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REVIEW ARTICLE

Pericapsular Nerve Group (PENG) block versus fascia iliaca compartment (FI) block for hip surgery: a systematic review and meta-analysis of randomized controlled trials

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Pericapsular nerve group block;
Fascia iliaca block;
Hip surgery;
Hip replacement;
Meta-analysis

Abstract

Background: This study compares Fascia Iliaca compartment (FI) block and Pericapsular Nerve Group (PENG) block for hip surgery.

Methods: Pubmed, Embase and Cochrane were systematically searched in April 2022. Inclusion criteria were: Randomized Controlled Trials (RCTs); comparing PENG block versus FI block for hip surgery; patients over 18 years of age; and reporting outcomes immediately postoperative. We excluded studies with overlapped populations and without a head-to-head comparison of the PENG block vs. FI block. Mean-Difference (MD) with 95% Confidence Intervals (CI) were pooled. Trial Sequential Analyses (TSA) were performed to assess inconsistency. Quality assessment and risk of bias were performed according to Cochrane recommendations.

Results: Eight RCTs comprising 384 patients were included, of whom 196 (51%) underwent PENG block. After hip surgery, PENG block reduced static pain score at 12h post-surgery (MD = 0.61 mm; 95% CI 1.12 to -0.09; $p = 0.02$) and cumulative postoperative oral morphine consumption in the first 24h (MD = -6.93 mg; 95% CI -13.60 to -0.25; $p = 0.04$) compared with the FI group. However, no differences were found between the two techniques regarding dynamic and static pain scores at 6 h or 24 h post-surgery, or in the time to the first analgesic rescue after surgery.

Conclusion: The findings suggest that PENG block reduced opioid consumption in the first 24 h after surgery and reduced pain scores at rest at 12 h post-surgery. Further research is needed to fully understand the effects of the PENG block and its potential benefits compared to FI block.

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Introduction

It is well-established that regional anesthesia techniques reduce postoperative opioid consumption and pain scores, leading to higher patient satisfaction and better outcomes.[1] Considering the increase in the life expectancy of the population and the development of new techniques and implants, the incidence of hip surgery due to trauma or elective causes is expected to grow.

The Fascia Iliaca compartment (FI) block is a popular analgesic strategy for this surgery, but analgesia from this block is only moderate.[2] This drawback results from the innervation of the anterior hip capsule by the obturator, the accessory obturator, and the femoral nerves, as reported by previous anatomic studies. In contrast, the literature suggests that the articular branches of these nerves are inconsistently blocked by this technique.[3-6] Trying to improve those drawbacks, in 2018, Girón-Arango et al developed a new ultrasound-guided technique for the blockade of those articular branches to the hip, the Pericapsular Nerve Group (PENG) block.[7]

We conducted a systematic review of the literature and meta-analysis of Randomized Controlled Trials (RCTs) that compared FI and PENG blocks for hip surgery. Our primary outcomes were static and dynamic pain scores at different timeframes. Secondary outcomes were cumulative opioid consumption in the first 24 hours and the time to first opioid rescue.

Methods

The International Prospective Register of Systematic Reviews (PROSPERO) was used to prospectively register the protocol for this study (CRD42022339628), which is compliant with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[8]

Eligibility criteria

Studies meeting the following criteria were included: RCTs; comparison of PENG block versus FI block; patients over 18 years of age undergoing hip surgery; report of any of the clinical outcomes of interest; and outcome assessment conducted in the immediate postoperative period. We excluded studies with overlapping patient populations or without a control group.

Search strategy and data extraction

The search was conducted via PubMed, EMBASE, and the Cochrane Central Register of Controlled Trials for studies that met the eligibility criteria published until April 2022. The precise search strategy consisted of: ("hip arthroplasty" OR "hip replacement" OR "hip fracture" OR “hip-fracture” OR "THA" OR "hip surgery" OR “femur fracture”) AND ("PENG block" OR "Pericapsular nerve group block") AND ("fascia iliaca block" OR "fascia iliaca blockade" OR "fascia iliaca compartment block" OR “fascia-iliaca compartment block” OR “iliac fascia block”). The search strategy was conducted by two authors (P.A. and R.L.); besides searching databases, references from the included studies were manually reviewed. No language restrictions were applied to the search. Two authors (R.L. and B.I.) independently extracted baseline characteristics and recorded them on an Excel template for the elaboration of Table 1 and the outcome data based on predefined search criteria. Disagreements among the authors were resolved by consensus. PROSPERO registered the prospective meta-analysis protocol on June 24, 2022 (PROSPERO ID: CRD42022339628).

Endpoints

The outcomes of interest were static (at rest) pain score at 6 h post-surgery; dynamic (with hip movement) pain score at 6 h post-surgery; static pain score at 12 h post-surgery; dynamic pain score at 12 h post-surgery; static pain score at 24 h post-surgery; dynamic pain score at 24 h post-surgery; cumulative postoperative oral morphine consumption in the first 24 h; time to first analgesic rescue after surgery; and Postoperative Nausea and Vomiting (PONV). A meta-analysis with pooled results was performed whenever at least three RCTs had results for an endpoint. Considering that pain assessment could vary among studies, it was established that eligible studies should use either the Numeric Rating Scale (NRS) or the Visual Analog Scale (VAS) to evaluate a patient’s pain level. In both scores, zero corresponds to “no pain”, 5 corresponds to “moderate pain”, and 10 corresponds to “worst imaginable pain”.

Synthesis methods

The pain assessment and the opioid selection and dosage were expected to differ among studies; therefore, it is crucial to clarify the data gathered from each study included in this meta-analysis. For the pain rating, it was determined that the NRS and VAS scores were acceptably similar to be combined in the same pooled analysis; thus, no conversions were necessary.[9] Nevertheless, concerning cumulative postoperative opioid consumption, data from each trial were converted to an equivalent dose of morphine using an equianalgesic dosage conversion calculator;[10] hence, the analysis is given in terms of oral morphine consumption. Studies reporting results as median and Interquartile Range (IQR) were converted to estimate mean and Standard Deviation (SD).[11]

Table 1 Baseline characteristics of included studies.

Study	Design	Patients FI/ PENG	ASA	BMI FI/ PENG	Male (%) FI/ PENG	Age, y FI/ PENG	Surgical time FI/ PENG	IV PCA	FI Anesthetics	PENG Anesthetics
Aliste 2021[26]	RCT	20/20	I, II, III	28.4/ 27.6	35/35	59.6/ 56.8	73.5/ 74.9	Morphine (mg) IV PCA	40 ml adrenalized levobupivacaine 0.25%	20 ml adrenalized levobupivacaine 0.50%
Choi 2022[28]	RCT	27/27	I, II, III	25/ 25.8	59.3/51.9	61.51/ 60.27	69.90/ 67.43	Fentanyl (mcg) IV PCA	30 ml of adrenalized ropivacaine 0.2%	20 ml of adrenalized ropivacaine 0.2%
Hua 2022[12]	RCT	24/24	II, III	23/24	54.2/58.3	74/74	129/133	Sufentanil (mcg) IV PCA	30 ml ropivacaine hydrochloride 0.4%	20 ml ropivacaine 0.4%
Jadon 2021[13]	RCT	33/33	I, II, III	29.5/ 30/ 15	42.4/39.4	67.87/ 70.39	NA/NA	Number of doses of Tramadol 50 mg	NA	NA
Mosaffa 2021[18]	RCT	22/30	I, II	NA/NA	72.7/73.3	50/53	NA/NA	Morphine (mg) IV PCA	3 ml.kg^{-1} (a maximum of 40 ml) of ropivacaine 0.5%	3 ml.kg^{-1} (a maximum of 40 ml) of ropivacaine 0.5%
Natrajan 2021[19]	RCT	12-Dec	I, II	NA/NA	NA/NA	NA/NA	NA/NA	N/A	20 ml of 0.5% ropivacaine	20 ml of 0.5% ropivacaine
Senthil 2021[29]	RCT	20/20	I, II	NA/NA	50/60	52.5/ 53.9	NA/NA	Fentanyl (mcg) IV PCA	30 ml levobupivacaine 0.25% & 4 mg dexamethasone	30 ml levobupivacaine 0.25% & 4 mg dexamethasone
Shankar 2020[20]	RCT	30/30	I, II, III	NA/NA	30/66.6	49.54/ 53.58	NA/NA	N/A	25 ml ropivacaine 0.25%	25 ml ropivacaine 0.25%

BMI, Body Mass Index (kg.m^{-2}); FI, Fascia Iliaca compartment block; IV, Intravenous; PENG, Pericapsular Nerve Group block; PCA, Patient Controlled Analgesia; RCT, Randomized Control Trial; Surgical time, minutes; NA, Not Available; Age and BMI, mean.

Quality assessment and sensitivity analysis

To assess the risk of bias in each RCT, the risk of bias tool for randomized trials (RoB-2) was the chosen tool.[12] The risk of bias was conducted independently by two authors (P.A. and I.M.); a consensus was reached after discussing the reasons for divergences (Table 2).

To explore the robustness of the results and identify possible outliers, sensitivity analyses were conducted by systematically removing each study from the research and recalculating the results. Additionally, to verify the consistency of this review's findings, results were also calculated after removing studies with an increased risk of bias. Publication bias was assessed with funnel-plot analysis and Egger's test of all endpoints to evaluate the symmetric distribution of trials with similar weights; p-values < 0.05 were considered statistically significant.

The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) tool was used to assess the certainty of the evidence in this review as high, moderate, low, or very low.[13] The grading of the strength of recommendations was carried out by two independent authors (I.M. and P.A.) using the GRADEpro Guideline Development Tool (McMaster University and Evidence Prime, 2022); disagreements were settled by a third author (R.L.).

Statistical analysis

The Minimally Clinically Important Difference (MCID) in the pain score was set at -18.6 mm for improvement and 23.6 mm for worsening pain, as per findings by Danoff et al[14] The MCID for opioid consumption was set at 10 mg of Morphine Equivalents, as per findings by Laigaard et al[15] Treatment effects on continuous outcomes were compared using Mean Differences (MD) with 95% Confidence Intervals (95% CI). Cochran Q test, I^2 statistics, and visual inspection of the forest plots were used to assess heterogeneity; when the visual inspection of the forest plot was suggestive of heterogeneity in effect size, the p-value was < 0.10 or I^2 statistics was $\geq 25\%$, heterogeneity was considered significant, and a random-effects model was used. The statistical analysis was conducted using Review Manager 5.4 (Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark). Trial sequential analysis (TSA) was performed with the TSA software (Copenhagen Trial Unit, Centre for Clinical Intervention Research, Copenhagen).[16]

Results

Study selection and characteristics

As detailed in Figure 1, our complete search generated 78 results and 15 duplicates; 54 studies were excluded based on their titles or abstracts. The remaining 9 articles were thoroughly screened and, after consideration of the inclusion and exclusion criteria, eight RCTs were included in this systematic review and meta-analysis. The exclusion of the 9th study was based on the lack of report for outcomes of interest.

Pooled analysis of outcomes

In the 24 hours of follow-up post-surgery, no significant difference was found between PENG and FI blocks in terms of dynamic pain score at 6 h post-surgery (MD = -0.22; 95% CI -0.81 to 0.81; $p = 0.46$; $I^2 = 27\%$; Fig. 2A; 4 RCTs, 200 patients) nor regarding the static pain score at 6 h post-surgery (MD = -0.32; 95% CI -0.96 to 0.32; $p = 0.33$; $I^2 = 63\%$; Fig. 2B; 4 RCTs, 212 patients). Additionally, the analysis referred to the dynamic pain score at 24 h post-surgery (MD = 0.57; 95% CI -0.01 to 1.14; $p = 0.05$; $I^2 = 74\%$; Fig. 2C; 4 RCTs, 200 patients) and the static pain score at 24 h post-surgery (MD = -0.14; 95% CI -0.49 to 0.22; $p = 0.45$; $I^2 = 43\%$; Fig. 2D; 4 RCTs, 220 patients) yielded similar results. The time to first analgesic rescue after surgery was not significantly longer for patients with a PENG block (MD = 1.07; 95% CI -0.07 to 2.21; $p = 0.06$; $I^2 = 92\%$; Fig. 2E; 4 RCTs, 196 patients). Furthermore, incidence of PONV was not significantly

Table 2 Critical appraisal according to the RoB-2 tool for assessing the risk of bias in randomized trials.

	Risk of bias domains					
	D1	D2	D3	D4	D5	Overall
Aliste 2021	(+)	(+)	(+)	(+)	(+)	(+)
Choi 2022	(+)	(-)	(+)	(+)	(+)	(-)
Hua 2022	(+)	(+)	(+)	(+)	(x)	(x)
Jadon 2021	(+)	(+)	(+)	(+)	(+)	(+)
Mosaffa 2022	(-)	(+)	(+)	(+)	(+)	(-)
Matrajan 2021	(+)	(+)	(+)	(+)	(+)	(+)
Senthil 2021	(+)	(-)	(+)	(+)	(+)	(-)
Shankar 2022	(+)	(+)	(+)	(+)	(+)	(+)

Judgment: (x) High; (-) Some Concerns; (+) Low

Domains:
D1: Bias arising from the randomization process.
D2: Bias due to deviations from intended intervention.
D3: Bias due to missing outcome data.
D4: Bias in measurement of the outcome.
D5: Bias in selection of the reported result.

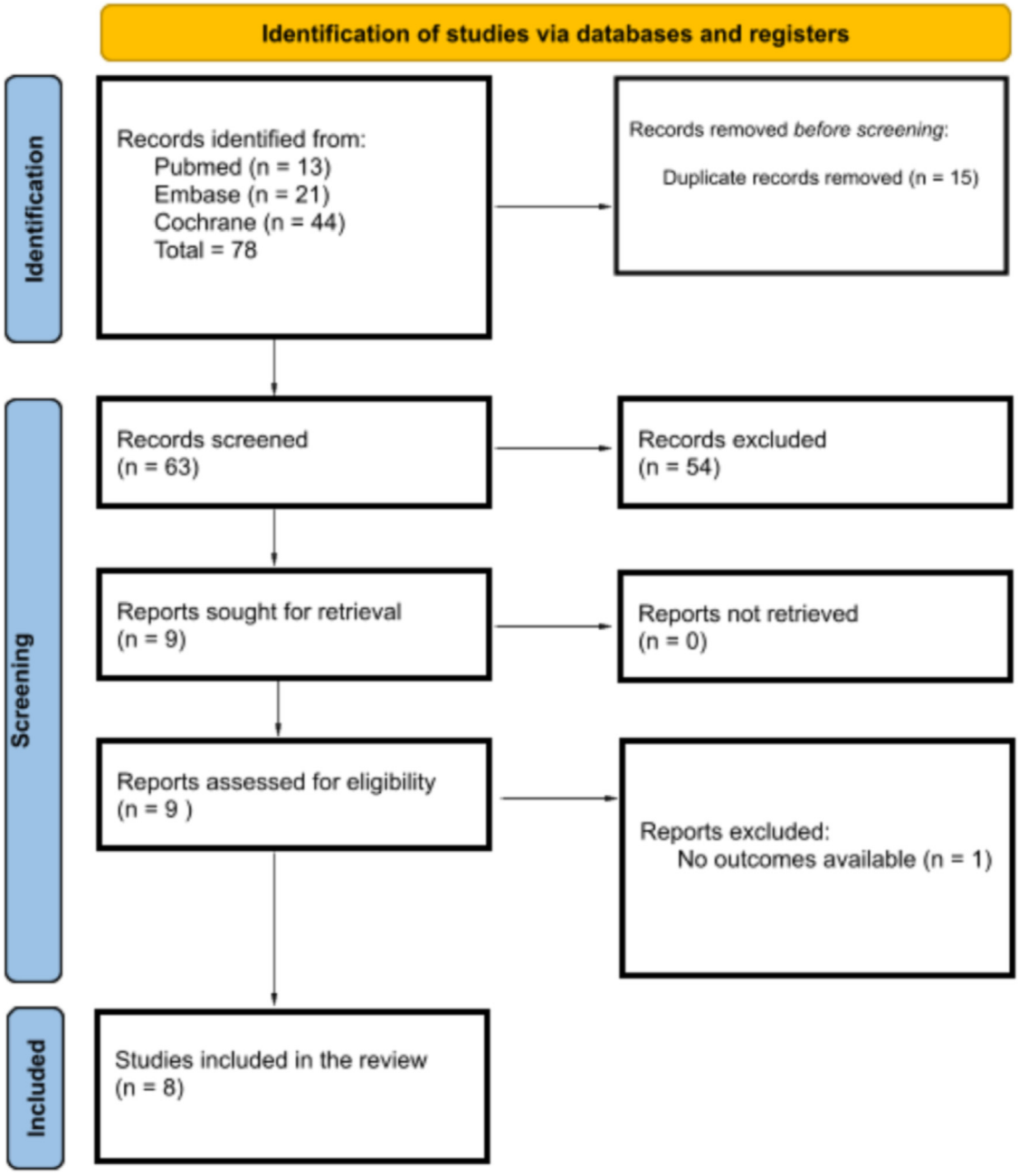


Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of study screening and selection.

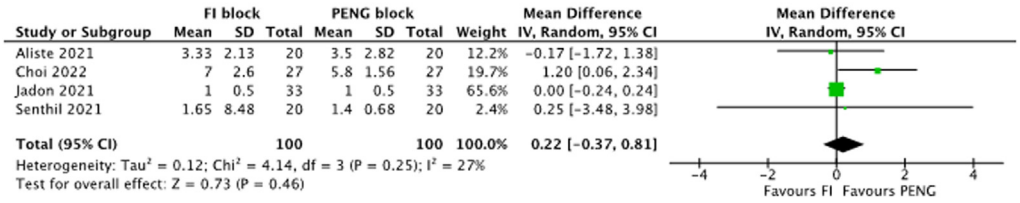
different in the groups (RR = 2.00; 95% CI 0.82 to 4.9; $p = 0.13$; $I^2 = 0\%$; Fig. 2F; 3 RCTs, 118 patients).

In contrast, the static pain score at 12h post-surgery was significantly lower among patients who underwent PENG block than for the FI group (4 RCTs, 218 patients) (MD = -0.61; 95% CI -1.12 to -0.09; $p = 0.02$; $I^2 = 73\%$; Fig. 3A). Moreover, there was a lower rate of cumulative postoperative oral morphine consumption in the PENG group with statistical significance (6 RCTs, 300 patients) (MD = -6.93; 95% CI -13.60 to -0.25; $p = 0.04$; $I^2 = 92\%$; Fig. 3B). This decreased opioid consumption in the PENG group did not remain in a subgroup analysis performed pooling the results of patients undergoing surgery for hip fractures (4 RCT, 206 patients) (MD = -6.29; 95% CI -13.85 to 1.27; $p = 0.1$; $I^2 = 92\%$; Fig. 3C). Only one RCT reported a dynamic pain score at 12h post-surgery,[17] hence it was impossible to perform a meta-analysis on that outcome.

Trial sequential analysis

In the TSA, neither pooled results for pain score at rest at 12 h postoperatively nor cumulative opioid consumption in 24 h reached the required information sample size. Both crossed the conventional boundary, confirming the significant statistical difference benefiting PENG over FI, but not crossing the monitoring boundaries. For the outcomes of static and dynamics pain scores at 6 h and 24 h post-surgery and time to first analgesic rescue, the z-curve did not cross

2A



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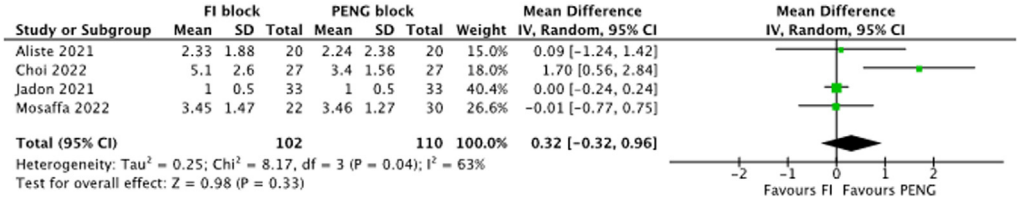

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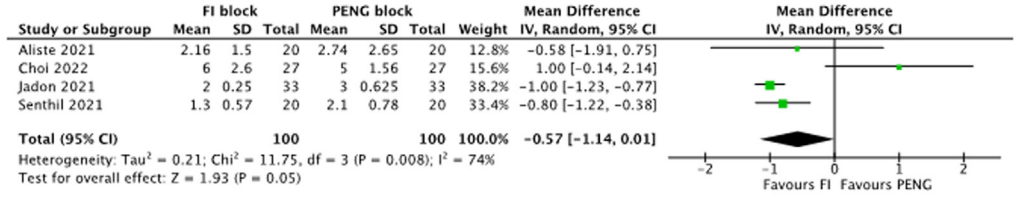

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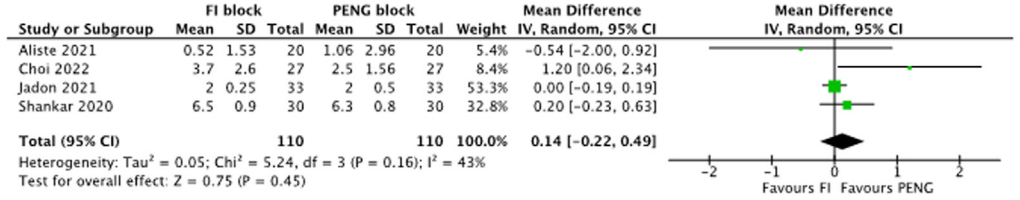

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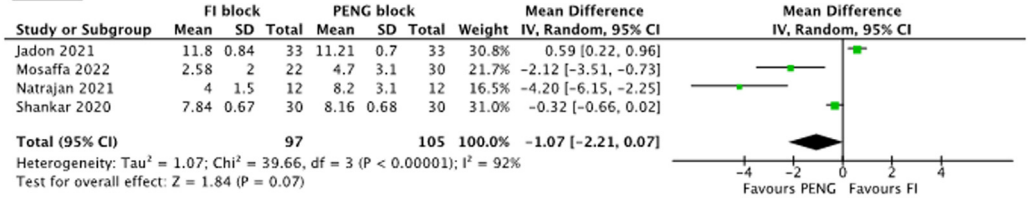

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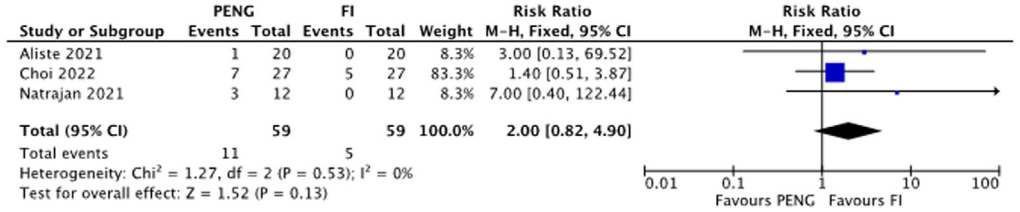
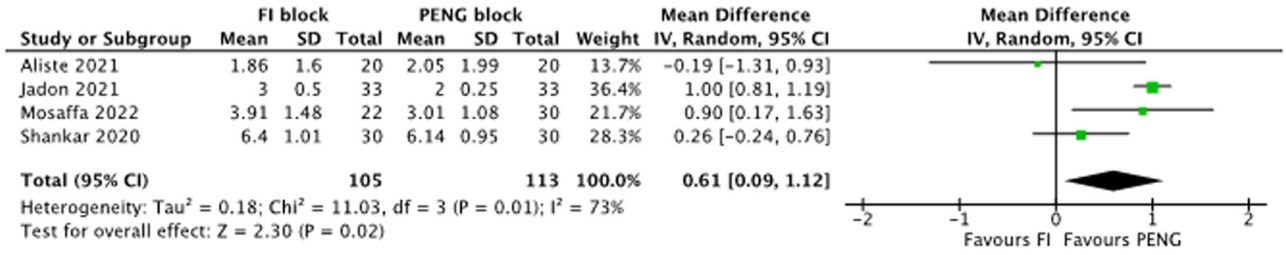


Figure 2 (A) Dynamic pain score at 6h post-surgery was not significantly different between PENG and FI block groups. (B) Static pain score at 6h post-surgery was not significantly different between PENG and FI block groups. (C) Dynamic pain score at 24h post-surgery was not significantly different between PENG and FI block groups. (D) Static pain score at 24 h post-surgery was not significantly different between PENG and FI block groups. (E) The time to the first analgesic rescue after surgery was not significantly different between PENG and FI block groups. (F) Postoperative nausea and vomiting were not significantly different between PENG and FI block groups.

3A



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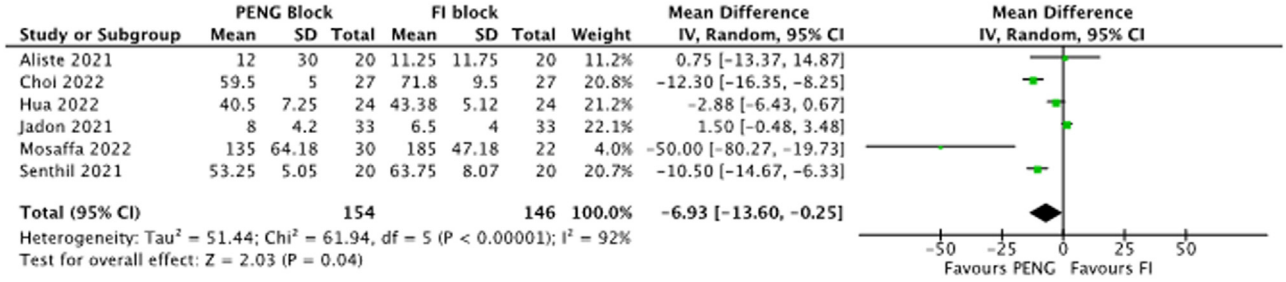

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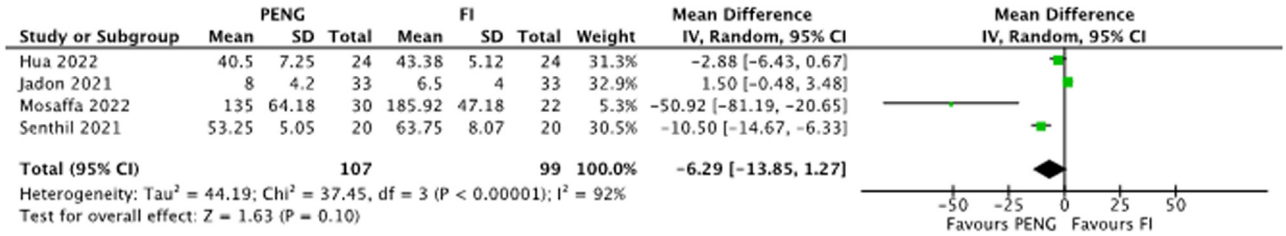

Figure 3 (A) Static pain score at 12h post-surgery was significantly lower in the PENG block group. (B) The cumulative postoperative oral morphine consumption in 24h was significantly lower in the PENG block group. (C) Opioid consumption in subgroup hip fracture was not significantly different between PENG and FI block groups.

the trial sequential monitoring boundaries and did not reach the required information sample size. These results are reported in Figure 5 in the Supplementary Material.

Quality assessment

In a pooled sensitivity analysis removing the only RCT with a high risk of bias,[18] the rate of cumulative postoperative oral morphine consumption, which at first favored the PENG group (MD = -6.93; 95% CI -13.60 to -0.25; $p = 0.04$; $I^2 = 92\%$; Fig. 3B), lost its statistical significance (MD = -8.61; 95% CI -17.65 to 0.43, $p = 0.06$; $I^2 = 94\%$; Fig. 4A). Nevertheless, considering the heterogeneity measured by I^2 statistics seemed to increase with the withdrawal of Hua et al,[18] a further analysis was conducted to assess the origin of the severe heterogeneity for this particular outcome. After the removal of each study, and even though heterogeneity was still high, the most robust reduction in heterogeneity was found with the exclusion of Jadon et al,[19] and once again it showed a significantly lower rate of cumulative postoperative oral morphine consumption among the PENG group (MD = -9.00; 95% CI -15.45 to -2.54; $p = 0.006$; $I^2 = 82\%$; Fig. 4B). Finally, a combined analysis removing both Hua et al[18] and Jadon et al[19] confirmed a statistically significant mean difference in favor of the PENG block with only moderate heterogeneity (MD = -11.26; 95% CI -17.97 to -4.56; $p = 0.001$; $I^2 = 68\%$; Fig. 4C). On funnel plot analyses, there was no evidence of publication bias, as a symmetrical distribution was observed around the meta-analysis point estimate based on the weight. Egger's test also indicates no evidence of publication bias (Figure S2 in the Supplementary Material).[20]

On the other hand, a sensitivity analysis could not be performed for the time to the first analgesic rescue after surgery, even though results evidenced a high heterogeneity among studies, because of the limited number of RCTs reporting this particular outcome.

According to the GRADE tool, the overall certainty of the evidence for the outcomes assessed was high at first and downgraded to moderate or low certainty due to a serious risk of bias, imprecision, or inconsistency. There was a large magnitude of the effect, upgrading by one level the corresponding outcome. Table 3 reports the evidence profile from this review, while Table 4 summarizes our findings. Both can be found in the Supplementary Material.

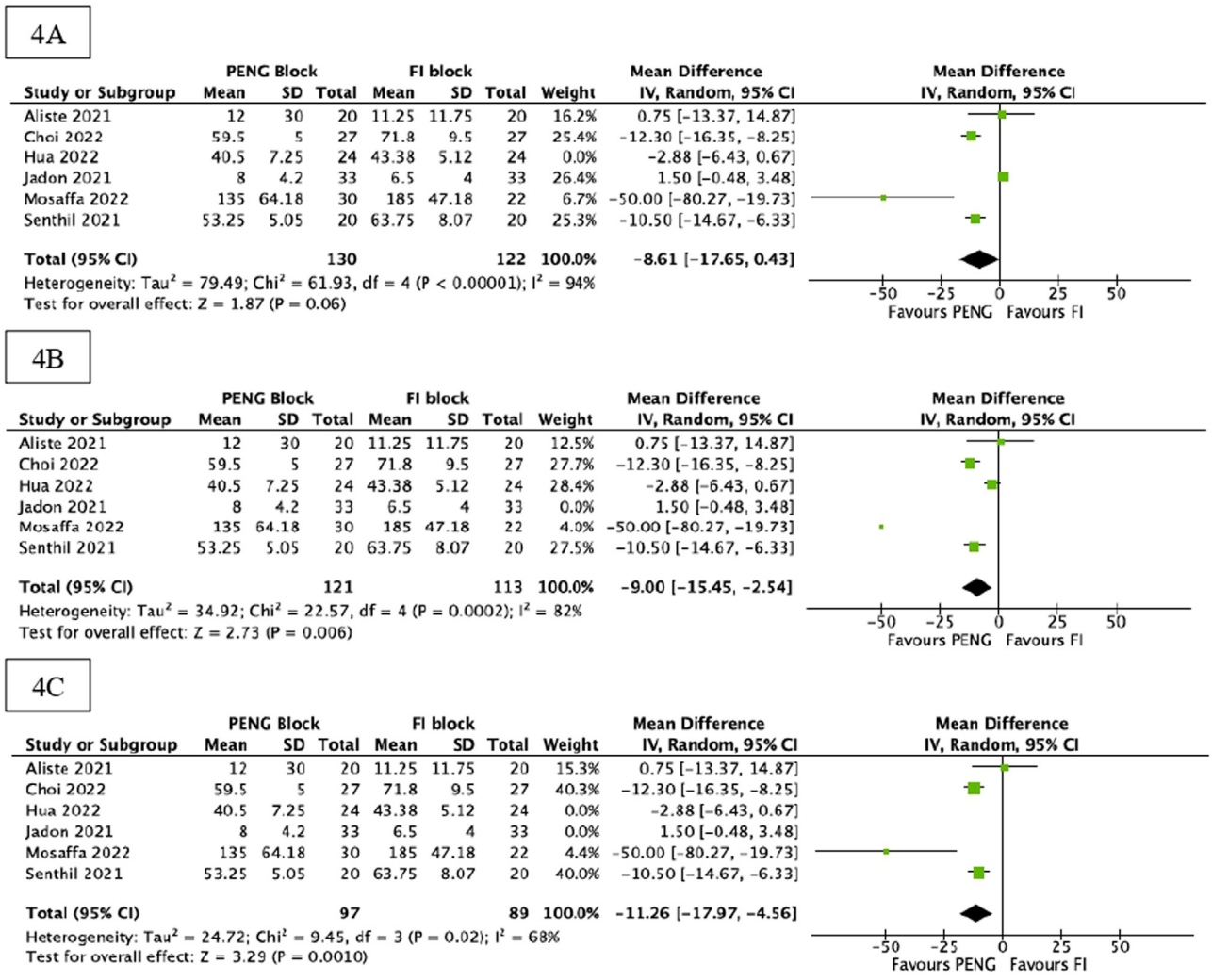

Figure 4 (A) Sensitivity analysis by removal of studies with a high risk of bias: the rate of cumulative postoperative oral morphine consumption was not significantly different between PENG and FI block groups. (B) Sensitivity analysis by removal of outliers: lower rate of cumulative postoperative oral morphine consumption among the PENG group with statistical significance. (C) Sensitivity analysis by removal of studies with a high risk of bias and outliers: lower rate of cumulative postoperative oral morphine consumption among the PENG group with statistical significance.

Discussion

This systematic review and meta-analysis of 8 studies and 384 patients compared the PENG Block to the FI Compartment Block. The main findings with PENG block include: 1 – Lower opioid consumption in the first 24 hours after surgery; 2 – Decreased pain score at rest 12 hours after surgery; 3 – No difference in the pain score at rest or with movement 6 hours after surgery; 4 – No difference in the pain scores at rest or with movement 24 hours after surgery; 5 – No difference in the time to first analgesia rescue after surgery; and 6 – No difference in the incidence of PONV.

Hip fracture is a typical orthopedic emergency in the elderly associated with significant morbidity and mortality. Adequate postoperative analgesia minimizing the need for opioids and their related adverse effects is fundamental for that population.[7] Considerable pain, if inadequately controlled, can impair early rehabilitation and functional recovery and reduce patient satisfaction after surgery.[21] Several blocks have been proven effective for hip surgery, like the fascia iliaca block and the femoral nerve block.[22,23] Despite their steadily increasing use, there is limited evidence of their effectiveness.[24]

This study compares postoperative pain scores and opioid consumption between PENG block and FI block after Total Hip Arthroplasty (THA) with a subgroup analysis of hip fracture surgeries. The most outstanding finding of this study was that despite limited evidence of its effectiveness, the PENG block showed a statistically significant lower opioid consumption than the FI block. This limited evidence can be explained by the fact that the PENG block is a relatively new regional anesthesia technique, with few studies published about it.[7]

The PENG block has been studied recently and its efficacy was reported in some clinical trials. It has shown decreased opioid consumption in the first 24 h postoperatively and decreased pain scores in the short-term postoperative period and post-anesthesia care unit after open hip surgeries

Table 3 Evidence profile: PENG block compared to FI block for hip surgery.

Outcomes	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Mean difference (95% CI)	Number of participants (studies)	Quality or certainty of the evidence (GRADE)
Cumulative post-operative oral morphine consumption	Serious[a]	Not serious	Not serious	Not serious	Not detected	MD −6.93 (−13.60 to −0.25)	300 (6 RCTs)	⊕⊕⊕⊕ High[b]
Dynamic pain score at 6 hours post-surgery	Not serious	Not serious	Not serious	Serious[c]	Not detected	MD −0.22 (−0.81 to 0.37)	200 (4 RCTs)	⊕⊕⊕◯ Moderate
Static pain score at 6 hours post-surgery	Not serious	Not serious	Not serious	Serious[c]	Not detected	MD −0.32 (−0.96 to 0.32)	212 (4 RCTs)	⊕⊕⊕◯ Moderate
Static pain score at 12 hours post-surgery	Not serious	Not serious	Not serious	Not serious	Not detected	MD −0.61 (−1.12 to −0.09)	218 (4 RCTs)	⊕⊕⊕⊕ High
Dynamic pain score at 24 hours post-surgery	Not serious	Not serious	Not serious	Serious[c]	Not detected	MD 0.57 (−0.01 to 1.14)	200 (4 RCTs)	⊕⊕⊕◯ Moderate
Static pain score at 24 hours post-surgery	Not serious	Not serious	Not serious	Serious[c]	Not detected	MD −0.14 (−0.49 to 0.22)	220 (4 RCTs)	⊕⊕⊕◯ Moderate
Time to first analgesic rescue after surgery	Not serious	Serious[d]	Not serious	Serious[c]	Not detected	MD −1.07 (−2.21 to 0.02)	202 (4 RCTs)	⊕⊕◯◯ Low
Subgroup for hip fracture opioid consumption	Serious[a]	Serious[d]	Not serious	Serious[c]	Not detected	MD −6.29 (−13.85 to 1.27)	206 (4 RCTs)	⊕◯◯◯ Very low
Postoperative nausea and vomiting (PONV)	Not serious	Not serious	Not serious	Not serious	Not detected	MD −2.00 (0.82 to 4.90)	59 (3 RCTs)	⊕⊕⊕⊕ High

CI, Confidence Interval; FI, Fascia Iliaca compartment block; GRADE, Grading of Recommendations Assessment, Development and Evaluation; MD, Mean Difference; PENG, Pericapsular Nerve Group block.

[a] 1 trial was considered to carry a high risk of bias. Downgraded by one level for risk of bias.

[b] The estimated effect is -6.93. Upgraded by one level for large magnitude of the effect.

[c] Wide confidence interval including null. Downgraded by one level for imprecision.

[d] There was high heterogeneity (I^2 = 90%). Downgraded by one level for inconsistency.

Table 4 Summary of findings: PENG block compared to FI block for hip surgery.

Outcomes	Anticipated absolute effects[a] (95% CI)		Relative effect (95% CI)	N° of participants (studies)	Certainty of the evidence (GRADE)
	Risk with FIC	Risk with PENG			
Cumulative postoperative oral morphine conumption Follow-up: mean 1 day	The mean cumulative postoperative oral morphine conumption was **0**	MD **6.93 lower** (13.6 lower to 0.25 lower)	–	300 (6 RCTs)	⨁⨁⨁⨁ High[a]
Dynamic pain score at 6 hours post-surgery Follow-up: mean 1 day	The mean dynamic pain score at 6 hours post-surgery was **0**	MD **0.22 lower** (0.81 lower to 0.37 higher)	–	200 (4 RCTs)	⨁⨁⨁◯ Moderate ✢
Static pain score at 6 hours post-surgery Follow-up: mean 1 day	The mean static pain score at 6 hours post-surgery was **0**	MD **0.32 lower** (0.96 lower to 0.32 higher)	–	212 (4 RCTs)	⨁⨁⨁◯ Moderate ✢
Static pain score at 12 hours post-surgery Follow-up: mean 1 day	The mean static pain score at 12 hours post-surgery was **0**	MD **0.61 lower** (1.12 lower to 0.09 lower)	–	218 (4 RCTs)	⨁⨁⨁⨁ High
Dynamic pain score at 24 hours post-surgery Follow-up: mean 1 day	The mean dynamic pain score at 24 hours post-surgery was **0**	MD **0.57 higher** (0.01 lower to 1.14 higher)	–	200 (4 RCTs)	⨁⨁⨁◯ Moderate ✢
Static pain score at 24 hours post-surgery Follow-up: mean 1 day	The mean static pain score at 24 hours post-surgery was **0**	MD **0.14 lower** (0.49 lower to 0.22 higher)	–	220 (4 RCTs)	⨁⨁⨁◯ Moderate ✢
Time to first analgesic rescue after surgery Follow-up: mean 1 day	The mean time to first analgesic rescue after surgery was **0**	MD **1.07 lower** (2.21 lower to 0.07 higher)	–	202 (4 RCTs)	⨁⨁◯◯ Low ✢**
Subgroup for hip fracture opioid consumption Follow-up: mean 1 day	The mean subgroup for hip fracture opioid consumption was **0**	MD **6.29 lower** (13.85 lower to 1.27 higher)	–	206 (4 RCTs)	⨁◯◯◯ Very low *✢**
Postoperative nausea and vomiting (PONV)	85 per 1.000	**169 per 1.000** (69 to 415)	**RR 2.00** (0.82 to 4.90)	118 (3 RCTs)	⨁⨁⨁⨁ High

[a] The risk in the intervention group (and its 95% Confidence Interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).
CI, Confidence Interval; MD, Mean Difference; RR, Risk Ratio.
GRADE Working Group grades of evidence.
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

compared to sham block and compared to conventional postoperative analgesia.[21,25,26]

Four trials reported time to first rescue with high heterogeneity in the pooled results (I^2 = 92%).[19,27-29] This heterogeneity can be explained by the differences in their local anesthetic choice and doses as showed in Table 1. While Mosaffa et al[27] and Natrajan et al[28] had conflicting results, with the first showing a significant shorter time for

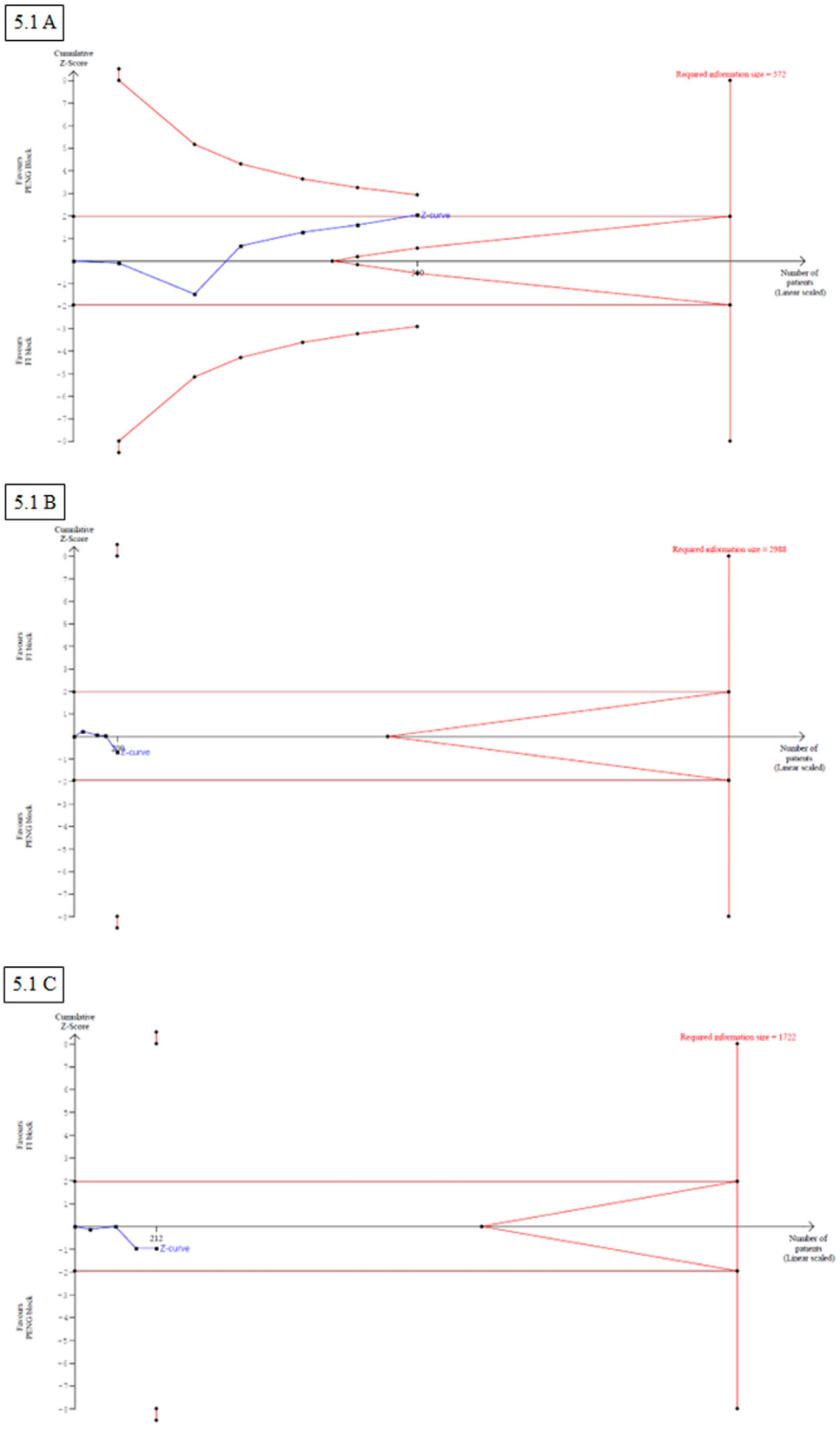

Figure 5 (1A) Cumulative opioid consumption 24 h. (1B) Dynamic pain score at 6 h. (1C) Static pain score at 6 h. (2A) Static pain score at 12 h. (2B) Dynamic pain score at 24 h. (2C) Static pain score at 24 h. (3A) Time to first rescue. (3B) Cumulative opioid consumption 24 h for hip fracture subgroup. (3C) PONV.

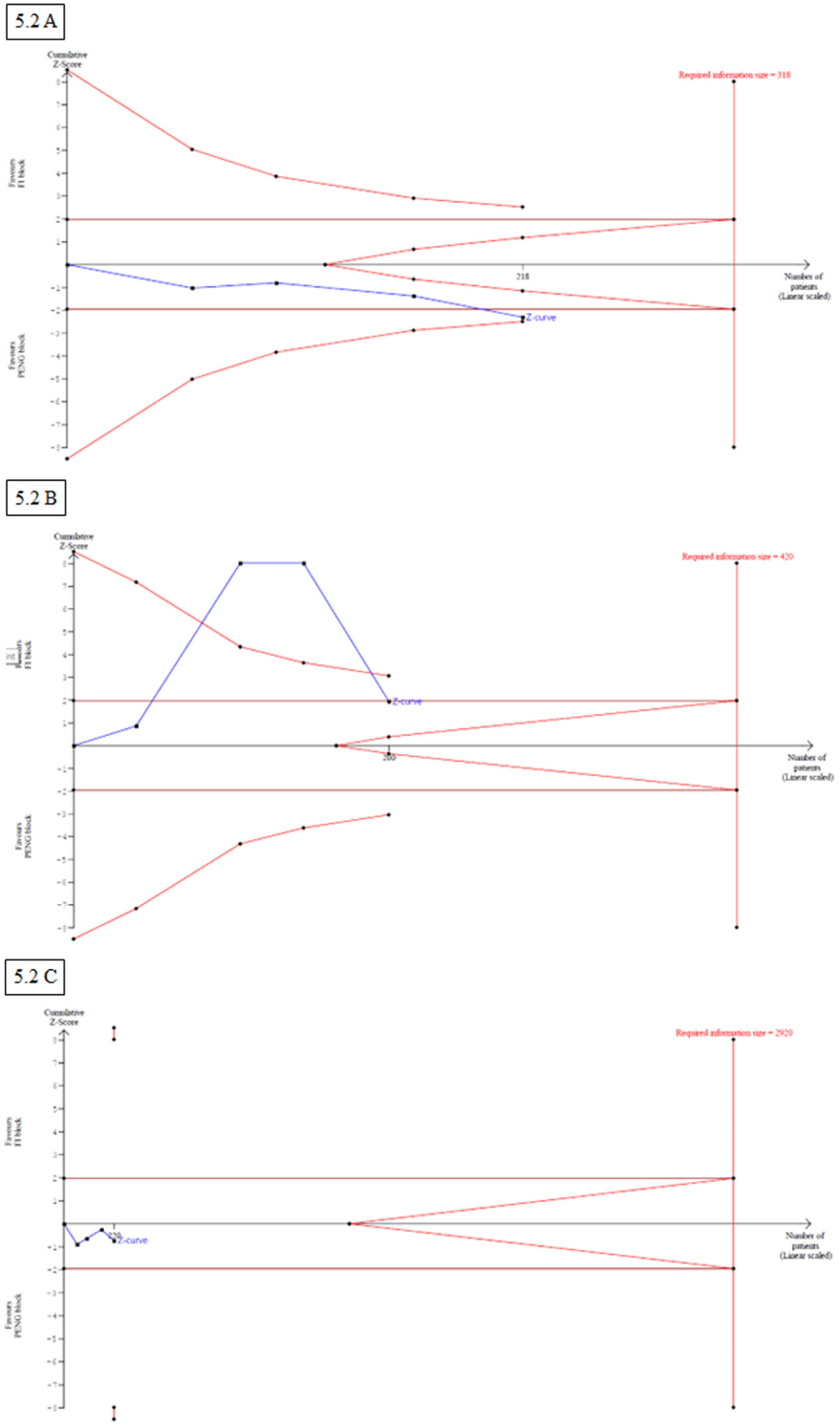

Figure 5 Continued.

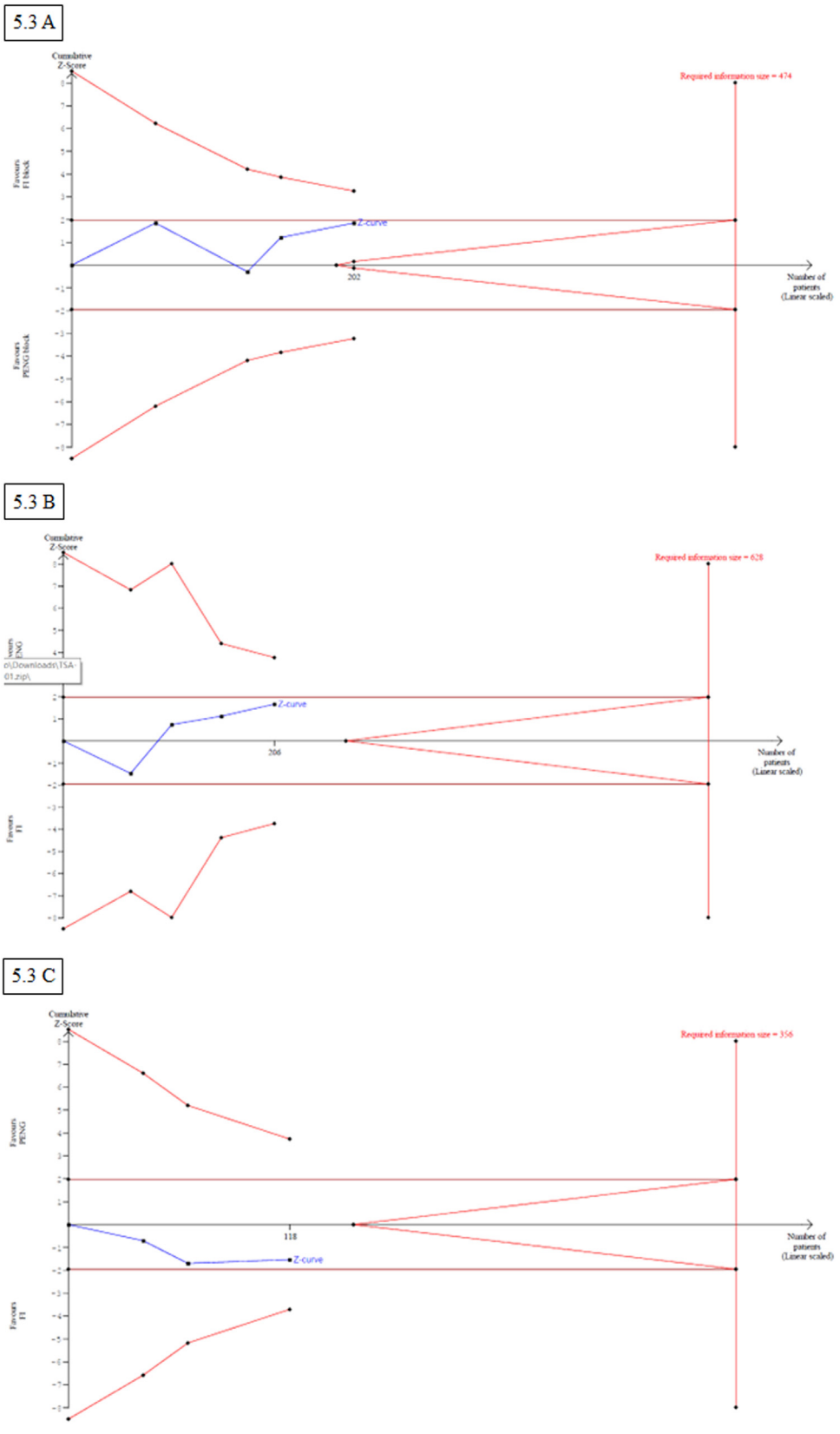

Figure 5 Continued.

the PENG group and the second a shorter time for FI group, no difference was found by Jadon et al[19] and Shankar et al[29] This meta-analysis did not find a significant difference between the time to first rescue after the surgery between FI and PENG blocks. The TSA performed for this outcome did not reach the required information sample size and the Z-curve stayed inside the non-statistically significant zone and not reaching the futility boundary (Fig. 5.3B), thus more studies are required for a definitive answer.

We could plot the results for pain scores at rest at 6 h, 12 h, and 24 h and pain scores at movement at 6 h and 24 h. The only statistically significant outcome was pain at rest at 12 h, which showed an MD of -0.61 (95% CI -1.12 to -0.09), favoring PENG block with moderate heterogeneity (I^2 = 72%). Jadon et al[19] and Mosaffa et al[27] had a similar result with significantly decreased pain score at rest at 12 h. This statistically significant decrease in the postoperative pain scores does not reflect a minimal clinically significant difference in the hip replacement pain score.[14] TSA performed for this outcome did not reach the required information sample size and showed a Z-curve not reaching the monitoring boundaries, not matching the statistically significant difference found in the meta-analysis (Fig. 5.2A), raising concerns of possible type 1 error, thus further studies are needed for this outcome. Important to note that all outcomes reporting pain scores had low to moderate heterogeneity.

Our meta-analysis showed a statistically significant reduction in opioid consumption in the first postoperative 24 h using the PENG block (Fig. 3B). PENG block had an MD of -6.93 mg of morphine in 24 h (95% CI -13.60 to -0.25) with high heterogeneity amidst all studies (I^2 = 92%). This significant difference was not sustained in the subgroup analysis with RCTs with hip fracture population (MD = -6.29, 95% CI -13.85 to 1.27) (Fig. 2F) Although statistically significant, this decrease in opioid consumption cannot be considered clinically significant, since MCID for opioid consumption was not reache.[15] The inconclusive data available in this study have impeded our ability to provide any significant recommendations or propose meaningful changes in the management of this patient population. TSA for cumulative opioid consumption in the first 24 hours once more did not reach the required information sample size and showed a Z-curve not reaching the monitoring boundaries, not matching the statistically significant difference found in the meta-analysis and again raising concerns for type 1 error (Fig. 5.1A). As for cumulative opioid consumption in the hip fracture subgroup, TSA had its Z-curve in the not-statistically significant zone, calling for more studies for additional conclusions (Fig. 5.3B). Results were converted to oral equivalents of morphine for better comparison and plotting.[10] Sensitivity analysis after removing the studies with a high risk of bias,[18] and the outlier,[19] decreased the heterogeneity (I^2 = 68%, previously 92%) with a further decrease in opioid consumption by PENG block patients (MD = -11.26 mg of morphine, 95% CI -17.97 to -4.56). Jadon et al[19] probably led to an increased heterogeneity for being the only study not using PCA for postoperative pain control.

A meta-analysis conducted by Farag et al[30] was recently published, which demonstrated a reduction in opioid consumption within the first 24 hours following the Pericapsular Nerve Group (PENG) block when compared to other interventions. However, there were notable disparities between Farag et al's meta-analysis and ours. Firstly, our meta-analysis only incorporated studies that compared PENG block to Femoral Nerve (FI) block, while Farag et al included studies that compared PENG block to various interventions and non-surgical populations, combining them in the same forest plot for multiple outcomes. Secondly, their search strategy failed to identify all studies that compared PENG block to FI block. Thirdly, Farag et al used the Standard Mean Deviation (SMD) as the effect measure, even for results reported in the same unit, whereas our study reported outcomes in mean deviation. These were methodological inadequacies in the planning, execution, and writing of the study, which do not comply with the Cochrane Guidelines and raise doubts about the validity of its results.[31]

This study has limitations. There was high heterogeneity for most outcomes, due to multiple reasons: (a) Clinical diversity with a different interpretation of pain by the different populations in the studies and cultural differences among patients;[32-34] (b) Differences among the RCT populations since we included studies with a wide range of hip surgeries, from elective primary THA to hip fracture surgeries. Even after performing a subgroup analysis only with the hip fracture population, heterogeneity was still high, which may be caused by variations in the surgical techniques from different countries and medical centers, differences in the local anesthetic drugs and dosage, different opioids, and delivery methods used in each RCT (Table 1). Although all data were converted to oral morphine equivalents,[10] opioids may have similar pharmacodynamics but variable pharmacokinetics, leading to different outcomes; (c) Methodological diversity: although similar enough to be compared,[9,35,36] pain assessment was not uniform among the studies, with different pain scores used, and a different patient approach using VAS or NRS can significantly change the pain assessment. Different pain scores have been elicited by simply showing VAS in a vertical or horizontal way;[37] and (d) Finally, some studies reported pain outcomes with median and IQR,[17,19] while others reported in mean and standard error. The conversion of medians and IQR to mean and SD, albeit validated,[11] may introduce inaccuracies. Also, there was a relatively low number of studies and low number of patients. A TSA showed that none of the outcomes reached the required information sample size, but on the other hand no Z-line crossed the futility boundary, calling for new studies comparing those blocks, with larger number of patients and better standardization of drugs and protocols.

Conclusion

The present meta-analysis suggests that PENG block reduces opioid consumption during the initial 24 hours post-procedure and decreases pain score at rest at 12 hours postoperatively, although those decreases may not be clinically significant. However, there was elevated heterogeneity in study outcomes. In addition, TSA findings suggest limited power to assess the difference between the two techniques. Hence, further studies with larger sample sizes, employing standardized methodologies, are warranted to establish more definitive conclusions.

Data sharing

Because this meta-analysis was based on data extracted from previously published research, all the data and study materials are available in the public domain. The authors of this meta-analysis do not have access to patient-level data of the individual studies. Researchers interested in individual-level data from the studies included in this meta-analysis are encouraged to contact the corresponding author from each study for such requests.

Implication statement

This study compares the efficacy of Pericapsular Nerve Group (PENG) block and fascia iliaca compartment block for hip surgeries by pooling the available data published to date. Our analysis aims to improve the evidence-based knowledge of PENG block regarding outcomes such as opioid consumption and pain scores of the patient.

Conflicts of interest

The authors declare no conflicts of interest.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.bjane.2023.07.007.

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