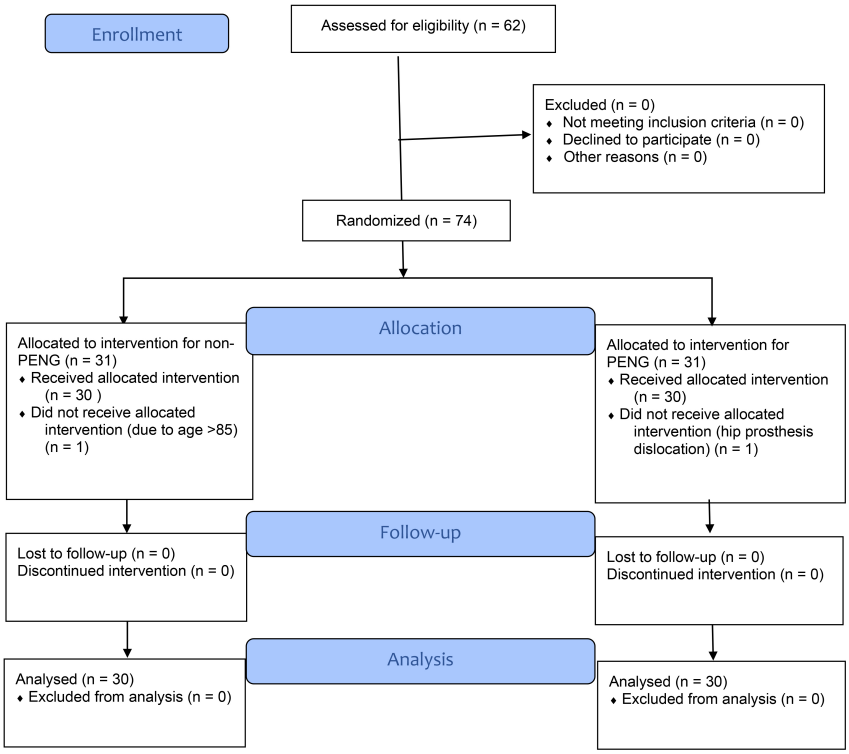

FIGURE 2. CONSORT 2010 Flow Diagram. PENG: Pericapsular Nerve Group.

There was no significant difference between the groups in terms of their demographics ($p > 0.05$). 56.7% of the patients in the PENG group and 63.3% of the control group were female. Nausea and vomiting were observed as adverse effects in both the control and PENG groups, but no significant difference was observed between the two groups regarding adverse events ($p > 0.05$). The patients preoperative demographic data is shown in Table 1.

There was no significant difference between the control and PENG groups regarding their HR and MAP at T_0, T_1, T_2 and T_3 ($p > 0.05$). The patients perioperative hemodynamic data is shown in Table 2.

No significant difference was observed between the control and PENG groups in VAS pain scores at T_3 (minute 30 at the recovery unit). However, the VAS pain scores at the 12th, 24th and 48th hours were significantly lower than those in the control group ($p < 0.01$). The patients postoperative VAS scores is shown in Table 3.

In the PENG group, the time to additional analgesia was significantly later, and the total amount of opioids used was significantly lower than in the control group ($p < 0.01$). The time to mobilization in the PENG group is significantly later compared to the control group ($p < 0.01$). The hip joint range of motion at the 24th hour is significantly higher in the PENG group compared to the control group ($p < 0.01$). There was no significant difference between the control and PENG groups regarding the length of hospital stay ($p > 0.05$). The patients postoperative outcomes is shown in Table 4.

TABLE 1. Patient and preoperative characteristics.

	Control Group (n = 30)		PENG Group (n = 30)		*p*
	Mean ± SD	Median	Mean ± SD	Median	
Age (yr)	64.3 ± 11.7	67.5	63.4 ± 12.0	66.0	0.778[a]
Weight (kg)	77.8 ± 9.1	77.0	77.7 ± 9.7	76.5	0.956[a]
Height (cm)	167.4 ± 7.7	165.0	167.7 ± 8.4	164.5	0.777[b]
BMI (kg/m^2)	27.4 ± 1.8	28.0	27.4 ± 2.2	28.0	0.970[b]
Operation time (min)	135.8 ± 13.1	137.5	129.5 ± 12.7	127.5	0.062[a]
	n	%	n	%	
Gender					
Female	19	63.3%	17	56.7%	0.598[χ^2]
Male	11	36.7%	13	43.3%	
Hypertension					
(−)	12	40.0%	11	36.7%	0.791[χ^2]
(+)	18	60.0%	19	63.3%	
Diabetes mellitus					
(−)	14	46.7%	17	56.7%	0.438[χ^2]
(+)	16	53.3%	13	43.3%	
Hypothyroidism					
(−)	23	76.7%	24	80.0%	0.754[χ^2]
(+)	7	23.3%	6	20.0%	
Atrial fibrilation					
(−)	28	93.3%	27	90.0%	0.640[χ^2]
(+)	2	6.7%	3	10.0%	
Advers events (Nausea/vomiting)					
(−)	25	83.3%	28	93.3%	0.228[χ^2]
(+)	5	16.7%	2	6.7%	
ASA score					
I	3	10.0%	2	6.7%	
II	23	76.7%	25	83.3%	0.640[χ^2]
III	4	13.3%	3	10.0%	

[a] Independent sample t test; [b] Mann-Whitney U test; [χ^2] Ki-kare test.
SD: Standard deviation; BMI: body mass index; ASA: American Society of Anesthesiologists; PENG: Pericapsular Nerve Group.

TABLE 2. Perioperative hemodynamic data.

	Control Group (n = 30)		PENG Group (n = 30)		*p*
	Mean ± SD	Median	Mean ± SD	Median	
HR					
T_0	81.2 ± 7.5	81.0	79.7 ± 12.8	77.0	0.263
T_1	72.6 ± 7.0	71.5	71.7 ± 9.7	72.0	0.609
T_2	71.7 ± 7.0	70.5	70.8 ± 8.0	71.0	0.830
T_3	73.1 ± 6.8	72.0	72.1 ± 7.7	72.0	0.727
MAP					
T_0	110.0 ± 14.1	110.0	112.0 ± 13.8	110.0	0.589
T_1	81.4 ± 11.4	85.5	84.4 ± 8.8	86.0	0.317
T_2	82.5 ± 8.8	83.5	80.7 ± 7.7	80.0	0.362
T_3	83.7 ± 8.7	85.0	83.0 ± 9.0	84.5	0.594

SD: Standard deviation; HR: heart rate; MAP: mean arterial pressure; PENG: Pericapsular Nerve Group.
T_0: the baseline, T_1: at the 30th minute after spinal anesthesia, T_2: at the end of surgery, and T_3: at 30th minutes in the recovery room.

TABLE 3. Postoperative VAS scores.

	Control Group (n = 30)		PENG Group (n = 30)		*p*
	Mean ± SD	Median	Mean ± SD	Median	
VAS score					
T_3	1.23 ± 0.86	1.00	1.23 ± 0.86	1.00	1.000
Postoperative 12th hour	4.90 ± 1.73	4.00	1.23 ± 0.86	1.00	<0.001
Postoperative 24th hour	4.63 ± 1.25	5.00	0.83 ± 0.87	1.00	<0.001
Postoperative 48th hour	3.13 ± 1.33	3.00	0.83 ± 0.87	1.00	<0.001

SD: Standard deviation; T_3: at 30th minutes in the recovery room. PENG: Pericapsular Nerve Group; VAS: Visual analogue scales.

TABLE 4. Postoperative outcomes.

	Control Group (n = 30)		PENG Group (n = 30)		*p*
	Mean ± SD	Median	Mean ± SD	Median	
Mobilization time (h)	23.0 ± 2.1	23.0	19.1 ± 1.6	19.0	<0.001
24th hour/hip joint range of motion	43.5 ± 6.8	45.0	62.3 ± 8.4	65.0	<0.001
Time to additional analgesia (h)	4.1 ± 1.1	4.0	8.5 ± 1.2	9.0	<0.001
Total opioid amount (mg)	353.3 ± 14.0	350.0	216.7 ± 9.6	210.0	<0.001
Length of hospital stay (d)	2.9 ± 1.6	2.5	2.5 ± 0.9	2.0	0.111

SD: Standard deviation; PENG: Pericapsular Nerve Group.

4. Discussion

Postoperative pain is one of the factors that can increase morbidity and mortality due to patient dissatisfaction, delayed mobilization, and the risk of developing cardiac and pulmonary complications, as well as chronic pain [22]. Postoperative pain has increased opioid use worldwide. Considering multimodal analgesia and anesthesia techniques for postoperative pain management, guidelines have been established regarding postoperative opioid use [23].

In this prospective, randomized, controlled study investigated the effect of pre-incisional PENG block on perioperative hemodynamic parameters, postoperative VAS pain score, time to additional analgesic administration, hip joint range of motion, time to mobilization time, length of hospital stay, and adverse events in patients who underwent posterior hip arthroplasty under spinal anesthesia.

While a significant reduction in postoperative VAS value was achieved with PENG block application, this group of patients also had shorter mobilization time, increased hip range

of motion, shorter duration of additional analgesia, and a decrease in the total amount of opioids used. We found no difference in the length of hospital stay between both groups.

Pascarella *et al*. [16] reported that patients who underwent PENG block had lower pain scores, less opioid requirement, greater hip range of motion, and shorter mobilization time and was no significant difference between the study and control groups regarding the length of hospital stay and adverse effects. Lin *et al*. [12] reported that randomized, double-blind study with the inclusion of 60 patients, the PENG block group had lower pain scores and greater quadriceps strength than the femoral block group.

Similarly, Sahoo *et al*. [15] applied preoperative PENG block in a total of 9 patients undergoing hip fracture surgery and compared the resting pain levels before and after the block, as well as the pain levels after 15° passive leg raising. Lower pain levels were reported after the PENG block. Kukreja *et al*. [17] reported that retrospective study of a total of 120 patients, the VAS pain score and opioid use within postoperative 24 hours were lower at all times compared to revision patients.

PENG block analgesia is only effective for the anterior hip capsule and it is inadequate for analgesia of the posterior capsule, which is innervated by the nerve to the quadratus femoris and superior gluteal nerve, both from the sacral plexus. In the literature, the PENG block has been compared with different blocks. In our study the group that did not receive a block, the surgery was started without any intervention following spinal anesthesia. At the end of surgery, 10 mL of 0.5% bupivacaine + 10 mL of 2% lidocaine was infiltrated into the surgical incision line by the surgical team for all patients. Aliste *et al*. [24] randomized study of a total of 40 patients compared pain scores, cumulative morphine consumption, opioid-related adverse effects; the ability of patients to undergo physiotherapy at the 24 and 48th hours; and the length of hospital stay in patients who underwent primary THA and received either PENG block or suprainguinal fascia iliaca compartment block. In the PENG group, better preservation of hip adduction was observed at the 3rd hour, and less sensory block in the hip's anterior, medial, and lateral regions was observed at all measurement times. In the PENG group, better preservation of hip adduction was observed at 3 hours, and there was less sensory block in the anterior, medial, and lateral regions of the hips at all measurement times. Mosaffa *et al*. [25], randomized controlled study involving 52 patients undergoing hip fracture surgery, preoperative fascia iliaca compartment block was compared with PENG block; reported that in the PENG block group, the VAS score at 15 minutes after the block and at 12 hours postoperatively was significantly lower, the time to first additional analgesia was significantly longer, and the morphine consumption dose at 24 hours was significantly lower. At the end of surgery, 10 mL of 0.5% bupivacaine + 10 mL of 2% lidocaine was infiltrated into the surgical incision line by the surgical team for all patients.

In our study, there was no significant difference between the groups regarding the adverse events observed. Zheng *et al*. [18] reported that in a randomized study of 70 patients with PENG observed that the intraoperative morphine dosage and postoperative vomiting were lower in the PENG group. Huda *et al*. [26] evaluated six randomized controlled trials comparing patients who underwent PENG block and those who did not in a meta-analysis and investigated opioid use, postoperative pain control, and block-related adverse effects in patients undergoing hip surgery with PENG block. In that meta-analysis, the investigators found out that in patients who received PENG block, opioid consumption in the first 24 hours postoperatively was significantly lower, the time to first additional analgesia was significantly longer, patient satisfaction was higher, and the risk of motor block was significantly lower.

Several studies in the literature evaluate the postoperative analgesic effect of PENG block and its effects on early mobilization. Our study's unique approach of administering PENG block under spinal anesthesia distinguishes it from others.

This study has some limitations that should be acknowledged. The first limitation is the small sample size; further studies with larger cohorts are necessary. Secondly, the goniometer's sensitivity might be low, and the quadriceps muscle strength was not evaluated.

5. Conclusions

Our study indicated a decrease in postoperative pain and total opioid consumption in patients undergoing PENG block application. It was observed that these patients had a later requirement for initial additional analgesia and greater hip joint range of motion, and they required a shorter time for mobilization. There was no significant difference between the groups regarding the adverse events observed. In future studies, the efficacy of PENG block with different approaches in patients receiving spinal anesthesia and in THA can be evaluated and side effects such as motor weakness can be analyzed in more detail. It has been concluded that the PENG block could be an effective and safe analgesic method as a significant part of multimodal analgesia in postoperative pain control in THA surgery.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

ZT and HAT—designed the research study; analyzed the data. DDT and HAT—performed the research. DDT and ZT—wrote the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The Ethics Committee of the Umraniye Training and Research Hospital approved the present study with its letter of approval no. B.10.1.TKH.4.34.H.GP.0.01/251 dated 11 August 2022 in accordance with the Helsinki Declaration, the regulation on patient rights, and ethical principles. Patients were asked to read the consent form, and the participants provided verbal and written consent for participating in the study.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Dicle Deri Turkan, Zeliha Tuncel, Hale Arkan Tuna. Effects of pericapsular nerve group block on patients under spinal anesthesia for total hip arthroplasty: a randomized, controlled, double-blind study. Signa Vitae. 2025. doi: 10.22514/sv.2025.045.