Comparison of cervical vertebral separation in the supine and seated positions using home traction units

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This study was performed for the purpose of comparing the magnitude of cervical vertebral separation during cervical traction in supine and seated positions using home traction units. A repeated measures design with two within-subject factors (type of traction and time) was used. Seventeen asymptomatic volunteers received cervical traction in seated and supine position. Subjects received 5 minutes of static traction in sitting or supine using a force of 13.6 kg while in 15 degrees of neck flexion. A lateral radiograph of the cervical spine was taken before traction force was applied and after five minutes of static traction. Anterior and posterior distances between the inferior border of C2 and the superior border of C7 were measured by a radiologist. After supine traction there were significant increases ($p = 0.001$) in posterior cervical vertebral separation compared to any changes after seated traction. There were no significant changes in anterior vertebral separation during either supine or seated traction positions ($p = 0.769$). Supine cervical traction may be more effective for increasing posterior vertebral separation than seated cervical traction.

Introduction

Application of cervical traction force has been a treatment option in physical therapy settings for a variety of cervical spine-related problems. Among the benefits reported for cervical traction is improved symptom resolution in symptomatic patients (Moeti and Marchetti, 2001; Shakoor et al, 2002; Swezey, Swezey, and Warner, 1999; Walker, 1986) and increased range of motion of cervical spine (Harris, 1977; Moffett, Hughes, and Griffiths, 1990) after treatment with traction.

It is suggested that the reported beneficial results with cervical traction may be due to reduction of disc derangement (Constantoyannis, Konstantinou, Kourtopoulos, and Papadakis, 2002; Crue and Todd, 1965; Harris, 1977; Judovich, 1952; Murphy, 1991), muscle relaxation (Deets, Hands, and Hopp, 1977; DeLarce who, 1980; Harris, 1977), increased diameter of the intervertebral foramina reducing compression of nerve roots (Crue and Todd, 1957; Crue and Todd, 1965; Harris, 1977), and gating of pain transmission at the spinal cord level (Deets, Hands, and Hopp, 1977; Grieve, 1982; Harris, 1977; Judovich, 1952). In clinical practice, a variety of home units are provided to patients who may benefit from frequent and regular cervical traction. Of the units available, some are designed to apply traction force while the patient is in a seated position and some are used with the patient in a supine position. Because in the seated position gravity exerts an axially directed force along the vertebral column, it would seem that at equivalent forces there

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would be less traction force applied to the tissues of the cervical spine in the seated position than in the supine position; perhaps this would translate to decreased efficacy for cervical traction in the seated position if vertebral separation is less. At present, few studies (Deets, Hands, and Hopp, 1977) have evaluated the ability of cervical traction to create vertebral separation in a seated position compared to a supine position.

Deets, Hands, and Hopp (1977) measured the interspace changes at the levels of C4-5, C5-6, and C6-7 in supine and seated positions during intermittent mechanical traction. Each subject underwent traction forces of 0 kg, 14 kg, and 18 kg on different days with a 7-second application of force and a 7-second release. Five repetitions of the force/release sequence were performed with a lateral radiograph taken during the last application of force. Subjects were maintained in 45 degrees of cervical flexion during traction application. The authors reported no significant differences between the supine and seated position in posterior vertebral separation except for separation at the C5/C6 intervertebral space during application of 14-kg force. Other intervertebral space measurements remained unchanged at all other force levels.

Judovich (1952) applied static cervical traction to seven subjects exhibiting symptoms of discogenic injury. Traction was applied in a seated position using incremental forces from 2.3 to 20.5 kg while taking lateral radiographs of the cervical spine at each level of force. He reported that the earliest change in cervical vertebral separation between the inferior border of C2 and the superior border of C7 occurred with a traction force of 11.4 kg and that the change in length of the cervical spine during traction ranged from 3 mm to 14 mm with an average of nearly 5-mm separation. This change in measurable length coincided with subjective reports of pain relief in almost half of his subjects. The magnitude of separation was not reported relative to the force of traction in this study, nor was there any statistical evaluation of the data reported. The duration of time that traction was applied was not reported.

Colachis and Strohm (1966) performed intermittent cervical traction on 10 subjects in supine with the cervical spine flexed to 24 degrees. Traction was applied for 7 seconds with a rest period of 5 seconds at a force of 13.6 kg for 25 minutes. Lateral radiographs were taken before traction, at 5-minute intervals for the 25 minutes of intermittent traction force application, and at 5, 10, and 20 minutes after traction was terminated. They reported statistically significant changes in posterior cervical separation at 5 minutes of 3.35 mm and at 25 minutes posterior cervical separation of 4.55 mm. In a separate earlier study, Colachis and Strohm (1965a) reported that the greatest amount of posterior cervical separation occurred at 24 degrees of cervical spine flexion.

Saunders (1999) reviewed the data from Colachis and Strohm (1965a) and suggested that anterior cervical vertebral separation decreased with flexion and that compression of the cervical spine occurred at 20 and 24 degrees of flexion. Therefore, Saunders (1999) recommended 15 degrees of neck flexion for nearly every clinical application when the goal is to increase the space in the intervertebral foramen.

The purpose of this study was to compare the anterior and posterior cervical vertebral separation achieved in asymptomatic college-aged males during cervical traction using home traction units in supine and seated positions while keeping the traction force, neck position, traction type, and duration of traction constant. The research hypothesis was that there would be greater posterior cervical vertebral separation between the inferior border of C2 and the superior border of C7 when traction was applied in the supine position vs. the seated position. The study was reviewed and approved by the University of Wisconsin-La Crosse Institutional Review Board (IRB) and by the IRB of Gundersen Lutheran Medical Center, La Crosse, Wisconsin.

Methods

Subjects

Seventeen male volunteers were recruited from a college-aged population (aged 18–30). Only males were used in the study so that any gender-based variability in joint laxity could be minimized. The subjects had no history of neck trauma, neck injury, or any past or present cervical complaints requiring medical care. No subject received therapeutic cervical traction prior to or during participation in this study.
Procedures

The two home traction units used were the Saunders Cervical HomeTrac™ and the Vertical Traction Kit from Bird & Cronin Inc., both provided by The Saunders Group, Inc. for use in this study. The Saunders Cervical HomeTrac™ allows the patient to remain supine during the treatment and is designed so that there is no traction force applied through the temporomandibular joint. Instead, the traction force is provided through an occipital cradle that fits around the back of the patient’s head. The HomeTrac™ allows the patient to control the amount of traction force applied by the traction unit through a handheld pneumatic pump (Olson, 1997, 1997a; Saunders Group, Inc., 1999). Prior to the collection of data for the study, the HomeTrac™ unit was tested to validate that the unit was providing the amount of force desired for this study.

The Vertical Traction Kit from Bird & Cronin Inc. is an over-the-door traction unit that uses a head halter secured around the mandible and the occiput (Bird & Cronin, Inc., 1998). Water bags with a capacity of 9.1 kg each along with a pulley system are used to provide the traction force. To begin traction, the patient sits facing the door holding the water bag and slowly increases the traction force by gradually releasing the bag until it hangs freely. At the end of the traction period, the patient removes the load by lifting the bag and detaching it from the pulley rope. To apply 13.6 kg of force, two water bags were attached to the pulley: one containing 9.1 kg of water and a second containing 4.5 kg of water. For this study, one of the researchers manually handled the water bags to initiate force application and to end traction force application.

Lateral radiographs were used to determine the amount of cervical vertebral separation between C2 and C7. A radiologist who was blinded to the type of traction and whether the radiograph was taken before or during traction measured the distance from the inferior border of C2 to the superior border of C7 for all cervical spine radiographs by using a ruler with gradations in millimeters.

The reliability of the goniometric measurements used to measure the amount of cervical flexion when the subjects were seated was assessed. Measurements from 10 college-aged male subjects were used to calculate both inter- and intraclass correlation coefficients (ICC) of cervical flexion angles measured via handheld goniometer. The two researchers who performed the goniometric measurements measured each neck flexion angle three times on each subject manually with a plastic goniometer produced by Sammons Preston. A composite cervical flexion angle was measured according to guidelines set by The American Academy of Orthopaedic Surgeons (American Academy of Orthopaedic Surgeons, 1965). The fulcrum of the goniometer was centered over the external auditory meatus with the stationary arm perpendicular to the floor and the mobile arm aligned with the base of the nares. As the subject performed cervical flexion, the mobile arm of the goniometer was realigned with the base of the nares to obtain the measurement of cervical flexion. The results of the measurements were read from the goniometer and recorded by the third researcher. The intraclass coefficients for the goniometric measurements performed by the two examiners were 0.95 and 0.96. The interclass correlation coefficient was 0.94. By using Munro’s descriptive terms for the strength of correlation coefficients, these values show strong consistency for cervical flexion goniometric measurements (Munro, Visintainer, and Page, 1986) in this study.

During the study, each subject received traction from both types of home traction units: the Saunders Cervical HomeTrac™ (supine) and the Vertical Traction Kit from Bird & Cronin Inc. (seated). Each subject was required to visit the clinic on three separate occasions. During the first session, subjects were provided an explanation of the procedures to be used in the study, the benefits, and possible risks. An informed consent form approved by the University of Wisconsin-La Crosse and Gundersen Lutheran Institutional Review Boards (IRB) was provided and signed at this time. Then, a 30-second trial application of both types of cervical traction was applied to the subjects. During the trial treatment of seated traction, the distance between the door and the subject’s chair that would provide 15 degrees of cervical flexion was determined by using a ruler and handheld goniometer. This was recorded for each subject, and the chair was positioned identically for the subsequent seated traction application. Prior to data collection, the subjects were randomly
assigned to receive either supine or seated traction during the first testing session. Prior to any traction force application, a lateral radiograph was taken of the cervical spine in the position in which the subject was to receive traction. Static traction was administered for 5 minutes with 13.6 kg of traction force while the subject’s neck was flexed to 15 degrees. Upon completion of 5 minutes of traction, another lateral radiograph was taken, and the traction force was released. At least 2 weeks later, each subject received traction using the other type of home traction unit during a second session. Again, a radiograph was taken before any traction force was applied and upon completion of 5 minutes of traction prior to the release of the traction force. The subjects were advised to inform the researchers if they experienced discomfort sufficient that they wished to stop traction so that the session could be terminated. Because the lateral radiographs expose subjects to a small amount of radiation, a lead apron was placed over the subject’s lap area during all radiographs.

The subjects receiving traction with the HomeTrac™ were positioned on a table in a supine position. The one-piece occipital cradle was placed around the occiput and the head strap was secured tightly around the head. The incline of the sliding carriage placed the patient into 15 degrees of neck flexion, which is preset on this traction unit. The angle of cervical flexion was confirmed to be 15 degrees by manual goniometry. After the initial radiograph, the air pressure was increased and maintained at 13.6 kg of force using the handheld pneumatic pump operated by a researcher. Static traction was administered for 5 minutes’ duration and at the end of the 5-minute period the second lateral radiograph was taken. When the radiograph was completed, the traction force was then slowly released.

Each subject receiving traction from the Vertical Traction Kit remained seated during the entire traction treatment. The subject was positioned identically to the position that was determined during the trial treatment to provide 15 degrees of neck flexion for seated traction. Next, the cervical head halter was placed on the subject by centering the mandible in the front-cupped section and placing the back-cupped section low on the occiput. The adjustment straps were fastened and tightened until the halter was snug, as determined by the subject. Two gait belts were placed around each subject’s chest diagonally and were secured to the chair to maintain body position. After the head halter was attached to the pulley cord, the two bags of water equaling 13.6 kg were slowly released until the bags hung freely from the pulley. A 15-degree neck flexion angle was again verified through goniometric measurement by the same examiner. After the subject was in traction for 5 minutes and another lateral radiograph was taken, the traction force was slowly released by lifting the water bags and releasing the head halter.

A single radiologist blinded to the type of traction and the position of the subject reviewed the supine and seated pre- and posttraction radiographs. Each radiograph was labeled by drawing a straight line across the end plates of the inferior border of C2 and the superior border of C7. The distance was measured anteriorly and posteriorly between the two lines to determine the amount of cervical vertebral separation between C2 and C7. The anterior and posterior distances were compared before application of traction in both supine and seated positions as well as at the end of 5 minutes of traction force application.

The reliability of the radiographic measurements was determined. Twelve radiographs that were previously measured were measured a second time following the same procedure as described previously, and the data were used to calculate an intraclass correlation coefficient. For both anterior and posterior radiographic measurements, the intraclass correlation coefficients were 0.99.

Statistical analysis

To compare the cervical vertebral separation differences (both anteriorly and posteriorly) between the seated and supine positions, a two-way repeated measures ANOVA (within subject design) was performed. The posterior and anterior separation data were analyzed separately. The independent variable was the position in which the traction was applied, seated or supine. The dependent variables included the amount of posterior and anterior cervical vertebral separation, measured in millimeters (mm). With statistical significance set at a two-sided level of 0.05 (type I error) and a power of 0.80 (i.e., type II error = 0.20) and the correlation coefficient
between any two points of time (repeated measures) set at 0.50 with effect size = 0.90, a minimum of 15 subjects was found to be required for the study. Alpha was set at 0.05.

**Results**

During and after application of traction in seated and supine positions there were no reports from subjects of discomfort associated with the traction. After 5 minutes of traction force application, there was a significant \( F(1,16) = 14.903; p = 0.001 \) increase in posterior separation in the supine position, but there was no significant change in posterior separation with traction applied in the seated position. Anterior separation did not change significantly \( F(1,16) = 0.089; p = 0.769 \) in either position (Figures 1 and 2).

The mean posterior cervical vertebral separation during traction in supine increased from 85.2 mm (SD = 4.28) pretraction to 89.1 mm (SD = 4.81) posttraction, a change of 3.9 mm (a 4.6% increase; Figure 1). The mean posterior cervical vertebral

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**Figure 1.** Distance from the inferior border of C2 to the superior border of C7 along the posterior aspect of the cervical vertebral column before application of 13.6-kg cervical traction force and after 5 minutes of static cervical traction in supine and seated positions. Significance \( (p < 0.05) \) is indicated by an asterisk. Error bars represent standard deviations.

**Figure 2.** Distance from the inferior border of C2 to the superior border of C7 along the anterior aspect of the cervical vertebral column before application of 13.6-kg cervical traction force and after 5 minutes of static cervical traction in supine and seated positions. There were no significant \( (p < 0.05) \) changes for either position. Error bars represent standard deviations.
separation during traction in the seated position increased from 92.7 mm (SD = 5.37) pretraction to 93.9 mm (SD = 5.49) posttraction. This 1.2 mm change (a 1.4% increase) was not significant.

The mean anterior vertebral cervical separation during traction in supine increased from 87.5 mm (SD = 5.19) pretraction to 87.6 mm (SD = 5.33) posttraction providing a mean change in anterior cervical vertebral separation of 0.1 mm, a 0.1% increase (Figure 2). The mean anterior cervical vertebral separation during traction in the seated position decreased from 92.4 mm (SD = 5.23) pretraction to 92.3 mm (SD = 6.67) posttraction. The mean change in anterior cervical vertebral separation in the seated position was 0.1 mm, a 0.1% decrease. Neither change was statistically significant.

Discussion

On the basis of the results of this study, supine traction resulted in a greater increase in posterior cervical vertebral separation than seated traction. The present study did not attempt to measure specific interspace distances but instead measured the posterior and anterior distances between C2 and C7 and the changes in these distances with 13.6 kg sustained traction force for 5 minutes in seated and supine positions. Traction in the supine position increased posterior cervical vertebral separation by 3.9 mm (a 4.6% change), whereas in the seated position at the same level of force posterior cervical vertebral separation increased by 1.2 mm (1.4%). This amount of separation with supine cervical traction is similar to that reported by Judovich (1952).

There was no change in anterior cervical vertebral separation during traction in seated and supine positions in the present study, which is in agreement with data from the study by Colachis and Strohm (1965). Deets, Hands, and Hopp (1977) suggest that the anterior anatomical curve of the cervical spine is decreased because of the flexed position used for cervical traction; it is possible that this is why anterior cervical vertebral separation does not increase with traction. The results of this study show no significant change in anterior cervical vertebral separation with seated or supine cervical traction.

Because this study was conducted on healthy college-aged males, clinicians must be cautious in attempting to generalize the results to a symptomatic patient population or a population differing significantly in composition. However, Crue and Todd (1957) applied cervical traction to 20 patients in supine and reported a greater relief of symptoms as cervical vertebral separation increased. Their study supports the use of cervical traction in supine over traction application in a seated position for symptom relief in patients. More recent reports indicate that cervical traction improves resolution of symptoms in patients (Constantoyannis, Konstantinou, Kourtopoulos, and Papadakis, 2002; Moeti and Marchetti, 2001; Swezey, Swezey, and Warner, 1999), but none evaluated cervical vertebral separation. If there is an improvement in symptoms as cervical vertebral separation is increased, this may result in a better functional outcome for the patient.

It is also important to recognize that the use of home traction units by patients without the assistance of an experienced clinician may result in positioning of the cervical spine differently than the standardized 15 degrees flexion used in this study, particularly in those units designed to be used by a patient in a seated position. Inconsistent positioning of the cervical spine during application of traction force will likely provide different results from those reported here. Home traction units that are preset for cervical spine positioning in supine like the HomeTrac unit may minimize the variability of cervical spine positioning for application of cervical traction by the patient at home.

Conclusion

The purpose of this study was to compare the amount of cervical vertebral separation achieved in college-aged males during cervical traction using home traction units in supine vs. seated positions while keeping all other traction parameters constant. Supine cervical traction in this study was more effective in increasing posterior cervical vertebral separation than was seated cervical traction. Neither supine nor seated cervical traction with the neck in 15 degrees of flexion was effective for increasing anterior cervical vertebral separation. Further research relating the degree of cervical separation and...
behavior of symptoms in patients with cervical spine dysfunction is necessary.

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