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Original Article

Anaesthesia Section

Efficacy of Pericapsular Nerve Group Block in Combination with Suprainguinal Fascia Iliaca Block in Comparison to PENG Block Alone for Postoperative Analgesia after Total Hip Arthroplasty: A Randomised Double-blind Controlled Study

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ABSTRACT

Introduction: The complex innervation of the hip joint may require a combined regional analgesia technique to achieve effective perioperative analgesia. The Pericapsular Nerve Group (PENG) and Suprainguinal Fascia Iliaca Compartment Blocks (SIFICB) are interfascial plane blocks aiming to involve the femoral, obturator, accessory obturator, and Lateral Femoral Cutaneous Nerves (LFCN), essentially innervating the hip joint.

Aim: To evaluate the efficacy of the PENG block and SIFICB compared with the PENG block alone for postoperative analgesia and functional recovery in patients undergoing Total Hip Arthroplasty (THA).

Materials and Methods: This double-blind, randomised controlled study was conducted at Sir Sayajirao General Hospital, Baroda Medical College, Vadodara, Gujarat, India. The study analysed 60 patients aged 18-65 years with American Society of Anaesthesiologists (ASA) status I-III who were posted for THA. Postoperatively, the PSB group received SIFICB (20 mL) and a PENG block (10 mL), while the PB group received only a PENG block (10 mL) with 0.5% bupivacaine and 8 mg dexamethasone. The Visual Analogue Scale (VAS) scores at rest and with 15° hip flexion, the duration of analgesia, the cumulative dose of rescue analgesic required, motor blockade, ability to perform quadriceps exercises, early ambulation, patient satisfaction, and complications over the first 6, 12, 24, and 48 hours were assessed. Statistical analysis was performed using the student's t-test, Chi-square test, and Mann-Whitney U test in MedCalc version 20.0.10.

Results: The two groups were comparable in terms of demographics. The patients belonging to the PSB group had significantly lower median pain scores {1 (0-2) vs 2 (2-3), p-value <0.001; 0 (0-0) vs 1 (0-2), p-value <0.001, respectively} at rest and {3 (2-4) vs 4 (3-5), p-value=0.007, and 2 (1-3) vs 3 (2-4), p-value <0.001, respectively} with 15° hip flexion at 24 and 48 postoperative time points with longer median duration of analgesia {40 (18-42) vs 8 (6.5-19.5) hours, p-value<0.0001} and reduction in median cumulative requirement of rescue analgesic {0 (0-1) vs 1 (1-2), p-value=0.002} compared to the patients with group PB. Group PSB patients walked a higher mean number of steps than group PB (137.1±30.97 vs 75.9±19.55, p-value<0.0001) after 48 hours.

Conclusion: A combination of the PENG and SIFICB provides lower VAS scores at rest and with 15° hip flexion, a longer duration of analgesia, and a reduced requirement for rescue analgesics in the first 48 hours postoperatively, in comparison to the PENG block alone after THA. It also preserves motor function, enabling more quadriceps exercises, and supports early mobilisation, ultimately leading to greater patient satisfaction.

Keywords: Functional recovery, Hip surgery, Postoperative pain, Regional anaesthesia

INTRODUCTION

The THA is a commonly performed orthopaedic surgery that aims to restore function and enhance a patient's quality of life. However, associated severe pain in the postoperative period delays the mobilisation and recovery, leading to complications, such as deep vein thrombosis, pulmonary embolism, atelectasis, pneumonia and higher chances of myocardial infarction, provoked by the stress response. However, achieving prolonged postoperative analgesia is crucial, as it facilitates early mobilisation, improves functional recovery, and enhances overall postoperative outcomes by preventing the progression of acute surgical pain to chronic pain [1,2]. The complex, multinerve innervation of the hip joint and the intense pain associated with the surgery make regional anaesthesia challenging in THA [1]. The anatomical study done by Short AJ et al., demonstrated the involvement of articular branches of the Femoral (FN), obturator and accessory obturator nerves as the sensory innervation of the anterior capsule of the hip joint, with the major contribution from 'high' branches of the femoral nerve [2]. This suggests that these three nerves should be the main targets for hip analgesia.

The PENG block aims explicitly at the articular branches of the femoral nerve, the obturator nerve, and the accessory obturator nerve [3-5]. However, it does not affect the lateral cutaneous branches of the iliohypogastric and subcostal nerves, which innervate the area of surgical incision [3,6]. The possible involvement of the femoral nerve, leading to motor blockade, cannot be excluded after a PENG block with higher volumes or medial/intramuscular injections of Local Anaesthetics (LA) [2]. Additionally, the limited duration of analgesia and the use of higher volumes or unintended medial/interstitial spread of LA during PENG block raise concerns about potential FN involvement, which could delay postoperative ambulation [7,8]. This advocates a mandatory reduction in the volume of LA used in the

PENG block and the combination of the PENG block with another regional block to provide better analgesia after THA. Literature available using various techniques to relieve incisional pain after THA with a PENG block, such as local infiltration of the surgical wound or combination with a LFCN block, but encouraging results are still awaited [1,3,6].

The FICB is designed to anaesthetise the femoral nerve and the LFCN [1]. When performed using the modified suprainguinal approach, this technique achieves a more effective blockade of the lumbar plexus, even with a smaller volume of LA [7]. This can prevent the motor blockade and delay mobilisation. Prior literature favoured the addition of a SIFICB or a lateral quadratus lumborum block to the PENG block for adequate and prolonged analgesia, when used for primary or revision hip surgeries [5,9]. Alternatively, the same combination has been shown to be no better than SIFICB alone [10]. Adding SIFICB to the PENG block may be advantageous by blocking the LFCN and the FN at a higher level, thereby providing better coverage of pain-generating areas with less LA volume than the PENG block alone [9]. Data still needs to be generated in this regard.

After reviewing the above literature, it was hypothesised that combining PENG with SIFICB can provide better analgesia without compromising mobility than PENG block alone. The present study aimed to compare postoperative analgesia and functional recovery after combining the PENG block with SIFICB versus the PENG block alone after THA. The primary objective was to assess postoperative pain relief, measured by VAS scores at rest and with 15° hip flexion, duration of analgesia, and total postoperative consumption of rescue analgesics following THA. Secondary outcomes included assessment of motor blockade, quadriceps exercise performance, the patient's ability to ambulate early, overall patient satisfaction, and any associated complications.

MATERIALS AND METHODS

This randomised, double-blind, controlled study was performed at Sir Sayajirao General Hospital, Baroda Medical College, Vadodara, Gujarat, India between May 2023 and April 2024. Approval was obtained from the Institutional Ethics Committee for Biomedical and Health Research (IECBHR/172-2023, dated 21/02/2023). The Clinical Trials Registry of India (CTRI) officially registered the trial on April 13, 2023, under the registration number CTRI/2023/04/051593. The data of all participants were used for educational and research purposes with the provision of written informed consent. Research was undertaken by the ethical principles described in the Declaration of Helsinki (2013) and the reporting standards established by the CONSORT guidelines.

Sample size: The sample size was calculated based on the parameter "static VAS score at 24 hours" from the previous study, which reported a value of 2.47±0.73 in the PENG block group [7]. Assuming a Standard Deviation (SD) of one and the standard effect size of 0.8, at a confidence interval of 95% and a power of the study 80%, 50 patients needed to be studied. Given a 15% dropout rate, we included 60 patients (30 per group). The calculation was based on the formula for comparison of two means:

$$n=\frac{2(Z_{\alpha/2}+Z_{\beta})^2\sigma^2}{d^2}$$

Where:

- $Z_{\alpha/2}$ for 95% confidence interval
- Z_{β} for 80% power
- σ=1 (standard deviation)
- d=0.8 (expected mean difference/effect size)

Substituting the values:

$$n=\frac{2(1.96+0.84)^2(1)^2}{(0.8)^2}=24.5=25 \text{ patients/group}$$

Thus, a minimum of 50 patients (25 in each group) were required. Considering an anticipated dropout rate of 15%, the adjusted sample size was calculated as:

$$N=\frac{50}{1-0.15}=58.8=60$$

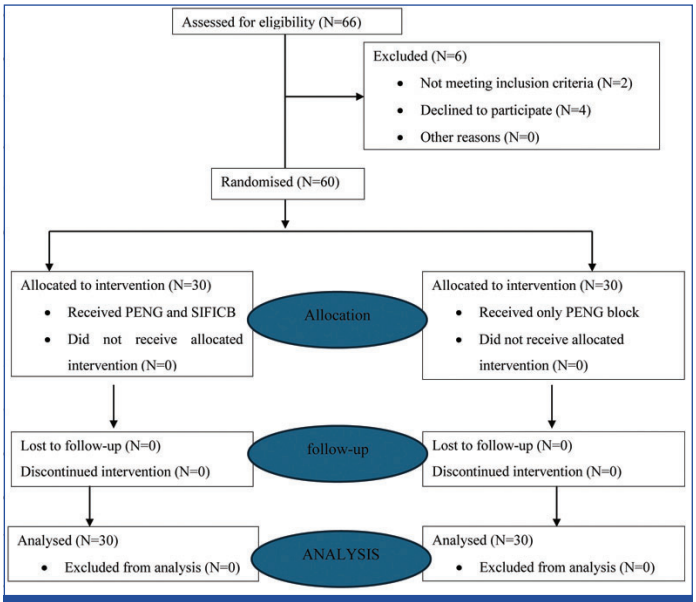
Therefore, the final total sample size was taken as 60 patients.

Inclusion criteria: Adult patients of 18-65 years of age and either gender, admitted for primary unilateral THA under spinal anaesthesia, with an ASA physical status classification of I to III were included in the study.

Exclusion criteria: Patients who declined to participate, had coagulation abnormalities, active surgical site infection, chronic opioid therapy, pre-existing neuromuscular disorders of the lower limbs, or a known allergy/contraindication to any study drugs (LAs, paracetamol, or opioids) were excluded from the study.

Study Procedure

All eligible participants underwent a detailed preanaesthesia evaluation, including the necessary investigations. The VAS for pain assessment, the anaesthetic technique, and the study protocol were explained to each patient before their participation, and enrolment was conducted by an anaesthesiologist who was unaware of their allocation. The participants were randomly divided into two groups by a statistician using a computer-generated sequence (www.randomizer.org) [Table/Fig-1]. The allocation sequence was concealed in sealed, opaque envelopes, opened only just before block administration. Group PB received an ultrasound-guided PENG block, while group PSB received an ultrasound-guided SIFICB in addition to a PENG block. To ensure double blinding, the participants were blinded to the procedure and outcome measurements were recorded by an independent observer blinded to group assignments. All nerve blocks were performed by a single anaesthesiologist to reduce the bias.



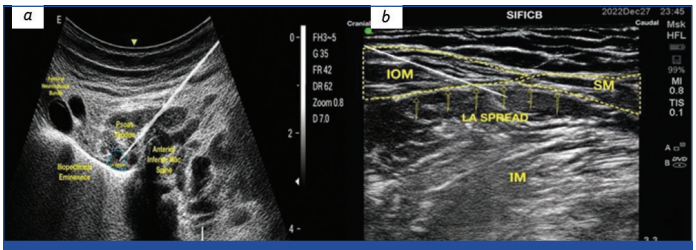
[Table/Fig-1]: Consolidated Standards of Reporting Trials (CONSORT) chart.

Before surgery, patients were confirmed to be nil per oral and an intravenous line was established using an 18-G cannula. In the operating theatre, standard multiparameter monitoring was applied, including oxygen saturation (SpO_2), electrocardiography, heart rate, and non-invasive blood pressure, with baseline readings recorded. Preloading was done with Ringer's lactate solution at 8-10 mL/kg. Ten minutes before starting the surgery, premedication included intravenous ondansetron (0.08 mg/kg) and paracetamol (1 g) for pre-emptive analgesia. Spinal anaesthesia was performed under full aseptic precautions, with patients in the sitting position, using 2.5 mL of 0.5% hyperbaric bupivacaine. The group PSB received a total

of 30 mL of LA, including 15 mL of 0.5% bupivacaine with 2 mL of dexamethasone (8 mg), and 13 mL of sterile water. Out of which 10 mL and 20 mL of LA were delivered in the PENG block and the SIFIC block, respectively. Group PB received a total of 10 mL of LA, consisting of 5 mL of 0.5% bupivacaine, 2 mL of dexamethasone 8 mg, and 3 mL of sterile water.

Both blocks were administered in the supine position. PENG block was administered using a low-frequency curvilinear ultrasound probe (2-5 MHz) that was initially positioned in the transverse plane at the Anterior Superior Iliac Spine (ASIS) and subsequently moved caudally to identify the Anterior Inferior Iliac Spine (AIIS). Then, the probe was rotated to align the Ilio-Pubic Eminence (IPE) and AIIS. Afterwards, the femoral vessels were used to expose the Iliopsoas Tendon (IPT) and the superficial iliopsoas muscle. With the in-plane technique, the tip of a 21-G, 50 mm Echoplex needle was positioned between the AIIS and IPE and deep to the psoas tendon. After hydrodissection confirmed the elevation of the psoas tendon, 10 mL of the LA solution was injected in five mL aliquots, following negative aspiration. Elevation of IPT and medial spread were observed to confirm the LA spread [Table/Fig-2a].

To perform SIFICB, the ASIS was visualised using a linear high-frequency probe (5-13 MHz) in the longitudinal plane. Then, after moving the probe medially, the sartorius, fascia iliaca, iliopsoas, and internal oblique muscles were identified. Subsequently, the muscle fasciae were identified as making the "BOW-TIE" sign. A 10 cm echogenic needle was inserted in-plane, cephalad to the inguinal ligament. The needle point was confirmed to be separated from the iliacus muscle using hydro-dissection while remaining beneath the fascia iliaca. The needle was subsequently advanced slightly backwards and cephalad, followed by the administration of 20 mL of LA solution in 5 mL aliquots. The uplifting of the deep circumflex artery following injection was considered a landmark to indicate fascia iliaca invasion, and the LA was observed to extend cranially to the point where the iliacus muscle travels underneath the abdominal muscles [Table/Fig-2b].



[Table/Fig-2]: a) Identification of the relevant anatomy and Local Anaesthetic (LA) spread of the Pericapsular Nerve Group (PENG) block; b) Identification of the relevant anatomy and LA spread of the Suprainguinal Fascia Iliaca Block (SIFICB) -formation of the "bowtie sign" by the sartorius and internal oblique muscles.

A blinded observer, unaware of the group allocation, assessed postoperative pain intensity, which was a primary parameter using a VAS score ranging from 0 (no pain) to 10 (worst pain) at rest and during 15° hip flexion at 6, 12, 24, and 48 hours postoperatively to compare the two groups. Intravenous tramadol (100 mg) was administered as rescue analgesia whenever the VAS score reached ≥4. The time from administration of LA until receipt of the first dose of rescue analgesic was considered as the duration of postoperative analgesia. The total dose of rescue analgesic administered within the first 48 postoperative hours was noted. The secondary parameters, such as the degree of motor blockade, were assessed using the Bromage scale [11]. The patients were trained in quadriceps exercises on the day before the preoperative visit. Postoperatively, they were asked to perform the same exercises at 24 and 48 hours, and the number of times each patient performed was recorded. We followed our institutional protocol, which allowed patients to ambulate postoperatively after 24 hours. Patients were evaluated by counting the maximum number of steps they could walk with support at 24 and 48 hours after surgery. Patient's satisfaction with the postoperative analgesia technique was categorically rated as 1-very much satisfied, 2-somewhat satisfied, 3-neither satisfied nor dissatisfied, 4-somewhat dissatisfied, and 5-dissatisfied. In both groups, complications encompassing nerve injury, Local Anaesthetic Systemic Toxicity (LAST), haematoma, vascular injury, motor blockade, or infection were documented and managed accordingly.

STATISTICAL ANALYSIS

The master chart was prepared using all data in Microsoft Excel. All quantitative data, encompassing age, the number of steps patients could walk, and the number of times quadriceps exercises were performed, were presented as mean and SD and analysed by student's t-test. The VAS score, duration of analgesia, rescue analgesic dose, motor blockade, and patient satisfaction scores were displayed as medians and interquartile ranges. To evaluate the normality of the VAS score and analgesia duration distributions, the Shapiro-Wilk test was used. Afterwards, the Mann-Whitney U test was employed for analysing non-normally distributed data. Non-parametric data, like sex and ASA grade, were presented as numbers or percentages and analysed by Pearson's Chi-square test. MedCalc statistical software (Ostend, Belgium; version 20.0.10) was used for the final statistical analysis. A p-value <0.05 was considered statistically significant.

RESULTS

All patients were studied and analysed. There were no dropouts. The two groups were comparable demographically [Table/Fig-3].

Parameter	Group-PSB (N=30)	Group PB (N=30)	p-value
Age (years)	56±11.3	52.5±13.89	0.28
Gender (M:F)	20:10	22:8	0.85
ASA I:II:III	0:18:12	0:19:11	0.95
Duration of surgery (minutes)	91.5±7.59	91.43±7.44	0.97

[Table/Fig-3]: Demographic data.
(Values are presented as mean±SD or numbers; Statistical analysis: Fisher's exact test or Pearson's Chi-square test, except for the age, by applying student's t-test; Duration of surgery-t-test, Abbreviations: ASA: American Society of Anaesthesiologists; CI: Confidence interval; SD: Standard deviation

Postoperatively, patients in the PSB group had significantly lower median VAS scores at rest at 24 hours and 48 hours compared with those in the PB group [Table/Fig-4]. Except at six hours, the median VAS scores for 15° hip flexion remained significantly lower in patients in group PSB at 12, 24, and 48 hours than in group PB [Table/Fig-5]. The patients in the PSB group experienced a longer duration of analgesia [Table/Fig-6]. The median cumulative intravenous analgesic requirement remained insignificant at six hours and 12 hours. Then, it remained significantly higher in group PB than in group PSB at 24 and 48 hours. At the same time, the median intravenous analgesic requirement during each time interval remained significantly lower at 12 hours and 24 hours in patients pertaining to the PSB group as compared to the group PB [Table/Fig-6].

The number of quadriceps exercises performed by patients has been significantly higher in the PSB group than in the PB group [Table/Fig-6]. No complications, including nerve injury, LAST, haematoma,

Time interval	VAS scores median (IQR)		95% CI	p-value
	PSB group	PB group		
6 hours	1 (0-2)	1 (0-2)	-1 to 1	1
12 hours	2 (1-2)	2 (2-4)	0-2	0.074
24 hours	1 (0-2)	2 (2-3)	0-2	<0.001
48 hours	0 (0-0)	1 (0-2)	0-1	<0.001

[Table/Fig-4]: Postoperative VAS scores at rest at different time intervals.
Values are presented as the median with the interquartile range. Statistical analysis: Test used-Mann-Whitney U Test; Abbreviations: IQR: Interquartile range; CI: Confidence Interval

Time interval	VAS scores Median (IQR)		95% CI	p-value
	Group PSB	Group PB		
6 hours	3 (2-4)	3 (3-4)	0-1	0.09
12 hours	3 (2-5)	4 (4-6)	0-2	0.03
24 hours	3 (2-4)	4 (3-5)	0-2	0.007
48 hours	2 (1-3)	3 (2-4)	1-2	<0.001

[Table/Fig-5]: Postoperative VAS scores with 15° hip flexion at different time intervals.
Values are presented as the median with the interquartile range. Statistical analysis: Test used- Mann-Whitney U Test; Abbreviations: IQR: Interquartile range, CI: Confidence interval

Parameter	Time interval	Group PSB	Group PB	p-value
Duration of analgesia (hours)		40 (18-42)	8 (6.5-19.5)	<0.001
Total number of rescue analgesic needed during each time interval	At 6 hours	0 (0-0)	0 (0-0)	0.69
	From 6 to 12 hours	0 (0-0)	0.5 (0-1)	0.03
	From 12 to 24 hours	0 (0-0)	0 (0-1)	0.02
	From 24 to 48 hours	0 (0-0)	0 (0-1)	0.054
Total number of rescue analgesic needed	Within 6 hours	0 (0-0)	0 (0-0)	0.69
	Within 12 hours	0 (0-1)	1 (0-1)	0.061
	Within 24 hours	0 (0-1)	1 (1-2)	0.003
	Within 48 hours	0 (0-1)	1 (1-2)	0.002
Motor blockade	At 6 hours	0 (0-1)	0 (0-1)	0.94
	At 12 hours	0 (0-0)	0 (0-0)	-
	At 24 hours	0 (0-0)	0 (0-0)	-
Number of steps patients were able to walk	At 24 hours	69.43±15.39	43±15.32	<0.0001
	At 48 hours	137.1±30.97	75.9±19.55	<0.0001
Number of quadriceps exercise performed	At 24 hours	9.4±2.1	7.1±2.5	<0.001
	At 48 hours	20.73±4.32	12.17±3.87	<0.0001
Patient satisfaction score	At the end of 48 hours	1.5 (1-3)	4 (3-4)	<0.0001

[Table/Fig-6]: Study parameters.
(Values are presented as mean±SD and median with inter-quartile range. Statistical analysis: Student's t-test and Mann-Whitney U Test; Abbreviations: CI: Confidence interval, DF: Degree of freedom; SD: Standard deviation)

vascular injury, motor blockade, or infection, in either group over 48 hours were encountered.

DISCUSSION

The study demonstrated better, longer-lasting pain relief and reduced demand for rescue analgesics after adding SIFICB to the PENG block during the first 48 hours post-THA, compared with the PENG block alone. The present study aligns with the prior case series we published [9]. Prolonged analgesia with lower pain scores and less consumption of oral morphine were reported by Kukreja P et al., with the group receiving the addition of PENG block to the quadratus lumborum block than the group receiving the quadratus lumborum block alone when used for revision THA [5]. The achievement of comfortable positioning before spinal anaesthesia and adequate postoperative analgesia, which was reported earlier using PENG and FICB individually [7,11-17]. Since its introduction in 2018, the PENG block has shown promising results; however, definitive evidence establishing its superiority over conventional regional analgesic techniques for hip surgery remains lacking. The LFCN blockade is mandated to intensify analgesia at the incisional site during hip surgeries [1,18,19]. Comparing the PENG block to SIFICB yielded mixed results; the PENG block group reported significantly lower VAS scores and a lower need for rescue tramadol, indicating prolonged analgesia [7,17,19]. This could be due to higher analgesic efficacy associated with the PENG block. In contrast, Aliste J et al., Choi YS et al., Koh WU et al., found similar efficacy between the two [16,13,20]. Inconsistent spread of LAs following SIFICB, with sparing of articular branches of the obturator nerve and difficulty in blocking the LFCN with a PENG block, has already been described previously [1,3]. Because the FN is commonly targeted by nerve impulses, adding the PENG block to SIFICB can augment analgesia for patients undergoing hip arthroplasty [21]. Koh WU et al., also recommended choosing the PENG block to cover anterior capsule pain and the SIFICB for lateral thigh coverage [20]. This also suggests that combining both blocks can yield better results, as reflected in significantly longer analgesia across all targeted nociceptive fibres, even with a limited volume of LA in the present study. Conversely, Nuthep L et al., found comparable analgesia with the addition of the PENG block to SIFICB compared with SIFICB alone [10]. This could be due to the inclusion of different patient sets and/or the use of a variable and higher volume of LAs in both groups (30 mL in patients who received SIFICB alone and 40 mL in combined blocks), along with multimodal analgesia.

Studies using the PENG block with variable amounts of LAs (10-30 mL) could mask inconsistencies in the results [12,13,22,23]. The higher the drug volume, the higher the chance of motor blockade. The demonstration of adequate diffusion of 10 mL of injected dye underneath a psoas tendon, as well as above the superior pubic ramus, justifies its analgesic potency while applying the PENG block [16]. This justified the volume of injectate used in the present study. The FICB, via the suprainguinal approach, showed greater analgesic efficacy at lower LA doses, as reported by Yamada K et al., [24]. Data available documenting variable drug volumes for SIFICB ranged from 20 mL to 60 mL, with a requirement of 15.01 mL and 26.99 mL of 0.25% ropivacaine, effective in 50% and 95% of patients, respectively, targeting blockade of the FN and LFCN. In comparison, 40 mL is required to block all three nerves, including the obturator nerve [24-26]. Gasanova I et al., and Desmet M et al., suggested limiting the drug volume to ≤ 30 mL to avoid quadriceps weakness associated with SIFICB [25,27]. Similarly, a 20 mL volume of LA was reported earlier in a cadaveric study to reach the FN and LFCN [28]. This justifies the 20 mL drug volume used for SIFICB in the present study.

The study also observed the preservation of quadriceps strength, facilitation of early ambulation, and improved patient satisfaction within 48 hours after THA with the addition of SIFICB to the PENG block. Adequate muscle strength was preserved in patients in both groups with appropriate volumes of LA. All patients were able to move the hip and knee joints at 6 hours in both groups, suggesting adequate motor-sparing analgesia in the early postoperative period without affecting motor power. Every patient has undergone physiotherapy effectively, with the ability to walk with support preserved after 24 hours, showing reasonable improvement after 48 hours postoperatively. These findings are consistent with the earlier case series [9]. Patients in the PSB group performed more quadriceps exercises and walked more steps at 24 and 48 hours than patients in the PB group. All were discharged on the third day after surgery. Prior literature reported a shorter time to first walk and improved hip mobility in the PENG block group compared with the SIFICB group [7,17,19]. This shows the motor-sparing quality associated with the PENG block. The preservation of motor function with superior analgesia leads to higher median patient satisfaction in the PSB group. Additionally, it helps to overcome the PENG block's wearing-off effect after 24 hours, as demonstrated by Farag A et al., [29].

Limitation(s)

The study's limitations included the inclusion of patients undergoing posterior incisional surgery, a single-centred approach, and the use of a fixed volume of LA. Precise dermatomal involvement from the blockade was also not assessed. Additionally, this study lacks the assessment of recovery after 48 postoperative hours in each group. Further multicentre studies are required to determine the analgesic efficacy of this PSB block in patients undergoing THA via various

approaches, including lateral and anterior approaches, and with different volumes of LAs, for functional analysis and recovery.

CONCLUSION (S)

A combination of PENG and SIFICB yields lower pain scores at rest and with 15° hip flexion throughout the postoperative period following THA. This ultimately led to a longer duration of analgesia and a reduced requirement for rescue analgesics in the first 48 hours postoperatively after THA, compared with the PENG block alone. It also preserves motor function, enabling more quadriceps exercises, and supports early mobilisation, ultimately leading to greater patient satisfaction and fewer complications. Further studies are warranted to establish its safety and efficacy in primary and revision arthroplasty.

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