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REVIEW

The Efficiency of Ultrasound-Guided Pericapsular Nerve Group Block for Pain Management after Hip Surgery: A Meta-analysis

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ABSTRACT

Introduction: Patients with hip surgery often experience moderate to severe postoperative pain, and need large doses of opioids to relieve it, which is not conducive to patient rehabilitation. Pericapsular nerve group (PENG) block is a new regional block technique that is considered to reduce postoperative pain and the use of opioids. The purpose of this study was to evaluate the efficacy and safety of PENG block for postoperative analgesia after hip surgery.

Methods: We searched multiple databases for randomized controlled trials (RCTs) published in English, which compared PENG block with fascia iliaca compartment block (FICB). The primary outcome was 24 h postsurgical opioid consumption (OC). The secondary outcomes were pain scores (PSs) at different timepoints after surgery and the incidence of postoperative nausea and vomiting (PONV).

Results: Five RCTs involving 234 patients were selected for our analysis. Our results show that the 24 h OC was drastically lower in PENG block versus FICB patients (SMD −0.60, 95% CI −1.08 to −0.11); $P < 0.05$, $I^2 = 69\%$). At the same time, there were no significant difference in postsurgical PSs between the two cohorts (6 h: MD −0.07, 95% CI −0.67 to 0.53; $P = 0.82$, $I^2 = 43\%$; 12 h: MD −0.60, 95% CI −1.40 to 0.19; $P = 0.14$, $I^2 = 31\%$; 24 h: MD 0.17, 95% CI −0.87 to 1.21; $P = 0.75$, $I^2 = 76\%$; 36 h: MD 0.80, 95% CI −0.92 to 2.51; $P = 0.36$, $I^2 = 73\%$; 48 h: MD −0.06, 95% CI −0.75 to 0.63; $P = 0.86$, $I^2 = 0\%$) and the incidence of PONV (RR 1.00, 95% CI 0.40–2.50, $P = 1.00$, $I^2 = 35\%$).

Conclusions: Our research shows that PENG block can reduce the use of opioids after hip surgery and is effective in postoperative analgesia. Future research should explore the injection method, concentration, and dosage.

Keywords: Hip surgery; Meta-analysis; Pericapsular nerve group block

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Key Summary Points

Why carry out this study?

Patients with hip surgery often need large doses of opioids to relieve postoperative pain, which is not conducive to patient recovery.

PENG block is a new regional block method, considered to relieve the pain of hip surgery effectively, and has no impact on lower limb muscle strength, but no systematic and persuasive evidence has been presented.

We conducted a systematic review and meta-analysis to explore the safety and efficacy of PENG in hip surgery.

What was learned from the study?

This study shows that PENG block has reduced the use of opioids after surgery and achieved the same analgesic effect as FICB within 48 h after surgery.

INTRODUCTION

Hip surgery is often accompanied by severe pain-induced postoperative adverse effects [1], such as enhanced blood pressure, delayed mobility, delirium, and deep vein thrombosis [2]. As a result, patients require large opioid doses for pain relief, which, in turn, induce drug-related complications like nausea, vomiting, itching, and respiratory inhibition, which are not conducive to patient recovery [3]. In the past few years, FICB has been considered a reliable method for postoperative analgesia after hip surgery [4]. This is equivalent to lumbar plexus block in pain management and OC. Although FICB provides adequate analgesia for patients, it has certain limitations, such as incomplete block and lower limb muscle weakness [5].

The distribution of nerve innervation and receptors in the hip is relatively complex. The anterior capsule of the joint is mainly controlled by the joint branches of the femoral nerve (FN), obturator nerve (ON), and accessory obturator nerve (AON). The posterior part of the joint is jointly supported by the superior gluteal nerve, the inferior gluteal nerve of the sacral plexus, and the nerve branches directly from the sacral plexus to the quadratus femoris. On the other hand, the anterior capsule of the hip joint (AC-HJ) and the upper part of the acetabulum are the most densely innervated areas of nociceptive nerves, and the density of receptors in the anterior side of the joint capsule is significantly higher than that in the posterior side. Therefore, the core of hip analgesia is the anterior capsule, and FN, ON, and AON are the keys to block [6]. PENG, a new regional block technique introduced by Girón-Arango et al. [7] in 2018, provides analgesia by blocking branches from FN, ON, and AON. It should only be aimed at the anterior branch of the hip joint, so it can achieve excellent analgesia without affecting the patient's muscle strength, thus promoting the patient's functional recovery after surgery [8]. Based on several RCTs, PENG block reduces pain after hip surgery and minimizes the demand for opioids [9, 10]. Moreover, it has little impact on lower limb muscle strength [11, 12]. However, these data lack systematic evidence.

Herein, we performed an extensive review and meta-analysis to determine the safety and efficiency of employing PENG block as analgesia following hip surgery.

METHODS

The reporting of this investigation is based on the PRISMA criteria (Preferred Reporting Items for Systematic Reviews and Meta-analyses). The research was based on previously published work, and no human or animal participants were involved.

Extensive Literature Screening

Two scientists independently screened databases, namely PubMed, Embase, Cochrane Library, and Web of Science for RCTs, published between the date of database establishment and 2 October 2022.

No restrictions were placed on language. The screening criteria included [("pericapsular nerve group block " OR "PENG block" OR "nerve block," OR "regional block" OR "regional anesthesia") AND ("hip replacement," OR "hip surgery" OR "hip arthroplasty" OR "total hip replacement" OR "total hip arthroplasty" OR "hip joint replacement")]. In addition, the reference sections of eligible articles were searched for additional relevant and eligible articles.

Article Selection and Data Accumulation

The following articles were included in the analysis: (1) those examining patients undergoing hip surgery; (2) those in which the analgesic intervention measure was PENG block and the control measure was FICB, and the method, location, drug concentration, and dosage were described in full detail; (3) those in which postoperative PSs and OC were assessed as outcome; (4) those in which the research design was RCT. Articles were eliminated from analysis if: (1) the research involved animals or cadavers; (2) the intervention measure was continuous PENG; (3) the control measure was placebo or another nerve block; (4) the article type was either review or case report. Following the elimination of duplicate literature, two researchers browsed the titles and abstracts to determine the eligibility of articles. Subsequently, they independently extracted data from eligible articles and compared the results. The information retrieved from all articles was as follows: author's name, publication year, the number of patients, patient age, ASA classification, PENG and FICB block techniques, anesthesia methods, patient-controlled intravenous analgesia (PCIA), and results.

Quality and Risk Assessment

Study selection bias risk was assessed via Cochrane Review Manager (Version 5.3; The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark,2014), using the following criteria: random sequence generation, assignment hiding, blinding, data integrity, selective reporting, and other biases. Two scientists independently evaluated each investigation and separated the articles into low risk (LR), unclear risk (UR), or high risk (HR).

Primary and Secondary Outcomes

The primary outcome was 24 h postsurgical OC. Opioids needed for rescue and patient analgesia post-operation and patient-controlled analgesia (PCA) usage constituted the overall OC. Secondary outcome measures were PSs at varying durations postsurgery and incidence of PONV. We included two forms of PENGs: visual analog scores and numerical rating scales. The active PSs were recorded for trials assessing PSs at various postsurgery stages.

Statistical Analysis

Review Manager (Version 5.3; The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark, 2014) was employed for our meta-analysis. Pooled risk ratio (RR) and 95% confidence intervals (CIs) were computed for dichotomous data. A p value < 0.05 was set as the significance threshold. Continuous data were assessed as mean difference (MD) and 95% CI. In other cases, standardized mean difference (SMD) was employed. If the study results revealed a median with an interquartile range, the mean and standard deviation were approximated using the Wan formula [13]. The trial heterogeneity was evaluated via I^2 statistic. An $I^2 > 50\%$ employed the random effect model, and $I^2 < 50\%$ employed the fixed effect model.

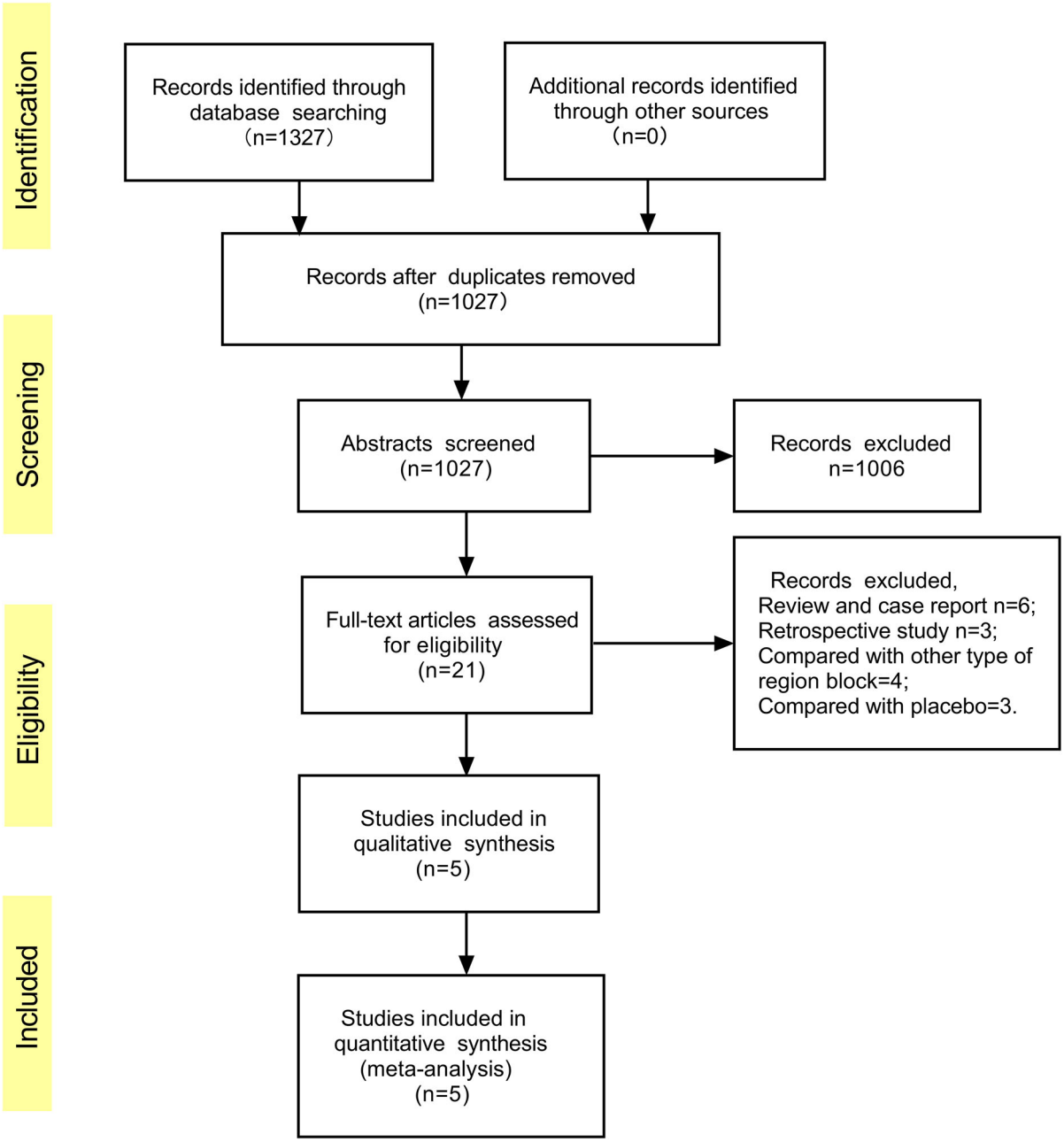

Fig. 1 The study selection process

Table 1 The details of included studies

Author	Size (*n*)	Age (years)	ASA scale	Type of surgery	Local anesthetic:		Anesthesia	PICA
					PENG group	FICB group		
Hao Hua 2022	48	65–85	II–III	Hip arthroplasty	0.40% ropivacaine 20 mL	0.40% ropivacaine 30 mL	SA	Sufentanil PCIA (100 μg) Infusion dose: 1 μg/h Bolus: 2 ml (1 μg/ml) LockoutTime: 15 min
Faramarz Mosaffa 2021	52	40–80	I–II	Hip surgery	0.50% ropivacaine 3 ml/kg (a maximum of 40 ml)	0.50% ropivacaine 3 ml/kg (a maximum of 40 ml)	SA	Morphine PCA (20 mg) Infusion dose: none Bolus: 1 mg LockoutTime: 15 min
Yong SeonChoi 2022	54	≥ 19	I–III	Total hip arthroplasty	0.20% ropivacaine 20 mL with epinephrine 1:200,000	0.20% ropivacaine 30 mL with epinephrine 1:200,000	GA	FentanylPCA (7ug/kg) Infusion dose: 2 mL/h Bolus:0.50 ml LockoutTime:15 min
Julián Aliste 2021	40	18–80	I–III	Total hip arthroplasty	0.50% levobupivacaine 20 mLwith epinephrine 5 μg/ml	0.25% levobupivacaine 40 mL with epinephrine 5 μg/ml	SA	MorphinePCA Infusion dose: none, Bolus: 1 mg LockoutTime: 8 min

Table 1 continued

Author	Size (*n*)	Age (years)	ASA scale	Type of surgery	Local anesthetic:		Anesthesia	PICA
					PENG group	FICB group		
K.S. Senthil 2022	40	≥ 18	I–II	Hip surgery	0.25% levobupivacaine 30 ml and 4 mg dexamethasone	0.25% levobupivacaine 30 ml and 4 mg dexamethasone	SA	Fentanyl PCA Infusion dose: none, Bolus: 20 μg, LockoutTime: 10 min

RESULTS

Search Results

Following a preliminary search, 1327 relevant articles were selected from the abovementioned databases. Subsequently, 300 repetitive and 1005 articles with irrelevant titles or abstracts were excluded. The complete text of the remaining 21 articles was read to determine eligibility. Sixteen additional articles were then excluded due to reasons listed as follows: they were reviews or case reports ($n = 6$) [14–19] or retrospective studies ($n = 3$) [20–22], or the comparison was with other forms of nerve block, and not FICB ($n = 4$) [23–26], or the comparison was with placebo ($n = 3$) [27–29]. Finally, five studies [10–12, 30, 31] were selected for our meta-analysis. The study selection criteria are summarized in Fig. 1

Study Characteristics

Overall, five RCTs involving 234 patients were selected for analysis. Among them, 121 patients belonged to the PENG cohort, and 113 belonged to the FICB cohort. The publication year of the qualifying articles was between 2021 and 2022. Both nerve blocks were conducted under ultrasound guidance. Ropivacaine was employed as a local anesthetic in three studies [10, 11, 30] and levobupivacaine in two studies [12, 31]. The local anesthetic concentration ranged from 0.20% to 0.50%. PCIA/PCA was employed as the postsurgical analgesia in five trials [10–12, 30, 31]. Details of the analyzed investigations are presented in Table 1.

Bias Risk

Five articles [10–12, 30, 31] clearly mentioned random sequence generation, and two reported allocation concealment [10, 11]. Patient blinding did not occur in any eligible investigation. All five studies described blinding assessors and performing attrition bias evaluation. There was no selective reporting. All investigations computed the sample population, and other biases

Fig. 2 Bias risks of analyzed investigations

were stratified as LR. The bias risks of articles are summarized in Fig. 2.

Outcomes

All five investigations reported OC within 24 h of surgery. The 24 h OC was drastically lower in PENG block versus FICB patients (SMD −0.60, 95% CI −1.08 to −0.11); $P < 0.05$, $I^2 = 69\%$,Fig. 3). Three studies reported OC within 48 h of surgery. On the basis of their results, the 48 h OC of PENG block patients was similar to that of the FICB patients (SMD −0.23, 95% CI −0.59 to −0.13); $P = 0.21$, $I^2 = 17\%$; Fig. 3).

The postsurgical PSs were examined at five distinct durations after surgery, namely 6 h, 12 h, 24 h, 36 h, and 48 h. Our analysis revealed no discernible differences in postsurgical PSs between the two cohorts (6 h: MD −0.07, 95% CI −0.67 to 0.53; $P = 0.82$, $I^2 = 43\%$; 12 h: MD −0.60, 95% CI −1.40 to 0.19; $P = 0.14$, $I^2 = 31\%$; 24 h: MD 0.17, 95% CI −0.87 to 1.21; $P = 0.75$, $I^2 = 76\%$; 36 h: MD 0.80, 95% CI −0.92 to 2.51; $P = 0.36$, $I^2 = 73\%$; 48 h: MD −0.06, 95% CI −0.75 to 0.63; $P = 0.86$, $I^2 = 0\%$, Fig. 4). Two investigations reported the PONV incidence, and a forest plot demonstrated no remarkable difference between the two cohorts (RR 1.00, 95% CI 0.40–2.50, $P = 1.00$, $I^2 = 35\%$, Fig. 5). Hua et al.[11] reported seven patients with postoperative quadriceps femoris weakness in the FICB cohort, relative to 0 in the PENG cohort ($P < 0.05$). Choi et al. [10] revealed a marked and comparable reduction in quadriceps strength in the operative leg in both cohorts. In the Aliste Julián [12] study, relative to FICB, PENG block produced fewer incidences of quadriceps block at the 3 (45% versus 90%; $P < 0.001$) and 6 h (25% versus 85%; $P < 0.001$) timepoints, and it enhanced knee joint extension. Lastly, the Senthil KS [31] study indicated that PENG block significantly improved quadriceps femoris muscle strength at 18 and 24 h postsurgery ($P = 0.009$ and $P = 0.005$, respectively). None of the five studies reported complications related to PENG block or FICB.

Publication Bias

Owing to the small number of analyzed articles, we did not perform a publication bias assessment.

DISCUSSION

This meta-analysis is the first to assess the safety and efficacy of PENG block following hip surgery. We revealed that, relative to FICB, PENG block drastically diminished OC at 24 h postsurgery; however, no marked difference was observed at 48 h post-surgery. Moreover, PSs recorded at five different timepoints postsurgery exhibited no marked differences between the two cohorts. Together, these results indicated that PENG block achieved the same analgesic effect as FICB after hip surgery and reduced OC postsurgery. However, due to inconsistent measurement methods, quadriceps femoris muscle strength could not be combined, and

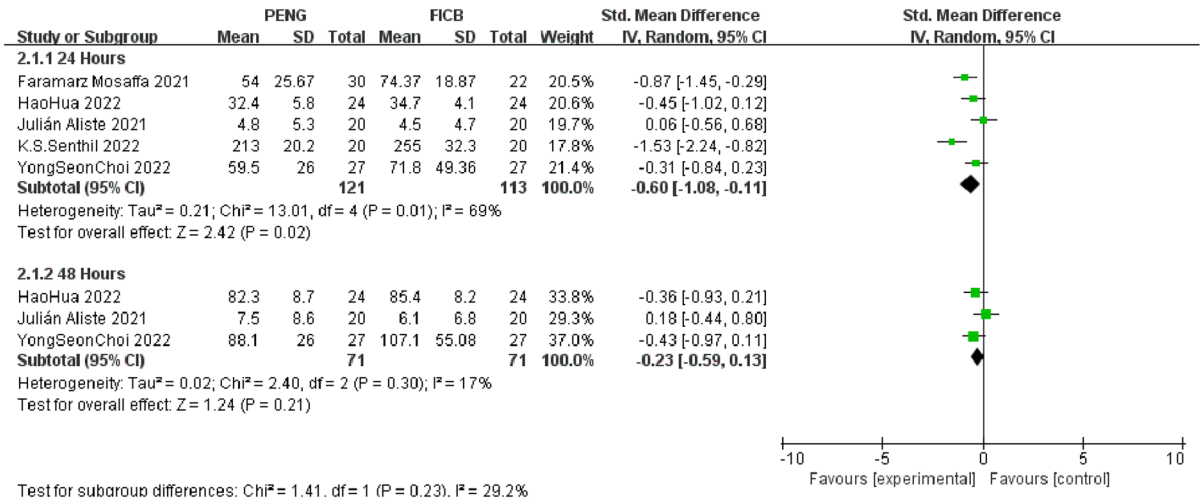

Fig. 3 Forest plot of pooled analysis depicting postsurgical opioid usage

further RCT tests are necessary to verify our results.

FICB is known to have a good analgesic effect after a hip surgery. However, it often leads to a decline in quadriceps femoris muscle strength, enhances patients' first mobility duration, and augments fall risk [32]. The AC-HJ, and the upper part of the acetabulum, are densely innervated with nociceptive nerves, and the density of these receptors in the anterior region is significantly higher than in the posterior region. Therefore, the core area for analgesia after hip surgery is the AC-HJ [33]. The AC-HJ innervation primarily originates from the FN, ON, and AON branches. PENG block involves administering local anesthetics into the AC-HJ, whereby it selectively acts upon the joint branches of the nerves mentioned above. This action retains the motor components of the joint; thus, it does not affect the patient's motor function, which is conducive to early rehabilitation. However, Yu et al. [34] reported two cases of quadriceps femoris weakness after the PENG block, which returned to normal after 24 h. Mistry et al. [35] speculated that the different injection sites, as well as different types, concentrations, and doses of local anesthetics, may contribute to the accidental involvement of FN motor branches, thus resulting in a decline of quadriceps femoris muscle strength. This investigation confirmed that the PENG block is highly effective as postoperative analgesia and reduces OC. However, additional investigations are warranted to verify the impact on the lower limb muscle strength. In addition, the optimal local anesthetic concentration and dose for the PENG block must be further determined.

LIMITATIONS

This work had certain limitations. First, the sample population of the included research was small, and future investigations involving a large patient population are warranted. Second, some studies presented results as median and interquartile intervals, which were converted to mean and standard deviation in this investigation. Unfortunately, this action may have affected our results. Third, the results could not be combined due to using different measurement methods to quantify quadriceps femoris muscle strength.

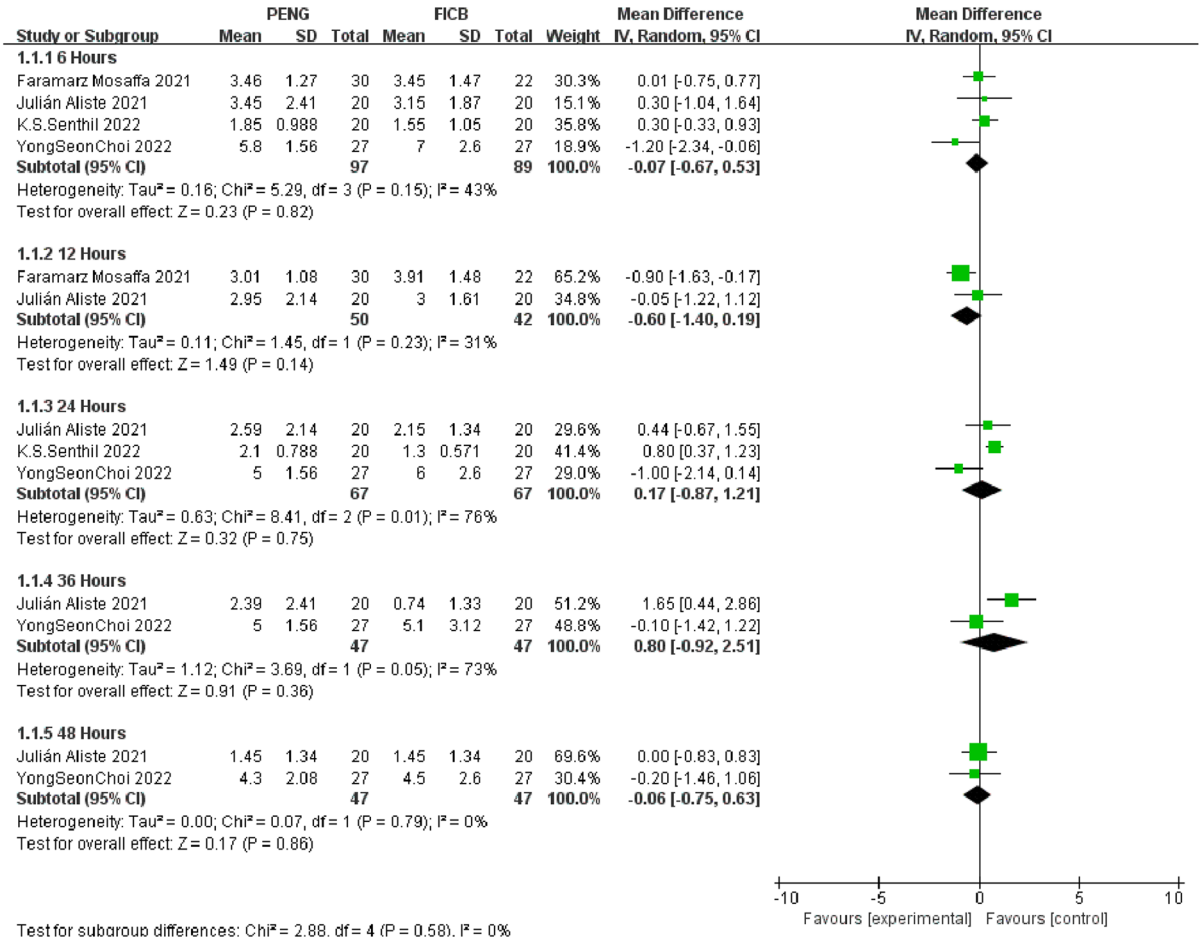

Fig. 4 Forest plot of pooled analysis illustrating the pain scores at various durations from surgery

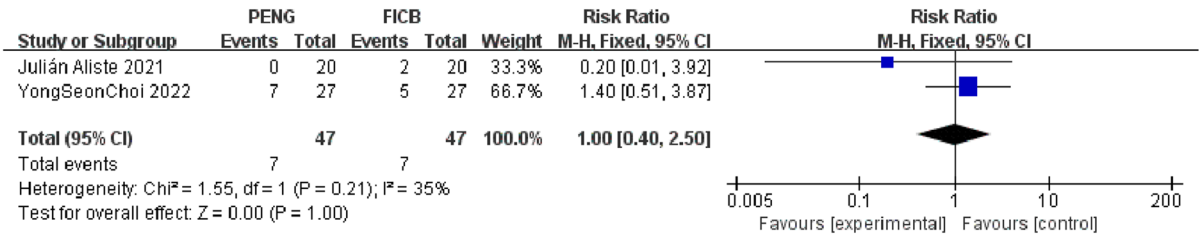

Fig. 5 Forest plot of pooled analysis depicting postsurgical nausea and vomiting incidences

CONCLUSION

In summary, PENG block is effective and safe as postoperative analgesia following hip surgery. However, its influence on the muscle strength of the affected limb requires further investigation and validation. In addition, the PENG injection method, concentration, and dosage also require further exploration.

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Author Contributions. Yi Wang and Huaichang Wen conceived the design of this meta-analysis. Yi Wang and Huaichang Wen performed the literature retrieval and article writing. Yi Wang and Mengli Wang contributed to the data extraction, and Meijing Lu revised the manuscript. All authors read and approved the final manuscript.

Disclosures. Yi Wang, Huaichang Wen, Mengli Wang, and Meijing Lu confirm that they have nothing to disclose.

Compliance with Ethics Guidelines. This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any authors.

Data Availability. All data generated or analyzed during this study are included in this published article and as supplementary information files.

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