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The effect of cervical traction combined with conventional therapy on grip strength on patients with cervical radiculopathy

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Objective: To determine if combining intermittent cervical traction with conventional physical therapy methods is more effective than using conventional approaches alone in the improvement of the grip strength and treatment of the patients with unilateral cervical 7 (C7) radiculopathy.
Design: Randomized controlled trial (RCT).
Setting: An outpatient physical therapy clinic, University of Social Welfare and Rehabilitation Science, Iran.
Patients: A sample of convenience of 30 patients with unilateral C7 radiculopathy participated in this study. Patients were assigned randomly to a control ($N=15$, mean age $=46.93 \pm 5.32$) and an experimental group ($N=15$, mean age $=47.53 \pm 5.6$).
Interventions: Electrotherapy/exercise treatment for control group and combined cervical traction and electrotherapy/exercise for experimental group. Ten physical therapy sessions, three times a week for each group.
Main outcome measures: Grip strength as an appropriate objective parameter was measured before treatment and after 5 and 10 treatment sessions.
Results: Statistical analysis (paired *t*-test) revealed significant increase in grip strength after 10 treatment sessions in control ($p<0.01$) and experimental group ($p<0.01$) compared with pretreatment score. In the ANCOVA, controlling for pretest scores, no significant difference was found between the two groups in the after 10 treatment sessions grip score ($p=0.65$). However, the change in grip strength after five sessions was significantly greater for the experimental group than for the control group ($p=0.04$).
Conclusions: The application of cervical traction combined with electrotherapy and exercise produced an immediate improvement in the hand grip function in patients with cervical radiculopathy.

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Introduction

Cervical radiculopathy is one of the most common health-related complaints.[1] Hult estimated that 50% of the adult population will experience neck and upper extremity pain at some time in their lifetime.[2] Cervical radiculopathy is a pathologic process, which has been defined as pain in the distribution of a specific cervical nerve root caused by nerve root compression. In more in-depth definition, it encompasses important symptoms other than pain, such as paraesthesia, numbness and muscle weakness in the dermatomal or myotomal distribution of an affected nerve root.[3] Cervical disc herniation and cervical spondylosis have been attributed as the main causes of cervical radiculopathy in the literature[4,5] and the most frequently involved nerve roots are the cervical 6 (C6) and cervical 7 (C7) cervical roots which are typically caused by C5–C6 or C6–C7 disc herniation or spondylosis.[6,7] Because the weakness of wrist extensor and finger flexor muscles is the common motor deficit pattern associated with C7 root involvement[8,9] and considering the role of synergistic function of these muscles in hand grip,[10] it is not surprising that several studies have shown a decrease of grip strength in patients with cervical radiculopathy.[11,12]

Physical therapy programmes play a significant role in treatment and improvement of symptoms in patients with cervical spine disorders.[9,13–15] Of physical therapy interventions, cervical traction has been considered as a therapy of choice for patients with cervical radiculopathy.[14,16–19] Investigators have attributed the therapeutic effects of cervical traction to various mechanisms, such as unloading the components of the spine by stretching muscles, ligaments and functional units,[9,20] reducing adhesions within the dural sleeve,[9,20] nerve root decompression within central foramina[9,21,22] and increasing joint mobility.[23] Saunders stated that traction decreases intervertebral disc pressure.[22] Others suggested that it relieves tonic muscle contraction[9,20] and improves vascular status in the epidural space and perineural structures.

Review of the literature showed that only a few randomized controlled trials (RCTs) have been conducted to determine the effectiveness of this modality in the treatment of various cervical syndromes. Additionally, in most of these studies the pain intensity, patient satisfaction or neck range of motion has been measured to investigate the efficacy of different treatment regimes in patients with cervical spine disorders.[13,15,19] Although subject-based outcome measures such as pain rating scales are valuable tools in the evaluation of physiotherapy treatments, objective measures are more reliable and should be more utilized in assessing patients.

Grip strength has been widely accepted as an objective index of the functional integrity of the upper extremity[24] and physical therapists usually measure it to monitor the success or failure of their treatment programmes.[24,25] Considering the decrease in grip strength in patients with C7 radiculopathy,[11,12] it seems that grip strength is an appropriate objective parameter to investigate the effectiveness of different treatment regimes.

No objective study has directly investigated the effect of cervical traction on grip strength in patients with cervical radiuclopathy. In this study we measured grip strength as an objective parameter to investigate the efficacy of cervical traction in addition to conventional physical therapy in the treatment of patients with C7 radiculopathy and compared these results with those of a conventional method of treatment.

Methods

Protocol

Thirty patients with unilateral C7 radiculopathy who had been referred by physicians for outpatient physical therapy evaluation and intervention participated in this study. The patient population in this study was a sample of convenience made up of subjects between the ages of 34 and 55 years. They were consecutive patients who agreed to participate and fulfilled the inclusion criteria. Patients were included if they had a history of neck pain for more than one month and unilateral C7 radiculopathy following herniated disc[4] or cervical spondylosis.[5] All patients suffered from C7 dermatomal numbness. Patients underwent magnetic resonance (MR) imaging, which detected pathological lesions corresponding to the C7 nerve root. The Spurling (neck compression) test, which is a useful manoeuvre with high specificity in the diagnosis of

cervical radiculopathy,[26] accentuated the symptoms of C7 nerve root involvement in all patients. Because the symptoms of C7 cervical radiculopathy are similar to those of some other disorders, a differential diagnosis was considered and conditions such as carpal tunnel syndrome, thoracic outlet syndrome, T4 syndrome and lateral epicondylitis were all ruled out. Patients were also excluded if they had a history of any systematic disease such as rheumatism and tuberculosis or cervical myelopathy, multiple sclerosis and motor neuron disease such as stroke and amyotrophic lateral sclerosis (ALS). After the initial screening, 30 patients fulfilled all inclusion criteria. Before participating in the study, all subjects signed an informed consent form approved by the human subjects committee.

Assignment

Patients were randomly assigned to a control group ($N=15$, mean age $=46.93\pm5.32$ years) and an experimental group ($N=15$, mean age $=47.53\pm5.6$ years). We used a block randomization method to keep the numbers in each group similar at all times. Physical characteristics of the patients in each group are shown in Table 1.

The treatment regimens for control group consisted of electrotherapy and isometric exercise.[14] The patients in the experimental group were treated identically to the control group but they also received cervical traction. Patients in each group received 10 physical therapy treatment sessions. Treatment frequency was three times per week for each group. In both groups, grip strength was measured before treatment and after the 5th and 10th treatment sessions. The electrotherapy modality in both groups consisted of ultrasound based on the method explained by Jordan *et al.*[27] In both groups exercises included isometric strengthening neck exercise.[15] Subjects were instructed to perform all exercises daily, 25 repetitions each (twice a day). All strengthening exercises were performed to a count of 7 s. In this study, the equipment used for intermittent cervical traction in the experimental group was the Eltrac 471. Each subject was instructed to lie supine with a special pad under his or her head. A 30-lb traction force at 24° angle of pull, was used for a period of 7 s, with a rest period of 5 s for 20 min in each treatment session. Studies have shown that the maximum mean vertebral separation occurs at 20 min without the exacerbation of patients' symptoms.[21]

Table 1 Demographic data of the subjects

Variables	Control group ($n=15$)	Experimental group ($n=15$)
Age (years)	46.93 ± 5.32	47.53 ± 5.6
Weight (kg)	68.9 ± 11.6	70.75 ± 13.36
Height (cm)	168 ± 7	165 ± 6
Pain duration (month)	4.87 ± 2.67	4.8 ± 3.73
Sex		
Male	($n=7$) 46.7%	($n=8$) 53.3%
Female	($n=8$) 53.3%	($n=7$) 46.7%
Affected side		
Right	($n=9$) 60%	($n=8$) 53.3%
Left	($n=6$) 40%	($n=7$) 46.7%

Values are means $\pm$ SD.
SD, standard deviation.

Grip strength as an appropriate objective parameter was measured before treatment and after 5 and 10 treatment sessions in both groups to investigate the efficacy of cervical traction in addition to conventional physiotherapy for the treatment of patients. To measure grip strength in an objective and quantitative fashion, a Martin Vigorometer similar to the one used in other studies,[25,28] was used after standardized procedures. The unit used in this study was calibrated and had 99% linearity. The patient's position was sitting with shoulder in adduction and neutral position and elbow in 90° flexion while the forearm and wrist were held in neutral position. The subject was instructed to squeeze the cuff of the Vigorometer as hard as possible and hold it for 5 s. No verbal encouragements were offered during the test. Two attempts were made and the highest reading was recorded.

Using 15 asymptomatic male volunteers ($N=15$, mean age $=42.71\pm4.87$), we assessed intratester reliability of the grip strength measurement. For this purpose, at first the examiner measured the grip strength in subjects and then after 20 min repeated the measurement randomly in the subjects in the same procedure to reduce the memory effect.

Blinding

Two physical therapists were involved in this study. One performed the physical therapy interventions in both groups, and the second, who was unaware of the group assignment, performed the measurements of grip strength before the first and after the 5th and 10th treatment sessions. The participants were also unaware of whether they were in the experimental or control group of the study. This study was a double-blind clinical trial design.

Statistical analysis

The intraclass correlation coefficient (ICC), two-way mixed effect model, was used to assess intratester reliability of the measurement. We calculated the ICC(3,1) as described by Shrout and Fleiss,[29] because only one judge evaluated the same population of subjects.

The 95% limits of agreements method of reliability assessment providing upper and lower limits for variation with a confidence level of 95% was measured by plotting a Bland–Altman plot to assess absolute reliability. Independent t-test was used to determine any difference in grip strength between two groups before treatment and paired t-test to determine any significant increase in grip strength after sessions compared with pretreatment score in the control and experimental groups. Analysis of covariance (ANCOVA) was calculated to determine the significance of differences between the control and experimental groups in post-test grip strength scores, with pretreatment scores used as covariates in the analysis. The test for homogeneity of regression coefficient was conducted because it is a necessary condition for valid application of the ANCOVA.

Results

The participant flow diagram in Figure 1 reports the numbers and timing of randomization assignment, interventions and measurements for each group (Figure 1). The ICC(3,1) was 0.92 for repeat measures of the grip strength. It indicates high intratester reliability for the measurement of grip strength. The Bland–Altman plot of agreement in grip strength scores between test and retest is shown in Figure 2. The (mean $\pm$ SD) grip scores for the first and second assessments were 19.46 ± 5.3 and 19.73 ± 5.17. The mean difference between the test and retest was -0.3. The 95% limits of agreement for the given data range from -4.4 to 3.9. The Bland–Altman plot demonstrated good agreement between test and retest (Figure 2). Statistical analysis (independent t-test) revealed no significant difference in age ($p=0.83$), weight ($p=0.73$), and pretreatment grip strength score ($p=0.23$) between the two groups.

Pre- and postmeasurement scores for the control and experimental group and the results of ANCOVA are provided in Table 2. The mean grip strength of the control group increased from 17.64 before treatment to 20.36 and 24.91 respectively after the 5th and 10th treatment sessions. The mean grip strength of the experimental group increased from 14.17 before treatment to 20.33 and 22.83 respectively after 5th and 10th treatment sessions (Table 2). The paired t-test result showed a significant increase in grip strength after 10 treatment sessions in the control ($p<0.01$) and experimental groups ($p<0.01$) compared with pretreatment score. The findings of ANCOVA revealed no significant difference between the control and experimental groups after the 10th treatment session grip score, with pretreatment score as the covariate (Table 2). However, in a separate analysis comparing the after 5th treatment session scores with the pretreatment score as the covariate, the change in grip strength after the 5th session was significantly greater in the experimental group than in the control group (Table 2).

Discussion

Grip strength measurement is an established method in the evaluation of hand function in various musculoskeletal and neuromuscular dysfunctions; however, no research has been conducted to determine if this objective test could be used as an outcome measure in the treatment of patients with cervical radiculopathy. The results of this study showed a significant increase in grip strength after 10 treatment sessions compared with pretreatment scores in control and experimental groups. We found no significant difference in the

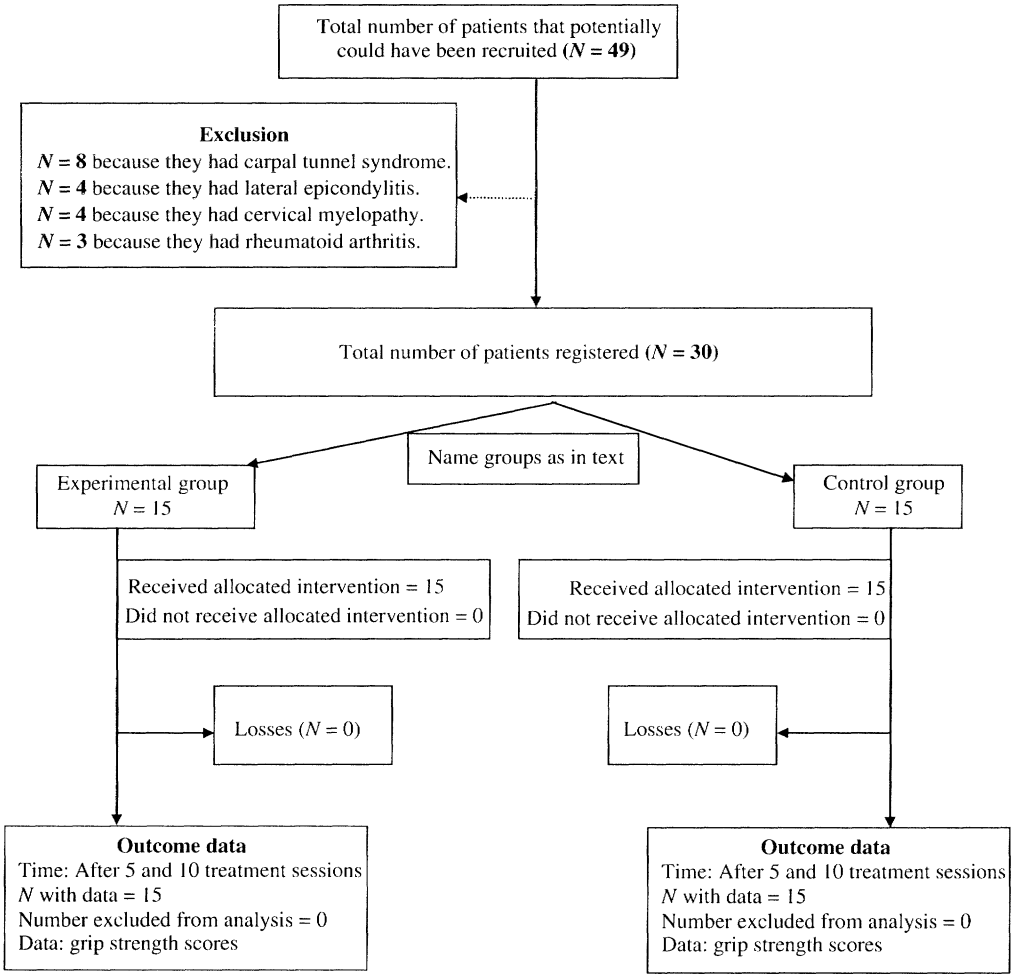

Figure 1 Flow diagram for randomized studies.

increase in grip strength between the two groups after 10 treatment sessions. Our data, however, showed a significant difference in the change of grip strength between the groups after the 5th session (Table 2). The fact that the experimental group showed a significantly greater improvement in hand grip strength after five sessions of treatment, but did not maintain this dominancy afterwards between the fifth and the tenth sessions, may suggest early associated changes following the application of cervical traction as the supplementary treatment in the experimental group. This finding is in accordance with other studies showing mechanical effects of traction in patients with cervical radiculopathy. Martin and Corbin[30] studied 61 patients with cervical radiculopathy treated by cervical traction (30–100 lb, 1–3 min, twice daily) and found that 67.2% experienced definite improvement at early follow-up. Saal *et al.*[15] reported good to excellent outcomes in 20 of 24 patients with cervical radiculopathy following cervical traction. In contrast, Goldie and Landquist[13] found that although the patients who underwent traction fared slightly better than those who underwent no traction, the difference was not statistically significant. This controversy could arise from the fact that in most of these studies pain intensity and patient satisfaction,

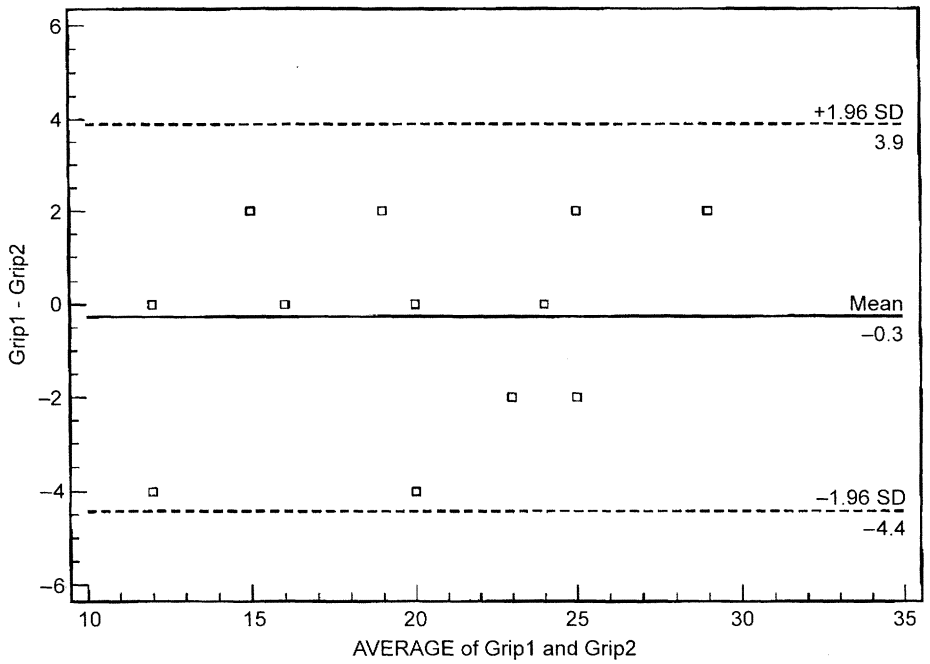

Figure 2 The Bland–Altman plot of agreement in grip scores between the test and retest. The mean of the test (Grip1) and retest (Grip2) scores is plotted on the *x*-axis and the differences between two scores on the *y*-axis. The horizontal interrupted lines represent the limits of agreement.

which are subjective data, have been measured to evaluate the treatment outcomes. One of the strong points of this study is that its outcome measures include grip strength, which is an objective measure.

The present study is also supported by recent electrodiagnostic studies that have also shown significant improvement of neurological deficit of the affected nerve root in patients with cervical radiculopathy after cervical traction.[16,31] Abdulwahab[16] found a significant increase in the flexor carpi radialis H-reflex amplitude (as a marker of root compression) and decrease in pain and radicular symptoms immediately after cervical traction in patients with unilateral C7 radiculopathy. He attributed these findings to a rapid remyelination of nerve root fibres following nerve decompression due to the application of cervical traction. According to Hattori *et al.*,[31] the improvement of nerve conduction in patients with cervical radiculopathy following traction therapy is partially due to the blood flow shift

Table 2 Grip strength score before and after treatment and ANCOVA in control and experimental groups with pretest scores as the covariates after 5 and 10 sessions

Grip strength scores	Control Mean ± SD	Experimental Mean ± SD	*p*-value of ANCOVA
Pretreatment (kPa)	17.64 ± 6.74	14.17 ± 6.9	–
After 5 sessions (kPa)	20.36 ± 5.57	20.33 ± 8.35	**0.04**[a]
Mean change after 5 sessions	2.72 ± 1.84	6.16 ± 4.30	
After 10 sessions (kPa)	24.91 ± 5.75	22.83 ± 8.76	0.65
Mean change after 10 sessions	7.27 ± 4.67	8.66 ± 4.69	

[a]Bold cell indicates significant difference in change of grip strength between groups after five treatment sessions.

from the nerve roots to the spinal parenchyma. The early improvement of hand grip strength seen in the experimental group after five treatment sessions in the present study could be explained by the physiological changes observed in the studies conducted by Abdulwahab,[16] and Hattori *et al.*[31] Both nerve root conduction and circulation improvements seem to contribute to the restoration of nerve function early enough to produce immediate effects in neuromuscular performance of the hand and grip. According to Erhard, traction manipulation in patients with muscle weakness, producing an immediate response of increase in muscle strength.[32]

The immediate results following the application of cervical traction are also reflected in the work of some other researchers who studied the anatomical behaviour of the functional segments in response to traction. Using MR imaging, Chung *et al.*[33] also found quick reduction (complete or partial) in disc herniation during cervical traction. Some speculated that one mechanical effect of traction is that it produces negative pressure in the intervertebral discs, which would suck back a disc protrusion and decrease the symptoms of radiculopathy. However, the observation of Andersson *et al.*[34] did not support the belief that traction can suck back a posterior disc protrusion by reducing the pressure within intervertebral discs. He stated that traction reduces the disc lesion by increasing the tension in the posterior annulus and the posterior longitudinal ligament.[34] In contrast to others, based on his anatomical studies, Bland[20] did not emphasize the disc protrusion as the cause of nerve root compression in cervical radiculopathy and argued that because posterior longitudinal ligament (PLL) is three- to four-fold thicker in cervical spine than in the thoracic and lumbar spine, and also because the posterior nerve roots exits are below the level of the discs from C3–C4 level caudally, it is less likely for the nerve root to be compressed by a protruded cervical disc. In fact, he suggested that any cervical radiculopathy to be a consequence of zygoapophyseal joint dysfunction and its interference with the nerve root and not the disc *per se*.

With respect to the result of the present study and those conducted by Chung,[33] and also Abdulwahab,[16] and the possible mechanisms of cervical traction in affecting the disc protrusion, it seems that both disc protrusion reduction and hand grip strength improvement are parallel phenomena following traction, since they occur in the same immediate fashion. In our study the early improvement in hand grip function seen in the experimental group could be attributed to the immediate reduction of the disc protrusion, zygoapophyseal joint mobilization[23] followed by an early nerve conduction improvement which consequently enhances the neuromuscular function of the hand grip.

One of the limitations and weaknesses of this study of this study was the sample size. Since our inclusion criteria were highly specific, the accessible population – that is patients with unilateral C7 radiculopathy and no other known related pathology – was limited to a relatively small group of patients for the time frame of this study. Another area of concern in our study is an anatomical consideration. We selected patients who had been referred by physicians and had unilateral C7 radiculopathy either due to a herniated disc or cervical spondylosis. With respect to the anatomical proximity of the ventral nerve root to the disc and the dorsal nerve root to the posterior structures such as facet joints, it has been suggested that a herniated disc is more likely to compromise the motor component of the cervical nerve root, whereas the sensory root is more susceptible to posterior encroachments such as facet joint. Having said that, and with regard to the suggested mechanism for nerve root decompression

Clinical messages

- The application of cervical traction combined with electrotherapy and exercise produce an immediate improvement in hand grip function in patients with cervical radiculopathy.
- Cervical traction can be prescribed for patients with cervical radiculopathy especially when increasing in grip strength is the short-term goal of the treatment.
- Cervical traction has an advantage in improving function quicker in patients with cervical radiculopathy.

following traction discussed earlier, it seems reasonable to expect that when a herniated disc is the main cause of impingement on the nerve root, cervical traction may help reduce the pressure on the ventral root more than the posterior sensory root and may expect an earlier restoration of motor functions such as grip strength. Therefore we suggest that this study could be done on patients with C7 radiculopathy only due to cervical disc herniation. This may also provide more insight into the possible mechanisms by which cervical traction may help reduce the symptoms of cervical radiculopathy.

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References

1 Kondo K, Molgaard CA, Kurland LT, Onofrio BM. Protruded intervertebral cervical disc: incidence and affected cervical level in Rochester, Minnesota, 1950 through 1974. *Minn Med* 1981; **64**: 751–53.
2 Hult L. The Munksfors investigation. *Acta Orthop Scand Suppl* 1954; **16**: 1–76.
3 Garvey TA, Eismont FJ. Diagnosis and treatment of cervical radiculopathy and myelopathy. *Orthop Rev* 1991; **10**: 595–603.
4 Hunt WE, Miller CA. Management of cervical radiculopathy. *Clin Neurosurg* 1986; **33**: 485–502.
5 Yu YI, Woo E, Huang CY. Cervical spondylotic myelopathy and radiculopathy. *Acta Neurol Scand* 1987; **75**: 367–73.
6 Henderson C, Hennessy R. Posterolateral foraminotomy as an exclusive operative technique for cervical radiuclopathy: a review of 846 consecutively operated cases. *Neurosurgery* 1983; **13**: 504.
7 Radhakrishan K, Litchy WJ, O'Fallon WM *et al*. Epidemiology of cervical radiculopathy. A population based study from Rochester, Minnesota, 1976 through 1990. *Brain* 1994; **117**: 325–35.
8 Benini A. Clinical features of cervical root compression C5–C8 and their variation. *Neuro Orthop* 1987; **4**: 74–88.
9 Ellenberg MR, Honet JC, Treanor WJ. Cervical radiculopathy. *Arch Phys Med Rehabil* 1994; **75**: 342–52.
10 Norkin CC, Leavngie PK. *Joint structure and function. A comprehensive analysis,* second edition. Philadelphia: FA Davis, 1992.
11 Brouillette DL, Gurske DT. Chiropractic treatment of cervical radiculopathy caused by a herniated cervical disc. *J Manipulative Physiol Ther* 1994; **17**: 119–23.
12 Hubka MJ, Phelan SP, Delaney PM *et al*. Rotary manipulation for cervical radiculopathy: observation on the importance of the direction of the trust. *J Manipulative Physiol Ther* 1997; **20**: 622–27.
13 Goldie I, Landquist A. Evaluation of the effects of different forms of physiotherapy in the cervical pain. *Scand J Rehabil Med* 1970; **2**: 117–21.
14 Tan JC, Nordin M. Role of physical therapy in the treatment of cervical disc disease. *Orthop Clin North Am* 1992; **23**: 435–49.
15 Saal JS, Saal JA, Yurth EF. Nonoperative management of herniated cervical intervertebral disc with radiculopathy. *Spine* 1996; **21**: 1877–83.
16 Abdulwahab S. The effect of reading and traction on patients with cervical radiculopathy based on electrodiagnostic testing. *J Neuromusculoskeletal Syst* 1999; **7**: 91–96.
17 Constantoyannis C, Konstantinou D, Kourtopoulos H *et al*. Intermittent cervical traction for cervical radiculopathy caused by large-volume herniated disks. *J Manipulative Physiol Ther* 2002; **25**: 188–92.
18 Olivero WC, Dulebohn SC. Results of halter cervical traction for the treatment of cervical radiculopathy: retrospective review of 81 patients. *Neurosurg Focus* 2002; **12**: clinical part 1.
19 Moeti P, Marchetti G. Clinical outcome from mechanical intermittent cervical traction for the treatment of cervical radiculopathy: a case series. *J Orthop Sports Phys Ther* 2001; **31**: 207–13.
20 Bland JH. *Disorders of the cervical spine. Diagnosis and medical management*. Philadelphia: WB Saunders, 1994.
21 Colachis SC, Strohm BR. A study of tractive forces and angle of pull on vertebral interspaces in the cervical psine. *Arch Phys Med Rehabil* 1965; **46**: 820–30.
22 Saunders DH. Use of spinal traction in the treatment of neck and back conditions. *Clin Orthop* 1983; **179**: 31–8.

23 Grieve GP. Neck traction. *Physiotherapy* 1982; **68**: 260–65.
24 Myers CR Grennan DM, Palmer DG. Hand grip function in patients with rheumatoid arthritis. *Arch Phys Med Rehabil* 1980; **61**: 369–72.
25 Culjak M, Skreb-Rakijasic N, Strizrep T. Measurement of motor strength of the hand using the Martin Vigorometer in evaluating the success of physical therapy in arthritis of the thumb. *Rheumatizam* 1993; **40**: 21–23.
26 Viikari-Juntura E, Porras M, Laasonen EM. Validity of clinical tests in the diagnosis of root compression in cervical disc disease. *Spine* 1989; **14**: 253–57.
27 Jordan A, Bendix T, Nielson H *et al*. Intensive training, physiotherapy, or manipulation for patients with chronic neck pain: a prospective, single-blinded, randomized clinical trial. *Spine* 1998; **23**: 311–19.
28 Desrosiers J, Bravo G, Hebert R, Dutil E. Normative data for grip strength of elderly men and women. *Am J Occup Ther* 1995; **49**: 637–44.
29 Shrout PE, Fleiss JL. Intraclass correlation: Use in assessing rater reliability. *Psychol Bull* 1979; **86**: 420–28.
30 Martin GM, Corbin KB. An evaluation of conservative treatment for patients with cervical disc syndrome. *Staff Meet Mayo Clin* 1954; **29**: 324–26.
31 Hattori M, Shiari 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.
32 Erhard RE. *Manual therapy in the cervical spine. HSC 96. The cervical spine*. La Crosse, WI: APTA, 1996.
33 Chung TS, Lee YJ, Kang SW, Park CJ, Kang WS, Shim YW. Reducibility of cervical disk herniation: Evaluation at MR imaging during traction with a nonmagnetic tration device. *Radiology* 2002; **225**: 895–900.
34 Andersson GBJ, Schultz AB, Nachemson AL. Intervertebral disc pressures during traction. *Scand J Rehabil Med Suppl* 1983; **9**: 88–91.