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Which is better to decompress the nerve roots in cervical radiculopathy: stretching or traction from foraminal opening position?

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Abstract

Introduction. Cervical traction has long been used to relieve compression of nerve roots caused by intervertebral discs. Yet, there is lack of knowledge on comparing the effect of traction decompression with neck muscle stretching in patients with cervical radiculopathy (CR). This study investigated the effect of different angles of decompression on the flexor carpi radialis H-reflex, Neck Disability Index (NDI), and pain level (determined with the visual analogue scale) in patients with CR and compared the results with neck muscle stretching.

Methods. Overall, 58 patients with CR were randomly assigned to 4 groups. Group A received a stretching protocol to the cervical musculature. Group B was treated with traction therapy from neutral position with rope angle 0°. Group C underwent traction therapy from 30° lateral bending toward the side opposite to radiculopathy. Group D was managed with traction from 15° flexion with 30° lateral bending to the side opposite to radiculopathy and 15° rotation toward the side of radiculopathy. All participants were assessed before and after 6 weeks of treatment.

Results. Mixed design MANOVA revealed that the H-reflex increased significantly ($p < 0.05$) after treatment in groups A, B, and D. However, it increased non-significantly in patients within group C. NDI and pain scores decreased significantly after treatment in all tested groups.

Conclusions. Decompression traction from retracted neutral position with 0° rope angle and foraminal opening directions is as effective as stretching of ipsilateral neck muscles in enhancing nerve root decompression and reducing pain in patients with CR.

Key words: stretching, cervical radiculopathy, traction decompression, H-reflex, Neck Disability Index

Introduction

Cervical radiculopathy is a pain and/or sensorimotor deficit syndrome caused by compression of a cervical nerve root. The compression can occur because of disc herniation, spondylosis, instability, trauma, or, rarely, tumours. Patient presentations range from complaints of pain, numbness, and/or tingling in the upper extremity to electrical-type pains or even weakness [1]. Management of cervical radiculopathy can be surgical or conservative. There is low-quality evidence that surgery may provide pain relief faster than physical therapy or hard-collar immobilization in cervical radiculopathy, but there is little or no difference in the long-term [2].

Cervical traction consists in administering a distracting force to the neck to separate the cervical segments and relieve the compression of nerve roots by intervertebral discs. It is commonly used to treat patients with cervical radiculopathy. However, a systematic review stated that no conclusions could be drawn about the efficacy of cervical traction because of the poor methodologic quality of the available data [3, 4].

Identifying the effect of cervical traction decompression and the proper traction decompression angles that significantly influence the Hoffmann's reflex (H-reflex) in patients suffering from internal disc disruption at the lower cervical spine will provide the researcher and clinician with potential intervention priorities for cervical discogenic radiculopathy rehabilitation programs. The H-reflex is a valuable electrodiagnostic technique for assessing nerve conduction through the entire length of afferent and efferent pathways, especially at the proximal segment of the peripheral nerve, and for evaluating neurophysiological changes in compressed nerve roots and efficacy of some of non-surgical managements in patients with radiculopathy [5].

The identified angles could then be targeted with treatment methods known to positively affect the proper use of traction decompression within cervical disc physical therapy interventions. For the clinician, it is hoped that they will incorporate such information to understand the effect of different decompression angles, so that efficient rehabilitation strategies can be developed.

So, this study was conducted to assess the effects of traction decompression and stretching exercise on the H-reflex, Neck Disability Index (NDI), and visual analogue scale (VAS) pain score in patients with internal disc disruption at the lower cervical spine.

Subjects and methods

The study was conducted in outpatient physical therapy clinics and electrophysiological study laboratories.

Patient selection

A purposive sample of 58 patients with C5–C6 and C6–C7 paramedian disc protrusion participated in the study. Their mean ± standard deviation (*SD*) age, body mass, and height

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were 35.05 ± 7.43 years, 72.84 ± 12.14 kg, and 169.32 ± 10.35 cm, respectively. They were randomly assigned to 4 groups by using statistical random tables. Group A included 15 patients who received a stretching protocol to the cervical musculature at the side of symptoms. Group B included 15 patients who were treated with traction therapy from neutral position with rope angle 0°. Group C (14 patients) underwent traction therapy from 30° lateral bending toward the side opposite to radiculopathy. Group D (14 patients) was managed with traction from 15° flexion with 30° lateral bending to the side opposite to radiculopathy and 15° rotation toward the side of radiculopathy. All individuals were asked to stop medical treatment until the follow-up measurements.

All participants had C5–C6 and C6–C7 paramedian disc protrusion manifested by unilateral symptoms in the C6–C7 roots dermatome and myotomes of the upper extremities. They had been diagnosed with cervical disc protrusion (C5–C7) for at least 3 months. The diagnosis was confirmed by physical and neurological examination, as well as radiological assessment by magnetic resonance imaging (MRI). All patients had a second grade of disc bulge (2–3 mm), which was detected with T_2 axial view of MRI.

Individuals were excluded from the study if they had upper cervical spine disc pathology, cord compression and upper motor neuron symptoms, curvature abnormalities of the neck including reversed curve (kyphosis) and deformities, cervical rib syndrome, double crush syndrome, diabetic neuropathy, text neck (defined as an overuse syndrome involving the head, neck, and shoulders, usually resulting from excessive strain on the spine from looking in a forward and downward position, also known as forward neck posture), short neck (Churchill's neck), marked facet joint, neuro-central joint arthropathic pathology, or osteoporosis.

Instrumentation

An electromyography system (Neuro-MEP-Micro) was used to record the flexor carpi radialis (FCR) H-reflex for all patients in all groups before and after treatment (Figure 1). VAS was applied to assess pain intensity before and 6 weeks after treatment in all participants. VAS is a valid and reliable tool for pain assessment [6]. The level of disability was indicated with NDI. According to Vernon and Mior [7], the NDI developers, the index is the most widely used and most strongly validated instrument for assessing disability in patients with neck pain. NDI consists of 10 sections; for each

Figure 1. Neuro-MEP-Micro version 2009

Figure 2. Triton® DTS traction unit model 2841 with surface electromyography

Figure 3. (A) Traction unit, (B) traction rope, and (C) Saunders head halter, head support

section, the total possible score is 5. If the first statement is marked, the section score equals 0; if the last statement is marked, the score equals 5. The patients were asked to choose the best description of their current state. When all 10 sections were completed, the score was calculated by dividing the obtained score by the total score, e.g. if the score recorded by a patient was 40, then NDI = $\frac{40}{50} \times 100$. In the current study, a Triton decompression system was used to apply traction force on the cervical vertebrae in patients within groups B, C, and D. The instrument consists of a Triton decompression traction unit and a QuikWrap^{TM} belting system (Figures 2 and 3).

Procedure

This study comprised 3 phases: preparatory and initial assessment, treatment, and re-assessment.

Preparatory and initial assessment phase

Upon arrival to the clinic, a brief orientation session on the nature of the study, the used equipment, and the tasks to be achieved was provided to each patient. Neurological and radiological assessment was performed in each participant to identify the level and direction of disc prolapse. Provocative tests were conducted to confirm the presence of radiculopathy and to check out the inclusion and exclusion criteria. A recording data sheet was filled in for each individual. Finally, each patient was randomly assigned to one of the 4 tested groups by using simple type of randomization techniques.

The skin was prepared for stimulating and recording by abrading the areas with a fine sandpaper and cleansing with alcohol. Electrodes with conductive gel were then applied to the appropriate locations and secured in place with adhesive tapes during the recording session.

FCR H-reflex recording has been shown to be a useful electrophysiological measure for evaluating C6–C7 radiculopathies [8]. The stimulating electrode was placed on the median nerve 3 cm proximally and 2 cm laterally to the medial epicondyle at the septum between brachialis and biceps brachii, with 1 muscle pulse at 0.2 pulse per second (Figure 4).

The recording electrode was placed over the belly of the FCR to record the H-reflex amplitude and M-wave (the early response that occurs 3–6 ms after the onset of stimulation) of the muscle, with the active electrode approximately over the FCR motor point and the reference electrode 2 cm laterally to it. A 2-cm (diameter) round metal ground electrode

Figure 4. Flexor carpi radialis H-reflex electrodes placement

was placed on the lateral aspect of the cubital fossa between the stimulating and recording electrode sites.

After the application of the electrodes, each patient's FCR H-reflex amplitudes were recorded in a relaxed sitting position. The participants were instructed to relax the forearm and keep the head in a neutral position during the recordings. Each patient was seated upright with the forearm rested on a pillow and the elbow slightly flexed while maintaining the forearm in supination. Electrical stimulation was applied to the median nerve at the arm, and 4 traces were recorded for each condition. The peak-to-peak amplitudes of the 4 FCR H-reflex traces were measured and averaged for each individual (Figure 5). Then, VAS was used to assess the intensity of the perceived pain. After that, NDI was applied to determine the level of disability in all patients.

Treatment phase

Stretching group (group A)

A stretching protocol to the cervical musculature at the side of symptoms was implemented. These muscles included the scalene muscles group (anterior, middle, and posterior fibres) (Figures 6–8) and the upper trapezius (Figure 9). Stretching was performed toward the pain-free side, maintained for 30 s, and repeated 3 times for each muscle; each session lasted for 15 min. The patients received 3 sessions of the stretching protocol per week. A pre-stretch isometric contraction (the hold-relax procedure) was applied to relax the

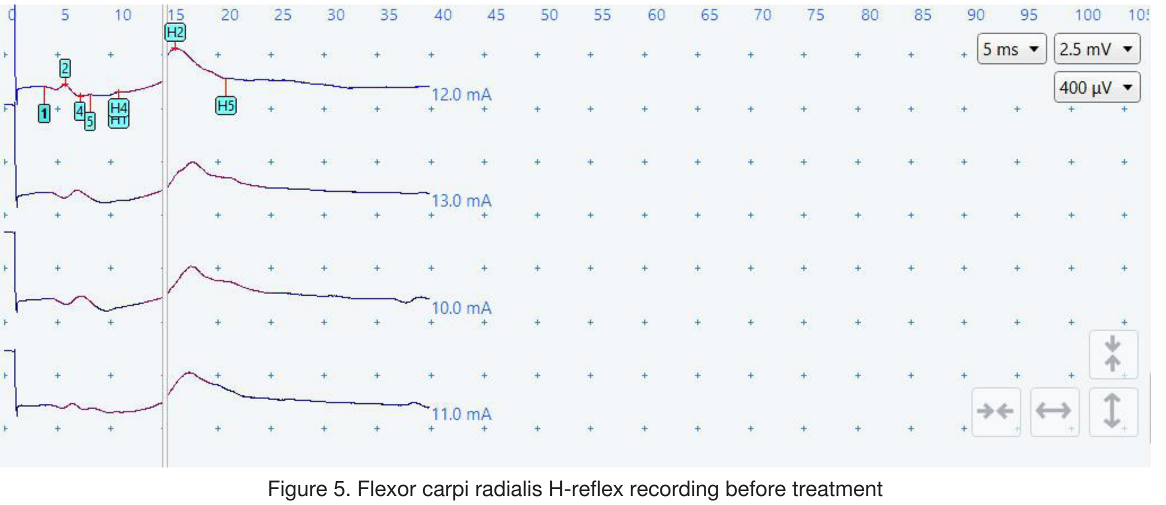

Figure 5. Flexor carpi radialis H-reflex recording before treatment

Figure 6. Stretching of the middle fibres of scalene muscles

Figure 8. Stretching of the posterior fibres of scalene muscles

Figure 10. Suboccipital myofascial release

Figure 7. Stretching of the anterior fibres of scalene muscles

Figure 9. Stretching of the upper fibres of the trapezius muscle

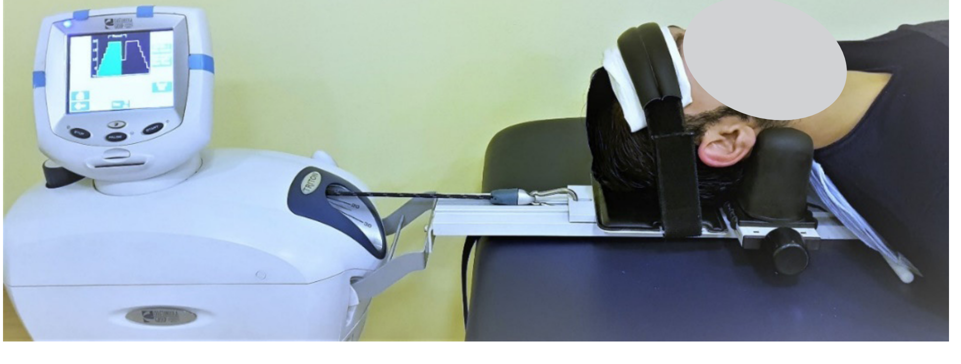

Figure 11. Traction decompression with rope angle 0°

muscle reflexively prior to stretching. Low-intensity stretch in a slow, sustained manner was performed. Patients in all groups also received suboccipital myofascial release (Figure 10). The myofascial release for the suboccipital area was applied with 3 repetitions, each lasting for 30 s, with the therapist's hands carrying the patient's head and the fingertips positioned under the occipital condyles, then fanning laterally and applying mild distraction force.

Traction decompression groups (groups B, C, and D)

Group B. Patients received traction from a neutral head position, with rope angle 0°. Intermittent traction was applied, maximum force was 16 kg, minimum force was 12 kg, the traction cycle of each minute consisted of 20-second static traction at the maximum force, then released down to the minimum force for 20 s, then the 20-second static traction was repeated. The traction session time was 15 min, and the traction force increased progressively with speed (50%) of increment of force (Figure 11).

Group C. Patients received traction while the head was in 30° lateral bending to the pain-free side. The same traction parameters as in group B were used (Figure 12).

Group D. Each patient received traction while the head was in 15° flexion, 15° rotation toward the painful side, and 30° lateral bending toward the pain-free side. The same traction parameters as in group B and group C were used (Figure 13).

All patients in the 4 groups were instructed and trained to perform a home program, which included general neck and shoulder girdle strengthening and stretching exercise as follows: (1) retracted neck extension from a prone position with scapular retraction and arm extension while externally rotated; (2) neck extension with a retracted position from a sitting position and mild self-leading resistance; (3) stretching to the ipsilateral neck muscle toward the pain-free side. The participants were instructed to perform all these exercises with 2 sets of 10 repetitions twice daily.

Re-assessment phase

The same whole procedure of the initial assessment was repeated to measure the H-reflex, NDI, and VAS pain scores after 6 weeks of treatment.

Statistical analysis

The statistical analysis was conducted with the Statistical Package for the Social Sciences (SPSS), version 20. Data were initially screened for the normality assumption as a prerequisite for parametric analysis. This was conducted through assessing for the presence of significant Kolmogorov–Smirnov and Shapiro–Wilk normality tests results and significant skewness and kurtosis in addition to the presence of extreme scores. Once data were found not to violate the normality assumptions, parametric analysis was performed. Mixed design multivariate analysis of variance (MANOVA) was used to differentiate between the 4 tested groups for the H-reflex, NDI, and VAS pain scores at both assessment time points. The level of significance was set at an alpha value of 0.05.

Before starting the test procedures, a pilot study was conducted to determine the appropriate sample size. The power analysis employed a power analysis equation at a significance level of 5% and a test power of 80%. The main outcome measure used in the power analysis was the H-reflex. The power analysis revealed that a minimum sample size of 48 participants was required for the study (12 in each group).

Figure 12. Traction decompression from 30° lateral bending

Figure 13. Traction decompression from 30° lateral bending, 15° flexion, and 15° rotation

Results

This study was conducted in 4 groups of a total of 58 patients with cervical radiculopathy (because of C5–C6 cervical disc prolapse) to examine the effect of different decompression angles and a stretching protocol on the H-reflex, VAS pain score, and NDI. It was intended to compare the tested variables before and after treatment and among the 4 tested groups.

The recorded mean ± *SD* scores of the H-reflex before and after treatment were 0.74 ± 0.42 / 1.10 ± 0.31; 0.88 ±

0.37 / 1.22 ± 0.39; 1.05 ± 0.41 / 1.12 ± 0.35; and 0.95 ± 0.38 / 1.32 ± 0.34 mV for groups A, B, C, and D, respectively. The mixed design MANOVA revealed that there were significant within-subject effects ($F = 63.150$, $p = 0.000$) and non-significant between-subject effects ($F = 0.956$, $p = 0.42$) for the H-reflex.

The subsequent multiple pairwise comparison tests showed that the H-reflex values increased significantly after treatment compared with initial pre-treatment values ($p < 0.05$) in groups A, B, and D. Moreover, the H-reflex post-treatment values increased non-significantly in patients within group C. Furthermore, there were no significant differences ($p > 0.05$) among the 4 tested groups in the mean values of H-reflex at both assessment time points (before and after treatment) (Table 1).

Regarding the VAS pain score, the recorded mean ± *SD* scores of the pre- and post-treatment assessments were 4.53 ± 1.35 / 1.73 ± 1.22; 4.93 ± 1.03 / 1.20 ± 0.77; 4.78 ± 1.42 / 1.92 ± 1.14; and 5.14 ± 0.77 / 1.50 ± 0.94 for groups A, B, C, and D, respectively. The mixed design MANOVA revealed that there were non-significant between-subject effects ($F = 0.376$, $p = 0.77$) and significant within-subject effects ($F = 337.99$, $p = 0.000$) for the VAS pain score.

The subsequent multiple pairwise comparison tests demonstrated that the VAS pain score decreased significantly after treatment compared with the pre-treatment assessment scores in all tested groups ($p < 0.05$). In turn, there were non-significant differences in the mean values of the pre-treatment, as well as the post-treatment assessments of VAS pain scores among all tested groups ($p > 0.05$). Table 2 shows the above findings.

Concerning NDI, the recorded mean ± *SD* scores of the pre- and post-treatment assessments were 31.74 ± 10.93 / 14.92 ± 5.45; 36.88 ± 12.87 / 13.95 ± 6.18; 34.98 ± 12.34 / 17.10 ± 7.66; and 41.09 ± 9.61 / 19.15 ± 10.49 for groups A, B, C, and D, respectively. The mixed design MANOVA revealed that there were significant within-subject effects ($F = 159.75$, $p = 0.000$) and non-significant between-subject effects ($F = 1.946$, $p = 0.133$) for NDI.

The subsequent multiple pairwise comparison tests demonstrated that NDI decreased significantly ($p < 0.05$) after treatment compared with pre-treatment values in groups A, B, C, and D. Moreover, the multiple pairwise comparison tests confirmed the previous results for the comparison among the 4 tested groups. These tests showed that there were no significant differences in the mean values of NDI among the 4 tested groups regarding the pre-treatment or post-treatment assessment scores ($p > 0.05$). These findings are presented in Table 3.

With regard to the interaction between the 2 independent variables, there was a significant interaction between the tested groups and the time of assessment for the H-reflex only ($F = 3.86$, $p = 0.014$). The significant interaction means that the effect of different tested groups on the mean values of H-reflex was influenced by the assessment time.

In turn, the interactions between the 2 independent variables for the VAS pain score and NDI were non-significant ($F = 1.98$, $p = 0.127$ and $F = 0.918$, $p = 0.439$, respectively). This means that the effect of different tested groups on the mean values of VAS and NDI was not influenced by the assessment time.

Discussion

The present study was performed to examine the effect of different decompression system angles on the H-reflex, NDI, and VAS pain score in patients with C5–C6–C7 disc protrusion and to compare the results with those obtained by

Table 1. Descriptive statistics, mixed design multivariate analysis of variance (MANOVA), and multiple pairwise comparison tests of the H-reflex among the 4 tested groups before and after treatment in patients with cervical radiculopathy

H-reflex (mean ± *SD*)							
Stretch group (A)		Rope angle 0° (B)		Lateral bending 30° from rope angle 0° (C)		Lateral bending 30° + flexion 15° + rotation 15° (D)	
pre	post	pre	post	pre	post	pre	post
0.74 ± 0.42	1.10 ± 0.31	0.88 ± 0.37	1.22 ± 0.39	1.05 ± 0.41	1.12 ± 0.35	0.95 ± 0.38	1.32 ± 0.34

Mixed design MANOVA		
Within-subject effects	$F = 63.150$	$p = 0.000$*
Between-subject effects	$F = 0.956$	$p = 0.42$
Interaction	$F = 3.86$	$p = 0.014$*

Multiple pairwise comparison tests												
	pre						post					
Group	1 vs. 2	1 vs. 3	1 vs. 4	2 vs. 3	2 vs. 4	3 vs. 4	1 vs. 2	1 vs. 3	1 vs. 4	2 vs. 3	2 vs. 4	3 vs. 4
p	1.000	0.288	1.000	1.000	1.000	1.000	1.000	1.000	0.589	1.000	1.000	0.845
Pre vs. post	group A						$p = 0.000$*					
	group B						$p = 0.000$*					
	group C						$p = 0.327$					
	group D						$p = 0.000$*					

* significant at alpha level < 0.05

Table 2. Descriptive statistics, mixed design multivariate analysis of variance (MANOVA), and multiple pairwise comparison tests of the visual analogue scale (VAS) pain score among the 4 tested groups before and after treatment in patients with cervical radiculopathy

VAS pain scores (mean ± *SD*)							
Stretch group (A)		Rope angle 0° (B)		Lateral bending 30° from rope angle 0° (C)		Lateral bending 30° + flexion 15° + rotation 15° (D)	
pre	post	pre	post	pre	post	pre	post
4.53 ± 1.35	1.73 ± 1.22	4.93 ± 1.03	1.20 ± 0.77	4.78 ± 1.42	1.92 ± 1.14	5.14 ± 0.77	1.50 ± 0.94

Mixed design MANOVA		
Within-subject effects	$F = 337.99$	$p = 0.000$*
Between-subject effects	$F = 0.376$	$p = 0.77$
Interaction	$F = 1.98$	$p = 0.127$

Multiple pairwise comparison tests												
	pre						post					
Group	1 vs. 2	1 vs. 3	1 vs. 4	2 vs. 3	2 vs. 4	3 vs. 4	1 vs. 2	1 vs. 3	1 vs. 4	2 vs. 3	2 vs. 4	3 vs. 4
p	1.000	1.000	1.000	1.000	1.000	1.000	0.982	1.000	1.000	0.380	1.000	1.000
Pre vs. post	group A						$p = 0.000$*					
	group B						$p = 0.000$*					
	group C						$p = 0.000$*					
	group D						$p = 0.000$*					

* significant at alpha level < 0.05

Table 3. Descriptive statistics, mixed design multivariate analysis of variance (MANOVA), and multiple pairwise comparison tests of the Neck Disability Index among the 4 tested groups before and after treatment in patients with cervical radiculopathy

Neck Disability Index (mean ± *SD*)							
Stretch group (A)		Rope angle 0° (B)		Lateral bending 30° from rope angle 0° (C)		Lateral bending 30° + flexion 15° + rotation 15° (D)	
pre	post	pre	post	pre	post	pre	post
31.74 ± 10.93	14.92 ± 5.45	36.88 ± 12.87	13.95 ± 6.18	34.98 ± 12.34	17.10 ± 7.66	41.09 ± 9.61	19.15 ± 10.49

Mixed design MANOVA		
Within-subject effects	$F = 159.75$	$p = 0.000$*
Between-subject effects	$F = 1.946$	$p = 0.133$
Interaction	$F = 0.918$	$p = 0.439$

Multiple pairwise comparison tests												
	pre						post					
Group	1 vs. 2	1 vs. 3	1 vs. 4	2 vs. 3	2 vs. 4	3 vs. 4	1 vs. 2	1 vs. 3	1 vs. 4	2 vs. 3	2 vs. 4	3 vs. 4
p	1.000	1.000	0.200	1.000	1.000	1.000	1.000	1.000	0.847	1.000	0.433	1.000
Pre vs. post	group A						$p = 0.000$*					
	group B						$p = 0.000$*					
	group C						$p = 0.000$*					
	group D						$p = 0.000$*					

* significant at alpha level < 0.05

using an ipsilateral neck muscle stretching protocol. A total of 58 patients with cervical radiculopathy participated in the study. They were randomly assigned to 4 groups. Patients within group A received a stretching protocol to the cervical musculature at the side of symptoms. Individuals in groups B, C, and D received traction therapy (Triton DTS) from different angles. Group B was treated with traction therapy from neutral position with rope angle 0°. Group C underwent traction therapy from 30° lateral bending toward the side opposite to radiculopathy. Group D was managed with traction from 15° flexion with 30° lateral bending and 15° rotation toward the painful side.

The findings of the current study revealed a significant increase in the FCR H-reflex amplitude with applying traction decompression from foraminal opening position, especially when using multi-axis decompression traction, as in group D and in group B. The significant improvements reported after mechanical traction for the cervical spine are suggested to have resulted from the physiological effects of mechanical traction. These include separation of the vertebral bodies, movement of facet joints, expansion of intervertebral foramen (IVF), and stretching of soft tissue, which were already reported by Graham et al. [3] and suggested to be the rationale for relieving the nerve root compression.

Maximum distraction of apophyseal joints depends on the combination of multiple factors, including traction force, as well as time and angle of cervical traction [9]. It was found that therapeutic traction increased IVF area and height (18.9% and 10.4% increases, respectively, with 15-kg traction weight) [10]. Additionally, ipsilateral axial rotation of 20° and 40° resulted in foraminal narrowing of up to 15% and 23%, respectively, and contralateral axial rotation of 20° and 40° led to foraminal widening of up to 9% and 20%, respectively [11].

In the same context, the effect of traction on the intervertebral space (with varying cervical spine postures) has been evaluated by several authors. Wong et al. [12] noted that the anterior and posterior intervertebral spaces were increased by traction from a neutral position and with 30° of flexion. The increase in the intervertebral space occurred especially in the C4–C5 disc (12%) in the neutral position and in the C2–C3 disc with 30° of flexion. The posterior intervertebral space mainly increased near the C6–C7 disc (37%) in the neutral position and the C6–C7 (20%) and C5–C6 (19%) discs with 30° of flexion. Hseuh et al. [13] reported the greatest enlargement of the posterior intervertebral space with 30° of flexion for the C4–C5 and C5–C6 discs and with 35° of flexion for the C6–C7 and C7–T1 discs.

The biomechanics of the nervous system may also explain the significant improvement that was found after cervical traction therapy from neutral position with rope angle 0° (as in group B). This explanation agrees with the concept stated by Breig [14], who postulated that the cord and nerve root folded and relaxed in the neutral position and the vessels increased in cross-section during flexion. As a result, an adverse mechanical tension occurs in which the nerve root sleeves unfold and become taut, and the blood vessels are constricted. Vaughn et al. [15] applied cervical traction with 0° and 30° of cervical spine flexion in 20 volunteers. They observed a significantly greater increase in the anterior intervertebral space for all cervical spine segments with 0° of flexion compared with 30° of flexion. The increase in the posterior intervertebral space was also significant.

The findings of the current study confirm those reported by Abdulwahab and Sabbahi [16] that correlate well with this mechanical explanation. Those authors implied that neck retraction appeared to increase the H-reflex amplitude in patients with radiculopathy, whereas the opposite effect was observed with cervical flexion posture. 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 [16]. This tension and compression may adversely affect the central nervous system and nerve root function because of the absence of the perineurium, which is the primary load carrying structure [17]. Abdulwahab and Sabbahi [16] also concluded that the traction could decompress the blocked and irritated small axons, which might result in FCR H-reflex amplitude recovery, and that reduction in the radicular symptoms after traction could support the possibility of decompression of the compromised nerve root.

Similarly, Morishita et al. [18] reported that the H-reflex amplitude was modulated by the variations in IVF diameter. The effect of increasing the IVF diameter and decreasing the amount of disc bulge should provide further significant facilitation of the H-reflex amplitude. In the present study, the amplitude of H-reflex was the measured variable and not the latency. Chen et al. [19] stated that the H-reflex amplitude was sensitive to changes of the magnitude of compressive force over the nerve roots. H-reflex latency does not reflect the degree of nerve root compression or decompression. The authors of this study indicated that the latency reported in some patients who had evidence of nerve root compression was within normal limits. It could be due to sparing of some functional large diameter axons with normal conduction velocity.

In the current study, the FCR H-reflex measurements were conducted from a sitting position, which was also reported by Zheng et al. [20], who found that the FCR H-reflex used for the diagnosis of cervical radiculopathy should be tested in loading conditions. Abdulwahab and Sabbahi [16] observed that any variation in the spinal load and the resulting compression/decompression forces on the nerve roots might be detected by the amplitude of H-reflex. The higher amplitude indicated less spinal load and compressive force over the nerve root in IVF. This may explain the nerve root decompression effect of traction and the recovery of the compromised H-reflex in this study.

In a study conducted by Khan et al. [9], it was concluded that FCR H-reflex could be useful in the diagnosis of root lesions. The probability of abnormal FCR H-reflex in a C7 root lesion is higher than that of a C6 root lesion. Moreover, Christie et al. [8] examined the intraclass reliability of the latency and amplitude of FCR H-reflex. The researchers assessed the stability and consistency of the latency and peak-to-peak amplitude of the H-reflex across 4 test sessions. They implied that H-reflex could be easily evoked in FCR and that the latency and amplitude of these recordings were highly reliable.

The demonstration that the H-reflex can be easily and consistently evoked in FCR has important clinical implications. The H-reflex amplitude recording presents high intersession and intrasession reliability. There are several factors that could affect the consistency of recordings, such as postural instability, electrode location, fatigue, mood, joint position, and muscle activity. Controlling these factors would increase the reliability of measurements. In previous reports, Hopkins et al. [21] and Mynark [22] suggest that 4–5 measurement trials are sufficient to obtain reliable results. Chen and Zhou [23] found that several representative traces were important for clinical decision making. Earlier studies indicated that 4 traces were the fewest needed to determine amplitude depression or recovery.

The biomechanics of vascular system may be another possible explanation for the results obtained in group B. It is suggested that the blood vessels of the dorsal and ventral roots 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 neutral posture [24].

In the present study, traction was applied from 15° of flexion among patients in group D. During full flexion and compression, posterior annulus fibres are prone to degenerate under tensile stress and an annular tear may lead to mechanical neck pain. Wong et al. [5] found that greater stress was observed on the posterior annulus fibres at the levels C4–C5, C5–C6, and C6–C7 during loaded neck flexion traction. To minimize the potential harm to soft tissues, it may be advisable to gradually increase the traction force and decrease the maximum force, in accordance with the targeted level.

A computed tomography study conducted by Sari et al. [25] confirmed the biomechanical effect of traction on the cervical spine from C2 to C7. It showed an elongation of 1.39 mm, a reduction in disc protrusion, and an increase in medullar canal surface area of 11.21 mm^2. MRI has been used to assess the effect of cervical traction in 25° of flexion posture and revealed complete resolution or significant reduction of disc protrusion in 72% of cases with a load of 13.6 kg [25].

In a cadaver study using computed tomography, Humphreys et al. [26, 27] reported that flexion alone or with traction significantly increased the foraminal area. They maintain, however, that the changes in cadaveric specimens may not accurately reflect the changes occurring *in vivo*.

As the normal curvature of the cervical spine is lordotic, in the case of flexion, bony factors play a major role in the increase in the foraminal area. In turn, traction is dependent mainly on the dynamic state of the soft tissues (ligaments, capsule, and intervertebral disc) and if they are not present in their normal physiological status, accurate measurements may not be obtained. Secondly, the age of the cadaveric specimens was in the higher range (65–80 years) compared with the younger age group (25–48 years) in the present study. These factors might explain the outcome differences regarding this study. The information obtained from this study can be used as a guide to improve the effectiveness of conservative treatment in patients with degenerative diseases of the cervical spine.

In the current study, the applied mechanical traction force was up to 16 kg. This was based on a study by Liu et al. [10], who used MRI to assess the effect of traction on the neural foramen between the 2nd and 7th cervical vertebrae. This was performed in the supine position with a neutral cervical spine posture and led to an increase in the height of the foramen (averaging 3.75, 8.67, and 10.43% for consecutive weights of 5, 10, and 15 kg). The increase in the foramen surface area averaged 5.81, 16.56, and 18.9% for the same series of loads.

During traction, the related soft tissues, including annulus fibres and ligaments, were under tensile stress [18]. The intermittent traction therapies acted to decrease the intradiscal pressure at the C4–T1 levels while simultaneously changing the lordotic angle. So, intermittent traction was applied in present study, and the traction force increased progressively. Decreasing the intradiscal pressure is thought to be helpful for retracting prolapsed discs [18], improving nutrient transport, and altering the chemical environment of nociceptors in the outer layers of annulus fibrosus [9]. A study performed by Wong et al. [12] showed that the mean intradiscal pressure was 0.125 MPa at C4–T1 levels under 100-N traction force. The previously reported widening of disc space during traction may decrease pressure and stretch the anterior and posterior longitudinal ligaments [20]. This may result in negative pressure within the disc space, which, in effect, sucks back the herniated nuclear substance and helps push the herniation back into place by stretching the posterior longitudinal ligament [21, 25].

In the present study, the traction was conducted in a lying position. As Jellad et al. [28] reported, when traction was conducted from a sitting posture, the subject was influenced by gravity and therefore muscle activity increased more than when traction was performed from a lying position or with head support. Moreover, Fater and Kernozek [29] noted that the space between intervertebral bodies increased more in a lying position than in a sitting position. The researchers concluded that the supine position was the more beneficial one as it allowed the soft tissues and muscles to be less tensed. This favours greater vertebral separation to relieve any compression on cervical spinal nerve roots, as well as the provoked pain and radicular symptoms. The supine position is also more comfortable and easier [9].

In the current study, significant reductions were revealed in pain intensity and disability in the 4 tested groups after treatment. In groups B, C, and D, this may be explained by the therapeutic effects of traction, as mentioned previously, as it unloads the components of the spine, stretches the muscles and ligaments, reduces the adhesions in the dural sleeves, and decompresses the nerve roots within the foramina, thereby alleviating distal symptoms [28, 29]. Additionally, it was suggested that traction relieved tonic muscle contractions, which improved the vascular status within the epidural space and perineural structures and decreased pain by providing muscle relaxation, stimulation of mechanoreceptors, and inhibition of reflex muscle guarding [30]. Traction also decreases pressure within the intervertebral discs. It is speculated that the negative intradiscal pressure occurring during traction might help reduce the herniated nuclear material [31].

When a muscle is stretched, the motor neuron receives both excitatory and inhibitory impulses from the receptors. If the stretch is continued for a slightly extended period, the inhibitory signals from the Golgi tendon organs eventually override the excitatory impulses and therefore cause relaxation [32]. This foundation would make stretching effective in this study for group A. The effect of stretching has been documented by several studies. Ylinen et al. [33] showed that both manual therapy and stretching were significantly effective short-term treatments for reducing neck pain.

Stretching the neck muscles at the painful side includes stretching of the scalene muscle group, stretching of the upper fibres of trapezius, and suboccipital myofascial release. During stretching of these muscle groups, the head and neck are needed to be moved toward lateral bending (away from the affected side). Lateral bending as a position rather than stretching direction causes foraminal opening and reduces the intradiscal pressure on the painful side, as confirmed by Muhle et al. [11], Sari et al. [25], Sato and Masui [34], and Nagib et al. [35].

There are numerous soft tissue structures surrounding the nucleus pulposus, including annulus fibrosus, anterior longitudinal ligament, and posterior longitudinal ligament. These tissues, along with other segmental ligaments, help stabilize the spine [36]. Chronic overstretching of these structures would inevitably lead to spinal instability and degeneration of the intervertebral discs, which may in turn cause mechanical and chemical irritation of the surrounding structures [37].

The current study was delimitated to the age range of 25–48 years. It was also restricted to cervical radiculopathy at the level of C5–C6–C7. As stated previously, cervical radiculopathy is a dysfunction of nerve roots of the cervical spine, with the C6 and C7 nerve roots most commonly affected [29]. In the younger population, it is a result of a disc herniation or an acute injury causing foraminal impingement of a given nerve. In older patients, cervical radiculopathy is often caused by foraminal narrowing from osteophyte formation, decreased disc height, as well as degenerative changes of the uncovertebral joints anteriorly and of the facet joints posteriorly [29].

Limitations

The limitations of the study are: (1) the inability to apply the findings to the elderly population; (2) the inability to control the daily living activities and work-related activities of each participant.

Conclusions

Applying traction decompression from foraminal opening positions has significant effects, as stretching the ipsilateral neck muscles, on the reduction of cervical radiculopathy. These effects were reflected in an improvement of FCR H-reflex amplitude and a reduction of the VAS pain score and the NDI score.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Research Ethics Committee of the Faculty of Physical Therapy, Cairo University (approval No.: P.T.REC/012/001780). ClinicalTrials.gov registration No.: NCT03888573.

Informed consent

Informed consent has been obtained from all individuals included in this study.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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