Systematic Review & Meta-Analysis

Comparison of analgesic effects of pericapsular nerve group block and fascia iliaca compartment block during hip arthroplasty: A systematic review and meta-analysis of randomised controlled trials

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ABSTRACT

Background and Aims: Postoperative pain for patients having hip arthroplasty ranges from moderate to severe. Many regional anaesthesia procedures treat postoperative pain to improve functional ability and quality of life. Evidence comparing the analgesic effects of the pericapsular nerve group (PENG) block and fascia iliaca compartment block (FICB) remains unclear. The analgesic efficacies of PENG and FICB in hip arthroplasty were compared to determine which technique is associated with superior analgesia. **Methods:** The electronic databases (PubMed, Cochrane Library, Google Scholar and Web of Sciences) were searched for published randomised controlled trials (RCTs) till 5 April 2023 comparing PENG block vs. FICB following hip arthroplasty. The primary outcome was pain scores [numerical rating scale (NRS) or visual analogue scale (VAS)] between 0 and 10 at rest and during movement at 24 h. Secondary outcomes included pain scores at rest and during movement within 30 min, at 6 h and 12 h, time to first rescue analgesia and cumulative postoperative opioid use in 24 h. We assessed the risk of bias using the Cochrane Collaboration Risk-of-Bias 2 tool. Using Grading of Recommendations Assessment, Development, and Evaluation (GRADE), the certainty of the evidence was assessed. Subgroup analysis was performed to explore the source of heterogeneity. **Results:** We included 12 RCTs examining 644 patients. Pain scores at rest at 24 h (standardised mean differences (SMDs): 0.17; 95% confidence interval (CI): -0.90 to 1.23; P = 0.76, moderate certainty) and during movement at 24 h (SMD: -0.58, 95% CI: -1.53 to 0.38, P = 0.24, moderate certainty) were not different in both PENG block and FICB. Pain scores at rest and during movement within 30 min may be lower with PENG block than FICB. However, the pain score at rest and during movement at 6 h and the time to first rescue analgesia were not different between the two treatment arms. The mean opioid consumption in oral morphine equivalents (mg) in 24 h may be lower with PENG than FICB. **Conclusion:** We observed no difference between the PENG block and the FICB at 24 h for pain at rest and movement with a moderate degree of certainty. However, PENG block showed improved analgesia within 30 min at rest and during movement, and reduce postoperative opioid consumption in 24 h with moderate certainty of evidence. Further large-scale and high-quality RCTs are required to supplement the present findings.

Keywords: Analgesia, fascia iliaca compartment block, hip arthroplasty, nerve block, pain, pericapsular nerve group

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INTRODUCTION

Postoperative pain for patients having hip arthroplasty ranges from moderate to severe.[1] Various studies reported the increased risk of perioperative difficulties and their negative impact on long-term prognosis. Many regional anaesthesia procedures treat postoperative pain to improve functional ability and quality of life. In 1989, Dalens and colleagues first described the fascia iliaca compartment block (FICB), which blocks the femoral nerve (FN), obturator nerve (ON) and lateral femoral cutaneous nerve (LCN) of the thigh at the same time.[2] The FICB, one of many localised analgesic procedures, is favoured by anaesthesiologists to provide acute and postoperative analgesia for hip fractures.[3] Recently, Girón-Arango *et al*.[4] described the pericapsular nerve group (PENG) block as an alternative regional anaesthesia technique to manage acute pain following a hip fracture. PENG acts by blocking the FN, ON and accessory ON (AON), where a local anaesthetic is injected into the myofascial plane located between the psoas muscle anteriorly and the pubic ramus posteriorly.[4]

Evidence comparing the analgesic effects of these techniques remains unclear. Numerous studies demonstrated that PENG block provided a better analgesic effect than FICB.[5-13] Recently, one study found that PENG block may have equivalent analgesic effects to FICB[14]; however, another study found that the analgesic effect was lower with FICB at different time intervals, while no intergroup differences were seen at other time intervals.[15] These issues challenge clinicians trying to use the best evidence to guide their clinical practice. We performed a systematic review and meta-analysis of randomised controlled trials (RCTs) to compare the efficacy of PENG versus (vs.) FICB for patients undergoing hip arthroplasty.

METHODS

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[16] were followed while conducting this study, which was registered prospectively in International Prospective Register of Systematic Reviews (PROSPERO) (CRD42022336392). At the time of protocol registration, there were no primary time points for pain scores, but following a literature search, we decided that the time point of 24 h is clinically relevant for both pain scores and opioid consumption. We also planned to perform subgroup analyses based on the type of FICB and type of surgeries.

Literature search

A systematic search was performed in electronic databases including PubMed (Medical Literature Analysis and Retrieval System Online (MEDLINE)), Web of Sciences (Clarivate Analytics), Cochrane Library of Controlled Trials and Google Scholar from inception until 5 April 2023. For unpublished data on ClinicalTrials.gov, ctri.nic.in and the International Clinical Trials Registry Platform (ICTRP) enquiries were done through mail. We searched using keywords, controlled vocabulary (Medical Subject Headings (MeSH)) and Boolean operators such as "hip surgery or hip arthroplasty," "pericapsular nerve group (PENG) block," and "fascia iliaca compartment block (FICB)." Furthermore, we manually searched the citations of the selected studies to identify any additional eligible studies. Supplementary Table 1 displays the search terms. Full reports of RCTs were identified in which PENG block and FICB were compared for hip arthroplasty. The criteria for inclusion and exclusion were established *a priori*. We included only RCTs published in English; patients who underwent hip surgery and were over the age of 18 years and reported any clinical outcomes of interest. We excluded case reports, case series, review articles, comments, letters to the editor, abstracts and conference presentations.

Population—patients undergoing hip arthroplasty (any type of hip surgery).

Intervention—PENG block.

Comparator—FICB.

Outcomes—our primary outcome was the pain score (1–10) as measured by the numeric rating scale (NRS) or visual analogue scale (VAS) at rest and during movement at 24 h, which was clinically important. However, we also captured pain scores at rest and during movement within 30 min, at 6 h and 12 h, as well as time to first rescue analgesia (hours) and consumption of cumulative oral equivalents of morphine (milligram) 24 h postoperatively.

Assessment of the methodological quality

We assessed the risk of bias using the Cochrane Collaboration Risk-of-Bias 2 tool[17] in duplicate (JP and AKY) to evaluate the methodological quality of each included RCT. We assessed the risks associated with selection bias (such as randomised sequence generation and allocation concealment), performance and detection bias (such as blinding), attrition

Table 1: Characteristics of included trials

Reference	Country	Group (number)	Block performed (Technique, volume)		Local anaesthetic given for PENG/FICB	Mode of anaesthesia	Types of surgery	Postoperative analgesia	Primary outcome
			PENG	FICB					
Aliste 2021[15]	Chile	PENG (20) FICB (20)	USG-guided PENG, 20 ml	USG-guided suprainguinal FICB, 40 ml	0.5% levobupivacaine with epinephrine 5 mcg/ml/0.25% levobupivacaine with epinephrine 5 mcg/ml	Spinal anaesthesia before block (i.e. 2 mL of bupivacaine heavy 0.5%) and 20 µg of fentanyl	THA	Intravenous morphine	Incidence of quadriceps Motor block (at 6 h) Secondary outcomes included static (at rest) and dynamic (with hip adduction) NRS scores
Choi 2022[14]	Korea	PENG (27) FICB (27)	USG-guided PENG, 20 ml	USG-guided suprainguinal FICB, 30 ml	Ropivacaine 0.2% with epinephrine 1:200,000 (5 µg/ml)/ropivacaine 0.2% with epinephrine1:200,000 (5 µg/ml)	General anaesthesia before block	THA	Intravenous fentanyl (converted to equivalent morphine)	NRS scores at rest and during 45◦ passive flexion of the hip up to 48 h following surgery
Jadon 2021[7]	India	PENG (33) FICB (33)	USG-guided PENG, 20 ml	USG-guided suprainguinal FICB, 20 ml	0.25% bupivacaine/0.25% bupivacaine	Spinal anaesthesia after block (1.8 ml bupivacaine (heavy) 0.5%- and 0.4-ml fentanyl (20 µg)	Positioning	Intravenous paracetamol	NRS at rest and on passive 15° limb lifting 30 minutes after the block and ease of spinal positioning
Mosaffa 2022[6]	Iran	PENG (30) FICB (22)	USG-guided PENG, 3 ml/kg	USG-guided infrainguinal FICB, 3 ml/kg (maximum of 40 ml)	0.5% ropivacaine/0.5% ropivacaine	Spinal anaesthesia after block	DHS fixation, gamma nail and screw fixation	Intravenous morphine	Evaluation of PENG in comparison with FICB in terms of VAS score
Natrajan 2022[8]	India	PENG (12) FICB (12)	USG-guided PENG, 20 ml	USG-guided infrainguinal FICB, 20 ml	0.5% ropivacaine/0.5% ropivacaine	Spinal anaesthesia after block	DHS fixation or hemiarthroplasty	Intravenous paracetamol	Evaluation of efficacy of postoperative analgesia in PENG versus FICB in terms of NRS score
Hua 2022[5]	China	PENG (24) FICB (24)	USG-guided PENG, 20 ml	USG-guided infrainguinal FICB, 30 ml	0.4% ropivacaine/0.4% ropivacaine	Spinal anaesthesia after block 2–2.5 mL of 0.5% bupivacaine hydrochloride heavy	Hemiarthroplasty or THA	Intravenous sufentanil	Evaluation of efficacy of postoperative analgesia in PENG versus FICB in terms of static and dynamic VAS score
Senthil 2022[9]	India	PENG (20) FICB (20)	USG-guided PENG, 30 ml	USG-guided infrainguinal FICB, 30 ml	0.25% levobupivacaine and 4 mg dexamethasone/0.25% levobupivacaine with 4 mg dexamethasone	Spinal anaesthesia after block 3–3.5 mL of 0.5% bupivacaine hydrochloride heavy	DHS fixation and proximal femur nailing	Intravenous fentanyl	Evaluation of efficacy of postoperative analgesia in PENG versus FICB in terms of VAS score
Kulkarni 2022[23]	India	PENG (30) FICB (30)	USG-guided PENG, 20 ml	USG-guided suprainguinal FICB, 20 ml	0.25% bupivacaine/0.25% bupivacaine	Spinal anaesthesia after block	Positioning	Not specified	Assessment of pain using NRS score before, after and during placement in sitting position
Shankar 2020[10]	India	PENG (30) FICB (30)	USG-guided PENG, 25 ml	USG-guided suprainguinal FICB, 25 ml	0.25% ropivacaine/0.25% ropivacaine	Spinal anaesthesia after block 3 mL of 0.5% bupivacaine hydrochloride heavy	Positioning	Intravenous tramadol	Assessment of pain using VAS score before and after block and postoperative analgesia
Kalashetty 2022[13]	India	PENG (45) FICB (45)	USG-guided PENG, 20 ml	USG-guided suprainguinal FICB, 30 ml	0.25% bupivacaine/0.25% bupivacaine	Spinal anaesthesia after block 2 mL of 0.5% bupivacaine hydrochloride heavy	IT/arthroplasty/ CRIF	Not specified	Evaluation of efficacy of postoperative analgesia 30 min post-PENG versus FICB in terms of static and dynamic VAS score

Contd...

Table 1: Continued...

Reference	Country	Group (number)	Block performed (Technique, volume)		Local anaesthetic given for PENG/FICB	Mode of anaesthesia	Types of surgery	Postoperative analgesia	Primary outcome
			PENG	FICB					
Vamshi 2023[12]	India	PENG (30) FICB (30)	USG-guided PENG, 30 ml	USG-guided suprainguinal FICB, 30 ml	0.25% bupivacaine with 1 µg/kg clonidine/0.25% bupivacaine with 1 µg/kg clonidine	General anaesthesia after block	THA	Intravenous morphine	Evaluation of efficacy of postoperative analgesia in PENG versus FICB in terms of dynamic NRS score
Kong 2022[11]	India	PENG (25) FICB (25)	USG-guided PENG, 30 ml	USG-guided suprainguinal FICB, 30 ml	0.375% ropivacaine/0.375% ropivacaine	General anaesthesia after block	PFNA	Intravenous fentanyl	Evaluation of efficacy of postoperative analgesia in PENG versus FICB in terms of static and exercise VAS score

USG—ultrasonography, PENG—pericapsular nerve group block, FICB—fascia iliaca compartment block, DHS—dynamic hip screw, THA—total hip arthroplasty, PFNA—proximal femoral nail antirotation, NRS—numeric rating scale, VAS—visual analogue scale, CRIF - closed reduction and internal fixation

bias (such as incomplete outcome data), reporting bias (such as selective reporting) and other biases.

Data extraction

Using a pre-defined proforma, data were extracted individually by the two authors (JP and AKY), and disagreements, if any, were resolved by consultation with the third author (AK). Bibliographical information (author, year and country), the technique of block performed, local anaesthetic with or without adjuvants, mode of anaesthesia, types of surgeries, types of postoperative analgesia, description of intervention and comparator and number of participants and pain-related outcomes (NRS or VAS score and opioid requirement at 24 h and the time to first rescue analgesia) were among the data extracted. Values for several events, mean with standard deviation (SD), standard error and 95% confidence interval (CI) for different parameters were extracted from texts, tables and images from the studies that met inclusion criteria. We contacted the corresponding author of a few articles[6–9] to get the information required. If necessary, the mean with SD was estimated using the recommended formula using the given median and interquartile range (IQR).[18] Values for opioids were converted to an equianalgesic oral morphine dosage (mg) by established practice.[19] As indicated previously, WebPlotDigitizer was used to extract data from graphical representations.[20,21]

Evidence for outcomes' quality

We assessed the certainty of evidence using the Grades of Recommendation, Assessment, Development and Evaluation (GRADE) approach in duplicate (BR and JP), which considered study design, indirectness, imprecision, inconsistency and publication bias, among other things, and discrepancies were resolved through discussion. According to GRADE, pooled data from RCTs start as high certainty and may be rated down to moderate, low or very low if issues are identified.[22]

Statistical analysis

For conducting a meta-analysis, we used RevMan version 5.3.5 (Copenhagen, The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). To pool the data for continuous outcomes with various units, standardised mean difference (SMD) with 95% CI was employed, and for the same units, mean difference (MD) was used. If there was low heterogeneity, it was assumed that the true effects of the intervention were the same in all included trials, and a fixed-effect model was chosen to reflect the best estimate of the intervention

effect. However, in high heterogeneity, we have chosen a random-effects model. Because the effect size for the outcomes is clinically relevant, we estimated the SMD for continuous variables using a random-effect model. The random-effects model was adopted in the analysis due to the intrinsic heterogeneity of block performance by different practitioners. We used a random-effect model and the DerSimonian and Laird approach to account for potential trial variation. Statistical heterogeneity (inconsistency) was assessed using four parameters: I-statistic, Chi-squared test, visual inspection of point estimates and visual inspection of CI overlap. To explore heterogeneity between studies, the I^2 measure was used. We used Begg's test and Egger's test for publishing bias. We conducted a sensitivity analysis to assess the stability of pooled data by eliminating one trial at a time. Subgroup analysis was conducted based on the types of surgeries and types of FICB to explore the possible sources of heterogeneity if there was significant heterogeneity.

RESULTS

Selection of study

Following the search, we initially identified 2960 studies; no additional records were found through other sources. We reviewed 984 full texts and included 12 RCTs[5-15,23] in the analysis [Figure 1]. These RCTs included 644 participants, 326 who underwent PENG block and 318 who received FICB.

Characteristics of included studies

During total hip arthroplasty (THA) or hip surgery, PENG block and FICB were administered under ultrasound guidance. Levobupivacaine 0.5% and epinephrine 5 μg/ml were administered in one trial for PENG block.

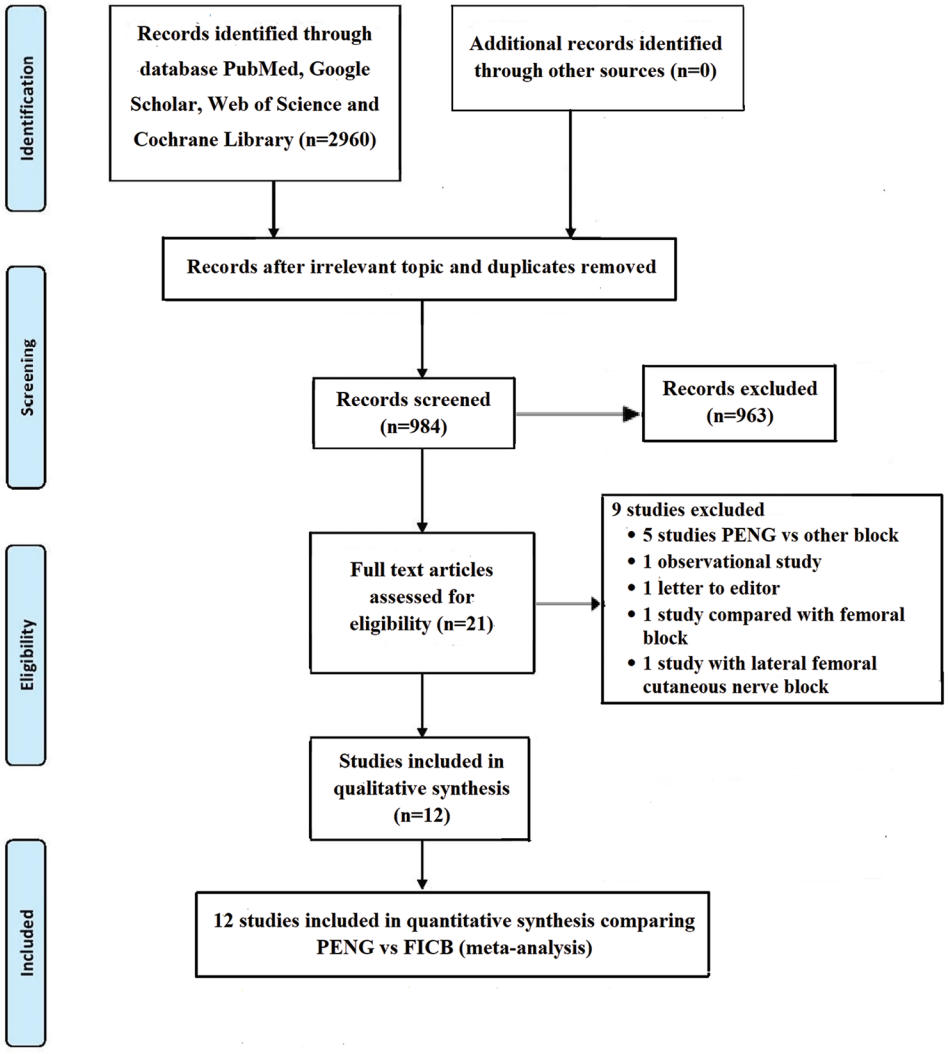

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram. PENG- pericapsular nerve group block, FICB- fascia iliaca compartment block, n-number of articles, vs-versus

However, 0.25% levobupivacaine and epinephrine 5 μg/ml were used for FICB.[15] One study used ropivacaine 0.2% with epinephrine 1:200,000 (5 μg/ml) for both blocks.[14] Two studies used ropivacaine 0.5% for both blocks[6,8]; however, one study used ropivacaine 0.4% for both blocks,[5] and one study used ropivacaine 0.25% for both blocks.[10] Three studies used bupivacaine 0.25% for both blocks[7,13,23]; however, one study used levobupivacaine 0.25% with dexamethasone 4 mg as an adjuvant for both blocks,[9] one study used 0.25% bupivacaine with 1 μg/kg clonidine[12] and another study used 0.375% ropivacaine.[11] The patients who were a part of the studies had ages ranging from 50 years to 74 years on average. All of the reviewed studies evaluated postoperative pain throughout a range of times. In five studies, pain was assessed using VAS,[5,6,10,11,13] whereas the other seven used the NRS.[7–9,12,14,15,23] The characteristics of the included studies are shown in Table 1.

Risk-of-bias assessment

The article by Natrajan *et al*.[8] was observed to have low quality due to improper random sequence generation and ambiguous selective reporting. The risk of bias using Cochrane's Risk-of-Bias tool is summarised in Figure 2. One study[23] revealed a high risk of bias in outcome assessment blinding (detection bias). In comparison, one study[8] showed a high risk of bias in random sequence generation (selection bias) and selective reporting (reporting bias). These two studies with a high risk of bias are highlighted in red. Indicators of low risk of bias are highlighted in green, while those of unclear risk of bias are highlighted in yellow. Despite a few flaws, such as allocation concealment and other types of bias, most of the studies included had high quality overall.

Quality of evidence for outcomes

To evaluate outcomes, we used the GRADE method. Pain scores at rest and during movement within 30 min and 24 h and cumulative postoperative oral morphine equivalent intake in 24 h demonstrated moderate quality of evidence. It was observed that pain scores at 6 h, at rest, during during movement at 12 h and the time to first rescue analgesia were evidence of low quality. Pain scores during movement at 6 h revealed very low quality [Supplementary Table 2].

Evidence is rated by the GRADE Working Group[24]:

A very low—true effect is likely to differ substantially from the estimated effect (uncertain effect).

The low—true effect might be markedly different from the estimated effect (may).

The moderate—true effect is probably close to the estimated effect (probable).

The high—it is highly certain that the true effect is close to the effect estimate.

Outcomes

Postoperative pain scores at rest and during movement at 24 h were reported in eight studies[5-9,11,14,15] and, six studies[5,7,11,12,14,15] respectively [Figure 2]. It was documented at rest within 30 min, at 6 h and 12 h by seven studies,[5-7,10,11,13,23] eight studies[5-9,11,14,15] and six studies,[5-8,10,15] respectively, and during movement at within 30 min, at 6 h and 12 h by nine studies,[5-8,10-13,23] six studies[5,7,11,12,14,15] and four studies,[5,7,12,15] respectively [Table 2].

Primary outcome

Pain scores at rest and during movement at 24 h

There was probably no difference between the pain score in PENG block and FICB at rest (SMD: 0.17; 95% CI: -0.90 to 1.23; $P = 0.76$, moderate certainty) [Figure 3] and during movement at 24 h (SMD: -0.58, 95% CI: -1.53 to 0.38; $P = 0.24$, moderate certainty) [Figure 4].

Secondary outcomes

Pain scores at rest and during movement within 30 min, at 6 h and 12 h

PENG block probably reduces pain scores relative to the FICB at rest within 30 min (SMD: -1.51; 95% CI: -2.28 to -0.73; $P = 0.0001$, moderate certainty). However, it remains unclear whether PENG block reduces pain scores at rest at 6 h (SMD: -0.61, 95% CI: -1.30 to 0.08, $P = 0.08$, low certainty) and at 12 h (SMD: -0.28, 95% CI: -0.66 to 0.09, $P = 0.14$, low certainty) [Supplementary Figure 1].

PENG block probably reduces pain scores relative to the FICB during movement within 30 min (SMD: -0.84; 95% CI: -1.58 to -0.10; $P = 0.03$, moderate certainty); however, it remains unclear during movement at 12 h (SMD: -0.36, 95% CI: -0.69 to -0.03, $P = 0.03$, low certainty, limited by imprecision and inconsistency). There was also no evidence for a difference in the pain score during movement at 6 h (SMD: -0.88, 95% CI: -1.77 to 0.01, $P = 0.05$, very low certainty) between the two treatment arms [Supplementary Figure 2].

Time to first rescue analgesia

Four studies[6-8,10] looked at 202 patients and reported the first rescue analgesia time (h). In the pooled

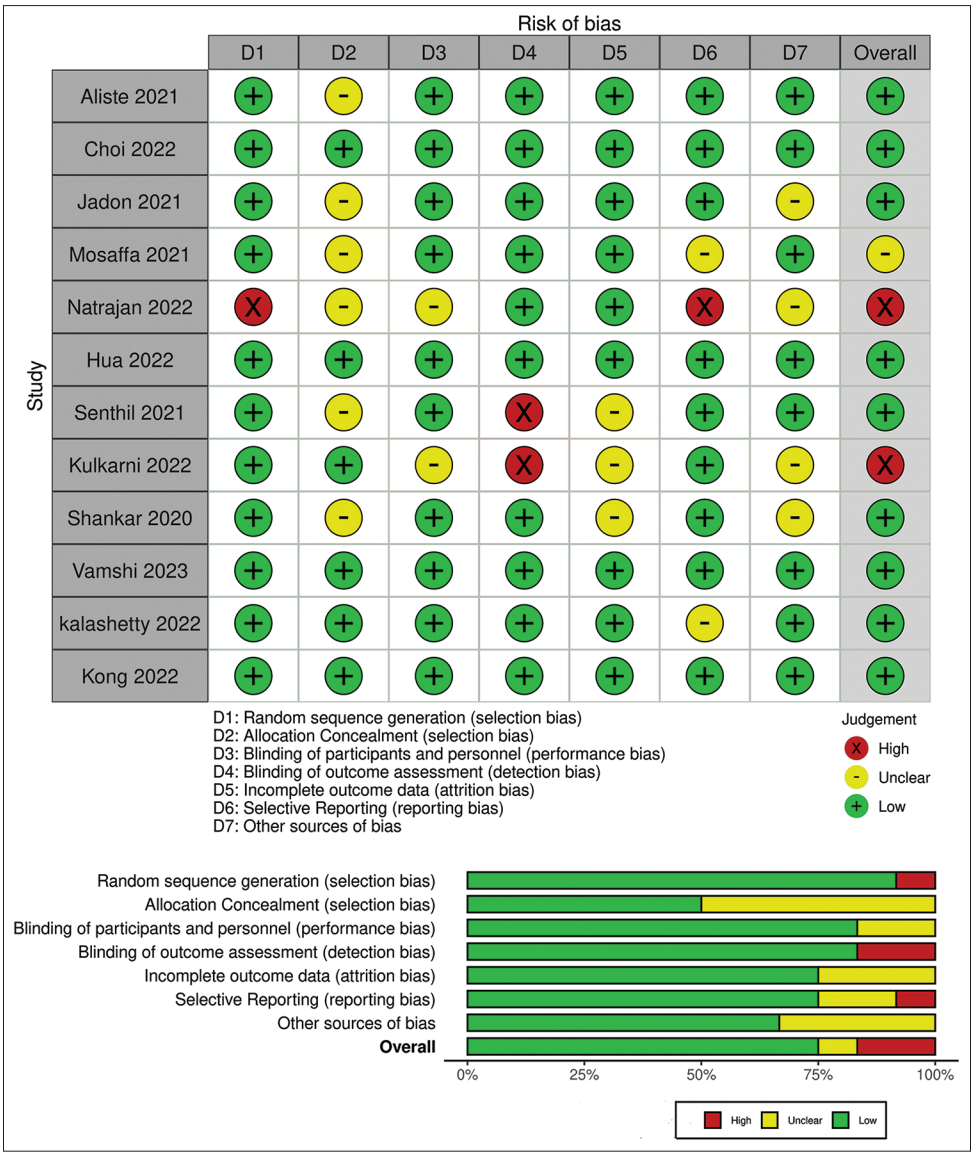

Figure 2: Risk of bias

Table 2: Meta-analysis of the outcomes

Outcomes	Trials (number)	Patients, number		SMD (95% CI)	I^2 (%)	*P*
		PENG	FICB [S.ing./I.ing]			
Pain scores at rest within 30 min[5-7,10,11,13,23]	7	217	209 [163/46]	-1.51 (-2.28 to -0.73)	92	0.0001
Pain scores during movement within 30 min[5-8,10-13,23]	9	259	251 [193/58]	-0.84 (-1.58 to -0.10)	93	0.03
Pain scores at rest at 6 postoperative hours[5-9,11,14,15]	8	191	183 [105/78]	-0.61 (-1.30 to 0.08)	90	0.08
Pain scores during movement at 6 postoperative hours[5,7,11,12,14,15]	6	159	159 [135/24]	-0.88 (-1.77 to 0.01)	93	0.05
Pain scores at rest at 12 postoperative hours[5-8,10,15]	6	149	141 [83/58]	-0.28 (-0.66 to 0.09)	59	0.14
Pain scores during movement at 12 postoperative hours[5,7,12,15]	4	113	113 [83/30]	-0.36 (-0.69 to -0.03)	10	0.03
Pain scores at rest at 24 postoperative hours[5,7-11,14,15]	8	191	191 [135/56]	0.17 (-0.90 to 1.23)	95	0.76
Pain scores during movement at 24 postoperative hours[5,7,11,12,14,15]	6	159	159 [135/24]	-0.58 (-1.53 to 0.38)	94	0.24
Time to first rescue analgesia[6-8,10]	4	105	97 [63/34]	1.07 (-0.07 to 2.21)	92	0.07
Postoperative morphine equivalent consumption within 24 hours[5,6,9-12,14,15]	8	206	198 [132/66]	-5.83 (-9.63 to -2.03)	88	0.003

PENG—pericapsular nerve group block, FICB—fascia iliaca compartment block, S.ing.—suprainguinal, I.ing.—infrainguinal, CI—confidence interval, I^2—heterogeneity, SMD—standardised mean difference

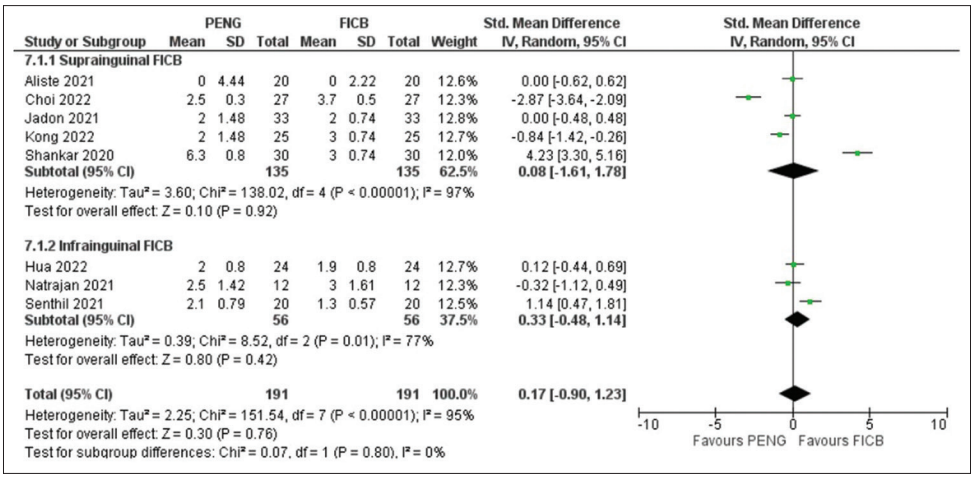

Figure 3: Forest plot for pain score at rest at 24 h

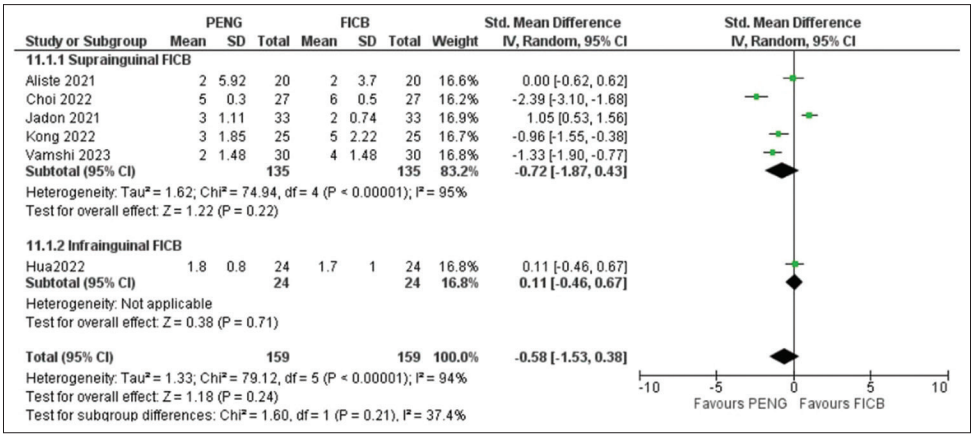

Figure 4: Forest plot for the pain score during movement at 24 h

analysis, benefit remains unclear for time to first analgesic request for patients given PENG as compared to FICB (MD: 1.07; 95% CI: -0.07 to 2.21; $P = 0.07$, low certainty) [Supplementary Figure 3].

Postoperative opioid consumption in 24 hours

Eight studies documented opioid usage 24 h postoperatively.[5,6,9-12,14,15] The mean cumulative opioid consumption in oral morphine equivalents (milligram) was probably less with PENG as compared to FICB in 24 h (MD: -5.83; 95% CI: -9.63 to -2.03; $P = 0.003$, moderate certainty) [Supplementary Figure 4].

Subgroup analysis

Our subgroup analysis is based on different types of FICB comparators (infrainguinal vs suprainguinal). We found no difference between PENG block and FICB at 24 h, both at rest and during movement in infrainguinal vs suprainguinal FICB. However, PENG block was better at reducing pain at rest within 30 min (SMD: -1.38, 95% CI: -2.28 to -0.48, $P = 0.003$) in suprainguinal FICB and no difference was noted in infrainguinal FICB. A similar effect was also observed with the pain score during movement within 30 min (SMD: -1.09, 95% CI: -1.98 to -0.21, $P = 0.02$) [Figures 3, 4, Supplementary Figures 1 and 2].

Subgroup analysis based on different types of surgeries showed that there was no difference in pain scores between PENG block and FICB at rest at 24 h; however, pain score was less with PENG block in proximal femoral nail antirotation (PFNA) (SMD: -0.84, 95% CI: -1.42 to -0.26, one study). It was observed that pain scores at rest within 30 min were less with PENG block in positioning (SMD: -1.12, 95% CI: -2.11 to -0.13, $P = 0.03$, three studies); however, pain scores within 30 min on movement were less with PENG block in total hip arthroplasty (THA) (SMD: -1.24, 95% CI: -2.39 to -0.08, $P = 0.04$, two studies) and positioning (SMD: -1.30, 95% CI: -2.29 to -0.31, $P = 0.01$, three studies) [Supplementary Figures 5 and 6].

The time for the first rescue analgesic request was longer in PENG than in infrainguinal FICB and

dynamic hip screw (DHS) (MD: 3.04; 95% CI: 1.02 to 5.07; two studies) [Supplementary Figures 3 and 7]. The postoperative cumulative oral morphine equivalent consumption (milligram) in 24 h was less in infrainguinal FICB (MD: -9.72; 95% CI: -18.39 to -1.05; three studies), DHS (MD: -14.04; 95% CI: -23.31 to -4.76; two studies) and THA (MD: -4.34, 95% CI: -7.03 to -1.66, three studies) [Supplementary Figures 4 and 8].

Publication bias and sensitivity analysis

Begg's test and Egger's test showed that the *P* value regarding pain scores at rest and on movement within 30 min, 6 h, 12 h and 24 h was more than 0.05 [Supplementary Table 3], which demonstrated that no publication bias existed in the outcome of pain scores.

The sensitivity analyses, excluding one study at a time, for pain scores at rest and during movement at various time intervals, time to first rescue analgesia and postoperative oral morphine equivalent intake in 24 h, were subjected to sequential analyses to evaluate the stability of the results. For the pain score outcome at 24 h, the sensitivity analysis did not observe any significant effect of any individual study. The rest of the sensitivity analysis is shown in Supplementary Table 4. The pain score before the nerve block at rest (baseline) is shown in Supplementary Table 5 to compare the pain score after the PENG block and FICB.

DISCUSSION

In accordance with the pooled data, there was no difference between the PENG block and the FICB at 24 h, both at rest and during movement. The pooled result suggests that PENG block and FICB have similar analgesic efficacy at 24 h, which is clinically important among the time points in the included studies. However, PENG block showed improved analgesia within 30 min at rest and during movement and reduced postoperative opioid consumption in 24 h with moderate certainty of evidence. A PENG block within 30 min will have a greater analgesic impact, which may help position the patient, particularly if given before spinal anaesthesia when the patient needs to be in a sitting or lateral decubitus position.

Regional anaesthesia is employed more frequently to deliver persistent analgesia in early postoperative period due to the developing applications of rapid recovery and the awareness of opioid-associated perioperative side effects. However, the "gold standard" regional anaesthesia for hip surgery is not yet agreed upon. The effectiveness of these two regional modalities was compared in the current meta-analysis to determine which approach is associated with superior analgesia.

The pain score during movement at 12 h was low in the PENG block. However, certainty was limited by imprecision and inconsistency. The time to first rescue analgesia and postoperative pain score both at rest and during movement at time intervals of 6 h and at rest at 12 h were similar across both regional modalities. The overall certainty of evidence in our analysis was low to moderate.

The high heterogeneity of the pooled analysis limits how reliable the result is; hence, we did a subgroup analysis. In the subgroup analysis, we did not observe differences between PENG block and suprainguinal or infrainguinal FICB at 24 h. However, the PENG block was more effective when compared with suprainguinal FICB at rest and during movement within 30 min. It seems that suprainguinal FICB is a better alternative for positioning the patient than infrainguinal FICB. However, the effect is more pronounced when compared to one vs. another group. Subgroup analysis based on the types of surgeries showed that pain scores at rest and during movement may be lower with PENG with positioning within 30 min. A similar effect was observed with THA within 30 min and at 12 h on movement, but the certainty was limited by imprecision and inconsistency.

Numerous studies assessed pain scores at 12 h and 24 h after surgery, but, by then, the acute postoperative pain peak associated with hip arthroplasty had already subsided.[25] It was observed that many studies pay little attention to the important first few hours of severe discomfort. Instead, random late time points are picked to evaluate the patient. In the future, it might be helpful to include time points between 0 and 8 h postoperatively in analgesic studies related to elective THA to ensure that early postoperative severe pain is considered. Severe acute pain after elective THA is time-limited.[25]

On sensitivity analysis, we did not observe any significant effect of any individual study on pain scores resulting at 24 h and postoperative oral morphine equivalent consumption. The current study's findings were also strengthened by the lack of publication bias observed in Begg's and Egger's tests. However, the quality of evidence was moderate for reducing pain

using PENG block compared with FICB at 24 h at rest and during movement.

Questions about characterising the anatomical basis of the PENG block are important. Histologically, the posterior capsule lacks sensory fibres and mostly comprises mechanoreceptors, while the anterior capsule primarily contains nociceptive fibres.[26] According to an anatomical study, the area of the joint with the greatest density of innervation is the anterior hip capsule.[26] High branches of the FN and ON innervate the anterior hip capsule, which suggests that these nerves are the main targets for hip analgesia. PENG is an interfascial plane block that prevents the FN, ON and AON from supplying articular branches.[27] PENG covers more hip joint articular nerves than FICB, so the block offers superior analgesia.

In a recently published meta-analysis,[28] only six studies were included; however, three RCTs[7,10,23] were excluded, and subgroup analysis in different surgeries was not conducted. MD was used for the pooled analysis of pain scores; however, in the included studies, both VAS and NRS were given. In another recently published meta-analysis,[29] subgroup analysis was not conducted, and one observational study[30] was included in the data analysis, although this was excluded in PRISMA. However, in the current meta-analysis, we used SMD for pain scores for pooled analysis (pain scores as 10-point scale VAS or NRS), and for time to first rescue analgesic request and oral morphine equivalent (mg), MD was used.

The findings of the current meta-analysis are limited by an impression that limits the certainty of evidence and could be improved by including more studies. The effect size for better analgesic effects might be moderate, and to detect those effects, well-conducted RCTs are required. The inconsistency between the studies was also high in most outcomes, suggesting variation in the study population characteristics and settings. The various factors such as differences in population characteristics and interventions might cause the high heterogeneity obtained in the present study.

As compared to conventional intravenous opioids, a peripheral nerve block is a preferred approach in the enhanced recovery after surgery protocol because it can minimise pain, hasten mobilisation and use of opioids and their associated side effects in early postoperative period.[31]

Limitations of the current study include a small sample size of the individual RCTs included in the study. There were only 644 participants in total across twelve RCTs. Second, adjuvants were used with local anaesthetic in some of the trials. Third, in a few trials, the volume, types and adjuvants of local anaesthetic varied. The number of studies was not adequate to account for subgroup analysis. Although there was a significant difference soon after surgery, we do not believe that it had an effect on our pain-related outcomes because the higher volume would be expected to increase the time till the first analgesic request. Fourth, several studies lacked clear information on the possibility of bias from selection and other causes. Fifth, we did not do subgroup analysis based on risk of bias because only a few items were classified as high risk of bias.

CONCLUSION

We observed no difference between the PENG block and the FICB at 24 h of rest and movement with a moderate degree of certainty. However, PENG block showed improved analgesia within 30 min at rest and during movement, and reduce postoperative opioid consumption in 24 h with moderate certainty of evidence. Further large-scale and high-quality RCTs emphasising particular types of surgical interventions and uniform comparative groups are required to supplement the present findings to reach the most effective conclusion.

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Conflicts of interest

There are no conflicts of interest.

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SUPPLEMENTAL DIGITAL CONTENT [FOR ONLINE]

Supplementary Table 1: Search strategy

((((((PENG) OR (FICB)) OR (Pericapsular Nerve Block)) OR (supra-inguinal fascia iliaca)) OR (pericapsular nerve block)) OR (pericapsular nerve group block)) OR (fascia iliaca compartment block)) AND (((Hip arthroplasty OR hip fracture OR spinal OR hip surgeries OR Femur fracture OR Analgesia OR Hip fractures OR Local anaesthetics)))

("PENG"[All Fields] OR "FICB"[All Fields] OR ("Pericapsular"[All Fields] AND ("nerve block"[MeSH Terms] OR ("nerve"[All Fields] AND "block"[All Fields]) OR "nerve block"[All Fields])) OR ("supra-inguinal"[All Fields] AND ("fascia"[MeSH Terms] OR "fascia"[All Fields] OR "fasciae"[All Fields] OR "fascias"[All Fields]) AND "iliaca"[All Fields]) OR ("Pericapsular"[All Fields] AND ("nerve block"[MeSH Terms] OR ("nerve"[All Fields] AND "block"[All Fields]) OR "nerve block"[All Fields])) OR ("Pericapsular"[All Fields] AND ("nerve"[All Fields] OR "nerve s"[All Fields] OR "nerved"[All Fields] OR "nerves"[All Fields]) AND ("group s"[All Fields] OR "grouped"[All Fields] OR "grouping"[All Fields] OR "groupings"[All Fields] OR "groups s"[All Fields] OR "population groups"[MeSH Terms] OR ("population"[All Fields] AND "groups"[All Fields]) OR "population groups"[All Fields] OR "group"[All Fields] OR "social group"[MeSH Terms] OR ("social"[All Fields] AND "group"[All Fields]) OR "social group"[All Fields] OR "groups"[All Fields]) AND ("block"[All Fields] OR "blocked"[All Fields] OR "blocking"[All Fields] OR "blockings"[All Fields] OR "blocks"[All Fields])) OR (("fascia"[MeSH Terms] OR "fascia"[All Fields] OR "fasciae"[All Fields] OR "fascias"[All Fields]) AND "iliaca"[All Fields] AND ("compartment"[All Fields] OR "compartment s"[All Fields] OR "compartments"[All Fields]) AND ("block"[All Fields] OR "blocked"[All Fields] OR "blocking"[All Fields] OR "blockings"[All Fields] OR "blocks"[All Fields]))) AND ((("hip"[MeSH Terms] OR "hip"[All Fields]) AND ("arthroplasty"[MeSH Terms] OR "arthroplasty"[All Fields] OR "arthroplasties"[All Fields])) OR ("hip fractures"[MeSH Terms] OR ("hip"[All Fields] AND "fractures"[All Fields]) OR "hip fractures"[All Fields] OR ("hip"[All Fields] AND "fracture"[All Fields]) OR "hip fracture"[All Fields]) OR ("spinal"[All Fields] OR "spinalization"[All Fields] OR "spinalized"[All Fields] OR "spinally"[All Fields] OR "spinals"[All Fields]) OR (("hip"[MeSH Terms] OR "hip"[All Fields]) AND ("surgery"[MeSH Subheading] OR "surgery"[All Fields] OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "general surgery"[MeSH Terms] OR ("general"[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields] OR "surgery s"[All Fields] OR "surgerys"[All Fields] OR "surgeries"[All Fields])) OR ("femoral fractures"[MeSH Terms] OR ("femoral"[All Fields] AND "fractures"[All Fields]) OR "femoral fractures"[All Fields] OR ("femur"[All Fields] AND "fracture"[All Fields]) OR "femur fracture"[All Fields]) OR ("analgesia"[MeSH Terms] OR "analgesia"[All Fields] OR "analgesias"[All Fields]) OR ("hip fractures"[MeSH Terms] OR ("hip"[All Fields] AND "fractures"[All Fields]) OR "hip fractures"[All Fields]) OR ("local anaesthetics"[All Fields] OR "anesthetics local"[Pharmacological Action] OR "anesthetics local"[Supplementary Concept] OR "anesthetics local"[All Fields] OR "local anesthetics"[All Fields] OR "anesthetics, local"[MeSH Terms] OR("anesthetics"[All Fields] AND "local"[All Fields]) OR ("local"[All Fields] AND "anesthetics"[All Fields])))

Supplementary Table 2: GRADE overall assessment of the quality of evidence for each result							
Outcome	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication bias**	**Quality of evidence**
Pain scores at rest within 30 min	Randomised trials	Not serious	Not serious	Not serious	Serious	Undetected	⊕⊕⊕◯ Moderate
Pain scores at rest at 6 h	Randomised trials	Not serious	Serious	Not serious	Serious	Undetected	⊕⊕◯◯ Low
Pain scores at rest at 12 h	Randomised trials	Not serious	Serious	Not serious	Serious	Undetected	⊕⊕◯◯ Low
Pain scores at rest at 24 h	Randomised trials	Not serious	Not serious	Not serious	Serious	Undetected	⊕⊕⊕◯ Moderate
Pain scores during movement within 30 min	Randomised trials	Serious	Not serious	Not serious	Not serious	Undetected	⊕⊕⊕◯ Moderate
Pain scores during movement at 6 h	Randomised trials	Serious	Serious	Not serious	Serious	Undetected	⊕◯◯◯ Very low
Pain scores during movement at 12 h	Randomised trials	Not serious	serious	Not serious	Serious	Undetected	⊕⊕◯◯ Low
Pain scores during movement at 24 h	Randomised trials	Not serious	Serious	Not serious	Serious	Undetected	⊕⊕⊕◯ Moderate
Time to first rescue analgesia	Randomised trials	Serious	Not serious	Not serious	Serious	Undetected	⊕⊕◯◯ Low
24 h postoperative morphine equivalent consumption	Randomised trials	Not serious	Not serious	Not serious	Serious	Undetected	⊕⊕⊕◯ Moderate

Supplementary Table 3: Begg's test and Egger's test for outcomes									
Time	**Subgroup**	**On rest**			**Eggers *P***	**On movement**			**Egger's *P***
		No. of studies	**Begg's *Z***	***P***		**No. of studies**	**Begg's *Z***	***P***	
<30 min	Infra	3	-0.52	0.6	0.617	4	0.01	0.99	0.63
	Supra	4	-0.68	0.5	0.14	5	-0.98	0.33	0.38
6h	Infra	4	0.1	0.9	0.8	1	-	-	-
	Supra	4	-1.36	0.174	0.08	5	-1.96	0.05	0.07
12h	Infra	3	0.52	0.6	0.9	2	1	0.3	-
	Supra	3	1.57	0.1	0.49	2	-	-	-
24h	Infra	4	0.01	0.99	0.8	2	-1.0	0.3	-
	Supra	4	-1.36	0.2	0.16	3	-1.57	0.1	0.17

No: number

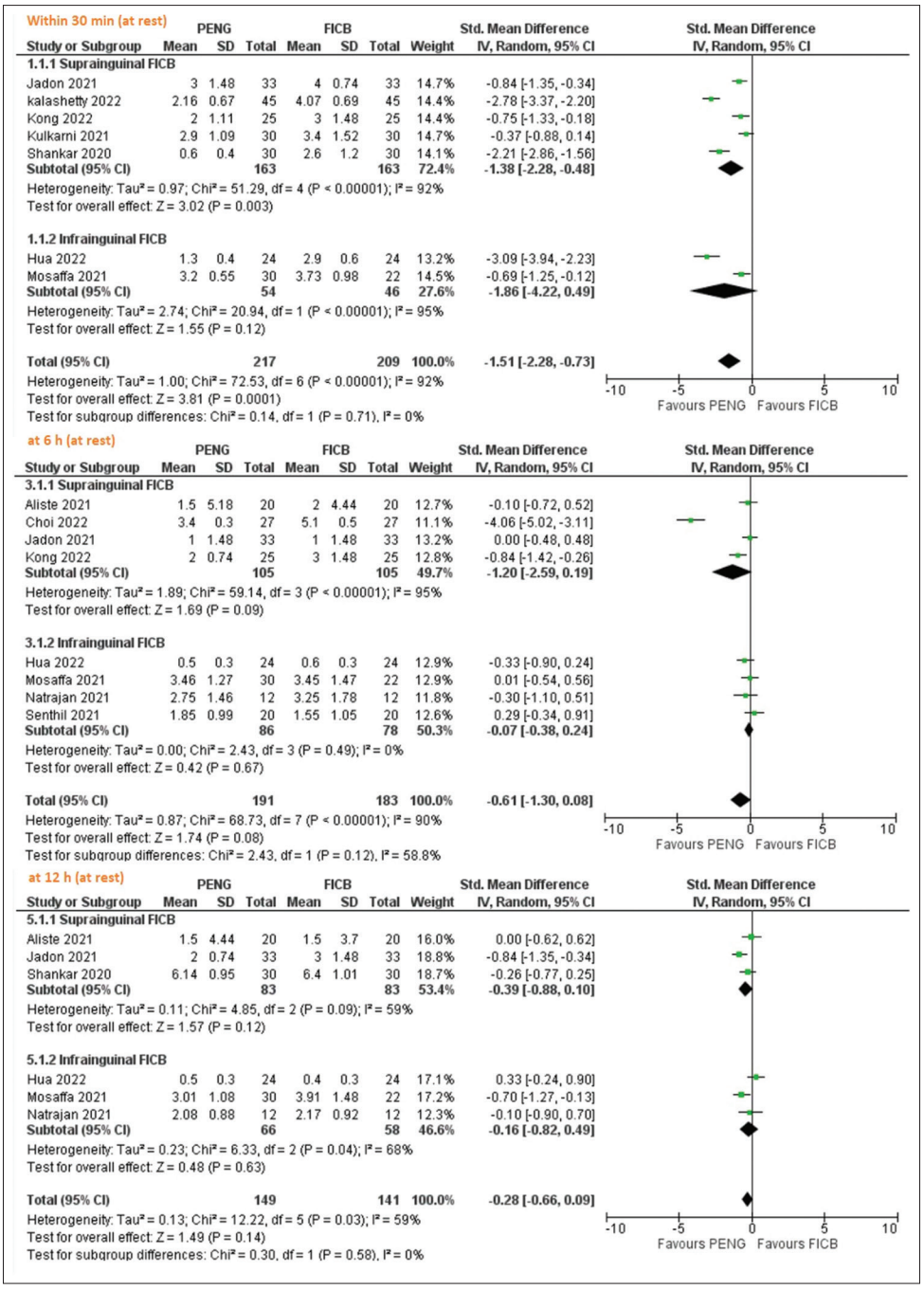
Supplementary Table 4: Sensitivity analysis performed by removing one trial at a time					
Outcomes	**Excluded study**	***Z***	***P*-value for difference**	***I*²**	***P*-value for heterogeneity**
Pain scores at rest within 30 min	Mosaffa *et al.*	3.63	0.0003	93	<0.00001
	Jadon *et al.*	3.46	0.0005	93	<0.00001
	Hua *et al.*	3.27	0.001	91	<0.00001
	Kulkarni *et al.*	3.99	<0.0001	91	<0.00001
	Shankar *et al.*	3.21	0.001	92	<0.00001
	Kalashetty *et al.*	3.50	0.0005	89	<0.00001
	Kong *et al.*	3.58	0.0003	93	<0.00001
Pain scores during movement within 30 min	Mosaffa *et al.*	2.37	0.02	93	<0.00001
	Jadon *et al.*	1.82	0.07	94	<0.00001
	Hua *et al.*	1.78	0.08	93	<0.00001
	Natrajan *et al.*	2.7	0.007	93	<0.00001
	Kulkarni *et al.*	2.09	0.04	94	<0.00001
	Shankar *et al.*	1.74	0.08	93	<0.00001
	Kalashetty *et al.*	1.79	0.07	91	<0.00001
	Kong *et al.*	2.68	0.007	92	<0.00001
	Vamshi *et al.*	1.99	0.05	94	<0.00001
Pain scores at rest at 6 postoperative hours	Choi *et al.*	1.28	0.20	30	0.20
	Aliste *et al.*	1.72	0.09	91	<0.00001
	Jadon *et al.*	1.72	0.09	91	<0.00001
	Hua *et al.*	1.61	0.11	91	<0.00001
	Mosaffa *et al.*	1.75	0.08	91	<0.00001
	Natrajan *et al.*	1.68	0.09	91	<0.00001
	Senthil *et al.*	1.91	0.06	91	<0.00001
	Kong *et al.*	1.46	0.14	91	<0.00001
Pain scores during movement at 6 postoperative hours	Choi *et al.*	1.34	0.18	87	<0.00001
	Aliste *et al.*	1.98	0.05	94	<0.00001
	Jadon *et al.*	1.95	0.05	93	<0.00001
	Hua *et al.*	2.11	0.04	93	<0.00001
	Kong *et al.*	1.39	0.16	92	<0.00001
	Vamshi *et al.*	1.62	0.11	94	<0.00001
Pain scores at rest at 12 postoperative hours	Aliste *et al.*	1.53	0.13	64	0.003
	Jadon *et al.*	0.88	0.38	41	0.15
	Hua *et al.*	2.5	0.01	37	0.17
	Mosaffa *et al.*	0.92	0.36	60	0.04
	Natrajan *et al.*	1.42	0.16	66	0.02
	Shankar *et al.*	1.18	0.24	67	0.02
Pain scores during movement at 12 postoperative hours	Aliste *et al.*	2.16	0.03	22	0.26
	Jadon *et al.*	2.11	0.03	10	0.33
	Hua *et al.*	1.42	0.15	48	0.17
	Vamshi *et al.*	0.92	0.36	0	0.71
Pain scores at rest at 24 postoperative hours	Choi *et al.*	1.20	0.23	94	<0.00001
	Aliste *et al.*	0.30	0.76	96	<0.00001
	Jadon *et al.*	0.29	0.77	96	<0.00001
	Hua *et al.*	0.27	0.79	96	<0.00001
	Senthil *et al.*	0.05	0.96	96	<0.00001
	Natrajan *et al.*	0.38	0.70	96	<0.00001
	Shankar *et al.*	0.94	0.35	91	<0.00001
	Kong *et al.*	0.51	0.61	96	<0.00001
Pain scores during movement at 24 postoperative hours	Choi *et al.*	0.13	0.90	88	<0.0001
	Aliste *et al.*	0.76	0.45	95	<0.00001
	Jadon *et al.*	1.48	0.14	94	<0.00001
	Hua *et al.*	0.79	0.43	95	<0.00001
	Kong *et al.*	0.43	0.67	95	<0.00001

Contd...

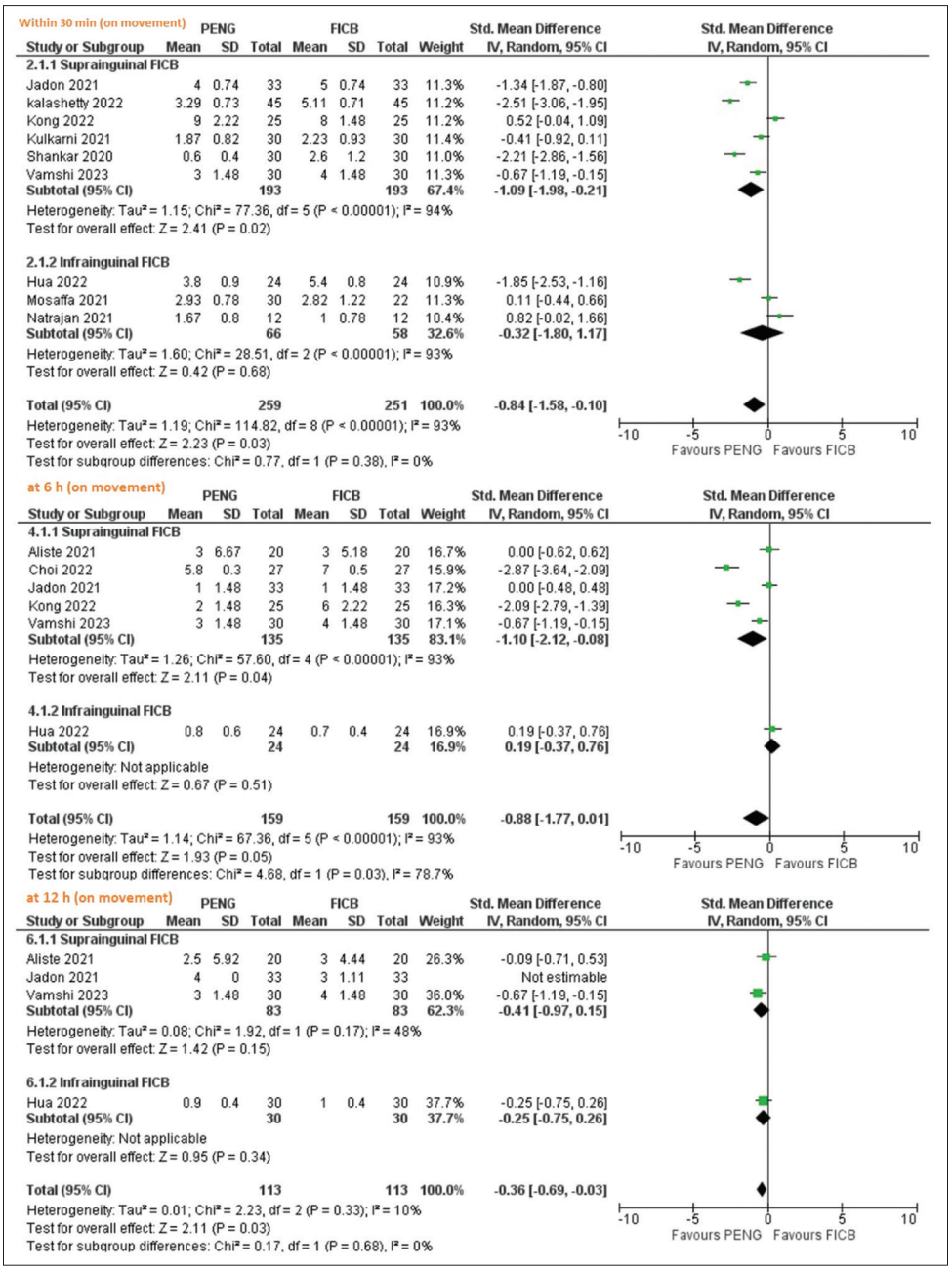
Supplementary Table 4: Continued...					
Outcomes	**Excluded study**	***Z***	***P*-value for difference**	***I*²**	***P*-value for heterogeneity**
Time to first rescue analgesia	Mosaffa *et al*.	0.65	0.52	91	<0.0001
	Jadon *et al*.	2.90	0.004	58	0.09
	Natrajan *et al*.	0.33	0.74	89	<0.0001
	Shankar *et al*.	0.75	0.45	93	<0.00001
24 hours postoperative morphine equivalent consumption	Aliste *et al*.	3.44	0.0006	88	<0.00001
	Choi *et al*.	3.20	0.001	87	<0.00001
	Hua *et al*.	3.18	0.001	88	<0.00001
	Mosaffa *et al*.	2.95	0.003	85	<0.00001
	Senthil *et al*.	2.77	0.006	85	<0.00001
	Shankar *et al*.	3.13	0.002	82	<0.00001
	Vamshi *et al*.	2.60	0.009	88	<0.00001
	Kong *et al*.	2.56	0.01	76	0.0003

Supplementary Table 5: Pain score before nerve block at rest (baseline)		
Study	**PENG (mean±SD)**	**FICB (mean±SD)**
Choi 2022[14]	2.6±0.4	2.8±0.5
Mosaffa 2022[6]	4.33±0.88	4.63±1.39
Kulkarni 2022[23]	6.03±1.40	6.63±1.45
Shankar 2020[10]	7.8±0.47	7.6±0.40
Hua 2022[5]	3.8±0.84	3.84±0.88
Jadon 2021[7]	6.0±0.74	5.0±1.11
Natrajan 2022[8]	7.67±1.86	7.33±1.42

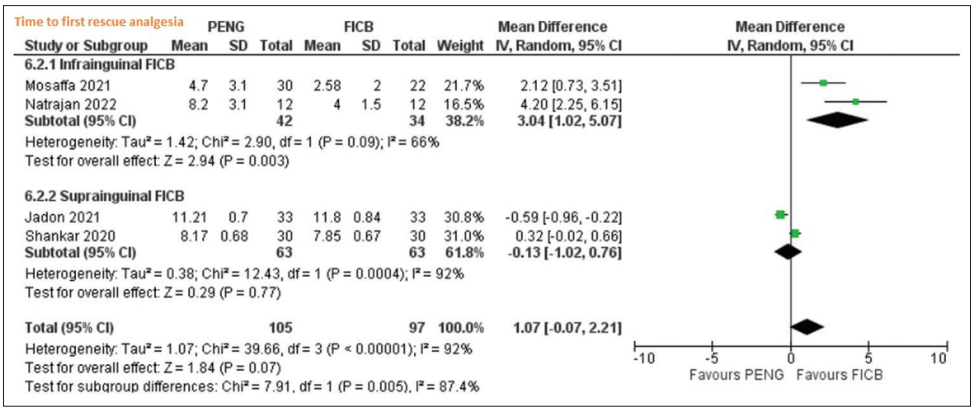
SD: Standard deviation, PENG: Pericapsular nerve group block, FICB: Fascia iliaca compartment block



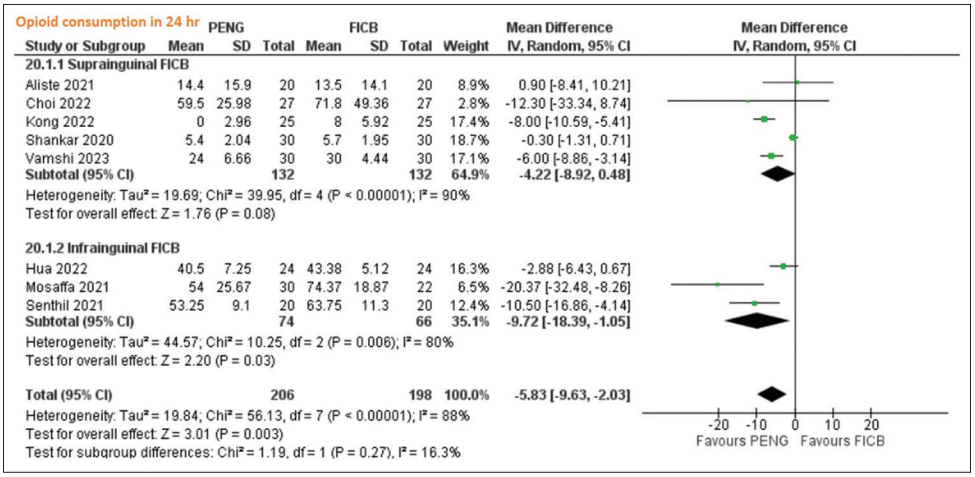
Supplementary Figure 1: Forest plot for pain scores at rest within 30 min, at 6 h and 12 h



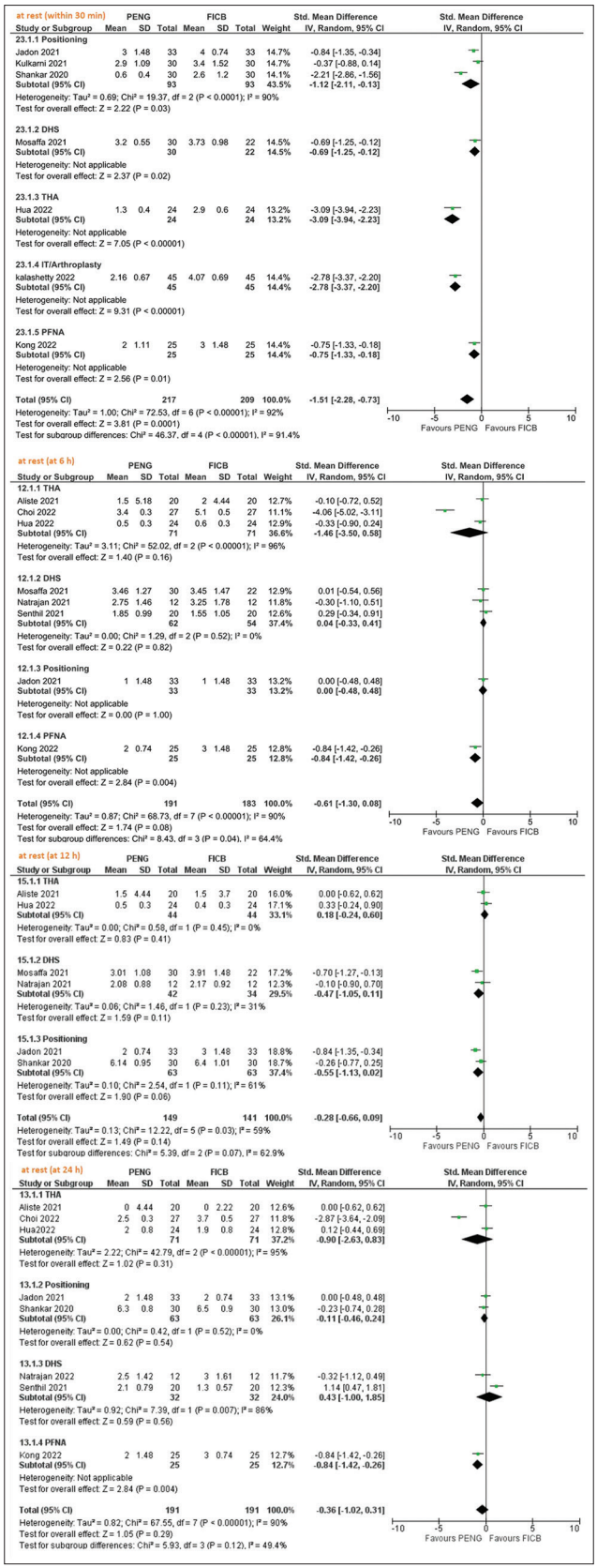
Supplementary Figure 2: Forest plot for the pain score during movement within 30 min, at 6 h and 12 h



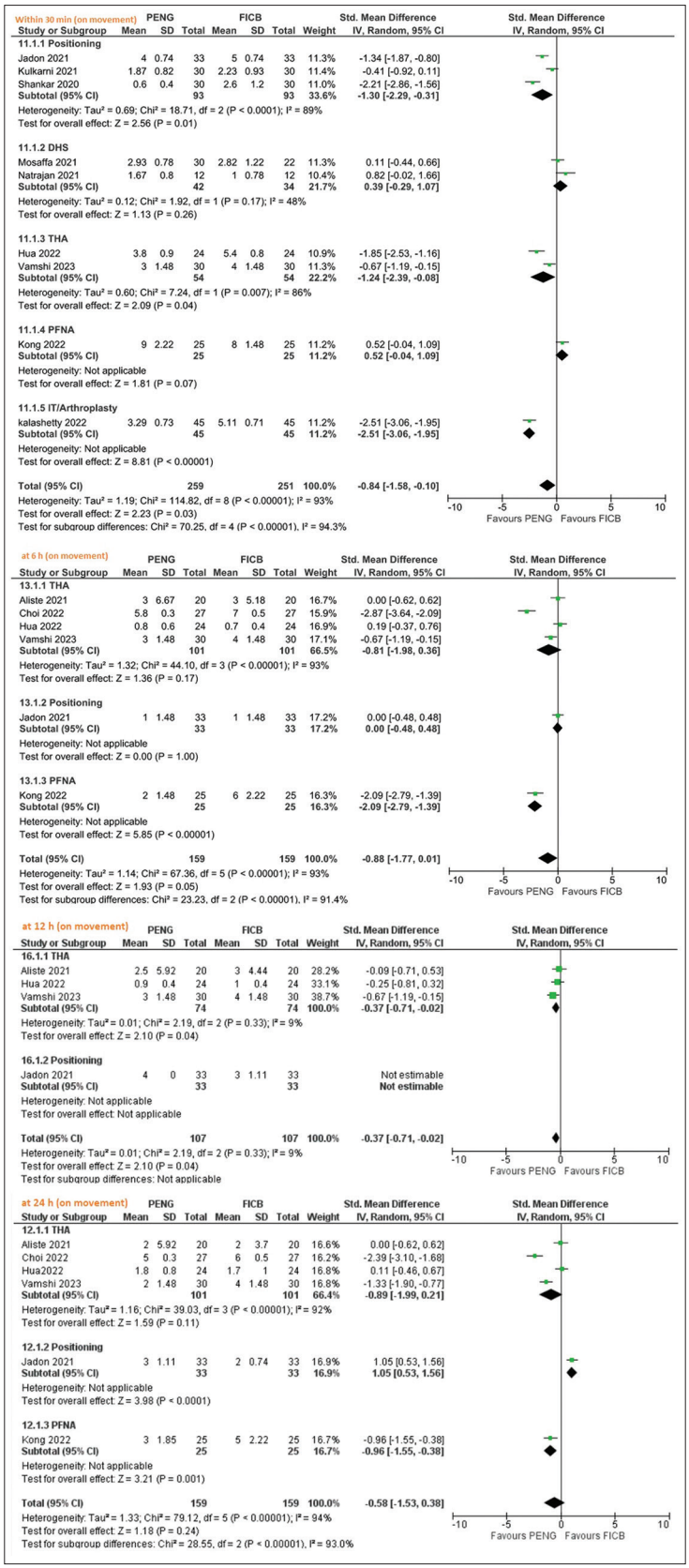
Supplementary Figure 3: Forest plot for time to first rescue analgesia



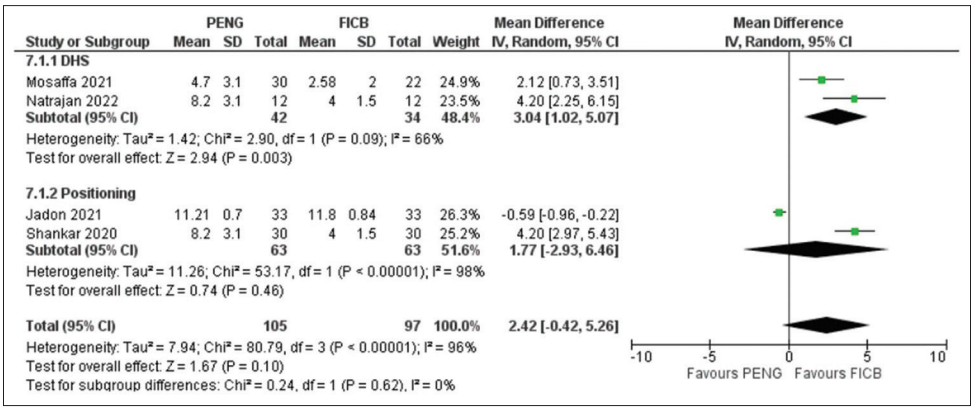
Supplementary Figure 4: Forest plot for postoperative oral morphine equivalent consumption in 24 h



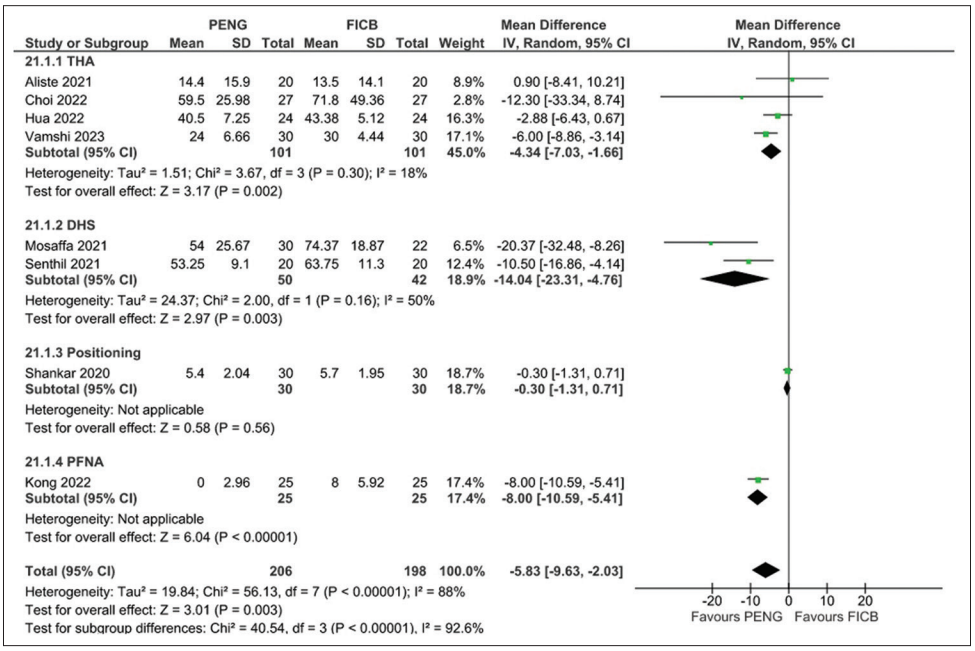
Supplementary Figure 5: Forest plot for pain score at rest within 30 min, at 6 h, 12 h and 24 h in different types of surgeries



Supplementary Figure 6: Forest plot for the pain score during movement within 30 min, at 6 h, 12 h and 24 h in different types of surgeries



Supplementary Figure 7: Forest plot for time to first rescue analgesia in different types of surgeries



Supplementary Figure 8: Forest plot for oral morphine equivalent consumption 24 h postoperatively in different types of surgeries