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SYSTEMATIC REVIEW

The efficacy of nerve block on headache intensity, frequency, and duration in patients with headache: a systematic review and meta-analysis

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Abstract

Background: Nerve block holds significant predictive and guiding value for subsequent minimally invasive procedures. This systematic review aimed to determine the effects of nerve block on cervicogenic headache. **Methods**: We searched the Cochrane Library, PubMed, EMBASE and Web of Science for randomized controlled trials (RCTs) involving adults (≥18 years) with cervicogenic headache who underwent nerve block. The major outcomes were pain intensity scores, weekly headache frequency, and headache duration before and after nerve block. We also assessed the outcomes according to different target nerves, corticosteroid combinations, and guiding methods. **Results**: A total of 17 studies (n = 885) were included in the review, all of which underwent qualitative synthesis, with 11 studies further subjected to quantitative synthesis. The results demonstrated that nerve block significantly alleviated pain, with a mean reduction of 1.62 points, and the effect was notable at 2 weeks, whereby pain intensity was reduced by 1.99 points. Nerve block also reduced headache frequency by 0.66 episodes/week and duration by 4.82 days. The efficacy did not significantly differ according to the target nerve, corticosteroid combination, or guiding method. **Conclusion**: Nerve block could relieve pain intensity and reduce the frequency and duration of cervicogenic headache, with the effect being significant at 2 weeks. Different target nerves, corticosteroid combinations, and guidance methods had no significant impact on efficacy. **The PROSPERO Registration**: CRD420251144807.

Keywords

Cervicogenic headache; Pain; Nerve block; Greater occipital; Headache

1. Introduction

The term “cervicogenic headache” (CH) originated in 1983, with an estimated prevalence ranging from 0.7% to 13.8% [1]. Nausea, vomiting, dizziness, visual disturbances, tinnitus, and occipital headaches have been described as typical symptoms [2], which may be associated with joint pathology, vertebral artery impairment, or migrainous origins [3], and are more commonly observed in younger populations [4]. Cervicogenic headache is a secondary headache arising from structural pathology of the cervical spine, including the facet joints, intervertebral discs, ligaments, and neural structures (C1–C3), with its anatomical and pathological mechanism primarily characterized by referral pain to the head, with neural structures playing a pivotal role [5, 6]. In the International Headache Society (IHS) classification of the ICHD-II edition (International Classification of Headache Disorders: the 2nd edition), the term “cervicogenic headache” was formally introduced for the first time [7], and the diagnostic criteria [8] included pain originating from the cervical region together with supporting clinical, laboratory, and/or imaging evidence.

Nerve block achieves pain relief by temporarily blocking nerve signal transmission [9] and is also an important therapeutic approach for cervicogenic headache, with different medications exerting their effects through distinct mechanisms. Lidocaine works by blocking sodium (Na^+) channels and reducing sodium ion currents, thereby inhibiting neuronal excitability [10]. Corticosteroid nerve blocks are also effective for cervicogenic headache and act via anti-inflammatory and analgesic effects by targeting both peripheral and central pain pathways [11, 12]. Nerve block also targets many different types of nerves. Medial branch block (MBB), which can be used to relieve chronic pain by allowing more precise targeting of specific pain-generating joints, may produce false-negative results if the correct joint is not blocked [13]. In contrast, greater occipital nerve block (GONB) has a broader application range and can alleviate pain arising from a wider range of structures, although its limitation lies in its inability to identify the specific joint or structure responsible for the pain [14].

Prior systematic reviews and meta-analyses have evaluated

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the use of nerve blocks for CH. One systematic review [15] reported pain intensity outcomes in 140 patients with CH after GONB and found that nerve block was a well-tolerated, low-cost, and repeatable treatment. However, this review only included studies from PubMed and Scopus and was limited by a small sample size of 140 patients. Another meta-analysis [16] showed that occipital nerve block reduced the severity and frequency of occipital headaches, but it lacked comparisons of headache durations or assessment on differences in treatment effects among nerve blocks performed under different target nerves, corticosteroid combinations, and guiding methods.

Herein, this present systematic review was designed to have broader scope than previous reviews by comparing differences in headache intensity, frequency, and duration in patients with CH undergoing nerve block and further evaluates outcomes according to different target nerves, corticosteroid combinations, and guidance methods. The results of the efficacy evaluation may provide a basis for subsequent surgical procedures, while the recommendations of this study may help guide clinicians and patients in selecting nerve block for cervicogenic headache and in considering its combined use with other treatment options.

The objective of this systematic review was to systematically evaluate the efficacy of nerve block in reducing the intensity, frequency, and duration of CH in comparison with placebo or no treatment.

2. Material and methods

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [17]. A study protocol was prospectively developed and registered in PROSPERO (Prospective Register of Systematic Reviews, number: CRD420251144807) prior to data collection. This systematic review was reported following the PRISMA 2020 statement. The complete PRISMA 2020 checklist is provided in **Supplementary material 1**.

2.1 Data sources

A systematic literature search was conducted across the following databases: the Cochrane Library, PubMed, EMBASE, and Web of Science. The search covered the period from database inception to October 2025, using search terms “Cervicogenic Headache” and “Nerve Block”. In PubMed, additional related keywords for these terms were identified and searched within the MeSH (Medical Subject Headings) thesaurus. To obtain high-quality evidence and effect estimates, only randomized controlled trials (RCTs) were included. To identify additional records, the reference lists of all included studies were independently screened by two authors (EY and JX). Any discrepancies were resolved through re-evaluation to ensure that no relevant literature was overlooked. The search strategy was adapted accordingly for each database, with the complete strategy provided in **Supplementary material 2**.

2.2 Eligibility criteria

The analysis included studies meeting the following criteria: (1) RCTs; (2) published in English; (3) including a minimum of 5 patients; (4) involving patients diagnosed with cervicogenic headache or its synonymous expressions; and (5) including nerve block as part of the treatment.

Studies were excluded according to the following criteria: (1) a total number of patients fewer than 5; (2) patients under 18 years of age; (3) treatment of headache without reference to neck pain or tenderness; (4) case reports, animal studies, abstracts, conference papers, retrospective reviews, non-randomized controlled studies, review articles, meta-analyses, or duplicate cohort studies; or (5) publication in languages other than English.

2.3 Search procedure

After obtaining records through the search strategy, duplicates were first removed. Then, two reviewers (WW and ZC) independently screened the titles and abstracts to exclude irrelevant studies and subsequently selected potentially relevant reports for further detailed evaluation.

2.4 Data collection and quality assessment

Data extraction was independently verified by two reviewers (YZ and CC), who cross-checked more than 90% of the extracted data. General patient information and study characteristics were collected, including sex, age, sample size, the number of patients in the treatment and control groups, and treatment types. The clinical data collected included the types of nerve blocks performed in these studies, medications used, and the reported outcome measures. The outcome measures comprised headache intensity, assessed using the Visual Analog Scale or Numeric Rating Scale, headache frequency, and the number of headache days.

Subsequently, the Cochrane risk-of-bias tool for randomized trials was used to assess the included studies across six domains. For each domain, the risk of bias was judged as “low”, “high”, or “unclear”.

2.5 Statistical analysis

Statistical analyses were conducted using RevMan 5.3 (The Nordic Cochrane Centre, Copenhagen, Denmark) and the risk-of-bias assessment was performed using R software (v4.3.3). Study heterogeneity was quantified using the I^2 statistic, with $I^2 < 50\%$ considered as low heterogeneity, whereas high heterogeneity prompted further investigation. A random-effects model was used to pool the outcomes and are reported as mean differences (MDs) with standard deviations (SDs). Data reported as medians and interquartile ranges were converted to means and standard deviations using an online tool (https://www.math.hkbu.edu.hk/~tongt/papers/median2mean.html). $p < 0.05$ was considered statistically significant.

For uniformity in outcome reporting, pain scores originally reported on a 0–100 scale were rescaled to a 0–10 scale. To standardize the measurement of headache frequency, data reported over multiple weeks were converted to a per-week

value.

3. Results

3.1 Article selection

A total of 688 records were identified through systematic searches using database-specific retrieval strategies across four databases. After removing duplicate references, 449 records remained for further screening. Following initial screening of titles and abstracts, 405 records were excluded, leaving 44 articles eligible for full-text review. Ultimately, 17 articles were selected for inclusion, while 27 articles were excluded for the following reasons: five were non-randomized controlled trials, four were available only as abstracts, one was not published in English, six were off-topic, two involved patients at the extremes of age, six lacked complete results, and three were case reports. Consequently, 17 studies [18–34] were included in the qualitative synthesis, and 11 studies [18–22, 25, 26, 29–31, 34] were included in the quantitative synthesis. The study selection process is illustrated in Fig. 1.

3.2 Study characteristics and treatment protocols

Demographic and clinical data are presented in Table 1 (Ref. [18–34]) and Table 2 (Ref. [18–34]). All 17 included studies were RCTs, comprising a total of 885 patients. Nerve block medications included lidocaine, dexamethasone, mepivacaine, bupivacaine, fentanyl, clonidine, and epinephrine. The control interventions included cognitive therapy and normal saline injections. The effects of nerve block interventions were evaluated across the included studies: six assessed nerve block interventions alone, two compared different pharmacological nerve block interventions, five evaluated nerve blocks versus placebo, and four investigated different nerve block techniques.

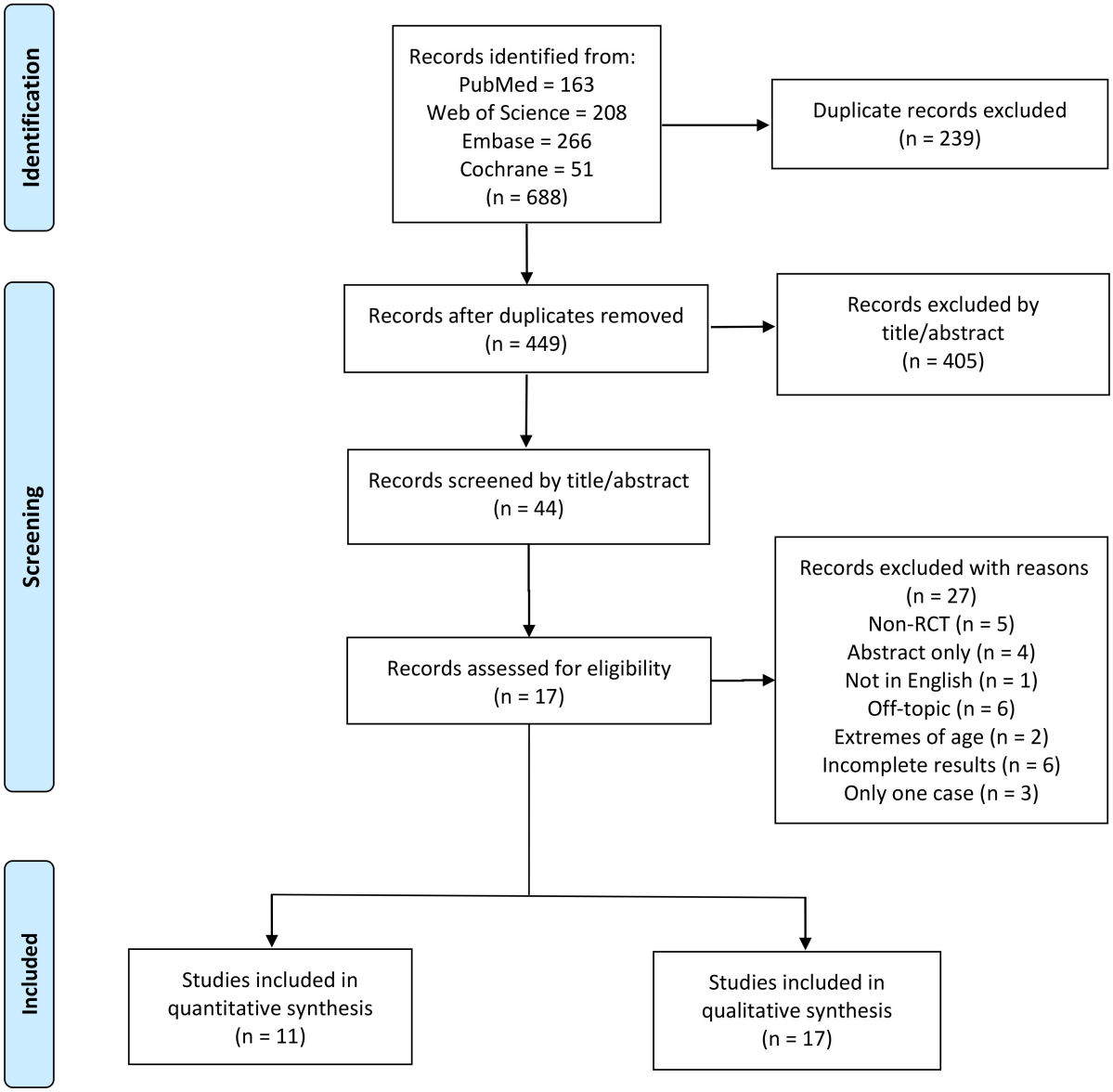


FIGURE 1. Preferred reporting items for systematic reviews and meta-analyses flow diagram. RCT, randomized controlled trial.

TABLE 1. Demographical characteristics of the patients.

Author (year)	Sample Size	Group	No of Treatment/Control	Age	Sex (M/F)
George *et al.* [21] (2002)	67	Nerve block group	34	28–67	27/40
		Cognitive therapy group	33		
Gabriela *et al.* [24] (2015)	30	5 mL group	10	44 ± 6	3/6
		10 mL group	10	42 ± 8	2/7
		15 mL group	10	43 ± 9	3/7
Gul *et al.* [29] (2017)	44	Group A (bupivacaine)	22	38.9 ± 7.2	2/20
		Group B (placebo)	22	38.0 ± 9.5	3/19
Jae *et al.* [33] (2019)	54	BTX group	27	52.2 ± 11.2	7/20
		BUP group	27	55.2 ± 10.5	8/19
Ma *et al.* [19] (2024)	7	"Three-in-one" block and Interfascial Plane blocks group	7	54.43 ± 14.18	4/3
Matthew *et al.* [22] (2017)	14	GON group	14	61.1 ± 17.4	7/7
Maurice *et al.* [25] (1998)	33	GON group	33	N/A	N/A
Michael *et al.* [23] (2008)	39	Deep cervical plexus group	39	51.0 ± 12.5	8/31
Oleg *et al.* [31] (2023)	70	Block group	35	44.7 ± 2.8	N/A
		Placebo group	35	43.1 ± 3.4	N/A
Peter *et al.* [18] (2000)	100	Nerve block group	100	N/A	31/69
Roderick *et al.* [20] (2013)	40	Fluoroscopy group	20	50.3 ± 14.5	7/14
		Ultrasound group	20	54.9 ± 15.17	6/15
Se Hee Na *et al.* [32] (2010)	26	Traditional method (Group C)	13	53.8 ± 11.3	6/7
		Ultrasonic doppler flowmeter-guided method (Group D)	13	55.7 ± 10.6	8/5
Silvia *et al.* [28] (2010)	150	ONB group	150	45.8	13/137
Wan *et al.* [34] (2017)	54	US group	28	49.2 ± 10.3	7/21
		FL group	26	47.6 ± 9.7	5/21
Zenat *et al.* [30] (2021)	60	GONB group	30	41.1 ± 10.0	3/27
		MCPB group	30	41.9 ± 11.3	5/25
Zoher *et al.* [26] (2006)	50	Block group	25	46.44 ± 9.63	6/19
		Placebo group	25	47.36 ± 10.25	7/18
Zoher2 *et al.* [27] (2006)	47	GON group	47	46.66 ± 10.03	12/35

BUP, bupivacaine; BTX, botulinum toxin; GON, greater occipital nerve; ONB, occipital nerve block; US, Ultrasoundguided; FL, fluoroscopy-guided; GONB, Greater occipital nerve block; MCPB, Multifidus cervicis plane block; M, men; F, female; N/A, Not Applicable.

TABLE 2. Clinical data of the patients.

Author (year)	Group	Comparator	Outcome	Result
George *et al.* [21] (2002)	Nerve block group	Nerve block	Visual Analogue Scales (VAS); Hospital Anxiety and Depression Scale (HADS); COOP-WONCA scale	Mean VAS scores in the nerve block group dropped slightly during treatment. Mean VAS scores in the cognitive therapy group rose during the trial. However, the mean VAS score of the remaining four in the last week was below the initial group mean.
	Cognitive therapy group	Eight weekly sessions of cognitive therapy utilizing Caudill's protocol		
Gabriela *et al.* [24] (2015)	5 mL group	10 mg dexamethasone (1 mL) + 2 mL 2% lidocaine + 0.5 mL saline + 1.5 mL nonionic iodine contrast	Duration of analgesia; VAS; rescue analgesics consumption; quality of sleep; quality of daily activities	The classical GON technique resulted in 2 weeks of analgesia and less rescue analgesic consumption, compared to 24 weeks after the subcompartmental technique ($p < 0.01$).
	10 mL group	10 mg dexamethasone (1 mL) + 2 mL 2% lidocaine + 3.5 mL saline + 3.5 mL non-ionic iodine contrast		
	15 mL group	10 mg dexamethasone (1 mL) + 2 mL 2% lidocaine + 5 mL saline + 7 mL non-ionic iodine contrast		
H.L.Gul *et al.* [29] (2017)	Group A (bupivacaine)	GON blockade (bupivacaine)	Number of headache days; VAS pain scores	Group A showed significant reductions in headache frequency and VAS scores at all three follow-up months (1st, 2nd, and 3rd). Group B showed significant reductions only in the first month, with no significant changes at the second and third months.
	Group B (placebo)	GON blockade (saline)		
Jae *et al.* [33] (2019)	BTX group	Ultrasound-guided GON block with the botulinum toxin type A	VAS score; Likert scale	The VAS score and patient satisfaction score (Likert scale) in 4, 8, and 24 weeks after injection were superior for the BTX than the BUP group.
	BUP group	Ultrasound-guided GON block with levobupivacaine and dexamethasone		
Ma *et al.* [19] (2024)	"Three-in-one" block and Interfascial Plane blocks group	"Three in One" approach, with nerve blocks/PRF plus IFP blocks	NRS scores	A noteworthy improvement in the NRS scores of all patients.

TABLE 2. Continued.

Author (year)	Group	Comparator	Outcome	Result
Matthew *et al.* [22] (2017)	GON group	1 mL of 2% lidocaine, 2.5 mL of 0.25% bupivacaine, and 3 mg of betamethasone was injected	NRS score	Compared with baseline, numeric rating scale scores decreased by a mean of 3.78 at 30 minutes ($p < 0.001$), 2.64 at 2 weeks ($p = 0.006$), and 2.21 at 4 weeks ($p = 0.01$).
Maurice *et al.* [25] (1998)	GON group	1–2 mL 0.5% bupivacaine injection at the ipsilateral greater occipital nerve	VAS	33 CeH patients' VAS pain was significantly reduced both immediately and as long as 7 days after the blockade.
Michael *et al.* [23] (2008)	Deep cervical plexus group	10 mL of 0.25% bupivacaine with 80 mg of methylprednisolone were injected in slow divided doses under fluoroscopic guidance	Pain scores	Thirty-three percent (33%) of the patients reported pain scores of $\leq$4 on the 0–10 pain scale after their last treatment.
Oleg *et al.* [31] (2023)	Block group	Greater occipital nerve blocks with 2 mL 2% cold solution lidocaine and 1 mL dexamethasone	VAS	10 days after treatment VAS pain intensity was significantly higher in the placebo group: 2.9 $\pm$ 0.9, while in the block group: 1.2 $\pm$ 0.3 ($p <$ 0.05).
	Placebo group	Injections of preservative-free normal saline		
Peter *et al.* [18] (2000)	Nerve block group	The subjects' self-report of depression and anxiety	VAS; self-report of depression and anxiety; ADLs	Following each nerve block session, subjects reported significant improvements in pain, depression, anxiety, quality of life, and daily functioning.
Roderick *et al.* [20] (2013)	Fluoroscopy group	Fluoroscopy-TONB	NRS; Percentage relief from preblock pain; electrical perceptual threshold ratio	Both imaging modalities, however, resulted in similar success rates (95% and 100%).
	Ultrasound group	US-guided TONB		
Se Hee Na *et al.* [32] (2010)	Traditional method (Group C)	Using a 27-G needle, just medial to the occipital artery	Pain (NRS); Distance from external occipital protuberance to injection site	The complete block rate of greater occipital nerve blockade in the doppler group was significantly higher than in the control group respectively (76.9% *vs.* 30.8%, $p < 0.05$).
	Ultrasonic doppler flowmeter-guided method (Group D)	After the probe was manipulated back and forth until the most audible site was found, Inject 1% lidocaine 3 mL		

TABLE 2. Continued.

Author (year)	Group	Comparator	Outcome	Result
Silvia *et al*. [28] (2010)	ONB group	Occipital nerve block	5-point Likert scale (“much better”, “better”, “same”, “worse”, “much worse”)	At the 1-month follow-up visit 78 (52%) exhibited evidence of a positive treatment response according to the primary outcome variable, and 90 (60%) reported their headache disorder to be “better” (44; 29%) or “much better” (46; 30%).
Wan *et al*. [34] (2017)	US group	Ultrasoundguided C2 and/or C3 transverse process injection	NRS	The pain intensity, as measured by NPS, significantly decreased at 2 wks after injection treatment in both US and FL groups, respectively, compared with that of baseline ($p < 0.05$).
	FL group	Fluoroscopy-guided C2 and/or C3 transverse process injection		
Zenat *et al*. [30] (2021)	GONB group	Greater occipital nerve block	VAS; Headache frequency	At the 2-week follow-up, VAS scores and median reductions were significantly better in the MCPB group (2.09%, −4.33) than in the GONB group (2.22%, −3.048) ($p < 0.001$). This significant advantage persisted at 4 weeks, with scores of 3.79 (−3.27) versus 4.44 (−3.095) ($p = 0.020$).
	MCPB group	Multifidus cervicis plane block		
Zoher *et al*. [26] (2006)	Block group	Each 10 mL of the injected mixture contained: 3 mL lidocaine 2%; 3 mL lidocaine 2% with epinephrine 1:200,000; 2.5 mL bupivacaine 0.5%; 0.5 mL fentanyl 50 μg/mL; and 1 mL clonidine 150 μg/mL	Duration of pain relief; Frequency of headaches; Duration of crises; VAS; TPI	Anesthetic block was effective in reducing the VAS and the TPI by approximately 50% from baseline values ($p = 0.0001$).
	Placebo group	Saline		
Zoher2 *et al*. [27] (2006)	GON group	Greater Occipital Nerve Blockade Using the Nerve Stimulator	VAS score; Needed Time to Perform All Repetitive Blocks (Days)	Forty-one patients (87%) required more than one injection to achieve six-month pain-relief period. For every three years of headache history, the outcomes demonstrated that a patient needed one additional injection to the basic injection.

VAS, Visual Analogue Scales; HADS, Hospital Anxiety and Depression Scale; COOP-WONCA, Primary Care Cooperative Information Project/World Organization of National Colleges, Academies; NRS, Numerical Rating Scale; BUP, bupivacaine; BTX, botulinum toxin; GON, greater occipital nerve; ADL, activities of daily living; TONB, Third occipital nerve blocks; ONB, occipital nerve block; US, Ultrasoundguided; FL, fluoroscopy-guided; GONB, Greater occipital nerve block; MCPB, Multifidus cervicis plane block; TPI, Total Pain Index; PRF, Pulse radiofrequency; IFP, interfascial plane; CeH, Cervicogenic headache.

All studies used the diagnostic criteria of ICHD-II or ICHD-III, except for George *et al.* [21] and Peter *et al.* [18], who described criteria from the International Headache Society without specifying a particular version, and Michael *et al.* [23], Oleg *et al.* [31], and Roderick *et al.* [20], who did not report any specific diagnostic criteria.

Headache intensity was the most frequently reported outcome and was assessed using the NRS (Numerical Rating Scale) in five studies, the VAS (Visual Analogue Scales) in ten studies, the Likert scale in one study, and both the VAS and Likert scales in one study. Two studies measured headache frequency, two assessed headache duration, and three evaluated the percentage of pain relief achieved by nerve blocks. Quality of life was assessed in three studies.

All 17 studies evaluated treatment effects following nerve block. Two studies reported short-term outcomes (1 week to 10 days), four assessed intermediate-term outcomes (2 weeks to 3 months), and four evaluated long-term outcomes (>3 months).

3.3 Risk of bias assessment

Figs. 2,3 present the summary and traffic -light plots of the Cochrane Risk of Bias assessment for the 17 included studies. Overall, eight studies were rated as having a low risk of bias, six as having some concerns, and three as having a high risk of bias.

Publication bias was assessed using funnel plots. Most funnel plots showed a symmetrical distribution, indicating a low risk of publication bias. However, the symmetry of some funnel plots could not be adequately assessed because of the limited number of included studies, suggesting that the possibility of publication bias could not be excluded.

The GRADE (Grade of Recommendations Assessment, Development and Evaluation) assessment indicated that the quality of evidence for most sensitivity analysis results was moderate, while a small proportion was of low quality. The GRADE assessment of the sensitivity analyses is presented in **Supplementary material 3**.

3.4 Comparison of headache intensity between nerve block and placebo groups

Data from four studies were comparable and subsequently pooled to analyze headache intensity between the nerve block and placebo groups following the intervention. The experimental groups received nerve blocks, while the control groups received placebo treatment.

A significant difference in headache intensity was observed between the nerve block and placebo groups. Compared with placebo, nerve block significantly alleviated the intensity of cervicogenic headache ($p < 0.00001$, $I^2 = 6\%$), with an average reduction of 1.62 points, as presented in Fig. 4.

The other qualitative studies [18–20, 22–25, 28, 30, 32–34] similarly reported that nerve blocks reduced headache intensity.

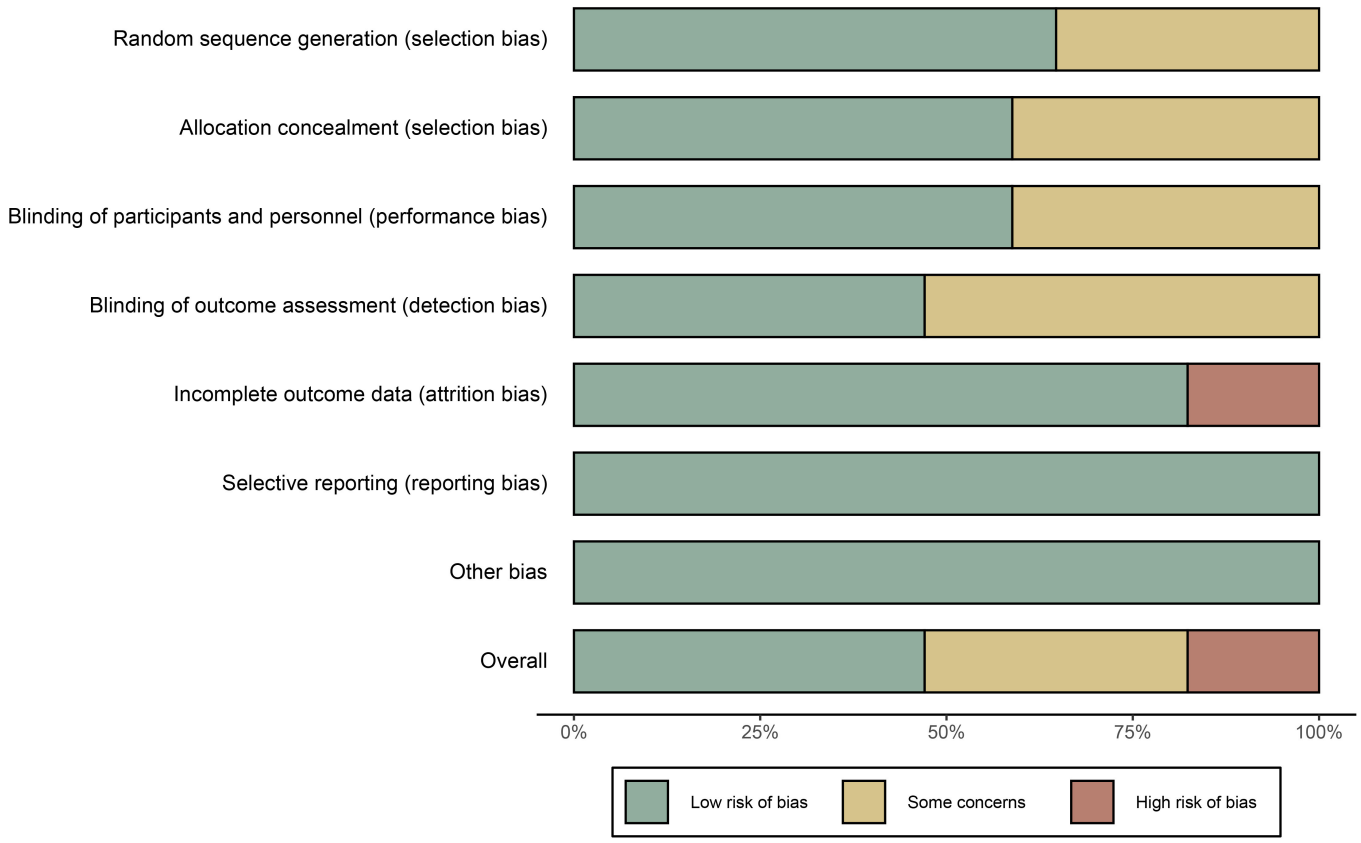


FIGURE 2. Risk of bias assessment for the included RCTs.

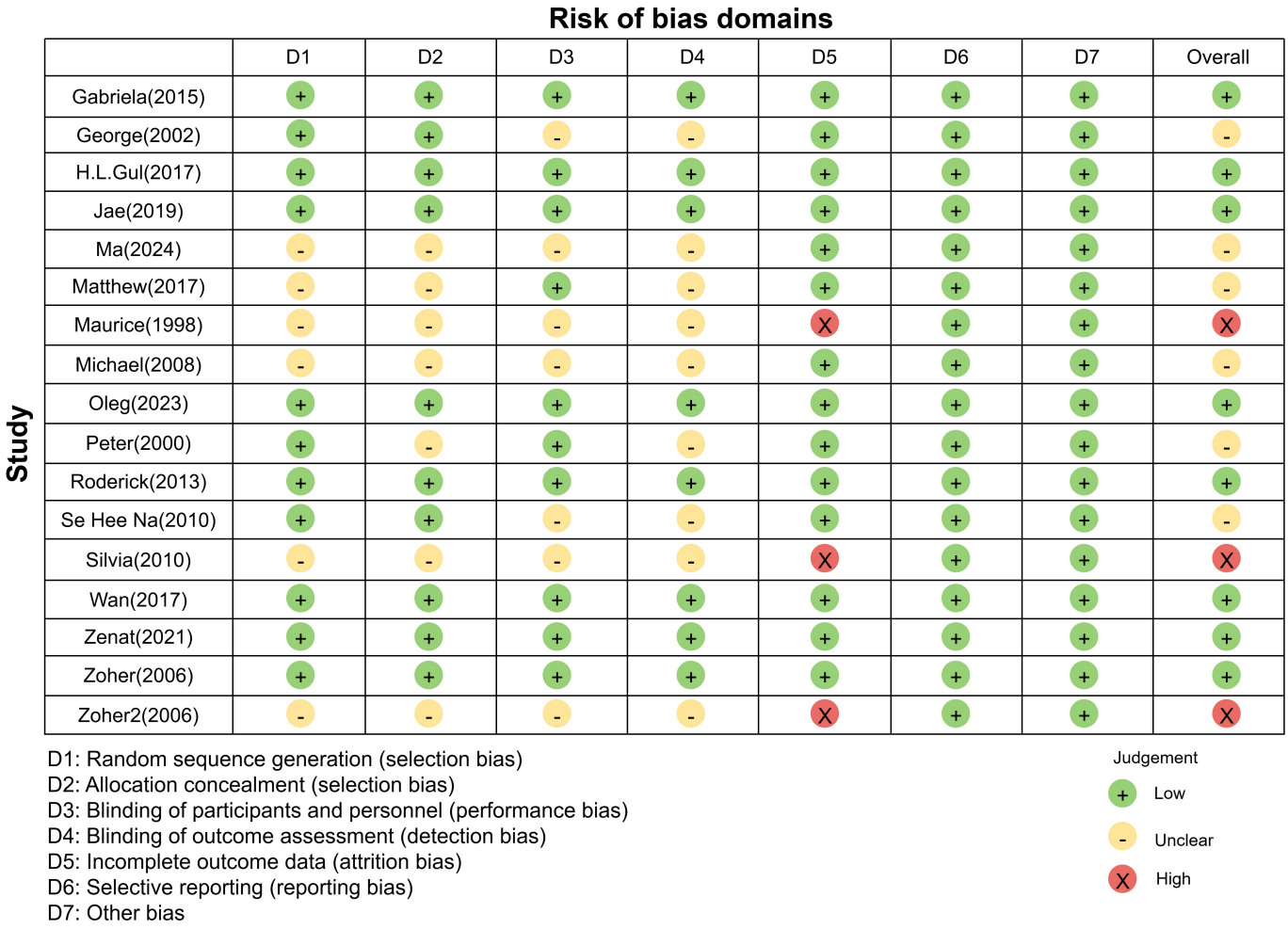


FIGURE 3. Summary of risk of bias assessment across the 17 studies.

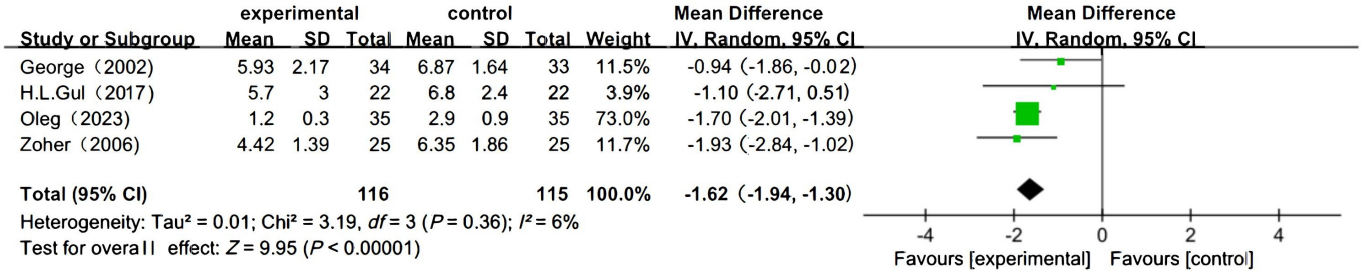


FIGURE 4. Comparison of nerve block and placebo in the intensity of cervicogenic headache. SD, Standard Deviation; IV, Information Value; CI, Confidence Interval; *df*, degree of freedom.

3.5 Impact of nerve block on headache intensity in cervicogenic headache across various time points

Further subgroup analysis was conducted to compare the effects of nerve block on headache intensity at different time points in patients with cervicogenic headache, as illustrated in Fig. 5. Compared with placebo, nerve block did not significantly reduce the severity of cervicogenic headache from immediately after the block to one-week post-block ($p = 0.07$, $I^2 = 7\%$). However, the effects of nerve block on headache intensity were more pronounced between two weeks and one month after treatment. Specifically, compared with placebo, nerve block significantly decreased pain severity, with an average reduction of 1.99 points at two weeks ($p < 0.00001$, $I^2 = 0\%$) and 1.28 points at one month ($p = 0.002$, $I^2 = 0\%$).

Among the studies included in the qualitative synthesis, Maurice *et al.* [25] reported that nerve blocks were effective both immediately after treatment and at 7 days post-treatment, while the findings of Wan *et al.* [34] suggested that the effect was optimal at 2 weeks.

3.6 Comparison of headache frequency and headache duration days after nerve block

Compared with placebo, a meta-analysis of four studies with comparable data demonstrated that nerve block reduced headache frequency in patients with cervicogenic headache

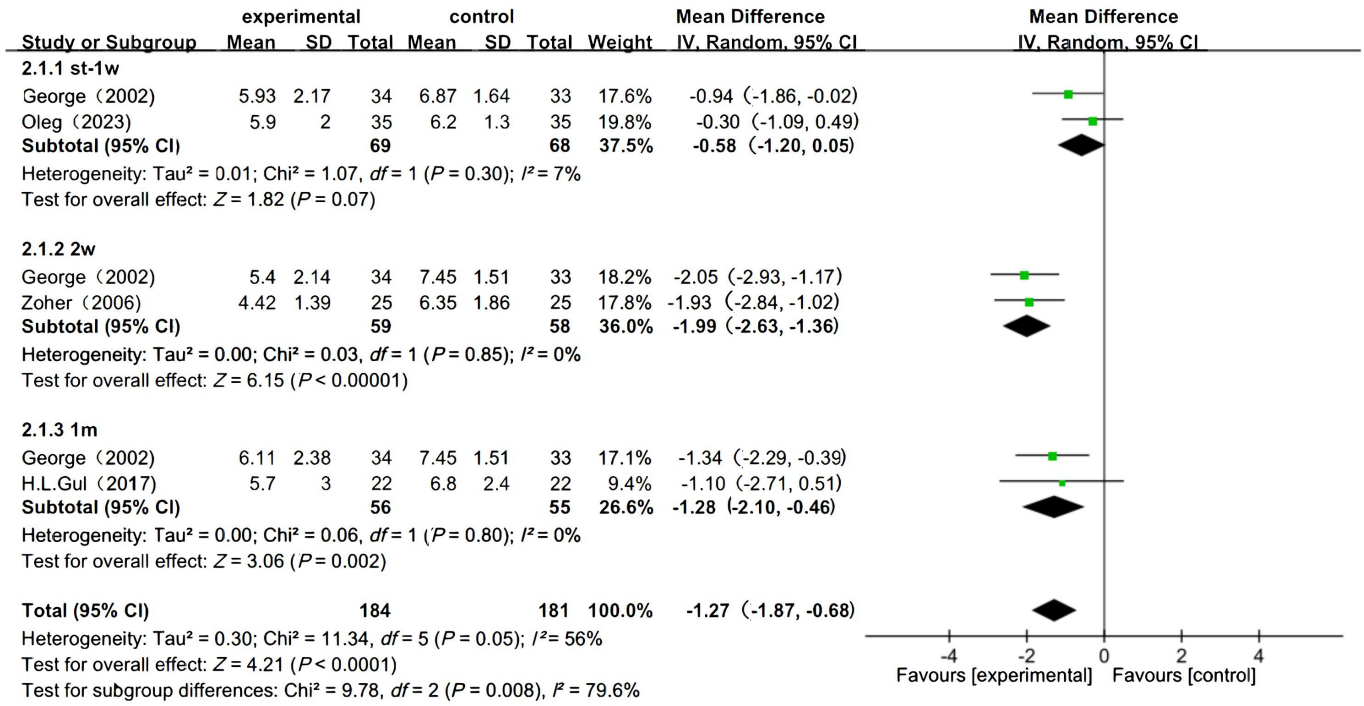


FIGURE 5. Comparison of the immediate and long-term effects of nerve block on cervicogenic headache intensity. SD, Standard Deviation; IV, Information Value; CI, Confidence Interval; *df*, degree of freedom.

by an average of 0.66 episodes per week ($p = 0.02$, $I^2 = 0\%$), indicating a consistent effect across the included studies, as illustrated in Fig. 6.

Similarly, a meta-analysis of two studies further supported these findings, showing that nerve block significantly decreased the average number of headache days by 4.82 days per week compared with placebo ($p < 0.00001$, $I^2 = 0\%$), as presented in Fig. 7.

3.7 Comparison of nerve block with various target nerves, corticosteroid combinations, and guiding methods

To further investigate the effects of different target nerves, corticosteroid combinations, and guiding methods on headache, we conducted a subgroup analysis.

First, both GONB and non-GONB nerve blocks provided significant clinical benefits compared with placebo (GONB: $p < 0.00001$, $I^2 = 0\%$; non-GONB: $p = 0.004$, $I^2 = 56\%$), with no clinically meaningful difference between the two groups ($p = 0.64$, $I^2 = 0\%$), as illustrated in Fig. 8.

Second, relative to placebo, both nerve blocks combined with and without corticosteroid significantly reduced the intensity of cervicogenic headache (with corticosteroid: $p < 0.00001$, $I^2 = 0\%$; without corticosteroid: $p = 0.02$, $I^2 = 0\%$). However, no significant difference was observed between the two approaches ($p = 0.09$, $I^2 = 66\%$), as illustrated in Fig. 9.

Third, no statistically significant difference in headache pain severity was observed between ultrasound-guided and fluoroscopy-guided nerve blocks ($p = 0.82$, $I^2 = 0\%$), as shown in Fig. 10.

4. Discussion

The purpose of this study was to evaluate the effects of nerve block on headache intensity, frequency, and duration in patients with cervicogenic headache.

The pooled evidence from seventeen RCTs supported the therapeutic use of nerve blocks for cervicogenic headache. The robustness of this finding was further supported by a favourable risk-of-bias profile, with eight studies rated as having a low risk of bias and only three rated as having a high risk of bias. Overall, nerve block was found effective in relieving cervicogenic headache, offering a treatment basis for possible subsequent clinical strategies. However, its optimal timing and the degree of pain reduction require further clarification. This meta-analysis demonstrated that, in patients with cervicogenic headache, nerve block could reduce the pain score by an average of 1.62 points, surpassing the minimal clinically important change (MCIC) reported in a previous study [35]. Therefore, nerve blocks represent a promising effective treatment modality for cervicogenic headache, possessing considerable clinical significance.

The meta-analysis results indicated that at two weeks after nerve block, the mean reduction in pain severity reached 1.99 points, which was greater than the immediate post-block effect. At one-month post-block, the mean reduction in pain severity was 1.28 points, which was slightly lower than that observed at two weeks. The enhanced efficacy may result from blocking pain transmission via the occipital nerves (TON (Third occipital nerve), GON (Greater occipital nerve), and LON (Lesser occipital nerve)), followed by local muscle relaxation and further relief of nerve compression, which may partly explain the additional improvement at two weeks. Chronic cervicogenic headache likely arises from the convergence of trigem-

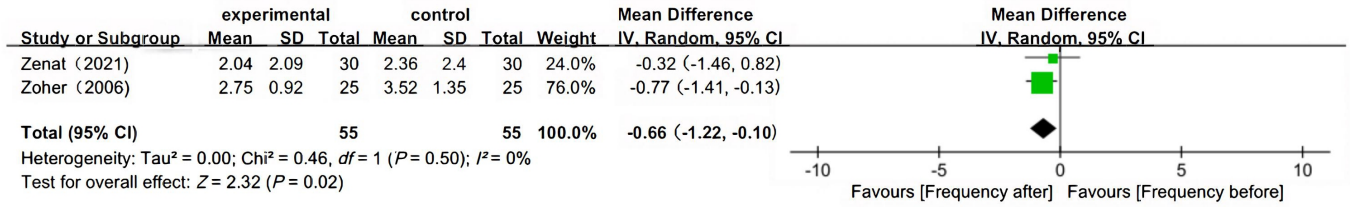


FIGURE 6. Comparison of headache frequency between nerve block and placebo. SD, Standard Deviation; IV, Information Value; CI, Confidence Interval; *df*, degree of freedom.

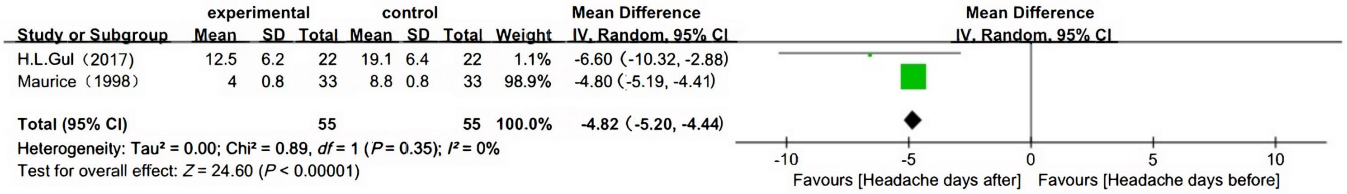


FIGURE 7. Comparison of headache duration days between nerve block and placebo. SD, Standard Deviation; IV, Information Value; CI, Confidence Interval; *df*, degree of freedom.

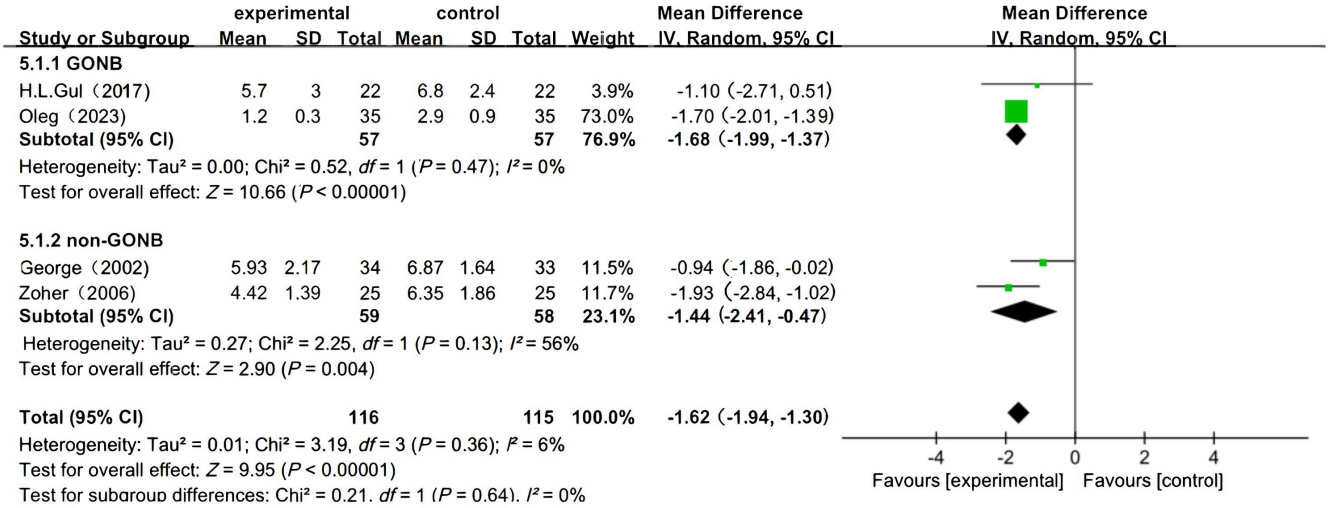


FIGURE 8. Comparison of GONB versus non-GONB for headache. SD, Standard Deviation; IV, Information Value; CI, Confidence Interval; *df*, degree of freedom.

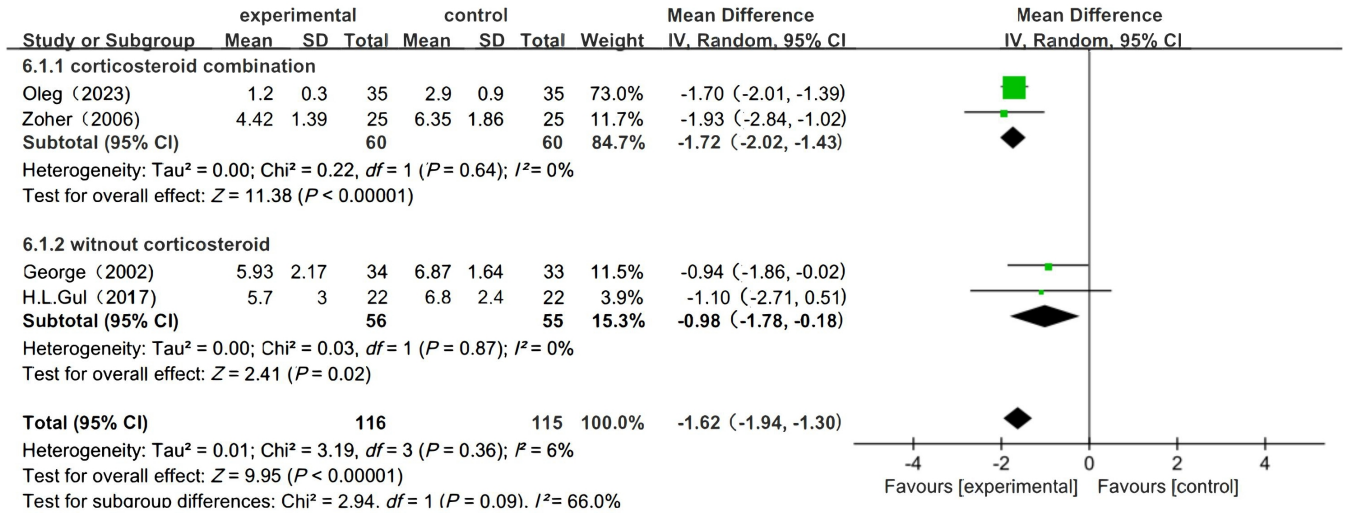


FIGURE 9. Comparison of corticosteroid combination versus without corticosteroid for headache. SD, Standard Deviation; IV, Information Value; CI, Confidence Interval; *df*, degree of freedom.

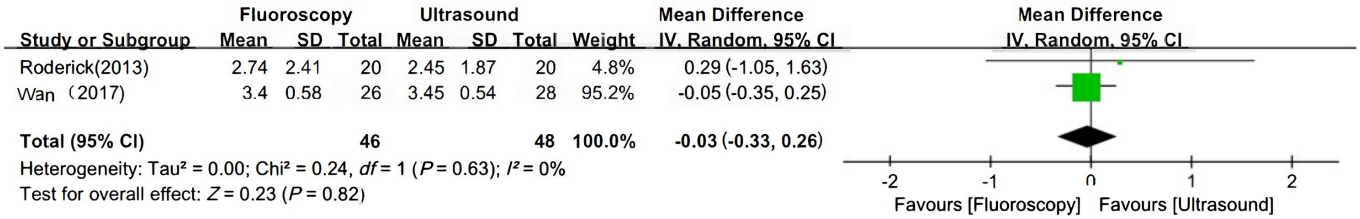


FIGURE 10. Comparison of ultrasound-guided versus fluoroscopy-guided nerve blocks for headache. SD, Standard Deviation; IV, Information Value; CI, Confidence Interval; *df*, degree of freedom.

inal and upper cervical (C1–C3) nerve inputs, with potential pain sources including the joints, muscles, C2–3 intervertebral disc, vertebral artery, and dura mater of the upper cervical spine [36]. Similarly, nerve block may suppress pain by inhibiting nociceptive neurons within the trigeminal-cervical complex, where occipital and trigeminal nerve inputs converge and signals cross the midline [37]. In mouse models, nerve blocks influenced central thermoregulatory mechanisms, with reduced preoptic area activity on immunostaining suggesting a potential pathway [38].

Cervicogenic headache refers to pain originating from the cervical spine. Physiologically, similar to pain of spinal origin, such as that arising from the shoulder, hip, or limb, this pain is characterized by the convergence of cervical and trigeminal afferents within the trigeminocervical nucleus [39]. The pain originates from dysfunction or direct pathology of structures innervated by the C1–C3 spinal nerves, including the atlanto-occipital and zygapophyseal joints (C0–C3), the C2–C3 intervertebral disc, local muscles and ligaments, bony elements, the dura mater, and vertebral arteries [40]. Nociceptive afferents from the C1–C3 spinal nerves converge within the nucleus via the spinal trigeminal tract onto second-order neurons, which integrate these signals with inputs from adjacent cervical nerves and the trigeminal nerve's first division. This convergence has been confirmed both anatomically and physiologically in experimental models [41, 42]. Nerve blocks work by interrupting neural signaling pathways, locally blocking targeted nerves to prevent pain signals from being perceived by the brain [43].

Our meta-analysis indicated that nerve blocks could significantly reduce headache frequency by an average of 0.66 episodes per week and decrease headache duration by at least 4.82 days. One study further substantiated these findings, demonstrating that GONB using triamcinolone-lidocaine or saline-lidocaine significantly reduced both pain severity and headache frequency [44]. Another meta-analysis demonstrated that GONB significantly reduced pain scores, headache days, and medication use compared with control, despite showing no effect on headache duration over a four-week period [45]. A 3-month retrospective analysis of 41 patients undergoing occipital nerve block also showed sustained reductions from baseline in both headache days and average headache duration at the 2- and 3-month evaluations [46].

One of the common treatments for cervicogenic headache is GONB. The GON, which originates from the C2 dorsal ramus and innervates the posterior scalp, serves as the target for local anesthetic injection [47]. Other various nerve blocks, such as the third occipital nerve block, supraorbital nerve block, paravertebral nerve block and spinal accessory nerve block, have also shown therapeutic effectiveness. In our study, no significant differences were observed among the various nerve blocks. In addition, other studies, such as that conducted by Nourhan Abdelmohsen Taha [48], also found no differential effects between sphenopalatine ganglion block and GONB on headache outcomes.

Regarding the anesthetic agents used for nerve block, such as lidocaine, mepivacaine, bupivacaine, fentanyl and clonidine, our study used saline or no injection as controls. One study suggested that combining different anesthetics could further prolong the duration of nerve blocks [49]. An analysis of GONB for chronic migraine (CM) found that the addition of corticosteroids did not provide additional benefits [50]. Another RCT demonstrated that, compared with lidocaine, a 2% articaine solution significantly reduced pain intensity and shortened the duration of pain paroxysms in patients with cervicogenic headache [51]. Liposomal bupivacaine and ropivacaine also showed potential advantages in pain relief [52, 53]. Future research could further investigate the comparative efficacy of different anesthetics used in nerve block.

The therapeutic effects of nerve blocks performed under different guidance methods were largely similar in our study, among which ultrasound guidance was the most commonly used. Ultrasound-guided nerve blocks could significantly relieve pain and were associated with a low incidence of complications [54]. Fluoroscopy was also a safe and effective approach for nerve block, whether performed using X-ray or CT (Computed Tomography) guidance [55, 56]. Findings from Roderick J. F's study [20] showed similar success rates between ultrasound-guided and fluoroscopy-guided procedures. Although the treatment outcomes of nerve blocks under different guidance methods were similar, ultrasound guidance is radiation-free, convenient, and easy to perform, whereas X-ray- or CT-guided procedures involve radiation exposure, which may influence patients' preferences when selecting a guidance method.

5. Conclusion

Nerve block is an effective minimally invasive treatment option that can reduce pain intensity, with notable effects at two weeks, and reduce headache frequency and headache duration. The effects of different target nerve blocks, the addition of corticosteroids and different guidance methods may not differ significantly to some extent. However, due to limitations in

the number and quality of the included studies, further high-quality clinical research is still needed for validation.

6. Study limitations

Our pooled analysis revealed substantial heterogeneity only in non-GONB block outcomes (I^2 = 56%). Heterogeneity likely stemmed from varied nerve types across the non-GONB group, and from population differences (age, gender, ethnicity, headache severity, disease stage, and duration). Sensitivity analyses showed that neither study was of low quality, and excluding any single study or altering statistical models did not materially change the results, indicating relatively robust conclusions.

The diversity of nerve blocks, mixed-type headaches and the lack of longer-term follow-up data had somewhat affected the reliability of the results, while some asymmetrical funnel plots and a small portion of low-quality GRADE suggested the presence of potential bias risk.

ABBREVIATIONS

VAS, Visual Analogue Scales; HADS, Hospital Anxiety and Depression Scale; COOP-WONCA, Primary Care Cooperative Information Project/World Organization of National Colleges, Academies; NRS, Numerical Rating Scale; BUP, bupivacaine; BTX, botulinum toxin; ONB, occipital nerve block; GON, greater occipital nerve; GONB, Greater occipital nerve block; ADL, activities of daily living; TONB, Third occipital nerve blocks; US, Ultrasoundguided; FL, fluoroscopy-guided; MCPB, Multifidus cervicis plane block; CM, chronic migraine; RCT, randomized controlled trial; CH, cervicogenic headache; MD, mean difference; SD, standard deviation; MCIC, minimal clinically important change; ICHD, International Classification of Headache Disorders; Na^+, Sodium ion; MBB, Medial branch block; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PROSPERO, Prospective Register of Systematic Reviews; GRADE, Grade of Recommendations Assessment, Development and Evaluation; TON, Third occipital nerve; LON, Lesser occipital nerve; CT, Computed Tomography.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

EY—conceptualization; writing–original draft. EY, JX—data curation. WW—methodology. EY, ZC, CC, YZ—investigation. EY, YZ—writing–review & editing. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

A detailed protocol was developed prior to initiating the systematic review and was prospectively registered in the PROSPERO international prospective register of systematic reviews under registration number CRD420251144807. Ethical approval and informed consent were not required. The study used previously published data and involved no direct participation of human subjects.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://files.jofph.com/files/article/2120748224287260672/attachment/Supplementary%20material.zip.

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