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Multimodal Treatment Program Comparing 2 Different Traction Approaches for Patients With Discogenic Cervical Radiculopathy: A Randomized Controlled Trial

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Abstract

Objective: The purpose of this study was to investigate the immediate and long-term effects of a 1-year multimodal program with the addition of 2 different traction approaches on the pain, function, disability, and nerve root function in patients with discogenic cervical radiculopathy (CR). This study also attempted to identify the optimal traction angle based on the maximum recovery of the peak-to-peak amplitude of the flexor carpi radialis (FCR) H-reflex.

Methods: This randomized clinical trial with one-year follow-up included a total of 216 (101 female) patients with unilateral lower discogenic CR were randomly assigned to 1 of 3 groups. The standard care group (C) received the multimodal program (pain relief methods, muscle strengthening, and thoracic spine manipulation). The ventroflexion traction group (A) received the same multimodal program as group C, with added traditional ventroflexion traction. The novel traction group (B) received the same multimodal program as group C in addition to a flexor carpi radialis (FCR) H-reflex-based traction method. Primary outcomes were the Neck Disability Index (NDI) and secondary outcomes included neck pain, arm pain, and the amplitude and latency of the H-reflex. Patients were assessed at 3 intervals (pre-treatment, 4 weeks post-treatment, and the 1-year follow-up).

Results: The mixed linear model with repeated measures indicated a significant group × time effect in favor of the novel cervical traction group (B) for measures of NDI ($F = 412.6$, $P < .0005$), neck pain ($F = 108.9$, $P < .0005$), arm pain ($F = 91.3$, $P < .0005$), H- reflex amplitude ($F = 207.7$, $P < .0005$), and H-reflex latency ($F = 58.9$ $P < .0005$). We found that the extension position of cervical spine (5° extension) was the position that achieved the maximum improvement in the novel cervical traction method.

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Conclusions: This preliminary study showed that a multimodal program with a novel cervical traction method added improved NDI, neck pain, arm pain, and the amplitude and latency of FCR H-reflex for a group of patients with chronic discogenic CR.
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Introduction

Discogenic cervical radiculopathy (CR) is a common clinical problem that is associated with functional limitations and persistent disability.[1] The sixth and the seventh cervical nerve roots are the most frequently involved. Despite the high annual incidence of this condition,[2] the identification of appropriate conservative management strategies appears to remain a clinical enigma.[3–5] The development of an effective intervention strategy is thus required.

While preliminary reports suggest that a multimodal treatment program consisting of manual therapy and exercise may result in positive outcomes for patients with CR,[6–10] efforts to successfully add cervical traction to a multimodal treatment program remain elusive. A study by Ragonese[11] concluded that when treating patients with a diagnosis of CR, an approach that combines manual therapy (including cervical traction) and therapeutic exercise appears to be superior to either intervention alone. These findings differ from a study performed by Young et al [12] that concluded the addition of mechanical cervical traction to a multimodal treatment program of manual therapy and exercise yields no significant additional benefit to pain, function, or disability in patients with CR. The protocol used for cervical traction may have been the reason a treatment effect was not identified.

A multitude of traction parameters are used in the clinical setting. However, there is no convincing evidence to suggest which parameters are most effective in the management of CR. In this regard, although the cervical traction angle is considered one of the most important variables that can affect the treatment outcome, to date there is little agreement on the most effective traction angle. Interestingly, ventroflexion traction has been advocated as the most effective position for lower cervical spine traction. Several studies have documented positive results using ventroflexion traction to treat CR.[13–15] Conversely, there are many other studies reporting the insignificant effectiveness of this position, especially for chronic CR.[12,16–18] Moreover, the long-term effects remain unknown, with studies reporting both positive [13–15] and negative results. [12,16–18]

In theory, the mechanical principles represented in the significant increase of cervical neural foramen and intervertebral separation after ventroflexion traction,[19] are the most likely explanations for choosing this traction angle. Regardless of these proven mechanical principles, all the previous studies [12–18] ignored the adverse mechanical tension that developed during ventroflexion traction.[20] Based on the literature, this tension may adversely affect the central nervous system and nerve root function due to the absence of the perineurium, which is the primary load carrying structure.[21]

The work of Harrison et al. was pioneering in regard to the association between the extension position and the normal biomechanics of the nervous system.[22–24] Although, the extension traction has become more popular,[25,26] the extension position is still questioned in treating CR.[27,28]

Specifically, while there is agreement about the important role of flexion-extension angles in management of CR with studies reporting both positive and negative results,[12–18] there is a gap in the literature concerning the nerve root function assessment during various flexion-extension angles, which represent a major hurdle preventing the exploration of the most effective traction angle.

Accordingly, the present study was designed to evaluate the immediate and long-term effects of a multimodal program with the addition of a novel cervical traction method compared to ventroflexion. This study also aimed to identify the optimal traction angle based on the maximum recovery of the peak-to-peak amplitude of the flexor carpi radialis (FCR) H-reflex versus the addition of traditional ventroflexion traction.

Methods

A prospective, randomized, controlled study was conducted at a research laboratory of our university and was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12613000169741). Patients of both genders with unilateral lower discogenic CR were recruited from the outpatient physiotherapy department of the El-Farouk Hospital. The patients participated in the study after signing an informed consent form prior to data collection. Recruitment began after approval was obtained from the Ethics Committee of the Faculty of Physical Therapy, Cairo University. The patients were included if they had a unilateral C5-6 or C6-7 disc herniation confirmed by imaging (computed tomography and/or magnetic resonance imaging), C6 or C7 dermatomal numbness, current continuous or intermittent pain or discomfort which has persisted for more than 3 months,[29] radiation of arm pain in the representative dermatomal areas for C6 and C7, diminished deep tendon reflexes in the affected arm, and no spinal deformity according to cervical spine derangement classifications. In addition, included patients had symptoms that were worse with cervical flexion/ protrusion, better with retraction, retraction with extension or side bending, and rotation to same side of symptoms.[30] Further, the inclusion criteria for these patients included a test item cluster identified by Wainner et al,[31] which included the presence of four positive examination findings (Spurling test, upper limb tension test, cervical distraction test, and less than 60° cervical rotation towards the symptomatic side).

Exclusion criteria included the presence of any signs or symptoms of medical ”red flags” (e.g., tumor, fracture, rheumatoid arthritis, osteoporosis, and prolonged steroid use), a history of previous cervical or thoracic spine surgery, signs or symptoms of upper motor neuron disease, vestibulobasilar insufficiency, amyotrophic lateral sclerosis, bilateral upper extremity radicular symptoms, pregnant woman, those with the inability to tolerate cervical flexion or extension position, the complete loss of sensation along the involved nerve root, intractable pain, being defined as having severe myelopathy determined by history and examination or motor loss greater than 3/5 based on neurologic examination, using the standard grading system ranging from 0 (no visible contraction) to 5 (normal strength).

The patients were randomly assigned to one of three groups by an independent person who picked one of the sealed envelopes containing numbers chosen by a random number generator. The randomization was restricted to permuted blocks of different sizes to ensure that equal numbers were allocated to each group. Each random permuted block was transferred to a sequence of consecutively numbered, sealed, opaque envelopes that were stored in a locked drawer until required. As each participant formally entered the trial, the researcher opened the next envelope in the sequence in the presence of the patient.

The patients in all three groups completed a 4-week multimodal program consisting of physical pain relief methods (infrared radiation, interferential therapy, and massage), muscle strengthening via isometric contraction of flexor and extensor muscles, and thoracic spine manipulation. Costello's report suggests that this multimodal treatment approach may be beneficial for patients with cervical radiculopathy.[8]

Infrared Application

The patient assumed a forward lean sitting position in which the area to be treated (the paraspinal muscles of the neck and trapezius muscle) was adequately exposed, supported and relaxed. The lamp was positioned at distance ranging from (50–75 cm). The duration of application was fifteen minutes per session.

Interferential Application

During interferential application, patients were asked to adopt a prone position. Interferential treatment was introduced using an electrotherapy device (Phyaction 787, Netherlands). The interferential therapy was delivered at an amplitude-modulated constant frequency of 100 Hz and a pulse duration of 125 μs due to its analgesic effect. A 20-min interferential session has been widely accepted by physiotherapy practitioners.[32] The inclusion of interferential current in a multimodal treatment plan seems to be more effective for reducing pain than a control treatment and is also more effective than a placebo treatment.[33]

Soft Tissue Mobilization

Soft tissue mobilization was performed on the muscles of the upper quarter with the involved upper extremity positioned in abduction and external rotation to preload the neural structures of the upper limb.[34] Manual pressure was applied to the soft tissues of the upper quadrant in a deep, stroking manner with the intention to decrease pain and improve the mobility of the soft tissues surrounding the pathway of the neural structures of the upper limb. The therapist concentrated on any tissues on the cervical and scapular region and upper extremity that were graded as tight or tender in the evaluation.

Thoracic Spine Manipulation

According to the model for describing thrust manipulations recently proposed by Mintken et al., [35,36] the following techniques were used:

1. A high-velocity, distraction force to the midthoracic spine on the lower thoracic spine in a sitting position. The therapist placed his upper chest at the level of the patient's middle thoracic spine and grasped the patient's elbows, pulling the elbows towards the therapist until the spine was firmly positioned against the therapist's upper chest. A high-velocity distraction thrust was performed in an upward direction.

2. A high-velocity, anterior-posterior force applied through the elbows to the upper thoracic spine on the midthoracic spine in cervicothoracic flexion. This technique was performed with the patient in a supine position. The patient clasped his or her hands across the base of the neck. The patient's arms were pulled downward to create spinal flexion down to the level the therapist attempted to manipulate. The therapist used his manipulating hand to stabilize the inferior vertebra of the targeted motion segment and his body to push down through the patient's arms, to perform a high-velocity, low-amplitude thrust.

3. A high-velocity, anterior-posterior force applied through the elbows to the middle thoracic spine on the lower thoracic spine in cervicothoracic flexion. This technique was performed with the patient in a supine position. The patient clasped his or her opposite shoulders with both hands. The patient's arms were pulled downward to create spinal flexion down to the level the therapist attempted to manipulate. The therapist used his manipulating hand to stabilize the inferior vertebra of the targeted motion segment and his body to push down through the patient's arms, to perform a high-velocity, low-amplitude thrust. There is sufficient evidence to support the use of thoracic spine manipulation for specific subgroups of patients with neck conditions.[37,38]

Strengthening Exercises

The strengthening exercise program was conducted according to the protocol described in Harman et al[39] and based on Kendall et al's approach.[40] Specifically, the program involved:

- Strengthen deep cervical flexors through chin tucks in the supine position with the head in contact with the floor. The progression of this exercise involved lifting the head off the floor in a tucked position and holding it for varying lengths of time (this process progressed in two second increments starting at two seconds, ie, 2, 4, 6, and 8 seconds).
- Strengthen shoulder retractors first while standing using a theraband [41] by pulling the shoulder back. The patient was asked to pinch the scapulae together without elevation or extension in the shoulder, holding this position for at least six seconds and then relaxing. The first progression involved conducting the shoulder retraction from a prone position using weights. The second progression used elastic resistance and weights. Participants performed each progression for two weeks.
- For serratus anterior strengthening, the patient was instructed to stand at the wall with arms approximately shoulder width apart and was then asked to push the wall away until the elbows are fully extended and the scapulae are protracted as far as possible. This conventional treatment was to be repeated three times per week for four weeks. Those in the standard care group (group C) received this multimodal program only.

The other 2 groups (A and B) additionally received intermittent mechanical cervical traction; the ventroflexion traction group (A) received the traditional ventroflexion traction. During ventroflexion traction, the patient was positioned supine on a softly padded table with a pillow under the knees for relaxation. A cervical range of moment device was used to set the 24 flexion angle (Fig 1).[42] This flexion angle was maintained during the traction by using neck wedges. According to the protocol of Young et al.,[12] the traction force was started at 9.1 kg (20 lb) or 10% of the patient's body weight (whichever was less) and increased approximately 0.91 to 2.27 kg (2–5 lb) every visit, depending on centralization or the reduction of symptoms. The maximum force used was 15.91 kg (35 lb). The on/off cycle was set at 50/10.

The novel cervical traction group (B) that received the FCR H-reflex-based traction method followed the same procedures of traditional traction with the only exception that the optimal head posture was selected according to the H-reflex findings. FCR H-reflex amplitude was recorded after the patient maintained the end range of 24° head flexion, mid position, 15° backward extension and 5° backward extension for

20 minutes. These different head positions were adjusted by using a cervical range of moment device (Fig 1). Extension traction involves using a table with some type of pad to extend the neck over and applying a force to the head, resulting in extension and longitudinal traction. The electrophysiological findings represented in peak-to-peak amplitudes were compared with the findings recorded during comfortable neutral positions. Then, we select the ideal position that induced peak-to-peak amplitude recovery to be our choice for cervical traction. The idea behind this technique is that head posture can significantly influence the H-reflex amplitude but not latency. Certain head postures can cause further H-reflex inhibition, indicating increased compression of an impinged nerve root, and other postures can cause H-reflex facilitation, indicating decompression of the nerve root. [43]

The peak-to-peak amplitude was selected as a compression–decompression indicator as it is a more sensitive predictor of normal physiologic changes than is latency, which needs a longer time to be changed.[43] Patients in all of the traction groups received cervical traction for 20 minutes, three times per week for four weeks. All traction was performed with a Triton Traction Machine (Chattanooga Group, Hixon, TN) using a Saunders traction device that pulls from the occipital area (The Saunders Group, Inc, Chaska, MN). Patients in all three groups were instructed to perform all strengthening exercises at home, twice daily as a home routine.

Outcome Measures

The baseline evaluation of the patients was conducted following the confirmation of eligibility and the provision of informed consent. Demographic characteristics were collected including the subject's age, gender, cervical pain history, and their most bothersome symptom. Measures of the treatment outcome were collected at baseline, after the 4-week intervention, and again repeated at the 1-year follow-up appointment.

The primary outcome measure for determining treatment assessment was disability measured using the NDI, which consists of 10 items related to daily living activities. The reliability, construct validity, and responsiveness to change have all been demonstrated in various populations.[44]

Other outcome measures used to compare the treatment effectiveness among the groups included neck pain, arm pain, and the neurophysiological findings (latency and peak-to-peak amplitude of FCR H-reflex). A separate 0–10 numeric rating scale was used to measure the average intensity of neck pain and arm pain over the past week. The patients were asked to place a mark along the line to denote their pain level; 0 reflecting "no pain" and 10 reflecting the "worst pain". The numerical rating scale has good reliability[45] and validity.[46]

For neurophysiological assessment, the latency and peak-to-peak amplitude of FCR H-reflex were measured following the protocol of Hiraoka and Nagata.[47] An electromyogram device (Tonneis Neuroscreen Plus Version 1.59, Germany) was used to measure this variable. The experiment was performed in a quiet room kept at a stable temperature ranging from 24°C to 26°C. The FCR H-reflexes were evoked by stimulating the median nerve approximately 5 cm above the cubital fossa using bipolar stainless electrodes. The stimulus duration was 1.0 m sec at a frequency of 0.2 Hz. The FCR H-reflexes were evoked at a level at which the 50% of the maximum H-reflex was evoked.

The electromyographic activity was recorded by means of standard disk electrodes placed on the right flexor carpi radialis muscle with 3 cm of separation between the electrodes. Care was taken to ensure that impedance at the recording site was below 10 kΩ. The

Fig 1. Adjustment of head position for the different traction techniques.

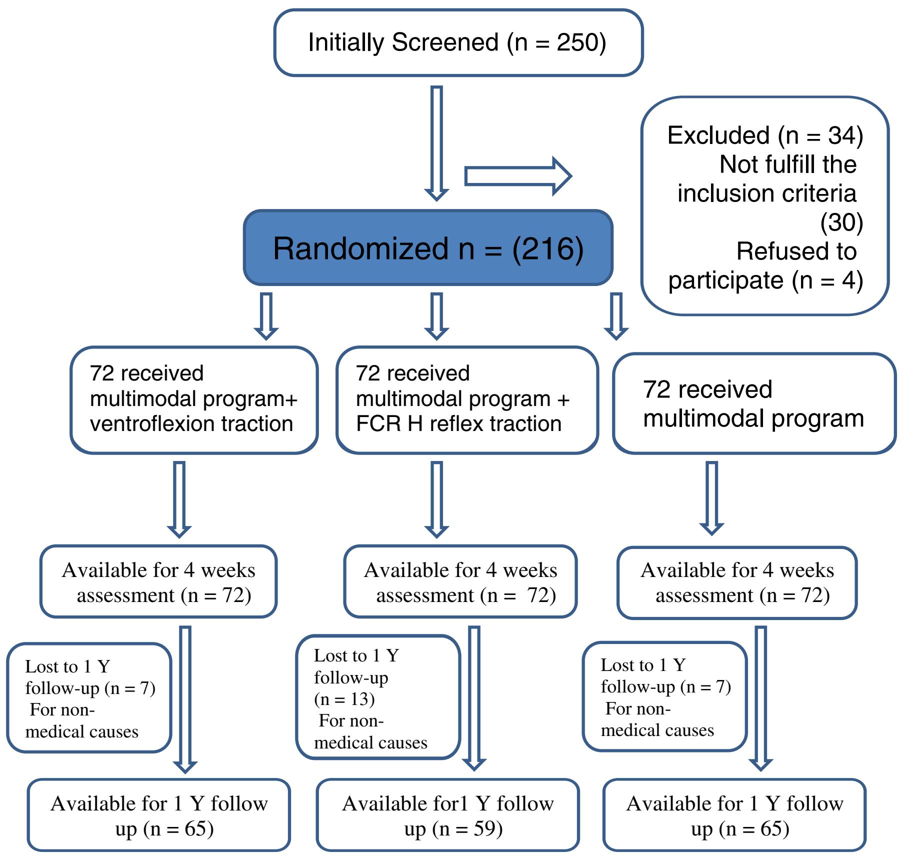

Fig 2. Flow of study participants.

reference electrode was placed over the ulnar styloid. The ground was placed just distal to the ulnar elbow area, and about half way between the stimulating and recording electrodes. Amplifier filter settings of 20 Hz and 3 KHz was used to record the H-reflex. To obviate differences in H-reflex amplitude based on the particular position of the recording electrode on the muscle, the amplitude of the H-reflex was expressed as a percentage of the maximal M wave amplitude of the same muscle.

Sample Size Determination

A priori power calculations indicated that 60 patients were needed in each group to detect the minimum clinically important difference between groups of 10 points on the NDI[43] assuming a standard deviation of 20 (two-tailed hypothesis, $\alpha = .05$, power = 80%). To account for high drop-out rates, the sample size was increased by 20%.

Statistical Analysis

The differences in the baseline data between the groups were analyzed using one way ANOVA for the continuous variables and χ^2 test for the categorical variables. Data were analyzed using SPSS (version 20.0), and a significance level was set at $P \leq .05$. The normality of the data was assessed using the One-Sample Kolmogorove Smirnov test. All data were found to be normally distributed.

A separate repeated measures, mixed-model analysis (involving both fixed and random effects) was performed for each of the primary and secondary outcomes, with alpha set at 0.05, on an intention-to-treat basis to compare the mean changes among the three groups. This model considered repeated measures over three time periods, and three groups were entered as fixed factors. Additionally, the crossover effect of group and time period was entered as an interaction term. The group x time interaction was selected to estimate the treatment effect. These were chosen for their strength in analyzing longitudinal biological data and accounting for correlations associated with repeated measurements. A random intercept for individuals was also included in the model to account for multiple measurements over time from the same participants. Because the linear mixed model estimates values for missing data, all randomized participants were included in the analysis.

Table 1 Baseline Demographics of the Participants

			Group (A) (n = 72)	Group (B) (n = 72)	Group (C) (n = 72)	p value[C]
Age (y)			40.2 ± 4.9	41.5 ± 6.1	41.7 ± 5.5	.08
Height (cm)			172.5 ± 4.3	171.4 ± 4.5	173.2 ± 2.9	.2
Weight (kg)			84.3 ± 7.8	82.5 ± 6.4	86.4 ± 9.2	.1
Gender (%)	Male		31(43%)	44(61%)	40(56%)	.08
	Female		41(57%)	28(39%)	32(44%)	
History of neck pain	Duration of current pain (wk)		15.7 ± 3.1	16 ± 3.3	17.5 ± 2.9	.1
	Duration since first onset (mo)		9 ± 1.5	7 ± 2	7 ± 2.4	.06
Most bothersome symptom, n (%)	Pain		12(17%)	4(5.5%)	13(18%)	.1
	Numbness/tingling		27(37.5%)	36(50%)	30(41.5%)	
	Both pain and numbness/tingling		33(45.5%)	32(44.5)	29(40.5%)	
Using medication (Yes/no)	Pre treatment		39(33)	37(35)	46(26)	.2
	After 4 wk		29(43)	25(47)	37(35)	.1
	At 1-y follow up		22(50)	20(52)	32(40)	.07
Using medication (a) n (Yes/no)	Tricyclic antidepressants	Pre treatment	29(43)	28(44)	30(42)	.9
		After 4 wk	19(53)	8(64)	21(51)	.01
		At 1-y follow up	19(53)	3(69)	21(51)	<.005
	NSAID	Pre treatment	30(42)	31(41)	29(43)	.9
		After 4 wk	22(50)	10(62)	14(58)	.04
		At 1-y follow up	20(52)	4(68)	19(53)	.001
	Opioids	Pre treatment	11(61)	13(59)	13(59)	.8
		After 4 wk	5(67)	3(69)	6(66)	.5
		At 1-y follow up	5(67)	0(72)	6(66)	.05
	Paracetamol	Pre treatment	2(70)	3(69)	2(70)	.9
		After 4 wk	4(68)	15(57)	2(70)	<.005
		At 1-y follow up	4(68)	20(52)	3(69)	<.005
	Other	Pre treatment	11(61)	12(60)	11(61)	.9
		After 4 wk	6(66)	5(67)	5(67)	.9
		At 1-y follow up	9(63)	0(72)	10(62)	.005

The values are the mean (SD) for age, height, weight, and duration of pain. The patients could have received more than one treatment. *NSAID*, non-steroidal anti-inflammatory drugs.

Results

Baseline and Demographic Data

A diagram of patients' retention and randomization throughout the study is shown in Fig 2. A total of 250 patients were initially screened. After the screening process, 216 patients were eligible to participate in the study. In total, 216 (100%) completed the first follow-up after 4 weeks of treatment, and 189 (87.5%) of them completed the entire study including the 1-year follow up. The demographic characteristics of the patients are shown in Table 1. The three groups were similar with regard to age, height, weight, gender, history of neck pain, most bothersome symptom, and use of medication.

The main results are summarized and presented as means (SD) in Table 2. The mixed linear model with repeated measures indicated a significant group × time effect in favor of the novel cervical traction group (B) in terms of NDI ($F = 412.6$, $P < .0005$), neck pain ($F = 108.9$, $P < .0005$), arm pain ($F = 91.3$, $P < .0005$), H-reflex amplitude ($F = 207.7$, $P < .0005$), and H-reflex latency ($F = 58.9$, $P < .0005$). A Tukey's pairwise comparison revealed the significant differences between group (B) and group (C), and between group (B) and group (A) in favor of group (B) for all the measured variables ($P < .0005$). There were no significant differences between group (C) and group (A) for all the measured variables, including neck pain ($P = 0.9$), arm pain ($P = 0.1$), H-reflex amplitude ($P = .08$), H-reflex latency ($P = .07$), and NDI ($P = .2$).

Discussion

This randomized controlled trial suggests that the addition of a novel cervical traction method (FCR H-reflex-based traction) to a multimodal treatment program in the form of physical pain relief methods (infrared, interferential therapy, and massage), muscle strengthening, and thoracic spine manipulation yields a significant additional benefit to disability, pain, nerve root function represented by the amplitude and latency of

Table 2 Mixed Model Analysis

		G(B)	G(C)	G(A)	Effects	F	P	Pairwise Comparisons Groups	MD	95% CI	*P*
Neck pain	1	6.9 ± .7.7	6.7 ± .9	6.5 ± .8	G	76.3	<.005	GB vs GC	−1.9	−2.3 to −1.4	<.005
	2	2.5 ± 1.8	4.8 ± 1.4	4.6 ± 1.4	T	506.9	<.005	GB vs GA	−1.7	−2.1 to −1.3	<.005
	3	2.8 ± 1.7	6.2 ± 1.3	6.3 ± 1.2	GxT	108.9	<.005	GC vs GA	.16	−.24 to .579	.9
Arm pain	1	5.8 ± 1	6.4 ± 1.1	6.1 ± 1.1	G	123.9	<.005	GB vs GC	−2.5	−2.9 to −2.09	<.005
	2	1.8 ± 1.5	4.6 ± 1.3	4.2 ± 1.4	T	428.7	<.005	GB vs GA	−2.1	−2.6 to −1.7	<.005
	3	1.9 ± 1.5	6.1 ± 1.4	5.8 ± 1.5	GxT	91.3	<.005	GC vs GA	.33	−.09 to .74	.17
Latency	1	20.8 ± .9	21.8 ± .7	22.6 ± 1.2	G	230.4	<.005	GB vs GC	−3.2	−3.6 to −2.7	<.005
	2	16.1 ± .8	20.5 ± 2.6	20.7 ± 2.6	T	444.7	<.005	GB vs GA	−3.6	−4.1 to −3.2	<.005
	3	15.8 ± .7	20 ± .6	20.3 ± 1.4	GxT	58.9	<.005	GC vs GA	-.4	−.87 to .02	.07
Amplitude	1	.9 ± .2	.84 ± .1	.8 ± .2	G	177.6	<.005	GB vs GC	.73	.61 to .84	<.005
	2	2.3 ± .6	1.2 ± .2	1.1 ± .2	T	479.4	<.005	GB vs GA	.84	.72 to .95	<.005
	3	2.2 ± .5	1.1 ± .3	.9 ± .2	GxT	207.7	<.005	GC vs GA	.11	−.006 to .22	.08
NDI	1	36.1 ± 2.9	39.33.3	37.6 ± 3.9	G	623.1	<.005	GB vs GC	−14.6	15.6 to 16.7	<.005
	2	9.8 ± 2.5	27.9 ± 3.8	27 ± 3.8	T	2283	<.005	GB vs GA	10.6	10.1 to 11.2	<.005
	3	12.1 ± 3.2	34.6 ± 3.9	34.6 ± 4.9	GxT	412.6	<.005	GC vs GA	−5.5	−6.1 to −4.9	.2

1, Pre-treatment; *2*, post-treatment; *3*, 1-year follow-up; *CI*, confidence interval for difference; *F*, variation between group means; *G*, Group; *G(A)*, ventroflexion traction group; *G(B)*, novel traction group; *G(C)*, standard care group; *GxT*, group × time interaction; *MD*, mean difference; *NDI*, Neck Disability Index; *T*, time.

FCR H-reflex in patients with CR. Furthermore, at 1-year follow up these positive effects were maintained and sometimes improved. On the basis of the current results, this study provides objective evidence that neurophysiological principles, and not just mechanical principles, have to be considered during lower cervical traction.

The current study findings make sense and agree with Abdulwahab,[48] who reported that the identification the optimum spinal posture that affects the maximum recovery of the FCR H-reflex is beneficial in the management of CR.

Still, it seems logical and it is generally accepted that ventro-flexion traction (especially for the lower cervical spine) is more beneficial in improving the nerve root function in CR due to effects on the intervertebral foramen. For example, Wainner and Gill[49] evaluated the nonsurgical treatment of cervical disc herniations with flexion distraction and reported that flexion distraction might be an effective therapy in the treatment of cervical disc herniation and improving neural function as indicated by a reduction of pain.

Though contradictory as it seems, we found that the extension position of cervical spine (5° extension) was the position that achieved the maximum improvement in the novel cervical traction method. The selection of 5 degree cervical extension as the optimal traction angle is correlated well with Harrison et al who stated that "slight extension is the preferred position of the spine as far as adverse mechanical stresses and strains in the CNS are concerned."[22] It is possible that clinicians have misconstrued the reports of canal narrowing in extension by not reading the extremely small values reported during slight extension of less than 1 mm of narrowing, which is insignificant.[22]

The biomechanics of the nervous system may possibly explain the significant improvement after the novel cervical traction method. This explanation makes sense and agrees with the concept of Brieg [19] who postulated that the cord and nerve root fold and relax in the extension position and the vessels increase in cross section during flexion. As a result, there is an adverse mechanical tension in which the nerve root sleeves unfold and become taut, and the blood vessels are constricted. Neurophysiologically, this concept was further supported by Sabbahi and Abdulwahab who reported that "All head positions, except flexion, facilitated the H-reflex".[43,48]

The amount of compressive force and tension in the nerve root were increased with flexion of the spine and decreased with extension of the spine.[22–24] This tension and compression may adversely affect the CNS and nerve root function because of the absence of the perineurium, which is the primary load carrying structure.[49] The observations of Abdulwahab and Sabbahi [50] also correlate well with this mechanical explanation. These authors found that neck retraction appeared to increase the H-reflex amplitude in patients with radiculopathy, whereas the opposite effect was found with cervical flexion posture.

Similarly, Harrison et al stated that "flexion, specifically prolonged flexion, is bad for the spine, especially in pathologic conditions."[22] The positive role of extension position in normalizing neural function was supported by McKenzie's protocol in centralizing the pain.[51] Several other related studies, while pertaining to lumbar area, have also highlighted the role of extension traction in improving the nerve root function and reducing pain.[52,53]

The biomechanics of vascular system may be another possible explanation for the favorable results of extension position. It is postulated that the blood vessels of the dorsal and ventral roots will deform with postural changes. The radicular and medullary arteries and veins will be under tension and thus narrowed with an increase in spinal canal length (flexion) and will be relaxed in the extended posture of the pons-cord tract.[19,54]

Mechanically though, it seems logical and is generally accepted that the loss of cervical lordosis is usually accompanied with axial or ventroflexion traction.[25] When the cervical spine is put into flexion, it has been shown that axial rotation increases dramatically, thus putting more torsional strain upon the annuals fibrosis, resulting in possible herniation and excess strain on spinal ligaments.[55] Extension cervical traction has not been shown to cause any of the above problems due to the lack of axial loading on the spine. Moreover, it has been shown that the use of extension cervical traction is essential in the treatment to restore lordotic cervical curve.[56]

In contrast to the current results, the efficacy of the extension position for treating CR is questioned in many studies.[27,28,57,58] Eubanks[57] reported that cervical spine extension significantly decreases the foraminal size and consequently increases nerve root pressure and radicular symptoms. Segmental stenosis as a direct result of hyperextension was supported by Lian-shun et al.[58] The conflicts found in the results by the previous and the current authors regarding nerve root function and flexion vs. extension traction can be explained in two ways. Previous studies have referred to an increase in the volume of the intervertebral foramen as a direct cause of decompression while simultaneously disregarding the adverse mechanical tension and shear experienced by the spinal cord and nerve roots. The second reason explaining the above conflict is that certain studies[27,28] ignored the fact that the nucleus pulposus behaves differently in normal versus degenerated discs.[59]

Limitations

Our analysis has potential limitations. The primary limitation was the lack of blinding. Every effort was made to standardize treatment and assessment protocols to minimize the potential bias from a lack of blinding. Blinding an independent outcomes assessor is highly recommended for future research.

The lack of random sampling of the population could be a limitation for the trial. Additionally, no attempt was made to control for medications taken by participants, which included opioid and non-opioid analgesics and non-steroidal anti-inflammatory drugs. However, medication use was similar at baseline, and the only difference was found at 1-year follow up. Additionally, it should be emphasized that this study was exclusively concerned with chronic CR and therefore no statement whatsoever can be made about the potential role of the investigated regimens in treating acute disorders. The study would naturally have been stronger with the inclusion of a no-treatment (control) group. However, this was not considered ethical or practicable with the study design chosen. Another limitation is that the selection of patients was limited to those with a C6 and/or C7 root lesion. Apart from the fact that the sixth and seventh roots are among the most common roots involved in cervical radiculopathy, the FCR H-reflex is known to be helpful only in the detection of C6 or C7 radiculopathy. Further studies can be taken up with different clinical outcome parameters for pain, hand grip strength and function.

As well, with the interpretation of the results, statistical significance does not always imply clinical significance. Therefore, this needs to be considered when interpreting the results.

Within these limitations, the unique contribution of our study is that it suggests that the addition of a novel mechanical cervical traction method to a multimodal treatment program may benefit patients with chronic discogenic CR. However, further clinical outcome and biomechanical studies are warranted to confirm these findings.

Conclusions

The results of this study suggest that a combination of novel cervical traction method (FCR H-reflex-based traction) and a multimodal program in the form of physical pain relief methods (infrared, interferential therapy, and massage), muscle strengthening via isometric contraction of flexor and extensor muscles, and thoracic spine manipulation may have short- and long-term positive effects on NDI, neck pain, arm pain, and the amplitude and latency of the FCR H-reflex in patients with chronic discogenic CR.

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No funding sources or conflicts of interest were reported for this study.

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