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Randomized Controlled Trials of Acupuncture for Neck Pain: Systematic Review and Meta-Analysis

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Abstract

Objectives: The objectives of this study were to assess the effectiveness and efficacy of acupuncture in the treatment of neck pain.
Data sources: The following computerized databases were searched from their inception to January 2008: MEDLINE (PubMed), ALT HEALTH WATCH (EBSCO), CINAHL, and Cochrane Central.
Review methods: Systematic review and meta-analysis were conducted on randomized controlled trials of acupuncture for neck pain. Two (2) reviewers independently extracted data concerning study characteristics, methods, and outcomes, as well as performed quality assessment based on the adapted criteria of Jadad.
Results: Fourteen (14) studies were included in this review. Meta-analysis was performed only in the absence of statistically significant heterogeneity among studies that were selected for testing a specific clinical hypothesis. While only a single meta-analysis was done in previous reviews, this review performed nine meta-analyses addressing different clinical issues. Seven out of nine meta-analyses yielded positive results. In particular, the meta-analysis based on the primary outcome of short-term pain reduction found that acupuncture was more effective than the control in the treatment of neck pain, with a pooled standardized mean difference (SMD) of −0.45 (95% confidence interval [CI], −0.69 to −0.22). Moreover, the meta-analysis with a pooled SMD of −0.53 (95% CI, −0.94 to −0.11) showed that acupuncture was significantly more effective than sham acupuncture for pain relief. However, there was limited evidence based on the qualitative analysis of the trial data to support the above conclusions. We provided a detailed analysis on the issue of heterogeneity of the studies involved in meta-analysis and examined the consistencies and inconsistencies among the present review and two other reviews conducted previously.
Conclusions: The quantitative meta-analysis conducted in this review confirmed the short-term effectiveness and efficacy of acupuncture in the treatment of neck pain. Further studies that address the long-term efficacy of acupuncture for neck pain are warranted.

Introduction

Neck pain is a common medical condition that may cause substantial morbidity. According to the recent data published by the United States' National Center for Health Statistics (www.cdc.gov/nchs/), about 15% of adults (18 years and older) experienced neck pain; the prevalence of neck pain peaks at age 50, and it occurs more commonly in women (17%) than in men (12%). Neck pain can be caused by acute or chronic cervical strain or sprain (e.g., whiplash), cervical disk disorders such as herniated nucleus pulposus, arthritic disorders (degenerative, rheumatoid, etc.) and miscellaneous disorders such as fibromyalgia and neoplasms.

Conservative interventions for neck pain include muscle relaxants, steroid injection, manual therapy, physical therapy, behavioral therapy, traction, cervical collar, electromagnetic therapy, and proprioceptive exercises. However, a study based on a rigorous evaluation of randomized controlled trials (RCTs) concluded that there was no clear evidence that any form of treatment was particularly effective

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for the management of chronic neck pain and there was a need for more high-quality studies with larger sample sizes in this area.[1]

Acupuncture has emerged as an alternative treatment modality for neck pain. Acupuncture, which is generally believed to have originated in China, is a technique of inserting needles into certain points on the body with the aim of restoring health and preventing diseases. The first RCT for assessing the effect of acupuncture on neck pain was conducted by Coan et al. in 1981, and a statistically significant result in favor of acupuncture was demonstrated.[2] There exist more than 10 systematic reviews concerning acupuncture treatment for pain, but only two of those are devoted to acupuncture specifically for neck pain. The first systematic review conducted by White and Ernst concluded that the available evidence (up to 1997) from sound clinical trials did not support the hypothesis that acupuncture was efficacious for neck pain, and of the eight high-quality trials, five were negative.[3] The second systematic review conducted by Trinh et al. concluded that there was moderate evidence (up to February 2006) that acupuncture was better than some sham treatments for neck pain relief.[4,5] The inconsistency in the conclusions between these two reviews could be ascribed to new data gathered after the first review or to the discrepancy in data interpretation. Furthermore, because of the heterogeneity among studies, no meta-analysis was performed by the first review, and only a single meta-analysis for combining evidence was performed by the second review. Under these circumstances, we were motivated to undertake a new systematic review with the following objectives: (1) summarizing the most current scientific evidence (up to January 2008) based on RCTs concerning the effectiveness of acupuncture on neck pain, (2) performing meta-analyses for statistically nonheterogeneous studies in multiple aspects, (3) addressing the issue of heterogeneity of the studies so far as meta-analysis is concerned, and (4) comparing the present review with previous ones and analyzing inconsistency across reviews.

Methods

Data sources and search strategies

The following computerized databases were searched from their inception to January 2008: MEDLINE (PubMed), ALT HEALTH WATCH (EBSCO), CINAHL, and Cochrane Central. Text word search of titles and abstracts was conducted using the following entries in various conjunction or disjunction: *acupuncture, electroacupuncture, neck pain, cervical pain, cervical spine, cervical spondylosis, cervical spondylopathy, cervical spondylitis, cervical radiculopathy, cervical disk, nerve root, arthritis, and osteoarthritis*. Only papers originally written in English or translated into English were considered. In addition, types of papers were limited to the following: clinical trial, RCT, National Institutes of Health RCT, and meta-analysis.

Study selection (inclusion and exclusion criteria)

Each study included in this review satisfied the following criteria: (1) the design was a RCT, (2) subjects participating in the study had neck pain for at least a month, (3) treatment interventions were limited to traditional acupuncture or electro-acupuncture, and (4) none of the exclusion criteria were met. The exclusion criteria consisted of the following: (1) subjects had pain at multiple sites and some sites were not directly radiated from neck pain, (2) neck pain was not the main symptom, (3) only different forms of acupuncture were compared, and (4) neck pain was not included in the primary outcome measure.

Validity assessment

The quality of studies was appraised by two authors (L.F. and J.L.) independently using the criteria of White and Ernst[3] adapted from the validated criteria of Jadad et al.[6] We awarded a maximum of 5 points in three aspects: randomization (2 points for an appropriate method, 1 point if no method described, or 0 point for an inappropriate method); blinding (1 point for patient blinding, and 1 point if the evaluator was blinded to therapy); and withdrawals and dropouts (1 point if a clear statement or a chart was provided). Patient blinding meant that the control intervention was indistinguishable from acupuncture. A score of 3 points or higher was considered high quality.

Data extraction

Data were extracted independently by the first and second authors (L.F. and J.L.) using predesigned forms. The information extracted from the raw data contained in the full papers included trial design, subject characteristics and diagnosis, randomization, blinding, dropout descriptions, treatment interventions, control procedures, treatment and control sample sizes, main outcome measures, and study results. Differences were settled by discussion to reach a consensus.

Study characteristics

The study design is a parallel or crossover RCT. Subject data included neck pain characteristics and duration. Both the number and duration of acupuncture treatment were described. Control procedures encompassed sham acupuncture, sham transcutaneous electrical nerve stimulation (TENS), sham laser, physical therapy, massage, waiting list, anti-inflammatory medication, and routine care. Outcome measures included pain measures based on various types of scale such as visual analog scale (VAS), disability measures, and functional measures such as range of motion (ROM).

Level of evidence

The scientific evidence collected to prove or disprove the effectiveness of the therapeutic interventions under study was rated by the system described by van Tulder et al.,[1] which consisted of four levels of evidence outlined below:

1. Strong evidence: generally consistent findings in multiple high-quality RCTs.
2. Moderate evidence: generally consistent findings in one high-quality RCT and one or more low-quality RCTs, or generally consistent findings in multiple low-quality RCTs.
3. Limited or contradictory evidence: only one RCT (high- or low-quality) or inconsistent findings in multiple RCTs.
4. No evidence: no RCTs.

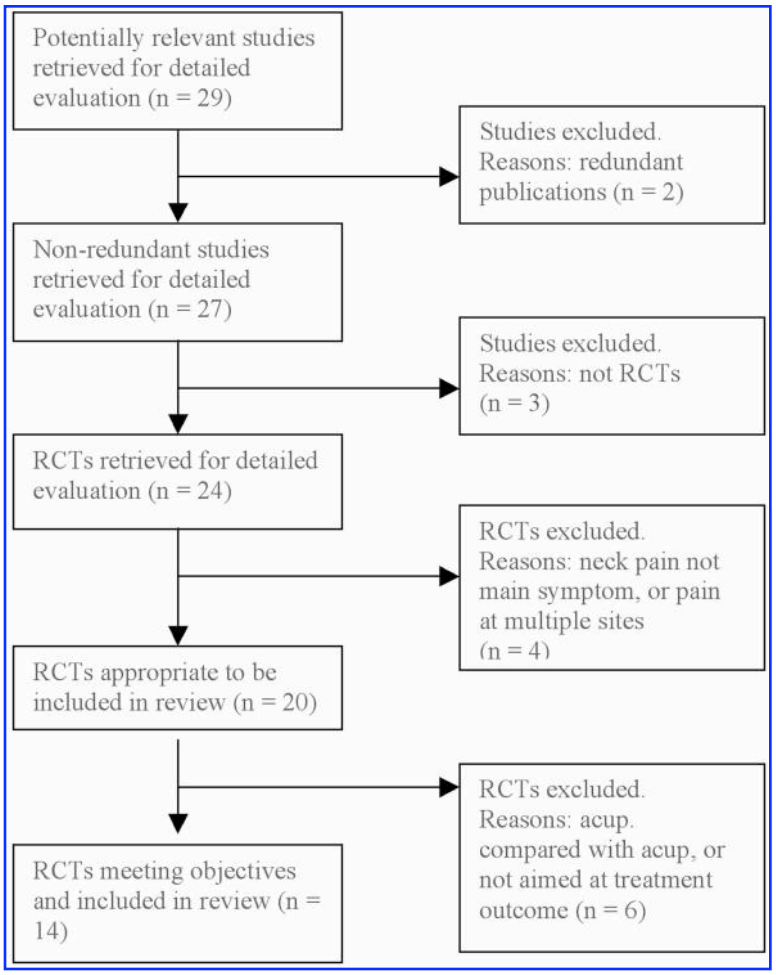


FIG. 1. The flow chart of the present meta-analysis. RCTs, randomized controlled trials; acup, acupuncture.

In other related criteria,[4,7] findings in a single, high-quality RCT are graded as moderate rather than limited evidence.

Quantitative data synthesis (meta-analysis)

Meta-analysis was conducted using the CMA software, version 2 (Biostat, Englewood, NJ). In the absence of statistically significant heterogeneity ($p < 0.05$) and data format incompatibility, we pooled data by using the random-effects model; otherwise, data were not combined. We performed separate analyses for each main outcome measure, for short-term and long-term effects, and for different control interventions, if appropriate. Effect size was measured by using standardized mean difference (SMD) for continuous data or odds ratio for dichotomous data. Statistical heterogeneity in a meta-analysis was assessed through a χ^2 test of homogeneity (I^2). An I^2 value of 25% represented a small degree of heterogeneity, 50% represented a moderate degree, and 75% represented a large degree of heterogeneity.[8]

Before analysis, 10 aspects were predefined for assessment, including short-term pain relief (continuous data), short-term pain relief (dichotomous data), long-term pain relief, range of motion, short-term disability improvement, long-term disability improvement, cervical radiculopathy, acupuncture versus sham acupuncture, acupuncture versus sham TENS, and acupuncture versus sham laser, respectively. Subgroups of data were collected without bias in each aspect.

The systematic review was conducted by following the standard procedure developed by the Cochrane Collaboration[9]. The meta-analysis was reported according to the QUOROM (Quality of reporting of meta-analysis) guidelines[10] available at the CONSORT website (www.consort-statement.org).

Results

Trial flow

The flow chart of the present meta-analysis in accordance with the QUOROM standard is displayed in Fig. 1.

Characteristics of studies

Our search criteria found 29 RCTs concerning acupuncture treatment of neck pain. Fifteen (15) studies[11–25] were excluded for the reasons defined in the exclusion criteria (Table 1). Hence, 14 RCTs[2,26–38] were included in this review, and their main study characteristics are summarized in Table 2. The study by Witt et al.[36] comprised an RCT and a nonrandomized cohort study, but only the RCT component was considered in the present review. The study by Itoh et al.[38] used three different sets of acupuncture points for the treat-

Table 1. Clinical Trials of Acupuncture for Neck Pain Based on the English Literature Search but Excluded from the Present Systematic Review

Author (date)	*Condition for exclusion*
Zhuang 2000[11]	Neck pain not main symptom
Kung et al. 2001[12]	Not RCT
König et al. 2003[13]	Redundant
Sator-Katzenschlager et al. 2003[14]	Acupuncture vs. acupuncture
Blossfeldt 2004[15]	Not RCT
He et al. 2005[16]	Redundant
Ceccherelli et al. 2006[17]	Acupuncture vs. acupuncture
Willich et al. 2006[18]	Pain not the primary outcome measure
Liu 2007[19]	Acupuncture vs. acupuncture, neck pain not main symptom
Jia et al. 2007[20]	Acupuncture vs. acupuncture
Guo et al. 2007[21]	Acupuncture vs. acupuncture
Wang et al. 2007[22]	Pain at multiple sites
Loy et al. 1983[23] (Trinh et al. review)	Not based on randomization
White et al. 2000[24] (Trinh et al. review)	Acupuncture vs. acupuncture
Kreczi et al. 1986[25] (White et al. review)	Pain at multiple sites

RCT, randomized controlled trial.

ment intervention, but only the trigger point group was compared with the control group in this review mainly because the use of trigger points (also known as Ashi points) was the primary method for acupuncture point selection especially for pain syndromes.[39]

The minimum duration of the neck pain for the subjects participating in each study considered here ranged from 1 month to 2 years. Several studies excluded patients with neurologic deficits or radiculopathy; some studies had radiculopathy as part of their inclusion criteria; and others did not mention this aspect in either the inclusion or exclusion criteria.

The control interventions can be classified into four types: sham acupuncture (needle insertion at false or irrelevant points or without real penetration into the skin), no treatment, inactive treatment (e.g., sham laser and sham TENS), and active treatment (e.g., physical therapy and massage). The outcome measures were based on pain relief and functional improvement, including subjective measures, such as pain and disability, and objective measures such as range of motion. We considered outcomes less than 3 months to be short term, and more than 3 months to be long-term. The overall quality of the 14 studies included in this review was satisfactory, with scores ranging from 2 to 5 and a mean score of 3.36.

The number of the treatment sessions is an important factor for assessing the adequacy of the acupuncture treatment. It was found that six or more treatments were associated with a better outcome.[40] In the present review, 10 studies performed at least 6 sessions, and two studies 5 sessions. One study examined the effect of a single treatment[31] and was considered as an exception. Only one study[33] was well below the norm of 6 sessions. In general, the studies included in this review were adequate by this measure.

Study results

The result of a study was viewed as positive if in the study, the acupuncture treatment was shown to be better than the control intervention with statistical significance ($p < 0.05$) according to the primary outcome measure. A negative result could be any of the following cases: acupuncture was no better or worse than the control intervention, or acupuncture was better than the control but the relative effect was not statistically significant. If a study used more than one type of control, results could be mixed. Of the 14 studies included in the present review, 9 studies[2,26,29,31,34–38] reported a positive result, 4 studies[27,28,32,33] reported a negative result, and one study[30] reported a mixed result. Among those reporting positive results, 8 studies were high quality and only one was low quality. In contrast, among those reporting negative results, half of them were poor quality. Thus, the evidence supporting the main hypothesis that acupuncture was effective in the treatment of neck pain was stronger than the evidence denying this hypothesis. Taken together, it seemed there was limited evidence for the above hypothesis from qualitative analysis. For the overall assessment, the probability of 9 positive studies out of 14 studies, with a probability of being positive ($p < 0.05$) for each study, is less than 0.000001. Thus, it would seem to be statistically conclusive in favor of acupuncture. Quantitative meta-analyses described later would provide further insight.

Acupuncture was compared with sham acupuncture in five studies[29,32,33,35,38]; three studies[29,35,38] produced positive results, whereas two[32,33] gave negative results. The inconsistent findings were rated as limited evidence in favor of acupuncture over sham acupuncture for neck pain treatment.

Some studies in the present review compared acupuncture with inactive treatment, which used inactivated devices in sham laser or sham TENS for modeling presumably the placebo effect. Among the four studies[26,27,34,37] using sham TENS as the control procedure, all but one[27] generated positive results. The inconsistent findings offered limited evidence in favor of acupuncture over sham TENS, but the evidence would have been rated strong if only high-quality studies[34,37] in this group had been considered. As for sham laser, two studies[30,31] used it as the control intervention; one[31] produced a positive result and the other[30] was negative. Both studies were conducted by Irnich and colleagues,

Table 2. Study Characteristics, Methods, and Results of Randomized Controlled Trials Concerning Acupuncture Treatment for Neck Pain

Study	*Design*	*Quality*	*Subjects*	*Acupuncture*	*Control*	*Rx N*	*Cx N*	*Outcome measures*[a]	*Results*
Coan et al. 1981[2]	RCT Parallel	3	Neck/root pain >6 mo	≥10 sessions 3–4/wks	Waiting list	15	15	Pain (numerical)	Rx > Cx
Petrie et al. 1983[26]	RCT Parallel	2	Neck pain >2 yrs	8 sessions over 4 wks	Sham TENS	7	6	Pain (descriptive)	Rx > Cx ($p < 0.01$)
Petrie et al. 1986[27]	RCT Parallel	2	Neck pain >6 mo	8 sessions over 4 wks	Sham TENS	13	12	Pain (VAS, MPQ)	Rx = Cx
David et al. 1998[28]	RCT Parallel	2	Neck pain >6 wks	6 session over 6 wks	Physical therapy	35	35	Pain (VAS) ROM	Rx = Cx
Birch et al. 1998[29]	RCT Parallel	3	Neck pain >6 mo	14 sessions over 12 wks	Sham acup., NSAIDs	15	16, 15	Pain (MPQ)	Rx > Cx ($p < 0.05$)
Irnich et al. 2001[30]	RCT Parallel	4	Neck pain >1 mo	5 sessions over 3 wks	Massage, Sham laser	56	60, 61	Pain (VAS) ROM	Rx > Cx1 ($p < 0.01$) Rx = Cx2
Irnich et al. 2002[31]	RCT Cross-over	5	Neck pain >2 mo	1 session	D.N., Sham laser	36	36	Pain (VAS) ROM	Rx > Cx1 Rx > Cx2 ($p < 0.01$)
Zhu et al. 2002[32]	RCT Cross-over	3	Neck pain >6 mo	9 sessions over 3 wks	Sham acup.	14	15	Pain (VAS) ROM, NDI	Rx = Cx
Nabeta et al. 2002[33]	RCT Parallel	4	Neck pain	3 sessions over 3 wks	Sham acup.	17	17	Pain (VAS)	Rx = Cx
White et al. 2004[34]	RCT Parallel	3	Neck pain >2 mo	8 sessions over 4 wks	Sham TENS	70	65	Pain (VAS), NDI	Rx > Cx ($p < 0.01$)
He et al. 2004[35]	RCT Parallel	4	Neck pain >3 mo	10 sessions 3–4 wks	Sham acup.	14	10	Pain (VAS, MPQ)	Rx > Cx ($p < 0.05$)
Witt et al. 2006[36]	RCT Parallel	3	Neck pain >6 mo	10 sessions over 3 mos	Routine care	1753	1698	Pain & Disability index	Rx > Cx ($p < 0.001$)
Vas et al. 2006[37]	RCT Parallel	4	Neck pain >3 mo	5 sessions over 3 wks	Sham TENS	61	62	Pain (VAS)	Rx > Cx ($p < 0.001$)
Itoh et al. 2007[38]	RCT Parallel	5	Neck pain >6 mo	6 sessions over 13 wks	Sham acup.	10	10	Pain (VAS), NDI	Rx > Cx ($p < 0.01$)

[a]Primary outcome measure.

Rx > Cx: The treatment is more effective than the control intervention.

Rx = Cx: No statistically significant difference between the treatment and control interventions.

RCT, randomized controlled trial; TENS, transcutaneous electrical nerve stimulation; acup., acupuncture; NSAIDs, nonsteroidal anti-inflammatory drugs; D.N., dry needling; VAS, visual analogue scale; MPQ, McGill pain questionnaire; ROM, range of motion; NDI, neck disability index.

but their earlier study[30] adopted the parallel design while later study[31] adopted the crossover design. The quality of both studies was scored high. This was contradictory evidence that acupuncture was superior to sham laser for neck pain treatment.

One study[30] compared acupuncture with massage and showed that acupuncture was significantly better than massage ($p < 0.01$). The evidence in this respect was limited[1] or moderate[7] since it was based on only one high-quality study. Acupuncture was also compared with physical therapy in one study,[28] which showed no differences between the two treatments. There was no evidence that acupuncture was more effective than physical therapy in the treatment of neck pain. Acupuncture was also compared with medication-alone therapy in one high-quality study,[29] which showed that acupuncture was significantly better than a nonsteroidal anti-inflammatory drug for pain control ($p < 0.05$). The level of evidence for this conclusion was limited[1] or moderate.[7]

A high-quality study[2] showed that acupuncture was more effective than a waiting-list control (i.e., patients in the control group were put on the waiting list without acupuncture). Another high-quality large-scale study[36] involving thousands of subjects demonstrated that acupuncture offered a significant improvement over the control of no treatment or conventional treatment (routine care) ($p < 0.001$).

In the present review, six studies[28,30,31,34,36,37] reported adverse effects associated with acupuncture treatment. The number of reported incidents ranged from none in two studies[28,31] to several in some other studies.[34,37] Two studies reported the rates of such incidents: 8.9%[36] and 33%.[30] No serious side-effects or complications were reported by any study. The data suggest that acupuncture is generally safe.

Quantitative data synthesis (meta-analysis)

Meta-analysis was performed only in the absence of statistically significant heterogeneity among studies that were selected for testing a specific clinical hypothesis. Heterogeneity was determined by the I^2 statistic. Pooling evidence was considered only for data with compatible formats (continuous versus dichotomous data). To minimize heterogeneity, studies with extreme effect size values (outliers) were removed in the meta-analysis. We performed nine meta-analyses under various objectives (Table 3), as described below.

The first meta-analysis addressed the short-term effectiveness of acupuncture on pain based on continuous data collected from five studies.[27,31–34] These studies showed that acupuncture offered more pain relief than the control intervention, but only one result[31] was statistically significant. Nonetheless, the pooled evidence was positive. The meta-analysis with a pooled SMD of −0.45 (95% CI, −0.69 to −0.22) (Fig. 2A-1) indicated that acupuncture was statistically significantly more effective than other sham interventions in pain relief for patients with neck pain. We also used a second set of subgroup data consisting of four studies[29,30,36,37] to conduct an analysis under the same objective. This subgroup used the data format based on the mean change in the pain index in contrast to the first subgroup that used the format based on the pre- and post-treatment means. The second subgroup had a large degree of heterogeneity among the studies, which undermined the feasibility for conducting a reliable meta-analysis (Fig. 2A-2). The second subgroup included a well-known large-scale clinical trial conducted by Witt et al.[36] Its extremely large sample size (>1000) relative to all other studies (<100) and small effect size variance may explain the significant heterogeneity in this subgroup.

The meta-analysis assessing the effectiveness of acupuncture on ROM was based on continuous data collected from two studies.[30,31] One (1) study showed that acupuncture improved ROM significantly better than massage, but there was no statistical difference between acupuncture and sham laser by the same measure[30] in contrast to significant difference in favor of acupuncture over sham laser in the other study.[31] The combined evidence with a pooled SMD of 0.42 (95% CI, 0.19–0.65) (Fig. 2B) supported the hypothesis that acupuncture is effective on ROM for patients with neck pain.

The meta-analysis concerned with the short-term effectiveness of acupuncture on disability was based on continuous data collected from two studies.[27,34] Both studies showed no significant difference between acupuncture and sham TENS for improving disability in patients with neck pain. The same conclusion was maintained by the meta-analysis with a pooled SMD of −0.15 (95% CI, −0.56 to 0.27) (Fig. 2C).

The meta-analysis assessing the long-term effectiveness of acupuncture on pain was based on continuous data collected from two studies,[34,37] although this was a secondary outcome measure in both studies. One study[37] showed that acupuncture reduced pain significantly better than sham TENS, but in the other study,[34] acupuncture had no significant advantage compared with the same control intervention. The meta-analysis with a pooled SMD of −0.30 (95% CI, −0.72 to 0.12) (Fig. 2D) found no statistically significant difference between acupuncture and sham TENS in long-term pain relief for patients with neck pain.

The next meta-analysis addressed the short-term effectiveness of acupuncture on pain, but unlike the first meta-analysis, it was based on dichotomous data, which were collected from two studies.[2,26] The results of both studies favored acupuncture over the control intervention for neck pain. The same conclusion was maintained by the meta-analysis with a pooled odds ratio of 26.3 (95% CI, 4.9–140.2) (Fig. 2E).

Of the 14 studies included in the present systematic review, radicular (nerve root) pain was explicitly mentioned in the inclusion criteria of only one study.[2] Literature search found two other RCTs[41,42] that examined the effectiveness of acupuncture for treatment of cervical radiculopathy, but these two studies were not included in the present systematic review because their full reports in English were not available. Therefore, only the data published in their abstracts were collected for this meta-analysis. All of the three studies reported that acupuncture was better than the control intervention (waiting list,[2] physical therapy,[42] or traction[41]) in terms of the rate of improvement. The meta-analysis with a pooled odds ration of 6.5 (95% CI, 2.6–16.6) (Fig. 2F) confirmed that acupuncture was statistically significantly effective for patients with cervical nerve root pain.

The data of the meta-analysis for comparing (true) acupuncture with sham acupuncture for pain relief were collected from three studies,[29,32,33] which used a placebo control intervention indistinguishable from acupuncture. In

Table 3. Objectives and Outcomes of Meta-Analyses and Associated Heterogeneity of the Studies

Meta-analysis	*Objective*	*Data format*	*Heterogeneity I^2 (p value)*	*Heterogeneity degree*	*Result (pooled evidence) statistical significance (p value)*
A-1	Acupuncture effect on pain relief (short-term)	Continuous	0.0 ($p = 0.53$)	Zero	Positive ($p = 0.00$)
A-2	Acupuncture effect on pain relief (short-term)	Continuous	99.9 ($p = 0.0$)	Large	Not determined
B	Acupuncture effect on ROM (short-term)	Continuous	0.0 ($p = 0.78$)	Zero	Positive ($p = 0.00$)
C	Acupuncture effect on disability (short-term)	Continuous	21.7 ($p = 0.26$)	Small	Negative ($p = 0.49$)
D	Acupuncture effect on pain relief (long-term)	Continuous	57.4 ($p = 0.13$)	Moderate	Negative ($p = 0.16$)
E	Acupuncture effect on pain relief (short-term)	Dichotomous	0 ($p = 0.98$)	Zero	Positive ($p = 0.00$)
F	Acupuncture effect on nerve root pain (radiculopathy)	Dichotomous	60.6 ($p = 0.08$)	Moderate	Positive ($p = 0.00$)
G	True vs. sham Acupuncture	Continuous	0.0 ($p = 0.73$)	Zero	Favor true acupuncture ($p = 0.01$)
H	Acupuncture vs. sham TENS	Continuous	0.0 ($p = 0.52$)	Zero	Favor acupuncture ($p = 0.046$)
I	Acupuncture vs. sham laser	Continuous	48.8 ($p = 0.16$)	Moderate	Favor acupuncture ($p = 0.019$)
J	Acupuncture effect on disability (long-term)	Continuous	99.8 ($p = 0.0$)	Large	Not determined

ROM, range of motion; TENS, transcutaneous electrical nerve stimulation.

these three studies, acupuncture had better average pain reduction than sham acupuncture, but the differences were not statistically significant. However, the meta-analysis with a pooled SMD of −0.53 (95% CI, −0.94 to −0.11) (Fig. 2G) found that acupuncture reduced more pain than sham acupuncture and the differences were statistically significant.

The meta-analysis for comparing acupuncture with sham TENS for pain reduction used the data collected from two studies.[27,34] In both studies, acupuncture reduced more pain than sham TENS, but the differences were not statistically significant. Despite this, the result of the meta-analysis with a pooled SMD of −0.32 (95% CI, −0.63 to −0.01) (Fig. 2H) showed significant differences in favor of acupuncture.

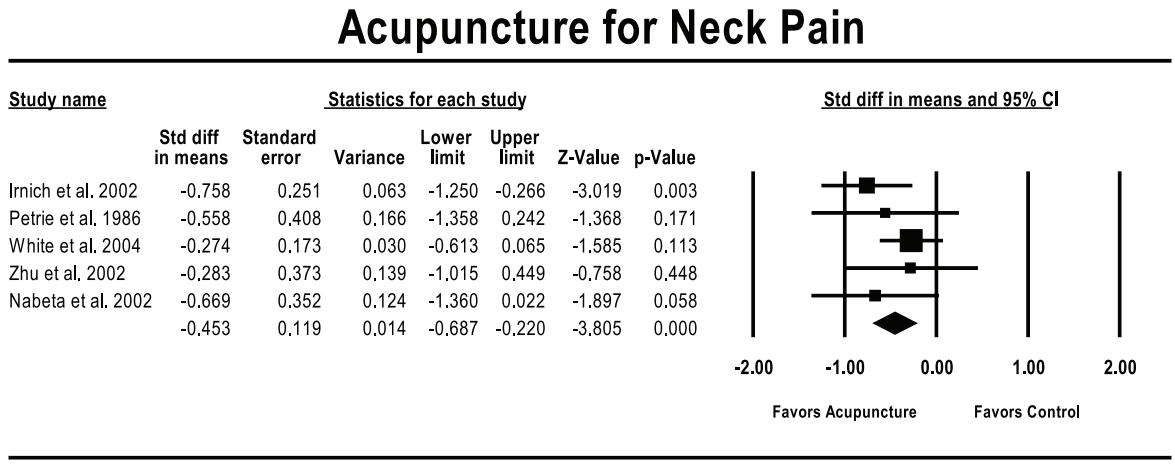
The data of the meta-analysis for comparing acupuncture with sham laser for pain reduction were collected from two studies.[30,31] One study[31] favored acupuncture over sham laser, whereas the other[30] found no statistically significant difference. The meta-analysis with a pooled SMD of −0.51 (95% CI, −0.93 to −0.08) (Fig. 2I) found that acupuncture reduced pain better than sham laser and the difference was statistically significant.

Discussion

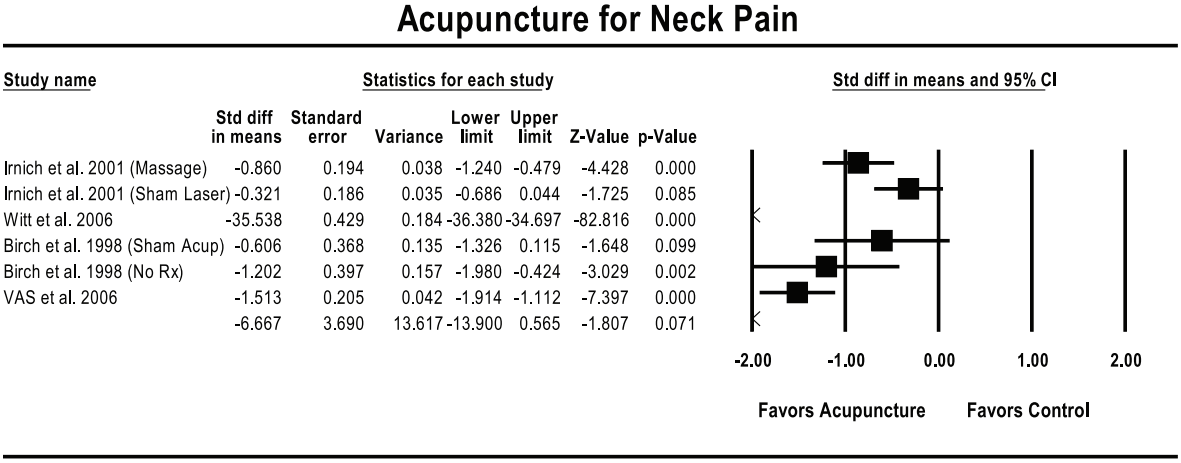
Out of the nine meta-analyses described above, seven meta-analyses yielded statistically significant results in favor of acupuncture for the treatment of neck pain. Of the two meta-analyses with negative results, one examined the short-term effectiveness of acupuncture on disability and the other the long-term effectiveness on pain.

Meta-analysis uses statistical techniques for analyzing results from different studies by providing a quantitative data synthesis to estimate the overall effect of a particular intervention on a defined outcome. It can allow more accurate data analysis than a qualitative or narrative synthesis and is a key element in many systematic reviews. However, meta-analysis is inappropriate in several situations, for example, when the primary studies are of poor quality, the effect size statistics cannot be computed, the research question is multivariate, or the studies are too heterogeneous.

It is still a very controversial issue as to what degree heterogeneity there should be that would preclude performing meta-analysis. Heterogeneity may appear in clinical settings (e.g., different types of neck pain, control interventions, outcome measures, etc.), methodological designs, data formats, or statistical properties. Clinical disparity will lead to statistical heterogeneity if the treatment effect is affected by the clinical factors that vary across studies. It can be argued that clinical diversity can be dealt with by meta-analysis using the random-effects model rather than taken as a basis for rejection, unless there is prior knowledge linking clinical differences to the treatment effect. Methodological heterogeneity can preclude meta-analysis in some circumstances, for example, when pooling data from RCTs and cohort studies. This is not an issue in the present review, as it only included RCTs. Heterogeneity in a meta-analysis is commonly assessed through a χ^2 test of homogeneity (I^2). However, there is a substantial overlap in I^2 values between systematic reviews that perform meta-analysis and those that do not.[43] We adopted a statistically justifiable rather than ad hoc approach so that meta-analysis was performed if there was no statistically significant heterogeneity based on the I^2 statistic among the studies collected under a particular objective.



A-1



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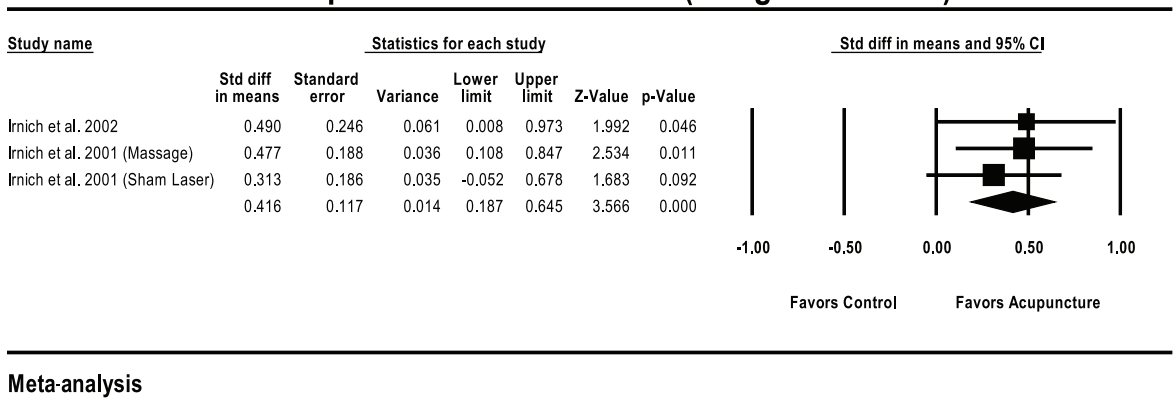
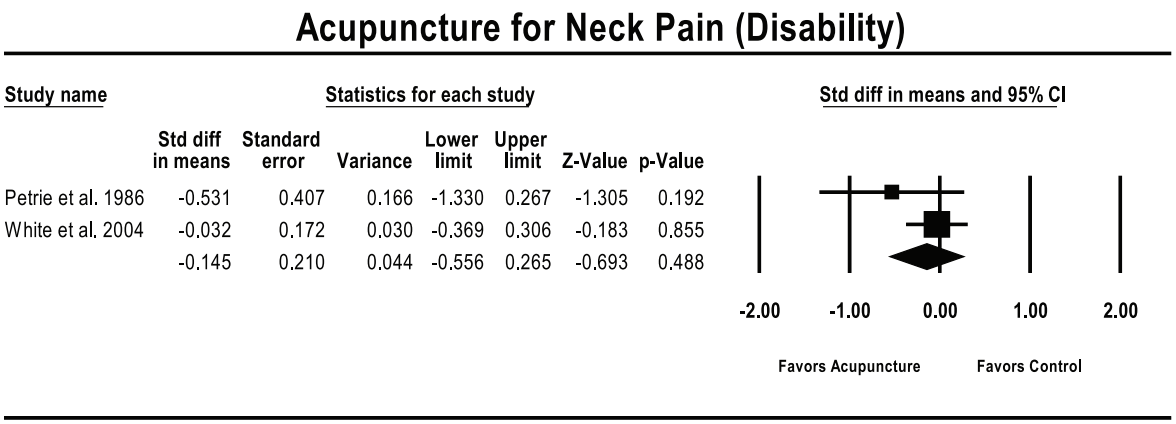
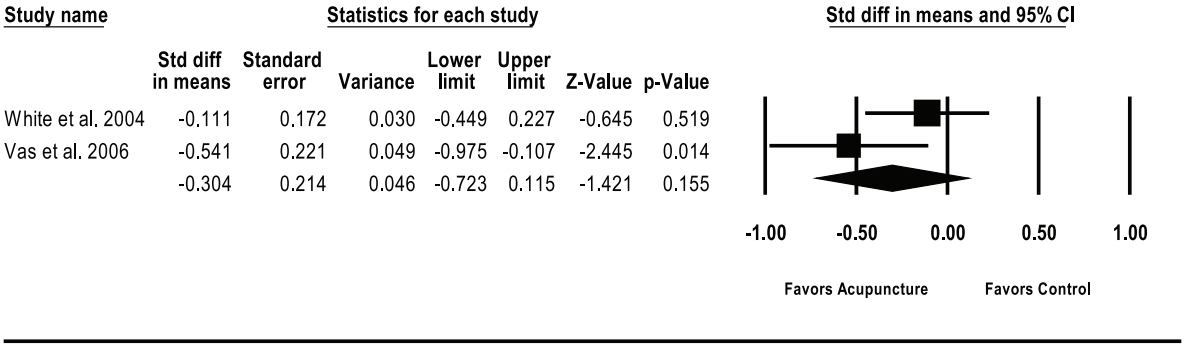


B

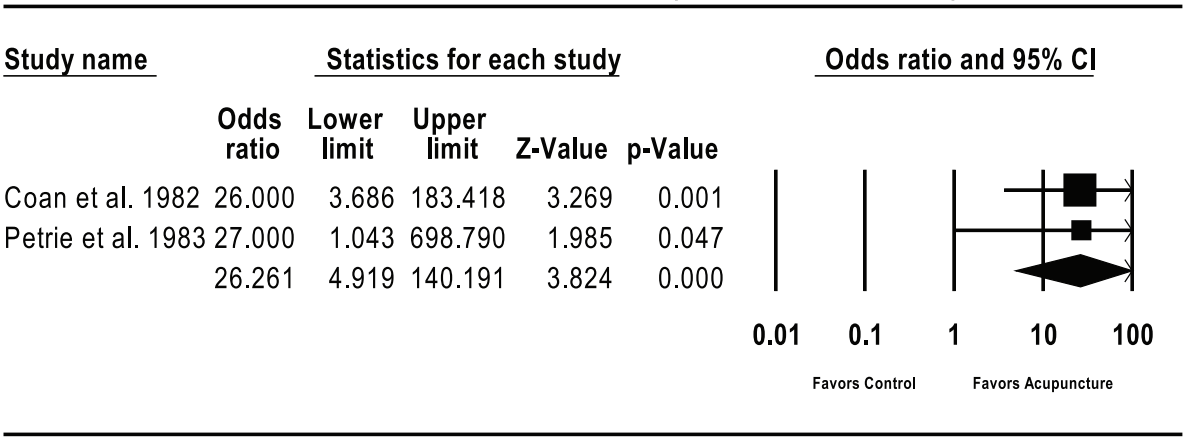
FIG. 2. (**A-1, A-2**) The short-term effect of acupuncture on pain based on continuous data. (**B**) The short-term effect of acupuncture on range of motion (ROM). (**C**) The short-term effect of acupuncture on disability. (**D**) The long-term effect of acupuncture on pain. (**E**) The short-term effect of acupuncture on pain based on dichotomous data. (**F**) The effect of acupuncture on cervical root pain. (**G**) Comparison of acupuncture with sham acupuncture for short-term pain reduction. (**H**) Comparison of acupuncture with sham transcutaneous electrical nerve stimulation (TENS) for short-term pain reduction. (**I**) Comparison of acupuncture with sham laser for short-term pain reduction. CI, confidence interval.



C



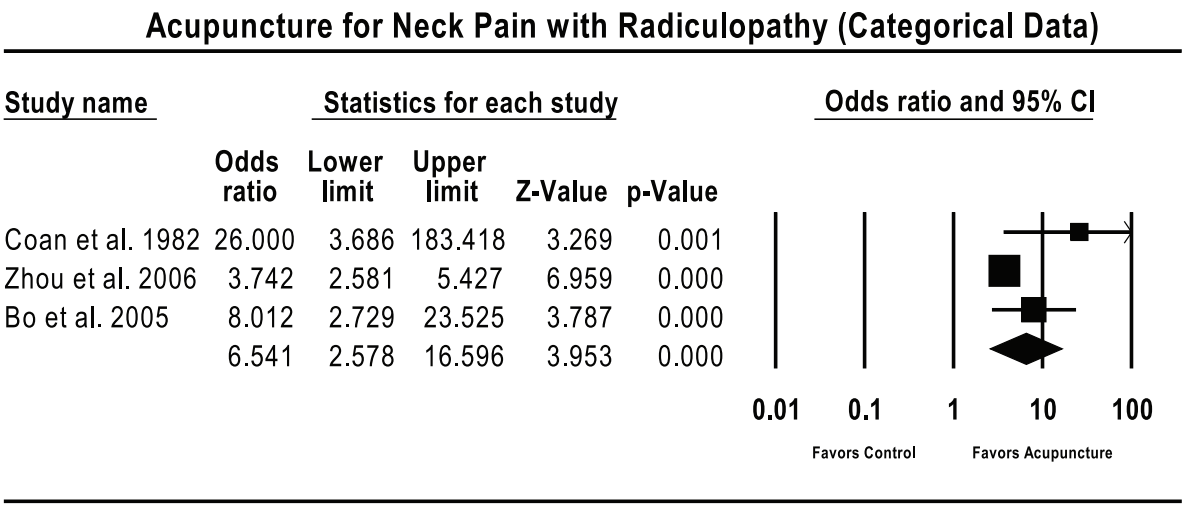
D



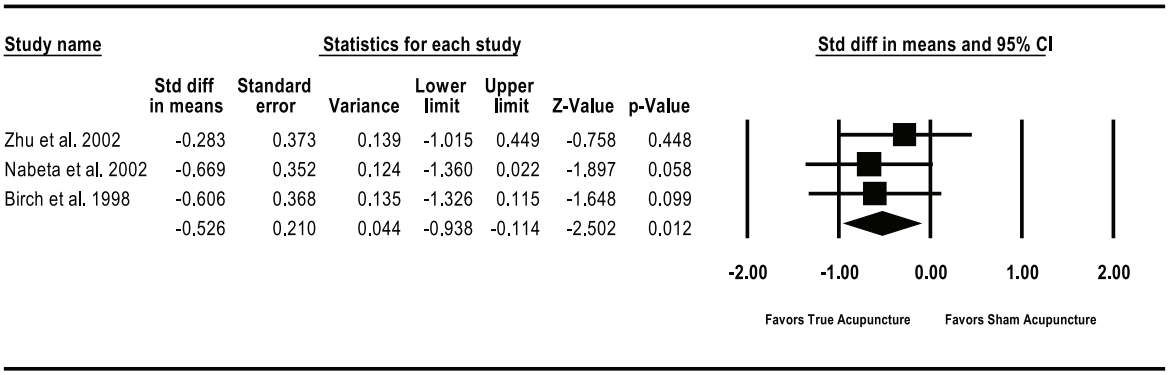
E

FIG. 2. *Continued.*

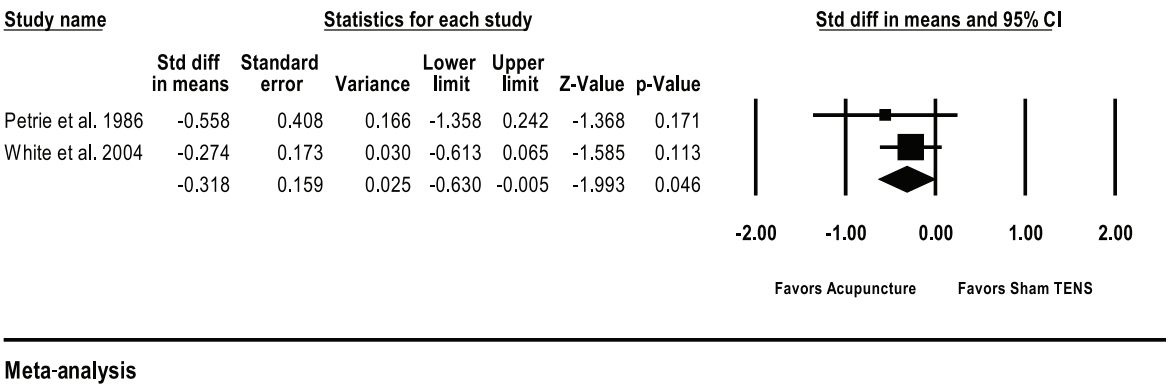
(*continued*)



F



G



H

FIG. 2. *Continued.*

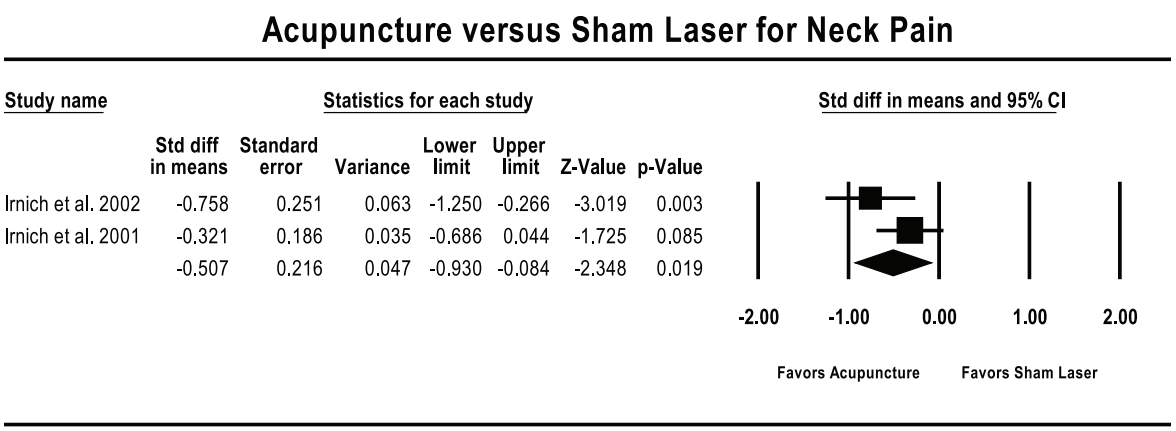


FIG. 2. *Continued.*

The 10 aspects defined for meta-analysis include treatment outcomes (pain, range of motion, and disability), a major complication (cervical radiculopathy), and sham control interventions commonly used in the studies of this review. Under the criteria defined, meta-analysis was performed on all subgroups of data, except the data associated with a high degree of heterogeneity.

The random-effects model addresses the heterogeneity of studies by taking into account the interstudy variation.[44] Heterogeneity is almost inevitable among studies conducted independently by different investigators at different geographical regions. Thus, it is a conservative strategy to use the random-effects model rather than the fixed-effects model when inherent heterogeneity is expected, even if there is no apparent statistical heterogeneity in the data. Meta-analysis performed under the random-effects model in the present review yielded results that were unbiased and provided an accurate estimate of the effects concerned, and hence the results are internally valid. Combining data from different studies on different populations makes the results generalizable to regular clinical practice, and hence the results are also externally valid.

The previous systematic review conducted by White and Ernst found that the studies included in the review were too heterogeneous and the results could not be combined in a meta-analysis.[3] This observation was true in our review if we considered the studies all together. However, by selecting studies according to specific data formats, control interventions, outcome measures, or etiologies, we were able to conduct meta-analysis in the absence of statistically significant heterogeneity in several circumstances. Among the meta-analyses conducted in the present review, five analyses had zero degree of heterogeneity, one had a small degree, and three had a moderate degree of heterogeneity (Table 3). In contrast, the systematic review conducted by Trinh et al.[4] performed only a single meta-analysis with zero degree of heterogeneity, which dealt with the comparison of acupuncture with inactive treatment for neck pain.

In the present study, each meta-analysis was based on a subgroup of data selected according to a particular predefined objective. As multiple subgroup analyses touch upon the issue of multiple testing, the significance of the results must be examined with caution. The effects to be tested should be determined before the data are analyzed so that bias toward a particular outcome can be minimized.[45] This rule of guidance has been adopted in the present study. A technique for dealing with the issue of multiple testing is to adjust the p value according to the number of analyses.[45] For instance, the result is considered statistically significant at a level of significance of 0.05 if the associated chance probability is less than 0.005 after the adjustment for the multiplicity effect due to nine analyses. With such adjustment, four analyses remain statistically significant in favor of acupuncture. However, since each meta-analysis is treated as independent of one another, the applicability of the above p value adjustment is questionable. Besides, such an adjustment was not used in other reviews where multiple meta-analyses were performed.[46]

The earliest systematic review of acupuncture for neck pain conducted by White and Ernst[3] included 14 studies. The second review on the same subject matter done by Trinh et al.[4] included 10 studies. In terms of study selection, the present review is closer to the second review. Our review included eight studies[2,26–31,34] of the Trinh review and six additional studies[32,33,35–38] that had not been selected in previous reviews. Two (2) studies of the Trinh review were not included in ours because one[23] was not based on the randomization principle, and the other[24] compared different sets of acupuncture points. Among the studies of the White and Ernst review, six were included in the Trinh review and five in our review. Studies published in German of the White and Ernst review were not selected by the other two reviews.

Conclusions

Neck pain has caused substantial morbidity and become a considerable socioeconomic burden. Acupuncture has drawn increasing interest as a modality for neck pain treatment. In this review, meta-analyses were performed for assessing the effectiveness of acupuncture on neck pain. Seven (7) out of the nine meta-analyses conducted yielded positive results, in particular, the analysis concerned with the pri-

mary outcome of short-term pain reduction and the comparison of real acupuncture with sham acupuncture, which represents the most rigorous control for acupuncture validation. However, the effect of acupuncture on disability and long-term pain relief for patients with neck pain was not proven. More high-quality RCTs that address the long-term efficacy of acupuncture for pain relief and functional improvement are warranted for further understanding the strength and limitation of this practice.

Disclosure Statement

The authors state that no competing financial interests exist.

References

1. van Tulder MW, Goossens M, Hoving J. Nonsurgical treatment of chronic neck pain. In: Nachemson A, Jonsson E, eds. Neck and Back Pain. Philadelphia: Lippincott Williams & Wilkins, 2000.
2. Coan RM, Wong G, Coan PL. The acupuncture treatment of neck pain: A randomized controlled study. Am J Chin Med 1981;9:326–332.
3. White AR, Ernst E. A systematic review of randomized controlled trials of acupuncture for neck pain. Rheumatology (Oxford) 1999;38:143–147.
4. Trinh K, Graham N, Gross A, et al. Acupuncture for neck disorders. Spine 2007;32:236–243.
5. Trinh KV, Graham N, Gross AR, et al. Acupuncture for neck disorders. Cochrane Database Syst Rev 2006;3:CD004870.
6. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized clinical trials: Is blinding necessary? Control Clin Trials 1996;17:1–12.
7. van Tulder M, Furlan A, Bombardier C, Bouter L. Updated method guidelines for systematic reviews in the Cochrane collaboration back review group. Spine 2003;28:1290–1299.
8. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003;327:557–560.
9. Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions. Chichester, UK: John Wiley & Sons, 2006.
10. Moher D, Cook DJ, Eastwood S, et al. Improving the quality of reports of meta-analyses of randomised controlled trials: The QUOROM statement. Quality of Reporting of Meta-analyses. Lancet 1999;354:1896–1900.
11. Zhuang L. Twenty one cases of vertebral-artery-type cervical spondylosis treated with acupuncture and moxibustion. J Tradit Chin Med 2000;20:280–281.
12. Kung YY, Chen FP, Chaung HL, et al. Evaluation of acupuncture effect to chronic myofascial pain syndrome in the cervical and upper back regions by the concept of Meridians. Acupunct Electrother Res 2001;26:195–202.
13. König A, Radke S, Molzen H, et al. Randomised trial of acupuncture compared with conventional massage and "sham" laser acupuncture for treatment of chronic neck pain–range of motion analysis. Z Orthop Ihre Grenzgeb 2003;141:395–400.
14. Sator-Katzenschlager SM, Szeles JC, Scharbert G, et al. Electrical stimulation of auricular acupuncture points is more effective than conventional manual auricular acupuncture in chronic cervical pain: A pilot study. Anesth Analg 2003;97:1469–1473.
15. Blossfeldt P. Acupuncture for chronic neck pain: A cohort study in an NHS pain clinic. Acupunct Med 2004;22:146–151.
16. He D, Hostmark AT, Veiersted KB, Medbo JI. Effect of intensive acupuncture on pain-related social and psychological variables for women with chronic neck and shoulder pain: An RCT with six month and three year follow up. Acupunct Med 2005;23:52–61.
17. Ceccherelli F, Tortora P, Nassimbeni C, et al. The therapeutic efficacy of somatic acupuncture is not increased by auriculotherapy: A randomised, blind control study in cervical myofascial pain. Complement Ther Med 2006;14:47–52.
18. Willich SN, Reinhold T, Selim D, et al. Cost-effectiveness of acupuncture treatment in patients with chronic neck pain. Pain 2006;125:107–113.
19. Liu YZ. Treatment of cervical spondylosis of vertebroarterial type with acupuncture regulating the governor vessel. Chinese Acupuncture and Moxibustion [Zhongguo Zhen Jiu] 2007;27:255–257.
20. Jia CS, Shi J, Ma XS, et al. Comparison of the analgesic effect of acupuncture between otopoint-penetrative needling and otopoint-straight needling for cervical type and nerve-root type cervicospondylopathy. Acupuncture Research [Zhen Ci Yan Jiu] 2007;32:186–189.
21. Guo YQ, Chen LY, Fu WB, et al. Clinically randomized controlled study on abdominal acupuncture for treatment of cervical spondylosis. Chinese Acupuncture and Moxibustion [Zhongguo Zhen Jiu] 2007;27:652–656.
22. Wang ZL, Chen LF, Zhu WM. Observation on the transient analgesic effect of abdominal acupuncture TENS on pain of neck, shoulder, loin and legs. Chinese Acupuncture and Moxibustion [Zhongguo Zhen Jiu] 2007;27:657–659.
23. Loy TT. Treatment of cervical spondylosis. Electroacupuncture versus physiotherapy. Med J Aust 1983;2:32–34.
24. White PF, Craig WF, Vakharia AS, et al. Percutaneous neuromodulation therapy: Does the location of electrical stimulation effect the acute analgesic response? Anesth Analg 2000;91:949–954.
25. Kreczi T, Klingler D. A comparison of laser acupuncture versus placebo in radicular and pseudoradicular pain syndromes as recorded by subjective responses of patients. Acupunct Electrother Res 1986;11:207–216.
26. Petrie JP, Langley GB. Acupuncture in the treatment of chronic cervical pain: A pilot study. Clin Exp Rheumatol 1983;1:333–336.
27. Petrie JP, Hazleman BL. A controlled study of acupuncture in neck pain. Br J Rheumatol 1986;25:271–275.
28. David J, Modi S, Aluko AA, et al. Chronic neck pain: A comparison of acupuncture treatment and physiotherapy. Br J Rheumatol 1998;37:1118–1122.
29. Birch S, Jamison RN. Controlled trial of Japanese acupuncture for chronic myofascial neck pain: Assessment of specific and nonspecific effects of treatment. Clin J Pain 1998;14:248–255.
30. Irnich D, Behrens N, Molzen H, et al. Randomised trial of acupuncture compared with conventional massage and "sham" laser acupuncture for treatment of chronic neck pain. BMJ 2001;322:1574–1578.
31. Irnich D, Behrens N, Gleditsch JM, et al. Immediate effects of dry needling and acupuncture at distant points in chronic neck pain: Results of a randomized, double-blind, sham-controlled crossover trial. Pain 2002;99:83–89.
32. Zhu XM, Polus B. A controlled trial on acupuncture for chronic neck pain. Am J Chin Med 2002;30:13–28.
33. Nabeta T, Kawakita K. Relief of chronic neck and shoulder pain by manual acupuncture to tender points: A sham-controlled randomized trial. Complement Ther Med 2002;10:217–222.

34. White P, Lewith G, Prescott P, Conway J. Acupuncture versus placebo for the treatment of chronic mechanical neck pain: A randomized, controlled trial. Ann Intern Med 2004;141:911–919.
35. He D, Veiersted KB, Hostmark AT, Medbo JI. Effect of acupuncture treatment on chronic neck and shoulder pain in sedentary female workers: A 6-month and 3-year follow-up study. Pain 2004;109:299–307.
36. Witt CM, Jena S, Brinkhaus B, et al. Acupuncture for patients with chronic neck pain. Pain 2006;125:98–106.
37. Vas J, Perea-Milla E, Mendez C, et al. Efficacy and safety of acupuncture for chronic uncomplicated neck pain: A randomised controlled study. Pain 2006;126:245–255.
38. Itoh K, Katsumi Y, Hirota S, Kitakoji H. Randomised trial of trigger point acupuncture compared with other acupuncture for treatment of chronic neck pain. Complement Ther Med 2007;15:172–179.
39. Cheng X. Chinese Acupuncture and Moxibustion. Beijing: Foreign Language Press, 2004.
40. Ezzo J, Berman B, Hadhazy VA, et al. Is acupuncture effective for the treatment of chronic pain? A systematic review. Pain 2000;86:217–225.
41. Bo ZY, Niu QQ, Zhu WG, et al. Multicenter controlled study on abdominal acupuncture for treatment of nerve root type cervical spondylosis. Chinese Acupuncture and Moxibustion [Zhongguo Zhen Jiu] 2005;25:387–389.
42. Zhou JW, Jiang ZY, Ye RB, et al. Controlled study on treatment of cervical spondylopathy of the nerve root type with acupuncture, moxibustion and massage as main. Chinese Acupuncture and Moxibustion [Zhongguo Zhen Jiu] 2006;26: 537–543.
43. Rothstein H. Should We Perform a Meta-analysis? Englewood, NJ: Biostat Inc., 2008.
44. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials 1986;7:177–188.
45. Walker E, Hernandez AV, Kattan MW. Meta-analysis: Its strengths and limitations. Cleve Clin J Med 2008;75:431–439.
46. Manheimer E, White A, Berman B, et al. Meta-analysis: Acupuncture for low back pain. Ann Intern Med 2005; 142:651–663.

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