Review article

The efficacy of acupuncture therapies in cervical spondylotic radiculopathy: A network meta-analysis

Yingtong Lin [a,1], Sha Zhong [b,c,1], Chaoyuan Huang [d,1], Gangyu Zhang [e], Ganghui Jiang [f,*]

[a] Clinical Medical College of Acupuncture Moxibustion and Rehabilitation, Guangzhou University of Chinese Medicine, Guangzhou, China
[b] First Clinical Medical School, Guangzhou University of Chinese Medicine, Guangzhou, China
[c] Department of Breast and Thyroid Surgery, Guangzhou Women and Children's Medical Center, Guangzhou, China
[d] Department of Gastroenterology, The Second Affiliated Hospital of Guangzhou University of Chinese Medicine, Guangzhou, China
[e] Department of Biomedical Engineering, University of Basel, Basel, Switzerland
[f] Acupuncture Moxibustion and Rehabilitation Center, First Affiliated Hospital of Guangzhou University of Chinese Medicine, Guangzhou, China

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ABSTRACT

Objective: To evaluate the efficacy of acupuncture-related therapy in the Bayesian setting by means of a network Meta-analysis.

Methods: Relevant clinical randomized controlled trials(RCTs) of acupuncture-related therapy for Cervical Spondylotic Radiculopathy(CSR) were searched in the Chinese and English databases from the inception to November 13, 2023. Two researchers reviewed the literature, extracted the data, assessed the risk of bias of the included studies independently, and then used Stata14.0 and WinBUGs14 to analyze.

Results: There are 28 RCTs in total, of which 2593 patients and 14 acupuncture interventions. Network Meta-analysis revealed that, regarding the VAS scores, Acupoint catgut-embedding, Fu's Subcutaneous Needling and Needle Knife are better than Conventional acupuncture, Electro-acupuncture, Sham needle, Western Medicine, and Electrotherapy; Conventional acupuncture is better than Electrotherapy and Sham needle; Qihuang needle is superior to Sham needle and Electrotherapy; besides, Acupoint catgut-embedding is better than Tuina (Message), Chinese Medicine, Warm needle as well. Regarding the NDI scores, Needle Knife, Warm needle, Fire needle, Long round needle, Acupoint catgut-embedding are better than Conventional acupuncture, Electro-acupuncture, and Cervical traction; Conventional acupuncture is superior to Electro-acupuncture, Cervical traction, Needle Knife and Warm needle; whereas we found Qihuang needle is superior to Acupoint catgut-embedding, besides, Need Knife is superior to Qihuang needle, Long round needle and Acupoint catgut-embedding. In terms of improving the Tanaka Yasuhiro 20-point scale scores(TY), Needle Knife and Qihuang needle are superior to Conventional acupuncture, Warm needle and Electro-acupuncture; moreover, Conventional acupuncture is better than Warm needle.

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* Corresponding author.
  E-mail address: jgh@gzucm.edu.cn (G. Jiang).
[1] Yingtong Lin, Sha Zhong and Chaoyuan Huang contributed equally and share first authorship.

Conclusion: In general, Acupoint catgut-embedding shows the best effect at relieving neck pain, then followed by Fu's Subcutaneous Needling and Needle Knife. Needle Knife is the best intervention in improving the functionality of the cervical spine. Like improving overall clinical performance, Needle Knife is the best treatment. Furthermore, our conclusion still needs to be confirmed by higher-quality documentation. In order to choose the best treatment for patients, clinicians are expected to take into account different clinical features and practical clinical settings with caution while choosing an acupuncture-related therapy in CSR.

Key Message: This article aims at selecting the best acupuncture-related treatment for clinicians to help patients in CSR, and the results of this study indicated that Acupoint catgut-embedding shows the best effect in relieving neck pain, Needle Knife shows the best effect in improving the functionality of cervical spine, Needle Knife shows the best effect in treating overall clinical performance.

1. Introduction

Cervical Spondylotic Radiculopathy (CSR) is a degenerative disease that occurs when the cervical nerve roots are compressed due to disc herniation, hyperplasia or loosening of the joint ligaments, and bone hyperplasia. This compression leads to pain in the shoulder and neck, as well as numbness in other areas. CSR is a common type of cervical spondylosis, accounting for approximately 60%–70 % of all cervical spine diseases. The incidence of CSR has gradually risen to affect 0.35 % of the global population [1]. The exact etiology of CSR is still unknown, but it is primarily characterized by pain, numbness, or soreness in the shoulders, neck, upper limbs, fingers, and corresponding nerve distribution areas. Age, gender, trauma, inflammation, metabolism, and genetics are believed to play a role in its development.

The treatment methods of CSR are given priority to non-surgical treatment and surgical treatment [2]. Surgical treatment, such as anterior or posterior cervical foraminotomy and release, as well as minimally invasive or endoscopic surgery, is only recommended for patients experiencing severe pain, failure to respond to conservative treatment, or muscle contraction [3]. However, despite its immediate benefits, studies have indicated that approximately 1%–8% of patients may experience serious complications associated with surgical treatment, including esophageal perforation, cervical vascular injury, nerve injury, or even death [4]. Additionally, the financial burden associated with surgery is also significant. For instance, the average annual cost of managing this condition in the Netherlands [5] is around 30 million Euros. Consequently, conservative treatment is preferred in order to minimize the risk associated with surgery for CSR [6,7].

Non-surgical approaches for treating CSR include drug therapy, Cervical traction, and physical therapy [8]. Drug therapy involves the use of pain medication, anti-inflammatory drugs, and specialized neurodrugs prescribed by doctors to address different symptoms [2], Non-steroidal anti-inflammatory drugs are considered the first-line drug for CSR [9]. However, these drugs may increase the risk of complications, such as gastrointestinal, liver, and kidney damage [10,11]. Non-drug therapy options include traction therapy, physical therapy, and Chinese Medicine therapy [12]. One form of Chinese medicine therapy is acupuncture, which is believed to alleviate pain by stimulating acupoints and activating the nerve-endocrine-immune system [13,14]. Studies have indicated that acupuncture therapy

Table 1
Searching strategy of studies from the PubMed database.

Number	Search terms
#1	Cervical Spondylotic Radiculopathy[Mesh]
#2	Cervical Spondylotic Radiculopathy[Title/Abstract]
#3	Radiculopathies[Title/Abstract]
#4	Radiculopathy, Cervical[Title/Abstract]
#5	Cervical Radiculopathies [Title/Abstract]
#6	Cervical Radiculopathy[Title/Abstract]
#7	Radiculopathies, Cervical[Title/Abstract]
#8	CSR[Title/Abstract]
#9	#1OR#2OR#3OR#4OR#5OR#6OR#7OR#8
#10	Acupuncture[Mesh]
#11	Acupuncture[Title/Abstract]
#12	Pharmacopuncture[Title/Abstract]
#13	Acupuncture Therapy[Title/Abstract]
#14	Needle[Title/Abstract]
#15	Blood-letting puncture[Title/Abstract]
#16	Auricular application pressure[Title/Abstract]
#17	Acupoint catgut embedding[Title/Abstract]
#18	Acupoint injection[Title/Abstract]
#19	Moxibustion[Mesh]
#20	Moxibustion[Title/Abstract]
#21	#10OR#11OR#12OR#13OR#14OR#15OR#16OR#17OR#18OR#19OR#20OR
#22	#9OR#21

can potentially accelerate the central nervous system to produce endogenous opioid peptides and activate related receptors, and then reduce the concentration of pain-related substances ET-1, SP while increasing the levels of CGRP, β-EP substances involved in pain relief [15,16]. However, there are various types of acupuncture therapies available, such as Conventional acupuncture, moxibustion, Needle Knife, Fire needle, and Fu's Subcutaneous Needling, among others. Despite this, to date, there have been no direct comparisons made regarding the clinical efficacy of these different treatments. Therefore, we conducted a network meta-analysis to compare the efficacy of these commonly used acupuncture therapies in patients with CSR. The goal of this analysis was to provide a basis for selecting the most effective acupuncture therapy for the clinical treatment of CSR.

2. Methods

2.1. Research registration

We have already registered this research protocol on the PROSPERO, (https://www.crd.york.ac.uk/prospero/; Registration name: Yingtong Lin; Registration number: CRD42023389703). There were no amendments at registration.

2.2. Search strategy

Based on the Chinese and English databases' inception through November 2023, we conducted a systematic search by using the combination of subject words and free words for RCTs of CSR, including CNKI, VIP, Wanfang, Chinese biomedical literature database (CBM), Pubmed, Cochrane Library, EMBASE, Medline. The English search terms are: "Cervical Spondylotic Radiculopathy", "Radiculopathies", "Radiculopathy, Cervical", "Cervical Radiculopathies", "Cervical Radiculopathy", "Radiculopathies, Cervical", "acupuncture", "needle", "blood-letting puncture", "moxibustion", "auricular application pressure", "acupoint catgut embedding", "acupoint injection". The Chinese search terms are:"jing zhui bing(Cervical spondylosis)", "shen jing gen xing jing zhui bing(Cervical Spondylotic Radiculopathy)", "zhen ci(acupuncture)", "zhen jiu(acupuncture and moxibustion)", "zhen(needle)", "jiu(moxibustion)", "xue wei mai xian(Acupoint catgut-embedding)", "xue wei zhu she(acupoint injection)", "zhen dao(Needle Knife)", "sui ji dui zhao shi yan(randomized controlled trial)", "RCTs"(Table 1 and supplemental file-search strategy).
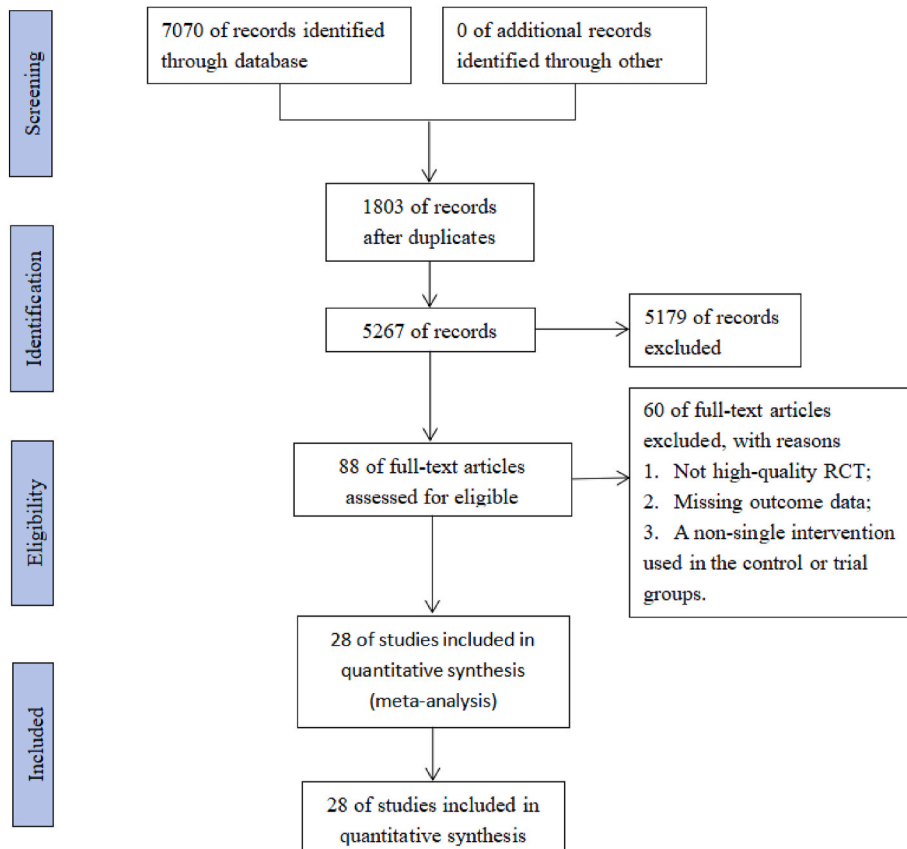

Fig. 1. Flowchart of the study search.

Table 2
Basic characteristics of the involved studies.

Studies	Sample size (Male/Female)	Age	Course of disease (month)	Interventions	Course of treatment (weeks)	Outcome Indicators
Wu 2022	T:47(24/23)	T:52.53 ± 11.02	T:41.88 ± 9.36	T:Conventional acupuncture	4	ab
	C:47(27/20)	C:51.94 ± 12.44	C:42.48 ± 8.64	C:Electro-acupuncture		
Zhang 2021	T:30(12/18)	T:41.27 ± 4.99	T:59.52 ± 19.44	T:Needle Knife	2	ac
	C:30(13/17)	C:39.63 ± 6.28	C:68.76 ± 25.32	C:Electro-acupuncture		
Sun 2020	T:35(17/18)	T:48.87 ± 5.04	T:33.72 ± 3.60	T:Fire needle	4	ab
	C:35(18/17)	C:49.24 ± 5.12	C:34.08 ± 3.84	C:Electro-acupuncture		
Kang 2018	T:41(23/18)	T:54.50 ± 4.60	T: 15.00 ± 28.08	T:Fu's Subcutaneous Needling	2	a
	C:40(22/18)	C:53.64 ± 3.45	C:26.76 ± 28.32	C:Electro-acupuncture		
Hu 2020	T:30(14/16)	T:48.83 ± 6.92	T:19.20 ± 3.00	T:Fu's Subcutaneous Needling	2	a
	C:30(13/17)	C:48.21 ± 7.13	C:16.80 ± 3.60	C:Electro-acupuncture		
Fu 2021	T:40(15/25)	T:42.40 ± 10.18	T: 18.36 ± 29.28	T:Qihuang needle	1	abc
	C:40(19/21)	C:46.65 ± 10.68	C:25.56 ± 39.36	C:Conventional acupuncture		
Zhao 2019	T:45(22/23)	T:56.30 ± 9.20	T:6.40 ± 2.60	T:Acupoint catgut Embedding	4	a
	C:45(20/25)	C:56.70 ± 10.50	C:6.30 ± 2.80 (year)	C:Conventional acupuncture		
Li 2021	T:40(24/16)	T:41.20 ± 7.90	T:4.10 ± 0.60	T:Needle Knife	2	ab
	C:40(22/18)	C:40.50 ± 7.80	C:4.30 ± 0.80 (year)	C:Conventional acupuncture		
Zheng 2017	T:30(17/13)	T:44.03 ± 10.40	T:9.76 ± 7.15	T:Needle Knife	4	ac
	C:30(15/15)	C:42.76 ± 11.32	C:10.60 ± 5.88	C:Conventional acupuncture		
Yuan 2017	T:59(28/35)	T:37.80 ± 13.40	T:27.50 ± 9.60	T:Long-round Needle	4	ab
	C:58(23/35)	C:29.30 ± 10.10	C:29.30 ± 10.10	C:Conventional acupuncture		
Xie 2014	T:30(16/14)	T:49.80 ± 2.70	T:1.20 ± 0.40	T:Fu's Subcutaneous Needling	4	a
	C:30(17/13)	C:47.60 ± 3.10	C:1.10 ± 0.30 (year)	C:Conventional acupuncture		
Fan 2012	T:30(14/16)	T:45.44 ± 8.13	T:16.39 ± 9.96	T:Needle Knife	3	ac
	C:30(16/14)	C:44.39 ± 7.91	C:16.60 ± 10.52 (week)	C:Conventional acupuncture		
Wang 2019	T:43(24/19)	T:45.87 ± 7.03	T:18.72 ± 2.13	T:Needle Knife	2	abc
	C:43(22/21)	C:46.78 ± 6.74	C:17.13 ± 2.38 (week)	C:Conventional acupuncture		
Li 2022	T:30(13/17)	T:50.47 ± 8.65	T:8.78 ± 2.10	T:Needle Knife	1	ac
	C:30(14/16)	C:47.00 ± 7.98	C:8.10 ± 2.38 (week)	C:Warm needle		
Yu 2021	T:64(20/44)	T:48.56 ± 14.73	T:70.33 ± 66.84	T:Conventional acupuncture	2	ac
	C:64(16/48)	C:43.41 ± 16.55	C:62.43 ± 92.74	C:Electrotherapy		
Sun 2010	T:36(15/21)	T:45.16 ± 9.62	T:46.32 ± 18.96	T:Conventional acupuncture	2	a
	C:36(16/20)	C:44.68 ± 9.21	C:46.92 ± 18.36	C:Chinese medicine(Tong-genping Granule,8g/bid)		
Fu 2010	T:57(17/40)	T:34.33 ± 10.32	T:46.93 ± 45.25	T:Conventional acupuncture	3	a

Table 2 (*continued*)

Studies	Sample size (Male/Female)	Age	Course of disease (month)	Interventions	Course of treatment (weeks)	Outcome Indicators
	C:55(15/41)	C:35.45 ± 10.27	C:37.82 ± 34.04	C:Sham Needle		
Qiu 2014	T:136(71/65); C:136(74/62)	T:46.00 ± 9.00	T:48.00 ± 24.00	T:Warm needle	2	a
		C:46.00 ± 8.00	C: 48.00 ± 24.00	C:Tui-na		
Yang 2019	T:40(23/17)	T:48.60 ± 6.20	T:61.20 ± 9.60	T:Warm needle	2	a
	C:40(21/19)	C:49.60 ± 5.80	C:51.60 ± 10.80	C:Conventional acupuncture		
Wei 2021	T:41(22/19)	T:53.26 ± 5.58	T:64.56 ± 17.40	T:Warm needle	2	a
	C:41(24/17)	C:52.93 ± 5.72	C:67.56 ± 13.44	C:Western Medicine(Fenbid0.3g/bid, Sibelium5mg/qd)		
Guo 2019	T:83(42/41)	T:59.25 ± 15.8	T:25.30 ± 13.60	T:Conventional acupuncture	3	b
	C:83(47/36)	C:57.37 ± 15.3	C:23.40 ± 12.70	C:Cervical traction		
Xu 2018	T:31(18/13)	T:40.77 ± 11.92	T:76.19 ± 47.96	T:Needle Knife	3	a
	C:33(19/14)	C:41.70 ± 14.06	C:74.85 ± 45.50 (day)	C:Conventional acupuncture		
Wang 2018	T:40(19/21)	T:46.58 ± 9.81	T:11.63 ± 7.94	T:Needle Knife	2	a
	C:40(15/25)	C:47.80 ± 9.45	C:11.25 ± 6.46	C:Electro-acupuncture		
Liu 2021	T:55(21/34)	T:51.02 ± 11.62	–	T:Warm needle	2	a
	C:62(19/43)	C:53.08 ± 14.52		C:Electro-acupuncture		
Li 2015	T:43(23/20)	T: 56.30 ± 8.50	T:5.10 ± 2.20	T:Acupoint catgut Embedding	4	a
	C:43(23/20)	C: 57.10 ± 7.30	C:5.60 ± 2.80	C:Conventional acupuncture		
Ding 2012	T:58(39/19)	T:29 ± 8	T:30.65 ± 8.94	T:Acupoint catgut Embedding	2	ab
	C:62(41/21)	C:30 ± 9	C:29.03 ± 9.53	C:Conventional acupuncture		
Jin 2022	T:43(26/17)	T:52.62 ± 3.37	T:9.36 ± 1.23	T:Warm needle	4	ab
	C:43(25/18)	C:51.89 ± 3.41	C:9.13 ± 1.52	C:Conventional acupuncture		
Pan 2022	T:35(19/16)	T:48.63 ± 3.57	T:4.11 ± 1.05	T:Warm needle	2	a
	C:35(18/17)	C:48.58 ± 3.51	C:4.07 ± 1.11	C:Conventional acupuncture		

Notes:a-VAS; b-NDI; c-TY.

2.3. Criteria for selecting articles

Study type: Randomized controlled study (RCT) of acupuncture-related therapy for the treatment of CSR, Jadad scores≥3, the language limited to Chinese and English, besides, the control group included in the review did not include medication as well as placebo treatment, and there were no restrictions to blindness, type of design, and type of publication. (2) Study subjects: patients who met the diagnostic criteria of CSR in "Standard for diagnosis and efficacy evaluation of Chinese Medicine syndromes and diseases" issued by Nanjing University [17], age between 18 and 65. (3) Interventions: The treatment of the trial group is acupuncture-related therapy (including Conventional acupuncture, Electro-acupuncture, Needle Knife, Fire needle, Fu's Subcutaneous Needling, Qihuang Needle, Acupoint catgut-embedding, Warm needle, Long round needle and so on), in comparison with the control group comprised another kind of acupuncture-related therapy or other single therapy (including Western Medicine, Chinese Medicine, Tuina (Message), Cervical traction, Electrotherapy and so on). (4) Outcome measures: (VAS) Visual Analog Scale, (NDI) Neck Disability Index, (TY) Tanaka Yasuhiro 20-point scale. (5) Exclusion criteria: Jadad scores < 3; the treatment protocol or course were unclear; either trial or control group comprised of multiple therapies; the diagnosis reported were not clearly divided into CSR (such as Cervical spondylosis, *Cervical spondylotic myelopathy*, Mixed *cervical spondylosis*, etc); data cannot be used; The original was not found; the full text of studies were not available; for studies with multiple articles or duplicate data, we analyzed only the article with the most complete data; non-randomized trials, case reports, letters, or comments were excluded.

2.4. Data extraction

According to the above screening criteria, in terms of data extraction, the literature management software Note Express 3.2.0 was utilized. Two investigators independently completed the task of data extraction, studies screening, and studies quality evaluation. Initially, studies that did not meet the inclusion criteria were excluded based on their titles and abstracts. Subsequently, titles and abstracts that met the inclusion criteria were further examined by acquiring and reading the full texts. Whenever opinions differed in the process of literature inclusion, a consensus will be reached by discussion. The extracted data was recorded in an Excel table, which included basic information on the research literature, intervention measures, efficacy evaluation criteria, outcome measures, adverse reactions, shedding rate, and other relevant details.
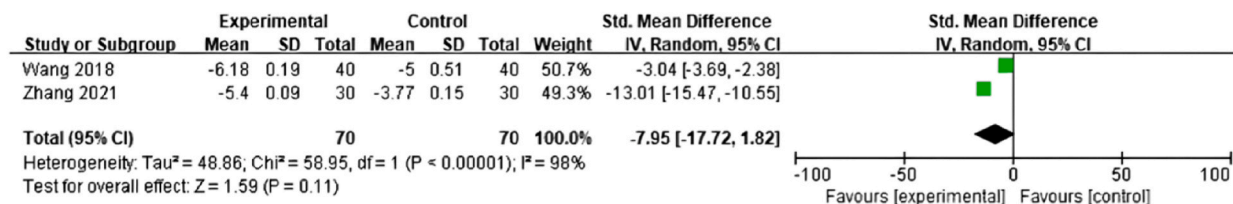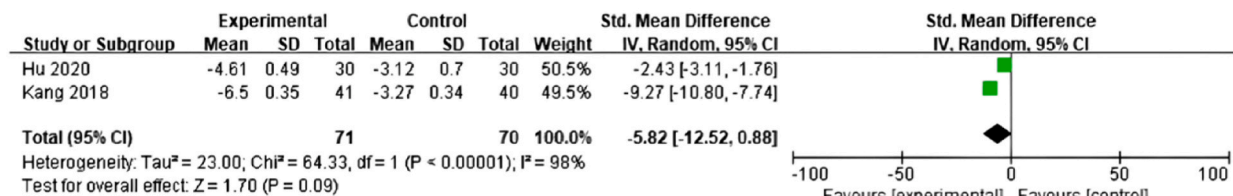

Fig. 2. Risk of bias assessment results.

2.5. Risk of bias assessment

Revman5.3, the risk bias assessment tool recommended by the Cochrane System Evaluation Manual (version 5.1) was used to evaluate the methodological quality of studies, including the generation of random sequence; allocation concealment; random
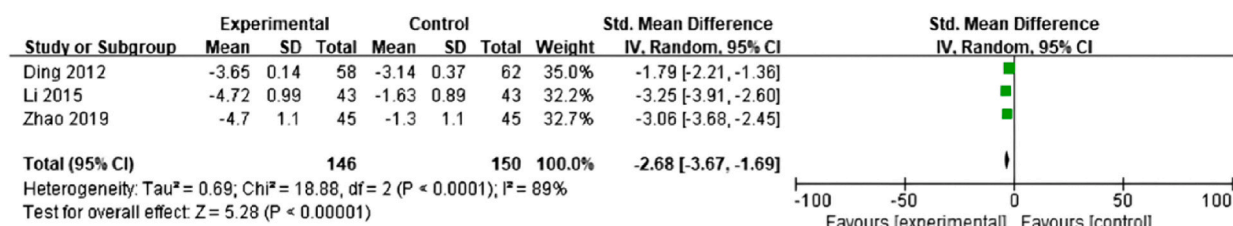

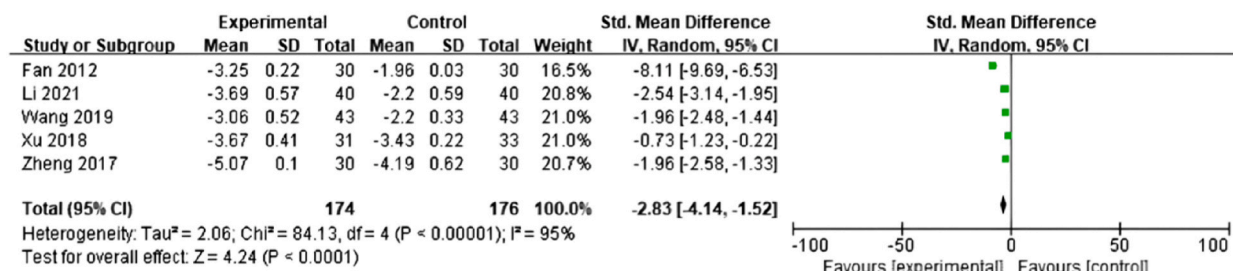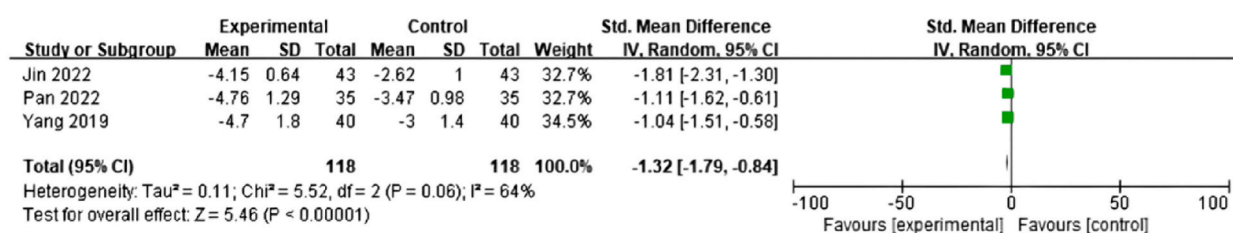
Fig. 3A. Forest plots of acupuncture-related treatments in VAS

sequence generation; blinding outcome assessment; blinding of participants and personnel; selective reporting; incomplete outcome data; other bias. On the basis of the risk of bias assessment guidelines, we judged each study as low risk of bias, high risk of bias, or uncertain. If different opinions arise during the evaluation process, we will solve the difference through discussion.

2.6. Statistic analysis

We used Revman 5.3 software to evaluate the results. Since all outcome measures are continuous variables, we selected the mean difference (MD) and its 95 % confidence interval (CI) as the effect size indicator. All included studies were two-arm studies. If $I^2 \leq 50$ % and $P \geq 0.05$, it indicates no significant statistically heterogeneity among the studies, and in such cases, a fixed-effect model should be adopted. Otherwise, it indicates statistically significant heterogeneity, and further analyses such as meta-regression, subgroup analysis, and sensitivity analysis can help identify the further sources of heterogeneity. If no significant clinical or methodological heterogeneity is found, a random-effects model will be applied for meta-analysis.

To compare the relationships between different interventions, we created a network meta-analysis evidence diagram and conducted heterogeneity and inconsistency tests using Stata 14.0 and WinBUGs 14. If loops are present, the consistency between direct and indirect comparisons will be assessed using the inconsistency factor (IF value). When the 95 % CI for the starting point is 0, it indicates that the direct and indirect evidence are consistent. Subsequently, a network meta-analysis is performed and the results are ranked accordingly. Additionally, to assess small-sample effects, it is important to plot "comparison-correction" funnel plots.

3. Results

3.1. Study retrieval results

A total of 7070 related studies were retrieved in this study, including 5931 studies from Chinese database and 1139 studies from English database, 1803 of them were excluded because of duplication, 88 studies entered the final screening stage. Eventually, only 28 studies were included in this network meta-analysis. Among them, the reasons for elimination mainly included: non-high-quality RCTs (3 studies), outcome measures did not meet the inclusion criteria (8 studies), multiple therapies being used in the control group or trial group (6 studies), unclear diagnosis (4 studies), missing data (6 studies), not randomized controlled trials (3 studies) (Fig. 1).

3.2. Basic features of included studies

A total of 28 studies were involved, including 2593 patients, 1292 of them from the trial group and 1301 from the control group, with a maximum sample size of 272 and a minimum of 60. Involved intervention are: Conventional acupuncture, Electro-acupuncture, Needle Knife, Fire needle, Fu's Subcutaneous Needling, Qihuang needle, Acupoint catgut-embedding, Warm needle, Long round needle, Electrotherapy, Chinese Medicine, Western Medicine, Sham needle and Tuina (Tuina (Message)).In terms of cases dropped and adverse reactions, two studies reported the drop, however, the outcome was not analyzed intentionally. Only one study reported the adverse reactions, which occurred in Fu's Subcutaneous Needling group of 3 patients with local bleeding after the treatment. Regarding the primary outcome measures, 27 studies reported the VAS scores [16,18–43], 9 studies reported the NDI scores [18,21,23, 26,32,34,35,40,44], and 6 studies reported the TY scores [21,27,33,36,41,43]. As for the diagnostic criteria, 18 studies adopted the "Standard for diagnosis and efficacy evaluation of Chinese Medicine syndromes and diseases" [17], 7 studies adopted the "Summary of the Second Symposium on Cervical Spondylosis" [45], 1 adopted "The experts consensus on the classification, diagnosis and non-surgical treatment of cervical spondylosis(2018)" [46], we found the diagnostic criteria involved have high similarity between each other after reading and comparison. The basic characteristics of the involved studies are shown in Table 2.

3.3. Risk of bias assessment results

Among the 28 studies, all of them are random allocation specifically, 11 studies used a random number table [22–24,29–31,37,39, 41,43,44], 4 studies used the visit order for random allocation [18,21,32,33], the number of using software to generate random numbers and group are three [20,27,40], mainly by PEM 3.1(2 studies) and SPSS 22 statistic(1 study), the rest of studies are reported no specific implementation of random allocation. 2 studies reported the allocation of hidden [20,27]. All studies reported not blind,
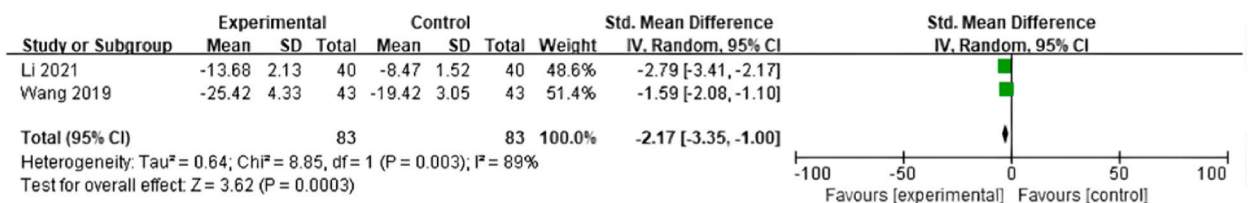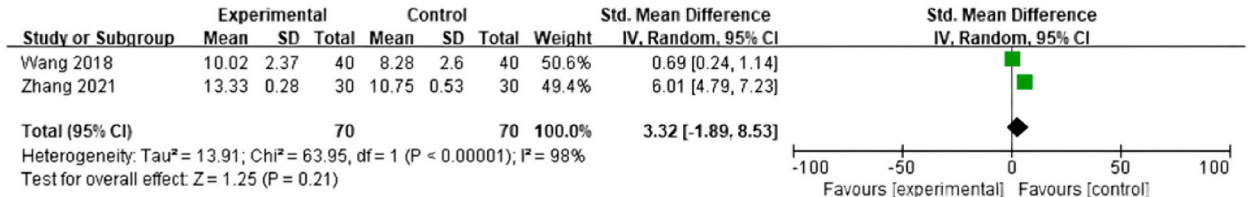
1.Needle Knife VS Conventional Acupuncture

Fig. 3B. Forest plots of acupuncture-related treatments in NDI

1.Needle Knife VS Electro-acupuncture

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Wang 2018	10.02	2.37	40	8.28	2.6	40	50.6%	0.69 [0.24, 1.14]
Zhang 2021	13.33	0.28	30	10.75	0.53	30	49.4%	6.01 [4.79, 7.23]
Total (95% CI)			**70**			**70**	**100.0%**	**3.32 [-1.89, 8.53]**

Heterogeneity: Tau² = 13.91; Chi² = 63.95, df = 1 (P < 0.00001); I² = 98%
Test for overall effect: Z = 1.25 (P = 0.21)

2.Needle Knife VS Conventional Acupuncture

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Xu 2018	7.35	0.21	31	5.64	0.26	33	48.2%	7.12 [5.76, 8.49]
Zheng 2017	7.21	0.02	30	5.89	0.28	30	51.8%	6.56 [5.25, 7.88]
Total (95% CI)			**61**			**63**	**100.0%**	**6.83 [5.89, 7.78]**

Heterogeneity: Tau² = 0.00; Chi² = 0.34, df = 1 (P = 0.56); I² = 0%
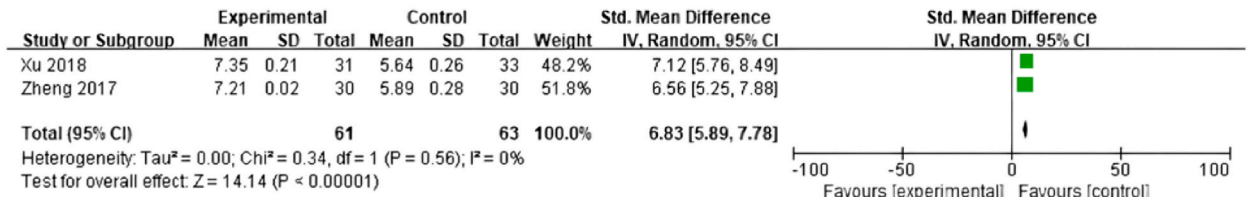Test for overall effect: Z = 14.14 (P < 0.00001)

Fig. 3C. Forest plots of acupuncture-related treatments in TY

considering the particularity of acupuncture-related treatment, the researchers and subjects cannot be treated blind. Except for one study that lacked disease course information [28], all of the outcome data were complete and not selectively reported, however, other sources of bias were unclear. To sum up, the methodological quality of the 28 involved studies was moderate (Fig. 2).

4. Directly compared meta-analysis results

4.1. VAS

Among the 28 studies involved, 27 studies [16,18–43] evaluated the VAS scores as an outcome measure. the meta-analysis forest plot shows that the curative effect of Acupoint catgut-embedding was better than Conventional acupuncture (SMD = 2.68, 95 % CI [−3.27, −1.69], $Z = 5.28$, P < 0.00001, $I^2 = 89$ %, 3RCTs), Needle Knife superior to Conventional acupuncture (SMD = 2.83, 95 % CI [−4.14, −1.52], $Z = 4.24$, $P < 0.0001$, $I^2 = 95$ %, 5RCTs), while Warm needle was better than Conventional acupuncture (SMD = 1.32, 95 % CI [−1.79, −0.84], $Z = 5.46$, P < 0.00001, $I^2 = 64$ %, 3RCTs). Whereas the efficacy of Needle Knife was not better than that of Electro-acupuncture (SMD = 7.95, 95 % CI [−17.72, 1.82], $Z = 1.59$, $P = 0.11$, $I^2 = 98$ %, 2RCTs), neither did Fu's Subcutaneous Needling (SMD = 5.82, 95 % CI [−12.52, 0.88], $Z = 1.70$, $P = 0.09$, $I^2 = 89$ %, 3RCTs), therefore, it seemed difficult to judge the
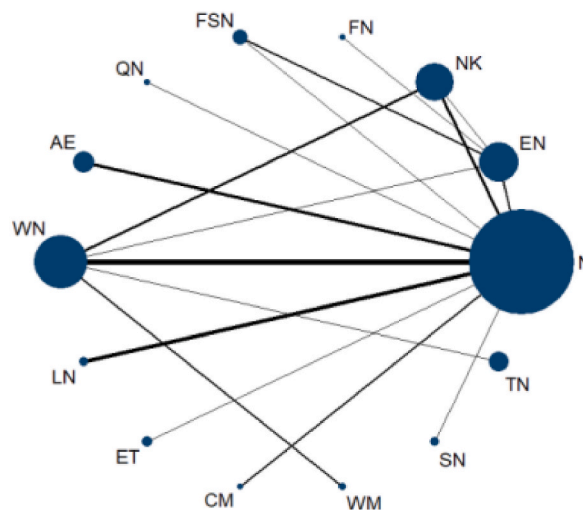

Fig. 4A. Network Diagram(VAS).
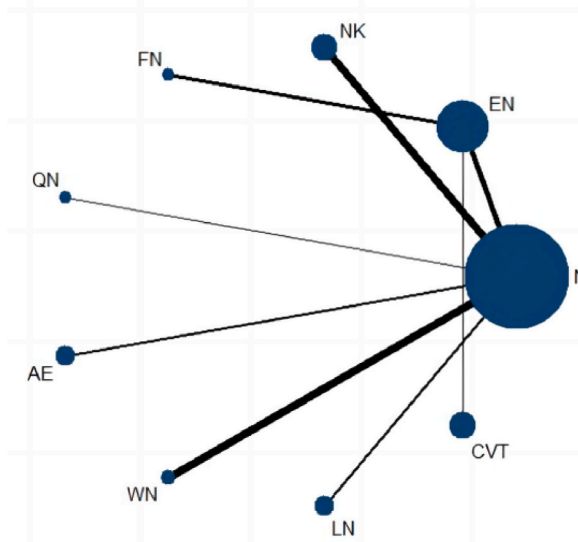
Network evidence plot for CRS(NDI)

Fig. 4B. Network Diagram(NDI).

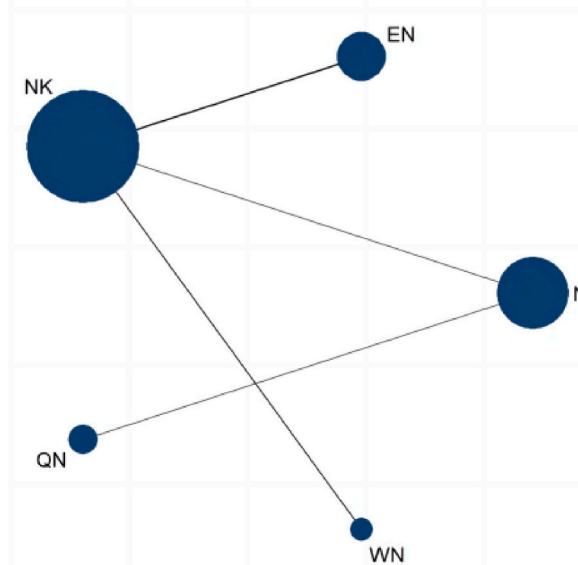## Network evidence plot for CRS(TY)

Fig. 4C. Network diagram(TY).

curative effect of these two interventions(Fig. 3A). In general, Descriptive analysis showed that the curative effect of Conventional acupuncture, Fire needle and Warm needle was better than Electro-acupuncture, besides, Qihuang needle, Long round needle, as well as Fu's Subcutaneous Needling were more effective in improving the VAS scores than Conventional acupuncture, nevertheless, Conventional acupuncture showed a greater effect than Chinese Medicine, Sham needle and Electrotherapy, what's more, Warm needle was better than Tuina (Message) and Western Medicine, apart from this, Needle Knife was better than Warm needle ($P < 0.05$). See the descriptive analysis results in supplementary materials (Fig. S1).
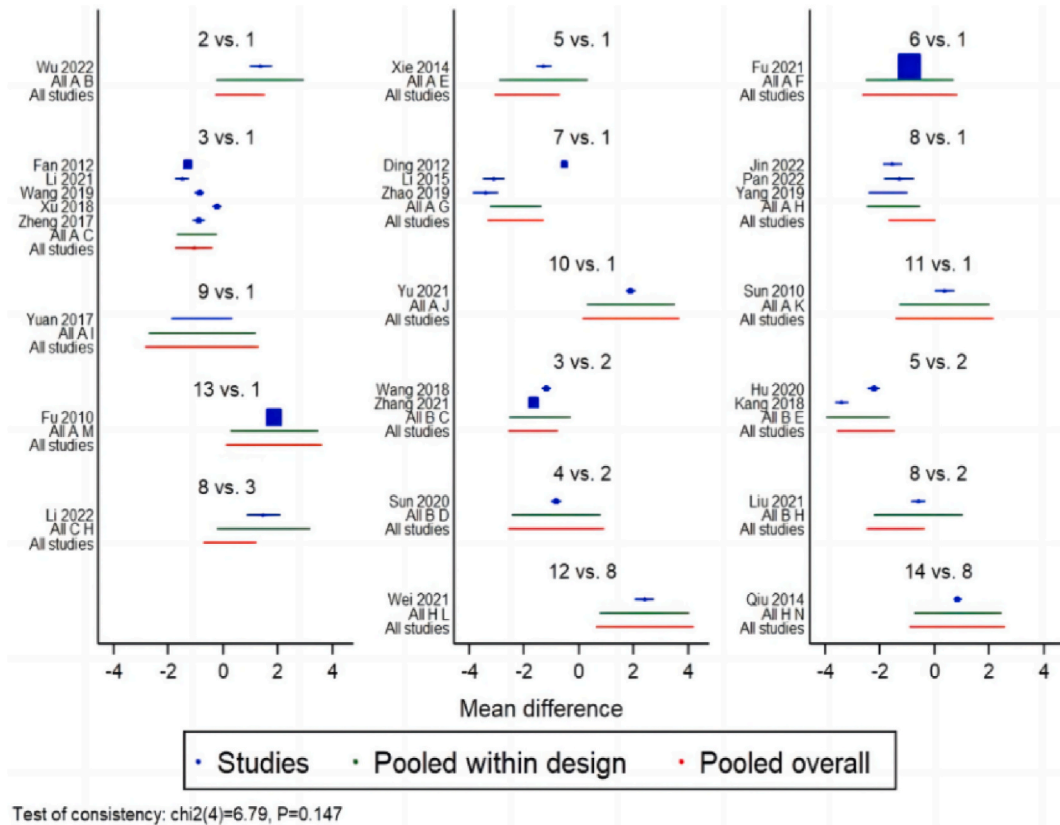
Fig. 5A. Inconsistency Analysis Results(VAS).
Notes:1-Conventional acupuncture; 2-Electro-acupuncture; 3-Needle Knife; 4-Fire needle; 5-Fu's Subcutaneous Needling; 6-Qihuang Needle; 7-Acupoint catgut-embedding; 8-Warm needle; 9-Long round needle; 10-Electrotherapy; 11-Chinese Medicine; 12-Western Medicine; 13-Sham needle; 14-Tuina (Message).

4.2. NDI

Among the 28 studies involved, 9 studies [18,21,23,26,32,34,35,40,44] evaluated NDI scores. The meta-analyzed forest plot showed that the curative effect Needle Knife was superior to the needle (SMD = 2.17,95 % CI [−3.35,1.00], $Z = 3.62$, $P = 0.0003$, $I^2 = 89$ %, 2 RCTs)(Fig. 3B). Descriptive analysis showed that the efficacy of Conventional acupuncture and Fire needle were better than Electro-acupuncture, besides Electro-acupuncture was better than Cervical traction, in addition to this, Qihuang needle, Long round needle, as well as Acupoint catgut-embedding, Warm needle were more effective in improving NDI scores than Conventional acupuncture ($P < 0.05$). See the descriptive analysis results in supplementary materials(Fig. S2).

4.3. TY

Among the 28 studies involved, 6 studies [21,27,33,36,41,43] evaluated the TY scores. The meta-analysis forest plot showed that Needle Knife is superior to needle (SMD = 6.89, 95 % CI [5.83, 7.78], $Z = 14.14$, $P < 0.00001$, $I^2 = 0$ %, 2RCTs), however, the efficacy of Needle Knife is not better than Electro-acupuncture (SMD = 3.32, 95 % CI [−1.89, 8.53], $Z = 1.25$, $P = 0.21$, $I^2 = 98$ %, 2RCTs) (Fig. 3C). Descriptive analysis showed that Qihuang needle was better than Conventional acupuncture, and Needle Knife was better than the Warm needle ($P < 0.05$). See the descriptive analysis results in supplementary materials (Fig. S3).

4.4. Heterogeneity analysis

The study utilized SMD as the effect size and conducted analysis on the 95 % credible interval (CI). Revman5.3 was employed to assess the heterogeneity of VAS, NDI, and TY. The findings indicated that only the heterogeneity test results of the scores for Needle Knife versus traditional acupuncture met the criteria of $I^2 < 50$ % and $P > 0.05$. This result is closely linked to the number of cases, treatment courses, and interventions of the studies included in the comparison. However, for the remaining heterogeneity test results, $I^2 > 50$ % and $P < 0.05$ (Fig. 3A–C).

The direct comparison of the meta-analysis results exposed significant heterogeneity, which may be attributed to the small sample

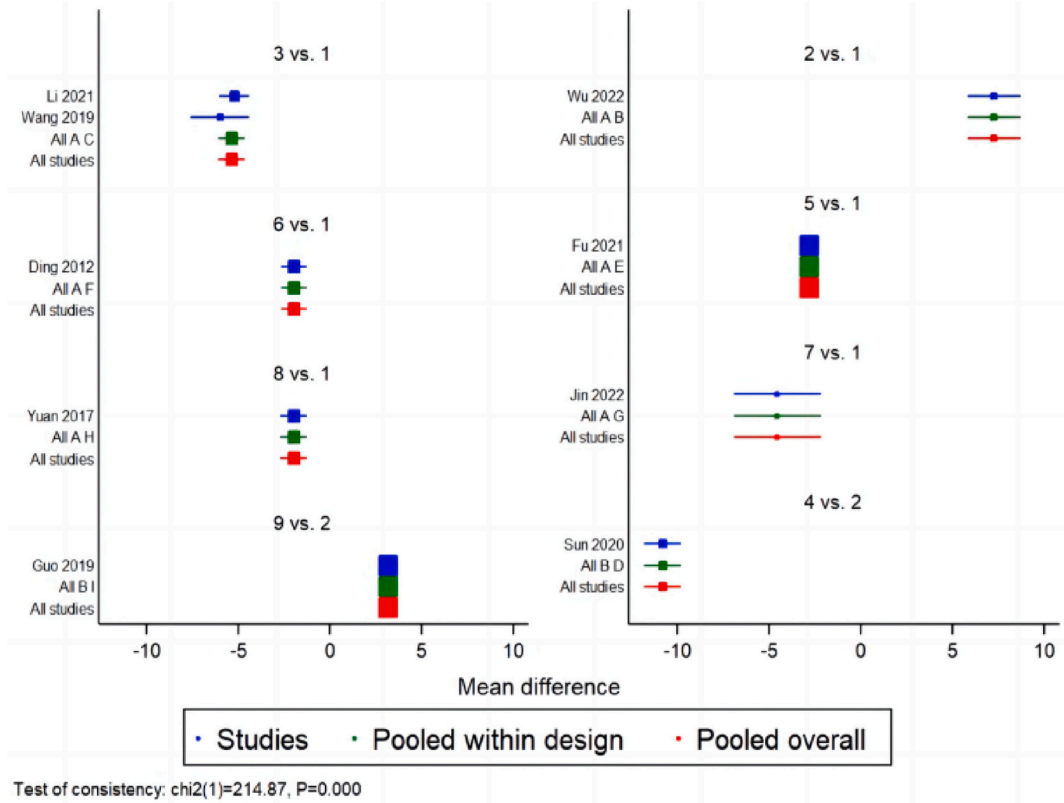**Fig. 5B.** Inconsistency Analysis Results(NDI).
Notes:1-Conventional acupuncture; 2-Electro-acupuncture; 3-Needle Knife; 4-Fire needle; 5Qihuang Needle; 6-Acupoint catgut-embedding; 7-Warm needle; 8-Long round needle; 9-Cervical traction.
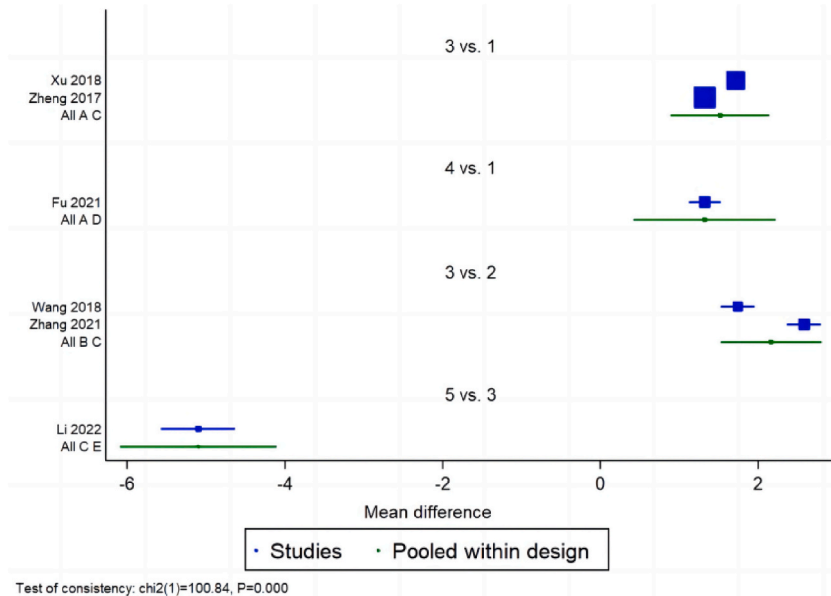

Fig. 5C. Inconsistency Analysis Results(TY).
Notes:1-Conventional acupuncture; 2-Electro-acupuncture; 3-Needle Knife; 4-Qihuang Needle; 5-Warm needle.
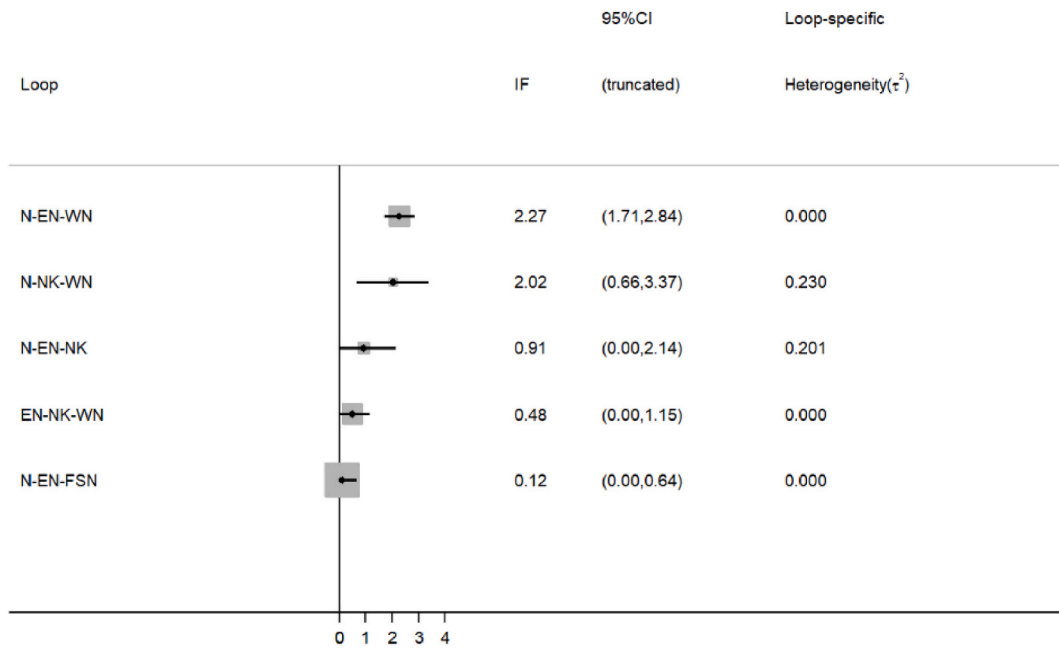
Fig. 6. Loops inconsistency Results(VAS).

size, population variations, and the absence of a blind implementation plan. Additionally, there was no uniformity in the treatment duration across each study, potentially introducing bias to the results. Nonetheless, the small sample size did not allow for further subgroup analysis. Fortunately, the sensitivity analysis demonstrated that the results remained consistent after eliminating any individual study, therefore the heterogeneity of this study was considered negligible and the analysis proceeded using a random effects model.

5. Network compared meta-analysis results

5.1. Network diagram

There are 17 pairs of the direct comparison results of VAS, forming 5 loops, including Conventional acupuncture - Electro-acupuncture - Warm needle, Conventional acupuncture - Needle Knife - Warm needle, Conventional acupuncture - Electro-acupuncture - Needle Knife, Electro-acupuncture - Needle Knife - Warm needle, Conventional acupuncture - Electro-acupuncture - Fu's Subcutaneous Needling. The network diagram of NDI showed 8 direct comparison results, but no loops, while the network diagram of TY showed 4 direct comparison results, and no loops either(Fig. 4A–C).

5.2. Inconsistency analysis

To test whether there was any inconsistency in the outcome measures, Stata14.0 was used. The results suggested $P_{VAS} = 0.1469$ (chi2 (4) = 6.79), $P_{NDI} = 0.0000$ (chi2 (1) = 214.87), $P_{TY} = 0.0000$ (chi2 (1) = 100.84)(Fig. 5A–C). Analysis of NDI and TY by the node-cutting method showed there was no inconsistency between the direct comparison of various interventions and the indirect comparison (P > 0.05)(See supplementary materials(Tables S1–S2)). The results of loops inconsistency presented there was no significant inconsistency in the results of the following 3 rings: Conventional acupuncture - Electro-acupuncture - Needle Knife, Electro-acupuncture - Needle Knife - Warm needle, Conventional acupuncture - Electro-acupuncture - Fu's Subcutaneous Needling. Whereas the loops inconsistency results of Conventional acupuncture - Electro-acupuncture - Warm needle and Conventional acupuncture - Needle Knife - Warm needle indicated large heterogeneity because the 95 % CI interval of the IF of their results did not contain 0 and the results are shown in Fig. 6. Therefore, the consistency of the involved studies is good.

5.3. Network meta-analysis of VAS

The VAS network meta-analysis yielded a total of 91 pairs of pairwise comparisons. The convergence assessment indicated that when the PSFR values reached 1, the inconsistent model and the inconsistent model produced similar results, indicating strong stability and consistency of the indicators. Therefore, the MCMC model was employed for the network meta-analysis of VAS results. The findings revealed that Conventional acupuncture was superior to Electrotherapy and Sham Needle. Acupoint catgut-embedding outperformed Conventional acupuncture, Electro-acupuncture, Tuina (Message), Sham needle, Western Medicine, Chinese

Table 3A
Network meta-analysis Results(VAS).

EN	1.67(−2.57, −0.76)	0.82(−2.58,0.94)	2.49(−3.56,−1.43)	1.51(−3.47,0.46)	2.91(−4.27,−1.54)	1.42(−2.47,−0.36)	1.38(−3.64,0.89)	1.29(−0.68,3.27)	0.24(−2.24,1.77)	0.99(−1.08,3.07)	1.25(−0.71,3.22)	0.58(−2.62,1.47)	0.61(−1.51,0.29)
1.67 (0.76,2.57)	NK	0.85 (−1.13,2.83)	−0.82 (−2.07,0.43)	0.16 (−1.72,2.04)	−1.24 (−2.47,−0.00)	0.25 (−0.71,1.21)	0.29 (−1.89,2.48)	**2.96 (1.08,4.85)**	1.43 (−0.48,3.35)	**2.66 (0.64,4.69)**	**2.92 (1.04,4.80)**	1.09 (−0.91,3.09)	**1.06 (0.38,1.74)**
0.82 (−0.94,2.58)	−0.85 (−2.83,1.13)	FN	−1.67 (−3.73,0.38)	−0.69 (−3.32,1.95)	−2.08 (−4.31,0.14)	−0.60 (−2.65,1.45)	−0.56 (−3.42,2.31)	2.11 (−0.53,4.76)	0.58 (−2.08,3.25)	1.81 (−0.90,4.53)	2.07 (−0.56,4.71)	0.24 (−2.45,2.94)	0.21 (−1.76,2.19)
2.49 (1.43,3.56)	0.82 (−0.43,2.07)	1.67 (−0.38,3.73)	FSN	0.99 (−1.13,3.10)	−0.41 (−1.98,1.16)	1.08 (−0.28,2.44)	1.12 (−1.27,3.50)	**3.79 (1.67,5.91)**	**2.26 (0.11,4.40)**	**3.48 (1.24,5.73)**	**3.75 (1.63,5.86)**	1.92 (−0.30,4.14)	**1.89 (0.70,3.07)**
1.51 (−0.46,3.47)	−0.16 (−2.04,1.72)	0.69 (−1.95,3.32)	−0.99 (−3.10,1.13)	QN	−1.40 (−3.43,0.63)	0.09 (−1.86,2.04)	0.13 (−2.58,2.84)	**2.80 (0.32,5.28)**	1.27 (−1.23,3.77)	2.50 (−0.14,5.14)	**2.76 (0.28,5.24)**	0.93 (−1.69,3.55)	0.90 (−0.85,2.65)
2.91 (1.54,4.27)	1.24 (0.00,2.47)	2.08 (−0.14,4.31)	0.41 (−1.16,1.98)	1.40 (−0.63,3.43)	AE	1.49 (0.15,2.83)	1.53 (−0.79,3.85)	**4.20 (2.16,6.24)**	**2.67 (0.60,4.73)**	**3.90 (1.67,6.13)**	**4.16 (2.13,6.19)**	**2.33 (0.12,4.54)**	2.30 (1.27,3.33)
1.42 (0.36,2.47)	−0.25 (−1.21,0.71)	0.60 (−1.45,2.65)	−1.08 (−2.44,0.28)	−0.09 (−2.04,1.86)	**−1.49 (−2.83,−0.15)**	WN	0.04 (−2.20,2.29)	**2.71 (0.75,4.67)**	1.18 (−0.80,3.16)	**2.41 (0.63,4.19)**	**2.67 (0.72,4.62)**	0.84 (−0.92,2.60)	0.81 (−0.05,1.67)
1.38 (−0.89,3.64)	−0.29 (−2.48,1.89)	0.56 (−2.31,3.42)	−1.12 (−3.50,1.27)	−0.13 (−2.84,2.58)	−1.53 (−3.85,0.79)	−0.04 (−2.29,2.20)	LN	**2.67 (−0.05,5.39)**	1.14 (−1.60,3.88)	2.37 (−0.50,5.24)	2.63 (−0.08,5.34)	0.80 (−2.05,3.65)	0.77 (−1.30,2.84)
−1.29 (−3.27,0.68)	−2.96 (−4.85,−1.08)	−2.11 (−4.76,0.53)	**−3.79 (−5.91,−1.67)**	**−2.80 (−5.28,−0.32)**	**−4.20 (−6.24,−2.16)**	**−2.71 (−4.67,−0.75)**	−2.67 (−5.39,0.05)	ET	−1.53 (−4.04,0.98)	−0.30 (−2.95,2.35)	−0.04 (−2.52,2.44)	−1.87 (−4.50,0.76)	**−1.90 (−3.66,−0.14)**
0.24 (−1.77,2.24)	−1.43 (−3.35,0.48)	−0.58 (−3.25,2.08)	**−2.26 (−4.40,−0.11)**	−1.27 (−3.77,1.23)	**−2.67 (−4.73,−0.60)**	−1.18 (−3.16,0.80)	−1.14 (−3.88,1.60)	1.53 (−0.98,4.04)	CM	1.23 (−1.44,3.90)	1.49 (−1.01,3.99)	−0.34 (−2.99,2.31)	−0.37 (−2.16,1.42)
−0.99 (−3.07,1.08)	−2.66 (−4.69,−0.64)	−1.81 (−4.53,0.90)	**−3.48 (−5.73,−1.24)**	−2.50 (−5.14,0.14)	**−3.90 (−6.13,−1.67)**	**−2.41 (−4.19,−0.63)**	−2.37 (−5.24,0.50)	0.30 (−2.35,2.95)	−1.23 (−3.90,1.44)	WM	0.26 (−2.38,2.90)	−1.57 (−4.07,0.93)	−1.60 (−3.58,0.38)
−1.25 (−3.22,0.71)	−2.92 (−4.80,−1.04)	−2.07 (−4.71,0.56)	**−3.75 (−5.86,−1.63)**	**−2.76 (−5.24,−0.28)**	**−4.16 (−6.19,−2.13)**	**−2.67 (−4.62,−0.72)**	−2.63 (−5.34,0.08)	0.04 (−2.44,2.52)	−1.49 (−3.99,1.01)	−0.26 (−2.90,2.38)	SN	−1.83 (−4.45,0.79)	**−1.86 (−3.61,−0.11)**
0.58 (−1.47,2.62)	−1.09 (−3.09,0.91)	−0.24 (−2.94,2.45)	−1.92 (−4.14,0.30)	−0.93 (−3.55,1.69)	**−2.33 (−4.54,−0.12)**	−0.84 (−2.60,0.92)	−0.80 (−3.65,2.05)	1.87 (−0.76,4.50)	0.34 (−2.31,2.99)	1.57 (−0.93,4.07)	1.83 (−0.79,4.45)	TN	−0.03 (−1.98,1.92)
−1.38 (−3.64,0.89)	1.29 (−0.68,3.27)	−0.24 (−2.24,1.77)	0.99 (−1.08,3.07)	1.25 (−0.71,3.22)	−0.58 (−2.62,1.47)	−0.61 (−1.51,0.29)	−0.77 (−2.84,1.30)	**1.90 (0.14,3.66)**	0.37 (−1.42,2.16)	1.60 (−0.38,3.58)	**1.86 (0.11,3.61)**	0.03 (−1.92,1.98)	N

Notes: The values in the table represent MD(CI 95 %), the results of statistically significant difference between the two interventions were in bold font.
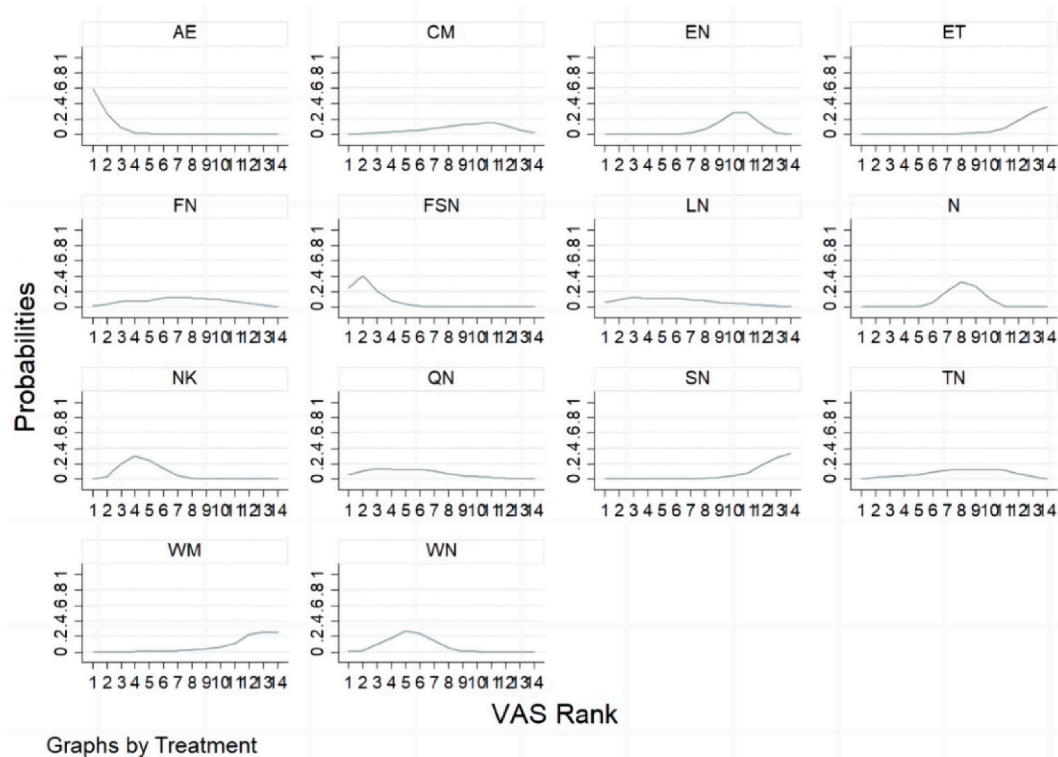
Fig. 7A. Ranking Possibilities Results(VAS). Notes: The specific meaning of abbreviations refer to Fig. 3A.The larger ares under the line indicates the higher rank.

Medicine, Electrotherapy, and Warm needle. Fu's Subcutaneous Needling was more effective than Conventional acupuncture, Electroacupuncture, Sham Needle, Western Medicine, Chinese Medicine, and Electrotherapy. Similarly, Qihuang needle exhibited a superior effect compared to Sham needle and Electrotherapy. Needle Knife surpassed Electro-acupuncture, Conventional acupuncture, Sham Needle, Western Medicine, and Electrotherapy. The remaining comparative difference results were not statistically significant (Table 3A). While the higher the SUCRA value meant bringing the better efficacy of the intervention in Stata analysis. After ranking the probability for 10,000 iterations, the conformal model of VAS scores resulted in the following ranking: Acupoint catgut-embedding > Fu's Subcutaneous Needling > Needle Knife > Qihuang needle > Warm needle > Long round needle > Fire needle > Tuina (Message) > Conventional acupuncture > Electro-acupuncture > Western Medicine > Sham needle > Electrotherapy(Fig. 7A)(See the sucra values in supplementary materials (Table S3)).

5.4. Network meta-analysis of NDI

The NDI network Meta analysis produced 36 pairwise comparisons. According to the convergence assessment, Conventional acupuncture was found to be better than Electro-acupuncture and Cervical traction. Moreover, Long round needle was found to be better than Conventional acupuncture and Electro-acupuncture, as well as Cervical traction. Additionally, Warm needle showed better results than Conventional acupuncture, Electro-acupuncture, Acupoint catgut-embedding, and Cervical traction. Furthermore, Acupoint catgut-embedding was determined to be superior to Conventional acupuncture, Electro-acupuncture, and Cervical traction. Qihuang needle was superior to conventional needle, Electro-acupuncture, Cervical traction, and Acupoint catgut-embedding. Moreover, Fire needle demonstrated better effectiveness than conventional needle, Electro-acupuncture, and Cervical traction. Similarly, Needle Knife showed better results than Conventional acupuncture, Electro-acupuncture, Cervical traction, Long round needle, Acupoint catgut-embedding, and Qihuang needle. No statistical significance was found in the rest of the comparative difference results (Table 3B). The higher the SUCRA value, the more effective the intervention. In the ranking result of the conformance model analysis, the efficacy rankings based on NDI scores were as follows: Needle Knife, Warm needle, Fire needle, Qihuang needle, Long round needle, Acupoint catgut-embedding, Conventional acupuncture, Electro-acupuncture, and Cervical traction(Fig. 7B)(See the sucra values in supplementary materials (Table S4)).

5.5. Network meta-analysis of TY

The TY network meta-analysis produced results for 10 pairs of comparisons. The assessment of convergence indicated that

Table 3B
Network meta-analysis Results(NDI).

|								
EN	−12.66 (−14.28,-11.04)	−10.78 (−11.78,-9.78)	−10.07 (−11.57,-8.56)	−9.25 (−10.85,-7.65)	−11.81 (−14.60,-9.02)	−9.28 (−10.88,-7.67)	3.19 (2.76,3.62)	−7.29 (−8.73,-5.84)
12.66 (11.04,14.28)	NK	1.88 (−0.02,3.78)	**2.59 (1.76,3.43)**	**3.41 (2.42,4.41)**	0.85 (−1.64,3.35)	**3.38 (2.38,4.39)**	**15.85 (14.18,17.52)**	**5.37 (4.65,6.10)**
10.78 (9.78,11.78)	−1.88 (−3.78,0.02)	FN	0.71 (−1.10,2.52)	1.53 (−0.35,3.42)	−1.03 (−3.99,1.94)	1.50 (−0.39,3.40)	**13.97 (12.88,15.06)**	**3.49 (1.73,5.25)**
10.07 (8.56,11.57)	**−2.59 (-3.43,-1.76)**	−0.71 (−2.52,1.10)	QN	**0.82 (0.02,1.62)**	−1.74 (−4.16,0.68)	0.79 (−0.03,1.61)	**13.26 (11.69,14.82)**	**2.78 (2.36,3.20)**
9.25 (7.65,10.85)	**−3.41 (-4.41,-2.42)**	−1.53 (−3.42,0.35)	**−0.82 (-1.62,-0.02)**	AE	**−2.56 (-5.04,-0.08)**	−0.03 (−1.01,0.95)	**12.44 (10.78,14.09)**	**1.96 (1.28,2.64)**
11.81 (9.02,14.60)	−0.85 (−3.35,1.64)	1.03 (−1.94,3.99)	1.74 (−0.68,4.16)	**2.56 (0.08,5.04)**	WN	**2.53 (0.04,5.02)**	**15.00 (12.17,17.82)**	**4.52 (2.13,6.91)**
9.28 (7.67,10.88)	**−3.38 (-4.39,-2.38)**	−1.50 (−3.40,0.39)	−0.79 (−1.61,0.03)	0.03 (−0.95,1.01)	**−2.53 (-5.02,-0.04)**	LN	**12.47 (10.80,14.13)**	**1.99 (1.29,2.69)**
−3.19 (-3.62,-2.76)	**−15.85 (-17.52,-14.18)**	**−13.97 (-15.06,-12.88)**	**−13.26 (-14.82,-11.69)**	**−12.44 (-14.09,-10.78)**	**−15.00 (-17.82,-12.17)**	**−12.47 (-14.13,-10.80)**	CVT	**−10.48 (-11.99,-8.97)**
7.29 (5.84,8.73)	**−5.37 (-6.10,-4.65)**	**−3.49 (-5.25,-1.73)**	**−2.78 (-3.20,-2.36)**	**−1.96 (-2.64,-1.28)**	**−4.52 (-6.91,-2.13)**	**−1.99 (-2.69,-1.29)**	**10.48 (8.97,11.99)**	N
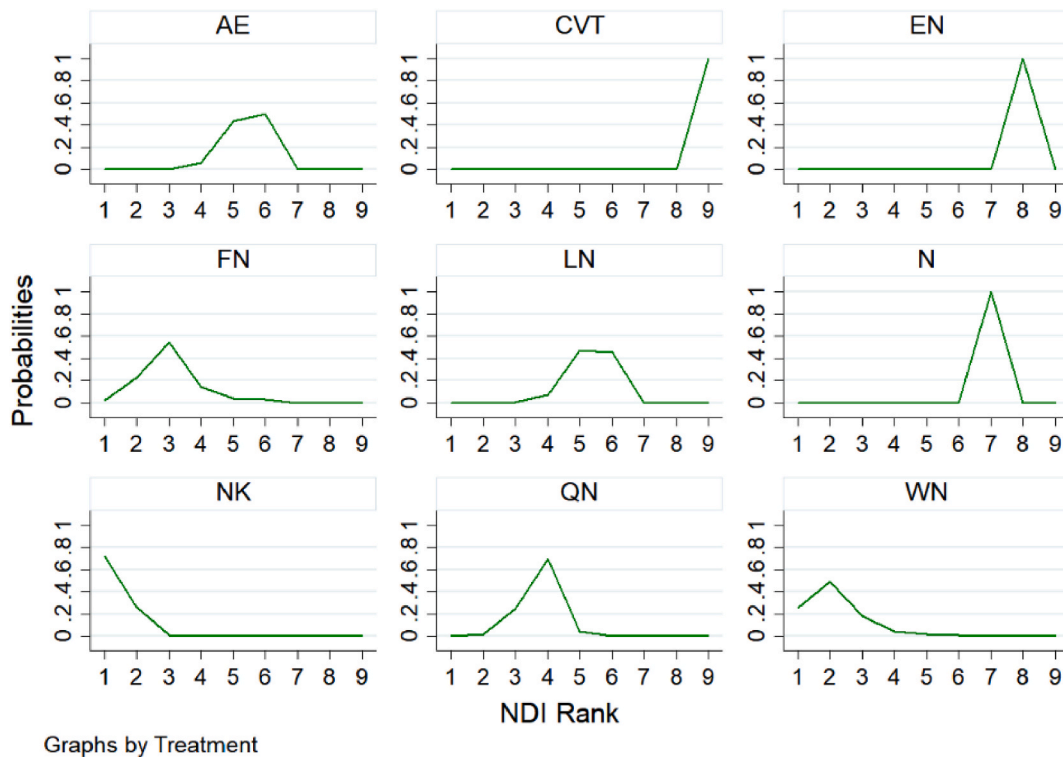
Fig. 7B. Ranking possibilities results(NDI).

Table 3C
Network meta-analysis results(TY).

| EN	2.16 (1.52,2.80)	1.97 (0.70,3.24)	−2.94 (−4.12,-1.76)	0.65 (−0.25,1.54)
−2.16 (-2.80,-1.52)	NK	−0.19 (−1.29,0.90)	−5.10 (-6.09,-4.10)	−1.51 (-2.14,-0.89)
−1.97 (-3.24,-0.70)	0.19 (−0.90,1.29)	QN	−4.91 (-6.39,-3.42)	−1.32 (-2.22,-0.42)
2.94 (1.76,4.12)	5.10 (4.10,6.09)	4.91 (3.42,6.39)	WN	3.59 (2.41,4.76)
−0.65 (−1.54,0.25)	1.51 (0.89,2.14)	1.32 (0.42,2.22)	−3.59 (-4.76,-2.41)	N

Conventional acupuncture was better than Warm needle. Additionally, Qihuang needle was found to be superior to conditional acupuncture, Warm needle, and Electro-acupuncture. The remaining comparison results did not show any statistical significance (Table 3C). The ranking of the intervention efficacy based on SUCRA values was as follows: Needle Knife > Qihuang needle > Conventional acupuncture > Electro-acupuncture > Warm needle (Fig. 7C)(See the sucra values in supplementary materials (Table S5)).

5.6. Small sample effect estimation

Stata14.0 was used to test the 27 studies included in VAS for small sample effect estimation. The funnel plot, corrected for comparisons, showed an asymmetric tilt towards the upper right, suggesting the presence of a small sample effect and potential publication bias (Fig. 8).

6. Discussion

With the shift in modern lifestyle and the mounting pressure in life, the incidence of CSR has been gradually increasing, particularly among the elderly population. The operation treatment, known for its definite effectiveness in addressing CSR, can be quite expensive and has a postoperative recurrence rate as high as 30 % [47]. Acupuncture, classified as a conservative treatment for CSR, has been proven effective and possesses similar pain-relieving properties as drug therapy [48]. The proper alignment and movement of the cervical spine heavily rely on the strength and tone of the neck muscles. A decline in these qualities can lead to abnormal spine motion and curvature. Prolonged alteration in the physiological curvature of the cervical spine without correction can cause spasms and swelling in the local neck muscles. This, in turn, can trigger local decompensation in the cervical spine, exacerbating its impact on normal spinal function, blood vessels, and local nutrient metabolism. Ultimately, this creates a cycle of dynamic and static imbalance
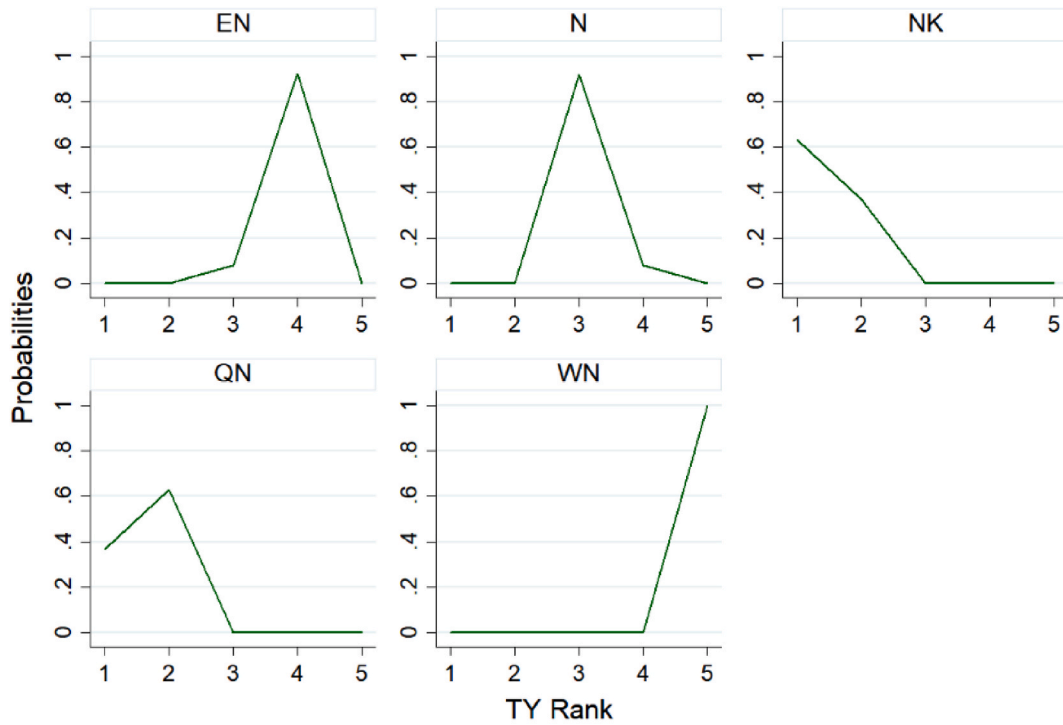
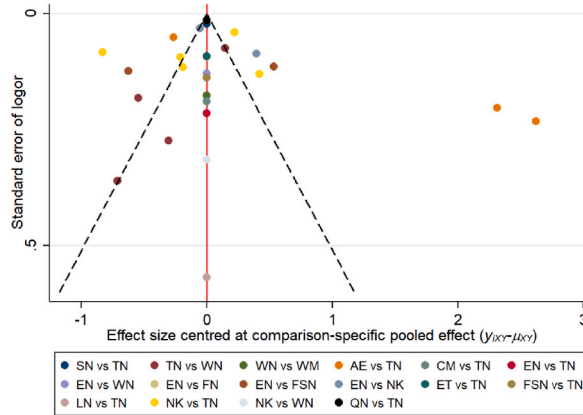**Fig. 7C.** Ranking possibilities results(TY).

Fig. 8. Comparison corrected funnel Plots(VAS).

in the cervical spine, further worsening its dysfunction [49,50]. Consequently, it is vital to enhance the soft tissue tension surrounding the cervical spine and restore its physiological curvature to alleviate pain and symptoms of nerve root compression. As a complementary and alternative therapy, several clinical trials [16,51–53] have demonstrated superiority of acupuncture in relieving pain in patients with CSR. Because there are different types of acupuncture therapy, each with different effects on symptom relief, this study conducted a Network Meta-analysis to determine the most suitable acupuncture intervention for CSR. The goal was to provide more options for the clinical treatment of CSR.

In this study, different acupuncture interventions were evaluated separately to assess their impact on VAS scores, NDI scores, and TY scores in CSR patients. The results showed that Acupoint catgut-embedding was better than Tuina (Message), Chinese Medicine, and Warm needle in terms of improving VAS scores. Acupoint catgut-embedding, Fu's Subcutaneous Needling, and Needle Knife were more effective than Conventional acupuncture, Electro-acupuncture, Sham needle, Western Medicine, and Electrotherapy in improving VAS scores. Moreover, Conventional acupuncture was better than Electrotherapy and Sham needle in this regard. Qihuang needle was found to be superior to Sham needle and Electrotherapy in terms of improving VAS scores. To enhance the NDI scores,

Needle Knife, Warm needle, Fire needle, Long round needle, and Acupoint catgut-embedding proved more effective than Conventional acupuncture, Electro-acupuncture, and traction. Traditional acupuncture outperformed Electro-acupuncture and Cervical traction. Additionally, Needle Knife, Warm needle, and Qihuang needle demonstrated better results than Acupoint catgut-embedding. Furthermore, Needle Knife surpassed Qihuang needle, Long round needle, and Acupoint catgut-embedding. Concerning YT scores improvement, Needle Knife and Qihuang needle outperformed Conventional acupuncture, Warm needle, and Electro-acupuncture. Conventional acupuncture exhibited more favorable curative effects than Warm needle. Considering the moderate quality of the studies involved and the influence of different TCM syndrome types on VAS types [20], it is important for clinicians to consider TCM syndrome differentiation and the clinical characteristics of CSR patients when utilizing acupuncture treatment. The ranking results provided are solely intended for reference by clinicians.

The Network Meta-analysis results demonstrated that acupoint embedding, Fu's Subcutaneous Needling, and Needle Knife were the most effective interventions in improving VAS scores. Needle Knife proved to be the best intervention for improving NDI scores, followed by Warm needle and Fire needle. In terms of TY scores improvement, Needle Knife and Qihuang needle were the most effective. Compared to traditional acupuncture, acupoint catgut embedding is a combination therapy that merges traditional acupuncture with modern physics, which utilizes the biophysical effects and biochemical changes caused by the needle and medicinal thread inside the acupoints. This stimulation targets the local acupoint receptors, reflexively reducing the excitability of the cervical sympathetic nerves and promoting local blood circulation. Consequently, it alleviates muscle or blood vessel spasms in the neck, corrects intervertebral joint disorders, and restores the biomechanical balance of the cervical spine [54]. One notable advantage is its prolonged stimulation of the corresponding acupoints after a single treatment, resulting in strong and sustained curative effects, similar to the "retention needle" effect of traditional acupuncture [25]. Furthermore, the use of the intestinal line in this therapy, as a heterogeneous protein, can induce immune metamorphosis, enhance the differentiation and proliferation of lymphocytes, and ultimately improve the human immune function [55]. Fu's Subcutaneous Needling is a treatment that combines Chinese Medicine and Modern Medicine. Its main focus is on the subcutaneous loose connective tissue, aiming to alleviate the ischemic and hypoxic condition of the soft tissue and affected muscles. This is achieved by using disposable floating needles to gently move through the subcutaneous tissues around specific MTrPs (also known as myofascial trigger points) or adjacent limbs. The objective is to improve the ischemic state of the affected cervical muscles, eliminate MTrPs, and promote muscle tissue recovery [56,57]. Another treatment that combines Chinese Medicine and Modern Medicine is the Needle Knife. This technique uses a needle that has both acupuncture and surgical scalpel properties. By making incisions, pulling, and stimulating the soft tissue, the Needle Knife helps reduce spasticity, decompresses, provides analgesia, and separates adhesions in the posterior cervical muscle group and joint capsule. Consequently, the local ischemia and hypoxia in the cervical spine improve [58,59]. however, Needle Knife can significantly downregulate SP levels that plays an important role in the process of nociception and pain signal afferents in the peripheral nervous system [60] in patients with CSR [26], and then reduce the pain symptoms of neck and shoulders, otherwise, it can also increased the average blood flow in the vertebral artery velocity so as to promote the associated dysfunction in CSR [61]. The Qihuang needle is thick, hard, and hollow, which allows for minimal resistance when injecting and can effectively expand, squeeze, and separate connective tissue at the deep acupoints. This process also pulls the receptors near the acupoints and enhances the excitability of human receptors during treatment. As a result, the needle sensation is easier to obtain [21,62], ultimately providing strong stimulation to our skin and blood vessels at the acupoints while minimizing harm. Studies have found that Fire needle reduce the inflammatory response by means of improving the serum levels of 6-keto-PGF1α and endothelial growth factor and reducing the expression of MMP-3 in articular cartilage [63,64]. Warm needle can also play a good role in reducing the serum levels of inflammatory factors such as TNF-α, IL-6, hs-CRP and ET [64], and then reduced the inflammatory edema in nerve roots or surrounding areas so as to alleviate the pain symptoms. Generally, needles used in the Needle Knife, Fu's Subcutaneous Needling, and Qihuang needle techniques are thicker, resulting in stronger local stimulation due to excessive mechanical pulling. Warm needle and Fire needle add a warm effect to traditional acupuncture, enhancing the acupuncture sensation experienced by individuals.

Since there are no ancient traditional Chinese books that mention CSR as a disease, modern TCM has classified it as "bi syndrome" based on the clinical symptoms. According to the "Huangdi Neijing," "bi syndrome" is mostly caused by liver and kidney deficiencies, as well as external factors like "wind, cold, and wet three qi," trauma, and strain. Based on the manuscripts analyzed in this study, it was found that Fire needle and Warm needle treatments were commonly used for the syndrome types associated with wind, cold, and wet, thanks to their unique thermal effects [16,23,28,29,32,38,39]. The "Jiaji" acupoints, located between the Bladder Meridian of Foot-Taiyang and the Governor Vessel meridians, are often selected for Acupoint catgut-embedding treatment [18,25,42], this helps regulate the qi, blood, Yin, and Yang of the viscera, primarily targeting liver and kidney deficiencies and other types of internal deficiencies. Thicker needles, such as those used in Fu's Subcutaneous Needling, Qihuang needle, Needle Knife, and Long round needle treatment, provide greater stimulation to muscles and acupoints [19,21,22,24,26,27,36,37,40,43], so that they offer quick relief for the uncomfortable symptoms associated with external strain in the syndrome type. Currently, acupuncture and Electro-acupuncture are widely and commonly used in the treatment of all types of CSR. Therefore, in addition to the study's conclusion, further research on selecting appropriate acupuncture methods based on different TCM syndromes is also a valuable direction in future study.

6.1. Limitations of the study

There were several limitations of this study: (1) The quality of involved studies was not very high, 10 studies did not employ explicit randomization allocation methods, 4 studies used unscientific methods of random allocation, which was allocated by the visit order. Regarding the allocation concealment, blind, in addition to the 2 other studies, none of the rest was described in detail, which might cause a bad impact on the credibility of the research results; (2) The diversity of acupuncture treatments and treatment courses had

possibility to cause some bias to the results; (3) Only Chinese and English studies were searched in this study, and the involved studies were mostly in Chinese database, the lack of high-quality English studies might contribute to some language bias. (4) The number of the involved studies for each intervention was small, some interventions even included only one study, so there was some bias due to the difficulty in doing further subgroup analysis; (5) In this study, only VAS, NDI and YT scores were included as the outcome measures for efficacy evaluation, and the number of involved studies for NDI, YT scores were small, so this study cannot fully reflect the actual efficacy of the various acupuncture interventions, therefore, further studies with a larger sample and high-quality RCT were needed.

7. Conclusion

All in all, through our Network Meta-analysis, Acupoint catgut-embedding showed the best effect in relieving neck pain, Needle Knife was the best intervention in improving the *functional activity* of the cervical spine, moreover, Needle Knife is the *best* treatment for the improvement of overall clinical performance. Furthermore, our conclusion still requires to be supported by higher quality literature to confirm. Last but not least, it is suggested that clinicians ought to consider the principle of TCM syndrome differentiation and the clinical characteristics so as to select the best acupuncture treatment for patients.

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Data availability statement

All data are publicly available, they are included in article, supplementary materials and reference, and further data can be obtained from the first author with reasonable request.

CRediT authorship contribution statement

Yingtong Lin: Writing – review & editing, Writing – original draft, Resources, Formal analysis, Conceptualization. **Sha Zhong:** Writing – review & editing, Writing – original draft, Data curation. **Chaoyuan Huang:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Gangyu Zhang:** Writing – review & editing, Formal analysis, Data curation. **Ganghui Jiang:** Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e31793.

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