ORIGINAL CONTRIBUTION
cervical spine, immobilization collars
spine, cervical, immobilization collars

Comparison of the Effectiveness of Different Cervical Immobilization Collars

Immobilization of the cervical spine is a common prehospital and emergency department maneuver. The ability of four different cervical collars to immobilize the cervical spine was studied using radiographic measurement in seven normal volunteers. Restriction of motion during flexion, extension, and lateral bending was studied. Differences between collars exist and require further study to identify the optimum device for immobilization of the cervical spine. [McCabe JB, Nolan DJ: Comparison of the effectiveness of different cervical immobilization collars. Ann Emerg Med January 1986;15: 50-53.]

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Received for publication June 12, 1984. Revisions received April 16 and August 12, 1985. Accepted for publication September 26, 1985.

Presented at the University Association for Emergency Medicine Annual Meeting in Louisville, Kentucky, May 1984.

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INTRODUCTION

Cervical spine injury is a common and often devastating injury. It may be present even in the absence of clinical signs and symptoms.[1] As a result, immobilization of the cervical spine prior to radiographic examination is the accepted standard of care for the multiple trauma patient. Many different cervical spine immobilization devices are available to accomplish this goal.[2]

Although a number of studies have compared the commonly available orthopedic immobilization devices,[3-5] there have been few studies of the devices used for prehospital immobilization of the cervical spine in the trauma patient. Podolsky and colleagues[6] showed, by goiniometric measurement, the superiority of hard foam and plastic collars over the more traditional soft cervical collar. They also demonstrated the advantage of using sand bags and tape in addition to the cervical collar.

No studies have compared, by radiographic measurement, the common styles of cervical immobilization collars used for prehospital immobilization of the cervical spine. We undertook this study to compare the degree of immobilization afforded by four different cervical immobilization collars representing three distinct design styles.

MATERIALS AND METHODS

Seven healthy adult male volunteers were studied. All had normal neck examination. None had a history of cervical spine injury or cervical spine disease. None was noted during the study to have a radiographic abnormality.

Four cervical spine immobilization collars were studied. These represented three distinct design types. Two of these types, the Philadelphia collar, and the hard foam extrication collar, are in common usage. The other two collars, polyethylene-1 and polyethylene-2, were manufacturers' versions of a newer polyethylene cervical immobilization collar. The four collars are shown (Figure 1).

The polyethylene collar is a light-weight, padded, prefabricated collar that stores in a disassembled, flat position. The collar is assembled at the time of application. Assembly of this collar is shown (Figure 2). The two models of polyethylene collars that were tested were very similar, with differences only in the lateral portion of the polyethylene part of the collar.

Each collar was applied to each subject following the manufacturers' instructions. For collars with multiple sizes available, the most appropriately sized collar was chosen; this usually was the medium collar. The subjects were seated upright. With each collar in place, each subject was asked to move his neck as far as possible in each of three directions: flexion, exten-

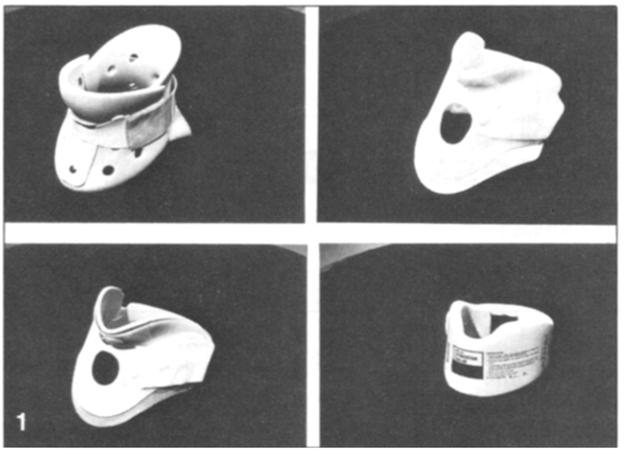


FIGURE 1. *Cervical collars, clockwise from top left: Philadelphia, polyethylene-1, extrication, and polyethylene-2.*

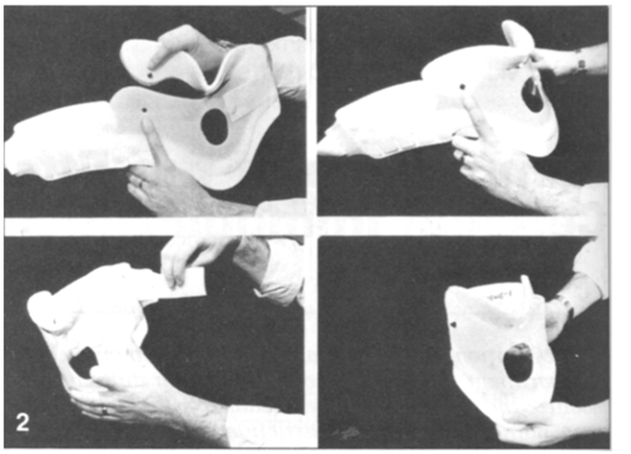


FIGURE 2. *Assembly of polyethylene collar.*

sion, and lateral bending. For each direction, a point of maximum movement was defined when the subject was unable to move further or when additional movement caused the collar to become unfastened. At the point of maximum movement in each direction, a radiograph of the cervical spine was taken.

The degree of spinal immobilization was determined for each collar in each direction of movement by measurement of the angle between the upper and lower cervical spine. For lateral bending, a line connecting the inferior portion of the mastoids was bisected by a perpendicular line. The angle between this line and the line joining the upper portion of the lateral processes of the first thoracic vertebrae was measured (Figure 3). For flexion and extension, the angle formed by lines joining the posterior aspect of the odontoid process and the inferior portion of the body of C7 was measured (Figures 4 and 5). Measurements were made independently by both authors. The two measurements were averaged for each radiograph. Variation of more than 5° on the same radiograph did not occur. Although some collars were identified easily in the radiographs, films from different subjects were randomly ordered and measured to minimize measurement bias.

In each subject, and for each direction of motion, the collars were ranked from one (providing the greatest degree of immobilization) to four. Average scores were determined for each collar for each direction of motion.

Statistical analysis was performed using a Student t test. The study protocol was approved by the Wright State University Institutional Review Board and the Miami Valley Hospital Research Committee.

For each individual, the degree of movement of the neck with each collar was compared to the maximum possible movement without a collar. The collars were ranked according to their ability to restrict neck motion.

RESULTS

The average rank scores for each collar for each direction of motion are shown (Table). For flexion, the polyethylene-1 had a statistically lower average score than did the other three collars ($P < .01$). This collar provided the greatest degree of immobilization in five of seven subjects. For extension, there was no statistical difference among the four collars. For lateral bending, the polyethylene-2 collar had an average score that was statistically lower than that for the Philadelphia and extrication collars ($P < .05$), but not the polyethylene-1 collar.

DISCUSSION

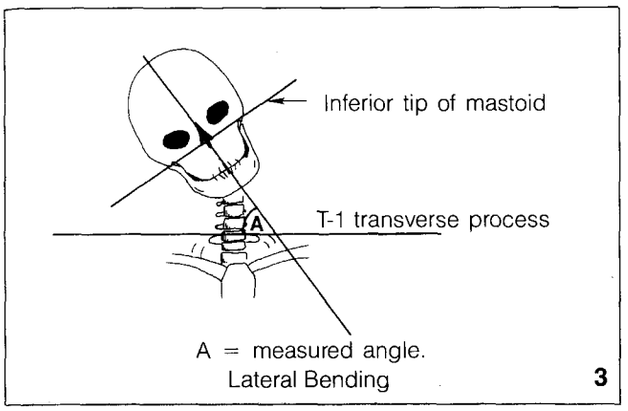
Our study compared four different cervical spine immobilization collars representing three distinct design types. The two polyethylene collars have similar designs and represent a new type of cervical spine immobilization collar. This new design type appears to have some advantages over both the Philadelphia and extrication collars. In limiting flexion, the polyethylene-1 collar was superior to all others. In restricting lateral bending, the polyethlene-2 collar was better than either the Philadelphia collar or the extrication collar. There was no difference in limiting extension.

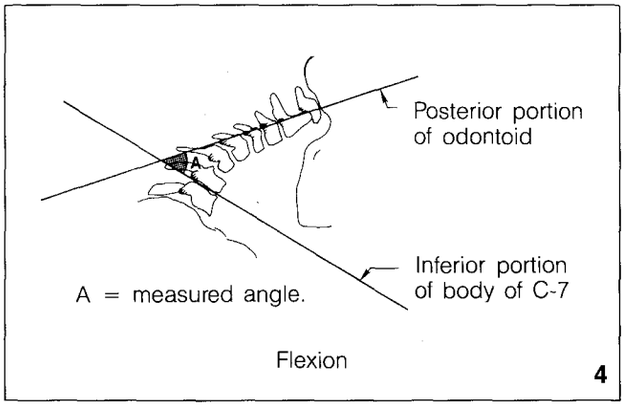
There are few published data on the efficacy of different immobilization devices and the studies have compared devices that are not practical for prehospital or emergency department use. Most papers dealing with this subject have compared different orthopedic devices used for long-term immobilization of the injured cervical spine.[3-5,7,8]

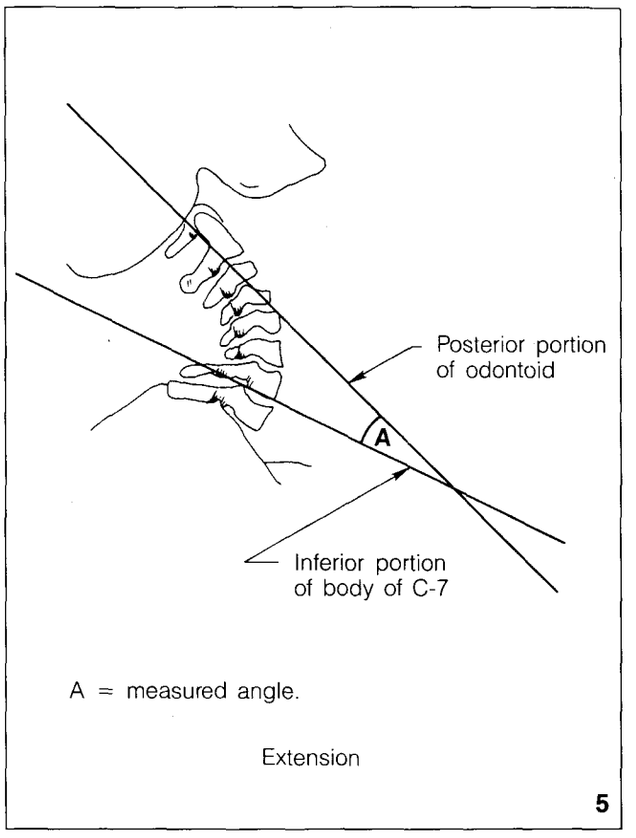
These studies have demonstrated, however, the superiority of the Philadelphia collar over the soft foam col-

TABLE. *Average rank scores (± SD)*

Collar	Flexion	Extension	Lateral Bending
Polyethylene -1	1.29 ± 0.49	2.79 ± 0.81	2.14 ± 0.85
Polyethylene -2	2.57 ± 1.13	2.50 ± 1.19	1.71 ± 0.70
Philadelphia	3.07 ± 0.45	2.00 ± 1.15	3.00 ± 0.76
Extrication	3.07 ± 1.24	3.14 ± 1.21	3.14 ± 1.46







lar.[3,5] Podolsky and colleagues[6] are the only investigators to compare different immobilization techniques applicable to the prehospital and ED settings. Four collars were studied with and without the addition of sand bags and tape by measuring neck movement by a goiniometric technique. The soft collar was found to limit only rotary movement of the neck. The Philadelphia collar was significantly better than the others in restricting extension. No significant differences were found in flexion.

Our study differs from that of Podolsky and colleagues[6] in that measurements were made from radiographs. We decided not to study the soft collar because many previous studies have demonstrated its deficiencies. We were unable to document any difference between collars in their ability to restrict extension. For flexion, the polyethylene collars provided more immobilization to the cervical spine, and the polyethylene-1 collar was statistically better than all three others. For lateral bending, the polyethylene collars provided more immobilization, but only the polyethylene-2 collar was statistically better.

These findings may be especially important if one considers the etiology of cervical spine injuries. Many authors[9,10] have stated the importance of hyperflexion in the production of cervical spine injury. In addition, for the confused ED patient, supine on a backboard, flexion of the neck is the movement most likely to be harmful. Hence, a collar with a clear superiority in limiting flexion of the neck is an important finding. The polyethylene-1 seems to be such a collar. The polyethylene-2 collar actually may be very comparable, but it did not prove to be as good in our study, perhaps due to the more limited number of available sizes.

A number of unresolved questions and problems deserve comment. Our study was performed with normal volunteers. Although this may be a useful model for initial assessment of the degree of immobilization provided by the different collars, it is difficult to know how to extrapolate these results to the spine-injured patient. Presumably, a collar affording a greater degree of spinal immobilization in the normal volunteer would do the same in the injured patient. Application to this setting, however, should be made cautiously.

Individual differences in neck motion in our subjects made absolute comparisons between subjects difficult. Each collar was measured against the others in the same subject. No absolute standard was possible.

Finally, a recent study by Aprahamian and coworkers[11] has shown the inability of a number of different collars, including the Philadelphia collar, to provide adequate immobilization of the cervical spine in experimentally induced spine injuries in cadavers during airway procedures. They suggest that the cervical immobilization device does little more than serve as a warning to physicians that a neck injury may be present.

FIGURE 3. *Lateral bending measurement technique.*

FIGURE 4. *Flexion measurement technique.*

FIGURE 5. *Extension measurement technique.*

SUMMARY

In spite of these limitations, we believe that the results demonstrate some differences between various collar types. Our current research efforts using a cadaver model with an unstable neck injury and a larger number of immobilization devices may help define further the ideal cervical collar.

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