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Clinical Study

Spinal manipulation and perineural electrical dry needling in patients with cervicogenic headache: a multicenter randomized clinical trial

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Abstract

BACKGROUND CONTEXT: Spinal manipulation, spinal mobilization, and exercise are commonly used in individuals with cervicogenic headache (CH). Dry needling is being increasingly used in the management of CH. However, questions remain about the effectiveness of these therapies and how they compare to each other.

PURPOSE: The present study aims to compare the combined effects of spinal manipulation and dry needling with spinal mobilization and exercise on pain and disability in individuals with CH.

STUDY DESIGN/SETTING: Randomized, multicenter, parallel-group trial.

PATIENT SAMPLE: One hundred forty-two patients (n=142) with CH from 13 outpatient clinics in 10 different states were recruited over a 36-month period.

OUTCOME MEASURES: The primary outcome was headache intensity as measured by the Numeric Pain Rating Scale. Secondary outcomes included headache frequency and duration, disability (Neck Disability Index), medication intake, and the Global Rating of Change (GROC). Follow-up assessments were taken at 1 week, 4 weeks, and 3 months.

METHODS: Patients were randomized to receive upper cervical and upper thoracic spinal manipulation plus electrical dry needling (n=74) or upper cervical and upper thoracic spinal mobilization and exercise (n=68). In addition, the mobilization group also received a program of craniocervical and peri-scapular resistance exercises; whereas, the spinal manipulation group also received up to eight sessions of perineural electrical dry needling. The treatment period for both groups was 4 weeks. The trial was prospectively registered at ClinicalTrials.gov (NCT02373605). Drs Dunning, Butts and Young are faculty within the AAMT Fellowship and teach postgraduate courses in spinal manipulation, spinal mobilization, dry needling, exercise and differential diagnosis. The other authors declare no conflicts of interest. None of the authors received any funding for this study.

FDA device/drug status: Approved (ITO ES-160 Electro-Acupuncture Device).

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RESULTS: The 2 × 4 analysis of covariance revealed that individuals with CH who received thrust spinal manipulation and electrical dry needling experienced significantly greater reductions in headache intensity (F=23.464; p<.001), headache frequency (F=13.407; p<.001), and disability (F=10.702; p<.001) than those who received nonthrust mobilization and exercise at a 3-month follow-up. Individuals in the spinal manipulation and electrical dry needling group also experienced shorter duration of headaches (p<.001) at 3 months. Based on the cutoff score of ≥+5 on the GROC, significantly (X^2=54.840; p<.001) more patients (n=57, 77%) within the spinal manipulation and electrical dry needling group achieved a successful outcome compared to the mobilization and exercise group (n=10, 15%) at 3-month follow-up. Between-groups effect sizes were large (0.94<standardized mean score difference<1.25) in all outcomes in favor of the spinal manipulation and electrical dry needling group at 3 months. In addition, significantly (X^2=29.889; p<.001) more patients in the spinal manipulation and electrical dry needling group (n=49, 66%) completely stopped taking medication for their pain compared to the spinal mobilization and exercise group (n=14, 21%) at 3 months.

CONCLUSION: Upper cervical and upper thoracic high-velocity low-amplitude thrust spinal manipulation and electrical dry needling were shown to be more effective than nonthrust mobilization and exercise in patients with CH, and the effects were maintained at 3 months.

Keywords: Acupuncture; Cervicogenic headache; Dry needling; Exercise; Spinal manipulation

Introduction

The International Classification of Headache Disorders defines cervicogenic headache (CH) as, “headache caused by a disorder of the cervical spine and its component bony, disc, and/or soft tissue elements, usually but not invariably accompanied by neck pain” [1]. The prevalence of CH has been reported to be between 0.4% and 20% of the headache population [2,3], and as high as 53% in patients with headache after whiplash injury [4]. The dominant features of CH usually include: unilaterality of head pain without side-shift, elicitation of pain with external pressure over the ipsilateral upper neck, limited cervical range of motion, and the triggering of attacks by various awkward or sustained neck movements [4,5].

Individuals with CH are frequently treated with manual therapies including both nonthrust mobilization and thrust manipulation [6]. Spinal mobilization consists of slow, rhythmical, oscillating techniques whereas manipulation consists of high-velocity low-amplitude thrust techniques [7]. Several studies have investigated the effect of spinal manipulation and/or mobilization in the management of CH [8–12]. The systematic review by Bronfort et al. reported that spinal manipulative therapy (both mobilization and manipulation) were effective in the management of CH [13]. However, they did not report if manipulation resulted in superior outcomes compared to mobilization for the management of this population. A more recent multicenter clinical trial found upper cervical and upper thoracic thrust manipulation to be more effective than nonthrust mobilization and exercise in patients with CH [14].

While some studies have endorsed acupuncture as part of a cost effective [15,16], multimodal approach [17,18] for chronic daily headaches, most clinical practice guidelines on the use of acupuncture for migraines [19], tension-type headaches [20], and CH [20] remain inconclusive. A recent systematic review [21] and several Cochrane reviews [22–25] concluded there is low-to-moderate quality evidence that acupuncture provides meaningful reductions in the frequency of migraine and tension-type headache. Furthermore, an overview of Cochrane reviews found acupuncture to be an evidence-based treatment strategy for tension-type headache, migraine, neck pain, and joint osteoarthritis [26]. Nevertheless, another systematic review found inconclusive evidence to strongly support the use of dry needling (not acupuncture) in the management of tension-type headache or CH [27].

It is important to understand that patients with CH usually require multimodal treatment [10,17]. No previous studies have directly compared the combined effects of manual therapies such as thrust spinal manipulation and dry needling versus nonthrust spinal mobilization and exercise in patients with CH. Therefore, the purpose of this randomized clinical trial was to compare the effects of thrust spinal manipulation and electrical dry needling versus nonthrust spinal mobilization and exercise in patients with CH. We hypothesized that patients receiving spinal manipulation and electrical dry needling would experience greater improvements in all outcomes than patients receiving cervical and thoracic nonthrust mobilization combined with exercise.

Methods

Study design

This randomized, single-blinded, multicenter, parallel-group trial compared two treatment protocols for the management of CH: thrust spinal manipulation and dry needling

versus nonthrust spinal mobilization and exercise. The primary end-point was headache intensity as measured by the Numeric Pain Rating Scale (NPRS). Secondary outcomes included headache frequency and duration, disability as measured by the Neck Disability Index (NDI), medication intake (the number of times the patient had taken prescription or over-the-counter analgesic or anti-inflammatory medication for their headaches during the past week), and the Global Rating of Change (GROC).

The current clinical trial was conducted following the Consolidated Standards of Reporting Trials extension for pragmatic clinical trials [28]. The study was approved by the ethics committee at Universidad Rey Juan Carlos, Madrid, Spain (URJC-DPTO 31-2014) and the trial was prospectively registered (ClinicalTrials.gov: NCT02373605).

Participants

Consecutive individuals with CH from 13 outpatient physical therapy clinics in 10 different states (Alabama, Arizona, Arkansas, Colorado, Michigan, Montana, New York, North Carolina, South Carolina, Texas) were screened for eligibility criteria and recruited over a 36-month period (from February 10, 2015 to February 15, 2018). For patients to be eligible, they had to present with a diagnosis of CH according to the revised diagnostic criteria [5] developed by the Cervicogenic Headache International Study Group [5,29,30]. CH was classified according to the "major criteria" (not including confirmatory evidence by diagnostic anesthetic blockades) and "head pain characteristics" recommended by the Cervicogenic Headache International Study Group. Therefore, in order to be included in the study, patients had to exhibit: (1) unilaterality of the head pain without side-shift, starting in the upper posterior neck or occipital region, eventually spreading to the oculofrontotemporal area on the symptomatic side; (2) pain triggered by neck movement and/or sustained awkward positions; (3) reduced range of motion in the cervical spine [31] (ie, less than or equal to 32 degrees of right or left passive rotation on the Flexion-Rotation Test [32–34]; (4) pain elicited by external pressure over at least one of the upper cervical joints (C0-3); and (5) moderate to severe, nonthrobbing and nonlancinating pain.

Patients were excluded if they: (1) exhibited other primary headaches (ie, migraine, tension-type headache); (2) suffered from bilateral headaches; (3) exhibited any red flag (ie, tumor, fracture, metabolic diseases, rheumatoid arthritis, osteoporosis, resting blood pressure greater than 140/90 mm Hg, prolonged history of steroid use, etc.); (4) presented with two or more positive neurologic signs consistent with nerve root compression; (5) presented with a diagnosis of cervical spinal stenosis; (6) exhibited bilateral upper extremity symptoms; (7) had evidence of central nervous system involvement; (8) had a history of whiplash injury; (9) had prior surgery to the head or neck; (10) had received treatment for head or neck pain within the previous 3 months; or (11) had pending legal action regarding their symptoms. Patients were also excluded if they were pregnant.

The most recent literature suggests that premanipulative cervical artery testing is unable to identify those individuals at risk of vascular complications from cervical manipulation [35,36], and any symptoms detected during premanipulative testing may be unrelated to changes in blood flow in the vertebral artery [37,38]. Hence, premanipulative cervical artery testing was not performed in this study; however, screening questions for cervical artery disease had to be negative [35,39,40]. All participants signed an informed consent prior to their participation in the study.

Treating therapists

Thirteen physical therapists (mean age, 41.8 years, standard deviation 8.9) participated in treatment for patients in this study. They had an average of 15.2 (standard deviation 10.8) years of clinical experience, and all had completed the same 54-hour postgraduate certification program that included practical training in electrical dry needling for CH and the same 60-hour postgraduate certificate program that included practical training in nonthrust and thrust spinal manipulation techniques to the cervical and thoracic spine. In addition, all physical therapists delivering treatment were Fellows-in-Training within the APTA-accredited American Academy of Manipulative Therapy Fellowship in Orthopaedic Manual Physical Therapy postgraduate program and, therefore, received advanced clinical training in the diagnosis and treatment of CH. All participating therapists were required to study a manual of standard operating procedures and participate in a 6-hour training session with the principal investigator to ensure the standardization of the protocol and treatment.

Randomization and blinding

Following baseline examination, patients were randomly assigned to receive spinal manipulation and dry needling or spinal mobilization and exercise. Similar to our previous trials [14,41,42], concealed allocation was conducted using a computer-generated randomized table of numbers created by a statistician who was not otherwise involved in the trial and did not participate in analysis or interpretation of the results. Individual and sequentially numbered index cards with the random assignment were prepared for each of the 13 data collection sites. The index cards were folded and placed in sealed opaque envelopes. Blinded to the baseline examination, the treating therapist opened the envelope and proceeded with treatment according to the group assignment. Patients were instructed not to discuss the particular treatment procedure received with the examining clinician. The examining clinician remained blinded to the patient's treatment group assignment at all times; however, based on the nature of the interventions it was not possible to blind patients or treating therapists.

Interventions

All participants received up to eight treatment sessions at a frequency of once or twice per week over a 4-week period. Both groups received an impairment-based manual therapy approach using either high-velocity low-amplitude thrust manipulation or nonthrust mobilization directed primarily to the upper cervical (C1–2) and upper thoracic (T1–2) articulations as described in our previous trial [14]. Details regarding the thrust spinal manipulation and nonthrust spinal mobilization procedures are provided in Appendix 1.

The nonthrust mobilization group also received a program of craniocervical flexion exercises [43–45] and periscapular progressive resistance exercises [10] that were taught to the patient by an experienced physiotherapist on the first treatment session and supervised on subsequent sessions. Exercises were gradually progressed according to tolerance of each individual patient. That is, progression only occurred if the patient reported a decrease in symptoms and in the absence of excessive soreness, defined as soreness lasting longer than a few hours post-treatment. Specific details regarding the exercise program are also provided in Appendix 1.

The thrust spinal manipulation group also received up to eight sessions of electrical dry needling for 20-minute durations at a frequency of 1 to 2 times per week for 4 weeks using a semistandardized protocol of 8 to 12 needles that included 6 to 8 occipito-cervical points, 1 distal point in the ipsilateral hand and up to 5 oculofrontotemporal points—based on the presence of trigger points or the report of sensitivity or pain by the patient in that region—as depicted in Fig. 1. Additionally, placement of up to four needles in the upper thoracic (T1–3) paraspinal region was optional. Each needle insertion site, angulation, and anatomical target is summarized in Appendix 1. Within both groups, fewer treatment sessions could be delivered by the treating therapist if symptom resolution occurred sooner.

Sterilized disposable stainless-steel acupuncture needles were used with three sizes: 0.18 mm x 15 mm, 0.25 mm x 30 mm, 0.30 mm x 40 mm. The surface of the oculofrontotemporal region, posteroinferior occiput, posterolateral upper cervical region, and posterior upper thoracic spine were cleaned with alcohol. The depth of needle insertion ranged from 10 mm to 30 mm depending on the point selected (intramuscular, periosteal, perineural) and the patient's constitution (ie, size and bone depth, muscle and/or connective tissue thickness). Following insertion, needles were manipulated bidirectionally to elicit a sensation of aching, tingling, deep pressure, heaviness or warmth [46–49]. The needles were then left in situ for 20 minutes [50] with electric stimulation (ES-160 electrostimulator ITO co.) in pairs to up to eight of the occipito-cervical and upper thoracic needles using a low frequency (2 Hz), moderate pulse duration (250 μs), biphasic continuous waveform at an intensity described by the patient as "mild to moderate" [50,51].

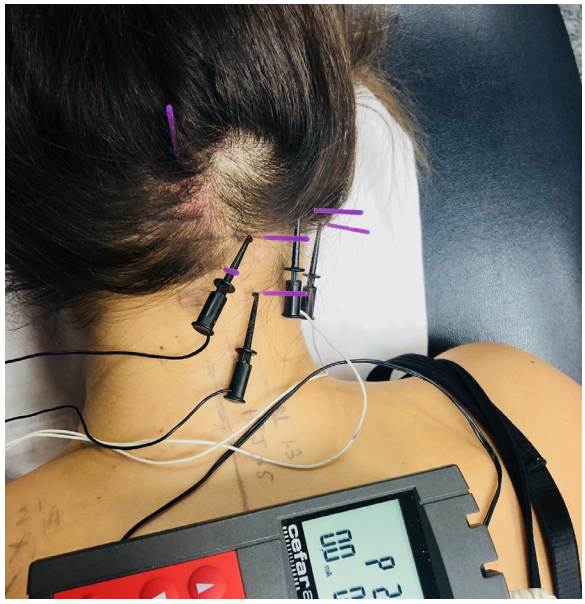

Fig. 1. Semistandardized protocol of 8 to 12 needles of electrical dry needling for cervicogenic headache.

Outcome measures

Among all outcomes included in the clinical trial registry, the primary outcome of the current trial was headache intensity [14] as measured by the NPRS. Patients were asked to indicate the average intensity of headache pain over the past week using an 11-point scale ranging from 0 ("no pain") to 10 ("worst pain imaginable") at baseline, 1 week, 4 weeks, and 3 months following the initial treatment session [52]. The NPRS is a reliable and valid instrument to assess pain intensity [53–55]. The minimal clinically important difference (MCID) for the NPRS has been shown to be 2.5 in patients with CH [56].

Secondary outcomes included the NDI, the GROC, headache frequency, and headache duration at baseline, 1 week, 4 weeks, and 3 months after the initial treatment. The NDI is the most widely used instrument for assessing self-rated disability in patients with neck pain [57–59]. The NDI is a self-report questionnaire with 10 items rated from 0 (no disability) to 5 (complete disability) [60]. The numeric responses for each item are summed for a total score ranging between 0 and 50; however, some evaluators have chosen to multiply the raw score by 2, and then report the NDI on a 0% to 100% scale [58,61]. Higher scores represent increased levels of disability. The NDI has been found to possess excellent test-retest reliability, strong construct validity, strong internal consistency, and good responsiveness in assessing disability in patients with CH [56]. The MCID for the NDI has been reported to be 7.5 in patients with CH [56].

Headache frequency was measured as the number of days with headache in the last week, ranging from 0 to 7 days. Headache duration was measured as the total hours

of headache in the last week, with six possible ranges: (1) 0 to 5 hours, (2) 6 to 10 hours, (3) 11 to 15 hours, (4) 16 to 20 hours, (5) 21 to 25 hours, or (6) 26 or more hours.

Medication intake was measured as the number of times the patient had taken prescription or over-the-counter analgesic or anti-inflammatory medication in the past week for their headaches, with five options: (1) not at all, (2) once a week, (3) once every couple of days, (4) once or twice a day, or (5) three or more times a day. Medication intake was assessed at baseline and at 3 months after the first treatment session.

In addition, 1 week, 4 weeks, and 3 months following the initial treatment session, patients completed a 15-point GROC question based on a scale described by Jaeschke et al. [62]. The scale ranges from −7 (a very great deal worse) to 0 (about the same) to +7 (a very great deal better). Intermittent descriptors of worsening or improving are assigned values from −1 to −6 and +1 to +6, respectively. Scores of +4 and +5 have typically been indicative of moderate changes in patient status [62].

Treatment side effects

Patients were asked to report adverse events that they experienced during any part of the study. In the current study, an adverse event was defined as a sequelae of 1-week duration with any symptom perceived as distressing and unacceptable to the patient that required further treatment [63]. Particular attention was given to the presence of ecchymosis and postneedling soreness within the group receiving dry needling.

Sample size determination

The sample size calculations were based on detecting between-groups moderate effect sizes of 0.575 on the main outcome (headache intensity) at 3-month follow-up period, a two-tailed test, an alpha level (α) of 0.05 and a desired power (β) of 90%. The estimated desired sample size was calculated to be at least 65 subjects per group. A dropout percentage of 10% was expected, so 70 patients were included in each group.

Statistical analysis

Statistical analysis was performed using SPSS software, version 26.0 (Chicago, IL, USA), and it was conducted according to intention-to-treat analysis for patients in the group to which they were first allocated. Mean, standard deviations, and/or 95% confidence intervals (CI) were calculated for each variable. The Kolmogorov-Smirnov test revealed a normal distribution of the variables (p>.05). Baseline demographic and clinical variables were compared between both groups using independent Student t-tests for continuous data and chi-square tests of independence for categorical data.

The effects of treatment on headache intensity, headache frequency, and disability were each examined with a 2-by-4 mixed model analysis of covariance (ANCOVA) with treatment group (thrust spinal manipulation and dry needling vs nonthrust spinal mobilization and exercise) as the between-subjects factor and time (baseline, 1-week, 4-week, and 3-month follow-up) as the within-subjects factor, and adjusted for baseline data for evaluating between-groups differences. Separate ANCOVAs were performed with headache intensity (NPRS), headache frequency and disability (NDI) as the dependent variable. For each ANCOVA, the main hypothesis of interest was the two-way interaction (group by time) with a Bonferroni-corrected alpha of 0.0125 (four-time points). We used chi-square tests to compare self-perceived improvement with GROC and changes in medication intake. To enable comparison of between-group effect sizes, standardized mean score differences (SMDs) were calculated by dividing mean score differences between groups by the pooled standard deviation. Numbers needed to treat (NNT) and 95% CI were also calculated at the 3-month follow-up period using each definition for a successful outcome.

Results

Between February 2015 and February 2018, 312 consecutive patients with CH were screened for eligibility criteria. One hundred forty-two (45.5%) satisfied all the inclusion criteria, agreed to participate, and were randomly allocated into the thrust spinal manipulation and dry needling (n=74) group or the nonthrust spinal mobilization and exercise (n=68) group. Randomization resulted in similar baseline characteristics for all variables (Table 1). The reasons for ineligibility are found in Fig. 2, which provides a flow diagram of patient recruitment and retention. No patients were lost at any of the follow-up periods in either group. None of the participants in any group reported receiving other interventions during the study. There was no significant difference (p=.465) between the mean number of completed treatment sessions for the manipulation and dry needling group (mean: 7.2) and the mobilization and exercise group (mean: 7.4).

Forty-five patients assigned to the spinal manipulation and dry needling group (60.8%) experienced postneedling muscle soreness and 18 (24.3%) experienced mild bruising (ecchymosis) which most commonly resolved spontaneously within 48 hours and 2 to 4 days, respectively. In addition, three patients (4.1%) in the dry needling group experienced drowsiness or nausea, which spontaneously resolved within several hours.

Adjusting for baseline outcomes, the 2-by-4 mixed-model ANCOVA revealed a significant Group*Time interaction for the primary outcome (NPRS: F=23.464; p<.001): patients receiving spinal manipulation and electrical dry needling experienced significantly greater reductions in headache intensity at 4 weeks (Δ −1.8, 95%CI −2.5 to −1.1, p<.001)

Table 1
Baseline characteristics by treatment assignment

Baseline variable	Thrust spinal manipulation + dry needling (n=74)	Nonthrust spinal mobilization + exercise (n=68)
Gender (male/female)	19/55	14/54
Age (years)	39.8±14.1	40.6±13.1
Weight (kg)	72.2±13.0	72.7±14.4
Height (cm)	168.7±8.0	167.2±8.9
Duration of symptoms (years)	4.5±5.8	4.4±4.9
Medication intake n (%)		
Not at all	5 (6.8%)	6 (8.8%)
Once a week	9 (12.2%)	9 (13.2%)
Once every couple of days	25 (33.8%)	21 (30.9%)
Once or twice a day	27 (36.5%)	24 (35.3%)
Three or more times a day	8 (10.8%)	8 (11.8%)
Number of treatment sessions	7.2±1.3	7.4±1.2
Headache intensity (NPRS, 0–10)	6.1±1.5	6.1±1.6
Disability (NDI, 0–50)	21.0±8.7	21.1±8.6
Headache frequency (0–7 days)	4.7±1.8	4.5±1.6
Headache duration n (%)		
0–5 hours	0 (0.0%)	7 (10.3%)
6–10 hours	9 (12.2%)	14 (20.6%)
11–15 hours	21 (28.4%)	7 (10.3%)
16–20 hours	18 (24.3%)	13 (19.1%)
21–25 hours	10 (13.5%)	13 (19.1%)
26 or more hours	16 (21.6%)	14 (20.6%)

NPRS, Numeric Pain Rating Scale, 0 to 10, lower scores indicate less pain; NDI, Neck Disability Index, 0 to 50, lower scores indicate greater function; Headache frequency, number of headache days in the last week, 0 to 7, higher scores indicate worsening; Headache duration, total headache hours in the last week, higher scores indicate worsening; Medication intake, the number of times the patient had taken prescription or over-the-counter analgesic or anti-inflammatory medication in the past week for their headaches.

Data are mean (SD) except for gender and medication intake.

and 3 months (Δ −2.9, 95%CI −3.5 to −2.3, p<.001) than those receiving spinal mobilization and exercise (Fig. 3). Between-groups effect sizes were large (SMD: 0.80) at 4 weeks and large (SMD: 1.25) at 3 months after the first treatment session in favor of the spinal manipulation and electrical dry needling group.

Similarly, significant Group*Time interactions were also found for headache frequency (F=13.407; p<.001, Fig. 4) and related-disability (NDI: F=10.702; p<.001, Fig. 5) and in favor of spinal manipulation and dry needling (Table 2). For headache frequency and disability (NDI), between-groups effect sizes were medium (SMD: 0.68) and large (SMD: 0.88) at 4 weeks, respectively. At 3 months after the first treatment session, the between-groups effect sizes were large (SMD: 0.97) for headache frequency and large (SMD: 0.94) for disability in favor of the manipulation and dry needling group.

No significant effect of different treatment locations on the treatment effect was observed for headache intensity (NPRS: F=2.343; p=.128), headache frequency (F=1.743, p=.189) or disability (NDI: F=2.593, p=.081). There was heterogeneity between different treatment locations for the baseline characteristics of age (p=.002) and duration of symptoms (p=.001), and for the baseline outcome measures of headache intensity (p=.003), headache frequency (p=.001), and disability (p=.001). However, considering all 13 treatment locations together, there was no significant difference between the groups (Table 1) in any of the baseline characteristics or outcomes including: age (p=.721), weight (p=.804), height (p=.288), duration of symptoms (p=.840), headache intensity (p=.944), frequency (p=.650), and disability (p=.966).

A three-way mixed-model ANCOVA (ie, Group*Time*-Duration of Symptoms) was used to determine if the between-subjects variable of duration of symptoms had any effect on the results. That is, there was no significant effect of the duration of symptoms on headache intensity (NPRS: F=0.345; p=.558; partial eta-squared=0.002), headache frequency (F=2.357, p=.127; partial eta-squared=0.017), or disability (NDI: F=0.130, p=.719; partial eta-squared=0.001). More specifically, the duration of symptoms accounted for 0.2%, 1.7%, and 0.1% of the variance in headache intensity (NPRS), headache frequency and disability (NDI), respectively.

Individuals in the spinal manipulation and dry needling group experienced shorter duration of headaches at 4 weeks (p<.001) and 3 months (p<.001) than individuals in the mobilization and exercise group (Table 2). Significantly (Fisher exact test; p<.001) more patients in the spinal manipulation and dry needling group (n=49, 66%) completely stopped taking medication for their pain compared to the spinal mobilization and exercise group (n=14, 21%) at 3 months. Based on the cutoff score of ≥+5 on the GROC, significantly (Fisher exact test; p<.001) more patients (n=57, 77%) within the manipulation and dry needling group achieved a successful outcome compared to the mobilization and exercise group (n=10, 15%) at 3 months follow-up (Table 3). Therefore, based on the cutoff score of ≥+5 on the GROC at 3-month follow-up, the NNT was 1.61 (95% CI 1.33, 2.02) in favor of the spinal manipulation and electrical dry needling group. Likewise, based on a 50% improvement from baseline to 3 months in headache intensity on the NPRS, the NNT was 1.87 (95% CI 1.50, 2.47) in favor of the spinal manipulation and electrical dry needling group.

Discussion

Principal findings

To our knowledge, this study is the first randomized clinical trial investigating the effectiveness of the combination of spinal manipulation and dry needling in patients with CH. The results suggest that a mean of seven sessions of thrust spinal manipulation and electrical dry needling, using a standardized manipulation protocol targeting primarily the atlanto-axial joints and a semistandardized intramuscular and perineural electrical dry needling protocol targeting the

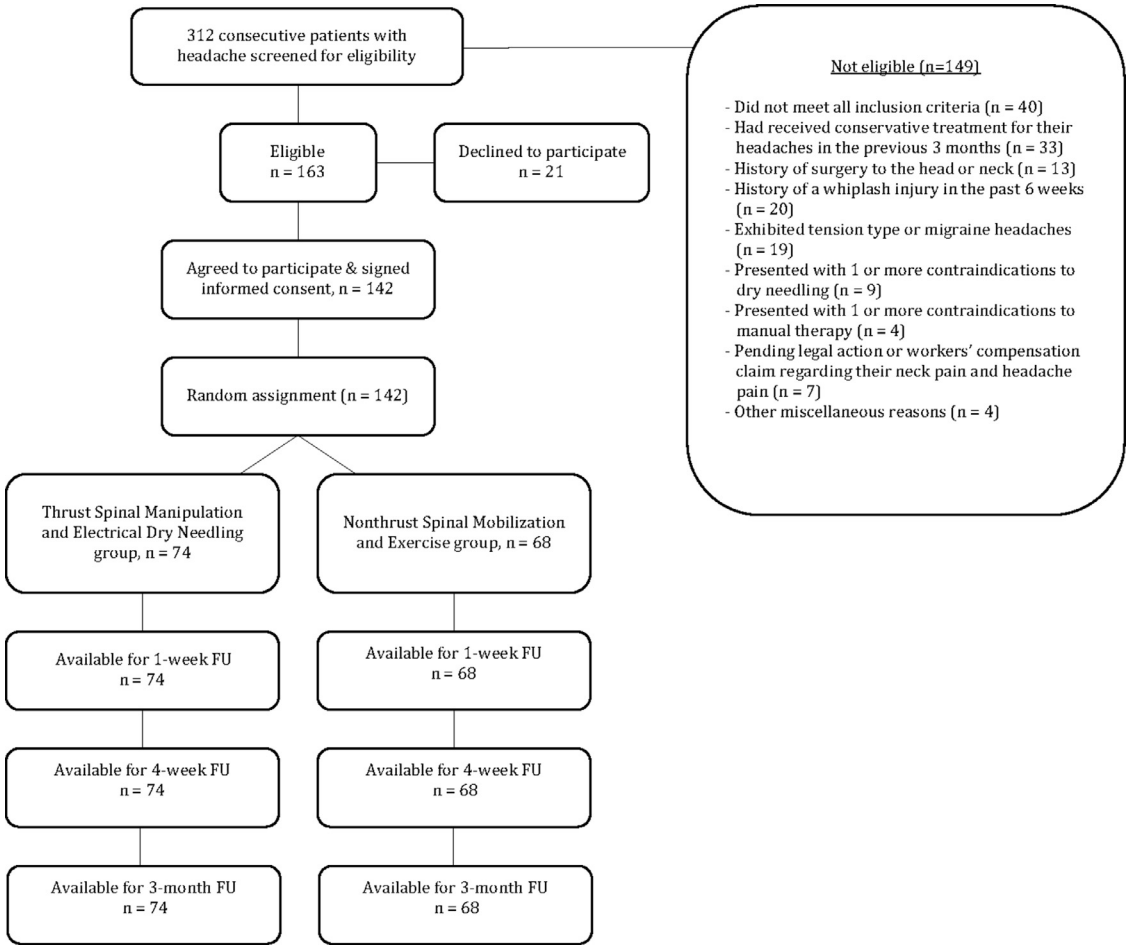

Fig. 2. Flow diagram of patient recruitment and retention.

suboccipital muscles, greater and lesser occipital nerves of the upper cervical spine, myofascia of the posterior occiput, and the supraorbital muscles and ophthalmic branch of the trigeminal nerve within the oculofrontotemporal region, at a frequency of 1 to 2 times per week over 4 weeks, resulted in greater improvements in headache intensity, disability, headache frequency, headache duration, and medication intake, than nonthrust spinal mobilization and low-load cervical exercises. For the primary outcome of headache intensity, between-groups effect sizes were large at both 4 weeks and 3 months in favor of the spinal manipulation and dry needling group. The between-groups difference for changes

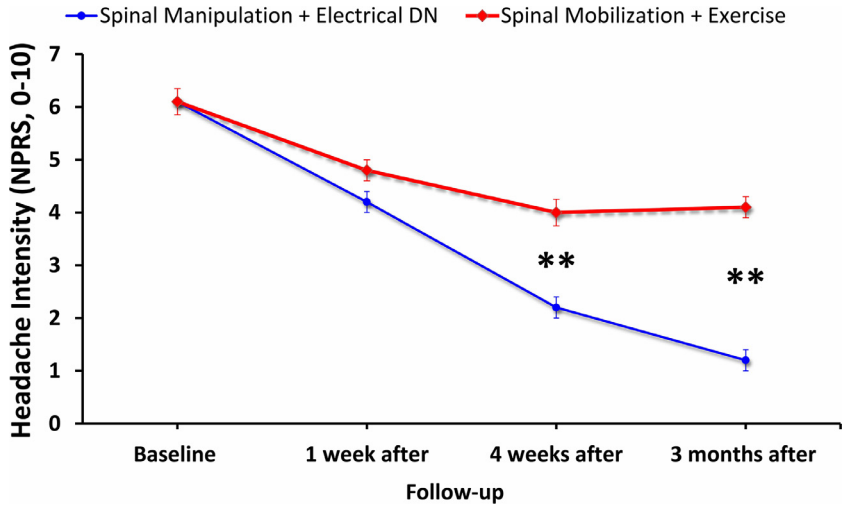

Fig. 3. Evolution of headache intensity throughout the course of the study stratified by randomized treatment assignment. Data are means (standard error).

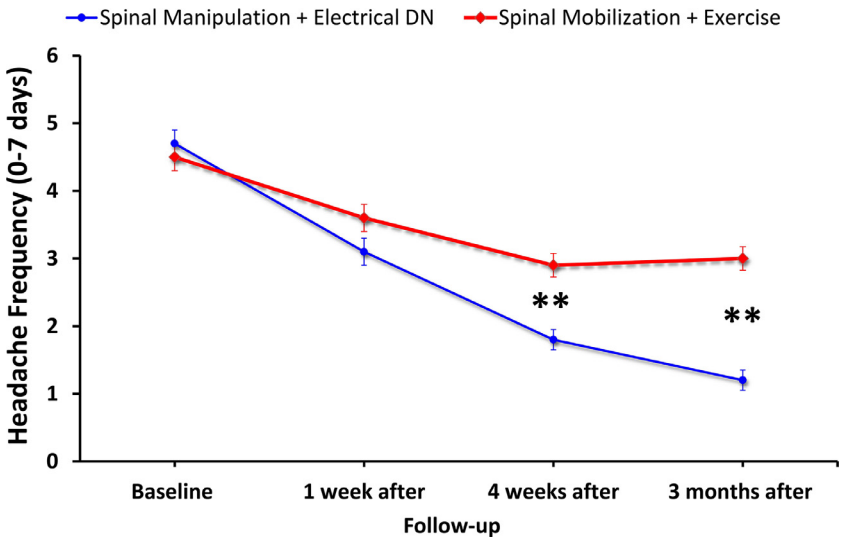

Fig. 4. Evolution of headache frequency throughout the course of the study stratified by randomized treatment assignment. Data are means (standard error).

in headache intensity at 3 months, as measured by the NPRS (2.9 points) exceeded the reported MCID for CH [56]. In addition, for disability (NDI), the point estimate for the between-groups difference at 3 months (8.8 points) also exceeded the respective MCID (ie, 7.5 points) in patients with CH [56]. Finally, the NNT suggests for every two patients treated with the combination of thrust spinal manipulation and electrical dry needling, rather than nonthrust spinal mobilization and exercise, one additional patient with CH achieves clinically important reductions in headache intensity and "moderate" to "large changes" in self-perceived improvement ratings at 3 months.

Comparison of the results to other studies

Jull et al. [10] demonstrated treatment efficacy for spinal manipulative therapy and exercise in the management of CH; however, the treatment package included both mobilization and manipulation. Thus, it remains unknown what proportion of individuals actually received high-velocity low-amplitude thrust manipulation, and whether or not the treatment was directed to the upper cervical articulations. Similar to the findings of the current study, another randomized controlled trial of patients with CH found six to eight sessions of upper cervical and upper thoracic manipulation were shown to be more effective than mobilization and exercise in patients with CH [14]. Although a recent systematic review reported that there is inconclusive evidence to strongly support the use of dry needling in the management CH [27], acupuncture is recommended in the NICE guidelines as an option for migraine prophylaxis and alleviation of tension-type headache [64].

Ishiyama et al. found significant reductions in headache intensity, headache frequency, and medication intake

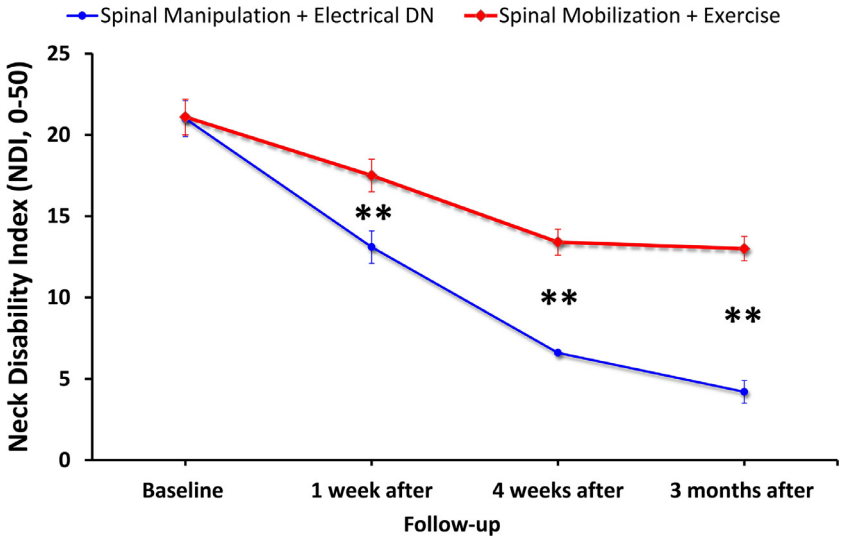

Fig. 5. Evolution of neck pain-related disability (NDI) throughout the course of the study stratified by randomized treatment assignment. Data are means (standard error).

Table 2
Within-group and between-groups mean scores by randomized treatment assignment

Outcomes	Timeline scores: mean±SD (95% CI) within-group change scores: mean (95% CI)		Between-group differences: mean (95% CI)
	Spinal manipulation+dry needling (n=74)	Spinal mobilization+exercise (n=68)	
	Numeric Pain Rating Scale—headache intensity (0–10)		
Baseline	6.1±1.5 (5.8, 6.5)	6.1±1.6 (5.7, 6.5)	
1 week	4.2±2.1 (3.7, 4.7)	4.8±2.0 (4.3, 5.3)	
Change baseline → 1 week	−1.9 (−2.4, −1.4)	−1.3 (−1.7, −0.9)	−0.6 (−1.25, 0.0); p=.049
4 weeks	2.2±1.8 (1.8, 2.6)	4.0±2.0 (3.5, 4.5)	
Change baseline → 4 weeks	−4.0 (−4.4, −3.5)	−2.1 (−2.6, −1.6)	−1.8 (−2.5, −1.1); p<.001
3 months	1.2±1.4 (0.9, 1.5)	4.1±1.9 (3.7, 4.6)	
Change baseline → 3 months	−4.9 (−5.3, −4.5)	−2.0 (−2.5, −1.5)	−2.9 (−3.5, −2.3); p<.001
	Neck Disability Index—disability (0–50)		
Baseline	21.0±8.7 (19.0, 23.1)	21.1±8.6 (19.0, 23.2)	
1 week	13.1±7.8 (11.3, 14.9)	17.5±9.3 (15.3, 19.8)	
Change baseline → 1 week	−8.0 (−9.2, −6.7)	−3.5 (−4.8, −2.2)	−4.5 (−6.2, −2.7); p<.001
4 weeks	6.6±4.9 (5.4, 7.7)	13.4±8.5 (11.3, 15.5)	
Change baseline → 4 weeks	−14.4 (−16.2, −12.7)	−7.7 (−9.2, −6.2)	−6.8 (−9.0, −4.5); p<.001
3 months	4.2±4.1 (3.2, 5.1)	13.0±8.0 (11.0, 14.9)	
Change baseline → 3 months	−16.9 (−18.8, −14.9)	−8.1 (−9.9, −6.3)	−8.8 (−11.4, −6.0); p<.001
	Headache frequency (0–7 days)		
Baseline	4.7±1.8 (4.3, 5.1)	4.5±1.6 (4.2, 4.9)	
1 week	3.1±1.8 (2.7, 3.5)	3.6±1.6 (3.2, 4.0)	
Change baseline → 1 week	−1.6 (−2.0, −1.2)	−0.9 (−1.2, −0.5)	−0.6 (−1.2, −0.2); p=.012
4 weeks	1.8±1.5 (1.4, 2.1)	2.9±1.5 (2.5, 3.2)	
Change baseline → 4 weeks	−2.9 (−3.4, −2.5)	−1.7 (−2.0, −1.3)	−1.1 (−1.8, −0.7); p<.001
3 months	1.2±1.3 (0.9, 1.5)	3.0±1.6 (2.7, 3.4)	
Change baseline → 3 months	−3.4 (−3.9, −3.0)	−1.5 (−1.9, −1.1)	−1.8 (−2.5, −1.4); p<.001

NPRS, Numeric Pain Rating Scale, 0 to 10, lower scores indicate less pain; NDI, Neck Disability Index, 0 to 50, lower scores indicate greater function; Headache frequency, number of headache days in the last week, 0 to 7, higher scores indicate worsening.

following 3 months of C2 peripheral nerve field stimulation (ie, stimulation of the C2 dermatome in the occipital area that is innervated by the greater occipital nerve) using electroacupuncture in patients with migraine or tension-type headache [65]. Additionally, several previous clinical trials have reported favorable outcomes following occipital nerve stimulation or occipital nerve field stimulation with implanted devices for drug-resistant chronic migraine and cluster headache [66–69]. The less invasive nerve field stimulation involves stimulating nerve endings within the subcutaneous tissue instead of the main nerve trunk; furthermore, the electrical stimulation can be delivered using an acupuncture needle (ie, electroacupuncture) rather than a surgical electrode [65,70]. To our knowledge, the current trial is the first to have investigated the combined effect of high-velocity low-amplitude thrust spinal manipulation and perineural electrical dry needling in patients with CH.

Rationale for perineural electrical dry needling

A recent systematic review concluded that most acupuncture trials used multiple needles with electric stimulation in the vicinity of the head, neck, and upper limbs to treat CH [71]. Likewise, in a systematic review of tension-type headache trials, Hao et al. concluded electroacupuncture to be more efficacious than manual acupuncture [50]. In addition to significantly increasing endogenous opioid levels—ie, increased plasma β-endorphin levels—and

Table 3
Self-perceived improvement with Global Rating of Change (GROC) in both groups n (%)

Global rating of change (GROC, −7 to +7)	Thrust spinal manipulation+dry needling (n=74)	Nonthrust spinal mobilization+exercise (n=68)
1 week after first treatment session		
Moderate changes (+4/+5)	10 (13.5%)/10 (13.5%)	4 (5.9%)/5 (7.4%)
Large changes (+6/+7)	12 (16.2%)/2 (2.7%)	1 (1.5%)/1 (1.5%)
4 weeks after first treatment session		
Moderate changes (+4/+5)	9 (12.2%)/12 (16.2%)	11 (16.2%)/6 (8.8%)
Large changes (+6/+7)	25 (33.8%)/11 (14.9%)	6 (8.8%)/2 (2.9%)
3 months after first treatment session		
Moderate changes (+4/+5)	7 (9.5%)/9 (12.2%)	10 (14.7%)/5 (7.4%)
Large changes (+6/+7)	23 (31.1%)/25 (33.8%)	5 (7.4%)/0 (0.0%)

significantly reducing plasma cortisol levels [72], electrical dry needling may enhance intra and extra neural microcirculation via local neovascularization and vasodilation through autonomic reflexes and nitric oxide release [73,74]. Moreover, electroacupuncture has been found to reduce the expression of pro-inflammatory cytokines (ie, interleukin-1 β and tumor necrosis factor-α) in the synovia of joints [75] and inflamed soft-tissue [76,77], and block the systemic release of inflammatory factors in the periaqueductal gray area of the brain stem [78]. This may lead to decreased inflammation of the densely innervated periarticular connective tissue of the upper cervical articulations, suboccipital muscles, and the greater occipital nerve, lesser occipital nerve, third occipital nerve, and great auricular nerve [75–78], which is most frequently reported by patients as the region of the origin of symptoms before they proceed unilaterally into the posterior occiput and oculofrontotemporal region [4,29,79].

Implications for clinicians on needle retention and treatment frequency

In the current trial, individuals received electrical dry needling for 20-minute durations at a frequency of 1 to 2 times per week for 4 weeks. Notably, there are no standards or guidelines for the duration of needle retention or treatment frequency in patients with CH; [27] however, Hao et al. [50] concluded that needle retention for 30 minutes was superior to no needle retention (SMD: 0.45), and twice-a-week treatment was superior to once-a-week treatment (SMD: 0.46). Similarly, in the majority of acupuncture clinical trials for migraine headache, needles have been left in place for 10- to 30-minute durations [80–83].

Strengths and limitations

Major strengths of the current study include a large sample size with 13 treating physical therapists from 13 clinics in 10 different geographical states, and the use of the same standardized spinal manipulation and dry needling protocol and dosage parameters. However, we only assessed mid-term follow-up; thus, we do not know if the significant between-groups differences observed at 3 months would be sustained in the long term. Furthermore, we cannot be certain that the results are generalizable to other manual therapy and dry needling protocols, dosages, or techniques. Although the experimental group was compared to conventional physical therapy, we did not include a dry needling placebo group, which should be considered in future studies. In addition, therapist and patient treatment preferences were not collected and could potentially affect the results.

Conclusion

The results of the current randomized clinical trial demonstrated that patients with CH who received thrust spinal manipulation and electrical dry needling experienced significantly greater improvements in headache intensity, disability, headache frequency, headache duration, and medication intake as compared to the group that received nonthrust spinal mobilization and exercise. Future studies should examine the effectiveness of different types and dosages of spinal manipulation and electrical dry needling and include a long-term follow-up.

Author's contribution

JD, RB, and CFdlP participated in the conception, design, data acquisition, statistical analyses, data interpretation, drafting and revision of the manuscript. IY was involved in the data interpretation, drafting and revision of the manuscript. NZ, KF, KW, and JeD were involved in data collection, statistical analyses and revision of the manuscript. All authors read and approved the final version of the manuscript.

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Supplementary materials

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