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STIFNECK™ EXTRICATION COLLAR

CLINICAL INFORMATION PACKET

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STIFNECK™ DOCUMENTATION
Safety and Efficacy

Several scientific studies have been initiated to evaluate both the safety and efficacy of the Stifneck™ extrication collar developed by California Medical Products. With respect to an assessment of *safety* issues, a great deal of work has been done at the Regional Spinal Cord Injury Care System (RSCICS) at Rancho Los Amigos Medical Center. In fact, several important modifications were made to the collar based upon RSCICS investigations. Enclosed are the second of two X-ray studies done at the RSCICS that looked at both the immobilization provided by the collar and its ability to maintain the patient's cervical spine in the neutral position.

The results of these studies prompted Rodney H. Adkins, Ph.D., Co-Director of the RSCICS, to submit a letter to the editors of the *Journal of Emergency Medical Services* (JEMS) regarding the purpose and performance of rigid cervical collars. This letter and the studies performed at the RSCICS point out the fact that, while rigid extrication collars offer many benefits over other types of collars, the design, size selection, and application of rigid collars are critical factors that should be assessed carefully prior to their adoption as a routinely used emergency medical device.

Two X-ray studies published in the *Annals of Emergency Medicine* looked at the *efficacy* of Stifneck™ by comparing it directly with other collars as well as different immobilization systems. The first of these articles by McCabe, et al. directly compared a prior and current version of the Stifneck™ collar (identified as Polyethylene 1 and 2, respectively) with the Philadelphia™ collar and the Ferno extrication collar ("Comparison of the Effectiveness of Different Cervical Immobilization Collars"). In this article, Dr. McCabe found that "This new design type appears to have some advantages over both the Philadelphia and extrication collars."

The second article, "A Radiographic Comparison of Prehospital Cervical Immobilization Methods" by Graziano, et al., compared the immobilization capabilities of our collar alone to those of a fully strapped short board, a KED™ device, and an XP-1™ device. Surprisingly, the Stifneck™ alone provided ~ 80% of the cervical immobilization afforded by the best of these other systems. Since the authors state that "when compared to a previous study, these results affirm the California Stifneck™ collar to be one of the best overall collars", a copy of this previous study has also been enclosed for your reference ("A Comparison of Methods of Cervical Immobilization Used in Patient Extrication and Transport", *Journal of Trauma*, 1985; 25:649-653). These studies together provide an indirect X-ray comparison of the Stifneck™ with the Philadelphia™, Hare Extrication, and Thomas collars and show it to be superior.

It is our belief that after an assessment of the attached materials and a brief review of our in-service training video and package insert, along with some hands on experience with the collar itself, you will feel confident that the Stifneck™ collar is a valuable component in overall axial-skeletal immobilization.

Note: Laerdal Medical Corporation has numerous articles dealing with cervical spine issues on file. If you are interested in receiving a listing of these articles, please contact us.

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Draft Copy 1983

MODIFICATION AND RADIOGRAPHIC ANALYSIS OF A NEW CERVICAL EXTRICATION COLLAR

BY

Perry R. Secor, M.D.

INTRODUCTION

This is a follow-up study to a recently performed study involving a newly introduced cervical extrication orthosis. This device was designed to be used in the pre-hospital setting by the emergency technician. These collars ideally immobilize the traumatized cervical spine protecting it from further damage during transit to a major trauma center. The first study, performed by DR. DAVID CALDWELL and DR. JIUN-RONG PENG revealed that the device provided excellent immobilization but also caused hyperextension at the occiput - C1 and C1 - C2 levels. Obviously this wasn't an acceptable situation and design modifications were undertaken. The manufacturer consulted the staff of the Rancho Los Amigos Spinal Injury Project who recommended specific changes be made. After these changes were instituted, a second study was undertaken to radiographically evaluate the modified collar.

MATERIALS AND METHODS

The STIFNECK cervical orthosis is composed of two different density polyethylene plastic materials. A high density polyethylene provides structural strength and a polyethylene foam serves to pad the contact areas. The device stores in a low, flat profile. It assumes a three dimensional configuration after a segment of the brace is rotated and secured with a plastic fastener. The orthosis is designed to be slid posteriorly under the arch of the subject's neck and secured in position with a large Velcro™ strap. The collar is radiolucent allowing cervical x-rays without brace removal.

This device has five distal contact points. These are bilateral clavicles, bilateral trapezius muscles and the sternum. Proximally it contacts the posterior soft tissues overlying the occiput and anteriorly the mandible and its soft tissues.

The seven subjects in this study were all males between the ages of 23 and 33. The group was purposely drawn from because it represents the population at greatest risk to sustain cervical trauma. The evaluation methods are identical to those used by CALDWELL and PENG in the previous evaluation of the original STIFNECK orthosis. A restatement of their methods follows.

In each subject a normal unrestricted extreme range of active motion in flexion, extension, rotation and lateral bending was determined and compared with the ranges of motion wearing the brace. The brace was applied according to instructions supplied with the brace. Ten x-rays were taken of each volunteer. The tube to film distance was maintained at 2.75 meters to limit distortion. The estimated total radiation exposure was 0.9 grams as determined by JOHNSON (1977) and protocol. Lead goggles and groin lead covers were worn to protect from radiation scatter.

The flexion and extension motion with and without the brace was determined on lateral x-rays in extension. The change in neutral alignment following application of the brace was also measured. Lines were drawn on the x-rays tangential to the base of the skull along the inferior margin of the ring of the atlas and through the tips of the inferior lips of each vertebral body C-2 through C-7. Angles between the lines were recorded at each level. The lines that converged posteriorly were given a negative value to designate extension. Conversely the lines that converged anteriorly were a positive value to designate flexion. The actual flexion and extension motion at each level was computed by subtracting the angle measured on the neutral lateral x-ray from the angle measured on the flexion or extension lateral film.

The change in neutral alignment following application of the braces was determined by subtracting the neutral alignment angles from the braced neutral measurements. The brace neutral angles were used to normalize the braced motion values. Lateral bending motion with and without the brace was measured on AP x-rays. The average of right and left bending films with and without the brace was recorded. A metallic rod held in the subject's teeth was used as the upper reference line. The lower reference line was drawn through the superior margin of the transverse processes of T-1. Rotation motion with and without the brace was measured using photographs of the head and shoulders. The average of right and left rotation with and without the brace was recorded. A piece of tape placed over the top of the head in the mid-sagittal plane was used as the upper reference marker. The lower reference line was drawn from the anterior edge of the table. The shoulders were pressed back against the table during rotation to limit movement of the thoracic spine.

RESULTS

Table I summarizes the mean maximum active motion of the modified collar. This device does a good job of restricting flexion allowing only 13 % of the unbraced motion. It however is much less effective in limiting extension, rotation and lateral bending. Table II summarizes the segmental alignment at the cervical vertebral levels from the occiput to C7. When one compares the segmental alignment between the unbraced and braced using paired T-TEST one finds no statistical difference. In summary the modified cervical orthosis offers a fair degree of immobilization without significant distortion of the unbraced resting segmental alignment.

DISCUSSION

Cervical orthoses generally have two areas of contact - one at each end of the neck. The STIFNECK cervical orthosis has a unique contact system at the base of the neck. The standard orthosis has a four point contact system which includes bilateral clavicles and bilateral trapezius muscles. The STIFNECK has an additional fifth contact point stabilizing the neck against lateral bending and rotation. It also acts as a rigid structural element protecting against cervical flexion. If the anterior member is too high and the orthosis placed on the patient tightly, the orthosis acts as a wedge forcing the neck into distraction and extension at the upper cervical levels. The STIFNECK orthosis' proximal contact points include the occiput posteriorly and the mandible anteriorly. The anterior contacts are bony and secure. The posterior contacts are the hair and shin over the occiput which are much less secure. This explains the better limitation of flexion than extension.

Table III is a comparison between the modified and original orthosis. As seen in this table both are good at controlling flexion. Also the original orthosis is nearly twice as effective in controlling extension, rotation and lateral bending as the modified orthosis.

Table IV compares the neutral segmental alignment of the two orthoses. It is clearly seen that the original orthosis hyperextends the proximal cervical spine. The modified orthosis (RLAH #2) leaves the vertebral segment unaltered. The design change between RLAH #1 and RLAH #2 consisted primarily of decreasing the height of the anterior flare. This effectively eliminated the hyperextension problem in the subject population studied. It should be noted that if this orthosis were placed on a child or small adult hyperextension of the proximal cervical spine could occur.

There are few studies in the orthopaedic literature analyzing cervical extrication orthoses. In a published study JOHNSON, ET AL performed a numerical analysis of several commonly used cervical orthoses. The studied population and numerical range of motion of the unbraced subjects compare well with this study. Assuming these two groups are of the same population allows numerical comparison of the STIFNECK with existing devices. This comparison is shown in Table V. As seen here the STIFNECK (RLAH #2) performs slightly better than the popular Philadelphia collar.

Finally it must be noted that this study was performed on normal subjects. It is unknown what the collar would do for an unstable cervical spine.

In this study a modified version of the STIFNECK cervical extrication collar was evaluated. Normal male subjects were subjected to x-ray and head photographic analysis. From this quantitative values were generated using a method described by JOHNSON, ET AL. The modified orthosis provided significant immobilization in all planes of cervical motion without distortion of the normal resting vertebral alignment. The degree of immobilization was of the magnitude of the Philadelphia collar. Direct information concerning immobilization of the unstable cervical spine was not obtained in this study.

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TABLE I

MEAN MAXIMUM ACTIVE MOTION

	Unbraced	Braced	% Motion Allowed
Flexion	59	10	13
Extension	50	21	41
Rotation	80	40	50
Lateral Bending	32	19	63

TABLE II

SEGMENTAL NEUTRAL ALIGNMENT

Level	Unbraced	Braced	Change	Paired T-TEST
OC-C1	-2	-4	2E	0.2
C1-C2	-26	-27	1E	0.2
C2-C3	-4	-2	2F	0.2
C3-C4	-6	-5	1F	0.4
C4-C5	-2	-1	1F	0.6
C5-C6	-2	-1	1F	0.2
C6-C7	-4	-3	1F	0.4
TOTAL	-47	-44	3F	0.6

TABLE III

MEAN MAXIMUM ACTION MOTION COMPARISON

	Unbraced		Braced		% Motion Allowed	
	RLAH #1	RLAH #2	RLAH #1	RLAH #2	RLAH #1	RLAH #2
Flexion	44	59	5	10	12	13
Extension	55	50	9	21	20	41
Rotation	77	80	15	40	18	50
Lateral Bending	29	32	11	19	34	63

TABLE III

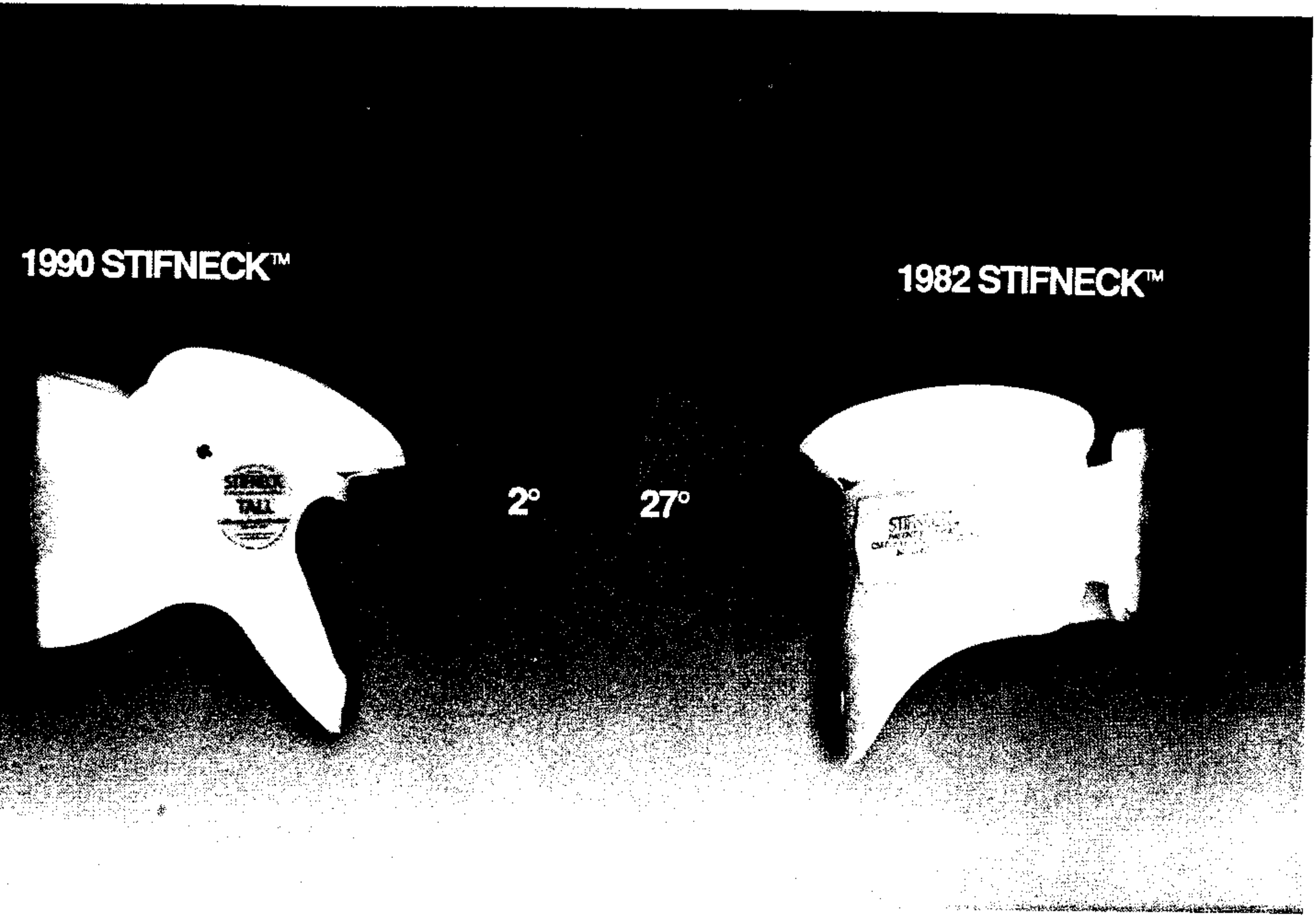
MEAN MAXIMUM ACTION MOTION COMPARISON

	Unbraced		Braced		% Motion Allowed	
	RLAH #1	RLAH #2	RLAH #1	RLAH #2	RLAH #1	RLAH #2
Flexion	44	59	5	10	12	13
Extension	55	50	9	21	20	41
Rotation	77	80	15	40	18	50
Lateral Bending	29	32	11	19	34	63

TABLE V

COMPARISON WITH OTHER CERVICAL ORTHOSIS
PERCENT NORMAL MOTION ALLOWED

	FLEXION	EXTENSION	ROTATION	LATERAL BENDING
SOFT COLLAR	77	81	83	92
PHILADELPHIA	30	44	44	66
STIFNECK				
RLAH #1	12	20	18	34
RLAH #2	13	41	50	63
SOMI BRACE	7	58	34	66
FOUR - POSTER BRACE	11	18	27	46


1990 STIFNECK™
1982 STIFNECK™
2°
27°

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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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.

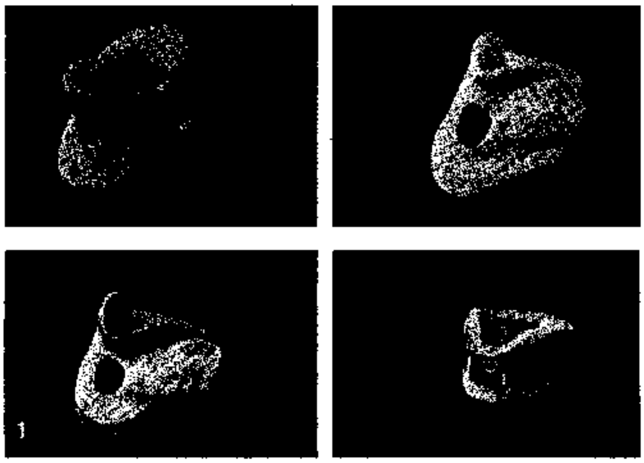
MATERIALS AND METHODS

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-



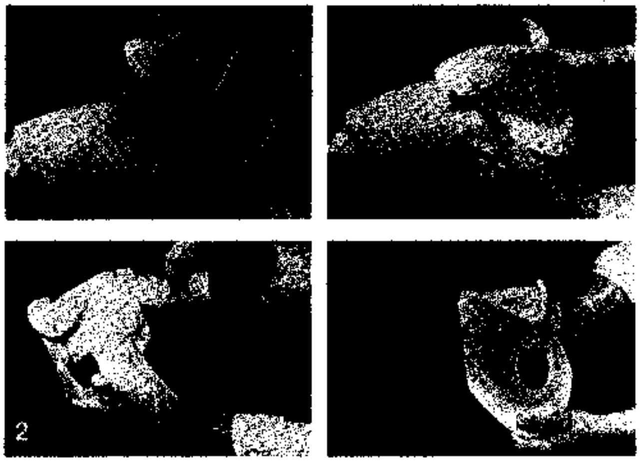


FIGURE 1. *Cervical collars, clockwise from top left: Philadelphia, polyethylene-1, extrication, and polyethylene-2.*

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

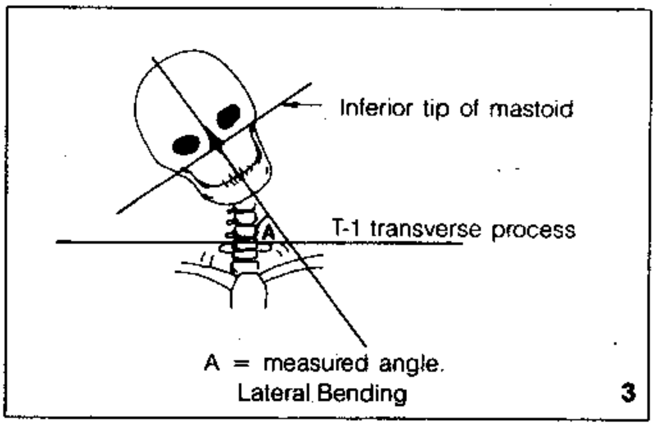
Our study compared four different cervical spine immobilization collars representing three distinct design types. The two polyethylene collars have similar designs and represent a new type of cervical spine immobilization collar. This new design type appears to have some advantages over both the Philadelphia 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.

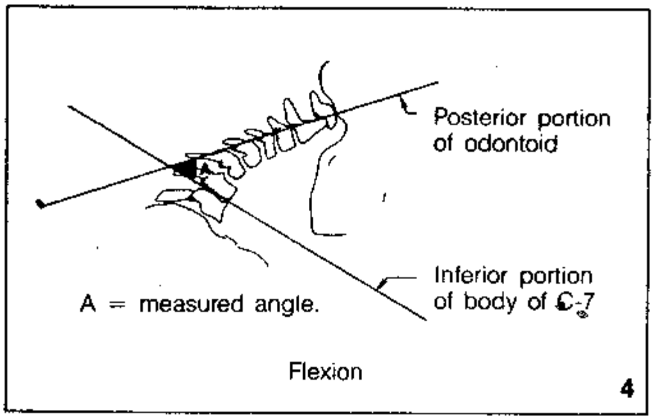
There are few published data on the efficacy of different immobilization devices and the studies have compared devices that are not practical for prehospital or emergency department use. Most papers dealing with this subject have compared different orthopedic devices used for long-term immobilization 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





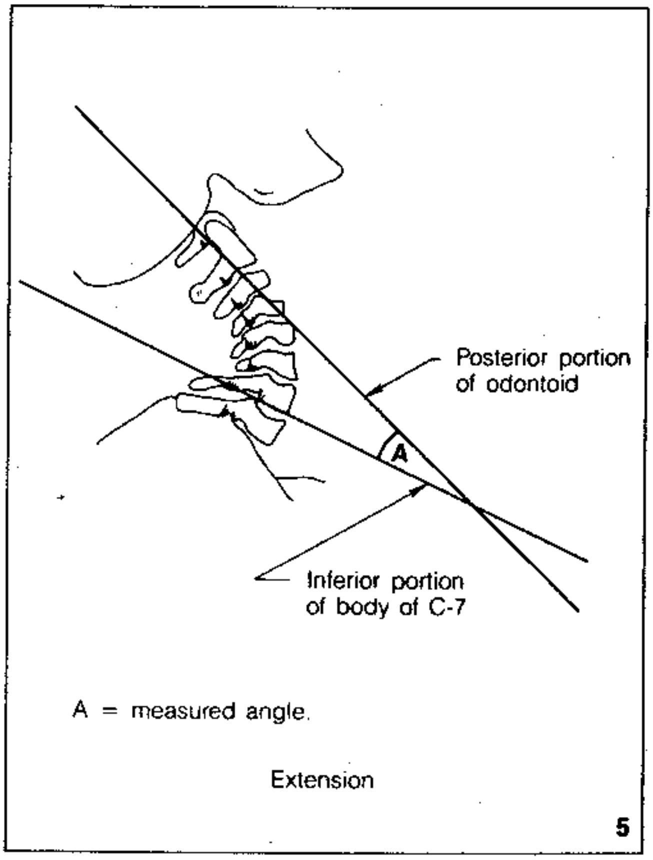


FIGURE 3. *Lateral bending measurement technique.*

FIGURE 4. *Flexion measurement technique.*

FIGURE 5. *Extension measurement technique.*

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.

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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A Radiographic Comparison of Prehospital Cervical Immobilization Methods

Three methods of prehospital cervical immobilization were studied radiographically and compared to the short board technique (SBT). The methods were California Stif-Neck Immobilizing Collar® (CSC), Kendrick Extrication Device® (KED), and Extrication Plus-One® (XP-One). Forty-five volunteers were immobilized in the short board (SB) and one of the test devices studied. Cervical movement in the sagittal and frontal planes was measured radiographically. Movement in the horizontal plane was measured directly. Two-tailed, paired t test analysis was performed comparing test devices to the SBT. The SBT proved to be significantly better (P < .05) in the following comparisons: the CSC in extension and lateral bending; the KED in lateral bending; and the XP-One in extension. We confirm the SBT as the standard of comparison against which newer prehospital devices can be compared objectively. Of the three devices compared against the SBT, the factory-fabricated short board devices (KED and XP-One) provided the greatest degree of immobilization, in addition to logistical advantages over the SBT. [Graziano AF, Scheidel EA, Cline JR, Baer LJ: A radiographic comparison of prehospital cervical immobilization methods. Ann Emerg Med October 1987; 16:1127-1131.]

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INTRODUCTION

Significant cervical cord injuries can result from improper handling and inadequate immobilization during the extrication, transport, and evaluation of trauma victims.[1,2] Proper management at the scene of an accident requires efficacious use of cervical immobilization devices.

Several studies using radiographic techniques have compared various collars and orthoses, most of which have largely clinical uses and are not applicable to use in the prehospital setting.[3-7] A recent study compared four collars and a technique of immobilization similar to current prehospital methods, but radiographic techniques were not used.[2] Two recent studies compared a wide variety of devices used in the prehospital setting, but no objective measurements were made to evaluate their efficacy.[8,9]

Cline[10] recently demonstrated radiographically that of seven methods studied (Philadelphia collar, Hare extrication collar, rigid plastic collar, short board technique [SBT] and SBT/collar combinations), the methods involving the short board (Figure 1) were far superior to the collars in all planes of movement. Furthermore, SBT/collar combinations neither augmented nor reduced the immobilization provided by the short board alone. This study effectively established the SBT as a standard against which newer prehospital cervical immobilization devices could be compared.

We designed a controlled study to radiographically evaluate the efficacy of three newer commonly used cervical immobilization devices for which there are no objective published data in the medical literature. These devices were CSC, a one-piece wrap-around collar (Figure 2); KED, a factory-fabricated short board (Figure 3); and the XP-One, a factory-fabricated short board-collar combination (Figure 4). We then directly compared their efficacy to that of the SBT.

MATERIALS AND METHODS

Forty-five healthy volunteers were recruited from the Butterworth Hospital physician and nursing staff and the Davenport College Center for the

FIGURE 1. *Short board technique (SBT).*

FIGURE 2. *CSC (California Stif-Neck Collar*).*

Study of Emergency Medical Services. The study was approved by Butterworth Hospital, and informed consent was obtained. All volunteers were tested in the sitting position to approximate the condition frequently encountered in the prehospital setting. Gonads were shielded at all times. One EMT instructor applied all immobilization devices.

The short board method was applied according to the method described by Cline et al.[10] The California Stif-Neck Immobilizing Collar* (CSC) (Jobst, Toledo, Ohio), Kendrick Extrication Device* (KED) (FERNO-Washington, Inc, Wilmington, Ohio), and Extrication Plus-One* (XP-One) (Medical Specialties, Inc, Charlotte, North Carolina) were applied according to the manufacturer's recommended procedure. Each volunteer underwent nine radiographic views. Three views were obtained in each of the following conditions studied: unrestricted for baseline comparison, the SBT, and one of the three test devices to which the subject was randomly assigned. Each volunteer served as his own control.

Radiographs were obtained using a stationary grid (12:1) at a plate-focal point distance of 72 inches. For each view, subjects were instructed to exert maximal effort. The views consisted of two lateral cervical-spine views to test sagittal plane movement (one each in active flexion and extension) and an anterior-posterior view in active left lateral bending to test frontal plane movement. An occlusal radiopaque marker was placed between the teeth for the lateral bending view. Axial rotation, under baseline and test conditions, was measured directly using a large, specially designed protractor adjusted to the appropriate height.

Each of the nine radiographs for each volunteer was analyzed in similar fashion to that described by Cline et al.[10] For the sagittal views, tangential lines were drawn to the following landmarks: occiput and anterior foramen magnum; inferior borders of the neural arch and dens of C-2; and inferior anterior and inferior posterior borders of the bodies of each successive vertebra, C-2 to C-7. The angles formed by convergence of tangential lines between successive vertebral levels were measured and recorded. The angle formed between the base of the skull (occiput-foramen magnum) and the base of C-7 also was measured and recorded (occiput-C-7 angle).

For the frontal views (baseline and test views), a line was drawn tangentially to the rostral aspect of the transverse processes of T-1 and the angle formed by its convergence with a line directly extending from the radiopaque occlusal marker was measured and recorded. Lines that intersected off the radiograph were measured using Cobb's method.[11]

All data were submitted to comput-

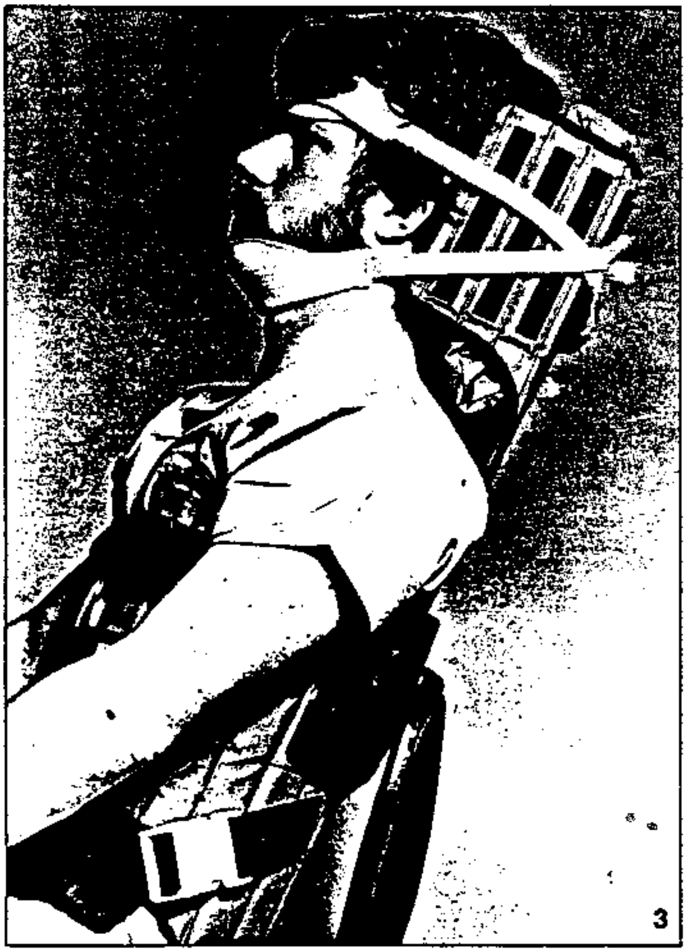

FIGURE 3. *KED (Kendrick Extrication Device*®*).*

FIGURE 4. *XP-One.*

erized statistical analysis. Two-tailed paired t test analysis was performed. Efficacy of short board immobilization then was compared directly to the cervical immobilization devices studied. For comparison to past studies, efficacy was further quantified as percent reduction of baseline movement.

RESULTS

Study subjects' ages ranged from 18 to 61 years, with a mean of 25 years. Among the three groups tested there were no significant differences in height and weight. The sex ratio was also comparable. All anterior-posterior views were used in analysis of frontal plane movement. Ten sets of lateral radiographs were unacceptable for sagittal view measurements. One was due to poor radiographic technique. In nine other sets there was an inability to visualize lower segments of the cervical spine (C-6 and/or C-7). These were discarded from sagittal view (flexion/extension) measurements because the occiput-C-7 angle was critical to that part of the study. The subjects of these "unacceptable" sagittal views differed significantly from the average ($P < .05$) in regard to both height (175 ± 11 cm versus unacceptable 189 ± 13 cm) and weight (68 ± 12 kg versus unacceptable 88 ± 16 kg).

The SBT was superior to the CSC in rotation and the KED in extension, while the KED was superior to the SBT in flexion. When total range-of-motion in the sagittal plane was examined statistically, the SBT proved significantly better ($P < .05$) than the CSC, while the KED and XP-One approached SBT efficacy.

The SBT was significantly different than the controls (unrestricted movement) at $P < .001$, in all planes of movement. When compared to the test devices (Table), the SBT proved significantly better ($P < .05$) than the CSC in extension and lateral bending; the KED in lateral bending; and the XP-One in extension. When values are expressed as percent reduction of baseline movement (Figure 5), the SBT was superior to all test devices in the horizontal plane (axial rotation) and the frontal plane (lateral bending). In the sagittal plane the SBT was superior to the CSC and the KED and differed from the XP-One by only one percentage point.

Thus, where differences were significant ($P < .05$), the SBT was superior when compared to all test devices. Furthermore, the SBT was consistently superior in all planes of cervical spine motion.

DISCUSSION

A critical process in the extrication and transport of trauma victims is the immobilization of the cervical spine. Cervical spine injury and attendant neurologic deficit continues to be a personally devastating and economically burdening situation. Although most cervical cord injuries are irreversible, there remains a significant proportion that allegedly occur in the

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A Comparison of Methods of Cervical Immobilization Used in Patient Extrication and Transport

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We radiographically studied the efficacy of seven methods of cervical immobilization used in the prehospital setting. The methods were: Philadelphia collar, Hare extrication collar, rigid plastic collar, Philadelphia collar + short board, Hare extrication collar + short board, rigid plastic collar + short board, and the short board used alone. Ninety-seven normal volunteers were randomized to one of these seven methods and each volunteer served as his or her own control. Efficacy was expressed as per cent reduction of baseline movement in the sagittal, frontal, and horizontal planes.

The short-board technique appeared to be superior to all the three collars studied. The collars provided no augmentation of immobilization over that provided by the short board alone. We believe that the short-board technique described herein, which is commonly used in the prehospital setting, can be used as the standard of comparison against which newer prehospital devices can be objectively compared.

Cervical immobilization is a critical part of the process of extrication and transport of trauma patients. Accordingly, various devices and techniques have been developed to accomplish this in the most efficacious manner. That significant cervical cord injuries can result from improper handling and poor immobilization is well documented (8, 10). Previous studies have investigated the efficacy of various immobilization methods. Several studies employing radiographic techniques have compared various collars and orthoses, most of which have largely clinical uses and are not applicable to use in the prehospital setting (1, 2, 4–6). Another more recent study compared four collars frequently used in the prehospital setting as well as a technique of immobilization similar to current methods used in the prehospital setting, but radiographic methods were not used (8). Finally, a recent study in the literature of Emergency Medical Services (EMS) compared a wide variety of devices used in the prehospital setting but there were no objective measurements made to evaluate their efficacy (3).

We designed a controlled study to evaluate the efficacy of three commonly used collars used alone and in combination with a short-board technique as well as the short-board technique used alone.

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MATERIALS AND METHODS

Ninety-seven healthy volunteers were recruited from the hospital physician and nursing staff, Davenport College Center for the Study of Emergency Medical Services, and the local chapter of the American Red Cross. Ages ranged from 18 to 54 years (mean age, 28 years). Each volunteer was randomized into one and only one of the seven methods of immobilization tested. The methods were Philadelphia collar (All Orthopedic Appliances), Hare extrication collar (Dynamed), rigid plastic collar (Thomas), Philadelphia collar with short board, Hare extrication collar with short board, rigid plastic collar with short board, and short-board technique alone. Random sampling with replacement was used to maximize the sample size for each method. Informed consent was obtained. All volunteers were tested in the sitting position to approximate the condition frequently encountered in the prehospital setting. Each volunteer served as his or her own control.

Four unrestricted (baseline) radiographic views of the cervical spine were obtained using a stationary grid (12:1) at a plate-focal point distance of 72 inches. The views consisted of: neutral (lateral), active flexion (lateral), active extension (lateral), and active lateral bending (anterior-posterior). An occlusal radio-opaque marker was placed between the teeth for the lateral bending view (6). Volunteers were randomized to either left or right lateral bending for the frontal views in order to limit radiographic exposure. Axial rotation under baseline and test conditions was measured directly using a large specially designed protractor adjusted to the appropriate height (Fig. 1).

The immobilization method to which the volunteer was randomized was then applied. A single EMT instructor applied all devices in the study. Volunteers randomized to a collar-only method were first seated in a straight-backed, padded chair and instructed to hold their heads in a neutral position. The manufacturer's recommended procedure for application was used for each collar.

For the short-board methods we selected a variation of the Ohio Extrication Short board (OES) for use in the study (Fig. 2). Accessory equipment included: two 9-foot Ferno-Washingpossibly improve its efficacy.

The significant difference in height and weight between the subjects measured and the nine patients whose sagittal views were unacceptable underscores our common clinical experience that patients with generous necks are difficult to "clear" radiographically. Because the inability to visualize the lower cervical segments occurred in the controls, we believe this "impaired visualization" is due to physique factors rather than from interference as a result of test device or SBT application. The extent to which the ten excluded subjects introduced selection bias is unclear. It should be noted that there were subjects in the measurable test groups of similar size and stature.

Because the control groups differed, comparisons between the CSC, KED, and XP-One are inferred. The KED and XP-One provided similar reduction of baseline movement in the horizontal and frontal planes. Neither was better than the SBT in exclusively matched control groups. In the sagittal plane the XP-One and the SBT were similar, both being better than the CSC and KED. The results regarding the efficacy of the factory-fabricated short boards (with and without collars) show them to be better than collars and approach the efficacy provided by the SBT. This is encouraging because they offer certain logistical advantages over the SBT.

Application of the SBT varies. The fabricated boards, however, offer standardized application and training without regional differences and are more easily applied. Another advantage is that all straps are attached directly to the fabricated boards, whereas with the SBT they are not. Most importantly, the fabricated boards are much more rapidly applicable. This was not quantified in the study. Time required for application is extremely important with the risks of concomitant hypovolemic shock in the blunt trauma victim.

A recent study suggests that bilateral sand bags joined with 3-inch cloth tape across the forehead provides excellent immobilization.[2] It remains to be determined if the efficacy provided by the SBT and the fabricated short boards differs from that described by Podolsky et al.[2] Major differences between the studies involving position (sitting vs supine) and means of obtaining measurements (radiographs vs hand-held goniometer) preclude direct interstudy comparison. Both studies confirm that the mechanism of splinting the head and torso to a rigid object is basic to cervical spine stability.

CONCLUSION

Using radiographic methods, we confirmed the SBT as described by Cline[10] as a standard against which newer prehospital cervical immobilization devices could be compared. We objectively demonstrated two factory-fabricated short board devices (KED, XP-One) to be highly efficacious and superior to the collar studied here.

Continuing research in this area, through the cooperation of emergency medicine, emergency medical services, and cervical immobilization device manufacturers, is encouraged to determine the most practical and superior means of cervical immobilization used in the extrication and transport of trauma victims.

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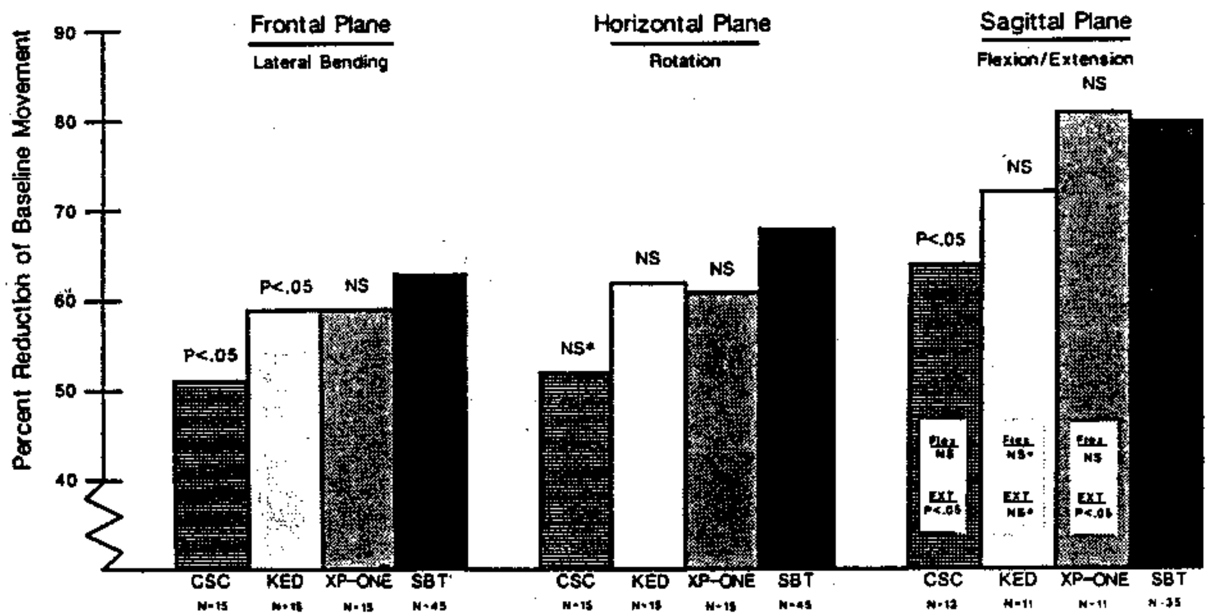
TABLE. *Three cervical immobilization methods as they directly compare to the SBT*

Plane of Motion	CSC	SBT	P‡	KED	SBT	P	XP-One	SBT	P
Frontal Plane (lateral bending)*	16 ± 7†	12 ± 5	$P < .05$	13 ± 8	8 ± 6	$P < .05$	16 ± 10	13 ± 10	NS
Horizontal Plane (rotation)*	39 ± 17	26 ± 23	NS	28 ± 18	24 ± 23	NS	30 ± 19	22 ± 21	NS
Sagittal Plane (flexion)	29 ± 22§	34 ± 13	NS	46 ± 15	37 ± 15	NS	37 ± 14	34 ± 18	NS
Sagittal Plane (extension)	69 ± 10§	54 ± 13	$P < .05$	66 ± 14	55 ± 16	NS	56 ± 12	45 ± 16	$P < .05$
Sagittal Plane (total ROM)‖	40 ± 28	20 ± 17	$P < .05$	20 ± 19	18 ± 22	NS	19 ± 16	11 ± 9	NS

*Mean degrees of movement of rotation or lateral bending. †Standard deviation in degrees as measured for each group. ‡NS, no statistically significant difference. §Mean degrees of measurement (occiput-C-7 angle) as measured for each group. ‖Total range-motion in mean degrees of movement (extension [occiput-C-7] — flexion [occiput-C-7]) for each group.



The significance of the reduction demonstrated by each method compared to its control (unrestricted movement) was $P < .001$.
The significance values shown refer to the movement reduction of the method shown compared to the SBT (Table). The volunteers for each test group (CSC, KED, XP-One) represent exclusive subsets of the volunteers for the SBT.
NS, no significant difference at $P < .05$.
5 *Significant at $P < .01$.

FIGURE 5. *Cervical immobilization efficacy.*

extrication and transport stage. There is a paucity of published literature and, therefore a deficient objective data base, regarding a "standard of care" in this important prehospital treatment modality.

Cervical collars have gained acceptance as a means of stabilization and immobilization, though recent studies show them to be less than ideal.[2,10] In our study we demonstrated that the CSC reduces cervical spine motion in the sagittal, frontal, and horizontal planes by 64%, 51%, and 52%, respectively. When compared to a previous study, these results affirm the CSC to be one of the best overall collars.[10] However, though the CSC is an excellent collar, it is inferior to both extrication devices studied and to the SBT. The mechanism of splinting the head and torso to a rigid object (SBT, KED, XP-One) appears to be superior in cervical stabilizing efficacy to the use of a cervical collar.

The SBT was superior to the KED in the frontal plane ($P < .05$) and limited extension to a greater degree. The prior application of a standardized high-backed collar to the KED could

FIG. 1. Axial rotation was measured directly using a specially designed protractor of variable height. A wire pointer extending from the center of standard safety glasses was used to enhance accuracy of rotational measurement.

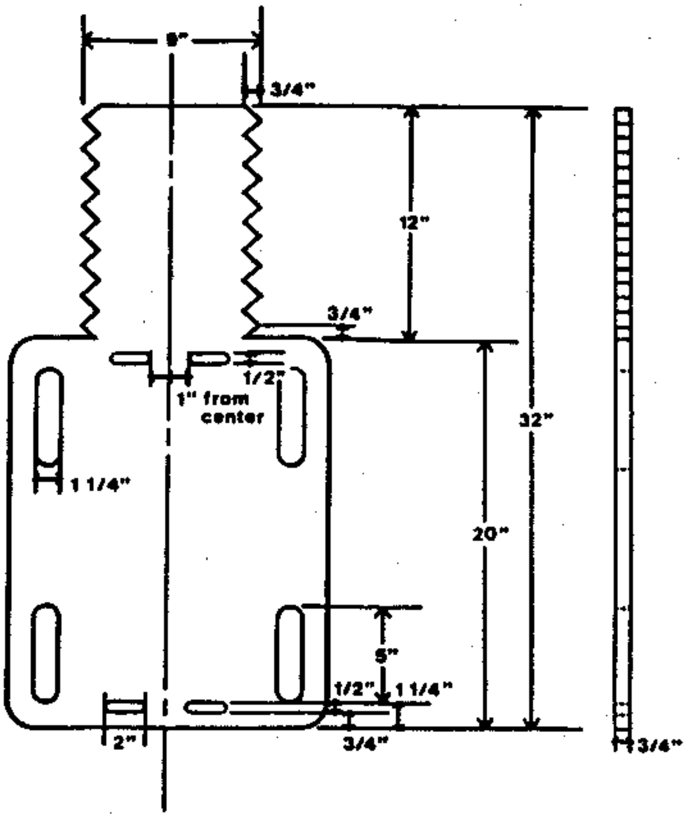


FIG. 2. Modified Ohio Extrication Short board.

ton straps, one 6-foot Ferno-Washington strap, two rolls of 4-ply 4-inch × 6-foot Kerlex® gauze, and 12-inch × 18-inch hospital towels as needed for padding and cervical alignment. The OES was placed in the chair with the two 9-foot straps inserted through the bottom holes and the volunteers were instructed to sit with their backs squarely to the board. The two straps were then positioned between the legs and over the shoulders and secured. The shoulders were then positioned against the board and the straps were tightened, securing the volunteer's trunk to the board. The head was then secured by first positioning the head against the board in the neutral position. The volunteer was instructed to maintain the neutral position while the rescuer wrapped the Kerlex first around the chin and then the forehead (one roll for each). The chin wrap was directed to the chin at approximately 45° downward from its anchored position at the top of the head piece. The forehead wrap, in similar fashion, was initially anchored to the base of the short board headpiece and directed at a similar angle toward the forehead. The initial wrap for each was slightly loose and each successive wrap tighter, thereby preventing torque of the head in the direction of the wrap. The final step was to secure a 6-foot strap through the lower handle holes of the short board and over the volunteer's waist (Fig. 3).

After the immobilization method was completed, radiographs of the cervical spine in active flexion, active extension, and active lateral bending were obtained. Gonads were shielded at all times.

Each of the seven radiographs for each volunteer was then analyzed with observer blind. For the sagittal views, tangential lines were drawn to the following landmarks: occiput and anterior foramen magnum; inferior borders of anterior and posterior C1; inferior anterior and inferior posterior borders of the bodies of each successive vertebra, C2 to C7. The angles formed by the convergence of tangential lines between successive vertebral levels were measured and recorded (Fig. 4). The angle formed between the base of the skull (occiput–foramen magnum) and the base of C7 was also measured and recorded. For the frontal views (baseline and test views), a line was drawn tangentially to the rostral aspect of the transverse processes of T1 and the angle formed by its convergence with a line directly extending from the radioopaque occlusal marker was then measured and recorded. Lines which intersected off the radiograph were measured using Cobb's method (10) (Fig. 5). Paired t-tests were performed with each subject serving as his or her own control and efficacy was quantified as per cent reduction of baseline movement.

RESULTS

The radiographs of one volunteer were unacceptable due to poor technique. On ten sets of radiographs, various levels of the cervical spine were not visible on at least one of the lateral views, precluding measurements at that vertebral level. In three of these ten, this involved at least one of the test views. On 86 sets of radiographs all vertebral bodies were visible, allowing measurement of the intervertebral angles of the entire cervical spine.

Because each volunteer was randomized to only one method, statistical significance between methods was not testable since the controls were different for each group.

FIG. 3. Volunteer fully immobilized in rigid plastic collar and short board.

Significant differences in efficacies must be inferred from comparisons of the percentages listed. The effectiveness of each of the seven methods is expressed as per cent reduction of control movement (Table I). Among the collars, the Philadelphia collar was clearly superior in restriction of movement in the sagittal plane. The Hare extrication collar appeared to be better in frontal plane restriction and the rigid plastic collar provided the greatest restriction in the horizontal plane.

Of all methods, those involving short-board use were clearly superior to the collars in all planes of movement. In reduction of sagittal and frontal plane movement, methods involving short-board use were superior and were within 5% and 2%, respectively. In reduction of axial rotation, the Philadelphia collar + short-board method and the short board alone were the superior methods and were within 2%.

Reduction of movement at each vertebral level in the sagittal plane was also analyzed using similar statistical methods. The largest amount of baseline movement occurred at the C5–C6 level which supports a previous study (2). Below the C3 level all methods involving use of the short board appeared to be consistently superior to the collars used alone. Among these, there was no clearly superior method. At the C3 level and above there was no consistently superior method among the seven tested.

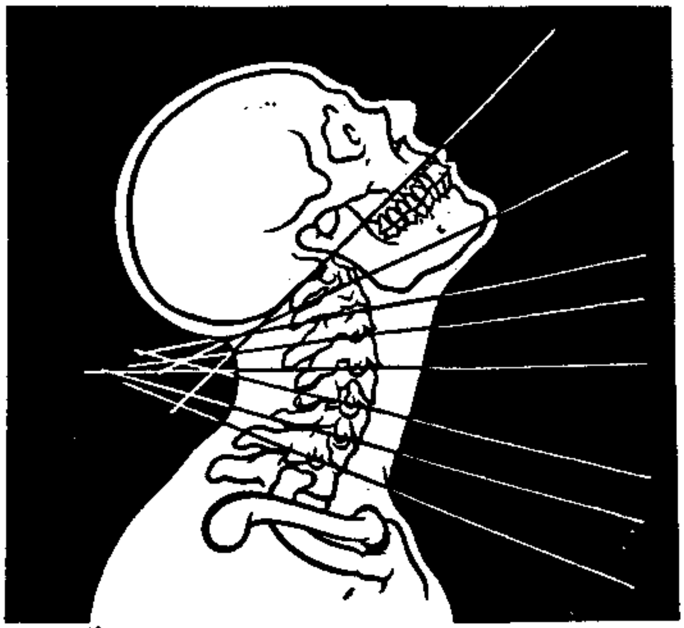


FIG. 4. Drawing depicting lateral radiograph of active extension (unrestricted). Tangents were drawn to the base of the skull and the base of each successive vertebra (see text). The angles formed by the convergence of tangents at each successive vertebral level were measured and recorded.

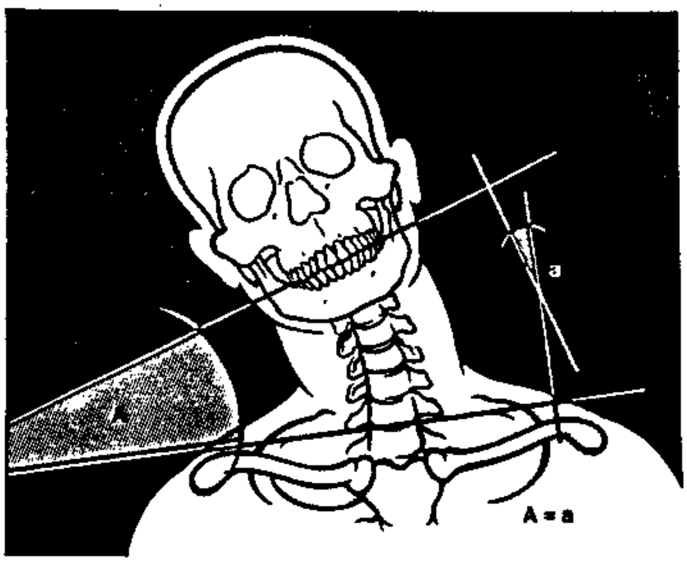


FIG. 5. Drawing depicting AP radiograph of active lateral bending. Lateral bending was quantified by measurement of the angle formed by the convergence of a tangent to T1 and a line extending from the occlusal marker. Cobb's method was used to measure angles which converged off the radiograph. This method involves drawing perpendiculars to the tangents. The angle formed by the intersection of the perpendiculars is equal to the angle formed by the tangents.

DISCUSSION

The three cervical collars tested, when used alone, do not provide as much immobilization as the short-board

TABLE I
Cervical immobilization efficacy

Method	Sagittal Plane (Occiput-C7)		Frontal Plane (Lateral Bending)		Horizontal Plane (Axial Rotation)	
	(% Reduction of Control)	No. of Volunteers	(% Reduction of Control)	No. of Volunteers	(% Reduction of Control)	No. of Volunteers
1. Philadelphia collar	(69)	14	(28)	15	(43)	15
2. Hare extrication collar	(51)	12	(55)	13	(39)*	12
3. Rigid plastic collar	(56)	13	(41)	14	(50)	14
4. Philadelphia collar + short board	(84)	11	(64)	12	(73)	12
5. Hare extrication collar + short board	(86)	14	(66)	14	(63)	14
6. Rigid plastic collar + short board	(89)	9	(66)	14	(66)	14
7. Short board only	(88)	13	(64)	14	(71)	14

The statistical significance of the reduction demonstrated by each method compared to its control group <0.001 *except* * where $p < 0.02$.

technique described. Furthermore, when combined with the short board, the collars did not augment or reduce the immobilization provided by the short-board technique. Among the three collars used alone, each was superior to the other two in *one* but not more than one of the three planes of movement. There was no consistently superior collar among the three that we tested.

It has been suggested that the chinstrap technique may hinder airway access and for this reason it was deleted in the 1977, 1980, and 1983 revisions of the essential equipment list for ambulances by the American College of Surgeons' Committee on Trauma. An actual increased frequency of aspiration due to its use is to our knowledge unproven and possible improved airway access must be balanced against possible unacceptable reduction of immobilizing efficacy. It remains to be seen if the immobilization provided by a two-point technique such as we describe is superior to the use of sand bags and tape such as that studied by Podolsky et al. (8).

It should also be noted that methods involving short-board use consistently held the cervical spine in variable degrees of extension compared to the collars in our study. This was only a gross observation because measurements of such differences were not possible since lateral views were not taken under test conditions without active movement. This could perhaps have been corrected by the use of further posterior padding. Further study of short-board techniques to minimize this extension are necessary. A board design allowing for the kyphotic curve of the thoracic spine could possibly minimize cervical spine extension.

A major disadvantage of the short-board technique is the time required for proper application. We did not quantify this in our study, but it is well known that proper immobilization in the prehospital setting requires considerable time. This becomes critical to trauma victims who may be at risk for hypovolemic shock. Accordingly, various new devices have been manufactured which are much more rapidly applicable and which employ the same principles of immobilization used in the short-board technique (3). These devices need further study.

Short-board immobilization is currently widely used in EMS. We have provided a detailed description of this method and believe that it should become the established standard against which newer prehospital cervical immobilization devices should be compared.

The marked proliferation of cervical immobilization devices designed for prehospital use in recent years emphasizes the urgency for establishment of a standard of care in this setting (3). We believe that this is best accomplished using radiographic methods, similar to those described here and elsewhere, to compare the many devices available against the short-board technique we describe (5, 6). Cooperation among Emergency Medicine, Surgery, and Radiology, with the availability of basic and clinical research facilities and the field of EMS with its experience in the prehospital use of these devices is both recommended and desirable.

Acknowledgments

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LETTERS

The Collar that Does

I read your February Innovations column, "A Collar That Could (Maybe)," with much concern, and feel I must comment.

There is an important point which I believe is missed in the article, a point which is so obvious that many professionals involved with emergency medicine often overlook it. The purpose of a cervical extrication collar is to immobilize and maintain the cervical spine in a *neutral* position and thus, to prevent damage to the spinal cord. The purpose is *not* to support or immobilize the head. It is clear that the more the head is immobilized, the more the neck is immobilized. However, immobilization of the neck does not necessarily mean that the cervical spine is maintained in a neutral position.

In order to obtain immobilization, cervical collars are generally designed in such a way that they push the head upward away from the shoulders in a line somewhat perpendicular to the shoulders. The collars serve to stretch the neck, as it were. Fundamentally, this is done by applying upward forces to various bony protuberances of the head (e.g., the alignment of the cervical spine will not be in the neutral position, but in some other position as dictated by the applied forces). For example, if force is applied to the chin without a compensating force applied to the back of the head, the cervical spine will be forced into extension. Furthermore, if the forces applied are equal, but very strong, the neutral position again will *not* be maintained. In this case, the natural curvature of the cervical spine will be straightened. In essence, this action places the upper cervical spine in extension and the lower cervical spine in flexion.

If there is a fracture and/or dislocation of the cervical spine, forcing it (as with a cervical collar) into a position other than neutral is likely to damage the spinal cord. Precisely the consequence which the collar is supposed to prevent. In this regard, "clenched teeth," as you stated in your article, may not be "a good sign" but a very bad sign.

Because of the complexity of the relationships between the immobilization of the head and neck, and the maintenance of neutral alignment of the cervical spine, the only valid means for assessing the effectiveness of a cervical collar is with X-ray studies.

Within the last two years, we have conducted a series of radiographic studies on the Stifneck Collar manufactured by California Medical Products. The results of these studies are very pertinent to your article and one is somewhat counterintuitive. In general, the results confirm the points discussed in the previous paragraph. However, in addition, it was found that considerable immobilization of the cervical spine in the neutral position could be maintained by the latest version of the Stifneck Collar without a great deal of head immobilization. That is, subjects wearing the collar could move their heads a substantial amount when asked to place their head/neck in flexion and/or extension. However, the X-rays revealed very little movement of the cervical spine itself.

Apparently, the observed head movement was due to the ability of the head and atlas to pivot on the odontoid process without disturbing alignment of the remainder of the cervical spine. Although this movement entails movement of the first cervical vertebrae, because the aperture of the spinal canal at that point is relatively large, this movement is not as undesirable as movement of the rest of the cervical spine.

In closing, given the extremely severe and costly consequences of spinal cord injury, I would suggest that judgments regarding the effectiveness of cervical extrication collars or immobilization devices of any type be reserved until such time that X-ray analyses can be performed.

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Care System of Southern California
Downey, California

Jems replies: *Why is information like this staying in the closet? If research is defensible, it needs to be published — in EMS journals as well as medical journals. Thanks for taking the time to share these comments with our readers; we know they'd welcome the opportunity to read an article by you and to evaluate your study mechanism and the results of your study.*

*We welcome readers' comments. Write to **jems**, P.O. Box 1026, Solana Beach, CA 92075.*

Based on results from these studies, California Medical Products made further improvements to assure neutral positioning and at the same time to provide greater immobilization of the cervical spine. This new and improved collar with extra extension support was introduced in March, 1985. This newest version of the Stifneck™ was evaluated and found effective by the Center for Emergency Medicine under the direction of Dr. Ron Stewart. The results of their X-ray study showed the Stifneck™ collar to out perform the Philadelphia collar.

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Best In The Business

The New Stifneck Collar

There is no perfect extrication collar.

That's what we said in December 1982, in the first portion of a three-part report on spinal immobilizers. In that issue, we outlined 16 properties which we considered necessary for an ideal collar. But we speculated that, like all perfect tools, a perfect extrication collar would probably never exist.

My mom lives in a little town called Eureka, just south of the Oregon border – 900 miles out of my district. She means a lot to me. If she's ever involved in an accident, I hope she gets Eureka's best crew, in their first-out rig – with all their best equipment. If she needs a collar, I hope she gets a Stifneck.

There are other good tools on the market, but in my opinion, the new Stifneck is the best in the business.

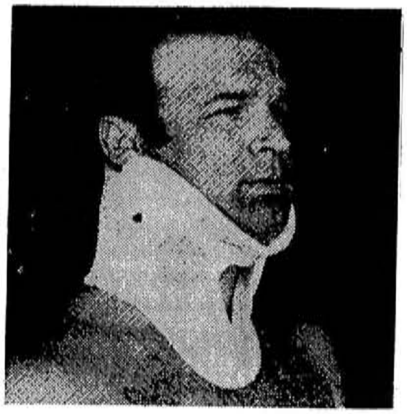
I've been accused of being unscientific in making statements like that one, and I don't pretend to be a scientist. Sometimes I'm wrong, too, but not about collars. Not about this collar. What's so hot about this collar?

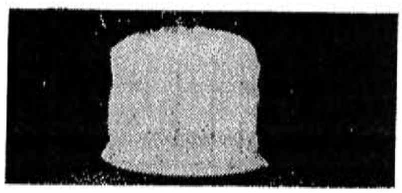
The overall reinforced height of the Stifneck's posterior panel has been increased by about 30 percent. That has the effect of forcing a patient's chin forward into its cradle, while preventing the cradle from causing extension of the neck. It also has the effect of improving the collar's ability to limit lateral motion – in my opinion, a weakness of the original design.

Serrations in both the upper and lower edges of the new posterior panel enable the collar to provide allowances for variations in the size and shape of the upper thoracic vertebrae, the superior borders of the trapezius muscles, and the occiput. When combined with the anterior panel's padded lower margin and its distensible upper one, those serrations enable a rescuer to properly fit this collar to a large patient population.

Fit them – and *immobilize* them.

"Innovations" is a regular feature of **jems** *that highlights new products and services. It is not an objective evaluation, but rather, the author's opinions on innovations in EMS. This edition was written by Thom Dick, a full-time paramedic in San Diego (Calif.) and associate editor for* **jems**.





The new Stifneck is relatively comfortable, too – an important feature in a device that can be responsible for serious injury in a patient with unstable cervical fractures who actively resists its placement.

The tracheal hole in the front of the collar has been modified. Its new, enlarged triangular shape enables a rescuer to insert *two* fingers through the collar to palpate carotid pulses on either side of the neck, as well as the base of the trachea and the thyroid cartilage.

Collar sizes are now labeled by means of color-coded tags, which are easily distinguishable in darkness or daylight.

The original Stifneck was held together by means of snap-type fasteners, one of which had an annoying tendency to separate where the apex of the chin cradle was fastened to the front of the collar's shell. The new collar employs better fasteners throughout its design; we've used it on over a hundred patients without a hitch.

Stifneck does not come into contact with the neck. Therefore, it does not impinge on the thyroid cartilage (thereby hindering a patient's ability to swallow). Nor does it tamponade the neck veins – a neglected factor which we think should be studied. We think that to tamponade the neck veins would elevate intracranial pressures. It would be suspected if, following application of an extrication collar, a patient was to exhibit facial flushing. (Ever seen that happen?)

The Stifneck is made of high-density polyethylene – a molecular compound which maintains its characteristics over a wide range of temperatures. We heated one to 150 degrees Fahrenheit for 30 minutes to see if it would get soft. It didn't.

The padding around its edges is polyethylene, too – a closed-cell foam, which doesn't absorb fluids such as blood or emesis. You clean it with a contact-cleaner, and wipe it dry.

All of which makes the Stifneck sound downright perfect.

But the Stifneck is not perfect. While its chin cradle fastener can be unsnapped and the collar stored flat, it won't fit into the average trauma box that way. It can be stored assembled and squashed flat; the shell doesn't lose its shape that way, but that's still a pain.

We had trouble labeling the collar; at over $20 a pop, you don't want people "forgetting" who owns your collars. But we found that several brands of felt-tip markers make permanent marks on the color-coded size labels. If a one-by-four-inch piece of that material were stuck to the collar's posterior panel, it would provide plenty of room for identification.

That's all; there's nothing else wrong with the Stifneck. Even the price isn't bad, when you consider an average life expectancy of one year per collar.

It's currently being used in New York City, Washington, D.C., L.A. and Orange Counties, California, in the Province of Quebec and by the British Army, and as a basic component of the U.S. Army's medics' packs. They probably use 'em in Eureka, too.

For more information, contact Geoff Garth, California Medical Products, 334 Colorado Place, Long Beach CA 90814, 213/494-7171. □

Editor's Note: *At press time, we are expecting (but haven't yet seen) a new collar by Jobst. New products in this line are constantly evolving.*

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ANNOTATED BIBLIOGRAPHY
SELECTED ARTICLES AND PUBLICATIONS
CONCERNING CERVICAL SPINE ISSUES AND COLLARS

<u>SAFETY: NEUTRAL ALIGNMENT ISSUES</u>

Secor P: Modification and Radiographic Analysis of a New Cervical Extrication Collar. Regional Spinal Cord Injury Project, Rancho Los Amigos, Downey, California, 1983.

A follow-up to the study which discovered that a 27 degree chin piece angle on the original Stifneck™ prototype caused hyperextension. Hyperextension was eliminated by reducing the angle of the chin piece to give a more horizontal orientation. Collar safety (maintenance of neutral alignment) is differentiated from efficacy (limitation of head motion) and, therefore, cervical spine movement.

Dick T: A Collar That Could (Maybe). JEMS, February, 1985.

In reviewing the new Nec-Loc™ collar, Thom Dick introduced the concept of clenched teeth as a criteria for indicating proper sizing and good functioning of a cervical collar. Subsequent research and discussion in the journals indicated that clenched teeth may actually be an indication of unsafe immobilization based on both cervical spine and airway management considerations.

Adkins R: The Collar That Does. JEMS, April, 1985.

In response to Thom Dick's article (referenced above,) Dr. Adkins wrote "The purpose of a cervical extrication collar is to immobilize and maintain the cervical spine in a <u>neutral</u> position and thus, to prevent damage to the spinal cord. The purpose is <u>not</u> to support or immobilize the head." . . . In this regard, "clinched teeth", as you stated in your article, may not be a "good sign" but a "very bad sign."

Adkins R: Letter to Lawrence Motley, M.D., February, 1988.

Referencing the study by Dr. Secor, Dr. Adkins indicated that a collar with a highly angled chin piece (prototype Stifneck™ collar) disrupted the neutral alignment of the cervical spine by hyperextending the upper cervical vertebral segments (C-3 Up) and by flexing the lower cervical segments (C-5 Down). In other words, the application of a collar produced the effect that it was actually created to prevent. This dangerous situation was eliminated by reducing the angle of the chin piece. Dr. Adkins stated that "zero motion <u>from the position of neutral alignment</u> is the ultimate goal of all cervical collars."

Spires M: Abstract: Cervical Myelopathy After a Dental Procedure: Case Report. Archives of Physical Medical Rehabilitation, Volume 71, September, 1990.

> ". . . this case illustrates that even moderate neck extension during common activities can induce myelopathy . . ."

Boden SD, McCowin PR, Davis DO, Dina TS, Mark AS, Wiesel S: Abnormal Magnetic Resonance Scans of the Cervical Spine in Asymptomatic Subjects. Journal of Bone of Joint Surgery, September, 1990.

> Degenerative disease of the cervical spine frequently occurs in the absence of clinical symptoms. A study of sixty-three volunteers who had no history of symptoms indicative of cervical disease discovered that "The disc was degenerated or narrowed at one level or more in 25% of the subjects who were less than 40 years old, and in almost 60% of those who were older than 40." This and the preceding reference indicate the criticality of maintaining neutral alignment of the cervical spine during cervical spine immobilization.

EFFICACY: RELATIVE MOTION STUDIES, COLLAR COMPARISONS

Fisher SV, Bowar JF, Awad EA, Gullickson G: Cervical Orthoses Effect on Cervical Spine Motion: Roentgenographic and Goniometric Method of Study. Archives of Physical Medical Rehabilitation, March, 1977.

> "The Philadelphia™ collar is made of plastizote, is relatively new on the market and is tolerated well by patients and experimental subjects. These results indicated, however, that it inadequately immobilized the cervical spine . . . It should not be prescribed when instability of the cervical vertebrae is a problem."

Johnson RM, Hart DL, Simmons EF, Ramsey GR, Southwick WO: Cervical Orthoses: A Study Comparing Their Effectiveness in Restricting Cervical Motion in Normal Subjects. Journal of Bone and Join Surgery, April, 1977.

> The authors studied the Philadelphia™ collar, but did not include it among those collars recommended as "Rigid Conventional Braces that Provide the Best Control of Flexion and Extension at Different Levels of the Cervical Spine."

Johnson JC, Garman DA: To Find a Better Collar. Journal of Prehospital Care, January/February, 1984.

> This report summarized the findings of the State of Indiana Emergency Service Commission Report which performed a subjective analysis of ten cervical collars and rated the Stifneck™ collar highest overall.

Stewart RD: Letter to Mr. Jim Paturas, Chairman BTLS, dated December 5, 1985.

This letter presented the results of an X-ray evaluation conducted by Dr. Stewart which demonstrated that Stifneck™ provided superior immobilization to the Philadelphia™ collar in three planes of motion (flexion, lateral, rotational) and equivalent limitation of motion for extension. Dr. Stewart wrote ". . . I would urge those responsible for officially - sanctioned courses in trauma (PHTLS, ATLS, BTLS, etc. to either avoid endorsement of any specific collar (particularly the Philadelphia™) or to promote one or two rigid plastic collars <u>that have been demonstrated in peer-reviewed literature to immobilize the C-spine</u>. I emphasize this last point in that several collars are being promoted that have never been subjected to acceptable testing procedures."

McCabe JB, Nolan DJ: Comparison of the Effectiveness of Different Cervical Immobilization Collars. Annals of Emergency Medicine, 1986.

This study compared two prototypes of the Stifneck™ collar with the Philadelphia™ collar and a hard foam extrication collar. The polyethylene Stifneck™ prototypes provided superior immobilization to the Philadelphia™ collar in two out of three planes studied. "This new design type appears to have some advantages over both the Philadelphia™ and extrication collars."

Cline JR, Scheidel E, Bigsby EF: A Comparison of Methods of Cervical Immobilization Used in Patient Extrication and Transport. The Journal of Trauma, July, 1985.

This study compared the Philadelphia™ collar with several other extrication collars and collar/immobilization techniques. "Among the three collars used alone, each was superior to the other two in <u>one</u>, but not more than one of the three planes of movement. There was no consistently superior collar among the three that we tested" (Philadelphia™ collar, Hare extrication collar, rigid plastic collar - Thomas).

Graziano AF, Scheidel EA, Cline JR, Baer LJ: A Radiographic Comparison of Prehospital Cervical Immobilization Methods. Annals of Emergency Medicine, October, 1987.

This study compared the Stifneck™ collar against three methods of cervical spine immobilization (KED, XP-One, short board and tape). The data indicated that the Stifneck™ alone provided 80% of the immobilization which was offered by the best spinal immobilization system, i.e., short board and tape. "When compared to a previous study (Cline, see above reference) these results affirm the CSC (Stifneck™) to be one of the best overall collars."

Dick T: Best in the Business. JEMS, August, 1985.

This article contained Thom Dick's recommendation of the Stifneck™ as the overall superior extrication collar.

Marr J, Edmonds V: Cervical Orthoses: The Issue of Patient Compliance. Journal of Neuroscience Nursing", April, 1990.

This study examined the variables effecting patient compliance between the Stifneck™ collar and the Orthotech Collar for extended wear. "Since there was no apparent difference with respect to patient compliance between the two collar groups, we chose the Stifneck™ collar for in-patient and out-patient groups because of versatility and more reasonable cost."

Garrison HG, Whitley TW, Cline KA, McCabe JB, Hunt RC, Allison EJ: Abstract: Comparison of Rigid Cervical Immobilization Collars: Evaluation of Facility of Application. Annals of Emergency Medicine, May, 1990.

This abstract of a study compared the facility of application of the Stifneck™, Philadelphia™, and E-Collar. The majority of providers indicated that a one-piece collar with foam padding (Stifneck™) was easiest to apply (70%), required the least manipulation of the neck (71%), took the least time to apply (69%), and was the easiest to tell front from back (59%). The majority of providers (92%) regularly used the Philadelphia™ collar.

CERVICAL SPINE INJURY DIAGNOSIS AND OUTCOME

Walter J, Doris PE, Shaffer MA: Clinical Presentation of Patients With Acute Cervical Spine Injury. Annals of Emergency Medicine, July, 1984.

This study documented the occult nature of cervical spine injury. "The absence of mental status changes, cranio-facial injuries, range of motion abnormalities, and focal neurological findings is, therefore, not uncommon in patients who have sustained cervical spine injury."

Jacobs LM, Schwartz R: Prospective Analysis of Acute Cervical Spine Injury: A Methodology to Predict Injury. Annals of Emergency Medicine, January, 1986.

In an evaluation of 233 patients, ten elements were identified as being associated statistically with cervical spine injury. Twenty percent (5 of 24) of cervical spine injuries would have been missed if physicians had used physical exam and mechanism of injury as criteria. "Physician's cannot accurately predict the presence of cervical spine injury."

Toscano J: Prevention of Neurological Deterioration Before Admission to a Spinal Cord Injury Unit. Paraplegia, 1988.

Among 123 patients admitted to the Victoria Spinal Injuries Unit, Melbourne, Australia, this study documented 32 patients who suffered major neurological deterioration after the initial injury. The site of neurological deterioration was as follows:

- Accident site - 9.4%
- Initial ambulance assessment and ambulance transport - 28.1%
- Local hospital - 53.1%
- Ambulance transport from local hospital to the Spinal Unit - 6.3%
- Other - 3.1%

Herzenberg JE, Hensinger RN, Dedrick DK, Phillips WA: Emergency Transport and Positioning of Young Children Who Have an Injury of the Cervical Spine. Journal of Bone and Joint Surgery, January, 1989.

This article discussed the rationale and requirement for proper immobilization of young children in neutral alignment. Most children will be forced into hyperflexion when placed on a backboard if padding is not placed under their upper torso prior to board transfer.

Schriger DL, Larmon B, LeGassick T, Blinman T: Spinal Immobilization on a Flat Backboard: Does it result in neutral position of the cervical spine? Annals of Emergency Medicine, August, 1991.

"In a population of 100 young, healthy adults, immobilization on a flat backboard would place 98% of our study subjects in relative cervical extension." "The amount of occipital offset required to achieve neutral position varied from 0 to 3.75 in. (mean, 1.5 in.)." "Mean occipital offset for men (1.67 in.) was significantly greater than that for women (1.31 in.)." "Occipital padding would placed a greater percentage of patients in neutral position and increase patient comfort during transport." ""Despite the lack of a formal, technical definition of "neutral cervical position", our study suggests that a clinically valid determination...can be reliably made...[by field personnel].""

Tater CH, Sehlings MG: Review of the Secondary Injury Theory of Acute Spinal Cord Trauma with Emphasis on Vascular Mechanisms. Journal of Neurosurgery, July, 1991.

The purpose of this paper is to review the evidence supporting the theory that there is a secondary injury of the cord following the initial trauma. Secondary injury theory has been forwarded to explain the biochemical and pathological changes that occur post injury.

Stauffer ES, Mazur JM: Cervical Spine Injuries in Children. Pediatric Annals, June, 1982.

"The cervical spine in a child is not simply a small adult cervical spine. It's anatomy, physiology, radiographic appearance and response to trauma differ greatly from the mature cervical spine. Some of the differences and the principles of diagnosis and management of cervical spine injuries in children will be discussed here."

Hoffman MA, Spence LJ, Wesson DE, Armstrong PE, Williams JI, Filler RM: The Pediatric Passenger; Trends in Seat Belt Use and Injury Patterns. Journal of Trauma, September, 1987.

This study examined the pattern of seat belt use and injury profiles in all patients injured while riding in motor vehicles.

Brunette DD, Rockswold GL: Neurologic Recovery Following Rapid Spinal Re-alignment for Complete Cervical Spinal Cord Injury. Journal of Trauma, April, 1985.

This case report discussed the incidence and causes of acute spinal cord injury and documented the complete recovery of one patient as a result of proper patient care and rapid intervention.

Bracken M.B PhD, et al: A Randomized, Controlled Trial of Methyl-prednisolone or Naloxone in the Treatment of Acute SCI. New England Journal of Medicine, Vol 322, Num 20, May 17, 1990.

Patients were admitted to SCI centers after transfer from other initial receiving hospitals. The time of the first bolus from admission to the SCI center was 5.6 =/- 2.7 hours. All were basically under eight hours to first bolus. Over 50% of the patients had spinal fractures or dislocations. Over 40% had bone fragments involved with the fracture.

In both categories of patients, partial and complete injuries, there was greater sensory and motor functions at six weeks and six months for the patients treated with Methylprednisolone. Patients who received either drug more than eight hours after admission to the SCI center showed no improvement at six weeks or six months.

INDUSTRY ISSUES

Birnbaum, M: Supporting Research and Development. Prehospital and Disaster Medicine, July-September, 1990.

This editorial discussed the significant cost involved with proper research, development, clinical testing, documentation and product support for prehospital equipment. Dr. Birnbaum discussed the risks of the "copying syndrome". "Although the purchase of originals does not allow us to stretch our budgets, the long-term support of those who do the R&D will result in the ongoing efforts to develop those products which help us to meet the needs of those for whom we provide the care. If we demand high standards, we should support those who try to meet them."

Page J: Stop the Product Plunder. JEMS, September, 1989.

This editorial described the risks and deleterious effect of buying products produced by "knock-off" manufacturers rather than purchasing quality products from the originator.

Stewart RD: Things Are Seldom What They Seem . . . Annals of Emergency Medicine, September, 1989.

This article described the four fundamental considerations and the evaluation process which a product must survive before it can be used safely and successfully in the field.

Wolfberg D: Weeding Through the Product Jungle. JEMS, September, 1989.

This article presented a methodology for evaluating and selecting appropriate equipment for prehospital service.

Swan TH: Recovering Your Costs. Emergency, October, 1990.

This article presented the rationale and methodology for recovering ambulance service cost via patient billing.

NOTE: California Medical Products maintains the bibliography articles for cervical spine issues. Please contact CMP (800/732-4267) for complete documentation.