Original Article

Ultrasound-guided pericapsular nerve group (PENG) block versus femoral nerve block for positioning during spinal anaesthesia in proximal femur fractures: A randomised comparative study

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ABSTRACT

Background and Aims: Femoral nerve block is a widely used analgesia technique for positioning before spinal anaesthesia for proximal femur fracture surgeries. Pericapsular nerve group (PENG) block is a newer technique with motor-sparing characteristics. We compared the analgesic efficacy of these blocks for patient positioning for spinal anaesthesia. **Methods:** In this study, 60 patients were randomised to either the PENG group ($n = 30$) or the femoral group ($n = 30$). After performing the block, the pain was assessed every 10 min using a visual analogue scale (VAS) score for 30 min. The primary objective was the median [interquartile range (IQR)] reduction in pain (dynamic VAS with 15-degree passive limb elevation) at 30 min. Secondary objectives were ease of spinal position score (EOSP), angle obtained during positioning, duration of postoperative analgesia and quadriceps weakness. **Results:** The demographics were comparable in both groups. After 30 min, the median (IQR) VAS was 6 (5–7) in the PENG group and 5 (5–6) in the femoral group ($P = 0.004$). Secondary outcomes such as EOSP score and angle obtained by patients were comparable. In the postoperative period, patients had significantly lower pain in the PENG group compared to the femoral group. The duration of analgesia was prolonged with PENG block. Quadriceps weakness was significantly low with PENG block ($P < 0.001$). **Conclusion:** PENG block provides better analgesia than a femoral block before spinal anaesthesia for proximal femur fracture surgery. The postoperative duration of analgesia was also longer.

Key words: Anaesthesia, femoral nerve block, hip fractures, nerve blocks, pain management, pericapsular nerve group block, PENG, spinal anaesthesia

INTRODUCTION

Severe pain associated with proximal femur fracture makes spinal anaesthesia in a sitting position difficult. Regional blocks such as femoral nerve block (FNB) and fascia iliaca compartment block (FICB) provide good analgesia for positioning.[1,2] FNB is easy to perform and safe; therefore, it has been used for years to provide analgesia for sitting position for performing central neuraxial blockade after hip fractures. However, it can lead to postoperative motor weakness.[3] Pericapsular nerve group block (PENG) is a novel technique introduced in 2018.[4] It blocks the articular branches of the femoral nerve, obturator nerve and accessory obturator nerve supplying the anterior hip capsule. Some case series and randomised control studies suggest PENG block as an effective alternative for femur fracture pain relief.[5,6] The literature is scarce to compare the immediate analgesic effect of ultrasonography (USG)-guided PENG block and FNB

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for positional pain during spinal anaesthesia. So, we aimed to compare the analgesic effect of USG-guided PENG block and FNB during positioning before spinal anaesthesia in patients undergoing surgery for proximal femur fractures.

METHODS

This randomised controlled study was conducted at a tertiary care teaching hospital. The study was conducted after Institutional Ethics Committee approval (vide approval number: IHEC/21/OUT/SRPG014, dated 6 December 2021) and registration with the Clinical Trial Registry-India (CTRI/2022/01/039748, www.ctri.nic.in). Written and informed consent was obtained for participation in the study and use of the patient data for research and educational purposes**.** The study was conducted following principles of the Declaration of Helsinki, 2013, and good clinical practice. The data collected were kept anonymous. The study was conducted from 1 February 2022 to 30 September 2022.

Patients of 18 to 80 years of age with proximal femur fractures (neck of femur, inter-trochanteric, and sub-trochanteric fractures) undergoing surgery under spinal anaesthesia, having significant pain visual analogue scale (VAS) ≥4 and expected surgery duration of less than 150 min were included. Patients with old fractures (more than 7 days), polytrauma, bleeding disorders or coagulopathy, local site infection, difficulty expressing pain scores such as hearing disability, mentally challenged, dementia or psychiatric illness and who refused to take part were excluded from the study.

The independent person from this study allocated the randomisation sequence by simple randomisation (single block) 1:1 allocation for the PENG block and FNB groups. That randomisation sequence was sealed in sequentially numbered opaque sealed envelopes. The study investigator opened the envelope on the day of surgery after obtaining consent from the eligible participants. Patients were randomised into two groups: Group PENG and Group FNB. Patients were blinded to their allocation. In the preoperative room, pain score at rest (VAS-R) and at 15-degree passive limb elevation (the patient's fractured lower limb was elevated passively up to 15 degrees) in the supine position to assess pain during movement (dynamic VAS (VAS-D)) was recorded before giving block.[7]

Patients received a PENG block or FNB with USG guidance (Mindray Diagnostic Ultrasound System model Z6, Shenzhen, China) as per their allocation. For the PENG block, a low-frequency curvilinear probe was placed over the anterior inferior iliac spine and moved inferiorly to visualise the pubic ramus. Then, iliopectineal eminence was visualised, and the femoral artery and iliopsoas muscle was identified in the center. The area between the iliopectineal eminence and pubic ramus was our target point. Maintaining this view, a 23 G 70 mm block needle (B-Braun Melsung, Germany) was inserted using an in-plane technique, taking care to avoid injury to the femoral nerve. After good visualisation of the needle tip at the target point, 20 mL to 0.25% bupivacaine and dexamethasone 4 mg were injected after negative aspiration at each 5 mL. The local spread of the drug between the psoas muscle and pubic ramus was confirmed on the ultrasound screen.

For FNB, a high-frequency linear ultrasound probe was placed over the inguinal crease. In cross-section, femoral vessels and femoral nerve were identified. Just lateral to the artery and deep to fascia iliaca, the femoral nerve was located as a spindle-shaped structure with a honeycomb appearance. The 23 G 70 mm block needle (B-Braun Melsung, Germany) was inserted using an in-plane technique. After advancing the needle through fascia iliaca, 20 mL of 0.25% bupivacaine and injection dexamethasone 4 mg were injected after careful aspiration at the target point. Local drug spread was confirmed around the nerve on the USG screen. Both blocks were performed as per the standard techniques described earlier [Figure 1].[3,6]

VAS was assessed at rest (VAS-R) and 15-degree limb elevation (VAS-D) every 10 min for 30 min. After 30 min, patients were shifted to the operative room. A multipara monitor (Schiller Truescope II, Zhuhai, P.R. China) was attached (non-invasive blood pressure, pulse oximeter and five leads electrocardiogram). Patients were given a sitting position for spinal anaesthesia. At that time, comfort during sitting for spinal anaesthesia was assessed by the ease of spinal position score (EOSP) (1-sitting without pain and minimal help, 2-mild pain detected by grimacing or verbal expression, 3-severe pain but tolerates positioning with help, 4-unable to sit, requires additional analgesia).[6] If the patient could not sit due to pain and VAS was ≥4, it was considered block failure. Additional analgesia was provided with intravenous (IV) fentanyl 1.5 μg/kg.

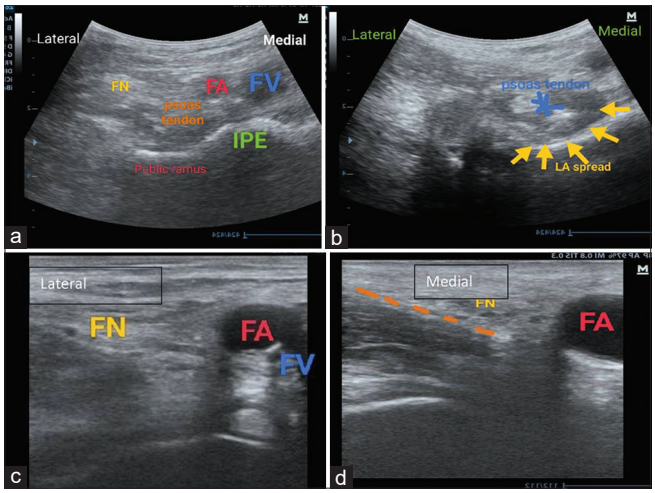

Figure 1: (a) Sonoanatomy of pericapsular nerve group (PENG) block, (b) local anaesthetic spread between psoas tendon and pubic ramus, (c) Sonoanatomy of femoral nerve, (d) needle path and drug around the femoral nerve. FA = femoral artery, FV = femoral vein, FN = femoral nerve, IPE = Iliopubic eminence, LA = local anaesthetics

The best angle obtained by the patient during sitting position (angle between operating room table and patient's back) was also recorded as good flexion (angle >90º), average flexion (angle <90º).[6] without twisting or using the hands for support and poor flexion and/or twisting or hand support. The anaesthesiologist who performed spinal anaesthesia was surveyed by team members for operator satisfaction (excellent, good, average, poor) regarding the patient's position.[6] Patients received spinal anaesthesia under all aseptic and sterile precautions with 0.5% heavy bupivacaine (without any adjuvant) as per the choice of the anaesthetist conducting the case, not a part of the investigator team. All patients received standard intraoperative care and monitoring. All patients received an injection of paracetamol 1 g IV before surgical closure and thrice a day after that as a part of multimodal analgesia. Postoperative pain score was assessed by VAS at 2, 4, 6, 12, and 24 h intervals. Complications such as haematoma, local anaesthetic toxicity or local site infection were noted. Possible situations for dropout were technical difficulties in performing block due to patient-related factors or USG machine-related factors, logistic issues related to the operating room, or unexpected surgery prolongation of more than 150 min. Such patients were excluded from the analysis.

The primary outcome measure was to note the difference in median reduction in VAS-D at 30 min after giving block in PENG and FNB. Secondary outcome measures were the differences in EOSP score, operator's satisfaction while performing spinal anaesthesia, duration of analgesia (measured as time from block to first demand of analgesic from the patient or VAS ≥4, whichever earlier) in the postoperative period and quadriceps muscle weakness in both the groups. Quadriceps muscle weakness was assessed by the Oxford muscle strength scale (from 0-no visible/palpable contractions to 5-movement through full range against gravity and full resistance) at 6 h. It was checked in a sitting position with the knee flexed. The patient was then asked to extend the leg against the resistance.

Sample size calculation was performed using the formula $N = [(4\sigma^2)\ (Z_{(1-(\alpha/2))} + Z_{(1-\beta)})^2] \div E^2$, where N is the total sample size, σ is standard deviation (SD) taken as 2, $Z_{(1-(\alpha/2))}$ taken as 1.96 with accepted confidence level 95%, $Z_{(1-\beta)}$, 0.84 with the power of the study 80%. E is the expected difference in means, taken as 1.5. The difference in mean and SD was derived from a pilot study on 20 patients (PENG-10 and FNB-10). From that, we found an expected difference in the mean reduction of VAS 1.5. and SD-2. Considering the participant ratio for PENG and FNB group 1:1 and 10% extra for possible dropouts, 60 patients were included, 30 in each group.

A master chart of the observed data and parameters was prepared in a Microsoft Excel sheet. Statistical analysis was performed using GraphPad Prism software (Demo version 7.0, GraphPad Software Inc., Boston). A descriptive analysis was performed for demographical details. The data were presented as mean (SD) and compared using an unpaired *t*-test. Other categorical outcomes such as the EOSP score, operator satisfaction, procedural difference, quadriceps weakness and demographic data (sex, American Society of Anesthesiologist [ASA] physical grading, type of fracture) were compared between the groups using Chi-square and Fischer's exact *t*-test as applicable. The median reduction in the VAS score from 'baseline' to '30' min was presented as median (interquartile range [IQR]) and compared with the non-parametric Mann–Whitney test. The difference in the VAS score between the two groups was calculated similarly. *P* value ≤ 0.05 was considered statistically significant.

RESULTS

A total of 78 patients were eligible for our study, out of which 61 underwent study interventions. Still, due to 1 dropout, 60 patients were finally included in the

study [Figure 2]. Demographic data in both groups showed no difference. The baseline VAS score was also comparable [Table 1].

The median reduction in pain in VAS-D was obtained by calculating the difference of baseline dynamic VAS and at 30 min after administration of block [(VAS D-b)–(VAS D-30)]. The median (IQR) was 6 (5–7) in the PENG group versus 5 (5-6) in the FNB group ($P = 0.004$) [Figure 3].

Patients in both groups showed no difference in the EOSP score. Also, 96.6% of patients in group PENG and 93.3% in group FNB could sit with no pain or mild pain 30 min after the block for spinal anaesthesia. There was no difference in the sitting angle obtained or operator satisfaction score for the performer of spinal anaesthesia.

Postoperative quadriceps weakness was noted more in the FNB group [Table 2]. Postoperative VAS (median [IQR]) was noted at 4, 6, 8 and 12 h in both groups [Figure 4]. The mean duration of analgesia (mean [SD], 95% CI) in the PENG group was 8.67 (1.40) (8.15–9.19) h, whereas it was 7.57 (1.17) (7.13–8.00) h in the femoral group ($P = 0.002$).

Table 1: Demographic profile of group pericapsular nerve group (PENG) and femoral nerve block (FNB)

Demographic data	Group PENG (*n*=30)	Group FNB (*n*=30)
Age (years)	55.8 (13.24)	59.53 (13.11)
Sex (Male: female) (*n*)	20: 14	10: 16
Weight (kg)	59.43 (7.92)	60.6 (7.81)
ASA physical status I/II (*n*)	2/28	7/23
Drug volume for SAB (mL)	3.5 (0.12)	3.46 (0.16)
Days of fracture	3.43 (1.35)	3.36 (1.62)
Fracture type (*n*)		
Neck of femur fracture	8	5
Intertrochanteric fracture	20	21
Sub trochanteric fracture	2	4
Baseline VAS VAS-R	6.5 (6-7.5)	6 (6-7)
VAS-D	8 (7-9)	7 (7-8.75)

Data are expressed as mean (standard deviation), median (interquartile Range) or numbers. VAS=Visual Analogue Scale, ASA=American Society of Anesthesiologists, SAB=subarachnoid block, PENG=Pericapsular nerve group block, FNB=Femoral nerve block, n=number

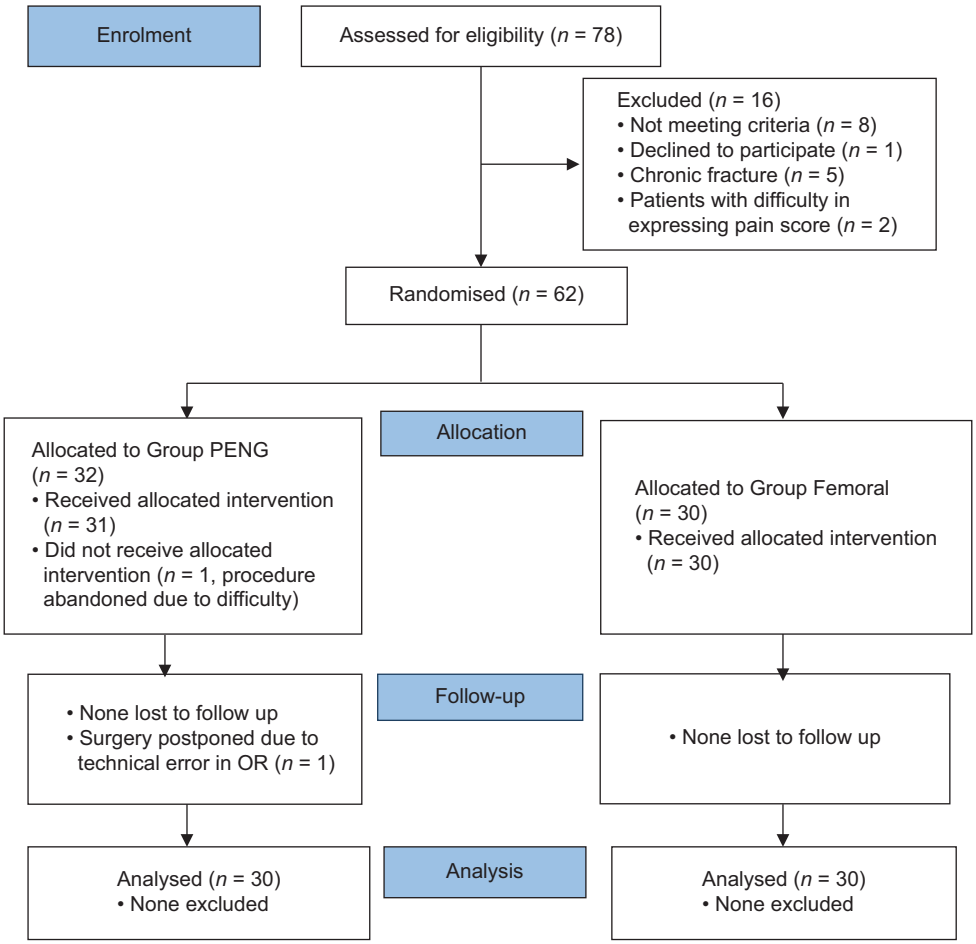

Figure 2: Consolidated standards of reporting trials (CONSORT) flow diagram depicting the study process

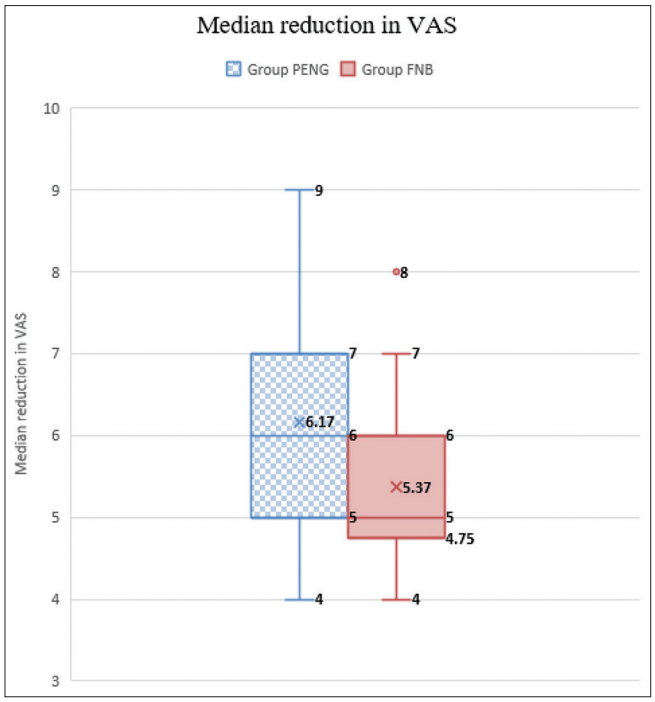

Figure 3: Median reduction in VAS at 30 min after block in PENG and FNB groups. Box plot showing a median reduction in the VAS score. The upper and lower margins of the rectangle suggest the 3rd and 1st quartiles, respectively. The line inside the rectangle suggests the median and cross marks show the mean. Whiskers suggests minimum and maximum values. Outliers are shown as points. Median (IQR) was 6 (5–7) in PENG group versus 5 (5–6) in FNB group (*P* value-0.004, Mann–Whitney test. VAS=Visual Analogue Scale, IQR=Inter Quartile Range, PENG=Pericapsular Nerve Group, FNB=Femoral Nerve Block

Table 2: Difference in post-operative quadriceps muscle weakness by Oxford muscle strength score

Oxford muscle strength score (0-5)	Group PENG (*n*=30)	Group FNB (*n*=30)	*P*
0	0	0	<0.001
1	1	1	
2	1	10	
3	6	12	
4	22	7	
5	0	0	

Data are expressed as numbers. PENG=Pericapsular nerve group block, FNB=Femoral nerve block

No procedure-related complications were noted in any of the patients.

DISCUSSION

The reduction in pain score was more significant with the PENG block than the FNB block in this study.

The anterior hip capsule is innervated by articular branches of the femoral nerve, accessory obturator nerve and obturator nerve, whereas the sciatic nerve innervates the posterior capsule. The

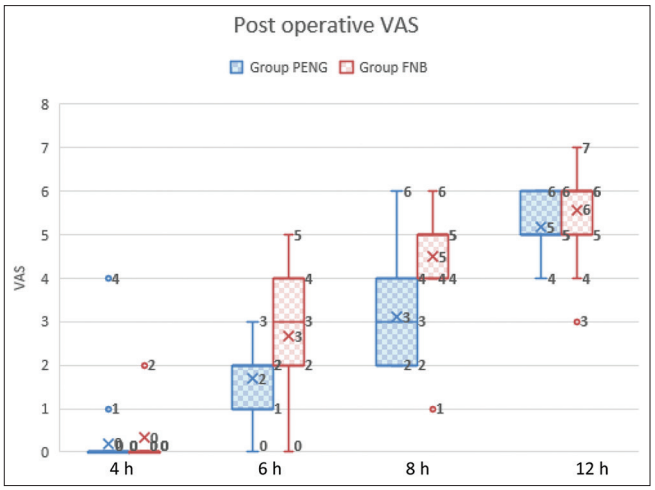

Figure 4: Box plot showing postoperative VAS score 0-10, observed at 4, 6, 8, and 12 h postoperatively, presented as median (IQR), Mann–Whitney test applied. Rectangles suggest an interquartile range (between the first and third quartile), dark lines suggest the median, and whiskers suggest maximum and minimum values. Outliers are shown as points. Cross marks show the values of the mean. Postoperative VAS score was comparable between both the groups up to 4 h. Patients in the PENG group had significantly lower pain at 6 h [2 (1-2) vs 3 (2-4), *P* value 0.004] and 8 h [3 (2-3.75) vs. 5 (4-5), *P* value < 0.001] postoperatively as compared to FNB group. VAS score was comparable at 12 h [5 (5-6) vs. 6 (5-6) *P* value 0.05]. VAS=Visual Analogue Scale, IQR=Interquartile Range, PENG=Pericapsular Nerve Group, FNB=Femoral Nerve Block

mechanoreceptor (nociceptive), responsible for pain, is mainly present in the anterior capsule.[7] The articular branches collectively do not get blocked in the FNB or FICB, which have been practised for procedural pain relief; thus, there is inadequate analgesia. PENG block is an interfacial block providing adequate analgesia by blocking articular branches of the femoral nerve, accessory obturator nerve and obturator nerve. Articular branches of these nerves are between the psoas muscle and the pubic ramus. Therefore, PENG block has the propensity to provide more complete and better analgesia. Various case series and randomised studies in the literature support this.[4,6,8-10]

Girón-Arango *et al*.,[4] in an index case series of PENG block, noted a median reduction 7-point at 30 min after the block. In a Cochrane review by Guay *et al*.[11] the data from the patients who were given FNB found a reduction of 3.4 points.

We could not find any study directly comparing immediate pain relief at 30 min after PENG block versus femoral block, although comparison with other interfacial blocks was documented. A few studies comparing PENG versus suprainguinal FICB suggested better pain relief with PENG block after 30 min.[8,12] The reason behind incomplete analgesia with these

blocks can be explained by a single nerve target in FNB, sparing the other two nerves of the anterior capsule and sparing the obturator nerve in FICB.[13]

This study found no difference in the EOSP scores between both groups. All patients provided optimal positions for giving spinal anaesthesia, as at the end of 30 min, the VAS score in all patients was below 4 points. Alrefaey *et al*.[6] compared EOSP after the PENG block versus control (no block). They observed that 24 patients in the PENG group could sit for spinal anaesthesia pain-free compared to the control group. Hence, they concluded it was an effective option for controlling positional pain. Jadon *et al*.[8] compared the ease of positioning for spinal anaesthesia after PENG block and FICB. They found better positioning with the PENG block.

The effect of blocks on postoperative pain relief was also observed at various time intervals up to 12 h. We found a significant difference in pain scores at 6 h and 8 h. The median pain score was 2 (1–2) vs. 3 (2–4) at 6 h and 3 (2–3.75) vs. 5 (4–5) at 8 h in the PENG and FNB groups, respectively. D-Yin Lin compared PENG and FNB for short-term analgesia. They observed pain score at 4 h was significantly lower with the PENG block group than with FNB.[14] Contrary to this, Allard *et al*.[5] did a cohort study to compare the analgesic effect of PENG block vs. Femoral block and 48 h morphine consumption. They did not find a difference in morphine consumption till 48 h postoperatively.

Quadriceps muscle strength observed at 6 h postoperatively was found to be better in the PENG block group in this study. Oxford muscle strength score was 4 out of 5 in 73% of patients in group PENG and 23% in the FN group block. The results were consistent with those of various studies. In a randomised controlled trial (RCT) performed by D-Yin Lin, between PENG block and FNB, they observed that more patients with PENG block had intact muscle strength compared to FNB.[14] Allard *et al*.[5] used the Medical Research Council (MRC) scale to grade quadriceps muscle weakness. Their analysis showed a statistically significant difference in MRC between both groups. The median of 5 IQR (4-5) was measured with PENG block and 2 IQR (2-3.8) in FNB. This sparing of motor innervation can be explained by the diffusion zone of LA in the PENG block. Only the articular branches with sensory innervation of the anterior hip capsule are blocked in this block. The femoral nerve has motor innervation of quadriceps muscles, usually blocked in FNB, leading to motor weakness. So, the motor-sparing effect of the PENG block can help in early mobilisation after surgery.

We used 20 mL of the drug with bupivacaine 0.25% and 4 mg dexamethasone. In an index case series, the authors used 20 mL of 0.25% bupivacaine with epinephrine (1:400,000) in four patients and 20 mL of 0.5% ropivacaine with epinephrine (1:200,000) plus dexamethasone 4 mg in remaining one patient.[3] In most case series and comparative studies of PENG block, 20 mL of LA solution has been used for analgesia for hip fractures.[5,6,14] However, acetabular fracture patients have reported a higher volume (30 mL).[15]

This study has a few limitations. Only patients were blinded in this study due to logistic issues. The volume of bupivacaine given in SA was not fixed and may affect analgesia duration up to 3 h. As per the protocol, the SA drug volume taken was left to the discretion of the treating anaesthesiologist, although the mean volume ultimately did not differ in both groups.

The primarily described technique for the PENG block is USG-guided. However, the blind approach has also been proposed by Jadon *et al*.[16] This can be utilised in resource-limited institutions where a USG facility is unavailable. Continuous PENG block with catheter *in situ* can be performed as a postoperative analgesic technique for prolonged analgesia after major hip fracture surgeries.

CONCLUSION

The PENG block provides better analgesia for sitting than FNB before spinal anaesthesia after proximal femur fractures. The postoperative duration of analgesia was also longer. The patient's comfort while sitting was comparable with both blocks, but quadriceps muscle strength was better preserved with the PENG block.

Study data availability

De-identified data may be requested with reasonable justification from the authors (email to the corresponding author) and shall be shared after approval as per the authors' Institution policy.

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Conflicts of interest

There are no conflicts of interest.

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