Original Article

Comparison of ultrasound-guided suprainguinal fascia iliaca compartment block and pericapsular nerve group block for postoperative analgesia and associated cognitive dysfunction following hip and proximal femur surgery

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Abstract

Background and Aims: Hip and proximal femur fractures in any age group require surgical reduction and fixation. Various regional techniques are popular for lower limb surgeries but adequate analgesia from these blocks is variable depending upon the type of surgery. We conducted a study to compare ultrasound-guided suprainguinal fascia iliaca compartment (SFIC) block and pericapsular nerve group (PENG) block for postoperative analgesia and cognitive dysfunction in patients undergoing hip and proximal femur surgery.

Material and Methods: Sixty-six patients, aged 18–65 years, American Society of Anaesthesiologists I and II undergoing hip and proximal femur surgery were randomized into two groups, group F for SFIC block (n = 33) and group P for PENG block (n = 33). After completion of surgery, an ultrasound-guided SFIC or PENG block was given. Visual analogue scale (VAS) score on movement and rest, muscle power (quadriceps strength), time to first rescue analgesia, total analgesic requirement, and postoperative cognitive dysfunction in the first 24 h were observed.

Results: A total of 66 patients participated in the study and 30 in each group were analyzed. VAS score at movement was significantly lower (P = 0.018) with better quadriceps muscle strength (P = 0.001) in the PENG block compared to the SFIC block group at 24 h postoperatively. Total opioid consumption in morphine equivalents (P = 0.03) was lower in the PENG block than in the SFIC block group for 24 h (28.5% vs. 71.4%). Cognitive impairment was comparable in both groups (3.3% vs. 16.7%, P = 0.097).

Conclusions: PENG block is better than SFIC block for postoperative analgesia with lesser opioid consumption, whereas postoperative cognitive dysfunction was comparable in both groups.

Keywords: Analgesia, cognitive dysfunction, hip surgery, nerve block, proximal femur surgery, visual analog score, postoperative

Introduction

Hip and proximal femur fractures are commonly observed in the elderly due to osteoporotic changes and in young individuals mostly due to high-velocity trauma. Surgical reduction and fixation is a definitive treatment in most patients.[1] The advantages of effective postoperative analgesia include patient comfort, early mobilization, lesser hospital stay, fewer complications, faster recovery, and reduced cost of care. Postoperative pain had been managed traditionally by systemic analgesics and central neuraxial blocks. Severe pain following surgery leads to an increase in the consumption of

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oral and injectable analgesics, which are associated with their various significant side effects.[1,2] Lower limb peripheral nerve blocks overcome the shortcomings of systemic analgesics and are considered as better alternatives for pain management during the perioperative period. They also lower the incidence of postoperative cognitive dysfunction (POCD), shorten the duration of hospital stay, and allow early mobilization.[2,3]

Various regional techniques including femoral nerve (FN) block, three-in-one FN block, sciatic nerve block, lumbar plexus block, and suprainguinal fascia iliaca compartment (SFIC) block, pericapsular nerve group (PENG) block are popular but moderate analgesia is achieved from these blocks as articular branches supplying hip and proximal femur are inconsistently blocked depending upon the type of surgery performed.[4]

The sensory nerve supply to the hip joint is anteriorly by FN, obturator nerve (ON), posteriorly by the articular branches of the sciatic nerve, nerves supplying quadratus femoris, and superior gluteal nerve. The anterior hip capsule is the main target for providing analgesia for hip and proximal femur surgeries and is innervated by FN, ON, and accessory obturator nerve (AON). The posterior capsule has mainly mechanoreceptors and has a minimal role in providing analgesia.[5,6] The sensory innervation of skin on the lateral thigh is by the lateral femoral cutaneous nerve (LFCN) and lateral cutaneous branch of the subcostal nerve.[7]

SFIC block was described by Hebbard *et al*. in 2011.[8] The potential space lying between the fascia iliaca anteriorly and iliacus and psoas major muscle posteriorly is known as the fascia iliaca compartment. Ultrasound (USG) has facilitated the development of a successful suprainguinal approach to the fascia iliaca compartment (FIC) block due to the proximal spread of local anesthetic beneath the fascia iliaca and above the inguinal ligament, which causes blockade of LFCN, FN, and ON. FIC block is a commonly used modality for postoperative analgesia; however, it does not block the AON and may reduce quadriceps muscle strength, which is required for early mobilization. PENG block provides profound analgesia of the hip by blocking articular branches of FN, ON, and AON and preserving quadriceps strength.

The PENG block was first described by Arango *et al*.[9] in 2018 as an ultrasound (USG)-guided regional block focusing on adequate blockade of articular branches of the hip and proximal femur supplied by FN, ON, and AON. The musculofascial plane between the psoas tendon anteriorly and the pubic ramus posteriorly is the target area for the block.

Several studies have been conducted previously comparing SFIC block or PENG block with systemic analgesia for hip and proximal femur surgeries, wherein the nerve blocks have been shown to provide superior analgesia with fewer complications.[10,11] A few studies have been conducted comparing USG-guided SFIC block and PENG block on postoperative analgesia but none of the studies included the associated postoperative cognitive dysfunction in patients undergoing hip and proximal femur surgery.[12-15]

Therefore, we conducted a study to compare USG-guided SFIC block and PENG block for postoperative analgesia and associated postoperative cognitive impairment in patients undergoing hip and proximal femur surgeries.

Material and Methods

This prospective, interventional, comparative, randomized, double-blind study was conducted in a tertiary care hospital and medical college after obtaining institutional ethics committee approval (IEC: 2020-11/CC-61) and Clinical Trial Registry India registration (CTRI/2021/06/034294). The study was conducted over 18 months (2020–2022) in accordance with the principles of the 2013 Declaration of Helsinki. The purpose and protocol of the study were explained and written informed consent was taken from all the patients included in the study. A total of 60 six patients, aged 18 to 65 years, of either sex, belonging to the ASA physical status I and II, scheduled for hip and proximal femur surgeries under spinal anesthesia were enrolled in this study. Patients with infection at the site of block, coagulopathy, pre-existing neurological disease, allergy to local anesthetic, severe cardiopulmonary disease, patients receiving opioids for chronic analgesic therapy, contraindication to spinal anesthesia and patients unable to comprehend VAS score were excluded from the study. Patients were allocated into two groups using computer-generated block randomization, that is, group F ($n = 33$) for patients receiving USG-guided SFIC block and group P ($n = 33$) for USG-guided PENG block.

The primary objective was to compare VAS on movement (10 degrees internal rotation) at 24 h in both the groups and the secondary objectives were to study VAS on movement and rest at 0, 1, 2, 4, 6, 12, and 24 h, respectively, muscle power (quadriceps strength), time to the first rescue analgesia, total analgesic requirement in 24 h (morphine equivalents), and associated postoperative cognitive impairment. With 80% power and a confidence interval of 95%, the sample size of 26 patients was calculated in each group with reference to the study conducted by Aprato *et al*.[16] To compensate for patient dropout and additional comparisons, the total sample size taken was 66 (33 patients per group). A total of 60 patients were analyzed with

30 patients in each study group [Figure 1]. The patient's age, height, and weight were recorded and body mass index (BMI) was calculated [Table 1]. VAS score (a scale of 0–100 mm was converted to the closest integer 0–10, with endpoints "0 = no pain" to the left and "10 = worst pain" to the right end) was explained to all patients during pre-anesthetic evaluation. Patients also received a tablet of alprazolam 0.25 mg a night before the surgery. In the operating room, standard ASA monitors were attached and baseline vitals such as blood pressure (BP, mmHg) [systolic, diastolic, and mean], heart rate (HR, bpm), and oxygen saturation (SpO_2, %) were noted. Using 25 G Quincke's spinal needle, a subarachnoid block was given using 2.6 mL of 0.5% heavy bupivacaine with 15 μg of fentanyl in L3–L4 or L4–L5 intervertebral space considering the height of the patients was comparable. Surgery was initiated after the sensory block was achieved at the T10 level. After the completion of the surgery, USG-guided SFIC block or PENG block was given under all aseptic precautions according to the allotted groups by an experienced anesthesiologist who was not involved in the study. The changes in the hemodynamic variables, VAS scores, and analgesia requirement were noted by another anesthesiologist who was also blinded to the technique of block.

In Group F (n = 33), a USG-guided SFIC block was given to the patient in the supine position, a linear 6–13 MHz USG probe (M Turbo, Sonosite, USA) was placed over the inguinal ligament in the sagittal plane, infero-medially to the anterior superior iliac spine. Upon sliding and rotating the probe medially, the "bow-tie sign" was identified as formed by the Sartorius and Internal Oblique muscle. A 21G, 100 mm needle (Stimuplex; B. Braun, Bethlehem, PA) was advanced using in-plane fashion to puncture the fascia iliaca. When the needle tip was visible just superficial to the iliacus muscle and below the fascia iliaca, 2 mL of a local anesthetic was injected for the confirmation of the needle tip location, which was followed by the administration of 30 mL of 0.375% ropivacaine incrementally.

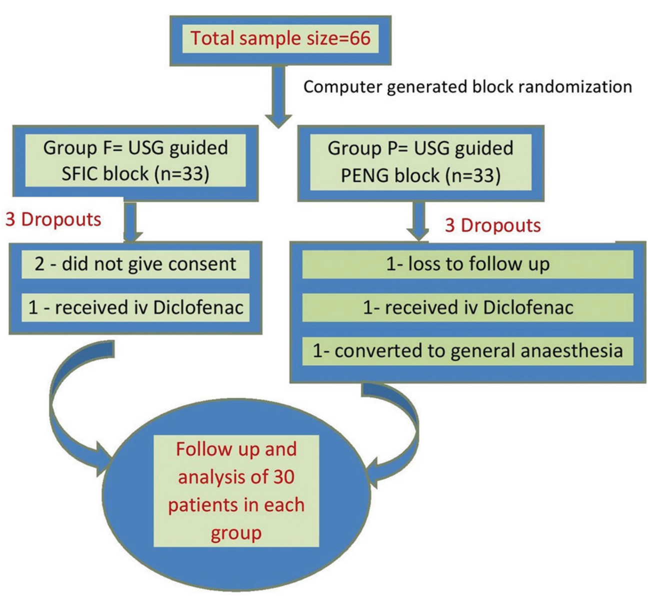

Figure 1: Consort diagram. n = no. of patients in each group, group F = SFIC block, group P = PENG block, SPO2 = oxygen saturation, IV = intravenous

In Group *P* (n = 33) USG-guided PENG block was performed with the patient in the supine position, a curvilinear 2–5 MHz low-frequency USG probe (M Turbo, SonoSite, USA) was initially placed in the transverse plane over the anterior inferior iliac spine and then aligned with the pubic ramus by rotating the probe counter-clockwise to approximately 45 degrees. In this view, iliopubic eminence, iliopsoas muscle and tendon, femoral artery, and pectineus muscle were identified. A 21G, 100-mm stimuplex needle was inserted from lateral to medial using an in-plane approach to place the tip of the needle in the musculofascial plane between the psoas tendon anteriorly and the pubic ramus posteriorly. Following the negative aspiration, the local anesthetic solution (30 mL of 0.375% ropivacaine) was injected in increments while observing for adequate local anesthetic spread in the musculofascial plane.

The total duration of surgery was recorded. Completion of surgery was considered as time zero in both groups. VAS score at the time zero was considered as the baseline score followed by subsequent evaluation at 1, 2, 4, 6, 12, and 24 h in the postoperative period at rest and at movement (10 degrees internal rotation). Hemodynamic variables were also recorded at the same time intervals. Patients with a VAS score ≥3 were given acetaminophen 15 mg/kg IV and VAS score ≥5 received rescue analgesia in the form of tramadol hydrochloride 1 mg/kg IV after the administration of ondansetron 0.08 mg/kg IV. The time of administration of the first dose of tramadol and total tramadol used in the first 24 h were recorded. Morphine equivalents (MEs) were calculated for the total tramadol used in the first 24 h (taking a conversion factor of 0.1).

Motor power was recorded in both groups at the same time intervals as the VAS score by assessing quadriceps femoris muscle strength using the Medical Research Council (MRC) grading (Grade 0-no contraction, Grade 1-flicker or trace of contraction, Grade 2-active movement with gravity eliminated, Grade 3-active movement against gravity, Grade 4-active movement against gravity and resistance, Grade 5-normal power), and the time needed for ambulation was also assessed in both the groups if muscle strength was grade 5.

Any delirium, confusion, or cognitive impairment was recorded in the patients of both the groups receiving opioids (morphine equivalents, ME) as rescue analgesia, noted at the same time intervals as the VAS score for the first 24 h in the postoperative period. Postoperative cognitive dysfunction (impairement of neuropsychological scores due to anesthesia or surgery) was observed in patients using the mini-COG score (mini-COG scoring (0–5) includes recall score (0–3) and clock drawing score (0–2), a score of ≤2 is suggestive of cognitive impairment).

Categorical variables are presented in number and percentage, and continuous variables are presented as mean ± standard deviation (SD) and median. The normality of data was tested by the Kolmogorov–Smirnov test. Quantitative variables were compared using the unpaired *t*-test/Mann–Whitney test between the two groups and qualitative variables were compared using Chi-square test/Fisher's exact test. A P-value of <0.05 was considered statistically significant. Analysis was performed using the Licensed Statistical Package for Social Sciences (SPSS) version 21 (IBM, Chicago, USA).

Results

Six out of the planned 66 patients were excluded and 60 patients were analyzed, with 30 in each group. Three were converted to general anesthesia, two were given IV analgesia against the study protocol, and one was lost to follow-up in the postoperative period.

All demographic data were comparable in terms of age, sex, weight, height, BMI, surgery time, and time taken to give the block in both groups, $P > 0.05$ [Table 1].

VAS score at rest was comparable at time 0 and 1 h in groups F and P and was significantly low at 2 h in group F as compared to group P [Table 2]. At 4 h, 6 h, 12 h, and 24 h, the VAS score at rest was significantly lower in group P as compared to group F ($P < 0.05$) [Table 2]. VAS scores at movement observed during time 0 h, 1 h, 2 h, 4 h, and 6 h showed no statistical difference between group P and group F, respectively, whereas VAS score at 12 h (2.87 ± 0.86 vs. and 3.53 ± 1.149, $P = 0.033$) and 24 h (2.55 ± 0.68 vs. 2.97 ± 0.974, $P = 0.035$) was statistically significant with lower VAS score at movement in group P as compared to group F [Table 3].

The muscle power at time 0 (2.03 ± 0.414 vs. 2.10 ± 0.305, $P = 0.48$), 1 h (2.63 ± 0.49 vs. 2.53 ± 0.50, $P = 0.441$), 4 h (2.73 ± 0.69 vs. 2.47 ± 0.629, $P = 0.124$) and at 6 h (3.20 ± 0.664 vs. 2.93 ± 0.691, $P = 0.131$) was comparable between group P and group F, respectively. However, muscle power at 12 h (3.10 ± 0.803 vs. 2.53 ± 0.681, $P = 0.005$) and 24 h (3.23 0.568 vs. 2.37 ± 0 ±0.718, $P = 0.001$) was significantly better in group P as compared to group F [Table 4]. The time needed for ambulation in all patients of both the groups could not be assessed as none of the patients were able to attain complete motor power (5/5 according to MRC grading) until 24 h in the postoperative period.

The time taken for the first rescue analgesia was significantly longer (9.23 ± 3.69 vs. 6.43 ± 5.67 hours, $P = 0.027$) in group P than in group F [Table 4]. The total opioid used in the form of tramadol converted to morphine equivalents was statistically lower in group P as compared to group F in the first 24 h postoperatively (5 vs. 12.5 ME, $P = 0.03$). The percentage of opioids required (ME) was 28.5% in Group P and 71.4% in Group F [Table 4].

Table 1: Demographic data comparing both groups in the study

	Group F (n=30)	Group P (n=30)	P
Age (y)	44.53±11.521	43.80±16.048	0.840
Sex (M/F)	14/16*	16/14*	0.606
Weight (kg)	61.4667±7.90780	59.2667±8.25847	0.296
Height (cm)	163.35±2.53	161.57±3.89	0.352
BMI (kg/m^2)	24.12±1.08	26.12±0.567	0.12
Operation time (h)	3.4467±0.68165	3.1900±0.79018	0.183
Block time (min)	9.33±1.241	9.43±1.455	0.776

*Values are presented as mean±SD. *Values are presented as numbers. Statistical analysis was performed using unpaired t-test. n=No. of patients in each group, group F=SFIC block, group P=PENG block, BMI=Body Mass Index*

Table 2: VAS score at Rest

Postoperative hour	Group P (n=30)	Group F (n=30)	P
0	1.57±0.568	1.47±0.571	0.499
1	1.60±0.814	1.47±0.730	0.507
2	2.30±0.702	1.73±0.691	0.003†
4	2.13±0.758	2.67±0.629	0.004†
6	2.63±1.12	3.30±1.29	0.035†
12	2.83±0.833	3.63±1.249	0.013†
24	2.47±0.730	2.90±0.712	0.023†

Values are presented as mean±SD. †P<0.05 is statistically significant. Statistical analysis was done using unpaired t test. n=No. of patients in each group, group F=SFIC block, group P=PENG block

Table 3: VAS score at movement

Postoperative hour	Group P (n=30)	Group F (n=30)	P
0	1.97±0.669	1.73±0.640	0.173
1	2.10±0.803	1.93±0.691	0.393
2	2.97±0.669	3.23±0.728	0.145
4	3.63±0.890	3.63±0.765	0.218
6	2.97±0.928	2.70±1.055	0.303
12	2.87±0.86	3.53±0.682	0.033†
24	2.55±0.682	2.97±0.974	0.035†

Values are presented as mean±SD. †P<0.05 is statistically significant. Statistical analysis was done using an unpaired t-test. n=No. of patients in each group, group F=SFIC block, group P=PENG block

The frequency of POCD was observed to be lower in group P as compared to group F but it was statistically insignificant in the first 24 h postoperatively (3.3% vs. 16.7%, $P = 0.097$) [Table 4].

On comparing postoperative changes in mean heart rate, systolic blood pressure, diastolic blood pressure, and oxygen saturation, both the groups F and P were comparable until the first 24 hours ($P = 0.41$, $P = 0.189$, $P = 0.649$, $P = 0.417$), respectively [Table 5].

Discussion

Pain in the postoperative period causes significant distress to patients that have adverse effects on the endocrine and immune system affecting wound healing. The incidence of postoperative pain is as high as 26–58% in patients undergoing hip surgeries.[17] Inadequate pain management leads to delayed mobilization and a longer duration of hospital stay. Patients with hip fractures usually are elderly and have multiple comorbidities, which demand cautious use of systemic analgesics.[1,2] Regional analgesic techniques such as FN block, SFIC block, and PENG block have become an integral part of patient care as per enhanced recovery after surgery (ERAS). Recent trends in pain management following hip and femur surgeries are structured toward providing effective analgesia with limited motor involvement.[18]

SFIC block has recently been used for better postoperative analgesia for hip and proximal femur surgeries as the drug spreads in a proximal direction and blocks FN and LFCN more effectively. It causes sparing of AON. Shariat *et al.*[19] and Kukreja *et al.*[20] showed that proximal spreading of local anesthetic was not adequate using the infra-inguinal technique. SFIC blocked the three nerves more consistently than the infra-inguinal approach. SFIC block also causes quadriceps and adductor muscle weakness due to dense blockade of ON and hence impairs ambulation.

PENG block has emerged as a reasonable alternative to SFIC block that produces good analgesia with predominantly sensory block as well as quadriceps muscle preservation.[14] Birnbaum *et al.*[21] stated that blocking sensory nerves such as ON, AON, and FN, which innervates the anterior hip capsule in the PENG block would adequately provide analgesia following hip surgeries. It causes sparing of LFCN. Articular branches of ON were blocked due to the proximity to the sub-pectineal plane but to a lesser extent than the SFIC block. The anterior capsule of the hip joint has primarily nociceptive fibers, whereas the posterior capsule has mechanoreceptors. PENG block has motor sparing benefits by sparing posterior mechanoreceptors and lesser blocks of ON than SFIC block.

With this background, we conducted a study to compare postoperative analgesic effects of USG-guided SFIC block and PENG block using 30 mL of 0.375% ropivacaine in hip and proximal femur surgeries. Ropivacaine is a long-acting local anesthetic that has reduced central nervous system and cardiac toxicity along with less propensity for motor blockade compared to bupivacaine, which enhances early mobilization and prevents complications of immobility such as atelectasis, pneumonia, and deep vein thrombosis.

In our study, we have found that VAS scores at rest and movement were significantly lower, muscle power was better, the time taken for the need of rescue analgesia was significantly

Table 4: Total evaluation at postoperative 24 h

postoperative 24 h	Group P (*n*=30)	Group F (*n*=30)	*P*
VAS score at rest	2.47±0.730	2.90±0.712	0.023†
VAS score on movement	2.55±0.682	2.97±0.974	0.018†
Muscle power	3.23±0.568	2.37±0.718	0.001†
Time for rescue analgesia (minutes)	9.23±3.692	6.43±5.679	0.027†
Total opioid consumption in Morphine equivalents	5±0.790	12.5±0.681	0.033†
No. of patients with Mini Cog Score ≤2	1*	5*	0.097

*Values are presented as mean±SD. *Values are presented as numbers. †P<0.05 is statistically significant. Statistical analysis was done using unpaired t test. n=No. of patients in each group, group F=SFIC block, group P=PENG block*

Table 5: Mean postoperative hemodynamic changes until first 24 h

Postoperative period (until 24 h)	Group P (*n*=30)	Group F (*n*=30)	*P*
Mean heart rate (bpm)	80.70±7.970	82.70±10.567	0.411
Mean Systolic Blood Pressure (mmHg)	117.17±10.774	112.77±14.602	0.189
Mean diastolic blood pressure (mmHg)	75.83±6.818	76.70±7.813	0.649
SPO_2 (%)	99.20±1.157	99.40±0.675	0.417

Values are presented as mean±SD. Statistical analysis was done using an unpaired t-test. n=No. of patients in each group, group F=SFIC block, group P=PENG block, SPO_2*=oxygen saturation* longer, total opioids used in the form of ME was lower in Group P as compared to Group F at 24th hour in the postoperative period. The incidence of POCD was found to be similar in patients with PENG block as compared to patients who received SFIC block at 24 h postoperatively [Table 4].

Similar results were observed in some other studies. Choi *et al.*[22] showed that Numerical Rating Scale (NRS) pain scores at rest were lower in the PENG block group as compared to the SFIC block and Mosaffa *et al.*[12] also showed that the VAS score at rest was lesser in the PENG block group than in the SFIC block group. Senthil *et al.*[13] showed that VAS score at movement was significantly lower at 14, 18, and 24 h and the overall muscle power was better in the PENG block group than in the SFIC block group. Ueshima *et al.*[14] showed the benefits of the PENG block on patient positioning for the procedure with no significant motor weakness, potential motor-sparing effect, and good analgesic efficacy for hip surgery. Natarajan *et al.* found that the postoperative NRS score was higher in the FIC block than in the PENG block, which was statistically significant at 1 h and 4 h.[15] Vamshi *et al.* conducted a study on a comparison of the efficacy of PENG block versus SFIC block in total hip arthroplasty and found that USG-guided PENG block causes a significant reduction in pain scores (NRS scores).[23]

Natrajan *et al.*[15] also found that the time for first rescue analgesia was significantly late in the PENG block group as compared to the SFIC block. Mosaffa *et al.*,[12] Kukreja *et al.*,[20] and Vamshi *et al.*[23] found that the total dose of morphine consumed was significantly lesser in the PENG block group as compared to the SFIC block group. A study performed by Aliste *et al.*[24] showed that no differences were found in static and dynamic pain scores as well as cumulative opioid consumption during 24 h and 48 h postoperatively after hip surgeries under spinal anesthesia in the PENG group and SFICB group. It could be because of the lesser volume of drugs used in the study, resulting in lesser spread of local anesthetic in the fascial planes.

POCD is a common complication in orthopedic surgeries, especially in elderly patients. Total hip arthroplasty and femoral neck fracture are common risk factors for POCD and greatly increase the mortality, morbidity, and medical burden of these patients. It is also increased with the use of systemic analgesics such as opioids.[25] The Mini-Cog score is a brief and validated tool used in the evaluation of the cognitive function of elderly patients undergoing elective surgery, which demonstrates good performance in predicting postoperative delirium.[25]

We found that the Mini-Cog score was comparable in both groups until the first 24 h postoperatively though the opioid requirement was significantly lower in group P. Yanan Wu and Rui Han found that perioperative continuous FN block reduces the incidence of POCD with a Mini-Cog score of ≤2 in patients with femoral neck fractures.[26] This difference could be because there were other confounding factors such as the type of surgery performed, pre-existing cognitive deficit, and age of the patient.

A few limitations of our study included non-assessment of sensory block, hip and proximal femur are two different types of surgeries; therefore, pain and concentration of local anesthetic could be confounding factors for assessing muscle strength, small study sample size, single-center based, and inter-operator variability for regional blocks. The effectiveness of the PENG block is also dependent upon the injection zone of the drug.[27] Very low incidence of POCD in patients receiving blocks for pain management and paucity of literature on the same.

Conclusion

USG-guided PENG block provides adequate postoperative analgesia to patients undergoing hip and proximal femur surgeries until 24 h with the preservation of quadriceps muscle function, which helps in early mobilization. PENG block also resulted in lesser opioid consumption, which is beneficial as per the enhanced recovery pathways though the incidence of postoperative cognitive impairment was found similar in both groups.

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Conflicts of interest
There are no conflicts of interest.

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