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REVIEW

The Efficacy and Safety of Ultrasound-Guided Nerve Block in the Treatment of Cervical Spondylotic Radiculopathy: A Systematic Review and Meta-Analysis

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Purpose: This meta-analysis systematically compares the clinical efficacy and safety of ultrasound-guided versus non–ultrasound-guided (ie, x-ray fluoroscopy, CT imaging, or anatomical landmark-guided) nerve blocks for cervical spondylotic radiculopathy (CSR).

Patients and Methods: Randomized controlled trials (RCTs) comparing ultrasound-guided with conventionally guided nerve blocks for CSR were searched in PubMed, Embase, Cochrane Library, Web of Science, China National Knowledge Infrastructure (CNKI), China Biology Medicine disc (CBM), Chongqing VIP Chinese Science and Technology Periodical Database (VIP) and Wanfang databases from inception to July 1, 2025. Literature screening, data extraction, and risk of bias assessment were performed independently by two reviewers using the Cochrane tool. Meta-analysis was conducted with RevMan 5.4 and Stata 19.0. Primary outcomes included overall response rate and Visual Analog Scale (VAS) scores; secondary outcomes comprised first-attempt success rate, Neck Disability Index (NDI), 36-Item Short Form Health Survey (SF-36), and complication incidence.

Results: Thirteen RCTs involving 1072 patients were included. The Grading of Recommendations, Assessment, Development and Evaluations (GRADE) evidence quality was moderate for overall response rate and low for other outcomes. Compared with conventional guidance, ultrasound-guided nerve blocks resulted in a significantly higher overall response rate (risk ratio (RR) = 1.10, 95% confidence interval (CI): 1.01–1.20, $p = 0.030$), greater reduction in VAS (MD = −0.72, 95% CI: −1.15 to −0.29, $p < 0.001$), improved NDI (mean difference (MD) = −1.03, 95% CI: −1.95 to −0.11, $p = 0.030$), and higher first-attempt success rate (RR = 1.25, 95% CI: 1.12–1.39, $p < 0.001$). Complication rates were lower but not statistically significant (RR = 0.53, 95% CI: 0.19–1.47, $p = 0.230$).

Conclusion: This meta-analysis demonstrates that ultrasound-guided nerve blockade is an efficacious and safe intervention for cervical spondylotic radiculopathy, offering advantages over conventional techniques. However, the current evidence is limited by the number and methodological quality of included studies. Future high-quality trials should adopt a multimodal assessment strategy, integrating objective physiological measures with patient-reported outcomes, to strengthen the evidence base and guide personalized management.

Keywords: ultrasonography, nerve block, cervical radiculopathy, meta-analysis, randomized controlled trials

Introduction

Cervical spondylotic radiculopathy (CSR) is a clinical syndrome resulting from irritation or compression of the cervical nerve roots, typically caused by pathological changes such as disc degeneration and osteophyte formation.[1] According to the International Classification of Diseases, 11th Revision (ICD-11), CSR is classified under code FA80.1 (radiculopathy due to cervical disc disorder or spondylosis).[2] Its primary manifestations include neck and shoulder pain, limb numbness, and may be accompanied by sensory abnormalities, muscle weakness, and even muscle atrophy, significantly impairing

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patients' quality of life.[3] The management of CSR is broadly categorized into surgical and non-surgical interventions.[4] Due to the inherent risks, trauma, and potential complications associated with surgery, non-surgical approaches are often the preferred initial treatment strategy.[5]

The Clinical Practice Guideline for CSR recommends injection therapy as an important non-surgical approach due to its efficacy in pain relief and functional improvement.[6] In recent years, the application of injection therapy for CSR has garnered increasing attention. Studies have demonstrated that it not only reduces pain but also enhances cervical range of motion and functional capacity.[7]

Neural injection therapy is a precise interventional technique that delivers therapeutic agents, such as local anesthetics and corticosteroids, to the vicinity of target nerves via percutaneous injection or catheter infusion for diagnostic or therapeutic purposes.[8] The development of chronic pain is closely associated with neuroinflammatory responses following tissue injury. After injury, the initial immune response releases inflammatory mediators, including substance P and Calcitonin Gene-Related Peptide (CGRP), which activate spinal N-Methyl-D-Aspartate (NMDA) receptors and trigger a neuroinflammatory cascade. This process ultimately leads to peripheral sensitization and a vicious cycle of pain.[9–11] By delivering agents directly to the site of involvement, nerve blocks can stabilize neural membranes, reduce abnormal ectopic discharges, and alleviate neurogenic inflammation, thereby mitigating symptoms associated with CSR.[12,13]

With the continuous advancement of precision medicine, nerve block therapy is evolving toward "individualization, visualization, and minimally invasive techniques." Traditional approaches relying on superficial anatomical landmarks have significant limitations, primarily due to the lack of real-time visualization, which compromises positioning accuracy. Although X-ray fluoroscopy and CT imaging provide partial visualization, they still fall short in clearly distinguishing soft tissues such as nerves and blood vessels and cannot track needle tip movement in real time, thereby increasing the risk of accidental vascular or neural injury. Furthermore, these techniques involve radiation exposure, offer low soft-tissue resolution, and are associated with higher costs.[14,15]

The application of ultrasound-guided technology has markedly improved this situation. It enables clear visualization of anatomical structures such as nerve roots and blood vessels in the cervical region, allowing operators to monitor needle position in real time, accurately guide the needle to the target nerve, and observe the distribution of injectate.[16,17] This enhances procedural safety and accuracy while effectively minimizing damage to surrounding tissues. Moreover, ultrasound guidance entirely eliminates the risk of ionizing radiation for both operators and patients.[18]

Although previous studies have investigated the efficacy of ultrasound-guided nerve block therapy for CSR, there is considerable heterogeneity in sample sizes, study designs, intervention protocols, and follow-up durations, leading to inconsistent conclusions. Therefore, based on the principles of evidence-based medicine, this study employs a meta-analysis to systematically evaluate the current literature, aiming to comprehensively assess the effectiveness and safety of this technique in treating CSR and to provide reliable evidence for its clinical application.

Materials and Methods

Study Protocol

The study was conducted in strict accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[19] Quality was assessed using the AMSTAR 2 (A MeaSurement Tool to Assess systematic Reviews 2) checklist.[20] The study protocol has been registered on the International Prospective Register of Systematic Reviews (PROSPERO) platform (Registration number: CRD420251087929).

Literature Search

The literature search was conducted independently by the first and second authors.

Databases

A comprehensive search was performed across the following eight databases to identify all Randomized controlled trials (RCTs) related to ultrasound-guided nerve block therapy for CSR: Web of Science, PubMed, The Cochrane Library, Embase, China National Knowledge Infrastructure (CNKI), China Biology Medicine disc (CBM), Chongqing VIP

Chinese Science and Technology Periodical Database (VIP), Wanfang Database. Additionally, the PROSPERO and Cochrane Database of Systematic Reviews were searched to identify any existing systematic reviews on the topic.

Search Strategy

The search strategy utilized both Medical Subject Headings (MeSH) and free-text terms. The English search terms included: "cervical radiculopathy", "cervical spondylotic radiculopathy", "Cervical Spondylosis", "Spondylosis", "Cervical", "neck disorder with radiculopathy", "cervical spondylotic", "neck pain with radiculopathy", "neck and arm pain", "nerve-root type cervical spondylosis", "ultrasound-guided", "muscle and bone ultrasound guided", "musculoskeletal ultrasound guided", "nerve block", "selective nerve root block", "nerve blocks", "nerve blockade", "randomized controlled trial", "randomized controlled trial", "controlled clinical trial", "randomly", "randomized", "trial". The search strategy was developed according to the PICOS framework and combined both subject headings (MeSH) and free-text terms. The strategy was appropriately adapted to the specific features of each database. Boolean logic operators ("AND" and "OR") were used to combine keywords. We applied no language restrictions to the search. We included studies published in languages other than English (ie, Chinese). For these studies, the full text was translated into English, and data extraction was independently cross-verified by bilingual researchers to ensure accuracy. The search covered the period from the inception of each database to July 1, 2025. The complete search strategy for PubMed is provided in Box 1.

Inclusion Criteria

Studies were selected based on the PICOS framework: P (Population): Patients diagnosed with CSR. I (Intervention): Ultrasound-guided nerve block. C (Comparison): Other interventions not involving ultrasound-guided nerve block. O (Outcomes): Primary outcomes: Overall Response Rate; Visual Analgue Scale (VAS). Secondary outcomes: First-Attempt Success Rate; Neck Disability Index (NDI); the MOS item short from health survey (SF-36), including the Physical Component Summary (PCS) and Mental Component Summary (MCS); incidence of complications. S (Study design): Only RCTs were included.

Exclusion Criteria

Studies were excluded based on the following criteria: ①Duplicate publications (studies with identical data and results were considered duplicates; only the most comprehensive or earliest published version was retained); ②Unavailable outcome data, even after attempting to contact the original authors; ③Animal studies; ④No clear reporting of whether ultrasound-guided nerve block was performed; ⑤Patients who underwent other surgical interventions.

Box 1 Literature Search Strategy Used in the PubMed Database

#1	("Cervical radiculopathy"[Mesh]) OR (cervical radiculopathy[Title/Abstract]) OR (Cervical spondylotic radiculopathy[Title/Abstract]) OR (Cervical Spondylosis[Title/Abstract]) OR (cervicalspondylotic[Title/Abstract]) OR (Nerve-root type cervical spondylosis[Title/Abstract]) OR (Neck and arm pain[Title/Abstract]) OR (Neck pain with radiculopathy[Title/Abstract]) OR (Neck disorder with radiculopathy[Title/Abstract])
#2	(ultrasound-guided[Title/Abstract]) OR (bone ultrasound guided[Title/Abstract]) OR (musculoskeletal ultrasound guided[Title/Abstract])
#3	(bone ultrasound guided[Title/Abstract]) OR (musculoskeletal ultrasound guided[Title/Abstract]) OR (nerve block[Title/Abstract]) OR (nerve block therapy[Title/Abstract]) OR (selective nerve root block[Title/Abstract]) OR (block, nerve[Title/Abstract]) OR (nerve blocks [Title/Abstract]) OR (nerve blockade[Title/Abstract])
#4	#2 AND #3
#5	(("Randomized Controlled Trial"[Publication Type]) OR (Randomized Controlled Trial[Title/Abstract]) OR (controlled clinical trial [Publication Type]) OR (randomly[Title/Abstract]) OR (randomized[Title/Abstract]) OR (trial[Title/Abstract]))
#6	#1 AND #4 AND #5

Literature Screening and Data Extraction

The literature search was conducted by two independent investigators. The retrieved records were imported into EndNote 20 for management. After removing duplicates, the investigators screened titles and abstracts to exclude irrelevant studies, as illustrated in Figure 1. Subsequently, the full texts of the remaining articles were assessed by both investigators according to the predefined inclusion and exclusion criteria. The following data were extracted: author(s), year of publication, sample size, mean age, mean disease duration (months), intervention details, treatment protocol, follow-up duration, number of dropouts and reasons for dropout, incidence of adverse events or complications, and outcome measures. Any disagreements between the two investigators regarding study eligibility or data extraction were resolved through discussion with a third investigator or the corresponding author. The data extraction process is summarized in Table 1.

Quality Assessment of Included Studies

Two investigators independently evaluated the methodological quality of the included studies using the Cochrane Risk of Bias Tool (version 5.0.2) and the Physiotherapy Evidence Data-base (PEDro) Scale. The Cochrane Risk of Bias Tool assessed the following seven domains: ① Random sequence generation; ② Allocation concealment; ③ Blinding of participants; ④ Blinding of outcome assessment; ⑤ Incomplete outcome data; ⑥ Selective reporting; ⑦ Other potential sources of bias. Any discrepancies between the two investigators were resolved through discussion with a third investigator or consultation with the corresponding author. The assessment process is summarized in Figure 2.

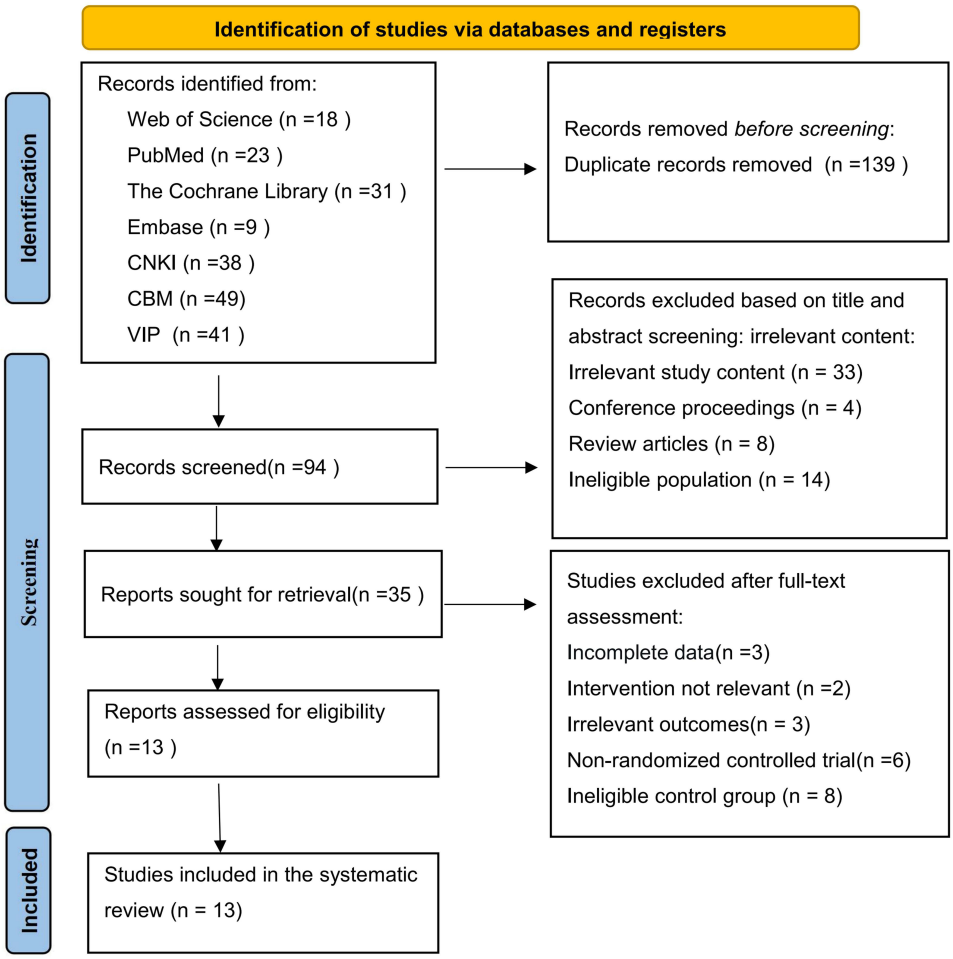

Figure 1 Literature Search Flowchart Based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement.

Table 1 Baseline Characteristics of the Included Studies

Studies	Sample Size (Male/Female)	Age	Course of Disease (Months)	Interventions	Course of Treatment (Doses)	Dropout	Follow-Up Period (Months)	Outcome Indicators
Kose 2024[21]	T:30(17/13)	55.1±10.03	10.13±4.25	US-guided cervical selective nerve root block	1	/	1, 3, 6	b f e
	C:30(14/16)	54.23±8.98	11.5±5.83	Fluoroscopy-Guided Interlaminar Epidural Injection	1	/		b f e
Jee 2013[22]	T:55(23/32)	56.69±9.32	6.65±2.10	Ultrasound-guided selective nerve root block	Both groups received an initial treatment. A second treatment was administered if the therapeutic response was inadequate	①	2, 12 (weeks)	b
	C:55(24/31)	57.76±9.56	6.53±2.21	Fluoroscopy-guided transforaminal block		②		b
Xie 2013[23]	T:30(13/17)	47±11	>12	Ultrasound-Guided Cervical Nerve Root Block	Both groups received one initial treatment. If the VAS remained ≥4 points after one week, a second treatment was administered. If the VAS was still ≥4 points after two weeks, a third treatment was performed.	/	4, 8 (weeks)	c d e
	C:30(14/16)	42±13	>12	Non-Ultrasound-Guided Cervical Nerve Root Block		/		c d e
Zhou 2019[24]	T:28(13/15)	52.25± 10.11	21.8±10.94 days	Ultrasound-Guided Cervical Nerve Root Block	1	/	1 (week)	a c e
	C:28(12/16)	52.64±9.76	19.67±10.68 days	Cervical Paravertebral Nerve Root Block via Traditional Anatomical Landmark Technique	1	/		a c e
Shen 2019[25]	T:40(17/23)	42	12±6	Ultrasound-Guided Cervical Nerve Root Block	Both groups received the initial treatment. If the VAS was ≥4 points at the 1-week follow-up, a second treatment was administered. If the VAS remained ≥ 4 points at the 2-week follow-up, a third treatment was performed.	/	3, 12 (weeks)	a c e
	C:40(19/21)	40	13±6	Non-ultrasound-guided cervical nerve root block		/		a c e
Liu 2020[26]	T:55(28/27)	51.33±6. 36		Ultrasound-Guided Cervical Nerve Root Block via Lateral Cervical Approach	Both groups received treatment once every 7 days, for a total of 4 administrations.	/	1, 3, 6	a b c d e
	C:53(27/26)	51.62±6. 14		Landmark-Guided Cervical Nerve Root Block via Anterior Cervical Approach		/		a b c d e

(*Continued*)

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Table 1 (Continued).

Studies	Sample Size (Male/Female)	Age	Course of Disease (Months)	Interventions	Course of Treatment (Doses)	Dropout	Follow-Up Period (Months)	Outcome Indicators
Wang 2020[26]	T:25	49.84±5.39	3.10±1.06 years	Ultrasound-Guided Cervical Paravertebral Nerve Block	1	/	4, 8 weeks	a b c
	C:25	49.84±5.39	3.10±1.06 years	Cervical Paravertebral Block	1	/		a b c
Li 2018[27]	T:60(42/18)	43.21±1.0	8.1±1.23	Musculoskeletal Ultrasound-Guided Nerve Root Block	patients in both groups received one treatment. A second treatment was administered if the response was inadequate.	/		c d
	C:60(43/17)	43.59±1.54	8.86±1.74	Landmark-Guided Nerve Root Block		/		c d
Meng 2020[28]	T:38(24/14)	41.62±7.13	7.53±2.81	Ultrasound-Guided Nerve Root Block	1	/	1	a b c d
	C:38(22/16)	43.27±6.15	6.42±2.19	Landmark-Guided Nerve Root Block	1	/		a b c d
Luo 2024[29]	T:46(28/18)	48.17±5.86	10.62±3.82	Ultrasound-Guided Cervical Transforaminal Block	1	/	1	a b d e
	C:42(25/17)	48.05±6.03	10.38±3.74	Digital Subtraction Angiography Guided Cervical Spinal Nerve Root Block	1	/		a b d e
Wang 2021[30]	T:46(28/18)	54.12±6.12	7.83±1.63	Ultrasound-Guided Cervical Intervertebral Foramen Block	1	/	7day, 3month	a b d e
	C:46(28/18)	53.71±5.98	7.76±1.65	CT-guided cervical transforaminal nerve block	1	/		a b d e
Zou 2021[31]	T:20(13/7)	42.5±8.15	25.4±2.57 days	Ultrasound-Guided Nerve Root Block	1	/	4hours,24hours,1week,1month	c e g
	C:20(12/8)	38.6±7.23	22.8±2.49 days	DSA-Guided Nerve Root Block	1	/		c e g
Wu 2018[32]	T:66(36/30)	40.4±2.5	5.8±1.5	Ultrasound-Guided Cervical Nerve Root Block	1	/	1week	c d g
	C66(38/28)	40.2±2.7	5.6±1.7	Landmark-Guided Nerve Root Block	1	/		c d g

Notes: T: Treatment Group; C: Control Group; a: VAS; b: NDI; c: Total Effective Rate; d: First-Attempt Success Rate; e: incidence of complications; f: SF-36; ①Three patients were excluded from the study. The reasons for exclusion were as follows: one patient experienced no improvement or worsening of pain after the first injection; one patient received a peripheral injection in the shoulder region (deviating from the study protocol); and one patient used medications other than acetaminophen during the study period. ②Five patients were excluded due to no improvement or exacerbation of pain following the first injection.

Data Extraction and Transformation

The VAS, NDI, PCS and MCS extracted from the included studies were represented as the difference between post-treatment and baseline values. The mean change (M_{change}) was calculated using the formula: ($M_{change}=M_{final}-M_{baseline}$). The standard deviation of the change (SD_{change}) was computed as follows: $SD_{change}=SD^2_{baseline}+SD^2_{final}-2\times R\times SD_{baseline}\times SDfinal$ (In the formula, R represents the correlation coefficient, $M_{baseline}$ denotes the mean at baseline, M_{final} indicates the mean after treatment, and SD refers to the standard deviation).

Outcome Measures

The primary outcomes included the overall response rate and VAS. Efficacy was determined based on criteria from the Criteria of Diagnosis and Therapeutic Effect of Diseases and Syndromes in Traditional Chinese Medicine or the Latest Domestic and International Standards for Disease Diagnosis and Treatment, or according to the degree of improvement in clinical symptoms. For the purpose of meta-analysis, which requires dichotomous variables for rate comparisons, efficacy was categorized into "effective" and "ineffective" groups, with all categories other than "ineffective" classified as "effective," consistent with previous studies. Secondary outcomes included: First-Attempt Success Rate; NDI; SF-36, and complication incidence.

Statistical Analysis

Meta-analysis was performed using Review Manager (RevMan) version 5.4.0 and Stata version 19.0. For dichotomous variables, the effect size was expressed as risk ratio (RR) with a 95% confidence interval (CI). For continuous variables, the mean difference (MD) with 95% CI was used. A significance level of $p < 0.050$ was applied for all statistical analyses. Heterogeneity was assessed using the I^2 statistic and Cochran's Q test (with a significance threshold of $p < 0.100$). An $I^2<50\%$ and $p > 0.100$ indicated low heterogeneity, while an $I^2 \geq 50\%$ or $p < 0.100$ suggested substantial heterogeneity. Sensitivity analysis was conducted to examine the influence of individual studies on the overall effect estimate and to explore potential sources of heterogeneity. Subgroup analysis was performed to assess the robustness of primary outcomes and further investigate heterogeneity. Publication bias was evaluated using funnel plot symmetry. A random-effects model was applied for all forest plots due to expected clinical and methodological variations among the included studies, such as differences in study design, patient characteristics, and intervention protocols.

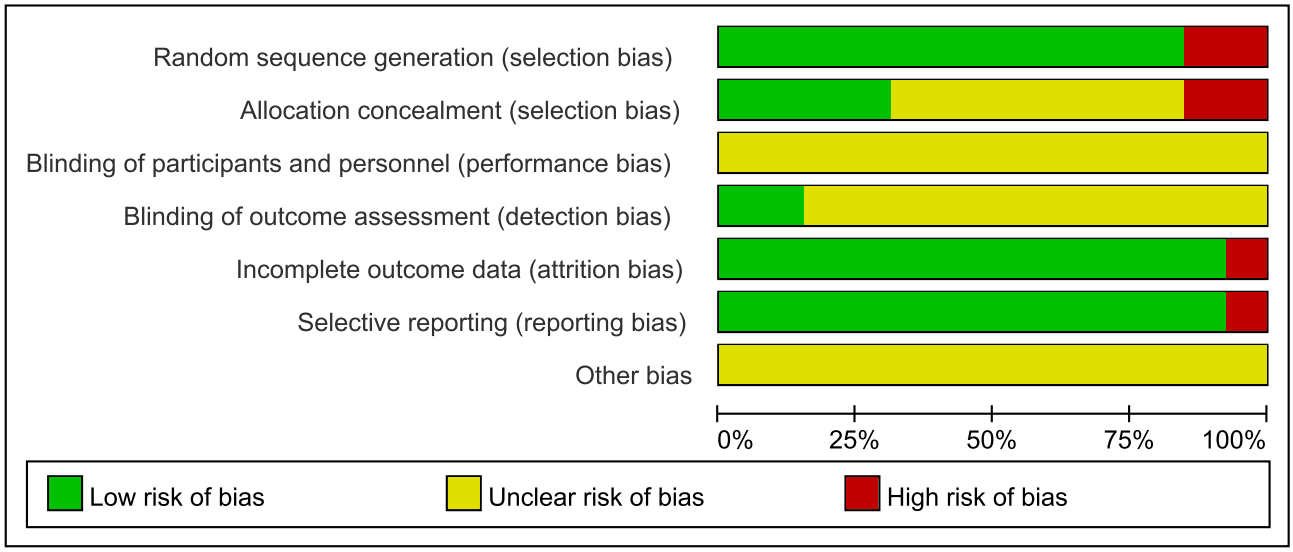

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Figure 2 Continued.

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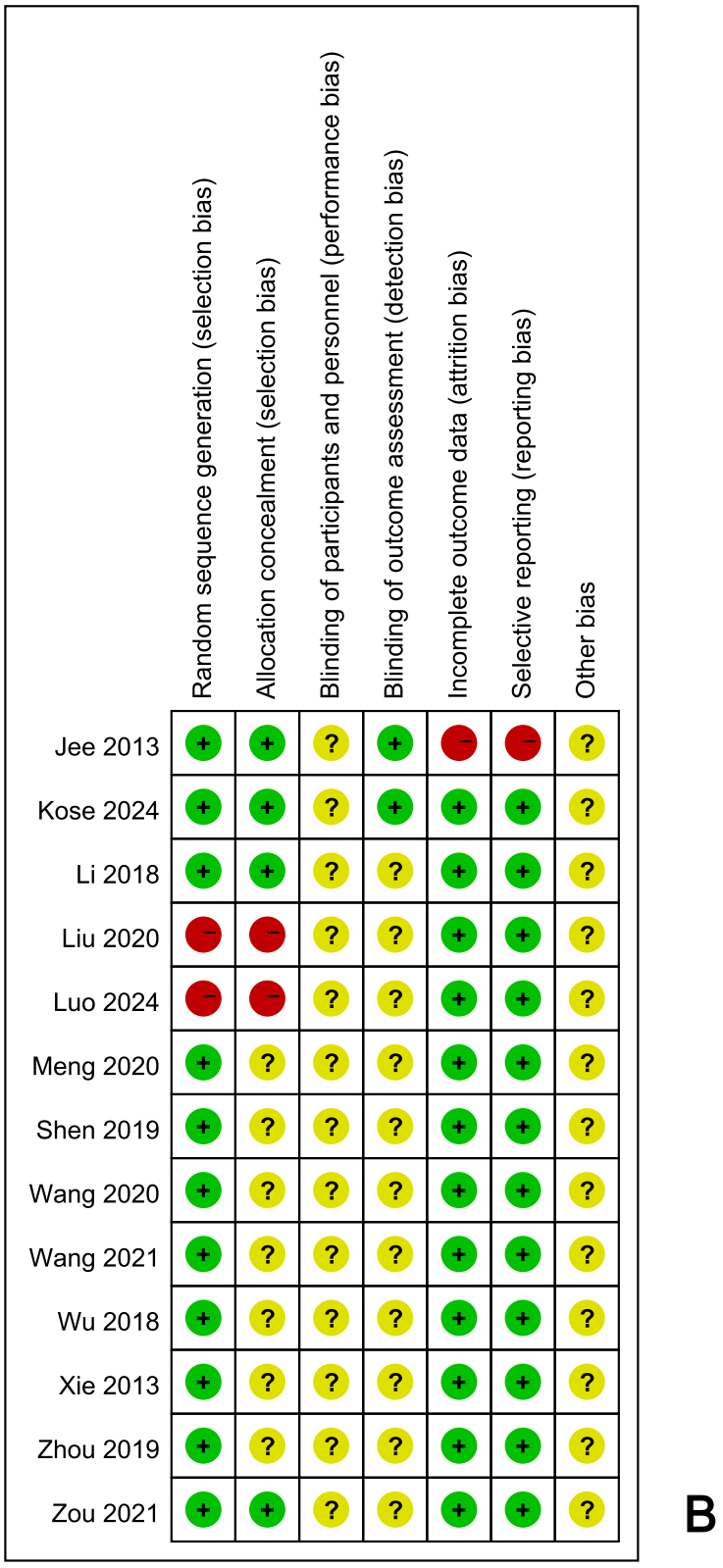

Figure 2 Results of the Cochrane Risk of Bias Assessment for the Included Studies. (**A**) Overall risk of bias across all included studies; (**B**) Detailed risk of bias for each individual study. Color code: Green, low risk; Red, high risk; Yellow, unclear risk. Symbols: "+", low risk; "-", high risk; "?", unclear risk.

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Evidence Quality Assessment

The overall quality of evidence for each outcome was evaluated using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach and categorized as "high," "medium," "low," or "very low." The assessment considered the following domains: risk of bias, inconsistency, indirectness, imprecision, and publication bias. Two investigators independently performed the GRADE ratings, with any discrepancies resolved through discussion or by consulting a third reviewer.

Results

Literature Search and Screening

A total of 256 records were initially identified through database searches. After removing 139 duplicates, 197 articles were excluded based on title and abstract screening. The remaining 59 articles underwent full-text review. Among these, 35 were excluded according to the predefined inclusion and exclusion criteria, resulting in 13 studies being included in the final analysis.

Characteristics of Included Studies

A total of 13 studies involving 1072 patients met the inclusion criteria. In the experimental groups, ultrasound-guided nerve block was employed as the primary intervention, while the control groups received other treatments excluding ultrasound-guided nerve block. The detailed characteristics are presented in Table 1. Among the included studies: 9 studies reported the overall response rate;[23–28,31–33] 7 studies reported VAS;[24–26,28–30,33] 6 studies reported NDI;[21,22,26,28–30] 8 studies reported First-Attempt Success Rate;[22,23,26–30,32] 2 studies reported quality of life using SF-36;[21,26] 7 studies reported the incidence of complications.[21,24–26,29–31]

Methodological Quality Assessment of Included Studies

According to the Cochrane Risk of Bias Tool, all 13 included studies mentioned the use of randomization methods.[21–33] Two studies described allocation concealment measures, among which two implemented blinding and two reported a high risk of bias related to blinding.[21,22] Studies performed blinding of outcome assessors. Study reported selective reporting or incomplete data.[21] None of the included studies mentioned other potential sources of bias. The results are summarized in Figure 2.

Meta-Analysis Results

Overall Response Rate

The overall response rate was reported in nine randomized controlled trials involving 722 participants.[23–28,31–33] As presented in Figure 3, significant heterogeneity was observed across studies ($I^2 = 77\%$; $p < 0.001$). The random-effects meta-analysis demonstrated that ultrasound-guided nerve block significantly improved the overall response rate compared to the control group in patients with CSR [RR = 1.10, 95% CI: 1.01 to 1.20; Z = 2.17, $p = 0.030$].

Visual Analog Scale

VAS scores were reported in seven randomized controlled trials involving 550 participants.[24–26,28–30,33] Significant heterogeneity was observed across studies ($I^2 = 89\%$; $p < 0.001$). As shown in Figure 4, the random-effects meta-analysis demonstrated that ultrasound-guided nerve block was associated with a statistically significant reduction in VAS scores compared to the control group [MD = −0.72, 95% CI: −1.15 to −0.29; Z = 3.29, $p = 0.001$].

Neck Disability Index

Data on the NDI were available from six studies involving 534 participants.[21,22,26,28–30] Low heterogeneity was observed across these studies ($I^2 = 4\%$; $p = 0.390$). The pooled meta-analysis demonstrated that the ultrasound-guided nerve block group achieved a statistically significant reduction in NDI scores compared to the control group [MD = −1.03, 95% CI: −1.95 to −0.11; Z = 2.19, $p = 0.030$]. The corresponding forest plot is presented in Figure 5.

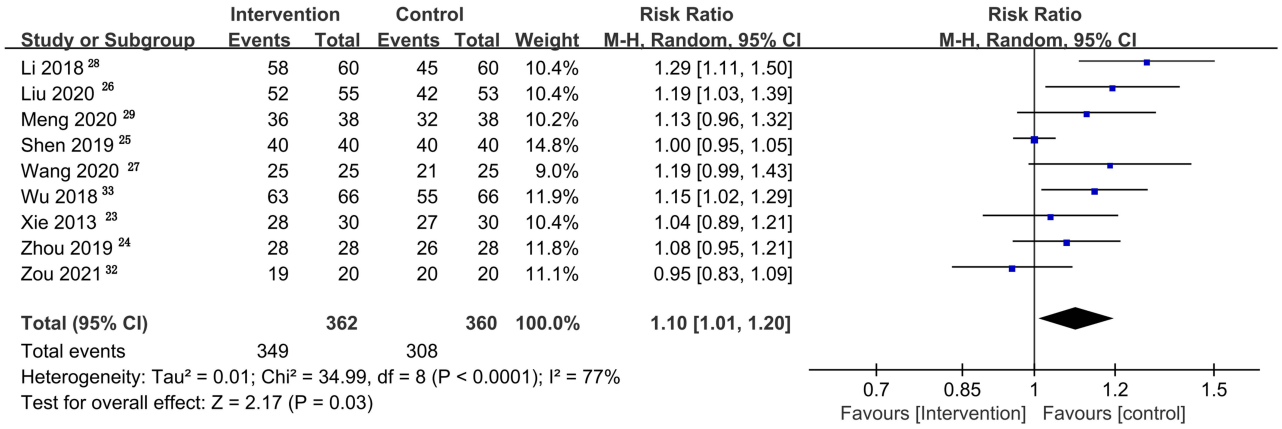

Figure 3 Forest plot of meta-analysis comparing the overall response rate between the ultrasound-guided nerve block group and the control group in patients with cervical spondylotic radiculopathy.
Abbreviations: CI, confidence interval; RR, risk ratio.

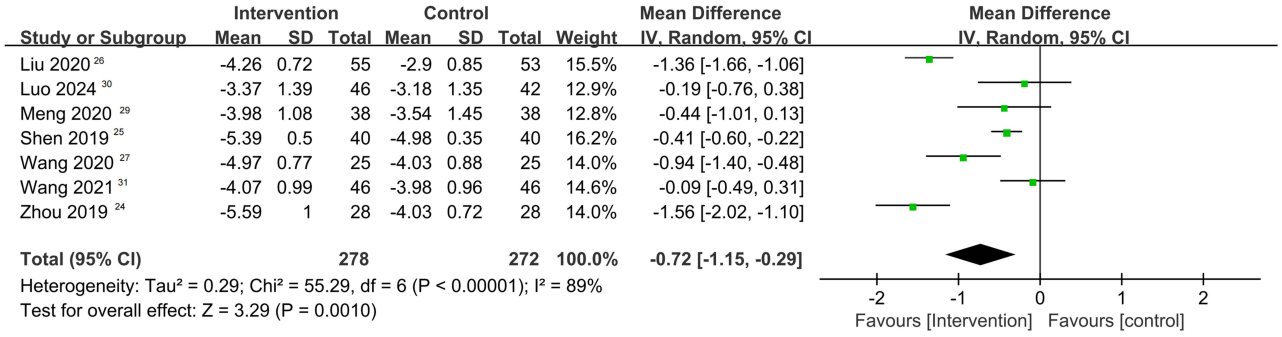

Figure 4 Forest plot of meta-analysis comparing the Visual Analog Scale (VAS) scores between the ultrasound-guided nerve block group and the control group in patients with cervical spondylotic radiculopathy.
Abbreviations: CI, confidence interval; MD, mean difference.

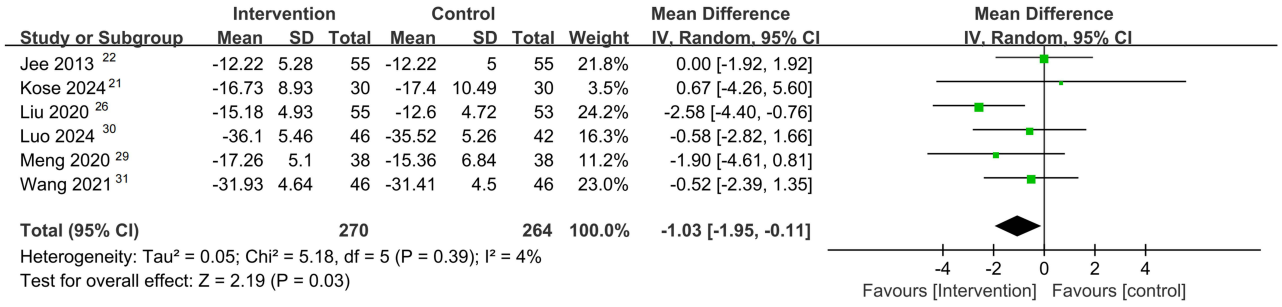

Figure 5 Forest plot of meta-analysis comparing the Neck Disability Index (NDI) scores between the ultrasound-guided nerve block group and the control group in patients with cervical spondylotic radiculopathy.
Abbreviations: CI, confidence interval; MD, mean difference.

First-Attempt Success Rate

The included eight studies reported the first-attempt success rate (defined as the number of successful target injections or correspondences between the injection site and the blocked area), involving a total of 786 patients.[22,23,26–30,32] Initially, a meta-analysis was conducted using the number of successful target injections or correspondences between the injection site and the blocked area as the outcome measure. As presented in Figure 6, the heterogeneity test indicated substantial

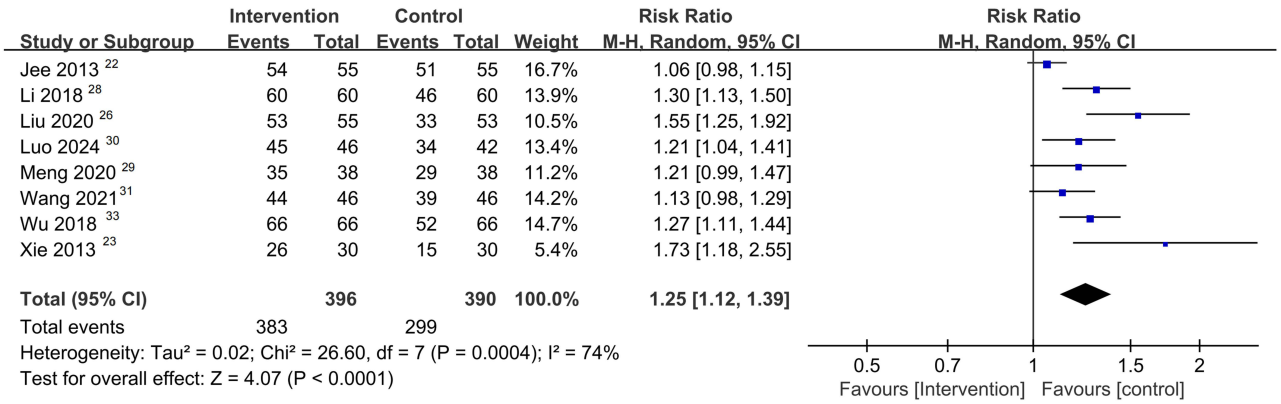

Figure 6 Forest plot of meta-analysis comparing the first-attempt success rate between the ultrasound-guided nerve block group and the control group in patients with cervical spondylotic radiculopathy.
Abbreviations: CI, confidence interval; RR, risk ratio.

and statistically significant heterogeneity across studies (I^2 = 74%; p < 0.001). The random-effects meta-analysis demonstrated that ultrasound-guided nerve blockade was associated with a significantly higher first-attempt success rate compared to the control group [RR = 1.25, 95% CI: 1.12 to 1.39; Z = 4.07, p < 0.001].Subsequently, a study-by-study comparison was performed, with the following results: Study[22:] The first-attempt success rate was 98.18% (54/55) in the observation group versus 92.73% (51/55) in the control group. Study:[23] 86.67% (26/30) in the observation group versus 50% (15/30) in the control group. Study:[26] 96.36% (53/55) in the observation group versus 62.26% (33/53) in the control group. Study:[30] 95.65% (44/46) in the observation group versus 84.78% (39/46) in the control group. Study:[27],100% (60/60) in the observation group versus 76.67% (46/60) in the control group. Study:[28] 92.10% (35/38) in the observation group versus 76.32% (29/38) in the control group. Study:[29] 97.83% (45/46) in the observation group versus 80.95% (34/42) in the control group. Study:[32],100% (66/66) in the observation group versus 78.79% (52/66) in the control group. The meta-analysis indicates that the first-attempt success rate shows an increasing trend in the observation group compared with the control group.

Physical Component Summary

Physical Component Summary (PCS) of SF-36, PSC scores were reported in two randomized controlled trials involving 168 participants.[21,26] With no significant heterogeneity detected (I^2 = 0%; p = 0.440), the pooled meta-analysis demonstrated a statistically significant greater improvement in PCS scores in the control group compared to the ultrasound-guided intervention group [MD = 3.50, 95% CI: 1.26 to 5.75; Z = 3.06, p = 0.002]. The forest plot for this outcome is presented in Figure 7.

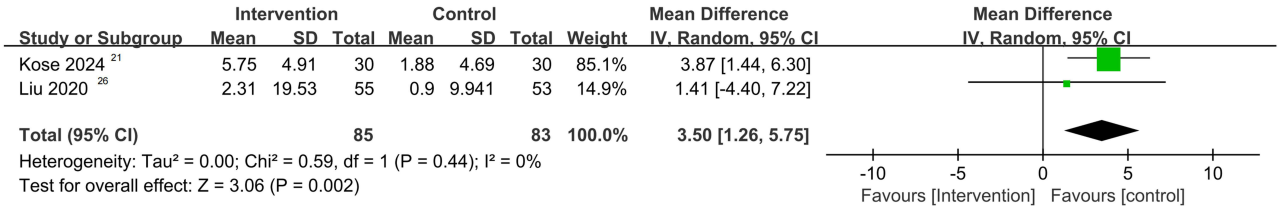

Figure 7 Forest plot of meta-analysis comparing the Physical Component Summary (PCS) scores of the 36-Item Short Form Health Survey (SF-36) between the ultrasound-guided nerve block group and the control group in patients with cervical spondylotic radiculopathy.
Abbreviations: CI, confidence interval; MD, mean difference.

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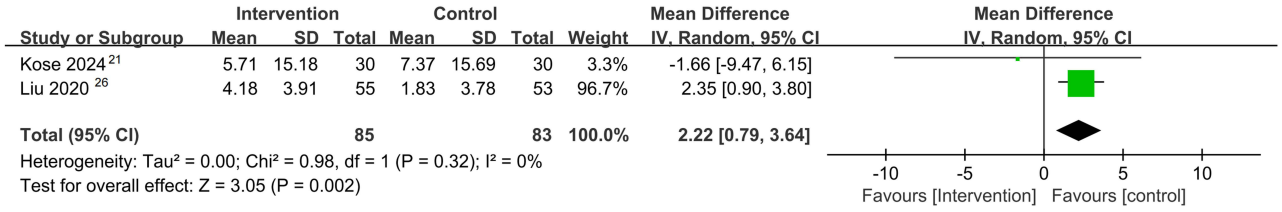

Figure 8 Forest plot of meta-analysis comparing the Mental Component Summary (MCS) scores of the 36-Item Short Form Health Survey (SF-36) between the ultrasound-guided nerve block group and the control group in patients with cervical spondylotic radiculopathy.
Abbreviations: CI, confidence interval; MD, mean difference.

Mental Component Summary

Mental Component Summary (MCS) of SF-36, MCS scores were reported in two randomized controlled trials involving a total of 168 participants.[21,26] The meta-analysis of these studies revealed a statistically significant difference between groups. Patients in the control group demonstrated a greater improvement in MCS scores compared to those receiving ultrasound-guided intervention, with a pooled MD of 2.22 (95% CI: 0.79 to 3.64; Z = 3.05, $p = 0.002$). There was no significant heterogeneity between the studies ($I^2 = 0\%$; $p = 0.320$). The forest plot for this outcome is presented in Figure 8.

Incidence of Complications

A total of seven studies involving 524 patients reported the incidence of complications.[21,24–26,29–31] The findings from each study are summarized as follows: Study: complication rate was 10% (3/30; dizziness, nausea, vomiting, and vasovagal reactions) in the intervention group and 13.3% (4/30) in the control group. Management and clinical outcomes were not reported. Study:[24] No complications occurred in the intervention group (0/28), while the control group had a complication rate of 7.14% (2/28; local hematoma). Management and outcomes were not described. Study:[25] Both groups had a complication rate of 2.5% (1/40). The intervention group reported 1 case of numbness (resolved spontaneously), and the control group reported 1 case of deep cervical hematoma (resolved with symptomatic treatment and good outcome). Study:[26] The complication rate was 1.82% (1/55; mild adverse reactions including dizziness, nausea, tachycardia, and sweating) in the intervention group and 13.21% (7/53) in the control group. Management and outcome details were not provided. Study:[29] The complication rate was 4.48% (2/46; puncture site hematoma and pain, 1 case each) in the intervention group and 23.81% (10/42; including 3 cases of nausea, 3 cases of puncture site hematoma, and 4 cases of puncture site pain) in the control group. Only prognostic outcomes were mentioned. Study:[30] The complication rate was 15.22% (7/46; dizziness [n=2], nausea [n=1], puncture site pain [n=3], and tinnitus [n=1]) in the intervention group and 2.17% (1/46; dizziness) in the control group. All cases received symptomatic treatment with good outcomes. Study:[31] The complication rate was 5% (1/20; dizziness) in the intervention group and 10% (2/20; puncture site hematoma) in the control group. All cases were managed symptomatically with good outcomes. Heterogeneity among the included studies for this outcome was moderate and not statistically significant ($I^2 = 44\%$; p = 0.100). The pooled meta-analysis indicated a trend toward a lower risk of complications in the ultrasound-guided intervention group compared to the control group. However, this difference did not reach statistical significance [RR = 0.53, 95% CI: 0.19 to 1.47; Z = 1.21, $p = 0.230$]. The forest plot for this outcome is presented in Figure 9.

Subgroup Analysis

To further explore the robustness of the primary outcomes and potential sources of heterogeneity, subgroup analyses were conducted based on the following factors: ① Type of intervention in the control group; ② Duration of follow-up in the intervention group receiving ultrasound-guided nerve block. The results are presented in Table 2.

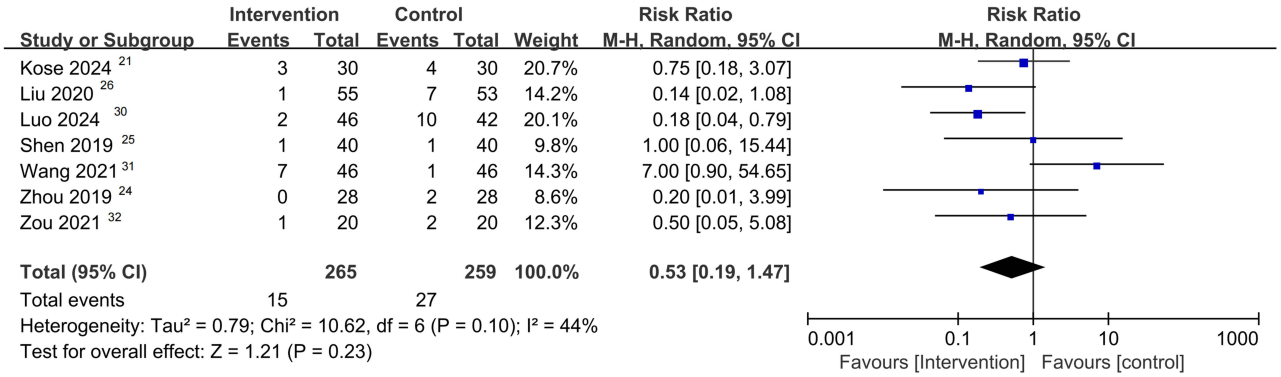

Figure 9 Forest plot of meta-analysis comparing the incidence of complications between the ultrasound-guided nerve block group and the control group in patients with cervical spondylotic radiculopathy.
Abbreviations: CI, confidence interval; RR, risk ratio.

Assessment of Publication Bias

According to the Cochrane Handbook for Systematic Reviews of Interventions, funnel plots should be used to assess potential publication bias only when more than 10 studies are included in a meta-analysis. With fewer studies, the power of the funnel plot test is insufficient to reliably detect asymmetry or evaluate the risk of publication bias. In the present review, none of the outcomes included 10 or more randomized controlled trials; therefore, funnel plot analysis was not performed.

Sensitivity Analysis

To assess the robustness of the primary outcomes and to explore potential sources of heterogeneity, a sensitivity analysis was conducted by sequentially excluding each individual study. The pooled estimates for both the total response rate and the VAS score remained stable, indicating that the overall findings were not driven by any single study. For the total response rate, the exclusion of the study by Shen[25] et al was found to reduce heterogeneity, suggesting it contributed notably to between-study variance (Table 3). In contrast, substantial heterogeneity (I^2 > 75%) persisted across all sensitivity iterations for the VAS score, implying that variability likely arose from multiple, complex factors such as differences in adjunctive exercise protocols among trials (Table 4). Similarly, in the analysis of block-related outcomes, the study by Jee et al[22] was identified as a potential source of heterogeneity (Table 5).

Table 2 Subgroup Analysis of Primary Outcome Measures for Ultrasound-Guided Nerve Block in the Treatment of Cervical Spondylotic Radiculopathy

Subgroup Analysis		All Included Studies	Control Group Therapy		Observation Period		
			Fluoroscopy-Guided Nerve Block	Landmark-Guided Nerve Block	≧1	>1 and ≤3 Months	>3 Months
VAS	Studies	7	2	5	7	5	1
	MD[95%]		−0.12 [−0.45,0.20]	−0.94[−1.46,-0.43]	−073[−1.12,-0.33]	−0.75[−1.14,-0.09]	Not applicable
	p		0.460	<0.001	<0.001	0.03	Not applicable
	I^2		0%	91%	86%	95%	Not applicable
NDI	Studies	6	2	4	6	5	3
	MD[95%]		−0.54 [−1.98,0.89]	−1.29[−2.78,0.21]	−0.29[−1.18,0.59]	−0.65[−1.61,0.32]	−1.43[−2.69,-0.17]
	p		0.460	0.090	0.510	0.190	0.030
	I^2		0%	33%	0%	0%	36%
First-Attempt Success Rate	Studies	8	5	3	Not applicable	Not applicable	Not applicable
	RR[95%]		1.20 [1.05,1.36]	1.33 [1.17,1.52]	Not applicable	Not applicable	Not applicable
	p		0.007	<0.001	Not applicable	Not applicable	Not applicable
	I^2		73%	34%	Not applicable	Not applicable	Not applicable

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Table 3 Sensitivity Analysis of Overall Response Rate Outcomes for Ultrasound-Guided Nerve Block in the Treatment of Cervical Spondylotic Radiculopathy

With the Exclusion of Study A	Heterogeneity Testing		Effect Size		
	I^2	*p*	RR	95% CI	*p*
Xie 2013[23]	81%	<0.001	1.11	[1.01,1.22]	0.040
Zhou 2019[24]	81%	<0.001	1.10	[1.00,1.22]	0.050
Shen 2019[25]	44%	0.080	1.12	[1.04,1.19]	0.002
Liu 2020[26]	77%	<0.001	1.09	[1.00,1.19]	0.060
Wang 2020[33]	79%	<0.001	1.09	[1.00,1.20]	0.060
Li 2018[27]	68%	0.002	1.08	[1.00,1.16]	0.002
Meng 2020[28]	80%	<0.001	1.10	[1.00,1.21]	0.050
Zou 2021[31]	79%	<0.001	1.12	[1.02,1.23]	0.020
Wu 2018[32]	79%	<0.001	1.09	[0.99,1.20]	0.070

Table 4 Sensitivity Analysis of VAS Score Outcomes for Ultrasound-Guided Nerve Block in the Treatment of Cervical Spondylotic Radiculopathy

With the Exclusion of Study B	Heterogeneity Testing		Effect Size		
	I^2	*p*	MD	95% CI	*p*
Zhou 2019[24]	87%	<0.001	−0.59	[−1.01, −0.16]	0.006
Shen 2019[25]	88%	<0.001	−0.78	[−1.30, −0.26]	0.003
Liu 2020[26]	83%	<0.001	−0.60	[−1.01, −0.20]	0.004
Wang 2020[33]	91%	<0.001	−0.68	[−1.17, −0.19]	0.006
Meng 2020[28]	91%	<0.001	−0.76	[−1.24, −0.28]	0.002
Luo 2024[29]	90%	<0.001	−0.80	[−1.27, −0.33]	<0.001
Wang 2021[30]	89%	<0.001	−0.83	[−1.29, −0.36]	<0.001

Table 5 Sensitivity Analysis of First-Attempt Success Rate Outcomes for Ultrasound-Guided Nerve Block in the Treatment of Cervical Spondylotic Radiculopathy

With the Exclusionof Study C	Heterogeneity Testing		Effect Size		
	I^2	*p*	MD	95% CI	*p*
Jee 2013[22]	42%	0.110	1.27	[1.17,1.39]	<0.001
Xie 2013[23]	70%	0.002	1.22	[1.11,1.35]	<0.001
Liu 2020[26]	66%	0.007	1.21	[1.10,1.33]	<0.001
Li 2018[27]	76%	<0.001	1.24	[1.10,1.40]	<0.001
Meng 2020[28]	78%	<0.001	1.26	[1.11,1.42]	<0.001
Luo 2024[29]	78%	<0.001	1.26	[1.11,1.42]	<0.001
Wang 2021[30]	78%	<0.001	1.27	[1.12,1.44]	<0.001
Wu 2018[32]	77%	<0.001	1.25	[1.10,1.42]	<0.001

Abbreviations: CI, confidence interval; MD, mean difference; RR, risk ratio; VAS, Visual Analog Scale.

Quality of Evidence

The GRADE evidence profiles for all outcomes are summarized in Table 6. According to the GRADE approach, the quality of evidence was rated as moderate in support of ultrasound-guided nerve block significantly improving the overall response rate compared to the control group. Low-quality evidence indicated that ultrasound-guided nerve block could

Table 6 Certainty of Evidence Assessment for the Included Studies

Outcome Measure	Quality Assessment					Sample Size		Certainty of Evidence
	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Intervention Group	Control Group	
Overall Response Rate (9RCTs)	Serious	Serious	Not serious	Not serious	Not applicable	362	360	Moderate certainty
VAS (7RCTs)	Serious	Serious	Not serious	Not serious	Not applicable	278	272	Low certainty
NDI (6RCTs)	Serious	Not serious	Not serious	Not serious	Not applicable	270	264	Low certainty
First-Attempt Success Rate (8RCTs)	Serious	Serious	Not serious	Not serious	Not applicable	396	380	Low certainty
PCS (2RCTs)	Serious	Not serious	Not serious	Not serious	Not applicable	85	83	Low certainty
MCS (2RCTs)	Serious	Not serious	Not serious	Not serious	Not applicable	85	83	Low certainty
Incidence of Complications (7RCTs)	Serious	Not serious	Not serious	Not serious	Not applicable	265	259	Low certainty

Abbreviations: VAS, Visual Analog Scale; NDI, Neck Disability Index; RCTs, Randomized controlled trials; PCS, Physical Component Summary; MCS, Mental Component Summary.

significantly reduce VAS and NDI, improve SF-36 and First-Attempt Success Rate, and reduce the incidence of complications, relative to the control group.

Discussion

This systematic review and meta-analysis provides robust, quantitative evidence that ultrasound-guided cervical nerve root block is an effective and safe therapeutic intervention for CSR. Compared to control interventions, ultrasound-guided cervical nerve root block demonstrates statistically significant and clinically meaningful superiority across a spectrum of outcomes, including pain relief, functional improvement, procedural precision, and patient safety.

Principal Findings on Efficacy and Safety

Pooled results confirm that ultrasound-guided cervical nerve root block leads to a substantial reduction in pain intensity (VAS MD = −0.72, 95% CI: −1.15 to −0.29) and a significant improvement in cervical function (NDI MD = −1.03, 95% CI: −1.19 to −0.11). Importantly, the likelihood of achieving a predefined clinical improvement was higher in the ultrasound-guided cervical nerve root block group (Overall Response Rate RR = 1.10, 95% CI: 1.01 to 1.20). These advantages may be attributed to real-time ultrasound guidance enabling precise drug delivery, which promotes adequate distribution of the medication around the nerve root, effectively inhibiting the release of inflammatory mediators and reducing central sensitization.[34–37] The real-time visualization unique to ultrasound guidance resulted in a 25% higher first-attempt success rate (RR = 1.25) and a corresponding 47% reduction in complications (RR = 0.53), benefit is achieved with exceptional procedural safety, this technique helps avoid injury to critical nerves and blood vessels, establishing a direct mechanistic link between imaging precision and enhanced safety.[38,39]

Interpretation of Heterogeneity and Results Robustness

Significant statistical heterogeneity was noted for some outcomes, notably VAS scores (I^2 = 89%). Pre-specified subgroup and sensitivity analyses were conducted to explore this variability and confirm the robustness of our conclusions. For the overall response rate, exclusion of an earlier study by Shen[25] et al reduced heterogeneity from 67% to 15%, yielding a more precise estimate (RR = 1.22). Similarly, for the first-attempt success rate, exclusion of the study by Jee[22] et al reduced heterogeneity from 73% to 42% while the estimate remained stable (RR = 1.27). This indicates that evolving technical standards in earlier studies contributed to initial variability. Crucially, leave-one-out sensitivity analyses confirmed that the direction and statistical significance of the primary benefits in pain relief and procedural success were unchanged by any single study, underscoring the solidity of these core findings.

Clinical Insights from Subgroup Analyses

Subgroup analysis further explored the robustness of primary outcomes and potential sources of heterogeneity. In terms of robustness: first, compared with the fluoroscopy-guided nerve block group, the surface anatomical localization group showed superior performance in reducing VAS [MD = −0.94, 95% CI (−1.46, −0.43), $p < 0.001$], improving NDI [MD =

−1.29, 95% CI (−2.78, 0.21), $p = 0.090$], and enhancing First-Attempt Success Rate [RR = 1.33, 95% CI (1.17, 1.52), $p < 0.001$]. This may be because the surface anatomical localization method uses bony and muscular landmarks to accurately identify the nerve sheath or compartment, allowing for precise injection into the fascial sheath surrounding the nerve. Alternatively, the smaller sample size in the fluoroscopy group may have influenced the statistical outcomes.

Impact of Follow-Up Duration on Therapeutic Outcomes

Subgroup analysis based on observation period revealed a distinct temporal pattern in the treatment effects of ultrasound-guided cervical nerve root block. While significant pain reduction (VAS) was achieved within the first month (MD = −0.73) and maintained through 1–3 months, functional improvement (NDI) demonstrated a more delayed yet progressive benefit. Notably, a statistically significant improvement in NDI was observed only in the subgroup with follow-up exceeding 3 months (MD = −1.43, $p = 0.030$). This suggests that the full therapeutic impact of an accurately placed nerve block extends beyond immediate analgesia, potentially involving the resolution of neuroinflammation and subsequent neural recovery, which in turn facilitates functional rehabilitation over time. Consequently, short-term assessments may substantially underestimate the clinical value of ultrasound-guided cervical nerve root block, underscoring the necessity for long-term evaluation (≥3 months) in future clinical trials to capture its comprehensive efficacy. Regarding heterogeneity control, all subgroup analyses showed varying degrees of reduction in heterogeneity for different outcome indicators, likely due to decreased influence from confounding factors.

Certainty of the Evidence

The overall strength of evidence was assessed using the GRADE framework. The certainty was moderate for the overall response rate, indicating reasonable confidence that the estimated benefit reflects the true effect. For all other critical outcomes—including pain intensity (VAS), functional improvement (NDI), first-attempt success rate, complications, and quality of life (SF-36 domains)—the evidence was graded as low certainty. This downgrading was primarily due to serious risks of bias in the included trials (eg, limitations in blinding) and, for VAS and procedural success, considerable statistical heterogeneity. Consequently, while the pooled results consistently favor ultrasound-guided cervical nerve root block, the magnitude of benefit for these outcomes should be interpreted with caution. Future high-quality RCTs with rigorous methodology and standardized protocols are needed to enhance the precision and reliability of these estimates.

Contextualizing Neutral and Limiting Findings

The analysis of generic health-related quality of life (SF-36) did not demonstrate a statistically significant benefit for ultrasound-guided cervical nerve root block. This finding likely reflects the broad nature of the SF-36 instrument, which may not be sensitive enough to capture domain-specific changes from a targeted pain intervention, rather than a true absence of effect on patient well-being. It underscores the importance of using pain-specific patient-reported outcome measures in future research. While ultrasound guidance offers the significant advantages of real-time visualization and absence of ionizing radiation, its application in the cervical spine is subject to inherent anatomical constraints. The technique's inability to penetrate bone or significant calcification results in acoustic shadows behind structures such as the laminae and facet joints. These shadows can obscure the visualization of nerve roots coursing in close proximity, particularly within the bony confines of the intervertebral foramen—a common pathological site in CSR. This limitation may impact the precision of needle placement when targeting these structures. In contrast, fluoroscopic or computed tomography (CT) guidance provides superior visualization of osseous anatomy. Therefore, pre-procedural assessment of individual spinal anatomy and operator expertise are crucial. In cases with challenging sonographic windows, the use of anatomical landmarks or adjunctive imaging modalities should be considered to ensure procedural safety and accuracy. Future studies should further delineate the sonographic visibility of neural structures across varying degrees of cervical degenerative anatomy.

Limitations

This study has several limitations: ①Most studies did not provide detailed parameters of the ultrasound-guided nerve block procedure (eg, injectate spread, procedure time), making it difficult to analyze intervariable relationships; ②The

included literature was predominantly in Chinese and focused on studies conducted in China, introducing potential language and regional biases; ③The limited number of original studies and the lack of large-sample, multicenter RCTs may affect the robustness of the meta-analysis results; ④ Some outcome measures had insufficient sample sizes, potentially reducing statistical power and evidence reliability; ⑤Due to the limited number of included studies ($n < 10$), publication bias assessment using funnel plots was not performed, increasing the risk of overreporting positive results; ⑥Methodological details such as randomization and blinding were often inadequately reported in the primary studies, potentially introducing bias.

Future Directions

To address these issues, future research should include well-designed, multicenter, large-sample RCTs with improved methodological reporting to provide higher-quality clinical evidence. CSR is a common clinical condition that significantly impacts patients' quality of life, necessitating treatment strategies that are both safe and effective. Future studies should build on existing evidence to establish standardized protocols for ultrasound-guided nerve block, including specific technical guidelines, treatment parameters, and course specifications. Additionally, exploring combined modalities integrating ultrasound-guided intervention with conventional rehabilitation therapy may enhance clinical outcomes through synergistic effects. Given the high recurrence rate of this condition, future research should also focus on evaluating the long-term efficacy and sustainability of this treatment approach.

Conclusion

In summary, ultrasound-guided nerve blockade demonstrates superior efficacy and a favorable safety profile for managing CSR, offering significant advantages over conventional guidance techniques in pain alleviation, functional improvement, and overall treatment response. However, these conclusions are tempered by the limited number and variable methodological quality of the currently available studies, underscoring the need for further validation through larger, high-quality randomized controlled trials. An additional consideration lies in the predominant reliance on patient-reported outcome measures, such as the VAS, for evaluating therapeutic success. While valuable, these subjective instruments can be influenced by psychosocial factors and may not fully capture objective pathophysiological changes in nerve root function. To strengthen future evidence, high-quality trials should adopt a multimodal assessment framework that integrates objective, physiology-based tools. These include electrodiagnostic techniques (eg, nerve conduction studies, needle electromyography) for quantifying nerve integrity and quantitative sensory testing (QST) for standardizing the evaluation of somatosensory function. Combining such objective metrics with validated patient-reported outcomes will provide a more comprehensive, reliable, and nuanced evidence base. This integrated approach is essential for enhancing the credibility of research findings, minimizing assessment bias, and ultimately guiding the optimization and personalization of CSR management strategies.

Abbreviations

CSR, cervical spondylotic radiculopathy; RCTs, Randomized controlled trials; CNKI, China National Knowledge Infrastructure; CBM, China Biology Medicine disc; VIP, Chongqing VIP Chinese Science and Technology Periodical Database; VAS, Visual Analog Scale; NDI, Neck Disability Index; SF-36,36-Item Short Form Health Survey; ICD-11, the International Classification of Diseases, 11th Revision; CGRP, Calcitonin Gene-Related Peptide; NMDA, N-Methyl-D-Aspartate; PRISMA, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses; AMSTAR 2, A MeaSurement Tool to Assess systematic Reviews 2; PROSPERO, International Prospective Register of Systematic Reviews; MeSH, Medical Subject Headings; PCS Physical Component Summary; MCS, Mental Component Summary; PEDro, Physiotherapy Evidence Data-base; Mchange, The mean change; Mfinal,The mean final; Mbaseline, The mean at baseline; SDchange, The standard deviation of the change; SDbaseline,The standard deviation of the baseline; SDfinal, The standard deviation of the final; RevMan, Review Manager; RR, risk ratio; CI, confidence interval; MD, the mean difference; the GRADE, Grading of Recommendations, Assessment, Development and Evaluations; CT, computed tomography; QST, quantitative sensory testing.

Data Sharing Statement

All data analysed during this study are included in this published article.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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References

1. Engebretsen KB, Taso M, Bjorland S. et al. A functional intervention within a cognitive approach to chronic cervical radiculopathy:Description of the nonsurgical treatment arm in a randomised controlled trial evaluating the effectiveness of surgery. *BMC Mus-culoskelet Disord*. 2024;25(1):629. doi:10.1186/s12891-024-07743-0
2. World Health Organization (WHO). International classification of diseases, 11th revision (ICD-11). Geneva: WHO; 2019 [Cited May 15, 2025]. Available from: https://icd.who.int/browse11/l-m/en. Accessed February 27, 2026.
3. Rafiq S, Zafar H, Gillani SA, et al. Comparison of neural mobilization and conservative treatment on pain, range of motion, and disability in cervical radiculopathy: a randomized controlled trial. *LoS One*. 2022;17(12):e0278177. doi:10.1371/journal.pone.0278177
4. Borrella-Andrés S, Marqués-García I, Lucha-López MO, et al. Manual therapy as a management of cervical radiculopathy: a systematic review. *Biomed Res Int*. 2021;2021:9936981. doi:10.1155/2021/9936981
5. Taso M, Sommernes JH, Kolstad F, et al. A randomised controlled trial comparing the effectiveness of surgical and nonsurgical treatment for cervical radiculopathy. *BMC Musculoskelet Disord*. 2020;21(1):171. doi:10.1186/s12891-020-3188-6
6. Bono CM, Ghiselli G, Gilbert TJ, et al. An evidence-based clinical guideline for the diagnosis and treatment of cervical radiculopathy from degenerative disorders. *Spine J*. 2011;11(1):64–72. doi:10.1016/j.spinee.2010.10.023
7. Kjaer P, Kongsted A, Hartvigsen J, et al. National clinical guidelines for non-surgical treatment of patients with recent onset neck pain or cervical radiculopathy. *Eur Spine J*. 2017;26(9):2242–2257.
8. Benzon HT, Elmofty D, Shankar H, et al. Use of corticosteroids for adult chronic pain interventions: sympathetic and peripheral nerve blocks, trigger point injections - guidelines from the American Society of Regional Anesthesia and Pain Medicine, the American Academy of Pain Medicine, the American Society of Interventional Pain Physicians, and the International Pain and Spine Intervention Society. *Reg Anesth Pain Med*. 2025. doi:10.1136/rapm-2024-105593
9. Peng B, DePalma MJ. Cervical disc degeneration and neck pain. *J Pain Res*. 2018;11:2853–2857. doi:10.2147/JPR.S180018
10. Garcia-Cosamalon J, Del Valle ME, Calavia MG, et al. Intervertebral disc, sensory nerves and neurotrophins: who is who in discogenic pain? *J Anat*. 2010;217:1–15. doi:10.1111/j.1469-7580.2010.01227.x
11. Navone SE, Marfia G, Giannoni A, et al. Inflammatory mediators and signalling pathways controlling intervertebral disc degeneration. *Histol Histopathol*. 2017;32(6):523–542. doi:10.14670/HH-11-846
12. Manchikanti L, Knezevic NN, Navani A, et al. Epidural interventions in the management of chronic spinal pain: American society of interventional pain physicians (ASIPP) comprehensive evidence-based guidelines. *Pain Physician*. 2021;24(S1):S27–S208.
13. Omoigui S, Fadare A. A new minimally invasive procedure for muscle, back, neck pain and radiculopathy - the myofascial nerve block. *Ann Clin Case Rep*. 2022;7(1):2233. doi:10.25107/2474-1655-v7-id2233
14. Conger A, Cushman DM, Speckman RA, Burnham T, Teramoto M, McCormick ZL. The effectiveness of fluoroscopically guided cervical transforaminal epidural steroid injection for the treatment of radicular pain; a systematic review and meta-analysis. *Pain Med*. 2020;21(1):41–54. doi:10.1093/pm/pnz127
15. Miskin N, Gaviola GC, Ghazikhanian V, Mandell JC. CT-guided transforaminal epidural steroid injections: do needle position and degree of foraminal stenosis affect the pattern of epidural flow? *Skeletal Radiol*. 2018;47(12):1615–1623. doi:10.1007/s00256-018-3002-9
16. Cui X, Zhang D, Zhao Y, Song Y, He L, Zhang J. An open-label non-inferiority randomized trail comparing the effectiveness and safety of ultrasound-guided selective cervical nerve root block and fluoroscopy-guided cervical transforaminal epidural block for cervical radiculopathy. *Ann Med*. 2022;54(1):2681–2691. doi:10.1080/07853890.2022.2124445
17. Jang JH, Lee WY, Kim JW, Cho KR, Nam SH, Park Y. Ultrasound-Guided selective nerve root block versus fluoroscopy-guided interlaminar epidural block versus fluoroscopy-guided transforaminal epidural block for the treatment of radicular pain in the lower cervical spine: a retrospective comparative study. *Pain Res Manag*. 2020;2020:9103421. doi:10.1155/2020/9103421
18. Wakeling C, Bateman A, Hatrick A, Chatakondu S. Combined fluoroscopic and ultrasound guided cervical nerve root injections. *Int Orthop*. 2016;40(12):2547–2551. doi:10.1007/s00264-016-3224-1
19. Page MJ, Mckenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Int J Surg*. 2021;88:105906. doi:10.1016/j.ijsu.2021.105906

20. Shea BJ, Reeves BC, Wells G, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ*. 2017;358(j4008). doi:10.1136/bmj.j4008
21. Kose HC, Guven Kose S, Celikel F, Tulgar S, Akkaya OT. Ultrasound-Guided cervical selective nerve root block versus fluoroscopy-guided interlaminar epidural injection for cervical radicular pain: a randomized, prospective, controlled study. *J Pers Med*. 2024;14(7):721. doi:10.3390/jpm14070721
22. Jee H, Lee JH, Kim J, Park KD, Lee WY, Park Y. Ultrasound-guided selective nerve root block versus fluoroscopy-guided transforaminal block for the treatment of radicular pain in the lower cervical spine: a randomized, blinded, controlled study. *Skeletal Radiol*. 2013;42(1):69–78. doi:10.1007/s00256-012-1434-1
23. Xie SC, He LL, Weng H, et al. Efficacy of ultrasound-guided nerve root block in the treatment of lower cervical radiculopathy. *Chin J Pain Med*. 2013;19(11):648–651.
24. Zhou MJ, Zhou PH, Zhang R, et al. Ultrasound-guided cervical nerve root block for the treatment of cervical spondylotic radiculopathy. *Med Inf*. 2019;32(14):101–103.
25. Shen ZE. Clinical study of B-ultrasound guided cervical nerve root block for lower cervical spondylotic radiculopathy. *Zhejiang J Traumat Surg*. 2019;24(3):626–628.
26. Liu W, Sun Y, Zhang W, et al. Analysis on the effect of ultrasonic-guided lateral cervical nerve root block on treatment of cervical spondylotic radiculopathy. *Chin J New Clin Med*. 2020;13(6):569–573.
27. Li Y, Zhao JY, Huang Y, et al. Efficacy analysis of musculoskeletal ultrasound-guided nerve root block for cervical spondylotic radiculopathy. *J Qiqihar Med Univer*. 2018;39(23):2777–2778.
28. Meng XY. Comparison of efficacy between surface landmark localization and ultrasound-guided selective nerve root block via intervertebral foramen for cervical spondylotic radiculopathy. *J CervicodyniaLumbodynia*. 2020;41(1):93–95.
29. Luo XY, Luo PF, Li YJ, et al. Clinical comparison of ultrasound and DSA-guided block in treatment of cervical radiculopathy. *J CervicodyniaLumbodynia*. 2024;45(1):92–95.
30. Wang LG, Wu ZL, Duan WQ, et al. A clinical comparison between ultrasound and computed tomography-guided cervical foraminal block for cervical spondylotic radiculopathy. *J CervicodyniaLumbodynia*. 2021;42(4):519–521.
31. Zou C, He YW, Long H, et al. A comparative study of clinical efficacy between ultrasound and digital subtraction angiography-guided cervical spinal nerve root block. *Chin J Pain Med*. 2021;27(9):701–704. doi:10.3969/j.issn.1006-9852.2021.09.012
32. Wu D, Huang YS, Su DW. Effect of cervical nerve root block on cervical spondylosis under ultrasound guidance. *J Clin Psychosom Dis*. 2018;24(4):154–156. doi:10.3969/j.issn.1672-187X.2018.04.047
33. Wang JL. Therapeutic effect of ultrasound-guided cervical paravertebral nerve block on cervical spondylotic radiculopathy. *Elect J Clin Med Literature*. 2020;7(35):63+65. doi:10.16281/j.cnki.jocml.2020.35.047
34. Benzon HT, Provenzano DA, Nagpal A, et al. Use and safety of corticosteroid injections in joints and musculoskeletal soft tissue: guidelines from the American Society of Regional Anesthesia and Pain Medicine, the American Academy of Pain Medicine, the American Society of Interventional Pain Physicians, and the International Pain and Spine Intervention Society. *Reg Anesth Pain Med*. 2025;12. doi:10.1136/rapm-2024-105656
35. Du DP, Pu SF; Expert Group on Ultrasound-Guided Technology for Pain Therapy in China. Chinese expert consensus on ultrasound-guided technology for pain therapy (2024 edition). *Chin J Painol*. 2024;20(6):805–857. doi:10.3760/cma.j.cn101658-20240604-00063
36. McLeod G, Reina MA. Nerve block, nerve damage, and fluid injection pressure: overturning the myth. *Br J Anaesth*. 2024;132(5):1022–1026. doi:10.1016/j.bja.2023.12.006
37. Brown J, Milgrim F, Driver L, et al. Efficacy and safety of adjunct medications in ED ultrasound-guided nerve blocks: a national ultrasound-guided NeRVE (NURVE) Block Registry Study. *Acad Emerg Med*. 2025. doi:10.1111/acem.70128
38. Kweon Y, Jeong G, Kim S, Yang C, Cho E, Leem J. A scoping review of clinical studies on procedures of ultrasound-guided injection to ensure hygiene and safety. *Healthcare*. 2025;13(10):1165. doi:10.3390/healthcare13101165
39. Buntragulpoontawee M, Chang KV, Vitoonpong T, et al. The effectiveness and safety of commonly used injectates for ultrasound-guided hydrodissection treatment of peripheral nerve entrapment syndromes: a systematic review. *Front Pharmacol*. 2021;11:621150. doi:10.3389/fphar.2020.621150