Original Article

DOI: 10.4274/haseki.galenos.2025.54264
Med Bull Haseki 2025;63(2):81-88

Comparative Efficacy of Pericapsular Nerve Group and Suprainguinal Fascia Iliaca Blocks in Elderly Patients Undergoing Surgery for Subtrochanteric Femur Fractures: A Double-blind Randomized Controlled Trial

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Abstract

Aim: Peripheral nerve blocks (PNBs) are crucial for reducing opioid use and ensuring pain relief in elderly patients following hip fractures. Our study aimed to compare two recently recommended hip blocks regarding their effectiveness in postoperative analgesia.

Methods: This randomized, double-blind study primarily evaluated pain scores [numeric rating scale (NRS); at the 0th, 4th, 8th, 12th, and 24th hours] and total analgesic consumption in elderly patients scheduled for proximal femoral nailing between January 2022 and June 2024. The study involved three groups (n=25): control, pericapsular nerve group block (PENG), and suprainguinal fascia iliaca block (SIFIB) groups, all receiving the same anesthetic management and rescue analgesia plan.

Results: The NRS values of the control group were significantly higher than those of Group SIFIB at all hours except the postoperative 8th hour; the value was still higher than that of Group SIFIB (p=0.055). There was no significant difference between the control and PENG groups after the eighth hour postoperatively. The NRS values of the SIFIB group were significantly lower than those of the PENG group at all hours except for the 8th hour postoperatively. Group SIFIB required significantly lower analgesia than Group PENG (p<0.001).

Conclusion: This study indicated that SIFIB may be the preferred PNB for elderly patients with femur fractures, providing effective analgesia while minimizing analgesic consumption during the first 24 hours postoperatively.

Keywords: Frail elderly, hip fractures, peripheral nerves, suprainguinal fascia iliaca block, pericapsular nerve group block, pain

Introduction

Hip fractures pose a significant global issue, leading to increased morbidity and mortality, particularly among the elderly population (1). Regional anesthesia is the preferred method for improving patient safety after hip fracture surgery, especially in elderly patients (2). Effective pain management with minimal opioid use is an essential goal for elderly patients with femur fractures (3). Other than the well-known side effects of opioids for the general population, elderly patients are more prone to respiratory depression, hemodynamic instability, and increased side effects due to reduced metabolism of opioids (4). Additionally, the tendency to avoid these effects, leading to ineffective postoperative pain management, may increase the risk of delirium and cognitive dysfunction in the elderly population (5). Since there are preexisting high clinical frailty scores of these patients, immobility-related complications such as tendency towards venous

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Received: 08.11.2024 **Accepted:** 09.05.2025 **Publication Date:** 04.06.2025

Cite this article as: Caliskan B, Daglar S, Sen O. Comparative efficacy of pericapsular nerve group and suprainguinal fascia iliaca blocks in elderly patients undergoing surgery for subtrochanteric femur fractures: a double-blind randomized controlled trial. Med Bull Haseki. 2025;63(2):81-88

thromboembolism, pulmonary aspirations, altered mental conditions, and cognitive impairment require more attention for early mobilization, if possible (6,7). Moreover, multimodal analgesia may not be an option to achieve these goals because non-steroidal anti-inflammatory drugs or even paracetamol may be contraindicated in this elderly group due to multiple comorbidities and possible drug interactions resulting from polypharmacy (8). With all this reasoning and these targets for elderly femur fracture patients, peripheral nerve blocks (PNBs) have been the analgesic plan of choice. However, a gold standard protocol for a block procedure has not been approved.

Lately, pericapsular nerve group block (PENG) targeting nociception of the anterior hip capsule and fascia iliaca blocks (FIBs), preferably the suprainguinal FIB (SIFIB), has been in the spotlight of research to determine and compare the analgesic efficacy and motor impairment after these blocks (9,10). Therefore, we designed a prospective study to identify a PNB suitable for elderly femur fractures, resulting in sufficient analgesia with minimum analgesic consumption and preserving motor function. We also focused on block procedures, specifically examining the duration required to perform the block. We searched for the tertiary effects on outcomes such as postoperative serious events and intensive care unit (ICU) admission.

Materials and Methods

Compliance with Ethical Standards

Ethical approval was obtained from University of Health Sciences Turkey, Istanbul Haseki Training and Research Hospital Clinicial Research Ethics Committee (approval no.: 18-2021, date: 24.11.2021). The study was recorded at clinicaltrials.gov (NCT06277648, 02/19/2024).

Study Design and Population

We designed a double-blind, randomized, controlled study and assessed patients with subtrochanteric femur fractures scheduled for proximal femoral nailing (PFN) after January 2022 for eligibility. We conducted the study in our tertiary care hospital until June 2024, in accordance with the principles outlined in the Helsinki Declaration. After obtaining written informed consent, 75 patients (3 groups; 1:1:1 distribution; n=25) were allocated, and the Consolidated Standards of Reporting Trials flow diagram was used to present the progression (Figure 1). Patients eligible for inclusion in this study were those over 65 who had undergone PFN and had an American Society of Anesthesiologists (ASA) Physical Status classification of I to IV. These patients and their relatives were provided with information about the PNBs included in the study. They were educated on evaluating pain scores [numeric rating scale (NRS)]. Patients were excluded if they had one of the following criteria: refusal to participate, a history of neurological deficits or neuropathy, infection at the site of block application, coagulopathy, or allergy to local anesthetics. Patients were also excluded if they had cachexia, an actual body weight of less than 45 kilograms, severe cardiopulmonary insufficiency, renal impairment, or mental illness. The patients were excluded if there was a change of surgical plan or if the surgery was prolonged due to orthopedic complications of more than 3 hours, necessitating conversion of spinal anesthesia to general anesthesia.

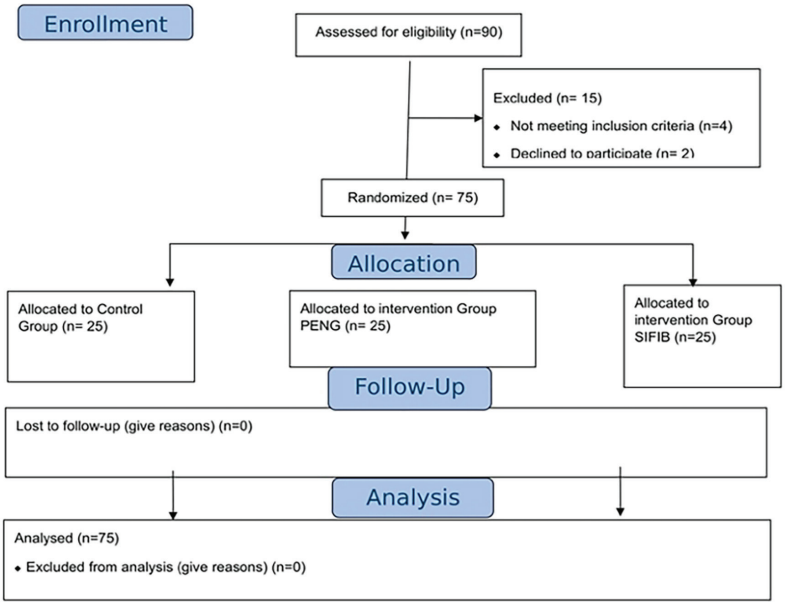

Figure 1. Consort flow diagram
PENG: Pericapsular nerve group block

Randomization, Blindness, and Standardization

Randomization was designed for 3 groups (n=25 for each group), named Groups A, B, and C, in a 1:1:1 ratio, using a computer-based algorithm and sealed in opaque envelopes by the surgeon assigned to the study. The investigator anesthesiologist selected an envelope based on the number written on it and proceeded with PENG if it was Group A and SIFIB if it was Group B. If the patient was in Group C, there was no intervention other than intravenous (IV) analgesia. The orthopedic surgeon responsible for the study was blinded to the study groups. This surgeon was the sole evaluator of postoperative pain scores, total analgesic consumption, and motor block. All block procedures were performed by the primary investigator (B.C.). The duration of block performance and number of needle manipulations before local anesthetic injections were recorded by the anesthesia technician assisting the procedure.

All patients received standard spinal anesthesia procedures with 10 mg of heavy Marcaine (2 mL of bupivacaine 0.5%) and 25 µg of fentanyl (0.5 mL) at the L3-4 intervertebral space with the aid of midazolam 0.02 mg/kg and ketamine 0.3 mg/kg for analgesia to achieve a sitting position. Patients in the study groups (Group PENG and SIFIB) received block procedures consisting of 30 mL of 0.375% bupivacaine postoperatively in the recovery room under monitoring. The same multimodal analgesia plan was ordered for all participants, consisting of paracetamol 1 g (four times daily), tenoxicam 20 mg (daily), and dexamethasone 8 mg once postoperatively, as our routine clinical practice. They received rescue analgesia only if they had persistent pain scores higher than 4 out of 10 or asked for analgesia, with tramadol administered at 1 mg/kg (maximum daily dose: four times daily).

Interventions: Block Procedures

The primary investigator (B.C.) performed a PENG block with the patient in a supine position following proper skin disinfection. Under the guidance of a low-frequency curvilinear ultrasound probe, the iliopubic eminence and the psoas tendon were identified by sliding the probe cephalad from the inguinal crease. Following negative aspiration, local anesthetic was injected between the periosteum and psoas tendon (Figure 2).

For SIFIB, the high-frequency linear probe was placed medial to the anterosuperior iliac spine in a parasagittal orientation to visualize the bow tie appearance formed by the sartorius, internal oblique, and iliacus muscles. The needle tip was placed under fascia iliaca through an in-plane approach, and local anesthetic was injected from the caudad to the cephalad direction (Figure 3).

Outcome Measures

The primary outcome of this study is the pain score. They were assessed by the same orthopedic surgeon using the NRS (NRS, which ranges from 0 to 10, where zero represents the absence of pain, and 10 signifies the worst imaginable pain) at postoperative intervals of 12, and 24 hours.

Secondarily, the blinded orthopedic surgeon recorded the number of times rescue analgesia was applied within 24 hours postoperatively. Block performances were also compared based on the duration of interventions and by assessing the presence of motor block, specifically hip adduction, at the postoperative 6th hour. The incidence of postoperative serious events and ICU admissions was also noted.

Sample Size

The sample size was based on detecting a change of 2 units or more in mean pain scores (the primary outcome)

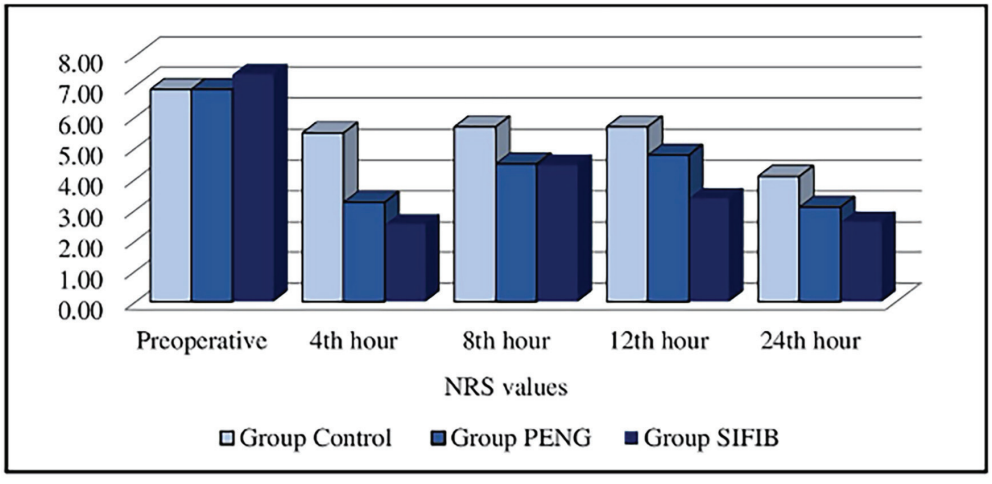

Figure 2. PENG block
NRS: Numeric rating scale, PENG: Pericapsular nerve group block, SIFIB: Suprainguinal fascia iliaca block

using analysis of covariance on the outcomes at the follow-up time point. Using an estimated standard deviation of 2 units for pain scores (0-10) with standard type I and type II error rates, we calculated that 20 patients per group would be needed. To allow dropouts or exclusions, we enrolled 25 patients in each group to have a total sample size of 75 participants.

Statistical Analysis

The SPSS 27.0 program was used in the analyses. Mean, standard deviation, median, minimum, maximum, frequency, and ratio values were used in the descriptive statistics of the data. The distribution of variables was measured using the Kolmogorov-Smirnov test. Analysis of variance (Tukey test) was used to analyze quantitative independent data with normal distribution. The Kruskal-Wallis and Mann-Whitney U tests were used to analyze quantitative independent data with non-normal distribution. The chi-square test was used in the analysis of qualitative independent data. The statistical significance threshold was $p<0.05$.

Results

There were no significant differences between the groups in terms of demographic data, ASA scores, and the Charlson Comorbidity Index (CCI) (Table 1).

In terms of NRS values, there were no significant differences between block groups in preoperative values (Figure 4). The NRS values of the control group were significantly higher than Group SIFIB at all hours except the postoperative 8th hour ($p=0.00$) (Figure 2). There was also no significant difference between the control group and the PENG group after the eighth hour postoperatively (Figure 4). Accordingly, the NRS values of the SIFIB group were significantly lower than those of the PENG group at all hours except the postoperative 8^{th} hour. The value was still lower than PENG ($p4^{th}=0.000$, $p8^{th}=0.055$, $p12^{th}=0.000$, $p24^{th}=0.002$) (Figure 4).

Moreover, the total analgesia requirements within 24 hours were significantly higher in the control group ($p<0.001$) (Figure 5). Group SIFIB required significantly lower analgesia than Group PENG ($p<0.001$) (Figure 5).

The rate of motor blockade after 6 hours did not differ significantly between groups ($p=0.684$) (Table 1). Moreover, the incidence of postoperative serious events and ICU admissions was not significantly different between groups (Table 1). However, the duration of block performance was significantly longer in Group PENG than in Group SIFIB ($p=0.001$) (Table 1).

Discussion

Our study revealed that the elderly patients receiving SIFIB had better analgesia with minimum analgesic consumption at postoperative 24 hours when compared not only with the control group but also with the patients receiving PENG block and preserving motor function. This study also presented the duration of maximum efficacy for each fascial plane block, typically lasting 8 hours. However, between the two, SIFIB proved to have prolonged efficacy, still high enough to outperform the control group until 24 hours postoperatively. Additionally, the shorter duration of SIFIB performance compared to the PENG block underlines the practicality of this block, especially for unstable patients with a high comorbidity index or under anticoagulation.

Anesthesia and analgesia management in femur and hip surgeries is an ongoing area of research, since no standalone protocol has proved efficient for all surgical techniques in this anatomical area with its multi-neural source of postoperative pain (11). Besides, the older population has been a particular concern due to their existing fragility and comorbidities, making pain

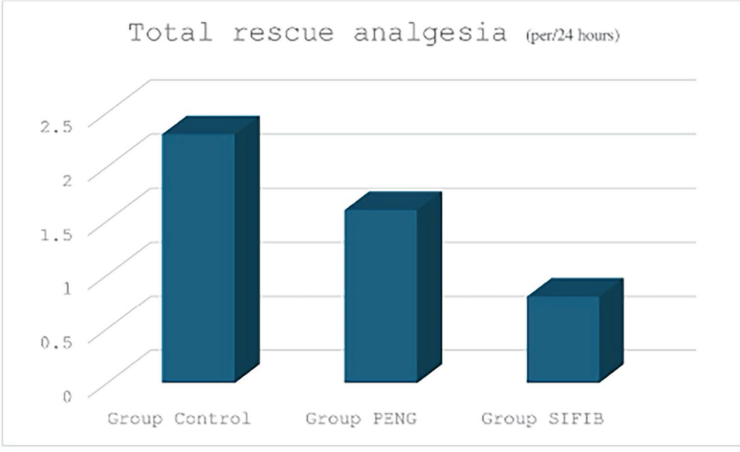

Figure 3. Supra-inguinal ascia iliaca block
PENG: Pericapsular nerve group block, SIFIB: Suprainguinal fascia iliaca block

management an essential determinant of mortality and morbidity (3). The challenge is ensuring adequate pain management and avoiding the side effects of the possible multimodal analgesia protocols (5,6). Accordingly, these elderly populations generally have CCI over four and ASA scores of III and IV, as observed in our study population. These features make a method that is both effective and simple superior for this patient group, especially for patients with unstable comorbidities or those using anticoagulation. Although most of the research on pain

Table 1. Demographics related to patients, nerve blocks and postoperative outcomes

			Group control[1]	Group PENG[2]	Group SIFIB[3]	p-value	
Age (year)	**Mean±SD**		79.0±9.8	78.2±9.2	80.0±6.7	0.784	A
	Median		77.0	80.0	81.0		
Gender	**Female**	**n-%**	16-64.0%	16-64.0%	14-56.0%	0.799	X^2
	Male	**n-%**	9-36.0%	9-36.0%	11-44.0%		
BMI	**Mean±SD**		25.7±6.0	26.0±6.8	25.2±5.7	0.906	A
	Median		24.3	26.3	24.8		
ASA score	**I**	**n-%**	1-4.0%	6-24.0%	4-16.0%	0.115	X^2
	II	**n-%**	21-84.0%	10-40.0%	15-60.0%		
	III	**n-%**	3-12.0%	8-32.0%	6-24.0%		
	IV	**n-%**	0-0.0%	1-4.0%	0-0.0%		
CCI	**Mean±SD**		4.4±1.4	4.5±1.6	4.8±1.1	0.423	K
	Median		4.0	4.0	5.0		
Duration of block performance (min)	**Mean±SD**			5.2±1.2	4.1±1.1	**0.001**	K
	Median			5.0	4.0		
Motor block	**(No)**	**n-%**	0.0%	22-88.0%	21-84.0%	0.684	X^2
	(Yes)	**n-%**	0.0%	3-12.0%	4-16.0%		
Postoperative ICU	**(No)**	**n-%**	18-81.8%	24-96.0%	20-83.3%	0.266	X^2
	(Yes)	**n-%**	4-18.2%	1-4.0%	4-16.7%		
Postoperative serious event	**(No)**	**n-%**	17-77.3%	22-88.0%	18-75.0%	0.475	X^2
	(Yes)	**n-%**	5-22.7%	3-12.0%	6-25.0%		

A: ANOVA, K: Kruskal-Wallis (Mann-Whitney U test), X^2: Chi-square test, [1]Difference between Group control $p<0.05$, [2]Difference between Group SIFIB $p<0.05$
SD: Standard deviation, PENG: Pericapsular nerve group block, SIFIB: Suprainguinal fascia iliaca block, BMI: Body mass index, ASA: American Society of Anesthesiologists, CCI: Charlson Comorbidity Index, ICU: Intensive care unit

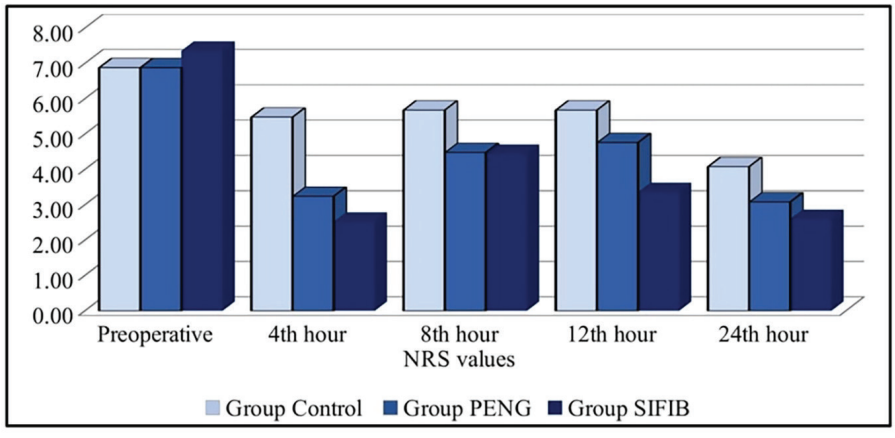

Figure 4. Comparison of NRS values
PENG: Pericapsular nerve group block, SIFIB: Suprainguinal fascia iliaca block, NRS: Numeric rating scale

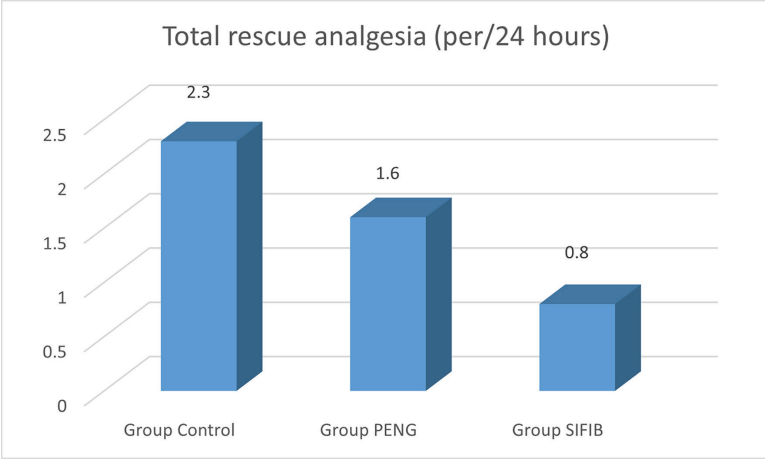

Figure 5. Comparison of total rescue analgesia
PENG: Pericapsular nerve group block, SIFIB: Suprainguinal fascia iliaca block

management focuses on hip prostheses, the orthopedic approach to these fragile patients mostly involves femur surgeries to decrease surgery-related postoperative complications (12). That is why the search for analgesia management for elderly femur fractures, which involve the same anatomical concerns as areas innervated by the femoral, lateral femoral cutaneous (LFCN), and obturator nerves, is guided by these protocols, of which we selected PENG and SIFIB from among this limited range (13,14).

Recent studies have shown that compared to IV analgesic treatment or sham block, PENG block provides adequate analgesia for elderly patients after neck and intertrochanteric femur fractures (15,16). Moreover, Li et al. (17) demonstrated its additional advantage in aiding the positioning of spinal anesthesia along with its long-lasting analgesic effectiveness for 24 hours postoperatively, possibly achieved by adding dexamethasone to the local anesthetic solution. The ease of spinal positioning was compared between femoral block, SIFIB, and PENG. Suprainguinal fascia iliaca block and PENG were found to be more effective (18,19). That success is predictable, as Girón-Arango et al. (20) described the PENG block targeting the femoral nerve, obturator nerve, and accessory obturator nerve in 2018. However, as in our study, a small amount of ketamine (IV) could be sufficient to aid in achieving spinal anesthesia in patients with subtrochanteric femur fractures. PNBs could be applied postoperatively just before the diminishing effect of existing analgesia with neuraxial anesthesia. Besides, the target of PNBs could be a disadvantage if the surgical area comprises LFCN innervation, the PFN surgery, mostly preferred in elderly subtrochanteric femur fractures as described in this study. The reason why the PENG block was not as successful in our study as it is in the literature may be that the surgical approach in these fractures falls more within the innervation field of the LFCN. The location of the incision and the type of surgical approach used in hip surgery can influence the source of postoperative pain. Therefore, PNBs should be tailored to match the specific needs of each patient, particularly in the elderly population, which is the focus of this study. Although PENG has become widespread as a prominent block in hip fractures, the possible disadvantage of PENG has driven the motivation for studies like ours to compare it with FIB, and our findings still favor PENG for providing better analgesia (21,22). However, SIFIB has gained interest over FIB for lower extremity surgeries targeting LFCN, resembling the effect of a lumbar plexus block (23). Our focus is on the potential of SIFIB as a rival to the PENG block, a topic shared by recent studies involving hip arthroplasty, which have shown conflicting results (24,25). While Vamshi et al. (24) found superior analgesia with PENG over SIFIB and presented a lower incidence of quadriceps weakness by observing knee extension and hip adduction, Keskes et al. (25) exhibited adequate but similar pain scores at all hours during the first 24 hours postoperatively. Our results show that PENG ensures analgesia for only eight hours postoperatively, while SIFIB provides it for 24 hours except at the 8th hour, which is the expected duration of the highest effectiveness for a fascial plane block. Interestingly, this occurred in both the PENG and SIFIB groups. This phenomenon could be due to rebound pain, and the lasting effect of SIFIB, along with rescue analgesia, could be sufficient in the following hours. Nevertheless, the required total analgesic requirement within 24 hours was lower in the SIFIB group. Although the studies comparing these two blocks have found higher analgesic consumption in the SIFIB, the study populations consisted of patients undergoing hip arthroplasties. Few studies have examined SIFIB in hip fractures as in our study.

Nuthep et al. (26) observed the superiority of the SIFIB and PENG combination in elderly patients undergoing hip fracture surgery. Pain scores were similar within 48 hours postoperatively (26). That observation could support our results that SIFIB may be superior to PENG in analgesic management, not in hip arthroplasty, but rather in femur fracture surgeries that cover the LFCN area associated with pain stimuli. Future studies could further investigate this hypothesis by adding an LFCN block to PENG in hip fractures to compare the analgesic efficacy with SIFIB, as PENG with an LFCN block has been shown to be more effective than SIFIB in hip arthroplasty (9).

Our study is the first prospective randomized study to compare SIFIB and PENG in elderly hip fracture surgeries by including a control group. Most of the previous literature did not have a control group to further evaluate the effectiveness of each intervention (27,28). Besides its significant results of perioperative pain scores and total analgesic consumption favoring SIFIB, we demonstrated a similar incidence of motor block, specifically for hip adduction. Although motor block is generally considered undesirable after a PNB, it should not be a deciding factor in selecting the type of block when postoperative mobilization is not feasible or necessary, as demonstrated by the patient group in our study. Thus, determining which PNB is more effective may yield more favorable results when the evaluation primarily focuses on its practical advantages, aside from analgesic efficacy. Based on this logic, we evaluated the practicality of PNB in our study groups. Notably, the duration of the block performance with SIFIB was lower than that of PENG, which is not surprising because of its superficial localization and ease of application. That property of SIFIB could be fundamental for elderly patients on anticoagulation, not only for analgesia but also for anesthesia, either as a sole technique or in combination with a sciatic block in lower extremity surgeries of high-risk patients (29).

Study Limitations

Our study had some limitations. We could not observe the dynamic NRS scores of the patients because there was no rehabilitation program after the surgery. Apart from this, we evaluated motor block only by hip adduction due to restricted knee extension post-surgery. Following this study's results, a question was raised to compare pain scores after SIFIB and PENG, preferably by adding LFCN, with a more extensive study population of elderly femur fractures to analyze the rebound pain within 24 hours.

Conclusion

In searching for a PNB for elderly femur fractures, our study compares the SIFIB and PENG block and finds SIFIB to be the preferable choice to ensure efficient analgesia with minimum analgesic consumption during the first 24 hours after surgery while also preserving motor function. In addition, the practicality of SIFIB performance as an easily visualized superficial block gains an advantage, especially for fragile elderly patients with comorbidities possibly needing anticoagulation and postoperative ICU admission. These elderly patients should still receive rapidly administered, long-lasting, safe analgesia management, as SIFIB was shown to be the best-suited candidate for this goal.

Ethics

Ethics Committee Approval: Ethical approval was obtained from University of Health Sciences Turkey, Istanbul Haseki Training and Research Hospital Clinicial Research Ethics Committee (approval no.: 18-2021, date: 24.11.2021).

Informed Consent: Verbal and written consent was received from all patients.

Acknowledgements

We thank Ece Yamak Altınpulluk for her help in revising and editing this manuscript.

Footnotes

Authorship Contributions

Surgical and Medical Practices: B.C., S.D., O.S., Concept: B.C., Design: B.C., Data Collection or Processing: B.C., S.D., O.S., Analysis or Interpretation: B.C., Literature Search: B.C., Writing: B.C.

Conflict of Interest: No conflicts of interest were declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

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