

Efficacy of Ultrasound-Guided Pericapsular Nerve Group (PENG) Block for Postoperative Analgesia and Early Functional Recovery in Patients Undergoing Hip Fracture Surgery: An Observational study

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ABSTRACT

Introduction: Effective postoperative analgesia is essential for early mobilization following hip fracture surgery. This study evaluated postoperative analgesia and early functional recovery following ultrasound-guided pericapsular nerve group (PENG) block. **Materials and Methods:** This prospective observational study included 90 patients undergoing hip fracture surgery. Postoperative pain scores, duration of analgesia, rescue analgesic requirements, quadriceps muscle strength, early mobilization, patient satisfaction, and adverse events were assessed. **Results:** The mean NRS score at rest was 1.2 ± 0.7 immediately postoperatively, increasing to 2.8 ± 1.1 at 12 hours. The mean duration of analgesia was 10.8 ± 3.2 hours, and 31.1% of patients required no rescue analgesia. Normal quadriceps strength was observed in 92.2% of patients at 24 hours. The mean time to first mobilization was 18.6 ± 5.4 hours, while 60.0% walked with assistance within 24 hours. Overall, 88.9% of patients were satisfied or very satisfied with pain management. **Conclusion:** PENG block may provide effective postoperative analgesia while supporting motor preservation and early functional recovery following hip fracture surgery.

Keywords: PENG block; Hip fracture; Postoperative analgesia; Quadriceps strength; Early mobilization.

INTRODUCTION

Hip fractures are among the most common orthopedic emergencies, particularly in the elderly population, and are associated with substantial morbidity, mortality, prolonged hospitalization, and functional disability[1]. With increasing life expectancy and the rising prevalence of osteoporosis, the global burden of hip fractures continues to increase. Surgical management, including internal fixation and hip arthroplasty, is the preferred treatment for most patients. However, postoperative pain remains a significant challenge, as inadequate pain control can delay mobilization, impair rehabilitation, prolong hospitalization, and adversely affect functional recovery. Effective postoperative analgesia is therefore essential for improving clinical outcomes following hip fracture surgery [2]. The hip joint has complex sensory

innervation, with the anterior capsule receiving articular branches primarily from the femoral, obturator, and accessory obturator nerves [3]. Postoperative pain results from capsular irritation and extensive soft tissue manipulation during surgery. Traditionally, systemic opioids and nonsteroidal anti-inflammatory drugs have been used for pain management. However, opioids are associated with adverse effects, including nausea, vomiting, respiratory depression, sedation, and postoperative delirium, particularly in elderly patients with multiple comorbidities[4]. These limitations have encouraged the adoption of multimodal analgesic strategies incorporating regional anesthesia to provide effective pain relief while minimizing systemic analgesic requirements [5,6]. Conventional regional analgesic techniques, including femoral nerve block (FNB), fascia

iliaca compartment block (FICB), and lumbar plexus block, have demonstrated analgesic benefits in hip surgery [7,8]. However, their effectiveness may be limited by incomplete sensory coverage and varying degrees of quadriceps muscle weakness resulting from femoral nerve motor blockade. This motor impairment may delay early ambulation, interfere with physiotherapy, and increase the risk of postoperative falls [9]. Consequently, there is growing interest in regional analgesic techniques that provide adequate pain relief while preserving lower limb motor function. The ultrasound-guided pericapsular nerve group (PENG) block, first described by Girón-Arango et al. in 2018, is a relatively recent regional anesthetic technique designed to target the articular branches supplying the anterior hip capsule [10]. It involves depositing local anesthetic between the psoas tendon and the superior pubic ramus under ultrasound guidance. By primarily targeting sensory innervation, the PENG block aims to provide effective analgesia with minimal motor impairment, although quadriceps weakness may occasionally occur due to local anesthetic spread [11,12]. Its potential motor-sparing properties make it particularly relevant for patients requiring early postoperative mobilization. Previous randomized controlled trials and observational studies have demonstrated encouraging results with the PENG block, including reduced postoperative pain scores, lower opioid consumption, prolonged analgesia, and improved patient comfort [13,14]. However, findings regarding its comparative analgesic efficacy and effects on early functional recovery remain inconsistent. Early mobilization is particularly important following hip fracture surgery, as it helps restore functional independence and reduces complications associated with prolonged immobilization [15]. Further evidence from routine clinical practice is therefore needed to establish the effectiveness of the PENG block in improving postoperative analgesia and facilitating rehabilitation. The present observational study was designed to evaluate the efficacy of ultrasound-guided PENG block for postoperative analgesia and early functional recovery in patients undergoing hip fracture surgery.

MATERIALS AND METHODS

The present hospital-based, prospective observational study was conducted in the Department of Anaesthesiology at a tertiary care hospital to evaluate the efficacy of ultrasound-guided pericapsular nerve group (PENG) block for postoperative analgesia and early functional recovery in patients undergoing hip fracture surgery. A total of 90 patients undergoing hip fracture surgery and receiving ultrasound-guided PENG block were included.

Inclusion Criteria

1. Patients aged 18 years or older, of either sex.
2. Patients undergoing hip fracture surgery, including internal fixation or hip arthroplasty.
3. Patients with American Society of Anesthesiologists (ASA) physical status I–III.
4. Patients receiving ultrasound-guided PENG block for postoperative analgesia.
5. Patients providing written informed consent.

Exclusion Criteria

1. Patients refusing to participate.
2. Known hypersensitivity to local anesthetic agents.
3. Infection at the proposed block site.
4. Pre-existing neurological deficits affecting the operated limb.
5. Coagulation disorders or contraindications to regional anesthesia.
6. Severe cognitive impairment or inability to assess pain reliably.
7. Chronic opioid dependence or long-term opioid therapy.

Study Procedure

Demographic and clinical characteristics, including age, sex, body mass index (BMI), ASA physical status, comorbidities, fracture type, and surgical procedure, were recorded. All patients underwent routine preanesthetic evaluation. Ultrasound-guided PENG block was performed by an experienced anesthesiologist under aseptic precautions. With the patient in the supine position, a curvilinear ultrasound transducer was used to identify the anterior inferior iliac spine, iliopubic eminence, psoas tendon, and superior pubic ramus. An echogenic needle was advanced using an in-plane approach, and local anesthetic was injected between the psoas tendon and superior pubic ramus following negative aspiration and confirmation of appropriate spread. All patients received surgical anesthesia and standard multimodal postoperative analgesia according to institutional practice. Postoperative pain, analgesic requirements, motor function, early mobilization, and adverse events were assessed.

Outcome Assessment

The following parameters were evaluated:

1. Postoperative pain: Pain intensity was assessed using the Numeric Rating Scale (NRS; 0–10) at 0, 2, 4, 6, 12, and 24 hours postoperatively, at rest and during movement, wherever feasible.
2. Duration of analgesia: The interval between PENG block administration and the first requirement for rescue analgesia was recorded.

3. Rescue analgesic requirement: Time to first rescue analgesia, total analgesic consumption, and number of rescue doses during the first 24 hours were recorded.
4. Motor function: Quadriceps muscle strength was assessed using the Medical Research Council (MRC) grading scale (0–5) after recovery from surgical anesthesia.
5. Early functional recovery: Time to first mobilization and the ability to sit, stand, walk with assistance, and participate in physiotherapy were assessed according to clinical condition and permitted weight-bearing status.
6. Patient satisfaction: Overall satisfaction with postoperative pain management was assessed using a standardized satisfaction scale.
7. Adverse events: Block-related complications, including vascular puncture, hematoma, local anesthetic systemic toxicity, infection, and motor weakness, as well as opioid-related adverse effects, were recorded.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS. 26 Statistics. Continuous variables were expressed as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), while categorical variables were presented as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test. Changes in postoperative pain scores were analyzed using repeated-measures ANOVA or the Friedman test, as appropriate. Pearson's or Spearman's correlation was used for continuous variables, while the chi-square test or Fisher's exact test was applied to categorical variables, wherever applicable. A two-sided p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 90 patients undergoing hip fracture surgery were included in the study, with a mean age of 65.8 ± 11.4 years and mean BMI of 24.6 ± 3.8 kg/m². The majority were female (56.7%) and belonged to the 61–80-year age group (53.3%). Most patients were classified as ASA II (53.3%). Hypertension (38.9%) and diabetes

mellitus (26.7%) were the most common comorbidities. Intertrochanteric fractures accounted for 46.7% of cases, and internal fixation was performed in 64.4% of patients (Table 1). Postoperative pain scores remained relatively low following PENG block. The mean NRS score at rest increased from 1.2 ± 0.7 at 0 hours to 2.8 ± 1.1 at 12 hours, subsequently decreasing to 2.5 ± 1.0 at 24 hours. Similarly, NRS scores on movement increased from 2.1 ± 0.9 to 4.0 ± 1.3 at 12 hours before declining to 3.6 ± 1.2 at 24 hours. Changes in both pain scores were statistically significant ($p < 0.001$) (Table 2, Figure 1). The mean duration of analgesia and time to first rescue analgesia were 10.8 ± 3.2 hours. Rescue analgesia was required in 68.9% of patients, while 31.1% required none. One rescue dose was administered to 43.3% of patients, two doses to 21.1%, and three or more doses to 4.4%. The mean rescue analgesic requirement was 1.0 ± 0.9 doses (Table 3). Quadriceps strength was largely preserved, with 66.7% of patients demonstrating MRC grade 5 strength at 6 hours, increasing to 92.2% at 24 hours. The mean time to first mobilization was 18.6 ± 5.4 hours. Within 24 hours, 93.3% of patients could sit, 80.0% could stand, and 60.0% could walk with assistance. Physiotherapy was initiated in 86.7% of patients within 24 hours, and 91.1% achieved mobilization within 48 hours. The mean hospital stay was 5.8 ± 1.9 days (Table 4). Time to first mobilization showed significant positive correlations with age ($r = 0.32$, $p = 0.002$), NRS at rest ($r = 0.41$, $p < 0.001$), NRS on movement ($r = 0.48$, $p < 0.001$), and rescue analgesic doses ($r = 0.36$, $p < 0.001$). Significant negative correlations were observed with analgesic duration ($r = -0.38$, $p < 0.001$) and quadriceps strength ($r = -0.43$, $p < 0.001$). Analgesic duration was also negatively correlated with rescue analgesic requirements ($r = -0.46$, $p < 0.001$), whereas BMI showed no significant association with mobilization time ($p = 0.089$) (Table 5, Figure 2). 88.9% of patients were either satisfied or very satisfied with postoperative analgesia. Adverse events were infrequent, including nausea (7.8%), transient quadriceps weakness (5.6%), vomiting (4.4%), and vascular puncture (1.1%). No cases of hematoma, local anesthetic systemic toxicity, or block-site infection were reported (Table 6, Figure 3).

Table 1. Baseline demographic and clinical characteristics of the study participants (N = 90)

Parameter	Value
Age (years), mean $\pm$ SD	65.8 ± 11.4
18–40 years, n (%)	5 (5.6)
41–60 years, n (%)	22 (24.4)
61–80 years, n (%)	48 (53.3)
>80 years, n (%)	15 (16.7)
Male, n (%)	39 (43.3)
Female, n (%)	51 (56.7)
BMI (kg/m ²), mean $\pm$ SD	24.6 ± 3.8

ASA I, n (%)	12 (13.3)
ASA II, n (%)	48 (53.3)
ASA III, n (%)	30 (33.3)
Hypertension, n (%)	35 (38.9)
Diabetes mellitus, n (%)	24 (26.7)
Intertrochanteric fracture, n (%)	42 (46.7)
Fracture neck of femur, n (%)	35 (38.9)
Subtrochanteric fracture, n (%)	13 (14.4)
Internal fixation, n (%)	58 (64.4)
Hip arthroplasty, n (%)	32 (35.6)

Table 2. Postoperative pain scores at different time intervals following PENG block

Time interval	NRS at rest, mean $\pm$ SD	NRS on movement, mean $\pm$ SD
0 hours	1.2 $\pm$ 0.7	2.1 $\pm$ 0.9
2 hours	1.5 $\pm$ 0.8	2.4 $\pm$ 1.0
4 hours	1.8 $\pm$ 0.9	2.8 $\pm$ 1.1
6 hours	2.2 $\pm$ 1.0	3.3 $\pm$ 1.2
12 hours	2.8 $\pm$ 1.1	4.0 $\pm$ 1.3
24 hours	2.5 $\pm$ 1.0	3.6 $\pm$ 1.2
Overall p-value	<0.001	<0.001

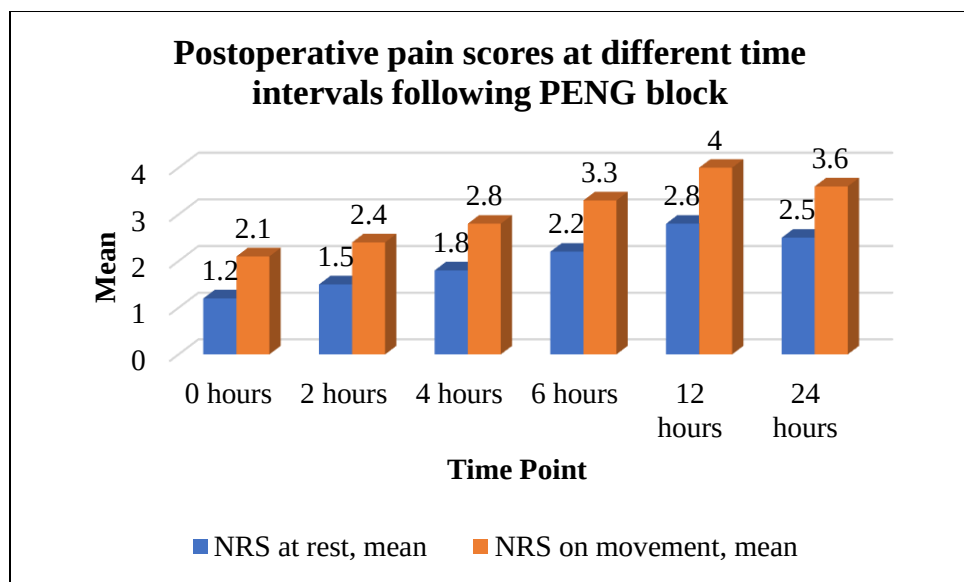


Figure 1. Postoperative pain scores at different time intervals following PENG block

Table 3. Duration of analgesia and postoperative rescue analgesic requirements

Parameter	Value
Duration of analgesia (hours), mean $\pm$ SD	10.8 $\pm$ 3.2
Time to first rescue analgesia (hours), mean $\pm$ SD	10.8 $\pm$ 3.2
Patients requiring rescue analgesia, n (%)	62 (68.9)
No rescue analgesia required, n (%)	28 (31.1)
One rescue dose, n (%)	39 (43.3)
Two rescue doses, n (%)	19 (21.1)
Three or more rescue doses, n (%)	4 (4.4)
Total rescue analgesic doses, mean $\pm$ SD	1.0 $\pm$ 0.9

Table 4. Postoperative motor function and early functional recovery

Parameter	Value
Quadriceps strength at 6 hours	
MRC grade 3, n (%)	8 (8.9)
MRC grade 4, n (%)	22 (24.4)
MRC grade 5, n (%)	60 (66.7)
Quadriceps strength at 24 hours	
MRC grade 3, n (%)	0 (0.0)
MRC grade 4, n (%)	7 (7.8)
MRC grade 5, n (%)	83 (92.2)
Early functional recovery	
Time to first mobilization (hours), mean $\pm$ SD	18.6 $\pm$ 5.4
Able to sit within 24 hours, n (%)	84 (93.3)
Able to stand within 24 hours, n (%)	72 (80.0)
Able to walk with assistance within 24 hours, n (%)	54 (60.0)
Physiotherapy initiated within 24 hours, n (%)	78 (86.7)
Mobilized within 48 hours, n (%)	82 (91.1)
Hospital stay (days), mean $\pm$ SD	5.8 $\pm$ 1.9

MRC: Medical Research Council muscle strength grading scale.

Table 5. Correlation of postoperative analgesic parameters with early functional recovery

Parameter	Correlation coefficient (r)	p-value
Age vs. time to first mobilization	0.32	0.002
BMI vs. time to first mobilization	0.18	0.089
Duration of analgesia vs. time to first mobilization	-0.38	<0.001
NRS at rest (6 hours) vs. time to first mobilization	0.41	<0.001
NRS on movement (6 hours) vs. time to first mobilization	0.48	<0.001
Rescue analgesic doses vs. time to first mobilization	0.36	<0.001
Quadriceps strength (6 hours) vs. time to first mobilization	-0.43	<0.001
Duration of analgesia vs. rescue analgesic doses	-0.46	<0.001

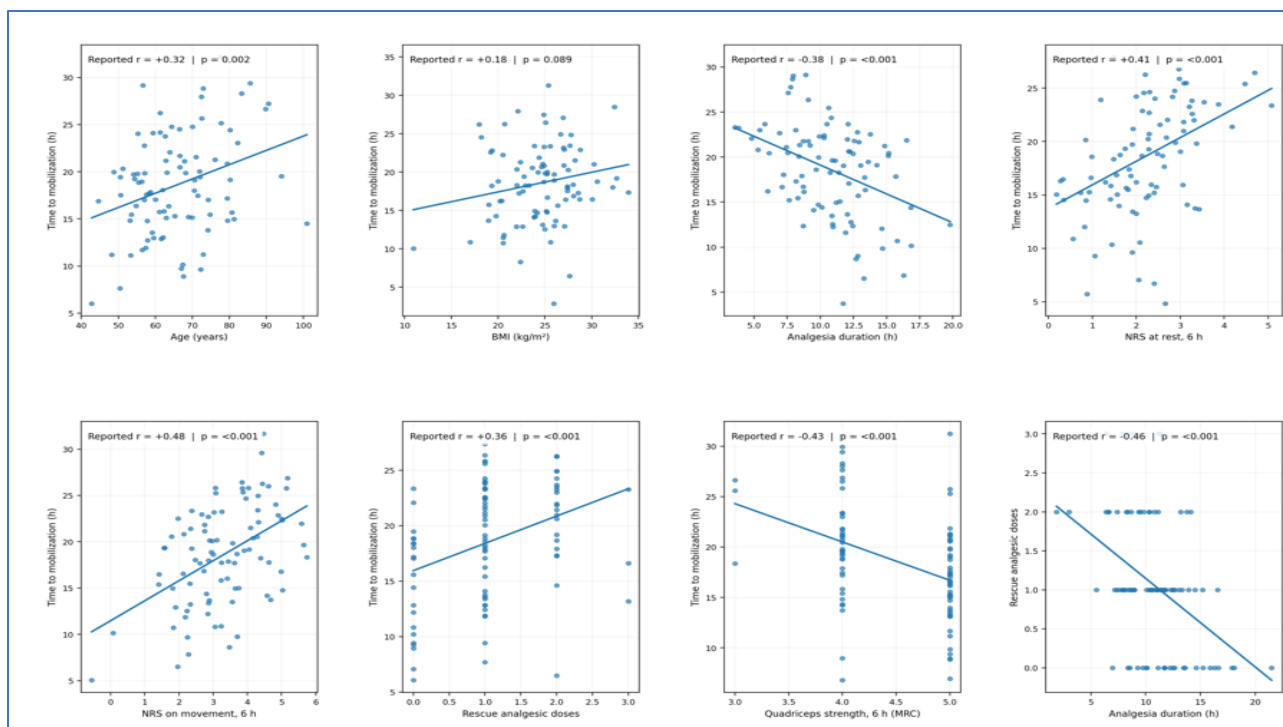
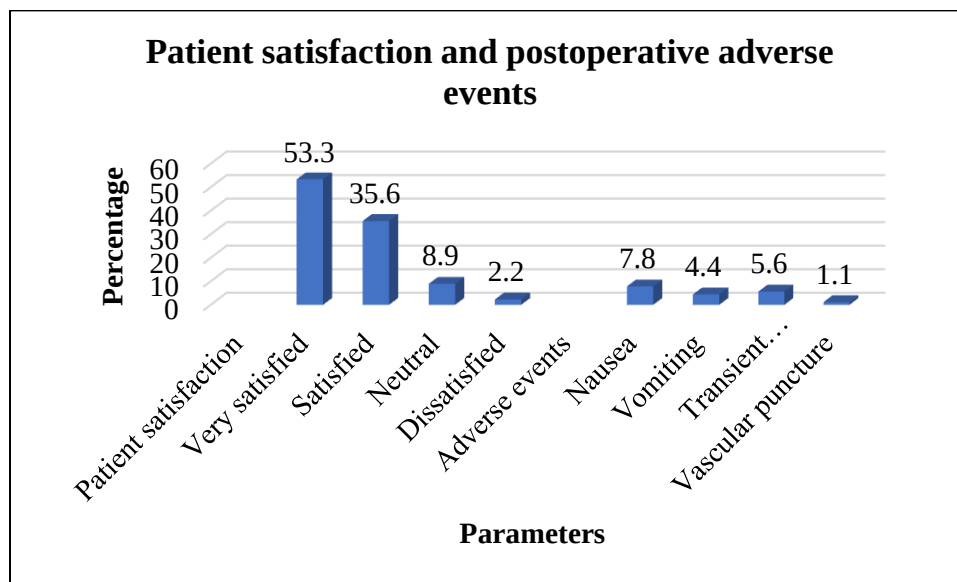
**Figure 2. Correlation of postoperative analgesic parameters with early functional recovery**

Table 6. Patient satisfaction and postoperative adverse events

Parameter	n (%)
Patient satisfaction	
Very satisfied	48 (53.3)
Satisfied	32 (35.6)
Neutral	8 (8.9)
Dissatisfied	2 (2.2)
Adverse events	
Nausea	7 (7.8)
Vomiting	4 (4.4)
Transient quadriceps weakness	5 (5.6)
Vascular puncture	1 (1.1)
Hematoma	0 (0.0)
Local anesthetic systemic toxicity	0 (0.0)
Infection at block site	0 (0.0)

**Figure 3. Patient satisfaction and postoperative adverse events**

DISCUSSION

The present observational study evaluated postoperative analgesia and early functional recovery following ultrasound-guided pericapsular nerve group (PENG) block in 90 patients undergoing hip fracture surgery. The findings demonstrated low postoperative pain scores, a mean duration of analgesia of 10.8 ± 3.2 hours, progressive recovery of quadriceps muscle strength, and early postoperative mobilization. In the present study, mean NRS scores at rest increased from 1.2 ± 0.7 immediately after surgery to 2.8 ± 1.1 at 12 hours, subsequently decreasing to 2.5 ± 1.0 at 24 hours. Corresponding movement-related pain scores were 2.1 ± 0.9 , 4.0 ± 1.3 , and 3.6 ± 1.2 , respectively. Farag et al. [16], in a meta-analysis of 15 trials involving 837 patients, reported significantly lower early postoperative pain scores with PENG block compared with FICB (SMD = -0.55 ; $p = 0.03$ at 30 minutes), although

differences were not significant at 6, 12, or 24 hours. Similarly, Cai et al. [17], in a meta-analysis involving 326 patients, reported significantly lower pain scores following FICB at 1–8 and 12 hours ($p < 0.05$), but not at 24 hours ($p = 0.206$). These findings highlight the role of regional anesthesia in early postoperative pain management. The mean duration of analgesia in the present study was 10.8 ± 3.2 hours. Rescue analgesia was required by 68.9% of patients, whereas 31.1% required no additional analgesia during the first 24 hours. Farag et al. [16] reported significantly lower cumulative opioid consumption at 24 hours following PENG block, although this benefit was not maintained at 48 hours. Cai et al. [17] also demonstrated reduced morphine consumption following FICB compared with placebo. These observations support the potential opioid-sparing benefits of regional analgesic techniques. Normal quadriceps strength (MRC grade 5) was observed in

66.7% of patients at 6 hours, increasing to 81.1% at 12 hours and 92.2% at 24 hours. Aliste et al. [18], in a randomized trial involving 40 patients, reported significantly lower quadriceps motor block with PENG block than with supra-inguinal FICB at 3 hours (45% vs. 90%; $p < 0.001$) and 6 hours (25% vs. 85%; $p < 0.001$). At 24 hours, 95% of patients receiving PENG block had no quadriceps motor block, compared with 65% receiving FICB. These findings support the potential motor-sparing properties of PENG block. In the present study, the mean time to first mobilization was 18.6 ± 5.4 hours. Within 24 hours, 93.3% of patients could sit, 80.0% could stand, and 60.0% could walk with assistance. The mean hospital stay was 5.8 ± 1.9 days. Gulotta et al. [19], in a study comparing accelerated and conventional recovery protocols following total hip replacement, reported a reduction in mean hospital stay from 4.1 to 2.6 days ($p < 0.0001$), with 58% of patients discharged within two days. However, Aliste et al. [18] observed no clinically significant differences in physiotherapy participation or hospital stay between PENG block and FICB. These findings suggest that functional recovery depends on adequate analgesia, motor preservation, and structured rehabilitation. In the present study, 88.9% of patients were satisfied or very satisfied with postoperative pain management. Nausea occurred in 7.8%, vomiting in 4.4%, and transient quadriceps weakness in 5.6%. Farag et al. [16] reported higher patient satisfaction and a lower incidence of postoperative vomiting following PENG block. Similarly, Cai et al. [17] reported a significantly lower incidence of nausea following FICB compared with placebo (RR = 0.41; $p = 0.010$). These findings emphasize the importance of effective analgesia and monitoring for adverse events. The present study showed positive correlations between time to first mobilization and NRS scores at rest ($r = 0.41$) and during movement ($r = 0.48$). Duration of analgesia ($r = -0.38$) and quadriceps muscle strength ($r = -0.43$) were negatively correlated with time to first mobilization. These associations suggest that lower pain intensity, prolonged analgesia, and preserved motor function may be associated with earlier postoperative mobilization.

STRENGTHS OF THE STUDY

The strengths of this study include its prospective observational design and the inclusion of 90 patients undergoing hip fracture surgery. The study evaluated multiple clinically relevant outcomes, including postoperative pain scores, duration of analgesia, rescue analgesic requirements, quadriceps muscle strength, early mobilization, physiotherapy participation, patient satisfaction, and adverse events. The assessment of both analgesic efficacy and motor function provides a broader evaluation of the potential clinical utility of ultrasound-

guided PENG block. In addition, the study examined correlations between analgesic parameters, quadriceps strength, and time to first mobilization, providing further insight into factors associated with early postoperative functional recovery.

LIMITATIONS

The study was limited by its single-center, relatively small sample size, and absence of a control group. The short follow-up period and variations in surgical procedures and rehabilitation protocols may have influenced the outcomes.

FUTURE DIRECTIONS

Future studies should include larger, multicenter patient populations and comparative designs, particularly randomized controlled trials comparing PENG block with other regional analgesic techniques and standard analgesic protocols. Longer follow-up may help determine whether the early benefits observed in pain control, motor preservation, and mobilization translate into sustained functional recovery and reduced hospital stay. Future research should also evaluate opioid consumption, rehabilitation outcomes, patient-reported functional measures, and cost-effectiveness. Standardization of surgical procedures, rehabilitation protocols, and analgesic regimens may further improve the comparability and generalizability of findings.

CONCLUSION

Ultrasound-guided PENG block may provide effective postoperative analgesia, reduce rescue analgesic requirements, and preserve quadriceps muscle strength in patients undergoing hip fracture surgery. The observed early mobilization and functional recovery suggest its potential role in enhanced recovery protocols. Further comparative studies are required to establish its efficacy and safety.

DECLARATIONS

Ethics Approval and Consent to Participate

Ethical approval was obtained from the appropriate Institutional Ethics Committee before commencement of the study. Written informed consent was obtained from all participants before enrolment.

Consent for Publication

Not applicable, as no individually identifiable patient information is presented in this manuscript.

Competing Interests

The authors declare that they have no competing interests.

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Author Contributions

All authors contributed to the conception and design of the study, data collection and/or analysis, interpretation of the findings, manuscript preparation, and critical revision of the manuscript. All authors approved the final version of the manuscript.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to institutional and ethical restrictions.

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AI Use Disclosure

The authors declare that no generative artificial intelligence tools were used to generate or substantially modify the scientific content of this manuscript. The authors remain fully responsible for the accuracy, integrity, and originality of the work.

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