The Effect of a Soft Collar, Used as Normally Recommended or Reversed, on Three Planes of Cervical Range of Motion

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Cervical orthoses have been prescribed routinely by physicians and physical therapists for the purposes of decreasing inflammation, pain, and spasm; controlling instability; supporting the cervical spine (decreasing compressive loading); and immobilizing the cervical spine following trauma (1,2,5,6,9,10,13,14). Soft cervical collars are readily available and comfortable for the patient to wear compared with other cervical orthoses, but the degree to which they immobilize the cervical spine is questionable and is the focus of this study.

Generally, the effectiveness of a cervical orthosis is determined by its ability to immobilize the affected area. Available studies of subjects with and without cervical dysfunction disagree as to the extent to which soft cervical collars can physically limit motion (1,2,5,6,9,10,11,13–15). The factors that affect the effectiveness of a soft cervical collar include height and size. Jones et al. concluded that soft cervical collars with sufficient anterior height were able to restrict motion in the upper cervical region (11). Other studies have found minimal or no significant restriction in cervical motion when the subject was wearing a soft cervical collar (5,10,15). Hart et al. suggested in their review that if the appropriate size was chosen, the soft collar afforded some vertical support of the cervical spine by reducing the amount of weight borne directly by the spine (9). In light of potential sensorimotor–skeletal interaction, Johnson et al. suggested that the soft collar is comfortable and may serve as a useful reminder to the patient to restrict his or her own motion (14). In this capacity, a flexible collar should satisfy the goal of providing gentle support (13). Dudgeon (6) believed, however, that long term use of a cervical orthosis might lead to muscle atrophy, causing further deterioration of a patient's neck. Beavis (2) countered that because immobilization was not complete, the neck muscles were allowed to contract isometrically within the collars, and atrophy and disuse were prevented. Finally, Althoff and Goldie (1) found...
that cervical collars in general, including soft collars, did not stabilize atlantoaxial instability in patients with rheumatoid arthritis.

Studies of subjects with cervical dysfunction that compared wearing a cervical collar and active treatment have also shown mixed results with regard to effectiveness of treatment. Mealy et al assessed residual pain and cervical movement at 4 and 8 weeks following a whiplash accident and found that wearing a soft collar was not as effective as the Maitland technique of neck mobilization in decreasing pain or increasing movement (17). In a similar study, Pennie and Agambar (18) compared 2 weeks of rest in soft cervical collars with active treatment of traction and exercises. They found no significant differences between the two treatments (collar vs. active) with regard to improvement in pain scores or cervical movement.

These studies used different methods to measure cervical range of motion in assessing the degree of immobility that a soft cervical collar provides. Many studies (5,6,10,11,13,15) have used radiographs to assess cervical motion, but the risks to subjects and the cost of radiographs is of concern (20). In addition, studies do not consistently use the same methods for analyzing radiographs and, thus, it is difficult to compare the results of radiographic studies.

Other studies (2,17,18) have used goniometry to measure cervical range of motion. The reliability of goniometric measurements varies depending on the joint studied, the movement measured, and the regional anatomy and biomechanics (3,7). Goniometric studies for the cervical spine have indicated intrarater intraclass correlation coefficients (ICC 1,1) between 0.78 and 0.90, and interrater ICCs (1,1) between 0.54 and 0.79 (23). Zachman et al found that interexaminer reliability of goniometer measurements, estimated with Pearson product moment correlation coefficients, varied from 0.37 to 0.86 (24). As a result of the substantial measurement error, it is difficult to interpret the results of studies that use the goniometer as their tool.

To date, studies examining the degree of immobilization provided by a soft cervical collar have produced conflicting results. It is important to know whether soft cervical collars can restrict motion because they are often prescribed for this goal. If collars are not capable of restricting motion, then they should not be prescribed for that purpose. To determine whether soft cervical collars can restrict cervical range of motion, a reliable method of measuring cervical range of motion is necessary. Recent studies have shown that the Orthopedic Systems Inc. Computerized Anatomometry-6000 Spine Motion Analyzer (OSI CA-6000 SMA) produces reproducible measurements of spinal range of motion. For cervical range of motion, intrarater ICCs (2,1) were between 0.77 and 0.94 and interrater ICCs (2,4) ranged from 0.87 to 0.93 (12). Angles measured with it are extremely close to known angles (21).

In addition to the method of measuring the effectiveness of the collar, the manner in which it is worn must be considered. Depending on the goal of treatment, practitioners recommend that patients wear a collar either as intended by the manufacturer or in the reverse fashion. When collars are worn as intended by the manufacturer, they may force the patient into a forward head position, prompting practitioners to suggest turning it around. The effect of the position of the collar on cervical range of motion has not been studied.

The purpose of this study was to test the hypothesis that a soft cervical collar when worn as intended by the manufacturer or reversed will limit cervical range of motion. Our null hypotheses were that a soft cervical collar worn either way does not limit cervical range of motion in any direction.

**METHOD**

**Subjects**

The study group consisted of 50 adult volunteers (24 men and 26 women). Means, standard deviations, and ranges of subjects' heights, weights, and ages are shown in Table 1. Forty-nine subjects were right-handed dominant and one subject was left-handed dominant. The subjects were recruited through advertisements at Northwestern University's physical therapy, medical, and dental schools and through personal contact by the authors. Subjects had no complaints of local or radicular cervical pain, and no history of cervical injury or disease. Informed consent was obtained from all subjects.

<table>
<thead>
<tr>
<th>Subject Characteristic</th>
<th>X</th>
<th>SD</th>
<th>Range</th>
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<tbody>
<tr>
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<tr>
<td>Men</td>
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<td>5.8</td>
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<tr>
<td>Women</td>
<td>26.0</td>
<td>5.7</td>
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<tr>
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<td>5.7</td>
<td>22-43</td>
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<tr>
<td>Height (m)</td>
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<tr>
<td>Men</td>
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<tr>
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<td>Weight (kg)</td>
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<tr>
<td>Total</td>
<td>70.3</td>
<td>17.2</td>
<td>44-118</td>
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**TABLE 1.** Means, standard deviations, and ranges of height, weight, and age of 50 subjects (24 men and 26 women).
Examiners

Testing was done by three full-time students in the last year of the entry-level masters degree program at Programs in Physical Therapy, Northwestern University Medical School, Chicago, IL. The examiners reviewed the instruction manual and standardized written protocol provided by the manufacturer of the OSI CA-6000 SMA (4) and were also trained by faculty with previous research experience with this measurement instrument. Before data collection was initiated, all three examiners participated in 6 hours of training in their roles.

Instrumentation

Subjects were fitted with one of three sizes of the soft cervical collar (small, medium, and extra large). The collars were made of 2.54 cm, medium density foam rubber covered with cotton stockinette. The collars were contoured higher in front with a notch for the chin and a hook and loop fastener in back for adjustable and easy closure (The Saunders Group, Inc., Minneapolis, MN).

Cervical range of motion was measured using the OSI CA-6000 SMA (Orthopedic Systems Inc., Hayward, CA). The OSI CA-6000 SMA simultaneously recorded spinal range of motion in three dimensions using six potentiometers mounted on a movable arm that was attached to the subject at two points along the spine.

To measure regional motion of the cervical spine between the atlan-to-occipital joint and first thoracic vertebra (T1), a skull cap was placed so that the anterior segment of its horizontal band rested slightly above the eyebrows and the posterior segment rested below the curvature of the external occipital protuberance. The thoracic harness, consisting of two rubber straps, was looped around each shoulder and under the axilla to secure the second aluminum mount over the upper thoracic spine. The movable arm linkage was attached between the posterior mount of the skull cap and the second mount over the upper thoracic spine (Figure 1). Examiners observed the subjects prior to and during testing to assure free movement of the linkage. After the movable arm linkage was connected, the subject was instructed to sit squarely against the back of a chair, feet flat on the floor, eyes straight ahead, with their hands on their thighs. Subsequently, the tester operating the OSI CA-6000 SMA computer electronically set the potentiometers to zero. After each testing condition, the initial starting posture was again assumed and the computer zeroed.

Procedure

Subjects were seated upright, facing forward in a steel-framed straight-backed chair. To prevent trunk motion, subjects’ pelvic and lumbar regions were held squarely against the chair with a standard seat belt, which was buckled at the back of the chair and tightened around subjects’ waists. Subjects rested their hands comfortably on their thighs, and they positioned their feet flat on the floor. Practice trials were given before each collar condition to ensure that subjects understood the commands and to enforce visually that there should be no motion at the thoracic and lumbar regions. Limiting motion at the thoracic and lumbar regions was controlled by observation and verbal instruction; it was not measured.

Subjects were fitted with one of three collar sizes so that they perceived the fit as comfortable but snug. The soft cervical collar was fitted to subjects’ necks in their initial starting position and fastened using the adjustable closure. Subjects were tested without the soft cervical collar.
(Figure 2), with the soft cervical collar worn as intended by the manufacturer (closure posterior) (Figure 3), and with the collar reversed (Figure 4).

Three examiners were present. One examiner consistently oriented subjects to the test procedure and fitted the subjects with the measuring device and collar. A second examiner consistently operated the OSI CA-6000 SMA computer and instructed subjects when and how to move, while the third examiner recorded data.

Subjects were instructed to perform flexion and extension, right and left lateral flexion, and right and left axial rotation. Subjects were instructed to lead with their eyes and move as far as comfortably possible to their cervical end ranges. End range was defined as the point at which the subjects were unable to move further, with no substitution movements. Specifically, during right and left lateral flexion, subjects were instructed not to elevate their shoulders. During right and left rotation, subjects were instructed to lead with their eyes and look over each shoulder. Subjects were instructed to deform the collar with all movement directions. Before any measurements were made, subjects practiced the movements three times before the no collar condition and one time for each collar condition. Four trials for each plane of movement were recorded for each testing condition (no cervical collar, collar worn as prescribed by the manufacturer, and collar reversed). A reliability analysis of the four trials for each motion among subjects produced intraclass correlation coefficients (2,1) (22) between 0.92 and 0.97. To examine whether order of collar placement (forward or reversed) affected the results, half of the subjects (even numbered) wore the collar forward first, and half (odd numbered) wore the collar reversed first.

**Data Analysis**

Means, standard deviations, and ranges measured from the external occipital protuberance to T1 were used to describe the ranges of motion recorded for each test condition. Within subject analyses of variance were performed to compare the maximum degree of each cervical motion across three conditions (no collar, collar as prescribed by the manufacturer, and collar reversed). Post hoc paired t tests with Bonferroni adjustment ($\alpha = 0.017$) were used to identify the specific differences. All analyses were performed with the Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL) and a personal computer (Apple Computer, Inc., Cupertino, CA).

**RESULTS**

Multivariate analysis of variance (ANOVA) indicated no differences in range of motion among subjects with regard to gender ($F(df = 49) = 1.30$, not significant) and order of soft cervical collar placement ($F(df = 49) = 0.95$, not significant). Therefore, data for all subjects were pooled for further analyses. Means and standard deviations of all six ranges of motions within each of the three conditions are listed in Table 2. Significant differences were found in all six ranges of motion among the three conditions (Table 2). Post hoc paired t tests showed that wearing a collar either as recommended or reversed produced significantly less motion than not wearing a collar (Table 3). For the motions of flexion, extension, and right rotation, the two conditions with the collar allowed different amounts of motion. For the motions of right lateral flexion, left lateral flexion, and left rotation, however, range of motion while wearing a collar as recommended did not differ from range of motion while wearing the collar reversed (Table 3).

**DISCUSSION**

The results of this study supported the hypothesis that healthy subjects wearing the cervical collar in either position produced less motion when compared with not wearing a collar. These results could be attributed to the measurement device, the subject type, subjects' unwillingness to deform the collar due to the need for more effort or the feeling of restriction, the location of the collar closure, and the starting head posture.

The device used to measure cervical range of motion was the OSI CA-6000 SMA, which has been shown to be highly reliable, and it closely reproduces measures of known angles, thereby detecting small degrees of motion with little error (12,21).
Subjects in this study were all healthy volunteers, thus leading to limited variability in relationship with the magnitude of motion that occurred. Small differences in range of motion with and without the collar (1.1–11°) thus produced effect sizes as large as 2.3 standard deviations (no collar vs. collar forward for left rotation). With effect sizes this large, statistical significance is easy to achieve (19).

Differences in range of motion seen with and without the collar may have been due to the increased effort required to deform the collar. In addition, a majority of subjects stated that the testing condition with no cervical collar was most comfortable because they perceived the collar as restrictive. Therefore, subjects may have been unwilling to deform the collar due to its restrictive nature.

The location of the collar closure may explain the differential motion restriction in the sagittal plane. The collar closure is a stiffer component of the collar as compared with the soft foam in the rest of the collar. Differences in range can be attributed to location of the collar closure depending on whether it was worn as recommended (closure posterior) or reversed (closure anterior). When the collar closure was located posteriorly, extension was more significantly limited and when the closure was located anteriorly, flexion was more significantly limited.

Alternatively, differential sagittal motion restriction may be explained by the initial head posture. When the collar is worn as recommended (closure posterior), the collar is higher anteriorly. To clear the anterior height of the collar, the subject may need to assume a forward head posture. In this position, the upper cervical spine appears more extended, the middle portion of the cervical spine is relatively extended, and the cervico-thoracic junction is flexed. When the collar is worn reversed, with the opening in front and the height of the collar pos-
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able. With the collar reversed, they have upper cervical extension as well as midcervical extension available. Thus, extension appears to be greater with the collar worn reversed (8).

Regardless of how the collar is worn, it limits motion as little as 3° and as much as 11° compared with not wearing the collar. The total sagittal excursion of the cervical spine is nearly the same, however, in both collar conditions (Table 2). It appears, therefore, that the differences in flexion and extension ranges with the different collar positions are more a function of the starting position of the head resulting from the location of the highest portion of the collar than the stiffness of the closure.

Right and left lateral flexion and left rotation were limited almost equally regardless of whether the collar was worn as prescribed or reversed. These results would be expected because the height and softness of the collar on both sides are the same. Statistically, right rotation was significantly more limited with the collar worn reversed than when worn as prescribed. However, this difference was less than 2°. Left rotation, while not significantly different, had approximately 1° difference in limitation between the prescribed and reversed conditions. The clinical relevance of these results is questionable because the difference in limitation between the two conditions for both motions is so small.

The clinical relevance of the limitations in motion produced by the soft cervical collar must be addressed further. The soft cervical collar was able to limit flexion approximately 11.5° when worn reversed, but only about 5.0° when worn as recommended. When the collar was worn as recommended, it limited extension approximately 8.6°, and when reversed, it limited extension about 4.7°. This finding clearly indicates that the recommended position of the collar should be reversed if the required effect is to limit flexion. Right and left lateral flexion were limited approximately 3.0°, whether the collar was worn as recommended or reversed. The soft cervical collar limited right rotation about 5.0° when worn as recommended and about 6.5° when worn reversed. Left rotation was limited about 8.0° with the collar as prescribed and approximately 8.9° when worn reversed. If the goal of using the collar is complete immobilization of the cervical spine, this amount of limitation may not be clinically meaningful.

The results of our study are similar to those of Johnson et al (13) who used radiographic measurements to document the effectiveness of soft collars in limiting cervical motion. Reporting limitations of motion as percentages of maximum range, they also found that soft cervical collars limit motion in the sagittal plane when compared with not wearing a collar and that flexion was limited more than extension (13).

Clearly, the soft cervical collar does not completely eliminate motion. On the other hand, if the goal of using the collar is to prevent patients from experiencing pain at the extremes of range, the amount of limitation offered by the collar may be clinically meaningful. Given the results of this study and considering that subjects were instructed to deform the collar, the collar does limit range of motion for all motions. If pain is a factor at the extremes of range, keeping the patient out of extreme ranges of motion addresses the issue of pain relief. This limitation produced by the collar may further serve to relieve minor muscle spasm and offer protection and support from further trauma. The soft cervical collar, however, does not seem to be an appropriate choice if a patient is experiencing serious instability or is in need of complete immobilization because it does not completely limit motion.

CONCLUSION

The results of this study indicate that soft cervical collars are capable of physically limiting motion in all directions when worn either way, but only up to 11°. Motions in the sagittal plane are controlled to a greater degree, depending on collar positioning. The soft cervical collar is inappropriate if complete immobilization of the cervical spine is the goal of treatment.

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REFERENCES


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