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Original Article

Evaluation of the Efficiency of Minerva Collar on Cervical Spine Motions

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ABSTRACT

Background: Various types of cervical collars have been used to immobilize the cervical spine. There is no information regarding the effectiveness of cervicothoracic collars (Minerva) on restriction of motions in cervical spine. Therefore, this study aimed to evaluate the immobilization achieved following the use of Minerva collar in cervical and cervicothoracic spine.
Methods: Twenty healthy subjects (10 females and 10 males) were recruited in the study, having no history of pain, deformity and surgery in the spine. A motion analysis system was used to record the motions of the cervical, upper thoracic and cervicothoracic in flexion, extension, lateral bending and rotation with and without Minerva collar.
Results: The motion restriction of the upper cervical spine obtained with Minerva collar varied between 86.32 and 90%. The range of flexion/extension of cervical and cervicothoracic parts decreased by 27.35 and 56.32%, respectively following the use of Minerva collar. The flexion/extension range of motion of this segment decreased by 77.85 and 63.25%, respectively between occiput and T12.
Conclusion: The maximum restriction of motion with Minerva collar was achieved in the cervical spine, due to the efficiency of Minerva collar in restricting the cervical motions, especially in the upper part.

Introduction

Various cervical orthoses have been designed to restrict and control the motions of cervical and cervicothoracic regions. The cervical orthoses which are also called cervical collars can be categorized into soft and rigid collars [1, 2]. They can be used in cervical fractures, soft tissue injuries, post-surgical immobilization and also in some kinds of degenerative diseases and deformations. The main purposes of use of cervical collars are to reduce pain, increase stability, maintain natural posture and also to reduce intervertebral segmental motions associated with cervical fractures [2].

Actually, another classification for cervical collars exists, which divides them into conventional based and unconventional collars. It should be emphasized that the efficiency of cervical and cervicothoracic collars depend on their standard stiffness to immobilize the cervical and cervicothoracic regions [1, 2]. If these collars are to be used to provide immobilization, then they should fit efficiently to enhance the maximum restriction of motions. There are some studies in literature which evaluated the efficiency of cervical collars on motion restrictions. However, most of them have be done on cadaver and based on X-ray evaluations [3, 4]. Based on the result of the available studies, soft collars provide the minimum values of motion restrictions compared to HALO orthosis, which restricts the cervical motion significantly [4-12]. Some

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studies on the efficiency of cervical collars on motion restriction of Miami, Philadelphia, Aspen, Thomas, four poster, and two poster collars exist [4, 6, 9, 10, 12-14]. However, today most of these collars have not been used due to their side effects and their inability to properly control the motions [4, 15-20]. There are no studies in literature regarding the motion restriction of Minerva collar. There is no doubt that Minerva collar have been prescribed in most cervical injuries. Therefore, this study was aimed to evaluate the effects of Minerva collar on motion restriction of cervical and cervicothoracic areas. The main hypothesis associated with this study is that Minerva collar significantly reduces the motions of cervical and cervicothoracic regions.

Methods

Twenty healthy subjects (10 males and 10 females, with the mean age of 26.55 year), with no pain in spine and head at the time of measurement and data collection, with no history of diseases, deformities and surgeries in spine, were recruited in this study.

Minerva Cervical Collar

This is a molded collar which restricts the motions of cervical and cervicothoracic regions. It extends from the upper part of the head (occiput) to the lower part of the thoracic region (T12). Figure 1 shows the Minerva collar used in this study. It should be emphasized that four casts were taken from the participants to produce four Minerva collars, which fits snugly on all of the participants. The collar was produced according to the standard procedures mentioned for this collar [21]. Finally, four orthoses were made in this study (Two for women and two for men)

A motion analysis system with 7 high speed cameras was used to record the motions of the upper cervical region (occiput), thoracic and cervicothoracic regions. Some reflective markers were attached on the occiput, spinous process of T12 and spinous process of C7. These markers settled on the orthoses with due attention given to the anatomical landmarks of every participant. The flexion\extension, axial rotation, and lateral bending ranges of motion were evaluated in this study. The time

Figure 1: The Minerva cervical collar used in this study.

interval between each test was 30 minutes. The change in the angle of the markers attached on the occiput and C7 relative to the vertical position was delineated as angular change in the cervical region. The change in the angle of the markers attached on C7 and T12 relative to the vertical position and the angle between occiput and T12 relative to the vertical position were delineated of the motion of the thoracic and cervicothoracic regions, respectively.

Figure 2 shows the angles which were evaluated in this study. The subjects were asked carry out the following motions: Flexion/extension of spine, lateral bending to right and left sides, and rotation to right and left sides. The head and neck were in static position for 3 seconds and then were involved in the aforementioned movements. The mean value of three repetitions was obtained for each motion. The data were collected with a frequency of 120 Hz and filtered with cut off frequency of 10 Hrz. It should

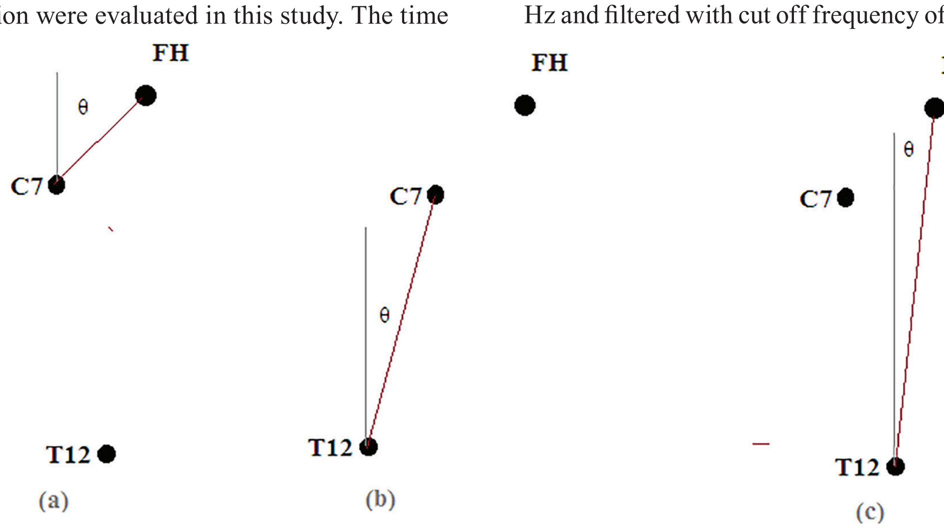

Figure 2: The angles on Cervical (a), thoracic (b) and cervicothoracic regions (c) evaluated in this study, FH=Forehead, C7: seventh cervical vertebra, T12: Twelfth cervical vertebra

be emphasized that the motions of the spine were divided into primary and secondary motions. The primary motion is defined as the motion which occurs in the main plane of motion (for instance, flexion/extension is the primary motion when the subjects move the head along the sagittal plane). The secondary motion is defined as the motion which occurs in other planes of motion (for instance, lateral bending and rotation are defined as the secondary motion when the subjects move their heads along the sagittal plane). Figure 3 shows the angle of cervical spine when a subject flexed the head along sagittal the plane. This method for measurement of angles is quite new.

The ranges of motions of flexion, extension, rotation (the mean value for both right and left sides) and lateral bending (the mean values for both right and left sides) were evaluated for each subject with and without Minerva collar. Finally, the collected data were entered into a SPSS software (version 20), which was used for all statistical analyses. The normal distribution of the parameters was evaluated using Shapiro-Wilk test. Since the data had a normal distribution, the difference between the range of motions with and without Minerva collar was checked using Paired t-test.

Results

The mean values of the motions of the cervical region (occiput relative to C7) with and without Minerva collar are shown in Table 1. Moreover, the percentages of motion restriction are also presented in this table. The mean values of flexion range of motion decreased by more than 90% (43.45° without collar compared to 4.05° with collar, P=0.00). In contrast, the use of Minerva collar decreased extension by 88.12% (P=0.00). Lateral bending to the right and left sides decreased by more than 86.32% with the use of collar (P=0.00).

The range of flexion and extension of the thoracic region decreased by 27.35% and 56.32%, respectively with the use of Minerva collar. The lateral bending range of motion of thoracic region decreased by 33.51% with the use of Minerva collar.

The effect of Minerva collar on the motion of cervicothoracic region (from occiput to T12) was also analyzed in this study. The flexion and extension range

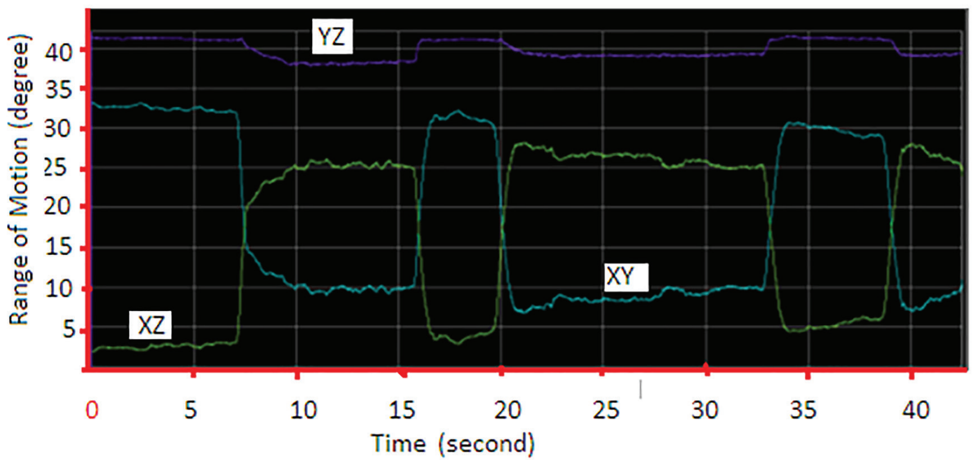

Figure 3: The angles of the cervical, thoracic and cervicothoracic regions collected in this study (flexion/extension=Plane XZ, lateral bending=Plane YZ and rotation=Plane XY).

Table 1: The Mean values of ROM (range of motion) and average percentage of motion restriction of all primary and secondary movements in the upper region of cervical spine (Occiput to C7), all P-values of the difference were 0.00.

Movements	No Orthosis	Std.Deviation (No Orthosis)	With Orthosis	Std.Deviation (With Orthosis)	Average percent of motion restriction	P value
Flexion (primary motion)	43.45	±12.609	4.05	±1.820	90.67	0.000
Rotation (secondary motion)	23.60	±12.364	2.20	±1.542	90.67	0.000
Lateral bending (secondary motion)	0.70	±1.625	0	0	100	0.069
Extension (primary motion)	44.20	±16.991	5.25	±3.024	88.12	0.000
Rotation (secondary motion)	37.95	±16.204	3.45	±3.590	90.90	0.000
Lateral bending (secondary motion)	2.10	±4.564	0.05	±0.223	97.61	0.061
Lateral bending (primary motion)	21.05	±12.714	2.92	±2.217	86.32	0.000
Flexion- Extension (secondary motion)	5.72	±5.101	1.17	±3.402	80.77	0.001
Rotation (secondary motion)	14.50	±12.750	1.32	±3.597	89.59	0.000
Rotation (primary motion)	22.70	±8.988	3.22	±4.2.8	85.94	0.000
Flexion- Extension (secondary motion)	22.15	±10.498	0.55	±0.974	97.21	0.001
Lateral bending (secondary motion)	27.67	±15.405	1	±1.884	96.38	0.000

of motion of this segment decreased by 77.85% and 63.25%, respectively (P=0.00). The ranges of motion of lateral bending with and without collar were 7.25 and 2.35 degree, respectively (67.75% motion restriction). It seems that rotation range of motion of this segment decreased more than the other motions when Minerva collar was used.

Discussion

Effective stabilization of cervical spine is recommended in treatment of cervical fractures [2]. There is no doubt that Halo vest orthosis provides a high degree of immobilization required to stabilize cervical fractures, especially for treatment of unstable injuries of the cervical spine [4, 15, 19]. However, pin track problems, inaccurate fitting of the vest and lack of patient compliance lead to clinical failure [17, 22, 23]. It should also be emphasized that when there is need to wear a cervical orthosis for an extended period of time, comfort becomes an issue [17-19]. Minerva collar is another orthosis recommended for cervical fractures. Considering its structure, it seems that the side effects of this collar are less than that of Halo orthosis. There are a few studies in literature regarding the magnitude of joint motion restriction achieved following the use of this cervical collar. However, most of these studies have been done on cadavers [16, 18]. Although there are a few studies on normal subjects [3, 4, 15, 17, 19, 20, 24-27], but in most of them goniometer was used to measure the range of motion of cervical spine [2, 3, 25]. Moreover, the effects of cervical collars on the motion of the upper cervical region were studied. Therefore, the aim of this study was to investigate the efficiency of Minerva collar on motion restriction of the cervical, thoracic and cervicothoracic areas.

The results of this study confirmed that Minerva collar restricted the motions of occiput relative to C7 by 90.67, 88.12, 86.32, and 85.94% in flexion, extension, lateral bending and rotation, respectively (Table 1). It seems that the restriction achieved by use of this collar is comparable with Halo orthosis. Based on the results of the research presented by Lauweryns et al, Halo vest orthosis restricts flexion and extension up to 76%. Moreover, the efficiency of this orthosis seems to be more than that of SOMI (Sterno-Ocipoto-Mandibular Immobilization) orthosis (SOMI brace restricts the motion of the cervical region in flexion by 93%, extension by 42%, lateral bending and rotation by 66%) [28]. It should be emphasized that the method of motion analysis differed in the current study and above mentioned studies. However, based on the results of various studies, HALO orthosis and SOMI provide maximum motion restrictions compared to other available collars. As can be seen from Table 1 and based on the results of the previous studies, it can be concluded that the efficiency of this collar to restrict the motions of the cervical region is more than that of other available collars including: Aspen collar, Miami, 2 poster, and 4 poster) [1, 3, 7, 8,11].

The effects of use of Minerva collar on the motions of the thoracic region was also evaluated in this study. As can be seen from Table 2, the effect of Minerva collar on the motions of lower part is not comparable with that of the cervical region. The flexion, extension and lateral bending were restricted by 27.35, 56.32 and 33.51%, respectively in the thoracic region. Unfortunately, there is no study in literature which evaluated the efficiency of cervical collars on the motion of lower part of cervical region. However, it can be concluded that the efficiency of Minerva collar on the cervical segment can be significantly more than that of thoracic part. It seems that configurations of collar in the cervical part together with a better fit on the occiput and mandible increased its efficiency in the cervical region.

The relative motions of occiput to T12 were also evaluated in this study. Based on the results of this study, Table 3, Minerva collar restricted flexion, extension, lateral bending and rotation by 77.85%, 63.25%, 67.75% and 81.04%, respectively. There are no studies in literature regarding the relative motion of occiput to T12. Based on the results of this part of the research, it can be concluded that this collar can also be used to produce reasonable restriction between occiput and T12.

The results of this research showed that Minerva collar produced high degree of motion restriction in the upper part of cervical region; however its influence on lower part of cervical region is reasonable. Due to high restriction achieved following the use of this collar, especially in the cervical region, this collar is recommended to be used

Table 2: The Mean values of ROM (range of motion) and average percentage of motion restriction of all primary and secondary movements between C7 and T12 (thoracic region).

Movements	No Orthosis	Std.Deviation (No Orthosis)	With Orthosis	Std.Deviation (With Orthosis)	Average percent of motion restriction	P value
Flexion (primary motion)	5.30	±4.769	3.85	±2.109	27.35	0.200
Rotation (secondary motion)	3.75	±4.191	2.25	±1.802	40	0.164
Lateral bending (secondary motion)	0	0	0	0	0	0.000
Extension (primary motion)	8.70	±10.478	3.80	±2.802	56.32	0.068
Rotation (secondary motion)	3.90	±5.149	2.35	±1.694	39.74	0.200
Lateral bending (secondary motion)	0	0	0	0	0	0.000
Lateral bending (primary motion)	4.87	±6.119	2.92	±2.699	33.51	0.278
Flexion- Extension (secondary motion)	1.50	±4.212	0.72	±1.181	51.66	0.362
Rotation (secondary motion)	1.52	±2.952	0.52	±0.735	65.42	0.108
Rotation (primary motion)	2.65	±2.381	1.37	±1.189	46.01	0.000
Flexion- Extension (secondary motion)	1	±1.651	0.67	±1.649	28.33	0.003
Lateral bending (secondary motion)	1.57	±2.252	0.17	±0.428	80.09	0.103

Table 3: The Mean values of ROM (range of motion) and average percentage of motion restriction of all primary and secondary movements between occiput and T12 (cervicothoracic region), all P-values of the difference were 0.00

Movements	No Orthosis	Std.Deviation (No Orthosis)	With Orthosis	Std.Deviation (With Orthosis)	Average percent of motion restriction	P value
Flexion (primary motion)	14.90	±7.489	3.30	±1.380	77.85	0.000
Rotation (secondary motion)	12.70	±7.204	2.15	±1.531	83.07	0.000
Lateral bending (secondary motion)	0	0	0	0	0	0.000
Extension (primary motion)	10.75	±6.934	3.95	±2.282	63.25	0.001
Rotation (secondary motion)	5.80	±6.395	2.75	±2.221	52.58	0.068
Lateral bending (secondary motion)	0.55	±1.276	0	0	100	0.069
Lateral bending (primary motion)	7.25	±3.402	2.35	±2.138	67.75	0.000
Flexion- Extension (secondary motion)	1.60	±1.839	0.50	±0.911	68.17	0.050
Rotation (secondary motion)	4.20	±3.812	0.62	±0.927	85.29	0.001
Rotation (primary motion)	8.86	±4.696	1.67	±1.075	81.04	0.000
Flexion- Extension (secondary motion)	6.44	±3.270	0.55	±0.899	90.92	0.003
Lateral bending (secondary motion)	9.33	±3.172	0.10	±0.311	98.87	0.000

instead of Halo vest orthosis. It restricts the motion of the cervical region significantly and does not have any side effects as Halo vest orthosis.

There was a limitation which should be acknowledged in this study. The main limitation was the characteristics of the participants. Only normal subjects were recruited in this study. Therefore, it is recommended that the efficiency of this collar be evaluated on the subjects with fracture of cervical region. Use of motion analysis system seems to be a practical and safe method to evaluate the efficiency of cervical collars.

Conclusion

The results of the current study showed that Minerva collar provides a high degree of immobilization especially in the upper part of cervical region. Therefore, the use of this collar is recommended especially instead of Halo vest orthosis.

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Conflict of interest: None declared.

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