A COMPARISON OF THREE CERVICAL IMMOBILIZATION DEVICES

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ABSTRACT

Objective. Prehospital cervical spinal cord injuries (SCIs) are rare but potentially catastrophic. Although spinal immobilization is resource-intensive, emergency medical services (EMS) personnel commonly immobilize trauma patients to prevent exacerbation of unrecognized SCI during transport. We compared the stabilization properties of a novel rigid, cervical immobilization collar (XCollar) with those of one-piece and two-piece rigid collars commonly used in the prehospital setting. **Methods.** This was a prospective laboratory study of healthy adult volunteers to determine total cervical motion in the horizontal, coronal, and sagittal planes in both seated and supine positions. Goniometric techniques were used to measure head and neck movement after marking anatomic landmarks. Ranges of motion were compared with a one-way analysis of variance (ANOVA). A Bonferroni correction was applied for multiple comparisons, setting significance at $p \leq 0.004$. **Results.** Twenty-five subjects (11 men; 14 women) completed the study. The subject pool represented a wide range of morphometrics. For most measurements, the XCollar permitted 10–15 millimeters of movement when applied without manual cervical stabilization. This was less than the movement permitted by both comparison collars. On average, the XCollar permitted less than 10 millimeters of movement in the sagittal and horizontal planes when the subject was in the seated position. **Conclusions.** The XCollar provided superior cervical stabilization without augmentation by manual stabilization in healthy adult volunteers in both the seated and supine positions when compared with other one-piece and two-piece rigid cervical collars. Although maximal stabilization was achieved only after the subjects were secured to a long spine board with a cervical immobilization device, the XCollar can provide an acceptable alternative to manual cervical stabilization in situations where the number of patients exceeds the number of EMS providers available to provide care. **Key words:** prehospital; immobilization; cervical; range of motion

INTRODUCTION

Cervical spine immobilization is commonly performed in the prehospital setting when treating patients suffering from a traumatic injury.[1] Although spinal cord injury (SCI) is uncommon in the context of total prehospital patient encounters, up to 20,000 cases may occur annually in the United States and Northern Europe.[2] Exacerbation of SCI during extrication or transport can be catastrophic, typically resulting in overtriage by emergency medical services (EMS) providers and prophylactic immobilization with a cervical collar and long spine board.

Multiple studies have examined prehospital cervical immobilization collars.[3–8] Although differences in collar effectiveness have been identified, many studies indicate that immobilization with a cervical collar alone is not sufficient and that manual stabilization should be applied until the patient is secured to a long spine board and cervical blocks are applied.[4,6,9] However, this recommendation requires two rescuers to attend to each patient, one to maintain manual cervical stabilization and one to assess and prepare the patient for extrication. This may not be practical in a mass casualty incident where even a small number of patients can overwhelm the initial responder's resources. This study compared a novel cervical immobilization collar with two commonly used prehospital cervical collars to determine the extent to which the head can be immobilized without manual cervical stabilization in both the supine and seated positions.

METHODS

The University of Pittsburgh Institutional Review Board approved this study. All subjects provided informed consent prior to any procedures being performed.

Subject Population

Subjects were recruited from the local university and medical center community. Eligible subjects were 18 years or older of either gender. Subjects were excluded if they self-reported claustrophobia or a medical

condition that prevented them from lying on a long backboard for up to 45 minutes.

Measurements

Cervical range of motion was measured in both the seated and supine positions. Subjects wore three cervical collars presented in randomized order. All measurements were collected in a single session by one investigator (DC) who is skilled in goniometry. The XCollar (Emegear, Carpinteria, CA) (Fig. 1) was compared with a common prehospital one-piece (Ambu Perfit ACE, Ambu, Glen Burnie, MD) and two-piece (Jerome NecLoc, Jerome Medical, Moorestown, NJ) extrication collar. All collars were applied by a single investigator according to the product packaging. For collars where multiple sizes are produced, the subject was sized according to the manufacturer's instructions. All sizes were available during the study.

The following anatomic landmarks were marked with a grease pencil to ensure reliable and repeatable measurements: 1) the right and left acromion processes, 2) the midsagittal point of a plane bisecting the inferior angle of the right and left scapulae, 3) the xiphoid process, 4) the tip of the nose, and 5) the most superior point of the external ear.

All measurements were taken twice with a tape measure and averaged. Linear range of motion was obtained to the nearest millimeter with the subject in the seated position. The subject was coached to maintain an upright back position to prevent rounding and anterior flexion of the shoulders. For best access to the anatomic landmarks and to allow the investigator to note shoulder movement, seated measurements were taken with the investigator standing behind the subject. The following measurement were taken while the subject was seated:

- Flexion and extension (sagittal plane): measured from the external occipital protuberance to the horizontal plane connecting the inferior angles of the right and left scapulae. A tape measure was used to measure the baseline distance between these
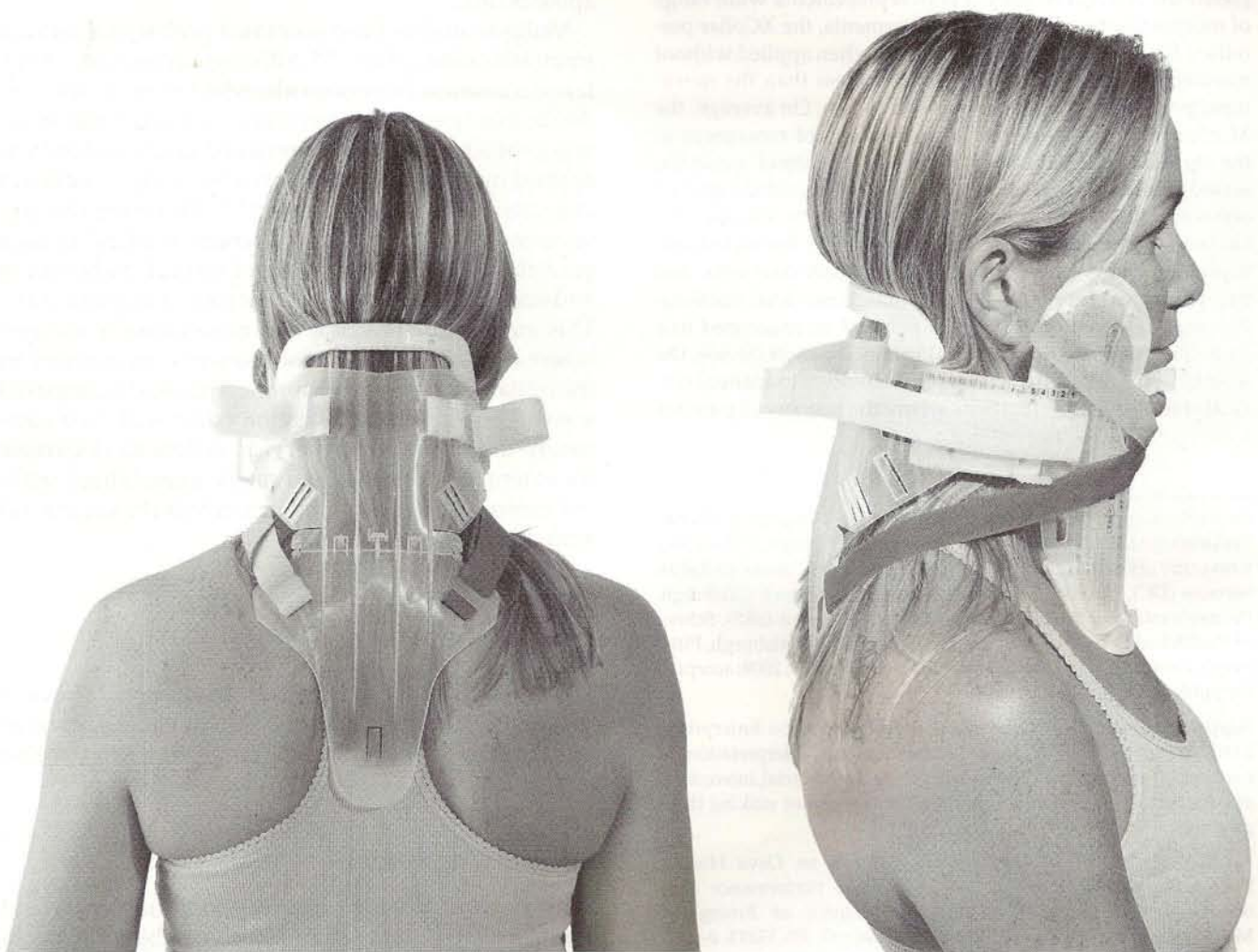

FIGURE 1. The back view (*left*) and side view (*right*) of the XCollar cervical immobilization device.

TABLE 1. Subject Morphometrics Presented as Mean (95% Confidence Interval)

Gender (n)	Age (Yr)	Height (cm)	Weight (kg)	BMI (kg/m^2)
Male (11)	22.4 (18.6, 26.1)	176.7 (174.2, 178.6)	88.2 (77.5, 98.9)	28.1 (25.1, 31.1)
Female (14)	24.0 (19.4, 28.6)	164.3 (159.2, 169.4)	65.8 (60.9, 70.7)	24.4 (22.6, 26.2)

BMI = body mass index.

landmarks. The subject was asked to flex his or her neck by looking down at the floor and extend the neck by looking up at the ceiling.

- Lateral flexion (coronal plane): measured from the external ear to the ipsilateral acromion process. The distance was measured in the neutral position, and then the subject was asked to bend his or her head to each side.
- Cervical rotation (horizontal plane): measured from the tip of the nose and the ipsilateral acromion process. The measurement was taken in the neutral position, and then the subject was asked to turn his or her head to the left and right. The distance was measured in both directions.

The following measurements were obtained with the subject secured to a long spine board (Ferno, Wilmington, OH) with three straps placed at the level of the fourth thoracic vertebra (approximate), at the anterior superior iliac spine, and immediately superior to the knees and with a cervical immobilization device applied (Ferno):

- Flexion and extension: measured from the tip of the nose to the xiphoid process. A tape measure was used to measure the baseline distance between these landmarks. The subject was asked to flex his or her neck by looking down at the feet and extend the neck by looking up.
- Lateral flexion: measured from the tip of the nose and the ipsilateral acromion process. The distance was measured in the neutral position, and then the subject was asked to bend his or her head to each side.
- Cervical rotation: measured from the tip of the nose and the ipsilateral acromion process. The measurement was taken in the neutral position, and then the subject was asked to turn his or her head left and right. The distance was measured in both directions.

Lateral flexion and cervical rotation measurements were repeated with the subject secured to the board with the cervical immobilization device removed.

Statistical Analysis

Demographic and morphometric data are presented as mean (95% confidence interval [CI]). Range-of-motion measurements were compared with a one-way analysis of variance (ANOVA). A Bonferroni correction was applied for multiple comparisons, setting significance at $p \leq 0.004$.

RESULTS

Twenty five subjects (11 men; 14 women) completed the study. Mean age was 23.2 (95% CI 23.1, 26.1) years. The subject pool represented a wide range of morphometrics (Table 1).

For most measurements, the XCollar permitted 10–15 millimeters of movement when applied without manual cervical stabilization. On average, the XCollar permitted less than 10 millimeters of movement in flexion, extension, and left/right cervical rotation when the subject was in the seated position. This was less than the movement permitted by both comparison collars (Fig. 2). No differences were identified between the extrication collars for lateral flexion.

With the subject supine on the long backboard without the cervical immobilization device applied, the XCollar provided superior immobilization in left/right cervical rotation and right lateral flexion when compared with the two-piece Jerome collar and was superior to the one-piece Ambu collar in right cervical rotation and right lateral flexion (Table 2). With the cervical immobilization device applied there was no difference between the collars for flexion, lateral flexion, or cervical rotation (Table 3). However, greater extension was possible in both the Ambu and Jerome collars when compared with the XCollar.

TABLE 2. Cervical Range of Motion in Millimeters (Mean ± Standard Deviation) for Subjects Secured to a Long Spine Board without a Cervical Immobilization Device

Device	Flexion	Extension	Left Rotation	Right Rotation	Left Lateral Flexion	Right Lateral Flexion
Ambu (1-piece)	9.2 (5.0)	24.4 (28.5)*	20.6 (11.4)	24.7 (13.3)*	17.4 (14.9)	28.3 (24.5)*
Jerome (2-piece)	11.1 (8.7)	25.6 (14.5)*	29.3 (15.3)*	25.6 (12.6)*	21.8 (18.0)	34.8 (18.5)*
XCollar (1-piece)	8.1 (6.6)	8.5 (5.5)	12.8 (14.6)	11.6 (7.2)	20.7 (14.9)	18.8 (14.3)
$F_{2,72}$ (p-value)	1.2 (0.31)	6.4 (0.003)	8.8 (<0.001)	11.9 (<0.001)	0.52 (0.6)	7.1 (0.002)

*Post hoc test different from the XCollar. No other significant comparisons were present.
$F_{2,72}$ = XXX.

Flexion - Extension

Left - Right Lateral Flexion
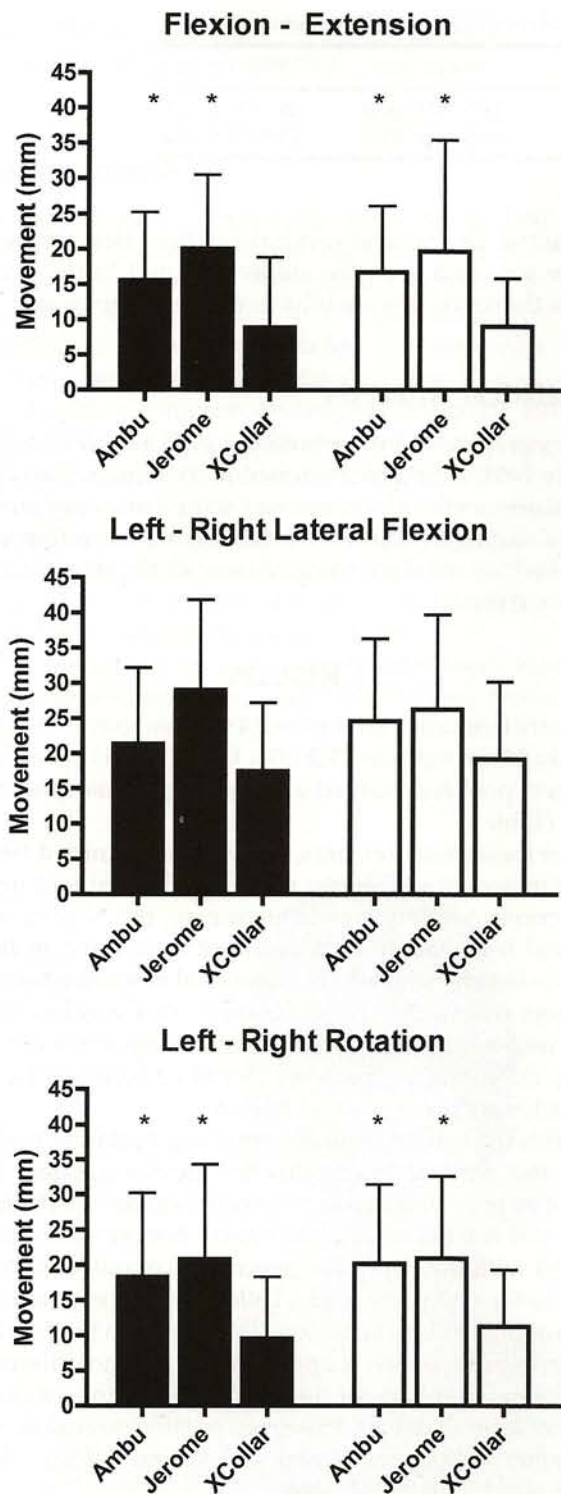

Left - Right Rotation

FIGURE 2. Cervical range of motion (millimeters) in the seated position for flexion–extension (*top panel*), left and right lateral flexion (*middle panel*), and left and right lateral rotation (*bottom panel*). *Different from XCollar (p ≤ 0.05).

DISCUSSION

True cervical immobilization is likely unobtainable. Even a halo frame, a substantial cervical orthotic device, allows a small amount of motion.[10] However, the rigid cervical immobilization collar remains the best al-

ternative for the initial prehospital stabilization of the cervical spine. Most cervical collars previously examined provide insufficient stabilization unless a rescuer applies manual cervical stabilization.[4,6,9] Many traumatic incidents, such as a multiple-vehicle crash, will generate more patients than an initial crew of two to three EMS providers can handle. The optimal prehospital situation is to maintain manual cervical stabilization until the patient is secured to the long spine board. However, this may not always be practical during the initial care of multiple casualties. The placement of an XCollar without manual stabilization could potentially expedite triage and treatment when rescuers are operating under altered protocols of a mass casualty incident.

In this study of healthy volunteers, the XCollar provided superior stabilization when compared with two other commonly used prehospital cervical immobilization collars in most planes when the subject was in a seated position and reduced active extension and right-sided motions when the subject was supine without a cervical immobilization device applied. The additional stabilization provided by the XCollar may be due to its design that extends the superior edge to the zygomatic arches and external occipital protuberance and the inferior margin well down past the manubrium and upper thoracic spine and differs from other devices that immobilize the neck between the mandible and clavicles.

A previous study identified superior immobilization in one-piece rigid cervical collars when compared with two-piece rigid and one-piece soft collars.[7] Although the one-piece rigid collar used in the present study differs from that used in the previous study, we were not able to identify any difference between the one-piece and two-piece collars. Although we were unable to identify other studies reporting different effects for left and right movement in the horizontal or frontal planes, the XCollar provided superior stabilization for right-sided movements when compared with both the Ambu and Jerome cervical collars. We cannot definitively identify the reason for this difference. However, we speculate that it may be related to the left-sided placement of the clip that secures the XCollar around the neck.

LIMITATIONS

Commonly cited studies of cervical collars utilized radiographic techniques to measure the degrees of motion between cervical vertebrae.[3,5,6,8] While radiographic techniques are required to identify paradoxical motion at the atlantooccipital and atlantoaxial articulations,[6,10] we felt that exposing healthy volunteers to multiple doses of ionizing radiation presented an unacceptable risk–benefit ratio. Additionally, employing goniometry eliminates the post hoc exclusions that are inherent to plain film analyses and ensures a complete data set. It is likely that reducing movement

TABLE 3. Cervical Range of Motion in Millimeters (Mean ± Standard Deviation) for Subjects Secured to a Long Spine Board with a Cervical Immobilization Device

Device	Left Rotation	Right Rotation	Left Lateral Flexion	Right Lateral Flexion
Ambu (1-piece)	23.6 (11.3)	11.0 (7.7)	14.2 (11.1)	14.6 (14.7)
Jerome (2-piece)	23.5 (10.2)	12.1 (10.2)	19.4 (16.3)	19.7 (15.1)
XCollar (1-piece)	16.9 (11.4)	7.8 (6.1)	15.1 (10.1)	15.1 (11.0)
$F_{2,72}$ (p-value)	3.0 (0.06)	1.8 (0.17)	1.2 (0.30)	1.2 (0.32)

No significant comparisons were present.
$F_{2,72}$ = XXX.

in the head and neck subsequently reduces spinal column movement. However, the true range of motion in the cervical spine is unknown.

Our study employed healthy volunteers in a controlled setting. Results may differ in patients with unstable spinal cord injuries. However, clinical studies of SCI patients are impractical making healthy subject studies necessary. Two cadaver studies with experimentally induced SCI have shown that the tested cervical devices are similar and of limited value, especially during airway maneuvers.[4,9] However, it is unclear if cadaver studies are directly comparable with studies of live subjects.

CONCLUSIONS

The XCollar provided superior cervical stabilization without augmentation by manual stabilization in healthy adult volunteers in both the seated and supine positions when compared with other one-piece and two-piece rigid cervical collars. Although maximal stabilization was achieved only after the subjects were secured to a long spine board with a cervical immobilization device, the XCollar can provide an acceptable alternative to manual cervical stabilization in situations where the number of patients exceeds the number of EMS providers available to provide care.

References

1. Burton JH, Dunn MG, Harmon NR, Hermanson TA, Bradshaw JR. A statewide, prehospital emergency medical service selective patient spine immobilization protocol. J Trauma. 2006;61(1): 161–7.
2. Bernhard M, Gries A, Kremer P, Böttiger BW. Spinal cord injury (SCI)—prehospital management. Resuscitation. 2005;66:127–39.
3. Cline JR, Scheidel E, Bigsby EF. A comparison of methods of cervical immobilization used in patient extrication and transport. J Trauma. 1985;25:649–53.
4. Del Rossi G, Heffernan TP, Horodyski M, Rechtine GR. The effectiveness of extrication collars tested during the execution of spine-board transfer techniques. Spine J. 2004;4:619–23.
5. Graziano AF, Scheidel EA, Cline JR, Baer LJ. A radiographic comparison of prehospital cervical immobilization methods. Ann Emerg Med. 1987;16:1127–31.
6. Hughes SJ. How effective is the Newport/Aspen collar? A prospective radiographic evaluation in healthy adult volunteers. J Trauma. 1998;45:374–8.
7. James CY, Riemann BL, Munkasy BA, Joyner AB. Comparison of cervical spine motion during application among 4 rigid immobilization collars. J Athl Train. 2004;39(2):138–45.
8. McCabe JB, Nolan DJ. Comparison of the effectiveness of different cervical immobilization collars. Ann Emerg Med. 1986;15: 50–3.
9. Aprahamian C, Thompson BM, Finger WA, Darin JC. Experimental cervical spine injury model: evaluation of airway management and splinting techniques. Ann Emerg Med. 1984;13:584–7.
10. Johnson RM, Owen JR, Hart DL, Callahan RA. Cervical orthoses: a guide to their selection and use. Clin Orthop Relat Res. 1981;(154):34–45.