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Comparison of the effects of constant force and gradual increased force of intermittent cervical traction in cervical radiculopathy

Krittika Thepsoda[1*]

[1]Department of Physical Therapy, Nan Hospital, Thailand.

KEYWORDS

Cervical traction; Cervical radiculopathy; Traction force; Traction weight; Cervical nerve root compression.

ABSTRACT

Cervical radiculopathy is a common disorder of the nerve root and is a pathologic process, which has been defined as pain in the distribution of a specific cervical nerve root. Mechanical cervical traction is one of the physical therapy interventions that has been proposed in the management of cervical radiculopathy. An important element that affects the efficiency of the cervical traction is using force or weight, which can be set as appropriate. Many studies have presented the effectiveness of intermittent cervical traction, but rarely mentioned about the efficiency or the reasonable force being used. Therefore, this study aimed to compare the therapeutic effect between constant force and gradual increased force of intermittent cervical traction on pain and the self-evaluated disability of cervical radiculopathy patients. Sixty-four cervical radiculopathy patients were randomly screened; eleven did not comply with the inclusion criteria and withdrew. The remaining 53 patients were divided into two groups. Group I (n=24) received constant force, and Group II (n=29) received gradual increased force of intermittent cervical traction. All patients were treated with superficial heat, a neck retraction exercise program to consistently practice at home every day, together with instructions on the correct neck posture and principles of ergonomics in activities of daily living. For Group II, the gradual increased force was required to be recorded and the increase of the force was discontinued in the event of pain or other forms of discomfort. Each patient reported responsiveness within a period of seven visits. The results of the first and last visits were collected with a visual analog scale (VAS) and the neck disability index (NDI). The findings showed that both groups experienced a significant (p-value < 0.01) improvement of pain (VAS) and disability (NDI). A comparison of the improvement, or the reduction of pre and post-treatment between both groups, found that Group II experienced a greater reduction than Group I for both evaluations with a significant difference (p-value < 0.01). This included the results of the gradual increased force (Group II) that found 48.27% of the patients had to discontinue at the fourth visit with the force 15.18 ± 0.98% of the total body weight (TBW). The mean duration of the physical therapy of Group I was 6.46 ± 1.06 visits and Group II was 5.66 ± 1.49 visits. It could be concluded that using gradual increased force of intermittent cervical traction displayed significant effective results for the treatment of pain and self-evaluated disability in a short period of time. This should be applied along with neck retraction exercises and postural education.

* **Corresponding author:** Krittika Thepsoda, PT, MSc. Department of Physical Therapy, Nan Hospital, Thailand.
E-mail: joykrittika@hotmail.com

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Introduction

Cervical radiculopathy is a common disorder in patients with neck pain. The symptoms are pain, paresthesia or numbness, weakness, or a combination of these signs and symptoms of the upper extremity. Common causes of these symptoms are associated with cervical disc herniation or the degenerative change or reduction in disc height, which can result in the foraminal compression of the spinal nerve[1-3]. The management strategies of cervical radiculopathy range from conservative approaches to surgery[4]. Frequently, the intervention of physical therapy used for cervical radiculopathy includes cervical traction, postural education, therapeutic exercises and manual therapy[3].

Spinal traction including cervical or lumbar traction can distract joint surfaces, reduce the protrusion of nuclear discal material, stretch soft tissue, relax muscles, and mobilize joints[2]. This study focused on cervical electrical mechanical traction that was used with other interventions in the Physical Therapy Unit of Nan Hospital, Mueang District, Nan Province, Thailand. Cervical mechanical traction is available in intermittent traction, as well as continuous or static traction. The effectiveness has been shown in several studies[6]. These studies have revealed moderate evidence of the benefits for intermittent traction[3] and moderate evidence of no benefits for continuous traction[6,7]. Intermittent traction has been effective in relieving pain, increasing the frequency of myoelectric signals, improving the blood flow in affected muscles, and improving the imbibition signs of disc nutrition through distraction and compression. Moreover, it has been used to reduce radicular symptoms by decreasing the foraminal compression and intradiscal pressures[25]. Higher forces were poorly tolerated with constant traction, and the need of greater forces to obtain the outcome of surface resistance was best used with intermittent traction. Therefore, intermittent traction therapy is a method in which the traction force and time are changed to make the therapy more effective. Gentle alternation of stretching and relaxation of the spinal column's soft tissue structures would prevent the formation of adhesions of the dural sleeve. In addition, intermittent traction produces would be applied twice as much as the separation for sustained traction. If the separation of the vertebral bodies is desired, high traction forces applied for short periods of time would achieve that goal[1]. Intermittent traction was therefore used in this study. A considerable part of the method was using the appropriate force or application of the weight. When the goal was to decrease the compression on a spinal nerve root or facet joint, sufficient force must be used to separate the facets of the joints in the area being treated. The force of traction could be adjusted during the treatment as recommended for improved results[2].

Many studies have presented the effectiveness of intermittent cervical traction, not only by using constant force, but also gradually increasing the force. However, the benefits of this method were not clearly presented, and they rarely mentioned about the efficiency or reasonable amount of force being used(8-10). Consequently, how to determine the level of the traction force to obtain the most effective or beneficial treatment for the patient was not known. Angela et al. concluded that the addition of intermittent cervical traction with TENS and exercise was even more effective in the management of cervical radiculopathy. The traction force was 10% of the patient's body weight, but the increment was adjusted according to the patient's tolerance. The frequency of the treatment received by the patients was five days per week for four weeks. However, their study did not mention about the amount of the force of traction used[9]. In cervical radiculopathy, 9-13 kg (20-30 lbs.), or approximately 7% of the patient's body weight is generally sufficient to achieve the appropriate outcome[2]. Nevertheless, increasing more traction force may produce improved results. MRI scans were used to assess the effect of traction on the neural foramen between the second and seventh cervical vertebrae in the supine position with a neutral cervical spine posture. The study found that increasing the traction force by 5 kg, 10 kg, and 15 kg resulted in the elongation of the width of the foramen by averaging 3.75%, 8.67% and 10.43% respectively,

but did not find any significant difference between 10 kg and 15 kg[11]. Ten percent of the total body weight (TBW) of continuous cervical traction significantly reduced the intensity of the pain in cervical radiculopathy patients who had three sessions per week for four weeks[12]. Hoseinpour et al. revealed that three weeks of physiotherapy, including intermittent cervical traction with 7% of the body weight, was more effective than acupuncture and strengthening exercises in cervical disc disease patients[13]. Additionally, Jellad et al. assessed the effect of intermittent cervical traction and discussed that manual traction below 6 kg gave similar results to mechanical traction up to 12 kg[14]. Bukhari et al also reported cervical mechanical traction with force that was equal to 10-15% of the body weight was more effective than manual traction[15]. Furthermore, Akinbo et al. investigated the effect of three different cervical traction weights, which were 7.5%, 10%, and 15%, respectively of the TBW. It was established that 10% of the TBW was the ideal weight with minimal side effects and had the highest therapeutic efficacy[16]. All those studies provided various recommendations about the traction force, and some studies took a longer period of time to provide treatment. Moreover, it should be noted that treatment that takes too long or has a high number of visits infers a low efficiency. In addition to making the treatment more difficult, this would also increase the cost. A more appropriate way of treatment would still be required. In the opinion of the author, when skeletal soft tissues are forced mechanically by traction, the stress-strain curve should probably be considered[1,17]. Constant or changing force may be applied to tissue with consequent changes in deformation: the main regions of the stress-strain curve are the toe, elastics region, and from the yield point to the failure point, which is called the plastics region[18]. For the purpose of effective treatment, the force of traction should be considered in order for enough stress to be used to enter the plastics region, which patients would improve faster and prevent recurrent symptoms without failure or any adverse reaction. The purpose of this study was to compare the therapeutic effect of constant force and gradual increased force of intermittent cervical traction on pain and self-evaluated disability of cervical radiculopathy patients.

Materials and methods

A randomized prospective study of cervical radiculopathy patients was conducted at the Physical Therapy Unit in Nan Hospital. All patients gave their informed consent to participate in this study, and this study was approved by the Ethics Committee of Nan Hospital (COA No.011). The patients with unilateral upper extremity pain, paresthesia, or numbness, with or without neck pain, were screened by a physical therapist. Patients who met the criteria were included in the study (Table 1).

Table 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
▪ Aged 30-70 years ▪ Male and female ▪ Unilateral upper extremity pain, paresthesia, or numbness ▪ Three of four tests of clinical examination:[3-5] - Spurling's Test - Distraction Test - Upper Limb Tension Test - Passive Accessory Central Vertebral Pressure Test	▪ History of previous cervical or thoracic spine surgery ▪ Bilateral upper extremity symptoms ▪ Signs or symptoms of upper motor neuron disease ▪ Medical "red flags" (e.g. tumor, fracture, rheumatoid, arthritis, and osteoporosis) ▪ Psychological problems ▪ Communication problems

Randomized patients were screened for participation (n=64), and six were excluded or refused to participate for a variety of reasons (Figure 1). Fifty-eight patients were assigned to one of the two groups alternately. Group I (n=28) received the constant force of intermittent cervical traction in a supine position, superficial heat, and therapeutic exercises, and Group II (n=30) received gradual increased force of intermittent cervical traction in the same position, superficial heat, and therapeutic exercises. Five subjects withdrew because they moved to another location, and it would be inconvenient for them to travel, which resulted in Group I having 24 participants and Group II having 29. A flow chart of the patients' recruitment and retention is presented in Figure 1.

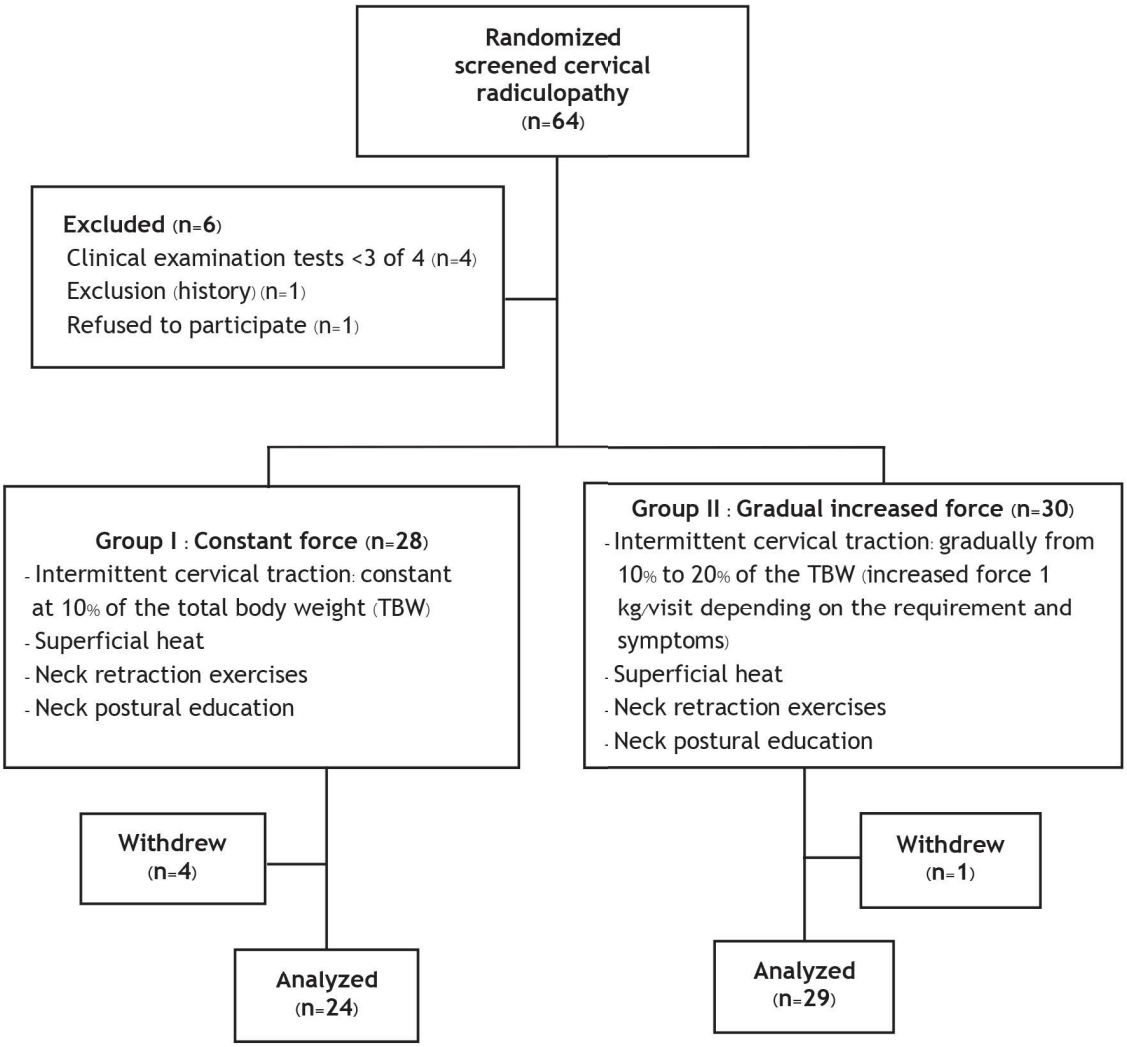

Figure 1 Flow chart of the patients' recruitment and retention

The intervention of both groups had different traction methods while other treatments were the same (Figure 1). In Group II, the intermittent traction force was started at about 10% of the patient's TBW[13], and increased by one kilogram each visit, depending on if the symptoms were the same or reduced, and stopped when the subject experienced increased pain or other forms of discomfort. The maximum force used was not more than 20% of the patient's body weight[13]. Each group was blind about the traction force.

Mechanical traction was performed in the supine position[19] with the neck at 20-30 degrees[2] of flexion. In the beginning, the force for both groups was calculated as 10%[16] of the body weight and rounded down to an integer number if it was < 0.5 kg and rounded up if it was ≥ 0.5 kg. In Group II, the force was gradually increased based on the patient's requirement and symptom response. If the symptoms improved or were unchanged, the force of traction would be increased. When the patient experienced more pain, or did not want to increase the force due to other forms of discomfort, the force would be maintained in this visit which would be considered to be increased in the next visit. All patients received the same instruction program with the documents about the correct neck posture and principles of ergonomics in activities of daily living together with the descriptions of recommended neck retraction exercises (10 times/set and three sets/three hours). Superficial heat was used primarily to control pain, and increase the soft tissue extensibility and circulation for about 20 minutes before cervical traction[2]. All remedies were conducted daily (five visits per week), and the patients reported a daily response within a period of seven visits. In each patient's final visit, they were evaluated to continue or discontinue the program of treatment according to their symptoms and requirements.

The visual analog scale (VAS) was applied to capture the patient's pain in every visit. VAS is a horizontal line, 100 mm in length, anchored by word descriptions at each end ranging from "no pain" to "very severe pain". Patients were asked to indicate the intensity of pain using marks on the line at the point that they felt, which represented their current pain. The VAS score was determined by measuring in millimeters from the left-hand end of the line to the point that the patient marked[2,20,21]. The neck disability index (NDI), self-report measures, was used in the first and last visits. NDI was collected at the baseline that contained 10 items with seven related to activities of daily living, two related to pain, and one related to concentration. Each item was scored from zero to five, and the total score was expressed as a percentage with the higher scores corresponding to greater disability. The maximum score was therefore 50. It should also be noted that the Thai version of the NDI is a valid and reliable measurement method of evaluating neck pain disability[22].

Statistical analysis

All statistical analyses were performed with statistical software. The independent t-test and chi-square test were used for comparing the two study groups, and the dependent t-test was used for comparing the pretreatment and post-treatment of the VAS and NDI of both groups.

Results

Fifty-three patients comprising 33 males and 20 females underwent analysis. They were screened into two groups, which Group I was the constant force and Group II was the gradual increased force. The mean age of both groups was 52.83 ± 7.34 years and 54.31 ± 10.31 years, the body mass index (BMI) was 23.53 ± 2.93 kg/m^2 and 22.53 ± 1.79 kg/m^2, and the duration of the symptoms was 10.83 ± 19.48 weeks and 4.97 ± 5.42 weeks, respectively. There were no differences between the groups in terms of age, BMI, duration of symptoms, and gender (Table 2).

Table 2 Comparisons of the baseline data in the study population

Characteristics	Group I Constant Force (n = 24)		Group II Gradual Increased Force (n = 29)		*p*-value
	Mean ± SD	Min - Max	Mean ± SD	Min - Max	
Age (years)	52.83 ± 7.34	37 - 67	54.31 ± 10.31	36 - 76	0.559
BMI (kg/m^2)	23.53 ± 2.93	18.22 - 28.28	22.53 ± 1.79	19.72 - 27.39	0.157
Duration of symptoms (weeks)	10.83 ± 19.48	1 - 96	4.97 ± 5.42	1 - 24	0.164
Gender: Male/Female	16 / 8		17 / 12		0.582

The first group had a significant (*p*-value < 0.01) improvement of both pain (VAS) and disability (NDI) after the treatment from a VAS value of 56.33 ± 17.51 to 32.08 ± 19.10 mm, and NDI value of 17.42 ± 6.60 to 13.13 ± 5.85. Furthermore, the second group had a significant (*p*-value < 0.01) improvement of pain and disability from a VAS value of 53.14 ± 19.50 to 9.79 ± 8.83 mm, and NDI value of 16.14 ± 5.67 to 5.59 ± 3.76. Comparing the improvement or the reduction of the pre and post-treatment between both groups, the study found that Group II had a greater reduction of the VAS and NDI than Group I with a significant difference (*p*-value < 0.01), whereas the reduction of the VAS and NDI in Group I was 24.25 ± 13.91 and 4.29 ± 4.89 and Group II was 43.34 ± 19.22 and 10.55 ± 5.08, respectively. Within the period of seven scheduled visits, the mean of Group I was 6.46 ±1.06 visits and Group II was 5.66 ± 1.49 visits (Table 3).

Table 3 Comparison of the VAS and NDI in the pre and post-treatment of the same group, and the reduction between both groups

Variable	Group I : Constant Force (Mean = 6.46 ± 1.06 visits)				Group II : Gradual Increased Force (Mean = 5.66 ± 1.49 visits)				Both Groups Comparison of Reduction
	n	Treatment	Mean ± SD	*p*-value	n	Treatment	Mean ± SD	*p*-value	*p*-value
VAS	24	Pre	56.33 ± 17.51	< 0.01	29	Pre	53.14 ± 19.50	< 0.01	< 0.01
		Post	32.08 ± 19.10			Post	9.79 ± 8.83		
		Reduction	24.25 ± 13.91			Reduction	43.34 ± 19.22		
NDI	24	Pre	17.42 ± 6.60	< 0.01	29	Pre	16.14 ± 5.67	< 0.01	< 0.01
		Post	13.13 ± 5.85			Post	5.59 ± 3.76		
		Reduction	4.29 ± 4.89			Reduction	10.55 ± 5.08		

In Group II, when the force was gradually increased and stopped by the patients when required, it was recorded in every visit. From the records, the patients requested to discontinue their force in days 2-5 in which the number of patients was one (3.45%), seven (24.14%), 14 (48.27%) and seven (24.14%), respectively. The mean of the maximum force used in visits 2-5 was 9.00 ± 0.00 kg, 8.14 ± 0.38 kg, 8.86 ± 0.36 kg, and 9.71 ± 0.95 kg, respectively. This was converted to a percentage of TBW, which was 11.69 ± 0.00%, 14.07 ± 0.64%, 15.18 ± 0.98% and 16.65 ± 0.84%, respectively ordered by day (Table 4).

Table 4 Day of the request to discontinue increasing the force (Group II): number, body weight, maximum force of traction and % force of TBW on the date of treatment

Day of the Request to Discontinue Increasing the Force (Group II)								
Day of Treatment		1st	2nd	3rd	4th	5th	6th	7th
Number (n=29)	Number	-	1	7	14	7	-	-
	Percentage	-	3.45%	24.14%	48.27%	24.14%	-	-
Total Body Weight (TBW) (Mean ± SD)		-	77 ± 0.00	58.00 ± 4.00	58.57 ± 4.54	58.57 ± 7.28	-	-
Maximum Force	Kg (Mean ± SD)	-	9.00 ± 0.00	8.14 ± 0.38	8.86 ± 0.36	9.71 ± 0.95	-	-
	% of TBW (Mean ± SD)	-	11.69 ± 0.00	14.07 ± 0.64	15.18 ± 0.98	16.65 ± 0.84	-	-

Discussion

This randomized study investigated the effects of the traction force. The results indicated significant differences (*p*-value < 0.01) of the VAS and NDI between the pretreatment and post-treatment in the same group. The gradual increased force (Group II) showed more significance (*p*-value < 0.01) of the VAS and NDI than the constant force (Group I) within a period of seven visits. The average number of Group I was 6.46 ± 1.06 visits, and Group II was 5.66 ± 1.49 visits.

This method created awareness of how to set the force in mechanical cervical traction for the effective treatment of cervical radiculopathy patients. The biomechanical effect of the traction on the cervical spine from C2 to C7 was an elongation of 1.39 mm, and reduction disc protrusion and increase in medullar canal surface area of 11.21 mm[2,23]. An MRI probe showed significant reduction of the disc protrusion in 72% of the cases with a load of 13.6 kg (30 lbs.)[24]. The study of Hafez and Zakaria[25] found that intermittent traction was more effective than sustained traction in the treatment of cervical spondylosis patients using three sessions per week for 12 weeks with no mention about the force. Fritz et al.[10] found that the addition of mechanical traction to exercise with cervical radiculopathy for four weeks resulted in decreased disability and pain although there was no mention about the force. Several researchers had reported favorable results. The conclusion of the intermittent traction study was an effective modality for patients with mild and moderate cervical osteoarthritis. One study had subjects performing three sessions a week for 10 weeks with a force of approximately 10% of the body weight, and the force was increased by one kilogram every three sessions. The maximum force used in the study was 13 kg[26]. Furthermore, the addition of intermittent cervical traction, that used a traction force of 10% of the patient's body weight and was adjusted incrementally according to the patient's tolerance together with TENS and exercise, was more effective in the management of cervical radiculopathy at five days per week for four weeks[9]. While this study showed a gradual increase of one kilogram of force for each time along with daily treatment and a suitable home program, it only took a short period of treatment with an average of 5.66 ± 1.49 visits. Moreover, it could make a significant difference of the evaluation of the VAS and NDI that reduced or improved in the same group, as well as when this was compared between the two groups.

Regarding the request to discontinue the increase in force, this ascertainment showed that the most appropriate force (48.27% of the number of Group II) in the fourth time was 15.18 + 0.98% of the TBW (Table 4). This force not only improved the symptoms of the patients, but also did not cause any adverse reaction or discomfort, which most patients were satisfied. As for too much traction force at 20% of the body weight or more, this caused more subtle perturbation in

the autonomic system and was accompanied by a higher incidence of discomfort[27]. In the author's opinion, the stress-strain curve[18] could probably explain the result of discontinuing the increasing force in that at the beginning of the traction, the tension of skeletal soft tissue was in the toe region. In that region, the relationship between the stress and strain was non-linear, and the slope increased with the increased loading. The reason for the increasing slope was the straightening of the wavy-like collagen fibrils. After the collagen fibrils were completely straightened, the elastic region began. In the elastic ranges, all changes of tissue were still reversible. When the force of traction was further increased from the elastic region, the slope of the curve changed, and the plastics region began. In the plastic region, when the traction force was sufficient, irreversible changes occurred in the tissue, and it did not return to the original strain. Although once the force was completely removed, the patients consistently improved, but after the plastic region, sudden failure of the tissue occurred and stress disappeared. The point of the breakdown is called the failure point, which is a warning sign of the traction. Increasing force was discontinued when it was found that the patient had more pain or another form of discomfort. If the force at the beginning was 10% of the TBW, it caused minimal side effects[16], likewise gradual increased force with precautions was beneficial. A series case study in 11 patients with cervical radiculopathy found that 91% improved when they were treated with a standardized approach, including manual physical therapy, cervical traction, and strengthening exercises. The mechanical traction in this series was started at 8.2 kg (18 lbs.), and was increased to a maximum of 0.5-0.9 kg (1-2 lbs.) per session and was adjusted to optimally produce centralization or reduction of the patient's symptoms, following a mean of 7.1 physical therapy visits. The study, however, did not show the maximum force used on the patient[28].

In the present study, neck retraction exercises were an elemental part in establishing the effectiveness of these results because the exercises promoted cervical root decompression, as well as reduced radicular pain[29]. Neck resting posture following neck retraction could reduce the mechanical forces on the intervertebral disc resulting in a decompression effect and pain reduction[30,31]. However, there were no studies using traction without adjuvant therapy, so further study should be conducted to compare the retraction exercises with and without traction. The correct neck posture and principles of ergonomics in activities of daily living were also instructed to the patients. Because living tissue had a biological memory, then the tissue was changed by external force and restored to its origin. Although the traction force was not stretched to the plastic region because of the side effects, it would be possible that retraction exercises and correct neck posture may be effective to improve the nature of the tissue changes. Apart from that, the duration of the symptoms of the subjects was about five to 11 weeks on average. The overall improvement might be because the subjects had experienced their symptoms less than three months before starting the treatment, so additional studies of a longer duration of symptoms should be conducted to confirm these results. Additionally, the age range and gender of the subjects in this study were wide, so further research must divide this into the respective sessions.

The force of the cervical traction is an important aspect for effective treatment in cervical radiculopathy. Based on the response to the treatment in this study, using gradual increased force was a significant proposal, as there were substantial effective results for the treatment of pain and self-evaluated disability in a short period of time, which should be applied together with neck retraction exercises and postural education. Clinicians could consider these methods in managing neck disorders requiring traction. Furthermore, in a larger sample population, patients with a prolonged duration of symptoms, long-term tracking, and division of the age range and/or gender should be implemented to approve the effectiveness.

Conclusion

It could be concluded that using a gradual increased force of intermittent cervical traction showed significant effective results for the treatment of pain and self-evaluated disability in a short period of time. This should be applied together with neck retraction exercises and postural education.

Take home messages

Cervical traction is an effective treatment for cervical radiculopathy disorder but the appropriate force should be carefully considered, in conjunction with therapeutic exercises and posture correction for each individual.

Conflicts of interest

The authors declare no conflict of interest.

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