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Cervical Intermittent Traction: Does it Really Work in Cervical Radiculopathy Due to Herniated Disc?

Servikal İntermitant Traksiyon: Herniye Disk Sebebiyle Oluşmuş Servikal Radikülopatide Gerçekten Etkili mi?

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Summary

Objective: Cervical intermittent traction is commonly used for the treatment of neck pain, predominately with nerve root involvement due to herniated disc or cervical spondylosis, however, there is no precise information on its effectiveness. The aim of this prospective randomized controlled trial was to compare the difference between two treatment protocols (regular physical therapy treatment -hotpack, ultrasound, TENS- and exercise, with or without traction) in the treatment of cervical 7 radiculopathy as a result of herniated disc.
Materials and Methods: 27 patients with unilateral C7 radiculopathy due to herniated disc verified by magnetic resonance imaging were recruited and randomly assigned to one of the two treatment groups (traction and control group). Traction group received regular physiotherapy, exercise, and intermittent cervical traction whereas control group received regular physiotherapy and exercise for 15 sessions (5 sessions per week). Primary outcome measures were the visual analogue scale and maximum grip strength of the affected side recorded at baseline and discharge.
Results: Statistical analysis revealed a significant increase in grip strength and significant decrease in visual analogue scale after 15 physiotherapy treatment sessions in both groups compared with pretreatment score (p=0.001 and p=0.001, respectively). The change in grip strength and in visual analogue scale after 15 sessions was significantly higher for the traction group than for the control group (p=0.037 and p=0.042, respectively)
Conclusion: Traction with regular physiotherapy modalities (hotpack, ultrasound, TENS) accompanied by home exercises for three weeks increased hand grip strength on the affected arm and reduced neck and arm pain substantially in C7 radiculopathy due to herniated disc. *Turk J Phys Med Rehab 2012;58:277-82.*
Key Words: Traction; radiculopathy; hand strength; physical therapy

Özet

Amaç: Servikal intermitant traksiyon, özellikle herniye disk veya servikal spondiloz sebebiyle sinir kökü tutulumu sonucu oluşan boyun ağrısı tedavisinde sıklıkla kullanılmaktadır. Ancak etkinliğine dair tam anlamıyla bir bilgi bulunmamaktadır. Bu prospektif randomize kontrollü çalışmadaki amaç, herniye disk sonucu oluşmuş servikal 7 (C7) radikülopatisinin tedavisinde iki farklı tedavi protokolünün arasındaki farkı (klasik fizik tedavi programı -sıcak paket-ultrason, TENS- ve egzersiz, traksiyonlu ve traksiyonsuz) karşılaştırmaktı.
Gereç ve Yöntem: Manyetik rezonans görüntüleme ile doğrulanmış herniye disk sebebiyle tek taraflı C7 radikülopatisi olan 27 hasta çalışmaya dahil edildi ve randomize bir şekilde iki tedavi grubundan (traksiyon ve kontrol grubu) birine dahil edildiler. Traksiyon grubuna klasik fizik tedavi programı, egzersiz ve servikal intermitant traksiyon uygulanırken kontrol grubuna klasik fizik tedavi programı ve egzersiz 15 seans (haftada 5 seans) boyunca uygulandı. Tedavi öncesinde ve sonrasında kaydedilen görsel ağrı skoru ve etkilenen taraftaki maksimum el sıkma gücü primer sonuç ölçümleri idi.
Bulgular: İstatistiksel analiz her iki grupta da 15 fizik tedavi sonrasında tedavi öncesi değerlere kıyasla el sıkma gücünde anlamlı artış, görsel ağrı skorunda anlamlı azalma olduğunu ortaya koymuştur (p=0.001 ve p=0.001, sırasıyla). 15 seans sonrasında el sıkma gücü ve görsel ağrı skorundaki değişim, traksiyon grubunda kontrol grubuna oranla anlamlı derecede daha fazlaydı (p=0.037 ve p=0.042, sırasıyla)
Sonuç: Herniye disk sebebiyle oluşmuş C7 radikulopatide üç hafta boyunca traksiyon ile klasik fizik tedavi modalitelerinin (hotpack, ultrason, TENS) ev egzersiz programı ile birlikte uygulanması etkilenen kolda el sıkma gücünü arttırmakta, boyun ve kol ağrısını azaltmaktadır. *Türk Fiz Tıp Rehab Derg 2012;58:277-82.*
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Introduction

Cervical radiculopathy (CR) is a common disorder of a cervical nerve root characterised by neck pain radiating to the arm and fingers corresponding to the dermatome involved and is common in the general population, with an annual incidence of approximately 83 per 100,000 (1,2). The condition may result in neck pain, however, the primary symptoms reported in this population are often upper-extremity pain, sensory symptoms (including burning, numbness, tingling) and weakness, which often result in significant functional limitations and disability.

CR is most commonly caused by disc herniation (DH) or cervical spondylosis (CS). C7 nerve root caused by C6-C7 DH or CS, is one of the most frequently involved levels in this condition (3). The primary actions of muscles innervated from C7 are forearm extension, wrist flexion, and finger extension. Radicular pain from C7 is usually perceived deeply through the shoulder girdle with the extension to the arm and forearm. Numbness and paresthesias are more commonly restricted to the central portion of the hand, third digit, and occasionally the forearm. Subjective weakness of the arm and hand is reported as well (4).

Hand grip strength may be negatively affected by local disorders of the arm or hand as well as by radiculopathy caused by nerve root compression in the cervical spine. As an objective and quantitative outcome measure, it has been previously validated by Joghataei to show the relationship between motor weakness in hand and C7 root involvement (5).

The overall prognosis of persons with CR is favorable. There are various treatment alternatives, range from conservative treatment including physical therapy, to surgical intervention implemented in patients diagnosed with CR. A combination of sensory loss, objective motor deficit and radicular pain is the main criterion in making decision for operation. However, 90% of patients diagnosed with CR in our society have been asymptomatic or mildly affected and can experience dramatic improvement without surgical intervention (3,4).

Several physical therapy interventions are commonly used in the management of CR, among these, the most effective physical therapy approach is still unclear (1,6). Of these, cervical traction has been considered as the therapy of choice.

Cervical traction consists of administering a distracting force to the neck in order to seperate the cervical segments and relieve compression of nerve root by intervertebral discs. Several techniques and different durations have been recommended in the literature (7). However, due to poor methodologic quality of the avaliable data, there is currently little evidence to suggest that individuals with CR may benefit from physiotherapy combined with traction aimed at improving hand strength, neck discomfort and to decompress nerve impingement (5,8,9). Joghataei et al. (5) randomly assigned 30 patients with C7 radiculopathy due to DH and/or CS to take part in a treatment programme consisting of regular physiotherapy and exercises either with or without intermittent cervical traction for 10 sessions. The group who received intermittent cervical traction exhibited better improvements in grip strength after 5 sessions, but not statistically significant differences were observed between the two groups after 10 treatment sessions. Since, the authors did not interpret the patients according to their etiology, the real benefits of the cervical traction could not be ascertained. The study, which intended to reveal different therapeutical effects of cervical traction to the patients with CR due to DH or CS, in terms of grip strength increase and pain decrease, is thought to be substantial.

With the above consideration, the present study was performed to compare the clinical parameters of traction with regular physiotherapy and regular physiotherapy alone in the treatment of CR due to DH.

Materials and Methods

Between January and December 2009, 198 consecutive patients over 18 years old with a diagnosis of either CR or neck and arm pain (symptoms extending distal to the shoulder) were examined and evaluated for eligibility criteria in a physical therapy and rehabilitation outpatient clinic in Ankara. A total of 27 patients met the eligibility criteria.

The patients were included if they had clinically and radiologically diagnosed C7 radiculopathy secondary to unilateral posterolateral herniated disc. Complaints had to be present for at least 6 weeks. Routine systemic examinations as well as neurologic examination, a reliable and valid nerve root provocation test (cervical compression -Spurling compression test-) that exactly reproduce the patient's extremity pain were applied for each patient during physical examination before treatment. In Spurling's compression test, radicular pain is exacerbated by extension and lateral bending of the neck toward the side of the lesion which causes additional foraminal compromise. A positive test is found with reproduction of the complaints (2). Magnetic resonance imaging (MRI) was done in all cases to exclude patients with degenerative CR and to observe the presence of a C7 radiculopathy secondary to posterolateral DH. MRI assessments of the cervical vertebrae revealed C6-C7 herniated nucleus pulposus on T2-weighted MRI in all patients. The ones of whom MRI findings showed multiple level disc herniations were excluded as well.

The patients were excluded from the study if they had one or more of the following conditions: (a) dysfunction and/or any operation in the shoulder, elbow and/or hand region; (b) local or generalised arhritis; (c) clinical signs of spinal cord compression; (d) limitations in arm functions; (e) bilateral upper-extremity symptoms; (f) pregnancy; (g) malignancy; (h) connective tissue or infections disease; (i) CR secondary to spondylosis.

Baseline assessments were performed by a blinded observer before randomization. Assessments included patient demographics, comorbidity, and baseline values of the outcome measures. All subjects completed 100 (mm) visual analogue scale (VAS), where 0 (mm) was “least pain imaginable” and 100 (mm) was “worst pain imaginable”, for the patient’s worst level of neck pain over the 24 hours before each evaluation. Maximum grip strengths (MGS) in the involved arm were measured using a squeeze dynamometer (Jamar) with the elbow at 90° of flexion. The mean strength of 3 trials for each measure was used to calculate the percentages of MGS of the arms.

They were randomly assigned (using a randomization list) to two groups: The traction and the control groups. Randomization was made according to the consecutive admissions of the patients to the outpatient clinic. In the traction group, the treatment package consisted of a intermittent cervical traction combined with "regular" physiotherapy programme involving ultrasound (1 watt/cm2 for 10 minutes), hotpack for 20 minutes, transcutaneous electrical nerve stimulation (TENS) (conventional TENS therapy once a day for 20 minutes, with a frequency of 60 Hz and impulse duration of 100 µsec), and cervical muscle strengthening via isometric contraction of flexor and extensor muscles (three sets of ten repetitions with one minute rest interval between each set), followed by stretching exercises for the spinal muscles. Intermittent cervical traction (7-second tractions, 5-second inter-traction rest, period for 20 min) were performed by certified physiotherapists. Each participant was asked to lie supine with a special pad under his or her head. The weight was gradually increased from five to twelve kilogram. During the traction, the neck was maintained in the most pain-free position.

The patients in the control group received 15 sessions (five per week) of "regular" physiotherapy alone, without any cervical traction. Physical examinations of the patients were repeated weekly during study period in order to observe changes in neurologic examination.

The patients were told to continue with the exercise even if they experienced mild pain. Both groups were advised not to use non-steroidal anti-inflammatory drugs (NSAIDs) or not to wear collar during the study period unless they suffer too much pain.

The permission for the study was obtained from the Local Medical Ethics Committee and informed consent was obtained from all subjects prior to participation.

Statistical analysis

SPSS version 15.0 for Windows was used for statistical analysis. The Kolmogorov-Smirnov test of normality was used to examine the normality assumption of the data. Fisher's exact test and the Mann-Whitney U-test were used to determine any difference in demographic characteristics, grip strength and VAS scores between the two groups before treatment as appropriate. The effect of treatment on outcome measures was examined using the Wilcoxon paired-sample test. Lastly, Spearman's correlation coefficient (r) was used to identify correlations between the outcome measures and duration of symptoms. All statistical tests were conducted at the 5% significance level.

Results

Apart from mild muscle pain seen in 4 patients in the traction group, there were no device-related problems and no systemic or local complications. The baseline characteristics were similar and without statistic significance for both groups (all p values>0.05, Table 1). All patients were re-assessed after the treatment period. There have been no withdrawals, thus, the total of 27 recruited patients have completed the study.

Eighteen of the 27 (66.6%) patients had neurologic deficits. Five (18.5%) had weak elbow extension of 4/5 on 5 point-scale in the myotomal distribution. Thirteen (48.2%) patients had a sensory loss in the dermatomal distribution of C7 (two of them had diminished triceps reflex at the same time). The arm pain of the nine (33.3%) patients with no neurological deficit was radicular referral zone pain in the distribution of C7.

None of our patients used analgesic medications or wore collar during the study period.

Following three weeks of physical therapy interventions, cervical and radicular pain were relieved in all patients except 3 in control group, 1 in traction group. Two patients (1 in control, 1 in traction group) demonstrated persistant weak elbow extension of 4/5, nine patients (6 in control, 3 in traction group) demonstrated persistant hypoesthesia in the dermatomal distribution of C7 with full cervical range of motion with mild pain and a negative Spurling's test. Deep tendon reflexes were unremarkable.

Both groups achieved significant decrease in pain scores (VAS) and significant improvement in maximum grip strengths (MGS) from the baseline at three weeks (p=0.001 and p=0.001, respectively).The change in grip strength and pain in VAS after 15 sessions was significantly higher for the traction group than for the control group (p=0.037 and p=0.042, respectively) (Table 2).

The duration of symptoms before treatment was positively correlated with the VAS score after the treatment (r=0.494, p=0.009). However, the duration of symptoms was not correlated with MGS after the treatment (r=-0.243, p=0.221).

Discussion

In this prospective randomised controlled study of patients with unilateral C7 radiculopathy due to DH, we found short-term success that treatment with regular physiotherapy and exercises in combination with intermittent cervical traction for three weeks, resulted in a significant reduction in arm and neck pain and significant increase in hand grip strength on the affected arm compared with regular physiotherapy and exercises alone. The differences in pain reduction before and after treatment for the control and traction groups were 33.57 and 44.62 mm on a 100-mm VAS, respectively and were highly statistically significant. Studies on VAS scores revealed that the minimum clinically significant difference in VAS pain scores has to be 9 mm (10,11).

Radiculopathy in the cervical spine is commonly encountered in clinical practice. The term "radiculopathy" refers to the whole complex of symptoms that can arise from nerve root pathology, including paresthesia, hypoesthesia, anesthesia, motor loss, and pain. The most common etiology is compression of the nerve roots occurred at the entrance zone of the intervertebral foramina. This can be due to anteriorly compression by DH (20-25% of cases) or posteriorly compression by CS; i.e. degenarative changes of the uncovertebral and zygapophyseal joints (70-75% of cases) (3,4,8).

Patient history and physical examination including neurological examination and specialized testing (Spurling's maneuver, distraction test) are usually sufficient to diagnose the radiculopathy and to determine the root level involved. Decreased muscle tendon reflexes, motor weakness or sensory deficits with the dermatomal/myotomal distribution are the clinical findings that may be found in physical examination. MRI, computed tomography, and myelography of the cervical spine are valuable diagnostic tools which usually show the etiology of the radiculopathy (12).

In the past, when myelography was accepted as the imaging modality of choice in the diagnosis of a radiculopathy, neurophysiological investigations were important in selecting patients for whom the small risks of contrast myelography were worth taking. However, the low risk of MRI has changed this and the role for neurophysiology is reduced. On the other hand, nerve conduction studies (NCS) and electromyography (EMG) are effective at localising the level of the nervous system involved or the site of the lesion but not the cause. Therefore, we did not perform NCS and EMG test for our study group (13).

Several treatment modalities are used in the management of CR, ranging from conservative treatment including physiotherapy to surgery. Persson et al. (14) reported that the outcomes associated with physical therapy were as good as those associated with surgical interventions. Previous studies indicate that combination of physical therapy interventions may supply improvement in management of CR. However, there is no convincing evidence to suggest which interventions are the most effective. Even though the clinical use of cervical traction for CR is common and is accepted as treatment of choice, the effect of cervical traction on clinical outcomes is still an open question.

Traction therapy for the cervical spine involves a tractive force applied to the neck via a mechanical system which improves conduction disturbance primarily by increasing the amount of blood flow from the nerve roots to the spinal parenchyma. This can be applied intermittently or continuously. When we look at the literature data, analysis reveals moderate evidence of benefit for intermittent traction, but no benefit for continuous traction in mechanical neck disorders (15,16).

There are several clinical trials showing negative impact of combining intemittent cervical traction with standard physiotherapy for CR (9,17,18). In a recently published study, Young et al. (9) found no significant additional benefit relating

Table 1. Baseline variables.

Variable	Traction Group (n=13)	Control Group (n=14) (Comparing groups)	Total (n=27)	p value
Age (y)	43±12.61	42.78±11.04	43.07±11.60	0.830
Sex, n(%)				0.999
Male	4(30.7)	4(28.5)	8(29.6)	
Female	9(69.3)	10(71.5)	19(70.4)	
Symptom duration (month)	16.46±24.64	17.92±22.80	17.22±23.25	0.202
Affected side (R/L)	5/8	8/6	13/14	0.332
Weight (kg)	71±13.86	68.14±11.05	69.51±12.32	0.488
Height (cm)	169.53±9.70	165.35±6.96	167.37±8.50	0.280

Values are means±standart deviation or frequency (percent)

Table 2. Mean (±SD) pain score and grip strength in both groups before and after treatment.

	Traction Group	Control Group	P value
VAS			
Before treatment	69.23±11.15	67.14±10.69	p=0.616*
After treatment	24.61±17.61	33.57±15.49	p=0.094*
Change in pain (VAS)	-44.62±15.6	-33.57±11.5	p=0.037
P value	p=0.001**	p=0.001**	
MGS (kg)			
Before treatment	23.42±7.99	28.5±9.29	p=0.259*
After treatment	28.21±10.42	29.9±9.59	p=0.685*
Change in grip strength (MGS)	4.79±5.12	1.39±1.71	p=0.042
P value	p=0.002**	p=0.012**	

*Comparison between Groups before and after treatment

** Comparison between before and after treatment scores within each group

to pain, function, or disability in patients with CR treated with cervical traction, manual therapy and exercise. However, they used clinical prediction rules such as the Spurling test, the distraction test and the upper limb tension test to select patients. While MRI and electrophysiological tests are accepted as gold standard methods in confirming the diagnosis, the results of this study might be negatively affected due to low accuracy of the diagnostic criteria. Borman (17) found no specific effect of traction over standard physiotherapeutic interventions in adults with chronic neck pain. In most of these studies, pain intensity was evaluated with subjective data.

To our best knowledge, all these trials were performed on patients diagnosed with CR due to DH and/or CS. There is only one trial investigating the impact of traction on patients diagnosed as having CR due to DH, solely. In this study by Saal et al. (19), patients with cervical herniated disc and radiculopathy were treated with a physical rehabilitation programme including cervical traction, therapeutic exercises, oral intake of NSAIDs, and patient education. 24 out of 26 patients in this study achieved good or excellent outcomes. One year later, patients' satisfaction still remained high. In contrast in another study, cervical traction combined with posture correction exercises had been applied to patients with CS. The clinical improvement was significant but almost similar (p=0.006) to that obtained by posture correction exercise and NSAIDs (20). It appears that CR due to DH is more responsive to cervical traction than CR due to CS. Different etiopathogenesis of CS and DH can be thought to be the reason of this condition.

CS is a common generalized progressive disorder affecting all levels of the cervical spine. It encompasses the process of degeneration of the intervertebral discs, osteophytosis of the vertebral bodies, hypertrophy of the facets and laminal arches, and ligamentous and segmental instability (21,22). This degenerative process may cause mechanical pressure on the spinal cord and on the nerve root either medially or laterally at one or multiple levels. In the treatment of CR due to CS during the traction application, symptoms of the compressed nerve root may improve whereas another level may get worse.

Joghataei et al. (5) mentioned that, the ventral nerve root which closes to the disc, contains nerves that serve the upper and lower limbs carrying visceral and somatic motor and dorsal nerve root which closes to the posterior structures such as facet joints, contains nerves that carry sensory information. In case of nerve root compression as a main cause of DH, the pressure on ventral nerve root might be reduced more than the pressure on dorsal sensory root with the application of cervical traction. This may be the explanation of the improvement in hand grip strength with earlier restoration of motor functions. We think that our findings are in concordance with that study. Even though Joghataei et al. found no clinically meaningful difference between the two treatment protocols (regular physiotherapy-exercises versus regular physiotherapy-exercises combined with intermittent cervical traction), both groups achieved improvement after 10 treatment sessions. Since they included patients with unilateral C7 radiculopathy either due to DH or CS in their study, and with respect to the higher prevelance of CS than DH in CR, it makes sense to expect negative results with the possible mechanism explained above. Further randomized controlled trials investigating the effectiveness of cervical traction in CR due to CS will be the answer to this question.

We aimed to use an ideal outcome measurement that will evaluate the clinical results of our study objectively. According to Abdulwahab (23), neck retractions appeared to increase H reflex amplitude of flexor carpi radialis which promote cervical root decompression and decrease radicular pain in C7 radiculopathy. Henderson et al. (24) reviewed the clinical presentations of CR patients and reported that 99% of patients had arm pain, %85 had sensory deficit, 71% reflex deficit and 68% had motor deficit. The individuals do not necessarily show motor deficit in physical examination even though they may suffer radicular pain and subjective weakness in their arms. We believe that hand grip strength in showing mild motor deficit is an objective and sensitive tool, therefore, it would be appropriate to use in daily practice.

As in the present study, duration of symptoms was previously shown to be a predictor of poor outcomes in people with CR (25,26).

The short-term follow-up in our study is a limitation because the subjects might have improved simply over the passage of time rather than because of influence of these physical therapy interventions, and we cannot be certain that the same outcomes would have exist at a long-term follow-up.

There are also some other limitations in our study. For obvious reasons, the patients could not be blinded. Because of our strict inclusion criteria, the number of participants had to be small. We did not include patients who failed to meet our inclusion criteria. In addition, our study can be criticized in view of lack of control group without treatment.

Conclusion

Cervical traction appeared to be a safe and effective noninvasive treatment method that increased the hand grip functions in patients with CR following herniated disc. Therefore, even without motor weakness, efficacy of the treatment can be evaluated with grip strength in these patients.

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Conflict of Interest:

Authors reported no conflicts of interest.

References

1. Cleland JA, Fritz JM, Whitman JM, Heath R. Predictors of short-term outcome in people with a clinical diagnosis of cervical radiculopathy. Phys Ther 2007;87:1619-32.
2. Costello M. Treatment of a patient with cervical radiculopathy using thoracic spine thrust manipulation, soft tissue mobilization, and exercise. J Man Manip Ther 2008;16:129-35.
3. Radhakrishnan K, Litchy WJ, O'Fallon WM, Kurland LT. Epidemiology of cervical radiculopathy: a population-based study from Rochester, Minnesota, 1976 through 1990. Brain 1994;117:325-35.
4. Carette S, Fehlings MG. Clinical practice. Cervical radiculopathy. N Engl J Med 2005;28:353:392-9.
5. Joghataei MT, Arab AM, Khaksar H. The effect of cervical traction combined with conventional therapy on grip strength on patients with cervical radiculopathy. Clin Rehabil 2004;18:879-87.

6. Sampath P, Bendebba M, Davis JD, Ducker T. Outcome in patients with cervical radiculopathy: Prospective, multicenter study with independent clinical review. Spine (Phila Pa 1976) 1999;24:591-7.
7. Colachis SC Jr, Strohm BR. Cervical traction: relationship of traction time to varied tractive force with constant angle of pull. Arch Phys Med Rehabil 1965;46:815-9.
8. Jellad A, Ben Salah Z, Boudokhane S, Migaou H, Bahri I, Rejeb N. The value of intermittent cervical traction in recent cervical radiculopathy. Ann Phys Rehabil Med 2009;52:638-52.
9. Young IA, Michener LA, Cleland JA, Aguilera AJ, Snyder AR. Manual therapy, exercise, and traction for patients with cervical radiculopathy: a randomized clinical trial. Phys Ther 2009;89:632-42.
10. Kelly AM. Does the clinically significant difference in visual analog scale pain scores vary with gender, age, or cause of pain? Acad Emerg Med 1998;5:1086-90.
11. Kelly AM. The minimum clinically significant difference in visual analogue scale pain score does not differ with severity of pain. Emerg Med J 2001;18:205-7.
12. Kuijper B, Tans JT, Schimsheimer RJ, van der Kallen BF, Beelen A, Nollet F, et al. Degenerative cervical radiculopathy: diagnosis and conservative treatment: a review. Eur J Neurol 2009;16:15-20.
13. Fuller G. How to get the most out of nerve conduction studies and electromyography. J Neurol Neurosurg Psychiatry 2005;76 Suppl 2:ii41-46.
14. Persson LC, Moritz U, Brandt L, Carlsson CA. Cervical radiculopathy: pain, muscle weakness and sensory loss in patients with cervical radiculopathy treated with surgery, physiotherapy or cervical collar. Eur Spine J 1997;6:256-66.
15. Hattori M, Shirai Y, Aoki T. Research on the effectiveness of intermittent cervical traction therapy, using short-latency somatosensory evoked potentials. J Orthop Sci 2002;7:208-16.
16. Graham N, Gross AR, Goldsmith C; Cervical Overview Group. Mechanical traction for mechanical neck disorders: a systematic review. J Rehabil Med 2006;38:145-52.
17. Borman P, Keskin D, Ekici B, Bodur H. The efficacy of intermittent cervical traction in patents with chronic neck pain.Clin Rheumatol 2008;27:1249-53.
18. Goldie I, Landquist A. Evaluation of the effects of different forms of physiotherapy in cervical pain. Scand J Rehabil Med 1970;2:117-21.
19. Saal JS, Saal JA, Yurth EF. Nonoperative management of herniated cervical intervertebral disc with radiculopathy. Spine (Phila Pa 1976) 1996;21:1877-83.
20. Shakoor MA, Ahmed MS, Kibria G, Khan AA, Mian MA, Hasan SA, et al. Effects of cervical traction and exercise therapy in cervical spondylosis. Bangladesh Med Res Counc Bull 2002;28:61-9.
21. Lestini WF, Wiesel SW. The pathogenesis of cervical spondylosis. Clin Orthop Relat Res 1989;:69-93.
22. Shedid D, Benzel EC. Cervical spondylosis anatomy: pathophysiology and biomechanics. Neurosurgery. 2007;60(Supp1):S7-13.
23. Abdulwahab SS, Sabbahi M. Neck retractions, cervical root decompression, and radicular pain. J Orthop Sports Phys Ther 2000;30:4-9; discussion 10-2.
24. Henderson CM, Hennessy RG, Shuey HM Jr, Shackelford EG. Posterior-lateral foraminotomy as an exclusive operative technique for cervical radiculopathy: a review of 846 consecutively operated cases. Neurosurgery 1983;13:504-12.
25. British Association of Physical Medicine. Pain in the neck and arm: a multicentre trial of the effects of physiotherapy. Br Med J 1966;1:253-8.
26. Rao RD, Currier BL, Albert TJ, Bono CM, Marawar SV, Poelstra KA, et al. Degenerative cervical spondylosis: clinical syndromes, pathogenesis, and management. J Bone Joint Surg Am 2007;89:1360-78.