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Comparison of Three Prefabricated Cervical Collars

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INTRODUCTION

The functional objective of any cervical orthosis is to limit unwanted cervical spine motion.[1] Motion control at the cervical spine is sought to ameliorate an array of problems which vary in etiology and severity.[6] Special cervical orthotic requirements may include one or more of the following: realignment of the cervical spine,[1] motion control in flexion, extension, anterior or posterior displacement, lateral flexion, axial rotation, and modest unweighting of the vertebrae.[1,7] Some common prescription criteria for use of a cervical orthosis are: post surgical management, immediate post-traumatic management, subluxations, degenerative diseases, and management of pain secondary to a multitude of disorders.[1,2,6,8] Each disorder may require one or more specific functions from a cervical orthosis.

In response to the different etiological factors and various manifestations of problems, many categories and types of cervical orthoses have become available to the orthotist.[1,3,4,5,6] The trends indicate a preference toward using prefabricated designs whenever possible,[9] and this has motivated manufacturers to design and market many prefabricated cervical orthoses. Most prefabricated cervical orthoses allow for minor adjustments only, with each having its own inherent advantages and disadvantages.

According to Johnson,[6] there are four categories of cervical orthoses. These are (in order from least to most restrictive) the cervical collars, poster cervical orthoses, cervicothoracic orthoses, and the halo skeletal fixation orthosis. Given the variety of orthoses available, prescription rationale includes consideration of function, comfort, and cost of the orthosis.

Effective stabilization is paramount. However, when a cervical orthosis needs to be worn for an extended period of time, comfort becomes an issue. Often, some restrictive efficacy is sacrificed for this purpose. When cervical spine instability is not apparent, the collar types are most frequently the first choice for use. The collar's kinesthetic reminder property plays an important role in limiting motion about the cervical spine.[1]

In emergency situations when supplies must be maintained, ease of application and cost are important. In view of this, the collar types have been widely used by paramedics for immediate post-traumatic cervical spine management.[10] However, it is known that collars are inadequate for controlling cervical spine instability. Paramedics will utilize sand bags about the injured body, particularly the head and neck, and tape the head to an underlying

Figure 1. (From left to right) The Philadelphia Collar, Nec-Lok®, and Soft Foam Collar.

board. These actions supplement the inadequacies of the various collars.

Many studies have been conducted on the popular cervical orthoses.[2,4,5,6] These studies have explored the relative motion control in the three anatomical planes. Documentation of motion in the sagittal, coronal, and transverse planes have been photographed and roentgenographed. The results are presented as percentages of motion restricted when compared to the normal range exhibited by the cervical spine.[4,5,6] In addition, the mechanics of motion at each individual vertebral level from the occiput through T-1 have been explored.[5,11] In all, documentation of motion in the three anatomical planes has provided sufficient information in determining the orthoses overall effectiveness for controlling motion of the cervical spine.[5,11] A secondary consideration is patient tolerance, which remains somewhat subjective and difficult to quantify. The orthotist obtains this information from patient feedback, appearance of the orthosis, and through trial fitting the orthosis, when possible.[7,10]

These studies are an excellent compilation of information for comparisons of cervical orthoses. However, there exists a need to document the new orthoses within each category, since many new cervical orthoses have been developed and marketed since the previous studies. It is the specific objective of this report to evaluate one of these new devices, the NecLok® cervical collar. The soft foam collar and the Philadelphia collar were used to establish internal criteria for comparison.

To date, no quantitative study has been conducted on the NecLok® cervical orthosis. A subjective analysis by the State of Indiana Emergency Medical Service Commission has rated this cervical collar superior over other cervical collars. Results were obtained by evaluating the orthoses according to the following criteria: simplicity, ease of cleaning, immobilization quality, ease of application, construction material, space needed for storage, sizes available, and manufacturer's wholesale price.[10]

MATERIALS AND METHODS

Ten subjects were selected, three female and seven male, with ages varying from 24 to 45 years. All subjects had normal cervical spines with no history of injury or disease. Each subject was tested for cervical range of motion in four treatment modes: wearing no orthosis and wearing each of the three test orthoses (Figure 1). All the orthoses were fit according to the manufacturer's recommendations.

Because of the accuracy of goniometry compared to roentgenography has been substantiated by others,[12,13,14,15] goniometry was used only to measure gross cervical motion in this study. By doing this, the high radiation exposures associated with roentgenography were avoided. Also, the angular errors associated with locating both gross anatomical landmarks and then convergent projections were avoided.

Each of the 10 subjects was seated in a standard, straight back chair and had their thoracic spine held against the chair back with the aid of a custom fabricated chest apron. In addition, each subject was instructed to exert a conscious effort to eliminate unnecessary motion, thus reducing unwanted thoracic and lumbar spine motion minimizing the introduction of errors into the cervical motion measurements.

For the purpose of this paper, motion in the sagittal plane is described as anterior/posterior motion. Previous studies have indicated that during an attempt to flex the cervical spine against mandibular restriction, some of the lower cervical vertebrae actually extend. In addition, gliding motion among the facets also contributes to motion in this plane.[5,6] Lastly, flexion and extension occurs about many axes and thereby contributes to anterior or posterior displacement of the structures proximal to those axes.

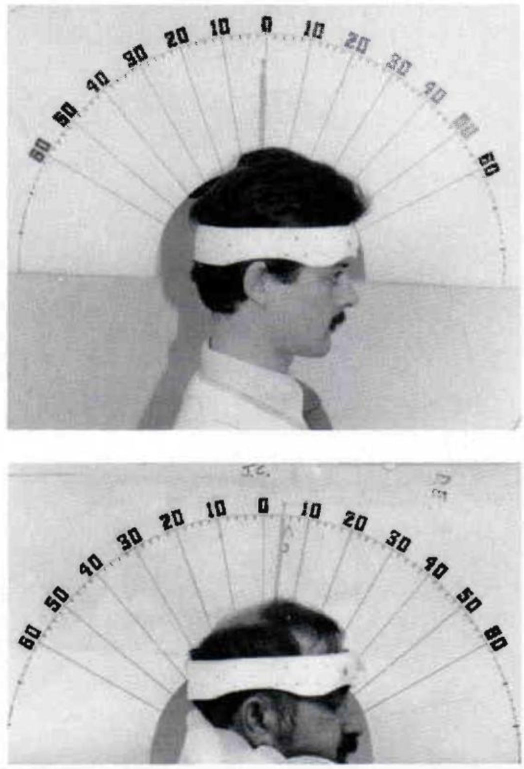


Figure 2. Anterior/posterior motion measurement.

Anterior/Posterior Motion

Anterior/posterior motion was measured as shown (Figure 2). An angular scale was positioned in the sagittal plane closely along the side of each subject. Each subject wore a custom fabricated head halter with an indicator needle attached (Figure 3). The indicator needle could be attached to various sites on the halter to accommodate the other measurements. The indicator needle traversed the scale during the ranging of the cervical spine and pinpointed the magnitude of angular motion. This allowed for a visual observation of an arc, depicting two end points of the full range of motion for that subject. The study goal was to obtain the subject's full arc measured in degrees (Figure 4).

Each of the 10 subjects were instructed on a procedure for allowing their neck to flex forward to the end of their range and then backward to the end of the extension range. The angular scale was marked at each end point of cervical spine motion. This procedure was repeated three times in each direction.

The platen with scale was calibrated in two degree increments. A camera was diametrically positioned from the scale to document the findings on film. A telephoto lens was utilized in an attempt to minimize errors created by parallax between the indicator needle and angular scale. Each photograph recorded three data end points, two of which were indicated on the angular scale with an ink marker (triangle and square), and the third was indicated with the needle protruding from the head halter. After it was determined that the difference of the three data points were not statistically significantly different, they were averaged into a single value representing one extreme range of motion. This procedure was repeated for each of the cervical collars used in this study.

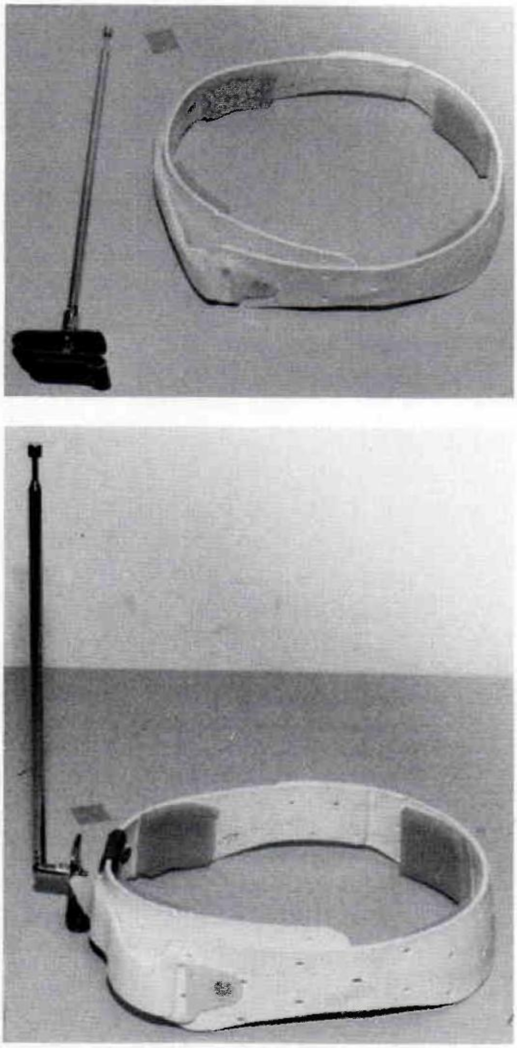


Figure 3. Head halter and indicator needle.

Lateral Flexion Motion

This testing procedure was repeated for lateral flexion. The angular scale was repositioned behind the subject's head in the coronal plane as shown (Figure 4). The indicator needle was also repositioned at the posterior aspect of the head halter. The subjects were instructed to flex their necks laterally to the left, and then to the right. This procedure was repeated for each of the various cervical orthoses tested. Photographs were taken in the same manner as described above.

Axial Rotation Motion

Axial rotation was measured with the platen and scale repositioned in the transverse plane (Figure 5). The subject's indicator needle was also repositioned, which allowed the needle to extend horizontally from the anterior aspect of the head halter and over the angular scale. The subjects were instructed to rotate their necks clockwise and then counterclockwise. This procedure was repeated for all the cervical orthoses tested. A mirror was positioned at a 45 degree angle over the subject's head to facilitate photographing the angular scale. Range of motion data were recorded in the same fashion as with anterior/posterior and lateral motion.

RESULTS

As indicated, all the observations were recorded in a continuum of degrees. These measurements described an arc which represented a total range of motion for that subject, for each observed anatomical plane. The cervical spine was measured as a whole unit without consideration to the angulations at each vertebral level. The

Figure 4. Lateral flexion measurement.

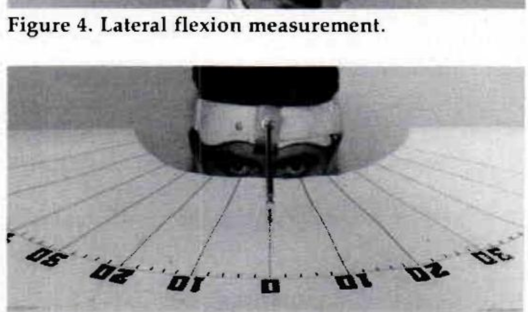
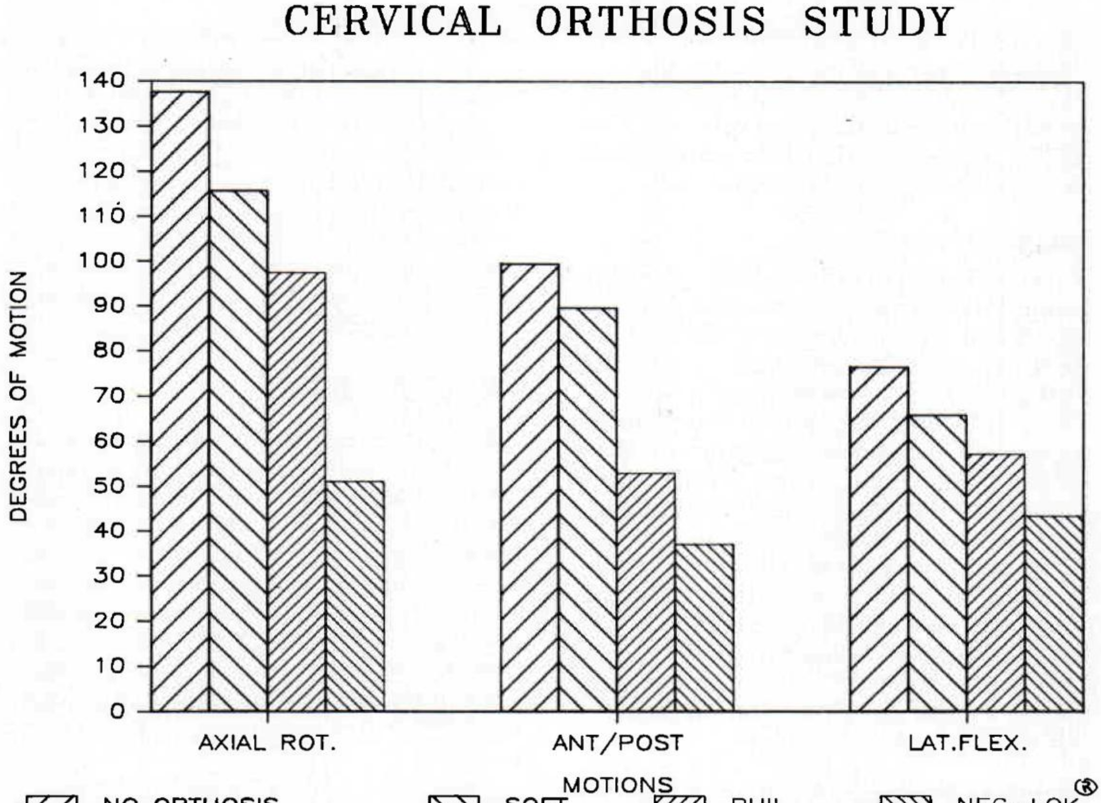


Figure 5. Axial rotation measurement.



Average Angular Arc in Degrees and Percent Restriction of Motion from Unrestrained Normal (N = 10)

	Axial Rot.	%R	Ant./Post.	%R	Lat. Flex.	%R
No Orthosis	137.60 (±10.8)	0.0%	99.53 (±15.7)	0.0%	76.83 (±12.8)	0.0%
Soft Foam Collar	115.70 (±13.9)	15.9%	89.70 (±15.6)	9.9%	66.00 (±11.7)	14.1%
Phil. Collar	97.57 (±20.3)	29.1%	52.97 (±08.3)	46.8%	57.27 (±14.6)	25.5%
NecLok® Collar	51.30 (±17.7)	62.7%	37.07 (±07.0)	62.8%	43.57 (± 9.1)	43.3%

MEAN (±1 sd)
%R + % Restrained Motion

p = Values Sheffe

Orthoses	1-2	1-3	1-4	2-3	2-4	3-4
Axial Rot.	0.0020	0.5000	0.0000	0.0119	0.0000	0.0000
Ant./Post.	N.S.	0.0000	0.0000	0.0000	0.0106	
Lat. Flexion	N.S.	0.0008	0.0000	N.S.	0.0001	0.0239

CODES: 1 = No Orthosis; 2 = Soft Collar
3 = Philadelphia Collar; 4 = Neclok® Collar

Table 1.

data were summarized by means and standard deviations and compared using Analysis of Variance. The Scheffe' test was used to do the multiple paired comparison. The CRISP Interactive Statistical Package was used for the statistical procedures.[16]

Axial Rotation

Axial rotation in the transverse plane exhibited the greatest difference among the individual treatment modes. The normal axial rotation measurement was 137.6 (±10.8) degrees, unrestrained (Table 1). The Soft Foam collar restricted rotation to 115.7 (±13.9) degrees, resulting in a 15.92 percent restriction from normal. The Philadelphia collar allowed 97.57 (±20.2) degrees of axial rotation, which resulted in a 29.9 percent restriction. The NecLok® collar allowed 51.3 (±17.6) degrees, which resulted in a 62.7 percent restriction. This is twice that of the Philadelphia collar. These initial three measurements indicate a significant difference from one another at $p < .05$ (Table 1).

Anterior/Posterior Motion

The average unrestrained anterior/posterior cervical spine motion computed to 99.53 (±15.7) degrees (Table 1). The Soft Foam collar's restrictive capability measured slightly less than normal with 89.70 (±15.6) degrees of total motion, a 9.88 percent restriction. A sharp drop with the Philadelphia collar was observed with 52.97 (±8.7) degrees, 46.78 percent of normal motion. The NecLock® had the greatest ability to control allowing 37.07 (±7.0) degrees of motion, 62.76 percent of normal motion. All three collars were statistically and significantly different from one another with $p < .05$ (Table 1). The Soft Foam collar did not display a significant difference from the "no treatment" mode.

Lateral Flexion

Lateral flexion measurements revealed the least amount of difference among the four modes of treatment (Table 1). The unrestricted measurements had a mean arc of 76.83 (±12.8) degrees of motion. The Soft Foam collar allowed 66 (±11.7) degrees, or 14.10 percent effective restriction from the normal range. The Philadelphia collar allowed slightly less at 57.27 (±14.6) degrees of motion, a 25.50 percent restriction. The NecLok® averaged 43.57 (±9.1) degrees of total motion, a 43.30 percent restriction. In this plane the Philadelphia and NecLok® collars were significantly different from no orthosis ($p < .01$) while the NecLok® was significantly different from both the Soft Foam and Philadelphia collar ($p < .01$).

DISCUSSION

The orthoses selected for this study are three commonly used cervical orthoses. This study verified other studies that have found cervical collars are less effective in controlling cervical spine motion than the more sophisticated category of cervical orthosis (e.g., SOMI,® Guilford two poster, and halo vest apparatus). However the prevalent application of cervical collars does indicate their importance in treating cases other than severe cervical spine instability.

The Soft Foam collar demonstrated a significant difference over no treatment at all (Figure 6). However, it offered very little immobilization of motion in the three planes which were studied. This collar's major effectiveness is derived through its kinesthetic reminder capabilities to withdraw which are inherently present with wear.

The Philadelphia collar offered substantially better immobilization than did the Soft Foam collar (Figure 6). However, its role in cervical spine immobilization is still considered ineffective. Previous studies have suggested its well accepted tolerance levels rather than its efficacy have gained this collar much popularity. In this particular study, it became apparent that good matching of proper collar size with patient, and proper application during donning, plays an important role in motion restriction effectiveness. Axial rotation immobilization was the most difficult motion to control. This was due to the collar's soft mandibular support, which the subjects of this study could overpower and occasionally extend and planes which were studied. This collar's major effectiveness is derived through its kinesthetic reminder capabilities to withdraw which are inherently present with wear.

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The NecLok® collar immobilized the cervical spine substantially more than the other two collars (Table 1). It proved to be the superior collar for immobilization in all three planes which were studied (Figure 6). All the subjects perceived the NecLock® to "feel more restrictive" than that of the other two collars. They claimed that it was less comfortable than the Philadelphia collar, yet it was not uncomfortable to wear.

The NecLok® collar has become popular among paramedics because of its advantages over the other cervical collars in its category. The NecLok's® attributes include the following: immobilization characteristics, superior ease of donning (may be applied with patient in any position, without log rolling), simple design, a cutout for tracheotomy, and it stores flat and compact, minimizing storage problems. In addition it is easy to clean, comes in three prefabricated sizes, and the price is less than that of the Philadelphia collar.[10]

This study demonstrates the value of objectively evaluating new collars (cervical restraints) as they are made available to the consumer to aid in the selection process.

AUTHORS

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Appendix A
Motion Restriction
No Orthosis Measured in Degrees Representing 100%
Cervical Collars in Percentage (%) From No Orthosis

Axial Rotation

Subject #	1	2	3	4	5	6	7	8	9	10
No Orth.	142.3	131.7	126.7	125.3	154.0	133.3	129*	156.7	135.7	140.7
Soft	18.0%	23.0%	23.4%	5.2%	18.4%	9.2%	19.6%	9.4%	22.6%	10.4%
Phil.	21.0%	30.0%	63.7%	16.0%	31.6%	29.5%	27.5%	38.0%	19.0%	15.2%
NecLok®	60.0%	77.4%	83.2%	48.4%	64.3%	70.7%	64.5%	66.4%	43.5%	49.5

Anterior/Posterior

Subject #	1	2	3	4	5	6	7	8	9	10
No Orth.	119.3	78.0	110.7	81.0	121.7	97.0	98.0	82.7	110.0	97.0
Soft	32.7%	0	17.2%	30.5%	15.4%	0	0.3%	1.7%	5.7%	0
Phil.	56.2%	54.2%	61.8%	34.2%	50.5%	38.5%	48.3%	27.0%	48.8%	39.5%
NecLok®	68.4%	67.9%	73.5%	65.1%	68.0%	53.9%	55.4%	49.6%	61.2%	60.1%

Lateral Flexion

Subject #	1	2	3	4	5	6	7	8	9	10
No Orth.	87.7	74.7	90.3	55.7	87.7	56.7	69.0	87.7	76.7	82.3
Soft	25.5%	0.5%	34.3%	10.2%	0	13.0%	7.2%	21.3%	12.2%	10.9%
Phil.	30.1%	2.3%	74.5%	19.2%	24.4%	6.5%	8.7%	23.3%	29.2%	19.4%
NecLok®	48.3%	29.5%	72.3%	26.4%	45.6%	65.8%	45.4%	51.8%	34.8%	31.1%

Figure 6.