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Effects of myofascial release technique in patients with unilateral cervical radiculopathy: A single blind-randomized clinical trial

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ABSTRACT

Objective: The aim of this study was to investigate the effectiveness of the myofascial release technique in individuals diagnosed with unilateral cervical radiculopathy.
Materials and methods: Thirty-four cervical radiculopathy patients were randomly assigned to either the myofascial release group or the exercise group. Both groups received conventional treatment. Additionally, the exercise group performed stretching and strengthening exercises while the myofascial release group received the myofascial release technique. The pain pressure threshold, muscle strength, cervical range of motion, pain, and disability variables were assessed for all patients.
Results: The myofascial release group demonstrated significantly larger improvements in flexion ($p = 0.001$), extension ($p = 0.037$), left rotation ($p = 0.012$), and left lateral flexion ($p = 0.001$) range of motions compared to the exercise group. Muscle strength in the wrist flexors ($p < 0.001$), wrist extensors ($p < 0.010$), biceps ($p < 0.001$) and triceps ($p < 0.001$) were significantly higher in the myofascial release group compared to the exercise group. And, again, the myofascial release group demonstrated significantly larger improvements in wrist flexors ($p < 0.001$), wrist extensors ($p < 0.001$), biceps ($p < 0.001$), triceps ($p < 0.001$), pectorals ($p < 0.001$), subscapularis ($p < 0.001$), upper trapezius ($p = 0.002$), and the pain pressure threshold. Finally, the myofascial release group demonstrated statistically significant improvements in pain ($p < 0.001$) and disability ($p < 0.001$) scales compared to the exercise group.
Conclusion: Evaluation of the arm muscle strength and pain pressure threshold variables in patients with cervical radiculopathy may benefit clinicians in the preparation of treatments. Cervical radiculopathy symptoms may improve after the application of myofascial release techniques. A customized cervical exercise program and conventional treatment could be added to the non-surgical treatment of cervical radiculopathy.

Introduction

Cervical radiculopathy (CR) is a common clinical condition, resulting from the compression of cervical nerve roots, and is responsible for neck and unilateral upper limb symptoms and disability.[1] Patients diagnosed with CR commonly complain of pain in their neck and one arm, with a combination of sensory loss, motor function loss, or reflex changes in the affected nerve-root distribution.[2] A recent systematic review suggests that the prevalence of cervical radiculopathy ranges from 1.21 to 5.8 per 1000.[3] The economic burden of cervicobrachial pain was estimated at approximately 868 million US dollars per year, gradually increasing with each passing day.[4]

In patients diagnosed with cervical radiculopathy, the weakening of one myotomal set of muscles results in other muscles being recruited to perform the missing function. These compensatory muscles can then be overused, leading to injury, pain, and musculoskeletal problems. Thus, cervical radiculopathy can then lead to musculoskeletal conditions. Conversely, musculoskeletal conditions arising from poor posture and muscle contracture can lead to forces pulling on the cervical spine, narrowing facets, worsened arthritis with cervical spondylosis, dehydration or height reductions in discs, and the formation of bone spurs that contribute to the cervical spine degenerative cascade which causes foraminal stenosis. Thus, musculoskeletal conditions can lead to cervical radiculopathy.[5] Additionally, a systematic review of the upper limbs

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conducted in 2019 suggests the existence of fascial continuity between the cervical and shoulder region with the forearm.[6]

Fascia is a type of connective tissue that is divided into 3 layers: the superficial layer, a layer of potential space, and a deep layer. As the fibers of the fascia run in many directions, it is capable of moving and changing with the surrounding tissues.[7] Fascia is a unit connective tissue structure surrounding the whole body and is a continuous piece of connected tissue-like chains.[8] Therefore, when fascia in cervical area is stretched, it can cause tightness, restriction, and pain in upper extremities.[7] It has recently been purported that the innervation of the fascia with its potential nociceptive function may be considered a possible mechanism in musculoskeletal pain.[9]

To the best of our knowledge, there are no studies that have applied the myofascial release technique while simultaneously evaluating the pain pressure threshold of the upper extremities of cervical radiculopathy patients. Moreover, no studies regarding the effects of cervical exercises or the myofascial release technique on the strength of the arm muscles in patients diagnosed with cervical radiculopathy could be found. In the present study, primary outcome measures were chosen to be the pain pressure threshold, the cervical range of motion, and muscle strength measures, while the secondary outcome measures were perceived pain, function and disability. The purpose of the present randomized clinical trial was to assess the effectiveness of the myofascial release technique and to compare it with a cervical exercise program in patients diagnosed with unilateral cervical radiculopathy. This goal can be assessed through the main hypothesis:

H_0: Muscle strength, cervical range of motion, and pain pressure threshold scores of the MRT protocol group are similar to muscle strength, cervical range of motion, and pain pressure threshold scores of the exercise group.

H_1: Muscle strength, cervical range of motion, and pain pressure threshold scores of the MRT protocol group are greater than muscle strength, cervical range of motion, and pain pressure threshold scores of the exercise group.

Materials and methods

Design and subjects

A randomized clinical trial was conducted between October 2020 and May 2021, with a total of 34 volunteers with cervical radiculopathy. All patients were informed of the aims of the study and signed an informed consent form. The study was approved by the Istanbul Medipol University Ethics Committee. This randomized clinical trial was registered with ClinicalTrials.gov (NCT04597112) and followed the guidelines of Consolidated Standards of Reporting Trials (CONSORT).

The inclusion criteria comprised of the following: diagnosed with cervical radiculopathy, displaying unilateral arm symptoms at least for a month,[10] and both genders belonging to the age group of 30 to 65 years.[11] The diagnosis was made by the physician using magnetic resonance imaging techniques in addition to a physical examination. We excluded patients who had a tumor, osteoporosis, previous cervical surgeries,[12] cervical trauma, congenital torticollis, were pregnant,[11] were long-term users of corticosteroids, long-term users of nonsteroidal anti-inflammatory drugs, or received conventional or myofascial therapy in the past year.[13]

Randomization

Two physiotherapists conducted this study. One of these physiotherapists was responsible for the inclusion and assessment of the participants in the study. The assessor therapist was blinded of the group allocation. After assessment, sealed envelopes were given to patients. Patients were instructed not to disclose the group they had been assigned to. Afterwards, patients were directed to the physiotherapist who was responsible for the treatments, and the group assignment of the participants was carried out by opening the sealed envelope. Thirty-four participants with cervical radiculopathy were randomly assigned to either the MYO group ($n = 17$) or the EXR group ($n = 17$). 32-disc herniation patients and 2 spinal stenosis patients were randomly distributed into the aforementioned 2 groups as subgroup. G-power analysis suggested the inclusion of 17 participants per group for 80 % power. In order to account for the possibility of drop-outs, 20 participants were included in each group (Fig. 1).

Interventions

The EXR group received a conventional treatment respectively consisting of ultrasound (US), transcutaneous electrical nerve stimulation (TENS), and hot pack (HP). The conventional treatment applications were made based on The Neck Pain Clinical Practice Guidelines.[14] In addition to this conventional program, the EXR group also received an exercise program. Sessions were conducted three times each week for four weeks. Ultrasound (Chattanooga Intellect® Mobile US 92081, USA) was applied to the affected upper and middle trapezius muscle and the suboccipital region at an intensity of 1.5 W/cm^2 and a frequency of 1 MHz for five minutes using a probe with an effective radiating area of 4 cm^2. The application was performed in full contact and at an angle of 90 degrees.[15] Transcutaneous electrical nerve stimulation (Chattanooga, Theta 64900, Mauguerre, France) was applied to the upper and middle trapezius muscle area for 20 min with a frequency of 100 Hz.[11] The hot pack (Hydrocollator® HotPack 92081, USA) was wrapped in two layers of towels and placed on the patient's neck.[11]

In addition to conventional treatment, the EXR group was treated with the exercise program three times a week for four weeks. The exercise program was a customized protocol based on The Neck Pain Clinical Practice Guidelines and the McKenzie protocol.[14,16] In the exercise program, patients were asked to perform cervical extensions, right and left lateral flexions, right and left rotations, chin-tuck exercises, upper trapezius stretching, and cervical extensor muscle group isometric strengthening exercises. Each exercise was performed for 10 repetitions and a duration of 10 s at a sitting position. The resting period lasted 5 s between each repetition, and 30 s between exercises. Stretching exercises were performed at the point where the tension was felt, and the patient was pain-free. The strengthening exercise was performed at the point where the contraction was felt, and the patient was pain-free. Each session lasted approximately 20 min.

In addition to the conventional treatment, the MYO group was treated with the myofascial release technique three times each for four weeks. Each session lasted 20- 22 min. The treatment included four fascia lines of the arm: deep front arm fascia, superficial front fascia, deep back arm fascia, and superficial back arm fascia (Fig. 2). The applications were performed using petroleum jelly (Vaseline). The whole myofascial intervention was performed similarly to a classic massage, but more aggressively. The other differences from a massage were the positioning of the patient according to the application area and the following of fascia lines.

During sessions, the therapist kept anatomical structures in the extended position for each part. First, for the deep front arm line, the therapist positioned patients lying on their backs. The therapist then held the patient's hand and applied low amounts of pressure from distal to proximal by using his thumb. MRT started from the palmar surface of the patient's fingers and thumb, and then continued on the thenar muscles (Fig. 3a). In the radial periosteum, radial collateral ligaments, and biceps brachii application, the physiotherapist applied low-pressure with his fingertips at an angle of 45 -degrees to the skin. The therapist kept his phalangeal joints in extension during this application (Fig. 3b-3c). A pectoralis minor MRT application was performed in the same 45 -degree hand position relative to the skin along the costal line without interfering with the ribs. Secondly, the superficial front arm line, the carpal tunnel, forearm flexor group, the medial intermuscular septum, and the pectoralis major were treated with the same 45-degree hand

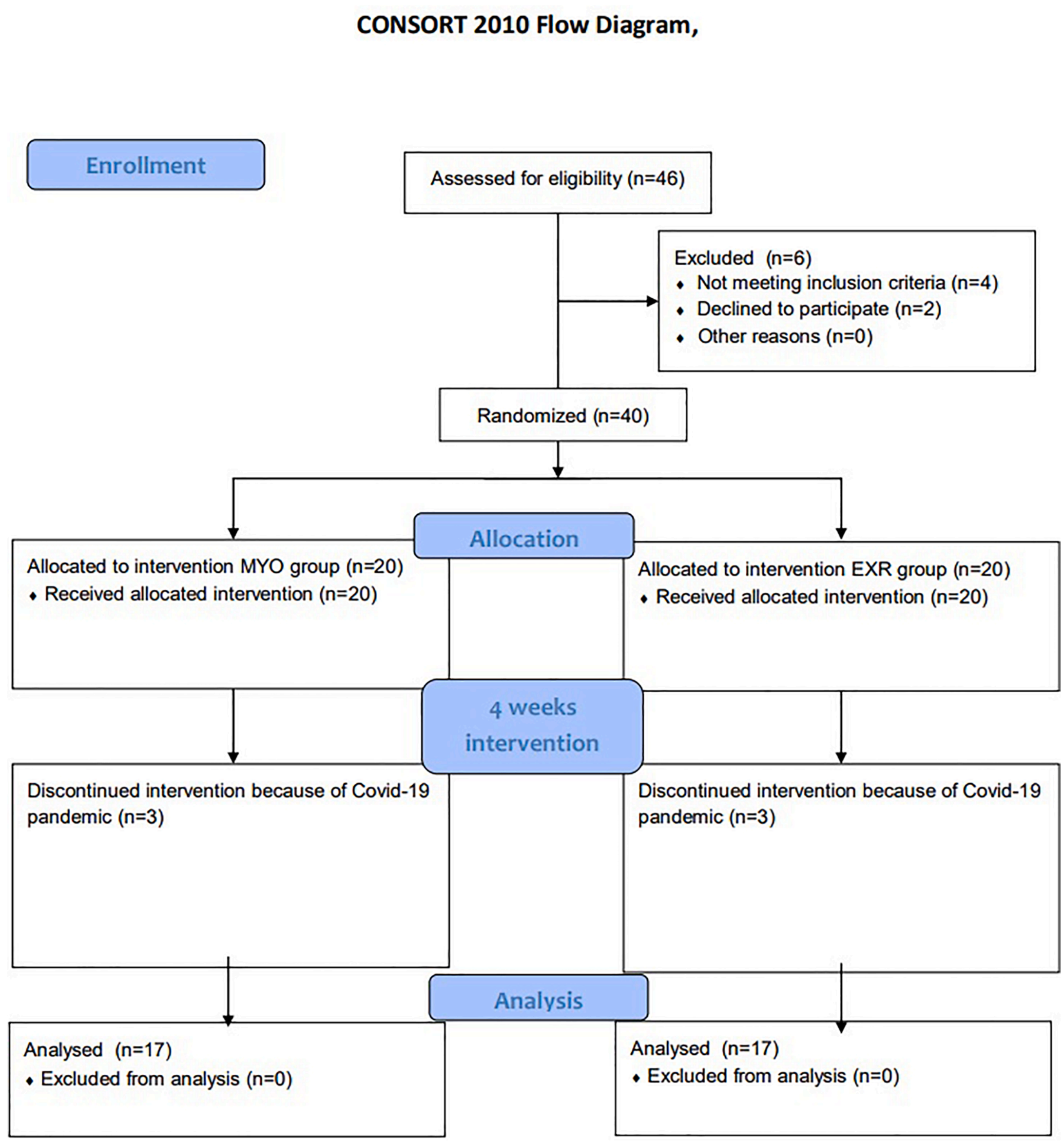

Fig. 1. Randomization Diagram
EXR: Exercise group; MYO: Myofascial release group n: number.

position in the supine position of the patient (Fig. 3c). In the pectoralis major application, the therapist was standing, and he aimed to reach the entire fascial surface by raising the patient's arm with the same 45-degree hand position (Fig. 3d). Thirdly, for the deep back arm line, MRT was applied to the ulnar collateral ligaments and fascia starting from the hypothenar muscles along the ulnar periosteum with the same 45 -degree hand position. Then, the therapist stood and placed the patient's arm in a 150 -degree flexion for the triceps and subscapularis application while the patient was in the supine position (Fig. 3e). The supraspinatus, infraspinatus, and teres major-minor were treated with the therapist's index and middle fingers in the side-lying position. Fourth and finally, for the superficial back arm line, MRT was applied with the fingertips of the therapist and at a 45 -degree angle to the extensor muscle groups from the wrist to the lateral epicondyle and lateral intermuscular septum, while the patient was in the supine position. The deltoid and upper and middle trapezius were released in the side-lying position (Fig. 3f).[17]

The MYO group was treated by a physiotherapist with five years of experience in physical therapy techniques and four years of completed training in the myofascial release technique methodology. The EXR group was treated by the same physiotherapist. In our expectations, no patients in either group suffered from any harm or unintended effect. After final assessments, participants of the EXR group were offered to have myofascial release sessions, and participants of MYO group were offered to have exercise sessions.

Study variables

Primary outcomes

The study conducted by Walton et al. provides evidence that clinicians can perform pain pressure threshold with adequate reliability for research and clinical purposes on people with and without neck pain.[18] Patients were placed in the supine position for pain pressure threshold assessment with an algometer (BASELINE® DOLORIMETER 12–1442 Algometry, Enterprises Fabrication, New York, USA). The algometer was perpendicularly applied to seven areas on the body (affected extremity): on the wrist flexors, wrist extensors, biceps brachii, triceps brachii, subscapularis, pectoral, which are brachial plexus dermatomes and also are the most painful areas of the trapezius.[12] The probe of the device was placed at the midpoint of the muscle and slowly pressed. While

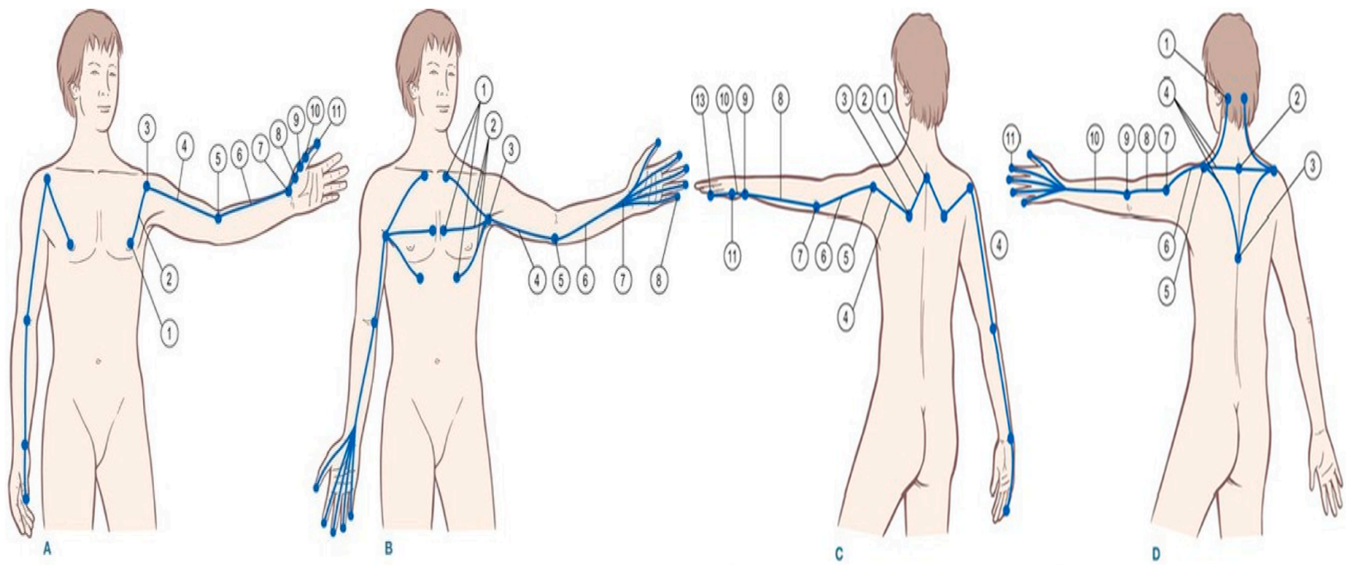

Fig. 2. Fascia Lines on Arm (Myers, 2018)
A-Deep front arm line B-Superficial front arm line C-Deep back arm line D- Superficial back arm line.

increasing the pressure over time, the patients were instructed to say "stop" as soon as the pressure became painful. The algometer measurements were repeated three times and the mean of the latter two was accepted as the result. The algometer measurement process was conducted according to the standard protocol described in the literature.[19] The value was recorded in kilograms/square centimeters.

The myometer provides a quantitative measurement of muscle strength and is more sensitive to variation than manual muscle testing.[20] The process of muscle strength measurements with the myometer (Lafayette Hand-Held Dynamometer, Model 01165A) involve the investigator holding the myometer steady, and the patient applying the maximum force they are capable of to the myometer for three to five seconds, similar to manual muscle testing of the relevant muscle. The value given by the myometer device is stated in kilograms. The patients were placed in the supine position for evaluation. The myometer was applied to the major muscle groups that are innervated by the most frequent sites of compression or damage (C5–C6–C7-C8) ,[21] including the biceps, triceps, wrist flexors, and wrist extensors. The measurement process was reattempted if the probe slipped or the patient experienced discomfort.

The study conducted by Luedtke et al.[22] concluded that the digital goniometer demonstrated strong concurrent validity and good-to-strong reliability, and that it can be practically utilized in clinical settings to accurately determine movement impairment in the upper cervical spine. Patients were seated with their feet supported on the ground and their bodies straight for the evaluation of cervical joint range of motion with a digital goniometer (BASELINE® Digital Absolute+Axis Goniometer/Baseline Evaluation Instrument®, Fabrication Enterprises, Inc.). This device was used to evaluate cervical flexion and extension, lateral flexion and rotation range of motion.

Secondary outcomes

We assessed pain values through the Visual Analog Scale (VAS). During the VAS evaluation, the patient was asked to mark their perceived pain level on the scale.

The Neck Disability Index (NDI) is the most common scale used to assess neck pain disability worldwide, and its Turkish validity and reliability study was performed by Kesiktaş, Ozcan, and Vernon.[23] NDI was used to measure the neck disability level of the patients in this study.

The Arm, Shoulder and Hand Problems Questionnaire (DASH) is a measurement tool for evaluating the functions of the upper extremity in musculoskeletal conditions reported by the patient. DASH's purpose is to detect upper extremity disorders of varying severity and to evaluate changes over time and outcomes of interventions.[24] Its Turkish validity and reliability study was performed by Düger et al. .[25] We used DASH to measure the upper extremity functions. All measurements were made by the physiotherapist who was also responsible for determining which participants and assessments were to be included.

Data analysis

In the study of Gauns,[11] when the group mean and standard deviation values of the "lateral flexion pre" measurements were used, the effect size was $d = 1.01$, so in our study, we found it appropriate to include a minimum of 17 individuals in each group for 5 % type 1 error margin and 80 % power. The calculation was made in the G*Power 3.1.9.2 program. The conformity of the data to the normal distribution was tested with the Shapiro Wilk normality tests. The descriptive statistics of the categorical variables such as gender in the demographic information form were presented as numbers (n) and percentages (%), and the descriptive statistics of the continuous variables (age, height, weight and all measurements before and after treatment) were min, max, median and mean ± sd. The paired *t*-test, a method utilized for the comparison of two dependent groups, was used in the inter-group comparisons of all pre-and post-treatment measurements according to the MYO and EXR groups, while the ANOVA variance analysis method was used for repeated measurements for intergroup comparisons. All results obtained were considered statistically significant at a level of $p < 0.05$. The effect sizes were expressed as partial eta-squared values within repeated measures ANOVA squared (η2p; small ≥ 0.01, medium ≥ 0.06, large ≥ 0.14) and Cohen's d (d; small ≥ 0.2, medium ≥ 0.5, large ≥ 0.8) was used to indicate the mean difference between groups.[26] All statistical methods used were carried out with the STATISTICA version 13.5.0.17 program.

Results

Thirty-four patients participated in the study to its conclusion. There was no significant difference between groups in demographical data and clinical features at a baseline level (Table 1). There were 12 women and 5 men in the myofascial release group (MYO group), and 12 women and

Fig. 3. 3a: Palmar release (superficial front arm line), 3b: anterior forearm release (superficial front arm line), 3c: anterior arm release (deep front arm line), 3d: pectorals release (superficial and deep front arm line), 3e: subscapularis release (deep back arm line), 3f: trapezius release (deep back arm line).

5 men in the exercise group (EXR group). The percentages of gender distribution were equal in the two groups.

Primary outcomes

Range of motion

The MYO group showed a statistically significant difference in all directions of the cervical joint range of motion ($p < 0.001$). The EXR group showed a statistical difference only in extension movement ($p = 0.012$). When the cervical joint range of motion evaluations were compared between the groups, the MYO group demonstrated statistically larger improvements in flexion ($p = 0,001$, $d = 0.83$, $\eta_{p2} = 0.301$), extension ($p = 0,037$, $d = 0.47$, $\eta_{p2} = 0.129$), left rotation ($p = 0,012$, $d = 0.76$, $\eta_{p2} = 0.182$), and left lateral flexion ($p = 0,001$, $d = 0.71$, $\eta_{p2} = 0.317$) directions (Table 2).

Muscle strength

There were statistically significant improvements in the strength of wrist flexors ($p = 0.013$), wrist extensors ($p = 0.005$), biceps ($p < 0.001$) and triceps ($p < 0.001$) in the MYO group. Significant worsening was observed in the wrist flexors muscle strength in the EXR group ($p = 0.008$). When the post-treatment evaluations were compared between the groups, the MYO group demonstrated statistically larger improvements in the muscle strengths of wrist flexors ($p < 0.001$, $d = 0.80$, $\eta_{p2} = 0.346$), wrist extensors ($p < 0.010$, $d = 0.51$, $\eta_{p2} = 0.188$), biceps ($p < 0.001$, $d = 1.17$, $\eta_{p2} = 0.306$), and triceps ($p < 0.001$, $d = 1.19$, $\eta_{p2} = 0.408$) (Table 3).

Pain pressure threshold

Statistically significant improvements were recorded in all muscle points evaluated between the MYO group for the pain pressure threshold evaluation ($p < 0.001$). Significant worsening was observed in the wrist

Table 1
The clinical and demographic features of the participants at baseline.

Variables	Myofascial Release Group ($n = 17$) Mean±SD	Exercise Group ($n = 17$) Mean±SD	p*
Age (years)	43.84 ± 8.86	46.86 ± 10.09	0.324
Gender (female/ male), n (%)	12(%70,5) / 5(%29,5)	12(%70,5) / 5(% 29,5)	
Height (cm)	165.11 ± 8.89	164.05 ± 9.72	0.723
Weight (kg)	74.58 ± 12.78	70.1 ± 11.88	0.257
BMI (kg/m2)	27.24 ± 4.09	26.47 ± 3.98	0.552
Affected arm (right/ left), n (%)	8 (47)/9(53)	7/10 (41,1/48,9)	
Underlying causes (CDH/ CSS), n	17/0	15/2	
DG Flexion (°)	39.13 ± 4.17	41.98 ± 11.57	0.243
DG Extension (°)	35.45 ± 8.00	37.29 ± 9.96	0.637
DG Right Rotation (°)	46.62 ± 8.02	45.32 ± 8.52	0.743
DG Left Rotation (°)	47.68 ± 6.22	48.97 ± 9.39	0.795
DG Right Lateral Flexion (°)	28.32 ± 6.10	30.84 ± 10.28	0.483
DG Left Lateral Flexion (°)	28.04 ± 5.01	31.82 ± 8.42	0.235
Mm Wrist Flexors (kg)	4.27 ± 1.75	4.88 ± 2.60	0.491
Mm Wrist Extensors (kg)	4.74 ± 2.01	5.12 ± 3.38	0.985
Mm Biceps (kg)	9.74 ± 4.14	8.22 ± 5.19	0.206
Mm Triceps (kg)	7.81 ± 3.02	7.58 ± 5.16	0.858
Al Wrist Flexors (kg/ cm^2)	2.16 ± 0.94	2.71 ± 0.83	0.217
Al Wrist Extensors (kg/cm^2)	2.06 ± 1.22	2.49 ± 1.15	0.484
Al Biceps (kg/cm^2)	1.88 ± 1.15	1.93 ± 0.82	0.565
Al Triceps (kg/cm^2)	1.85 ± 1.09	2.62 ± 1.19	0.196
Al Pectorals (kg/cm^2)	1.56 ± 0.87	2.15 ± 0.98	0.149
Al Subscapularis (kg/ cm^2)	1.56 ± 0.95	2.18 ± 1.28	0.079
Al Trapezius (kg/cm^2)	1.69 ± 1.06	1.93 ± 1.28	0.805
DASH score	44.16 ± 17.31	39.13 ± 14.75	0.610
NDI score	21.56 ± 7.59	16.02 ± 6.66	0.177
VAS (cm)	6.88 ± 2.93	5.87 ± 2.45	0.188

*: student t-test; $p < 0.05$ significance level; SD: Standart deviation; cm: centimeter; kg: kilogram; cm: cantimeter; BMI: Body Mass Index; m^2: squaremeter; CHD: Cervical Disc Herniatio; CSS: Cervical Spinal Stenosis; DG: Digital Goniometer; °: degree; Mm: Myometer; Al: Algometer; n: number.

flexor muscle groups ($p = 0.031$), triceps ($p = 0.034$) and subscapularis ($p = 0.019$) muscles in the EXR group. When the evaluations between the groups were compared, the MYO group demonstrated statistically larger improvements in the pain pressure thresholds of wrist flexors ($p < 0.001$, $d = 1.19$, $\eta_{p2} = 0.591$), wrist extensors ($p < 0.001$, $d = 1.05$, $\eta_{p2} = 0.494$), biceps ($p < 0.001$, $d = 1.15$, $\eta_{p2} = 0.371$), triceps ($p < 0.001$, $d = 1.08$, $\eta_{p2} = 0.561$), pectorals ($p < 0.001$, $d = 0.87$, $\eta_{p2} = 0.531$), subscapularis ($p < 0.001$, $d = 1.69$, $\eta_{p2} = 0.581$), upper trapezius ($p < 0.002$, $d = 1.05$, $\eta_{p2} = 0.273$) (Table 4).

Secondary outcomes

Functionality and disability

For DASH and NDI evaluations, statistically significant improvements were observed in the MYO group ($p < 0.001$). There were no statistical differences in the DASH ($p = 0.081$) and NDI ($p = 0.780$) disability indexes in the EXR group (respectively; $p = 0.081$, 0.780). When the evaluations were compared between the groups, the MYO group demonstrated statistically larger improvements for the DASH ($p < 0.001$, $d = 1.55$, $\eta_{p2} = 0.546$) and NDI ($p < 0.001$, $d = 1.45$, $\eta_{p2} = 0.553$) questionnaires (Table 5).

Perceived pain

Statistically significant changes were recorded in perceived pain values throughout the MYO ($p < 0.001$) and EXR groups ($p = 0.042$). When the evaluations between the groups were compared, the MYO group demonstrated statistically larger improvements in VAS ($p < 0.001$, $d = 1.46$, $\eta_{p2} = 0.358$) (Table 5).

Discussion

Cervical radiculopathy can be treated surgically or conservatively.[27] Conventional methods such as exercise, transcutaneous electrical nerve stimulation (TENS), therapeutic ultrasound (US), and hot packs are the most frequent choices of the patients who do not prefer surgery.[28] Exercise therapy is effective in the non-operative management of CR, as it can relieve pain and improve cervical functions.[29] Lima et al.[30] demonstrated that improvements in cervical functions are achieved by restoring the normal muscle balance by strengthening the muscles and stretching the tight muscles. Stolzman and Bement[31] found that exercise may activate conditioned pain modulation descending inhibitory pathways, resulting in subsequent pain relief. Therefore, the program in this study included stretching, strengthening, and range of motion exercises. TENS is considered to be a simple, non-invasive analgesic technique that is used extensively in health-care settings by physiotherapists.[11] There is experimental evidence to suggest that the analgesic effect of TENS may be modulated by the gate control theory or the endogenous opiate system.[32] US is frequently used in the conservative treatment of CR due to its thermal and non-thermal effects.[8,9] Typically, the thermal effects are employed for the treatment of pain, the reduction of subacute, chronic inflammation, and muscle spasm, and stretching of collagenous tissue in joints and connective tissue contractures. Low-dose non-thermal US is used for the stimulation of tissue repairs and the reduction of edema.[33]

Table 2
Comparison of range of cervical motions before and after treatment, within group and between group.

Digital Goniometer (°)	Myofascial Release Group ($n = 17$)		Within Group p*	Exercise Group ($n = 17$)		Within Group p*	Group*Time Interaction p**	ES Cohen d	Partial Eta Squared	95 % CIs
	Pre Treatment Mean (SD)	Post Treatment Mean (SD)		Pre Treatment Mean (SD)	Post Treatment Mean (SD)					
Flexion	39.13 ± 4.17	51.78 ± 5.35	**<0.001**	41.98 ± 11.57	44.81 ± 10.46	0.222	**0,001**	0.83	0.301	1.093/ 12.859
Extension	35.45 ± 8.00	45.96 ± 5.75	**<0.001**	37.29 ± 9.96	42.35 ± 9.02	**0.012**	**0,037**	0.47	0.129	−1.670/ 8.894
Right Rotation	46.62 ± 8.02	57.16 ± 3.85	**<0.001**	45.32 ± 8.52	50.13 ± 8.17	0.079	0,075	1.10	0.096	2.502/ 11.567
Left Rotation	47.68 ± 6.22	57.29 ± 4.69	**<0.001**	48.97 ± 9.39	52.38 ± 7.76	0.101	**0,012**	0.76	0.182	0.424/ 9.387
Right Lateral Flexion	28.32 ± 6.10	38.66 ± 6.40	**<0.001**	30.84 ± 10.28	35.67 ± 9.31	0.116	0,103	0.37	0.081	−2.595/ 8.571
Left Lateral Flexion	28.04 ± 5.01	40.93 ± 6.28	**<0.001**	31.82 ± 8.42	34.92 ± 10.1	0.100	**0,001**	0.71	0.317	0.131/ 11.880

SD:Standard Deviation; *:PairedSample t-test; **:Analysis of variance in repeated measures; °: degree; ES: Effect Size; CIs: Confidens Interval's; n: number.

Table 3
Comparison of myometer evaluations of individuals before and after treatment, within and between groups.

Myometer (kg)	Myofascial Release Group ($n = 17$)		Within Group p*	Exercise Group ($n = 17$)		Within Group p*	Group*time Interaction p**	ES Cohen d	Partial Eta Squared	95 % CIs
	Pre Treatment Mean (SD)	Post Treatment Mean (SD)		Pre Treatment Mean (SD)	Post Treatment Mean (SD)					
Wrist Flexors	4.27 ± 1.75	5.28 ± 1.19	**0.013**	4.88 ± 2.60	3.85 ± 2.23	**0.008**	**<0,001**	0.80	0.346	0.186/ 2.684
Wrist Extensors	4.74 ± 2.01	6.48 ± 2.20	**0.005**	5.12 ± 3.38	4.99 ± 3.49	0.779	**0,010**	0.51	0.188	−0.553/ 3.518
Biceps	9.74 ± 4.14	14.29 ± 5.06	**<0.001**	8.22 ± 5.19	8.36 ± 5.05	0.883	**0,001**	1.17	0.306	1.335/ 9.169
Triceps	7.81 ± 3.02	12.38 ± 4.46	**<0.001**	7.58 ± 5.16	7.15 ± 4.29	0.457	**<0,001**	1.19	0.408	1.285/ 8.208

kg:kilogram; SD: Standard Deviation; *: Paired Sample t-test; **: Analysis of variance in repeated measures; ES: Effect Size; CIs: Confidens Interval's; n: number.

Table 4
Comparison of algometer evaluations of individuals before and after treatment, within and between groups.

Algometer (kg/ cm^2)	Myofascial Release Group ($n = 17$)		Within Group p*	Exercise Group ($n = 17$)		Within Group p*	Group*Time Interaction p**	ES Cohen d	Partial Eta Squared	95 % CIs
	Pre Treatment Mean (SD)	Post Treatment Mean (SD)		Pre Treatment Mean (SD)	Post Treatment Mean (SD)					
Wrist Flexors	2.16 ± 0.94	3.32 ± 0.83	**<0.001**	2.71 ± 0.83	2.21 ± 1.02	**0.031**	**<0,001**	1.19	0.591	0.469/ 1.765
Wrist Extensors	2.06 ± 1.22	3.16 ± 0.75	**<0.001**	2.49 ± 1.15	2.22 ± 1.02	0.070	**<0,001**	1.05	0.494	0.314/ 1.567
Biceps	1.88 ± 1.15	2,85 ± 0,89	**<0,001**	1.93 ± 0.82	1.79 ± 0.95	0.462	**<0,001**	1.15	0.371	0.652/ 1.905
Triceps	1.85 ± 1.09	3.32 ± 0.86	**<0.001**	2.62 ± 1.19	2.16 ± 1.25	**0.034**	**<0,001**	1.08	0.561	0.412/ 1.911
Pectorals	1.56 ± 0.87	2.71 ± 0.67	**<0.001**	2.15 ± 0.98	1.79 ± 1.33	0.053	**<0,001**	0.87	0.531	0.177/ 1.645
Subscapularis	1.56 ± 0.95	3.06 ± 0.68	**<0.001**	2.18 ± 1.28	1.60 ± 1.01	**0.019**	**<0.001**	1.69	0.581	0.854/ 2.057
Trapezius	1.69 ± 1.06	2.96 ± 0.78	**<0.001**	1.93 ± 1.28	1.88 ± 1.22	0.885	**0.002**	1.05	0.273	0.351/ 1.795

cm: centimeter; kg: kilogram; SD: Standard Deviation; *: Paired Sample t-test; **: Analysis of variance in repeated measures; ES: Effect Size;.
CIs: Confidens Interval's; n: number.

Table 5
Comparison of the Neck Disability Index (NDI), Disability of Arm, Shoulder and Hand Problems (DASH) and Visual Analog Scale (VAS) evaluations of individuals before and after treatment, within and between groups.

	Myofascial Release Group ($n = 17$)		Within Group p*	Exercise Group ($n = 17$)		Within Group p*	Group*Time Interaction p**	ES Cohen d	Partial Eta Squared	95 % CIs
	Pre Treatment Mean (SD)	Post Treatment Mean (SD)		Pre Treatment Mean (SD)	Post Treatment Mean (SD)					
DASH score	44.16 ± 17.31	13.21 ± 9.87	**<0.001**	39.13 ± 14.75	34.42 ± 16.55	0.081	**<0.001**	1.55	0.546	−30.811/ −11:603
NDI score	21.56 ± 7.59	6.94 ± 2.01	**<0.001**	16.02 ± 6.66	15.56 ± 8.14	0.780	**<0.001**	1.45	0.553	−12.897/ −4.853
VAS (cm)	6.88 ± 2.93	1.14 ± 1.46	**<0.001**	5.87 ± 2.45	4.28 ± 2.65	**0.042**	**<0.001**	1.46	0.358	−4.653/ −1.632

DASH: Disability of Arm, Shoulder and Hand Problems; NDI: Neck Disability Index; VAS: Visual Analog Scale; SD: Standard Deviation; *: Paired Sample t-test; **: Analysis of variance in repeated measures; ES: Effect Size; CIs: Confidens Interval's; n: number; cm: centimeter.

Thermotherapy has been used to reduce chronic musculoskeletal pain and has been reported as a complementary intervention. Since the application of thermotherapy to the skin increases the temperature and the blood flow to the muscle and decreases muscle fatigue, it may be associated with an increase in muscle flexibility.[34]

A myofascial release is a form of manual therapy that involves the application of low load, long-duration pressure to the myofascial complex or restricted fascial layers, intended to restore optimal length, decrease pain, and improve function.[35] The pressure applied in the myofascial release equates to a few grams of force, and the hands tend to follow the direction of fascial restriction, hold the stretch, and allows the fascia to 'unwind' itself. The rationale for these techniques can be traced to various studies that investigated plastic, viscoelastic, and piezoelectric properties of connective tissues.[36]

In recent years, the growing interest in the myofascial system has generated an increase in studies on the effectiveness of myofascial release therapy (MRT).[37] Moreover, many studies have shown that exercise, either by itself or in combination with other treatment methods, can decrease pain effectively and improve functional status and quality of life in patients with CR.[29] In our study, we investigated the effectiveness of the myofascial release technique and compared it with an exercise program in individuals diagnosed with cervical radiculopathy. The results of the current study demonstrate that the myofascial release technique is more effective than the exercise program in reducing the pain pressure threshold and pain, improving cervical range of motion, upper extremity muscle strength, and disability values. To the best of our knowledge, this is the first study to evaluate upper extremity muscle strength and upper extremity pain pressure threshold after exercise or MRT therapy in cervical radiculopathy patients.

Primary outcomes

It has been hypothesized that fascial restrictions in one region of the body causes undue stress in other regions of the body due to fascial continuity.[35] Based on this information, we applied the myofascial release technique on arm fascia lines to treat the neck region. In this study, the myofascial release group demonstrated statistically significant improvements in the cervical range of motion. Additionally, these improvements were larger than those of the exercise group. The study conducted by Saíz-Llamosas et al.[38] was similar to our study, but instead investigated cervical mobility changes in "healthy" individuals using the myofascial release technique, and significant improvements were observed in the cervical range of motion. In the study conducted by Gauns,[11] "gross MRT" or an exercise program was applied to patients of mechanical neck pain with upper extremity symptoms, and the MRT group demonstrated larger improvements similar to our study. This parallelism in the studies can be explained as follows: as the MRT breaks the pain-spasm cycle by releasing muscles, the patient does not avoid movement due to pain, and the muscles allow movements by relaxing. For the biomechanical effects, the greater elasticity in the fascia, demonstrated through an increase in ROM, suggests that the MFR stimulated the fascia, leading to changes in viscosity and density, thus allowing it to transform into a more fluid state.[39]

Ylinen[40] stated that most studies on cervical exercises did not demonstrate a significant increase in cervical range of motion. Ylinen[40] emphasized that this circumstance may be related to low training loads or short training time. Short-term training interventions mainly induce neural adaptation, while tissue changes require much longer periods of time. In our study, the exercise program also did not effectively impact the cervical range of motion. The reason for the non-efficiency of the exercise program could be due to the fact that the exercises were not specifically arranged for the participating individuals. Also, the duration of the stretching exercises may have been too short to break the pain-spasm cycle.

Myofascial release restores optimal muscle length, reduces pain and improves function.[35] In our study, the myofascial release group demonstrated statistically larger improvements in pain pressure threshold evaluations compared to the exercise group. Hosseinifar et al.[13] also stated that the myofascial release method was effective in reducing pain and increasing the pain pressure threshold. The physiological effect of MRT on the relief of pain intensity in patients may be related to the removal of the obstruction of deep fascia and surrounding muscle fibers. The technique has potential benefits in promoting fluid circulation in and around tissues, strengthening the venous and lymphatic systems, and clearing areas of fluid deposition.[41] In addition to these effects, it is believed that applying pressure to the arm fascia and focusing on trigger points for an extended period of time may have increased the pain pressure threshold of individuals. In our study, there was a worsening of the pain pressure threshold in the exercise group that received conventional therapy. The reason for this outcome may be related to the fact that exercises were not performed on fascial arm lines and that cervical exercises alone were performed with the aim of centralizing the pain based on the McKenzie protocol.

Decreased muscle strength due to severe neck and arm pains in patients with cervical radiculopathy significantly hinders daily life their daily life activities. To the best of our knowledge, no study investigates the effect of cervical exercises or the myofascial release technique on arm muscle strength in CR patients, and our study may fill this gap. In our study, the myofascial release group demonstrated a statistically larger improvement in muscle strength compared with the exercise group. Restricted functions and painful movements may have reduced the active movements of patients, resulting in decreased in muscle strength or in no significant changes. It is thought that the MRT technique may have led to the more active use of their arm muscles by eliminating pain and movement restrictions. Thus, the muscles maintained their strength. A possible explanation for the significant improvement of muscle strength may be that the shortened sarcomeres were lengthened by ischemic compression and may have contributed to the contraction of the involved muscle.[42] The theory is that reactive hyperemia after applying ischemic compression may lead to an improved oxygen supply and a decreased production of nociceptive and inflammatory substances, thus resulting in less damage to the muscle fibers and consequently better strength production.[42]

Secondary outcomes

Cervical radiculopathy may cause severe disabilities.[43] Mehta et al.[44] emphasized that using DASH and NDI questionnaires together would enable the measurement of disability in all aspects of patients with neck pain. Based on this literature's information, we assessed disability and pain with these questionnaires. The myofascial release group demonstrated statistically larger improvements than the exercise group in post-treatment evaluations. Exercise did not positively affect the pain pressure threshold, range of motion and muscle strength. Therefore, existing disabilities may not improve. In a study conducted by Sambyal et al.,[45] it was found that myofascial release therapy reduced neck disability and could help patients return to their normal lives. In the clinical study conducted by Nitsure et al.,[46] the myofascial release group demonstrated significant reductions in pain intensity and disability scores compared to the control group, similar to our results. CR patients complain not only of cervical region problems but also of accompanying arm problems. The cause of their disability is often pain.[47] The positive effects of the myofascial release technique on arm muscle strength and pain may have significantly decreased disabilities by increasing the individual's activities of daily living, upper extremity functions and social participation. The MRT technique has a more holistic perspective than standardized exercise, as it includes the upper extremity in treatment.

There are some limitations of our study. In the exercise group, arm exercises were not performed, and only cervical exercises were provided, as the pain would not allow the individual to perform upper extremity stretch or strength exercises comfortably. However, strength evaluations were made from the arm. The result was, as expected, ineffective. Another limitation of the study was the lack of analysis by disease stage (subacute or chronic). Moreover, patients were not classified according to the affected levels. The CR onset date, diagnosis, and treatment initiation dates of the patients were not recorded. Additionally, patients were evaluated only after 12 sessions of treatment. Further studies needed for long-term effects.

In our study, fascial arm lines were intervened from the myofascial technique perspective, and dermatomes were intervened from the nervous system perspective. The fact that dermatomes are innervated by the cervical nervous system may provide a different perspective of this study for authorities who do not accept myofascial techniques. Adding myofascial release therapy to the non-operative management of cervical radiculopathy may benefit patients.

Conclusion

The results of our randomized clinical study demonstrated that the myofascial release technique was significantly superior to the cervical exercise program in terms of pain, muscle strength, cervical joint range of motion, pain pressure threshold, functionality, and disability in cervical radiculopathy. Myofascial release therapy may be beneficial in the non-operative management of cervical radiculopathy. Further research is needed to determine long-term effects of the myofascial release technique and cervical exercises.

CRediT authorship contribution statement

Fatih Bali: Investigation, Methodology, Writing – original draft, Writing – review & editing, Project administration, Supervision. **Gülay Aras Bayram:** Data curation, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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