**Appendix 5: Extracted data**

| **Reference** | **Methods** | **Participants** | **Interventions** | **Comparisons** | **Outcomes & most important results** | **Notes & authors' conclusions** |
| --- | --- | --- | --- | --- | --- | --- |
| Ala 2021 | Experimental: Randomized controlled trial (within subjects; cross-over)  Iran | 80 healthy adult volunteers (66 males and 14 females) with an average age of 48 years | (1) Philadelphia® collar  (2) Miami J® collar | No collar (baseline) | Collar vs no collar (baseline) Both the Philadelphia® and Miami J® collar contributed to significant expiratory flow restriction by decreasing the forced expiratory volume in the first second (FEV1), peak expiratory flow (PEF), PEF at 25–75%, and the ratio of the FEV1 to the forced vital capacity (FVC) (p < 0.001).  The average End Tidal CO2 (ETCO2) had a statistically significant increase after either type of collar application.  There was no statistically significant difference in terms of FVC.  Philadelphia® collar vs Miami J® collar The Philadelphia® collar's impact on expiratory flow restriction outpaced that of Miami J®: in comparison with Miami J®, the average FEV1 (p = 0.038), FEF25–75% (p =0.012), and FEV1/FVC (p=0.044) were significantly lower in the setting of Philadelphia® collar.  There was no significant difference in ETCO2 between these collar types. | Authors' conclusions: Philadelphia® and Miami J® collar application culminated in expiratory flow obstruction in healthy individuals. Our study also suggested that efforts to early removal of a cervical collar, particularly in patients with respiratory compromise, could be justified. |
| Asha 2021 | Case series  Australia | 2,036 patients (1,139 males, median age 54 years (IQR: 29-78)) evaluated for potential traumatic cervical spine injury in the ED from October 2017 to July 2018 | (1) Soft collar (n=1,133): - Pre-hospital rigid collar\* changed to a soft collar in the ED (n=497) - Soft collar applied in the ED (no pre-hospital collar) (n=636) (2) Pre-hospital rigid collar\* and remained in rigid collar\* (n=268)  \* Classified as rigid collars: Stifneck®, Philadelphia®, Miami J®. | No collar (n=582) | 9 patients developed a new neurologic deficit after arrival in ED:  - Soft collar group: n=6 (3 due to progression of intracranial injuries, 1 due to spinal cord injury and 2 with no organic cause found)  - Rigid collar group: n=3 (2 due to spinal cord injury and 1 with no organic cause found) - No collar group: n=0 | Authors' conclusions: The use of soft foam cervical collars in patients at risk for a cervical spine injury does not appear to increase the risk for secondary spinal cord injury. Secondary spinal cord injury can occur regardless of spinal immobilization due to progression of spinal cord oedema or hemorrhage. |
| Ay 2011 | Experimental: Non-randomized controlled trial (within subjects)  Turkey | 60 healthy volunteers (33 females and 27 males, median age 27 years (range 19-53)) | (1) Philadelphia® collar + Kendrick extrication device (2) Philadelphia® collar + long spinal backboard with straps  with 1-hour relaxation period between interventions  [Intervention 1 was deemed not to be relevant for this scoping review, because the Kendrick extrication device is not available to first aiders.] | No collar or backboard (baseline) | Full spirometry was performed in the supine position to measure pulmonary function parameters 5 and 30 minutes after application of the devices: forced vital capacity (FVC), forced expiratory volume in one second (FEV1) and FEV1/FVC.  Compared to baseline levels, after application of the long backboard, FEV1 and FVC levels were statistically significantly decreased after 5 and 30 minutes (both p<0.001). There were no significant differences in FEV1/FVC levels at 5 or 30 minutes. Compared to 5 minutes after application, after 30 minutes, there was a considerable decrease in FEV1 levels (p=0.048). There were no significant differences between 5th and 30th minute FEV1/FVC levels (p>0.05). FVC levels at the 5th minute were significantly higher than FVC levels at the 30th minute (p=0.002) | Identified from reference list of Jao 2023.  Authors' conclusions: In conclusion, in this study performed among volunteers, we determined that long spinal backboard causes a decrease in pulmonary functions. The decrease in the pulmonary functions becomes more pronounced when the immobilization period is extended. |
| Bednar 2004 | Experimental: Non-randomized controlled trial  Canada | 6 fresh human cadavers that underwent 3 levels of spinal destabilization in the laboratory | (1) Soft Straight Collar (soft) (2) Philadelphia® (semi-rigid) (3) Stifneck® (rigid) | No collar | *Incomplete posterior destabilization:* When compared with unsupported alignment after destabilization the cadavers show increased angulation, translation and distraction with all 3 collars in either loading mode, with no statistically significant difference in any of these displacements between types of collar. This is consistent with gross observations of the cadaver heads levering over the edges of the collars during these experiments: after release from the neutral position, the head, neck and collar rolled forward as a unit until the forehead of the cadaver met the tabletop.  *Complete destabilization:* After release from the neutral position, the movement of the head and neck with the semi-rigid collar was exactly as described for the posterior destabilization model until the distal anterior flange of the collar impinged on the manubrium. At this point apparent motion of the neck and collar stopped, but the head continued to roll forward slightly as the chin rolled over the hard proximal flange of the collar, effectively lengthening the neck through a 13-mm translation. Available baseline data show a trend toward more movement in the collared specimens than in the unsupported. There was a trend toward increased flexural translation in prone loading with the soft collar applied, but increased distraction of the index motion segments with more rigid collar support was such that the net malalignment was similar in all cases.  *Incomplete anterior destabilization:* In side-bending there was again little variance by type of orthosis. In extension the soft collar permitted increased angulation in some specimens, compared with the more rigid collars; but again, the large displacements recorded even with the stiffer devices suggests that they offer minimal protective benefit. Observed motion with the hard collar was exactly as described with the semirigid collar. | Authors' conclusions: The routine use of a hard cervical collar to protect the neck of an unconscious trauma patient from secondary displacement may not be effective.  Clinicians cannot depend on hard cervical collars to provide definitive support to the neck in cases of possible cervical instability.  For patients in collars who are being treated, there appears to be little benefit from hard versus softer devices.  In cases where tone in cervical soft tissue is lacking, the cervical orthoses studied may facilitate increased displacement of the unstable neck under load, as compared with the unsupported condition. Appropriate precautions in the care of cervical spine–injured patients are accordingly warranted. |
| Ben-Galim 2010 | Experimental: Non-randomized controlled trial (within subjects)  USA | 9 fresh whole human cadavers that underwent spinal destabilization | Ambu® Perfit ACE™ rigid collar (commonly used conventional extrication collar) | No collar | Application of the collar significantly worsened axial malalignment by causing distractive separation of the head and C1 vertebra away from C2. | Authors' conclusions: In nine whole, fresh human cadavers with simulated severe dissociative injuries to the upper cervical spine, application of a cervical extrication collar resulted in grossly abnormal distraction at the injured level. Although the collars did not cause the injuries, they appeared to promote further separation between vertebrae. |
| Bruton 2024 | Case series   Australia | 2,098 patients (7% 0 to <16 years, 59% 16-64 years, and 34% ≥65 years; 61% male) with spinal immobilisation applied by paramedics for potential traumatic cervical spine injury during pre-hospital care, in select metropolitan and regional geographical areas of a jurisdictional ambulance service from 1 May 2022 to 31 March 2023 in New South Wales. In 76 of those patients, a cervical spine injury was identified (40 ligamentous disruptions, 26 fractures and 8 spinal cord injury). | Soft cervical collar (instead of rigid collars that are normally used) | N/A | Primary outcome was the proportion of patients with spinal cord injury developing a new or worsening neurological deficit following pre-hospital soft collar application, identified through comparison of SPEED scores ((SPinal Emergency Evaluation of Deficits; validated tool) between scene assessment and arrival at hospital. Patient-reported experience measures (PREMs) and paramedic experiences were recorded by paramedics via a Research Electronic Data Capture (REDCap) survey while on scene or transporting the patient to the Emergency Department.   No patients with SCI had neurological deficits caused by pre-existing conditions or inability to assess neurological deficits because of decreased level of consciousness. Two of the eight SCI patients were identified to have experienced a worsening neurological deficit, representing 0.095% of the total soft collar applications, or 2.6% of all cervical spinal injuries (n = 76). Both cases were male, over 65 years of age, and experienced a fall. Both also had pre-existing conditions which complicated initial neurological (SPEED) assessment, including quadriparesis, cervical myelopathy, dementia and multiple spinal fixation procedures owing to prior falls. In both instances, the comprehensive case reviews determined that the patient outcomes were unlikely to have been attributable to the soft collar.  A large majority of patients surveyed found the soft collar to be either comfortable or very comfortable (n = 123, 65.4%). Paramedic assessment at the time of collar application showed that the majority of patients tolerated the application of the collar (97.9%, n = 183), with over four-fifths of patients being compliant with paramedic directions to immobilise (81.9%, n = 154). | The majority (91.9%, n = 113) of paramedics surveyed found the soft collar easy to apply. Over three-quarters (77.2%, n = 95) believed that the usage of soft collars resulted in less patient movement during the collar application process, whereas just under three-quarters (71.5%, n = 88) reported that patient compliance with immobility directions was good after the soft collar was applied. A majority of paramedics felt that the usage of soft collars was a useful tool to assist in minimising patient movement (n = 101, 82.1%).  Authors' conclusions: The use of soft foam collars in the pre-hospital environment for patients at risk of a cervical spinal injury failed to identify significant harms associated with the use of soft collars in the prehospital setting. Patients found these devices relatively comfortable, and clinicians reported overall ease of use with good patient compliance with immobility directives. Further large prospective studies are now needed to fully validate the safety of soft collars compared to hard collars in the prehospital context. |
| Castro-Marin 2020 | Observational: Retrospective cohort study  USA | Emergency medical services encounters recorded in a state-wide database between 1 January 2013 and 31 December 2015:  - 104,315 cases of traumatic injury (TI) - 51,199 cases of possible spinal trauma (P-ST)  - 5,178 cases of verified spinal trauma (V-ST) | After the implementation of spinal motion restriction protocols (post-SMR), designed to reduce long spine board use: - 64,396 TI cases - 31,744 P-ST cases - 3,246 V-ST cases | Before the implementation of those protocols (pre-SMR): - 39,919 TI cases - 19,455 P-ST cases - 1,932 V-ST cases | Incidence of spinal cord injury for post-SMR vs pre-SMR patients: - TI: 0.22% vs 0.20% (p=0.390) - P-ST: 0.45% vs 0.40% (p=0.436) - V-ST: 4.04% vs. 4.37% (p=0.561)  Odds Ratio adjusted for age and injury severity in the highest risk cohort of patients with V-ST post-SMR was 1.097 (95%CI [0.818;1.472]) | Authors' conclusions: No change in the incidence of spinal cord injury was identified following implementation of SMR protocols. |
| Chen 2022 | Observational: Retrospective cohort study  Australia, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, United Arab Emirates and Vietnam | 759 cases of spinal injury, aged 16 years or older, selected from the prospective PATOS registry of 43,752 EMS-transported patients between 1 January 2016 to 30 November 2018 | Prehospital spine immobilization, defined as neck collar and/or backboard, including scoop stretcher (n=438) | No prehospital spine immobilization (n=321) | - In univariable logistic regression, prehospital spinal immobilization was not significantly associated with favorable functional outcomes (OR 0.66; 95% CI, 0.42-1.02; p=0.061).  - In multivariable logistic regression, prehospital spinal immobilization was not associated with favorable functional outcomes (aOR 1.06; 95% CI 0.62–1.81; p = 0.826).  -In a subgroup of cervical spinal injury patients, prehospital spinal immobilization was associated with favorable functional outcomes in (aOR 3.14; 95% CI 1.04–9.50; p = 0.043). Patients with an ISS score of ≥ 9 and cervical SI showed a positive association between immobilization and favorable functional outcomes (aOR 5.50; 95% CI 1.02–29.69; p = 0.048). | Heterogeneity between immobilized/non-immobilized groups in terms of age, gender, mechanism, percent of cervical injuries, RTS, ISS, surgical intervention.  Authors' conclusion:  Prehospital spinal immobilization was not associated with favorable functional outcomes in traumatic patients with SI; however, subgroup analysis revealed that it may be beneficial for patients with cervical SI without TBI. (ISS ≥ 9) The authors suggest that paramedics should be more judicious when determining the presence of a cervical SI and should apply full spine immobilization if possible. |
| Chi 2005 | Experimental: Non-randomized controlled trial (within subjects)  Taiwan | 18 female volunteers (mean age 23 years (range 20-28)) from a university, without a history of cervical vertebral or disk disease | Stifneck Select rigid cervical collar | No collar (baseline) | Cervical range of motion (ROM) in 6 directions (flexion, extension, right and left lateral bending, right and left axial rotation) was measured before and after applying the collar, using the CROM device.  Unrestricted ROM in all directions ranged from 41.50° (7.25°) to 70.76° (15.4°).  (Unrestricted ROM for flexion, extension, right and left lateral bending, and right and left rotation were 52.11° (11.98°), 70.76° (15.4°), 41.50° (7.25°), 43.98° (7.27°), 65.17° (8.96°), and 65.78° (8.14°), respectively)  ROM in all directions was significantly restricted by cervical collar placement under all conditions. (Restricted ROM for flexion, extension, right and left lateral bending, and right and left rotation were 12.09° (6.16°), 16.48° (7.79°), 17.28° (5.78°), 14.11° (5.02°), 16.07° (6.00°), and 18.50° (6.93°), respectively) | Identified from the reference list of Tescher 2016.  Long-haired women were chosen, because this study wanted to assess the effect of clothing and hair covering the neck on immobilization using a cervical collar. For this scoping review, only the scenario where the hair and clothing did not cover the neck was considered useful. Data on other scenarios were not extracted.  Authors' conclusions: ROM in all directions was significantly restricted by cervical collar placement under all conditions. |
| Clemency 2021 | Observational: Retrospective cohort study  USA | 1,172 patients transported by emergency medical services to a single Level I trauma-designated hospital with spine or spinal cord injury due to blunt trauma between 1 January 2013 and 31 December 2017 | After the implementation of the spinal motion restriction (SMR) protocol  (between 1 January 2016 and 31 December 2017; n=623) | Spinal immobilization (SI) protocol, before the implementation of SMR  (between 1 January 2013 and 31 December 2014; n=549) | Incidence of disabling spinal injuries for SMR vs SI patients: 28/623 (4.5%) vs 28/549 (5.1%) (p=0.628)  Odds Ratio adjusted for age, gender, mechanism of injury, and highest level of spinal injury was 0.78, 95%CI [0.44;1.36] (p=0.374) | Authors' conclusions: This study did not demonstrate an increase in disabling spinal cord injuries after a shift from an SI protocol to an SMR protocol. |
| Colak 2020 | Observational: Interrupted time series  Turkey | 94 adult trauma patients (51 males and 43 females, mean age 42+/-16.1 years) referred to the ED between November 2017 and November 2018  Patients in whom a fracture and/or spinal injury were confirmed by direct cervical X-ray or cervical CT were excluded due to the inability to perform all serial ONSD measurements. | Cervical collar (at time of admission and 20 min after admission) (type not specified) | No cervical collar (cervical collar was removed at 20-minute time point and measurement was done 20 min later, so 40 min after admission) | At the time of admission, after 20 min and after 40 min, ONSD was measured 3 mm posterior to the globe at sagittal and transverse positions. The average of ONSD was determined by calculation of 92 the average of the transverse and sagittal measurements of the right and left ONSD.  ONSD was 4.8+/-0.9 mm at admission, 5.0+/-0.9 mm at the 20th minute of the admission, and was 4.4+/-0.9 mm at the 20th minute after removal of the CC. The changes in ONSD diameter during the follow-up were statistically significant (p < 0.05).  The alterations in ONSD values were statistically significant in both genders; in all types of trauma; in the presence and absence of head trauma, cerebral pathology detected by CT, altered state of consciousness, nausea/vomiting, headache; and in the absence of hypotension and bradycardia (p < 0.05). The alterations in ONSD in patients with hypotension and bradycardia were not significant (p > 0.05). There was a positive correlation between the ONSD values detected at admission and subsequent changes in mean arterial pressure (MAP) and respiratory rate following hospital admission. However, ONSD values were negatively correlated with Glasgow coma score (GCS) and oxygen saturation (p < 0.05). No correlation was observed between the ONSD pulse rate and temperature (p > 0.05). ONSD was found to be higher in the patients with head trauma, cerebral pathology detected by CT, altered state of consciousness, nausea/vomiting, headache, hypotension and bradycardia (p < 0.05). No correlation was detected between the ONSD values and the presence of cervical pathology at all three measurement periods (p > 0.05). | Identified from the reference list of Yazici 2024  Authors' conclusions: We conclude that CC increases the ONSD regardless of the type of cerebral trauma. Therefore, unnecessary CC applications should be avoided and the CCs should be removed without delay just after the suspicion of cervical trauma is eliminated. |
| Eisner 2022 | Experimental: Non-randomized controlled trial  USA | 30 healthy human volunteers without a history of spine injury (20 females and 10 males, median age 22 years (IQR: 18-24)) | (1) Stifneck® Select™ cervical collar (2) Folded towel (3) Commercial pre-sized foam immobilizer | No cervical spine immobilization | Cervical range of motion in flexion, extension, bidirectional lateral flexion, bidirectional rotation in seated and supine positions. A composite score was generated across 6 cardinal directions to compare the 4 immobilization methods. A score greater than 1 surpassed the non-inferiority margin and was deemed inferior.  The cervical collar method yielded the greatest restriction of motion in all categories, followed in order by the towel, foam brace, and control (p < 0.01). The towel immobilization protocol showed the greatest bilateral consistency across all conditions for both rotation and lateral flexion.  Cervical collar vs no immobilization Cervical collars reduced median cervical range of motion in six cardinal directions in seated and supine positions by an average of −36.83° seated (−17.75° supine) vs no immobilization.  Folded towel vs cervical collar Folded towels were found to be non-inferior for immobilizing the c-spine in extension and rotation, but not flexion, compared to cervical collars. Composite scores were 0.47 in the supine and 0.89 in the seated position.  Foam neck brace vs cervical collar Foam neck braces were inferior compared to cervical collars (seated composite score =2.35, supine composite score = 2.10) | Authors’ conclusions: Our findings suggest folded towels may provide adequate c-spine immobilization of extension and rotation compared to cervical collars. This low-cost method should be used in combination with  backboards to deliver affordable and effective prehospital spinal cord injury management in resource-limited settings of LMICs. |
| Engsberg 2013 | Experimental: Randomized controlled trial (within subjects; cross-over)  USA | 10 healthy volunteers, 4 EMS and 6 students, naive to extraction techniques | Extraction from a mock vehicle: (1) Cervical collar (type not specified) + unassisted self-extraction (2) Cervical collar + assisted extraction (3) Cervical collar + Kendrick Extraction device + assisted extraction  Assisted extraction was done by a pair of extractors (16 EMS in total, 10 with >5 years experience in the field).  [Intervention 3 was deemed not to be relevant for this scoping review, because the Kendrick device is not available to first aiders.] | Unassisted unprotected self-extraction (without collar or device to restrict cervical spine movement) | Movement were measured using a validated video technique with reflective points attached to subject.   Cervical collar limited movement compared with no restriction devices (~20°). The other assisted methods (cervical collar alone, or cervical collar + KED) did not provide further restriction of movement for flexion/extension and rotation of cervical spine. There was similar lateral flexion to the control for both assisted techniques. | Identified from list of included studies of the systematic review of Hood 2015.  Uses a technique probably available to first aider (type of collar not specified). These subjects had no neck pain and hence very indirect evidence with regards to a patient with a neck injury. The devices were applied by experienced paramedics, not first aiders. |
| Evans 2013 | Experimental: Non-randomized controlled trial  UK | 19 healthy volunteers (with no history of spinal injury and pathology, aged 18-40 years (7 males and 12 females, mean age 29 years (range: 18-38)) | 5 types of (semi)rigid collars: (1) Philadelphia® collar (2) Aspen® collar (3) Aspen Vista® collar (4) Miami J® collar (5) Miami J® Advanced collar  Subjects were asked to perform a set sequence of movements (forward flexion, extension, left rotation, right rotation, left lateral bend, right lateral bend) to their maximal ability without distorting the collars, returning to the neutral position between each movement. | Subjects were asked to perform the same set of movements without a collar | 3D kinematic data were collected during forward flexion, extension, lateral bending and axial rotation from uncollared to collared subjects. The physiological range of motion in the three planes was analysed using the Qualisys Track Manager System.  Collar vs no collar Movements in the sagittal, transverse and coronal planes were restricted by the application of a collar (all p<0.001).  Mutual comparisons of collars In the sagittal plane, the Aspen® collar was the most effective at restricting flexion/extension. Both the Aspen® and Philadelphia® collars were significantly more effective than the Aspen Vista® (p<0.001), Miami J® (p<0.001 and p<0.01, respectively) and Miami J® Advanced (p<0.01 and p<0.05, respectively) collars at restricting movement in this plane. The Aspen® collar restricted movement in this plane by 76.4 % compared to the Aspen Vista® (68.5 %), Miami J® (69.8 %), Miami J® Advanced (70.2 %) and Philadelphia® (75.1 %) collars.  In the transverse plane, the Aspen® collar was the most effective at restricting rotation and was significantly more effective than the Aspen Vista® (p<0.001) and Miami J® (p<0.05) collars at restricting movement in this plane. The Aspen® restricted rotation by 75.1 % compared to the Aspen Vista® (65.0 %), Miami J® (68.0 %), Miami J® Advanced (69.6 %) and Philadelphia® (69.3 %) collars.  In the coronal plane, the Aspen® collar was the most effective at restricting lateral bending movements. It restricted movement in this plane by 54.4 % compared to the Aspen Vista® (32.9 %), Miami J® (48.4 %), Philadelphia® (49.0 %) and Miami J® Advanced (50.1 %) collars. The Aspen Vista® collar was the least effective at restricting lateral bend and was significantly less effective than all the other collars (p<0.001). | Authors' conclusions: Our motion analysis study found the Aspen® collar to be superior to the other collars when measuring restriction of movement of the cervical spine in all planes, particularly the sagittal and transverse planes, while the Aspen Vista® was the least effective collar. |
| Gabrieli 2019 | Experimental: Randomized controlled trial (within subjects; cross-over)  Italy | 23 healthy adult male volunteers (mean age 26 years) | Extrication from a vehicle: (1) 'Instructed exit': instructed self-extrication (watched a video-clip showing autonomous exit and received instructions (mainly to keep head, neck and thorax aligned)) (2) Cervical collar (WizLoc 449-I™) application + unassisted self-extrication  (3) Cervical collar (WizLoc 449-I™) application + Ferno® XT™ extrication device by extrication crew  The extrication crew consisted of 2 professional prehospital rescuers with more than 5 years of experience in extrication maneuvers.  Each condition was repeated 5 times; the average values were used in analysis.   [Intervention 3 was deemed irrelevant to this scoping review, as it involves assisted extrication by professional rescuers with experience in extrication maneuvers] | (1) 'Autonomous exit': self-extrication without instructions (2) While sitting in the vehicle (prior to device application) | Infrared camera and anatomic markers were used to measure cervical spine angle, angular speed and acceleration in the sagittal plane. Surface wireless EMG electrodes measured muscle activity. Measurements were done while sitting in the vehicle ('pre'), during device application ('maneuver'), during sitting in the vehicle prior to exiting ('pre-exit'), during vehicle exiting ('exit'), and after exiting the vehicle ('post-exit').  During the maneuver and exiting period, the least range of motion was observed during cervical collar + unassisted self-extrication (~17°). The greatest range of motion was observed during autonomous exit and instructed exit (~45°). Extrication with a cervical collar + extrication device was observed to produce significantly greater motion than with cervical collar alone (~25° during maneuver and extrication; p<0.001).   The use of the cervical collar allows for a reduction in peak speed and acceleration compared to autonomous exit and instructed exit during exit (p< 0.001). Greater acceleration and angulation values were observed with cervical collar + extrication device compared with cervical collar alone during maneuver and exit (p<0.001).   For EMG activity, the lowest muscle activity was observed during maneuver for cervical collar application and cervical collar + extrication device. Lower EMG activity was observed during exit with cervical collar + extrication device compared with cervical collar alone *(*p<0.001). | (Identified from the reference list of Eisner 2022)  When a cervical collar and Ferno® extrication device are used, there is less active (muscular) control of the cervical spine and faster and more brisk movements of the cervical spine compared to cervical collar alone. The authors conclude that these data support the idea that spinal motion restriction via rigid cervical collar of awake and cooperative trauma patients is effective in reducing cervical spine motion in the sagittal plane during vehicle extrication. |
| Gavin 2003 | Experimental: Randomized controlled trial (within subjects; cross-over)  USA | 20 healthy volunteers with no history of cervical injury or pathology (10 males and 10 females, aged 21-44 years)  7 subjects were excluded because of poor video fluoroscopy image quality | 4 different cervical orthoses: (1) Aspen® collar (2) Miami J® collar (3) Aspen® 2-Post cervical thoracic orthosis (CTO) (4) Aspen® 4-Post CTO | No collar | The gross sagittal motion of the head was measured relative to the horizon with the use of an optoelectronic motion measurement system. Simultaneous measurement of cervical intervertebral motion was performed with the use of a video fluoroscopy machine.  Each orthosis significantly reduced gross and intervertebral motion in flexion and extension (p < 0.05).  No statistically significant differences were found between the Miami J® and Aspen® collars in reducing gross or intervertebral sagittal motion, except at C5-6. Both CTOs provided significantly more restriction of gross and intervertebral flexion and extension motion as compared to the two collars (p < 0.05). The Aspen® 2-post CTO and 4-post CTO performed similarly in flexion, but the Aspen® 4-post CTO provided significantly more restriction of extension motion (p < 0.05). | Authors' conclusions: The Miami J® and Aspen® collars were statistically similar in their capability to provide intersegmental motion limitation in flexion and extension, with the exception at C5-6. At this level, the Aspen® collar restricted flexion better than the Miami J® according to both our centroidal and angular intersegmental measurement techniques. Our findings suggest that either of the two collars could be used to treat similar cervical pathologies or injuries except those involving the C5-6 segment, where the Aspen® collar may provide better motion restriction. The Aspen® 4-post CTO restricted the motion around C4-5 the best and would be the most effective candidate of the orthoses tested to prevent this motion in flexion and extension. The Aspen® 2-post CTO restricted flexion motion effectively below C2 and may pose as an acceptable alternative to the SOMI, an orthosis commonly used to prevent flexion. |
| Ham 2016 | Case series  The Netherlands | 342 adult trauma patients admitted to the emergency department of one trauma centre in 2013, with standard spinal immobilization (198 males and 144 females, mean age 45 years (IQR: 27-61)) | Backboard (removed before the initial assessment in the trauma room) + cervical collar + headblocks | N/A | Incidence and severity of pressure ulcers (PUs), indentation marks and pain:   78.4% (95% CI: 73.6–82.6%) of the patients had PUs after removal or replacement of the extrication collar and headblocks in ED: - 258 (75.4%) patients had at least one category 1 lesion (non-blanchable redness of intact skin) as most severe PU - 10 (2.9%) had at least one category 2 lesion (partial thickness skin loss or blister) as most severe, with a mean of 2.5 lesions per patients (682/268).  - category 1 PUs were mainly located at the chest (19.6%), back (16.1%) and the shoulders (12.6–16.9%). Category 2 PUs were located at the back and shoulders.   In 221 patients (64.6%, 95%CI: 59.3–69.7%) indentation marks were identified. All indentation marks followed the pattern of the extrication collar. In 96 (28.1%) trauma patients, we observed at least one severe indentation mark, with a mean of 1.9 marks per patient (428/221). Mild indentation marks were mainly located at the chest (15.5%), back (10.7%) and shoulders (13.5%). Severe indentation marks were mainly located at the back (14.6%).  182 patients (63.2%, 95% CI: 57.3–68.8%) experienced pain (NRS >3). 48 (16.7%) experienced mild pain (NRS 1–3), 71 (24.6%) moderate pain (NRS 4–6) and 111(38.5%) severe pain (NRS 7–10). Pain occurred most frequently at the occiput (160 times). | Authors' conclusions: We found a high incidence of category 1 PUs and severe indentation marks and high pain scores from the application of the extrication collar and headblocks. Time, injury severity and patient characteristics were not associated with PUs, and indentation marks, however being female was significantly associated with pain from the extrication collar and headblocks. Cervical immobilization for preventive reasons can be lifesaving, but it is necessary to revise the current practice of cervical spine immobilization in the ED in terms of procedures and material use in order to decrease PU risk and pain. |
| Hernandez 2019 | Experimental: Non-randomized controlled trial (within subjects)  Spain | 16 healthy volunteers (10 males and 6 females, mean age 46 years) | (1) Self-extrication with a Stifneck® rigid collar (2) Self-extrication with a Xcollar® | Self-extrication without a collar | Movements produced during self-extrication.  Collar vs no collar Misalignment was a mean (SD) 3.12 (34.62) degrees greater during self-extraction with a Stifneck® collar in place (95% CI, –15.33 to 21.57 degrees; P=.7234) than during extraction without a collar.  Misalignment was also greater, by 5.95 (31.76) degrees, with an Xcollar® in place (95% CI, –10.98 to 22.87; P=.4654) than without a collar.  Stifneck® collar vs Xcollar® The between-collar comparison of differences showed that misalignment was 2.83 (12.10) degrees greater with the Xcollar® (95% CI, –3.62 to 9.27 degrees; P=0.3650). | Authors' conclusions: Misalignment of the cervical spinal column is similar during self-extraction with or without a cervical collar in place. |
| Holla 2012 | Experimental: Non-randomized controlled trial (within subjects)  The Netherlands | 10 healthy volunteers (6 males and 4 females, mean age 32.9 years (range: 23-47)) | (1) Stifneck® rigid collar  (2) Spine board + Sof-Loc head blocks (3) Spine board + Sof-Loc head blocks + Stifneck® rigid collar | No immobilization | Range of motion of the cervical spine during lateral flexion, flexion-extension and rotation were measured using a computerised digital inclinometer  Mean ± SD range of motion in degrees for (1) no immobilization, (2) rigid collar, (3) spine board + head blocks, and (4) spine board + head blocks + collar: - Lateral bending: (1) 77±15, (2) 40±10, (3) 10±10, (4) 12±9 --> statistics: (2) vs (1): p<0.005, (3) vs (2): p<0.005, (4) vs (3): p>0.05 - Flexion-extension: (1) 114±5, (2) 55±14, (3) 6±6, (4) 4±5 --> statistics: (2) vs (1): p<0.005, (3) vs (2): p<0.005, (4) vs (3): p>0.05 - Rotation: (1) 151±25, (2) 53±20, (3) 8±5, (4) 6±5 --> statistics: (2) vs (1): p<0.005, (3) vs (2): p<0.005, (4) vs (3): p<0.05 | Identified from reference list of Ham 2016.  Data on the effect on mouth opening were not extracted, as they relate to the technical condition of endotracheal intubation (excluded from this scoping review).  Authors' conclusions: The application of a rigid collar in addition to head blocks does not provide extra immobilization of the cervical spine and is therefore considered unnecessary. |
| Hudson 2023 | Experimental: Non-randomized controlled trial (within subjects)  UK | 23 healthy volunteers (52.2% male, 21-105 years) divided into 2 cohorts: 11 older (mean age 84 years) and 12 younger (mean age 25 years) | Miami J® collar | No collar (baseline) | Videofluoroscopy was performed before and 15 minutes after collar application. The Modified Barium Swallow Impairment Profile (MBSImPTM©) and Penetration-Aspiration Scale (PAS) were used to define and score swallow function and level of aspiration without and with the collar fitted.  Compared to no collar, application of the collar led to an increase in the median MBSImPTM© score amongst all participants in the oral phase of swallow (from 4 (IQR 2-6) to 5 (IQR 2-8), p =0.01) and combined oral and pharyngeal phase of swallow (from 5 (IQR 2-8) to 5 (IQR 4–12), p = 0.006). Analyses of pre- and post- collar wearing PAS levels showed no statistical significance (p = 0.181). Furthermore, there was no statistically significant change pre- and post- wearing the collar when comparing the old and young cohorts (p = 0.581). | Identified from reference list of Mitra 2024.  Authors' conclusions: Cervical hard collars change swallowing physiology in younger and older volunteers. Whilst we did not measure a statistically significant difference in the PAS level pre- and post- collar wearing, we feel it is important to highlight these changes in swallowing physiology and speculate that with collar use there is a potential risk of aspiration associated with these changes. Potential risk of aspiration should be carefully balanced with the benefit gained from collar use in the management of cervical spine injury (both in conservative and postoperative management). Although this is a small study it is important to highlight an area of concern of particular importance in the older population who have physiological changes to the swallow that occur with age (presbyphagia) and where baseline risk of aspiration is higher. |
| Hunt 2001 | Experimental: Non-randomized controlled trial (within subjects)  UK | 30 patients with severe traumatic brain injury managed at the neurosurgical ICU, without a confirmed spinal cervical injury (18 males and 12 females, age range 17-70 years) | Stifneck® rigid collar (applied as usual and left in place for 5 minutes) | No collar | Cardiovascular, intracranial pressure and cerebral perfusion pressure data were collected for 5 min prior to the application of the collar, during the 5-minute period when the collar was in place, and for 5 min after its removal. Arterial blood gases were measured at the beginning and end of the study period.  There were no significant differences in cardiovascular parameters before, during and after placement of the rigid collar.  Cerebral perfusion pressure was maintained >60 mmHg in all patients. There were also no changes in PaO2 and PaCO2 during the study period. Mean baseline intracranial pressure was 14.1 (6.6) mmHg and this rose to 18.8 (8.4) mmHg following the application of the rigid collar (p<0.0001). In all patients the rise in ICP was sustained at the higher level whilst the collar was in position. ICP decreased to baseline values immediately following removal of the collar. The mean increase in ICP in patients with a baseline ICP<15 mmHg was 3.6 (2.7) mmHg compared to 5.9 (3.1) mmHg in those in whom the baseline ICP was >15 mmHg (p < 0.05). | Authors' conclusions: We have demonstrated that rigid cervical collars cause a small rise in ICP. In most patients, this is unlikely to be of clinical significance, but in some the rise in ICP may be substantial and sustained whilst the collar is in place. Furthermore, the rise in ICP is largest in those with a baseline ICP>15 mmHg. Until further studies determine the effect of rigid collars on outcome after traumatic head injury, we recommend prompt radiological and clinical clearance of the cervical spine and removal of the collar at the earliest opportunity. If this is not possible, other forms of cervical spine stabilization should be considered. |
| James 2004 | Experimental: Randomized controlled trial (within subjects)   USA | 2 healthy male volunteers with no prior cervical spine injuries. One had a small-short neck size and the other a medium-regular neck size. | Cervical spine immobilization using 4 different commercially available rigid cervical collars; (1) NecLoc® (NL) collar (2) Stifneck® (SN) collar (3) Stifneck® Select (SNS) collar (4) Rapid Form™ Vacuum Immobilizer (VI)  17 certified athletic trainers performed 3 trials of collar application for all 4 collars for both volunteers. Head stabilization during the application of the collars was provided by trainees. | [Mutual comparison of collars] | Spinal movement was measured during application and during supine and seated range-of-motion testing. In addition, application time was measured.   Movement:  - During application:  The total angular distance of SN and SNS was significantly higher than that of NL, which in its turn was significantly higher than that of > VI (P<0,001). No significant differences were demonstrated among collars for peak angular displacement. The total linear distance during collar application for the VI was significantly greater than for NL, SN, and SNS (P<0,001). - During supine active ROM testing: SN and SNS < NL and VI (P<0,001). - During seated active ROM testing: SN and SNS < NL and VI (P<0,001).  Time of application:  The SN and SNS application times were significantly less than that for NL, which in turn was significantly less than that for VI (P <0.01). | Identified from the reference list of Rahmatalla 2019.  Authors' conclusions: Of the collars tested, the SN and SNS appear to be the optimal collars for use by certified athletic trainers. They were applied with the least motion in the fastest time and provided superior restriction during active range-of-motion testing. |
| Jao 2023 | Observational: Cross-sectional study (retrospective chart review)   USA | 658 adult blunt trauma patients transported by EMS and hospitalized with radiographic cervical spine injuries from 2011 to 2019 at a level 1 trauma center | Pre-hospital cervical spinal motion restriction (n=541) | No pre-hospital cervical spinal motion restriction (n=117)  (a cervical collar was placed in the ED) | Those without prehospital C-SMR had a significantly lower intensive care unit (ICU) admission rate (29.1% vs 55.2%) and median length of hospital stay (6 days vs 8 days), but not ICU length of stay (LOS). In-hospital mortality was not significantly different between those without prehospital spinal motion restriction and those with (4.3% vs 7.4%). Hospital discharge disposition was also not significantly different between groups. | Of the factors considered in multivariate analysis, only age (OR 1.02), discharge year (OR 1.21), and low fall mechanism of injury (OR 3.12) were significant predictors for non-SMR prehospital in those with spinal injuries. ED GCS and sex were not. Severity of injury in the defined body regions (ie, face AIS, chest AIS, abdomen AIS, extremity AIS) were also not significant predictors.  (Authors' conclusions were focused on the rates of certain cervical spine injuries in both groups and their significance, so were not extracted) |
| Jung 2023 | Observational:  Cohort study  China, India, Japan, Laos, Malaysia, Phiippines, Korea, Singapore, Taiwan, Thailand, United Arabic Emerates and Vietnam | 59,454 adult trauma patients aged 18 years or older without cervical spine injury, selected from the prospective PATOS registry of 91,383 patients transported by EMS to the participating hospitals January 2015 and December 2020 | Cervical spine immobilization | No cervical spine immobilization | Primary outcome: poor functional recovery at hospital discharge measured by the modified Rankin Scale4 (moderately severe disability), 5 (severe disability) and 6 (death). Secondary outcome: mortality at hospital discharge.  In multivariable logistic regression analysis (adjusted for age, sex, intentionality, place and mechanism of injury, acute alcohol use, mental change and severity of trauma), cervical spine immobilization was not associated with in-hospital mortality (aOR: 1.32, 95%CI [0.77-2.27]) or poor functional outcome (aOR: 1.19, 95%CI [0.91-1.45]). In a subgroup of patients with traumatic brain injury, although cervical spinal immobilization was not associated with in-hospital mortality (aOR: 1.16, 95%CI [0.91-1.34]), it was significantly associated with an increased rate of poor functional outcomes (aOR: 1.23, 95%CI [1.03–1.44]).  The ORs for poor functional outcomes of traumatic brain injury patients differed according to mean arterial pressure (MAP) (P < .01). The association of CSI with poor functional outcomes was maintained only in patients with decreased prehospital MAP (aOR: 1.38, 95%CI [1.14–1.56]), but not in patients with normal MAP (aOR: 1.12, 95%CI [0.93–1.24]). | Authors' conclusions: In patients without cervical spine injury but with traumatic brain injury, cervical spinal immobilization was associated with poor functional outcomes, but only in patients with low prehospital mean arterial pressure. |
| Karason 2014 | Experimental:  Randomized controlled trial (within subjects; cross-over)  Iceland | 10 healthy volunteers (5 males and 5 females, mean age 27.4 years (range 21-28)) | (1) Stifneck® collar (2) Philadelphia® Tracheotomy collar (3) Miami J® Advanced collar (4) Aspen Vista® collar | No collar (baseline) | Neck movement and invasive jugular vein pressure measurements were done at baseline, during collar application and after collar removal, in the supine and in 20° head-up position. Comfort levels were also measured.  Collar vs no collar (baseline) - Neck movement: decreased significantly from baseline (53 ± 9°) with all the collars (all p<0.001) - Internal jugular vein pressure: increased significantly compared to no collar (before or after application) for the Miami J®, Aspen Vista® and Philadelphia® Tracheotomy collars (all p<0.001)  Mutual comparisons of collars - Neck movement: Stifneck® 18 ± 7°, Miami J® 21 ± 10°, Philadelphia® Tracheotomy 22 ± 8° and Aspen Vista® 25 ± 9°.  The Philadelphia® Tracheotomy decreased motion significantly less than the Stifneck® (p=0.01). The Vista collar decreased motion significantly less than the other 3 collars (all p<0.05).  - Internal jugular vein pressure: Stifneck® (10.5 ± 2.1 mmHg), Miami J® (11.7 ± 2.4 mmHg), Aspen Vista® (13.5 ± 2.5 mmHg) and Philadelphia® Tracheotomy (16.3 ± 3.3 mmHg).  The Aspen Vista® and Philadelphia® Tracheotomy collars increased pressure significantly more than the Stifneck® and the Miami J® collars (all p<0.05). The Philadelphia® Tracheotomy collar showed the highest increase in pressure (p<0.001 vs Aspen Vista®). - Comfort: Aspen Vista® received the highest score (4.2 ± 0.8), followed by Miami J® (3.9 ± 1.0), Stifneck® (2.8 ± 1.0) and Philadelphia® Tracheotomy (2.2 ± 0.8). The Miami J® and Aspen Vista® collars were similar in comfort (p>0.05). The Stifneck® and the Philadelphia® Tracheotomy were significantly less comfortable than the other two collars (both p<0.05). | Authors' conclusions: Stifneck® and Miami J® collars offered the most efficient immobilization of the neck with the least effect on jugular venous pressure. Aspen Vista® and Miami J® were the most comfortable ones. |
| Kim 2018 | Experimental: Randomized controlled trial (within subjects; cross-over)  South Korea | 30 healthy students aged 21-25 years with no history of cervical spinal injury, pain or pathology (15 males and 15 females) | (1) Xcollar® (n=30 trials) (2) Philadelphia® Collar (n=30 trials) (3) Stifneck® Select™ Collar (n=30 trials) | No cervical collar | Cervical range of motion in three planes (involving flexion/extension, bilateral bending, and bilateral axial rotation) was measured first without a cervical collar in the unbraced condition, then, the same test was performed with the cervical collars. Cervical range of flexion and extension were measured in the seated position, and cervical range of bilateral axial rotation was measured in the supine position.  Collar vs no collar The cervical range of motion measured in the collar-wearing condition was significantly different from that in the unbraced condition.  All the neck collars showed the least restricted mean percentage of cervical motion in lateral bending (coronal plane), and the most restricted mean percentage of cervical motion in bilateral axial rotation (transverse plane).  Mutual comparison of collars On average, XCollar® permitted less than a mean of 10° of movement during flexion, extension, bilateral bending and bilateral axial rotation. This was less than the movement permitted by the other two cervical collars. Compared with the other two cervical collars, XCollar® presented superior cervical restriction in the three planes and was particularly more effective in restricting axial rotation movements. | Authors' conclusions: Although the three neck collars reduced cervical range of motion in this study, the amount by which the Philadelphia® collar and Stifneck® Select™ Collar immobilized the cervical spine was clinically less substantial because although many routine daily tasks require only 30%–50% of full cervical spine movement, these two cervical collars did not immobilize the neck sufficiently to prevent the movements. In contrast, XCollar® presented superior immobilization of CROM compared to the other two cervical collars. |
| Kolb 1999 | Case series  USA | 20 patients aged at least 16 years without cervical spine injury presenting to the ED and requiring a lumbar puncture (to rule out meningitis or a subarachnoid bleed) | Philadelphia® collar | No collar (baseline) | Initial cerebrospinal fluid pressure was measured before (i.e. when undergoing the lumbar punction) and after application of the collar.  Pressure increased after collar placement (baseline: 176.8 mmH2O; after collar: 201.5 mmH2O; MD+SD: 24.8+28.4 mmH2O; P=0.001). | Authors' conclusions: Pressure increased after collar placement. Although this difference of 24.8 mmH20 is statistically significant, it is uncertain if this would be clinically important. Nonetheless, this small increment in pressure could be significant in patients who already have an elevated intracranial pressure. |
| Krell 2019 | Experimental: Non-randomized controlled trial (within subjects)  USA | 31 healthy adult volunteers | WizLoc® rigid c-collar + traditional long backboard (LBB) | WizLoc® rigid collar + Ferno® Scoop Stretcher (FSS) | Electromagnetic sensors secured over the forehead, and C3 and T12 spinous processes, movement recorded by goniometer. Sagittal flexion, lateral flexion, and axial rotation were recorded during each of four phases:  (1) baseline (2) application (log roll onto the LBB or placement of the FSS around the patient) (3) 90-degree log roll with subjects secured to the device (4) lifting to a height of 1 meter [Results from the third and fourth fase were deemed irrelevant to this scoping review]  Approximately 6-8 degrees greater motion demonstrated in the sagittal, lateral, and axial planes during the application of the LBB compared with the FSS (both p < 0.001). Greater comfort and perceived security were reported with the scoop stretcher than the long backboard. | There is less movement of the spine during application of the scoop stretcher than the long backboard. The scoop stretcher is perceived as more comfortable and more secure than the long backboard.  This may have implications for first aid, where possible and if no further harm caused by delay, to wait for arrival of EMS to immobilize a person with suspected spine injury. This is currently the protocol for American Red Cross lifeguarding/aquatic guidelines - after removal of person from water with suspected spine injury, to have EMS perform the immobilization. |
| Kroeker 2019 | Experimental:  Interrupted time series  UK | 17 healthy volunteers (9 males and 8 females, age range: 22-29 years) | Stifneck® Select™ collar (rigid) | No collar (baseline) | Measurements of the circumference and cross-sectional area of the intrajugular vein were taken bilaterally using ultrasound before, immediately after, 1h after, 2h after, 3h after and 4h after application, as well as 5 minutes after removal of the collar.  The CSA of the IJV was 8.3±6.0 mm2 pre-RCC application. The CSA of the IJV doubled (18.92±10.55 mm2) after four hours and decreased back to 9.36±6.8 mm2 five minutes post-collar removal.  The circumference of the IJV was 17.29±6.03 mm pre-RCC application, increasing to 20.34±5.59 mm by the end of the fourth hour and returning to 16.14±5.16 mm five minutes post-collar removal.  Related-samples Friedman’s ANOVA test showed statistically significant differences for both left and right CSAs and circumferences of the IJV measured across the four hours (p<0.05). | Identified from the reference list of Colak 2020  Authors' conclusions: Ultrasound assessment of CSA of the IJV may correlate with changes in ICP. Further studies may provide insight into the effects of collar design, and guide future trauma protocol to minimize intracranial pressure fluctuations. |
| Ladny 2018 | Experimental: Randomized controlled trial (within subjects; cross-over)   Poland | 32 healthy paramedics (no further information) | Ambu® Perfit ACE™ collar | NECKLITE® collar | Self-assessed pain related to the cervical collar on a 10-point scale (1: no pain - 10: severe pain), and compression of the collar on the mastoid processes (1: no pressure - 10: strong pressure causing severe pain) were obtained via a questionnaire.  Pressure on the mastoid processes: 7±2 points for Ambu® vs 1±1 points for NECKLITE™ collar (p < 0.001).  Pain sensations associated with the cervical collar: 6±3 points for Ambu® collar vs. 1±1 points for NECKLITE™ collar (p < 0.001).  Patient preferences: 97% of participants declared, that they preferred the NECKLITE™ collar comparing to the Ambu® cervical collar. | Identified from the reference list of Szarpak 2018.  Data on the effect on mouth opening were not extracted, as they relate to technical conditions on endotrachial intubation (excluded from this scoping review).  "Pilot study" for Ladny 2020, but unclear if it concerns the same participants.  Authors' conclusions: A standard cervical collar causes an increase in pain due to the pressure on the mastoid processes and a sense of discomfort for the patient. The NECKLITE™ collar thanks to the possibility of better fit to the patient’s neck, does not cause any pain. |
| Ladny 2020 | Experimental: Randomized controlled trial (within subjects; cross-over)   Poland | 60 adult healthy volunteers (39 males and 21 females, median age 34 years (IQR: 30-42.5)) | (1) Ambu® Perfit ACE™ collar (2) Philadelphia® One-Piece™ collar (3) NecLoc® collar (4) NeXsplint Plus collar (5) NECKLITE™ collar | No collar (baseline) | Change in the optic nerve sheath diameter (ONSD) as a sensitive and helpful noninvasive surrogate for intracranial pressure. Ultrasound imaging was done at 5 and 20 minutes.  ONSD left diameter values: Baseline (no collar):  3.8 mm (IQR 3.65-3.93) Ambu®:  4.505 mm (IQR 4.285–4.61) after 5 min; 4.655 (IQR: 4.41–4.82) after 20 min  (both P<0.001 vs baseline) Philadelphia®:  4.73 mm (IQR: 4.49–4.895) after 5 min; 4.925 mm (IQR: 4.65–5.06) after 20 min  (both P<0.001 vs baseline) NecLoc®:  4.27 mm (IQR: 4.15–4.395) after 5 min; 4.415 mm (IQR: 4.27–4.55) after 20 min  (both P<0.001 vs baseline) NeXsplint Plus:  4.705 mm (IQR: 4.52–4.935) after 5 min; 4.92 mm (IQR: 4.68–5.115) after 20 min  (both P<0.001 vs baseline) NECKLITE™:  3.92 mm (IQR: 3.795–4;) after 5 min; 3.995 mm (IQR: 3.875–4.1) after 20 min (not significant vs baseline)  Similar results were found for the right diameter | Authors' conclusions: Our results demonstrated a statistically significant increase in the ONSD from baseline after cervical collar placement among healthy volunteers at 5 minutes and 20 minutes interval, respectively. Out of 5 cervical collars, Philadelphia® cervical collar appears to have maximum, while NECKLITE™ reported the lowest change in ONSD. In addition, no significant difference was noted between ONSD measurements at 5 and 20 minutes. This increase may be much more detrimental to traumatic brain injury patients. |
| Lee 2023 | Observational: Cross-sectional study (retrospective chart review)   Taiwan | 2,733 trauma patients (median age 62 years (IQR: 45-77 years), 59.7% male) with suspected of head and neck injuries hospitalised in one hospital in Taipei between Jan 2009 and May 2019 | Prehospital neck collar application (n=767) | No prehospital neck collar application (n=1,966) | Multivariable logistic regression analysis revealed that neck collar immobilization in the head and neck injury population was significantly associated with an increased odds of in-hospital mortality (adjusted OR: 1.850, 95% CI: 1.240–2.760, p = 0.003) Compared to the nCSI group, the c-spine immobilization group had a higher odds ratio of mortality in old age (age >= 65), consciousness-unclear (GCS =< 8), major traumatic injury (ISS >= 16 and RTS =< 7), mixed TBI, isolated TBI, and shock population. | Authors' conclusions: While our findings do not advocate for the complete abandonment of neck collars in all suspected head and neck injury patients, our study suggests that prehospital cervical and spinal immobilization should be applied more selectively in certain head and neck injury populations. This approach is particularly relevant for older individuals (age >= 65), those with unclear consciousness (GCS =< 8), individuals experiencing major traumatic injuries (ISS >= 16 or RTS =< 7), and patients in a state of shock (shock index >= 1). |
| Leenen 2020 | Experimental: Randomized controlled trial  The Netherlands | 60 healthy volunteers (45 females and 15 males, median age 23.2 years (24-40)) | Stifneck® cervical collar (n=31) | Philadelphia® collar (n=29) | Primary outcome: development of indentation marks at the neck (sternocleidomastoid muscle), mandible, shoulder, sternum and chin after 20 min, classified into ‘mild’ (mark without a bordering skin reaction) or ‘severe’ (mark with a bordering skin reaction: rubor, color or both). Secondary outcomes: skin temperature and experienced comfort (Likert scale from 1 (extremely uncomfortable) to 5 (highly comfortable)).  The total number of indentation marks was higher in the Stifneck group (n=95 versus n=69; P=0.002). More severe indentation marks observed at the chin, shoulder and sternum in the Stifneck® group. At the location in the neck, however, there were more in the Philadelphia® group.   There was a higher, but not significant, increase in skin temperature in the Philadelphia® group overall, compared to the Stifneck® group (1.3 °C versus 1.0 °C; P=0.024).  Median rating of experienced comfort over the immobilization period was 3/5 (IQR = 2–4) in the Stifneck® group and 3/5 (IQR = 2–3.5) in the Philadelphia® group. There was no significant difference between groups (P=0.506). | Participants were immobilized in the C-collar for 20 min in a supine position on a viscoelastic hospital mattress without pillow support  Authors' conclusions: In both the Stifneck® and Philadelphia® C-collars the occurrence of indentation marks was high. In comparison to the Stifneck® C-collar, fewer and less severe indentation marks were observed from the Philadelphia® C-collar. The skin temperature increased significantly with both collars; however, no clinical difference in increase of skin temperature between the two C-collars was found. Finally, the comfort level was rated as neither uncomfortable nor comfortable and was not statistically different for the C-collars. |
| Leonard 2012 | Observational: Prospective cohort study  USA | 285 children (<18 years) brought to hospital by EMS with possible spinal cord injuries, with or without spinal immobilization in place | Spinal immobilization: “having a cervical collar and/or being secured to a rigid spine board” (n=173) | No immobilization, although the children met the American College of Surgeons guidelines for spinal immobilization (n=112) | Patient reported pain, use of radiology, length of stay in the emergency department, ED disposition.   Both groups had similar trauma scores, GCS and length of stay in ED. Spine-immobilized children had significantly higher pain scores (P<0,05), use of radiology (57% vs 13%; P<0.0001 after controlling for GCS) and higher admission to hospital rates (42% vs 14%). | Identified from reference list of Nilhas 2022.  Reason for EMS transport of children with ACS criteria for SI transported without SI not reported. Only one child had a spinal fracture, was in the spine-immobilized group. |
| Liao 2018 | Experimental: Non-randomized controlled trial (within subjects)  Germany | 6 fresh cadavers (one female and five male) with ligamentous unstable craniocervical junction (two new trauma models: atlanto-occipital dislocation (AOD), and AOD together with atlanto-axial instability (AAI)) | Stifneck® Select™ cervical collar | No collar (baseline) | Compression of the dural sac and segmental angulation in the upper cervical spine were measured on video fluoroscopy after myelography during the application of a cervical collar. Furthermore, overall three-dimensional motion of the cervical spine was measured by a motion tracking system.  Mean dural sac compression was significantly increased to -1.1 mm (-1.3 to -0.7 mm) in case of AOD and -1.2 mm (-1.6 to -0.6 mm) in the combined model of AOD and AAI. Furthermore, there is a significant increased angulation at the C0/C1 level in the AOD model. Immense three-dimensional movement up to 22.9° of cervical spine flexion was documented during the procedure. | Identified from reference list of Hudson 2023.  Authors' conclusions: The current study pointed out that applying a cervical collar in general will cause immense three-dimensional movement. In case of unstable craniocervical junction, this leads to a dural sac compression and thus to possible damage to the spinal cord. |
| Lin 2011 | Experimental: Cross-sectional study  (retrospective chart review)  Taiwan | 5,139 lightweight motorcycle crash victims at low or moderate speeds who were directly transported to a hospital by EMS between January 2008 and December 2009 (2319 females and 2820 males, mean age 38 years (range: 10-96)) | Immobilized by cervical collar brace (n=2,605) | Not immobilized by cervical collar (n=2,534) | Out of a total of 8633 motorcycle crash victims, there were only 63 patients with cervical spinal injury.  There was no significant correlation when comparing cervical spine injury with applied neck collar or not (P=0.896).  Patients with or without a neck collar with cervical spine injury had significantly longer hospital ICU LOS compared with those patients who did not have a cervical spine injury but were admitted for other injuries (7.54±7.93 vs 2.33±1.63 days, P=0.002), whereas no difference was found in the total LOS in the hospital (17.43±9.35 vs 12.00±8.89, P=0.154). | Of the 8,633 motorcycle crash victims, 3,494 were excluded because of: - Traumatic cardiac arrest (n=26) - Transfer to or from other facilities (n=1239) - Incomplete data (n=831) - No follow-up (n=1398)  Authors' conclusions: Prehospital protocol for application of a cervical collar brace to people who have sustained a lightweight motorcycle accident in the urban area should be revised to avoid unnecessary restraint and possible complications. |
| Mahshidfar 2013 | Experimental: Randomised controlled trial  Iran | 60 adult trauma patients with possible spinal trauma transported to hospital by EMS, all fully conscious, no airway compromise, BP >90, no neurological deficit | Long backboard (Spencer Rock plastic backboard stretcher with Spencer contour head immobilizer) + rigid cervical collar (unspecified) | Vacuum mattress splint (Attucho ‘‘NYB’’ vacuum mattress TPU) + rigid cervical collar (unspecified) | Pain (10 cm visual analogue scale), speed to apply measured in seconds and ease of application on 5 point scale, "movement of patient during immobilization and transport" on 5 point scale.  Found statistically significant differences in all outcomes:  - More than triple the time to apply the vacuum mattress splint (VMS) compared with the long backboard (LBB) (654 vs 212 sec) - Better immobilisation with LBB than VMS (median scores 4 vs 1or 2 out of 5) - More patient comfort with LBB than VMS (median score 4 vs 1 out of 5) - More ease of application of LBB rated by EMS (median 4 vs 2 out of 5) | Identified via reference list of McDonald 2021.  Authors' conclusions: Results of this study showed LBB superiority to VMS in terms of ease and speed of application, immobilization rate, and patient comfort while used in immobilization of trauma victims. They note that EMS were inexperienced in the application of VMS (because of routine practice with the LBB), although trained in it for this study. |
| Maissan 2018 | Experimental: Randomized controlled trial (within subjects; cross-over)  The Netherlands | 45 healthy adult volunteers (22 males and 23 females, mean age 20.3+/- 1.9 years (age range: 18-31)) | Stifneck® rigid cervical collar | No collar | ONSD was measured simultaneously in both eyes by two experienced sonographers who were blinded as to whether a collar was applied to the neck or not.  The application of the collar resulted in a significant overall increase in ONSD (5.5±0.7mm vs. control 5.2±0.6 mm, p<0.001). However, a significant effect of eye (left vs. right) and the interaction of eye and collar was observed. Stratification on eye showed an increase of ONSD of 0.6mm (p<0.001) in the left eye and 0.1mm (p = 0.027) in the right eye after application of the collar. | Identified from reference list of Yazici 2024.  The cervical collar velcro was opened and closed again before every measurement, independent of application to the volunteer’s neck or not. This was done to blind the observers to audible clues as to the application or absence of the collar. |
| March 2002 | Case series  USA | 20 healthy adult volunteers | Immobilization for 1 hour with cervical collar and strapped to a long wooden backboard | N/A | Midline palpation of vertebra was performed every 10 minutes. Participants self-rated pain (1 lowest-10 highest) every 5 minutes.  3/10 had pain within 40 minutes 5/10 developed point tenderness of vertebrae by 60 minutes, (mainly at vertebrae C7) 8/20 complained over increasing discomfort over time. Median pain score increased from 1 (range 1-1) at 0 minutes to 4 (range 1-9) at 60 minutes | The authors conclude that immobilization causes false-positive exam for vertebral tenderness over time. |
| McDonald 2021 | Observational: Cohort study  Canada | 9 adult trauma patients with suspected spine injuries attended by prehospital EMS (6 females and 3 males) | Long backboard + head blocks + cervical collar | Cervical collar only | Range of movement both rotation and flexion/extension, and acceleration during different phases of prehospital care (loading, transport, unloading)  Substantial single- and multi-plane head-neck motion was observed among all participants.  Maximum single-plane displacements were between 11.3 ± 3.0 degrees (rotation) and 19.0 ± 16.6 degrees (flexion-extension). Maximum multi-plane displacements averaged 31.2 ± 7.2 degrees (range: 7.2 to 82.1 degrees). Maximum multi-plane acceleration averaged 5.8 ± 1.4 m/s2 (range: 1.2 to 19.9 m/s2).  There were no significant differences among participants between prehospital phase and treatment type (long backboard + head blocks + collar vs collar only).  Non-compliant participants (i.e. those struggling or attempting to remove the restraint devices) showed significantly more motion than compliant participants. | Authors conclusions: Among actual patients, movement appears to be greater than previously recorded in simulation studies, and to be associated with patient behavior. |
| McGrath 2009 | Experimental:  Non-randomized controlled trial (within subjects; cross-over)  USA | 13 healthy volunteers | SAM® splint molded to a cervical collar | Philadelphia® cervical collar | No statistically significant difference in 5 different movements was found. Mean degree of movement was 14.5-20.6 for SAM splint compared with 15.9-20.8 for Philadelphia® collar (all P≥0.068) The largest detected mean difference was 2.54 more degrees for SAM on extension. | Sample size and power calculation was done to detect an 11-degree difference. |
| Mitra 2024 | Observational: Retrospective cohort study   Australia | 1,762 trauma patients presenting to an adult major trauma center in Melbourne with a cervical collar placed by EMS (62% male) | After moving to the application of a soft collar (October-December 2021) (n=863) | Before moving to soft collars (i.e. application of semi-rigid collars) (October-December 2019) (n=899) | Spinal cord injuries were detected in 4 (0.44%) patients in the before period and 7 (0.81%) in the after period (OR 1.83; 95% CI: 0.53–6.29, P=0.50). After adjustment for age categories and mechanisms of injury, the association of soft collars and cervical SCI was not statistically significant (aOR 1.51; 95% CI: 0.43–5.27). There were no differences in the proportion of pressure sores diagnosed (0.11% vs 0.23%, P=0.97) or hospital-acquired pneumonia (2.0% vs 2.7%; P=0.44). | Additional results: Computed tomography (CT) of the cervical spine was performed in 795 (88.4%) patients in the semi-rigid collar period and 810 (93.8%) in the soft collar period (P=0.001). Soft collars were associated with higher rates of clearance of the cervical spine in the ED (OR 4.14; 95% confidence interval [CI]: 3.36–5.09).  Authors' conclusions: Following a change from prehospital semi-rigid collars to soft collars, more patients were investigated with a CT scan and more frequent clearance of the cervical spine occurred in the ED. There were no differences in the rates of spinal cord injuries, pressure sores or hospital acquired pneumonia, but the study was underpowered to detect significant differences. The practice of soft collars for prehospital care of patients with suspected neck injury requires ongoing surveillance. |
| Mobbs 2002 | Case series  Australia | 10 consecutive trauma patients (8 males and 2 females, mean age 29 years (range: 15-47)) with head injury with a GCS of 9 or less, presenting at the hospital with a hard Laerdal Stifneck collar in place | Reapplication of the same hard Laerdal Stifneck® collar at the same application pressure (24-48 hours after presentation) | Head held firmly between 2 sandbags; no cervical hard collar (before reapplication, at least for 30 min) | Nine out of 10 patients had a rise in ICP following application of the collar. The post-application intracranial pressure was significantly higher than the value recorded prior to application (mean difference 4.4 mmHg, P< 0.05). Intracranial pressure differences ranged from –3 to +12 mmHg (–7 to +171%). | Authors' conclusions: Early assessment of the cervical spine in head-injured patients is recommended to minimize the risk of intracranial hypertension related to prolonged cervical spine immobilization with a hard collar. |
| Nilhas 2022 | Observational: Cross-sectional study  (retrospective chart review)  USA | 277 trauma patients with documented spinal injury brought to hospital by EMS between January and August 2014 | On a long spinal board on arrival to ED (n=25) | Not on a long spinal board on arrival to ED (n=252) | Patients placed on long spine boards were more likely to be moderately or severely injured (ISS > 15: 36.0% vs. 9.9%, p =0.001) and more likely to have neurological deficits documented by emergency medical services (EMS; 30.4% vs. 8.8%, p = 0.01) and the trauma team (29.2% vs. 10.9%, p = 0.02). Patients placed on spine boards tended to have a GCS score of eight or less (12.0% vs. 2.8%), but this was not statistically significant (p = 0.052). There was no difference in proportion of patients with spinal injury between the groups and no patient in either group suffered spinal paralysis. As would be expected due to higher ISS and lower GCS scores, patients placed on an long spine boards were admitted more often to the ICU (12.0% vs. 1.6%), spent more time in the ICU (2.0 vs. 1.2 days), more often required mechanical ventilation (28.0% vs. 7.1%), and required greater time on mechanical ventilation (1.2 vs. 0.4 days). Mortality also was greater for patients arriving on a long spine board (16.0% vs. 2.4%; p = 0.008) as was the proportion of patients placed on comfort care (12.0% vs. 1.6%; p = 0.18). | Authors' conclusions: The long spine board was being used properly for more critically injured patients. |
| Nutbeam 2021 | Experimental: Non-randomized controlled trial (within subjects; cross-over)  UK | 10 healthy volunteers (7 female and 3 male, mean age 39 years (range 21-59)) with no previous knowledge of extrication, and no back or neck conditions | Self-extrication from a vehicle: (1) Without instructions, but with cervical collar (StifNeck® collar) (2) With instructions and no collar (3) With instructions and with collar  Cervical collars were fitted by a member of the study team trained in their use.  Instructions for self-extrication: "Step 1 ‘Do you understand what we are asking you to do?’ Try and keep your head as still as possible. Stop at any time if you feel pain or strange sensations in your body. Step 2 Slowly move your right foot and place it on the ground outside the car. Step 3 Using the steering wheel for support pull yourself forward. Step 4 Keep your left hand on the steering wheel and place your right hand on the edge of the seat behind you. Step 5 Turn slowly on your seat to face the outside, your left leg should follow when ready but remain seated. Step 6 With both feet flat on the floor stand straight up using your arms for balance. Step 7 Take two steps away from the car." | No instructions and no cervical collar | Movement and acceleration were measured by accelerometers.  The smallest cervical spine movements were recorded when a collar was applied and no instructions were given: mean 6.9 mm anterior/posterior and 4.4 mm lateral.  The largest overall movements were seen in the cervical spine anterior/posterior when no instructions and no collar were used (28.3 mm). For cervical spine lateral movements, no collar but with instructions produced the greatest movement (18.5 mm). | Put forward by ILCOR First Aid Task Force member as additional relevant study.   Authors' conclusions: In this study of healthy volunteers, self-extrication with no instructions but with a collar resulted in the smallest spinal movement of the four self-extrication approaches used. When a casualty is suitable for self-extrication, the instructions used in this study should not be used and a simple instruction to leave the vehicle delivered. In services which use collars, these may be applied to minimize spinal movement during extrication. It is unlikely that the movement minimization focus of current extrication techniques achieves its therapeutic goal and may contribute to the excess mortality of casualties who are trapped. The harms and benefits of current extrication strategies need careful consideration in this context. |
| Oosterwold 2017 | Observational: Cross-sectional study  (retrospective chart review)  The Netherlands | 1,082 trauma patients (59% male, mean age 43 years (range 18-93)) with full or partial immobilisation (not defined in paper) transported to one of two trauma centres between January 2008 and December 2012 by EMS | Spinal immobilization: (1) Standard method: rigid cervical collar + long backboard + head blocks + straps (n=911)  (2) Long backboard + straps (n=102) (3) Rigid collar (n=55) (4) Vacuum mattress + rigid collar (n=6) (5) Kendrick extrication device + rigid collar (n=4) (6) Kendrick extrication device (n=2) (7) Scoop stretcher + manual inline stabilization (n=1) (8) Scoop stretcher + rigid collar (n=1)  For those 259 patients immobilized by alternative methods, EMS staff stabilized 23 based on the mechanism of injury, and 236 on the basis of one of the other criteria of the Dutch National Protocol Ambulance Care.  [Interventions 5 and 6 were deemed irrelevant to first aid, because this is a specialized extrication device not available to first aiders] | Not applicable | Variables of interest covered demographics, alcohol use, nature of incident, clinical signs at scene including GCS, head injury, pain score, analgesic use, reason for spinal immobilization, reason for variation from “standard immobilization”, and adverse effects of spinal immobilization (pain, discomfort, shortness of breath, reduction in respiratory function, vomiting/nausea, anxiety/combativeness).  Vomiting or nausea was described in 87 (8.0 %) patients. More than half of these patients (50.6 %) received the antiemetic metoclopramide. In 45 (4.5 %) patients antiemetic drugs were administered prophylactically. Other adverse effects of spinal immobilization included pain (n = 10, 0.9 %,), shortness of breath (n = 3, 0.3 %) and anxiety/combativeness (n = 6, 0.6 %). There were no reports of progressive signs of spinal cord injury. | Identified from reference list of Nilhas 2022.  Adverse effects were recorded in 2% of patients in distinction to many studies in healthy volunteers undergoing spinal immobilization, leading to question of accuracy of reporting of adverse effects.  Authors' conclusions: The combination of a rigid collar, spine board with straps and head blocks (full spinal immobilization) was used in 84% of the patients. The remaining 16% received an alternative or incomplete form of spinal immobilization. [...] Pain scores were under-recorded by the EMS staff (29% of patients). [...] The adverse effects of spinal immobilization were incompletely documented in pre-hospital care reports. |
| Porter 2019 | Experimental: Randomized controlled trial   USA | 24 healthy volunteers aged 25-45 years with no history of cervical spine problems or prior injury | Improvised fleece jacket collar | EMT Select Extrication Collar (semi-rigid collar) | Degree of movement (flexion/extension, rotational and lateral flexion) measured with a handheld goniometer, and comfort level (1=very comfortable to 5=very uncomfortable/intolerable)  Comparison of averaged measurements across 3 cervical movements was non-significant between collar and fleece (P>0.05).  The fleece collar was more comfortable than the EMT Select Extrication collar (P<0.001). | No pre-immobilization measurements of movement. Measurements performed in upright position.   Authors' conclusions: The results of our small study showed that the improvised fleece jacket cervical collar was noninferior to a commercial cervical collar in restricting cervical movement while also being more comfortable. |
| Pryce 2016 | Experimental: Non-randomized controlled trial (within subjects; cross-over)  Canada | 13 healthy volunteers (10 male, mean age 30 years (range 21-57 years)) | Spinal immobilization with: (1) Ambu® Perfit ACE™ cervical collar (2) Rigid backboard (Pro-lite Spine Board) + cervical collar | No spinal immobilization | Range of movement and acceleration were recorded for single plane and multiplanar movements.  There was greater range of movement and acceleration with multiplanar movements than uniplanar movements.  Application of spinal immobilization appliances resulted in a consistent stepwise reduction in acceleration magnitude and range of movement: it was reduced with cervical collar alone, and further reduced with rigid backboard + collar. | Identified from reference list of McDonald 2021.  Original study of method used by McDonald 2021.   Authors' conclusions: Acceleration and displacement of the head increased with effort and decreased with more restraint. [...] Continuous, multi-dimensional motions produced greater displacement and acceleration than single-plane motions under similar conditions |
| Rahmatalla 2019 | Experimental: Randomized controlled trial (within subjects; cross-over)  USA | 16 adult healthy volunteers (all males, mean age 22.8 years) | (1) Cot + cervical collar (unspecified type of collar) (2) Long spine board + cervical collar + head blocks  (3) Vacuum mattress + cervical collar | Cot only | Intervention methods vs cot only All immobilization methods tested limited cervical flexion/extension to a similar extent relative to the cot only.  All three also limited cervical rotation as compared to the cot only in all rides. The long spine board and vacuum mattress methods but not the cot with collar, significantly reduced cervical lateral bend relative to the cot only.  Long spine board and vacuum mattress methods vs cot + cervical collar The long spine board and vacuum mattress methods decreased cervical rotation and cervical lateral bend to a significantly greater extent than the cot + cervical collar.  Long spine board vs vacuum mattress Under all but one condition (ambulance real-world field ride), cervical rotation was statistically significantly lower with the long spine board compared to the vacuum mattress. | Dynamic simulation model.  Vibrations and shocks recorded for during a real-life:  (1) Ambulance ride (2) Helicopter ride using a cot with a healthy human subject. 30 seconds from each segment were used to create real-world ride-files: a 2-minute ambulance and 2-minute helicopter ride-file. A 60-second augmented ride-file with shock intensities higher than the real-world rides was also created. Real-world and augmented ride-files were reproduced using a motion platform, with an ambulance clot and a helicopter clot rigidly attached to the platform.  Single clinician performed the immobilization.   Authors' conclusions: Overall, the long spine board and vacuum mattress with cervical collars were significantly more effective than the cervical collar alone for decreasing cervical motion relative to the cot alone. |
| Richter 2001 | Experimental: Non-randomized controlled trial (within subjects; cross-over)  Unclear (Germany? USA?) | 4 fresh frozen cadavers with spine injury that underwent destabilization via osteotomy  Testing was first performed on the intact spine (before osteotomy) | (1) Soft collar (unspecified type) (2) Miami J® collar  [The review team disregarded the Minerva jacket and Halo vest that were also investigated by this study, but not deemed relevant for this scoping review, as they are not available to first aiders] | No collar | All orthoses reduced the range of motion at both C1-2 and C2-3 of the intact spine significantly. In general, the soft collar provided the least control of motion in all planes.  The soft collar did not give any clinically relevant stability to the unstable spine. The Miami J® collar provided moderate control in the sagittal plane but a much better control of “torque” in the upper cervical spine compared to the soft collar. | Authors' conclusions: The Miami J® collar or similar designs seem to be a good choice for emergency immobilization of the cervical spine. |
| Roebke 2023 | Experimental: Non-randomized controlled trial (within subjects; cross-over)  USA | 3 cadavers with corpectomy for cervical spinal destabilization | SAM® splint | FastCast™ (spray-on foam splint) | Movement with no collar, SAM® and FastCast™.  Likert scale provided for variables by ortho consultants.   For the cumulative Likert scale score, FastCast™ (32 [28–34]) exhibited a higher total score than the SAM® splint (44 [42–47]; P<0.01). Likewise, FastCast™ exhibited a greater likelihood of higher Likert scores within each individual question as compared to the SAM splint (P≤0.04). In 100% of cases, raters indicated that FastCast™ passed the initial radiographic alignment following immobilization, whereas 66% of the SAM® splints passed (P=0.04). In 100% of cases, raters indicated that FastCast™ passed radiographic alignment after the gravity stress examination, whereas 47% of the SAM® splints passed (P<0.01). | Average time for the SAM® splint application was 40.3 seconds. Average time for FastCast™ application and hardening was 131 seconds.  Authors' conclusions: The FastCast™ is shown to be rated superior to SAM® splint immobilization for the cervical spine. This has significant clinical implications as the single-step spray-on foam is easy to transport and has multifaceted applications. |
| Russell 2024 | Experimental:  Randomized controlled trial  UK | 25 healthy volunteers (10 males and 15 females, median age 21 years (range: 18-38 years)) | Cervical collars: (1) Miami J® collar (2) Stifneck® Select™ collar (3) Philadelphia® Adjustable Tracheotomy Collar (4) Aspen Vista® collar | No collar (baseline) (only for skin hydration and transepidermal water loss)  OR  Mutual comparisons of different collars (all other outcomes) | Range of motion restriction was measured to evaluate effective immobilisation. Head, neck, and shoulder morphology was evaluated using three-dimensional scans. Pressure, microclimate, transepidermal water loss and skin hydration were measured at the interface between the device and the skin.  Cervical ROM No significant differences in range of motion were observed between the different collars. However, differences in mean value indicate that the Stifneck® Select™ collar was the most restrictive, and the Aspen® and Miami J® collars were the least restrictive.   Interface pressure The occiput experienced significantly higher interface pressures than the chin and mandibles for most collar designs. Interface pressure at the occiput was significantly higher for the Stifneck® Select™ extrication collar compared to the other collars (p<0.008).   Relative humidity  at the device skin interface was significantly higher for the Stifneck® Select™ and Philadelphia® collars corresponding to closed cell foam padding, in contrast to the open cell foams lined with permeable fabric used in the other collars.   Skin temperature Mean skin temperatures were lowest in the Aspen Vista® (34.2–34.8°C) collar and highest for the Philadelphia® (35.0–35.5°C) collar across each measurement site.  Skin hydration and transepidermal water loss TEWL and hydration did not differ significantly from baseline (p>0.5). No significant variations in these measures existed between the different collar designs (p>0.4).  Perceived discomfort  The perceived discomfort was significantly higher for the Stifneck® than the Miami J® and Aspen® collars (p<0.001). Although nonsignificant, the Stifneck® collar was also more uncomfortable than the Philadelphia® collar (p = 0.030). Discomfort correlated with both occipital pressure and skin humidity. | Authors' conclusions: The data collected in the present study demonstrate apparent differences in the interface pressure and humidity across common collar designs. A more than twofold increase in pressure at the occiput was observed in the Stifneck® Select™ collar compared to the MiamI J® collar. Collars that used closed-cell foam padding had 20 %RH higher humidity at the interface compared to those that used lined open-cell foams. Both factors are known to play a significant role in the increased risk of pressure ulcers. This was also evident in perceived discomfort for the end-users. Improving the design and fit of cervical collars will reduce the incidence of collar-related pressure ulcers, improve the patient’s quality of life, and reduce the cost of care. |
| Schneider 2007 | Experimental: Non-randomized controlled trial (within subjects; cross-over)  USA | 45 healthy adult volunteers | Cervical collars:  (1) Philadelphia® cervical collar  (2) Aspen® cervical collar (3) PMT® cervical collar (4) Miami J® cervical collar | Baseline (no cervical collar)  Cervicothoracic collars: (5) Minerva cervicothoracic orthosis (6) Lerman noninvasive halo (7) Sternal-Occipital-Mandibular Immobilizer  [The cervicothoracic collars were deemed irrelevant to this scoping review] | Participants were asked to maximally flex/extend, laterally tilt bilateral and axial rotate bilat without deforming the device.  All devices reduced intervertebral motion. Percentage of participants with intervertebral rotation >3 degrees on C1-C7, lowest rotation was mostly on C1-C2, greatest rotation was mostly on C3-C4-C5; No collar: 88.5-100% Miami J®: 21.9-95.5% Aspen®: 32.4-88.6% PMT®: 17.2-86.7% Philadelphia®: 13.8-90.9% | Authors' conclusions: For those conditions that require support but not rigid immobilization, such as in the case of a lateral mass fracture or following an instrumented fusion, any of the cervical orthoses provide adequate support. |
| Stone 2010 | Case series  USA | 42 healthy volunteers (22 males and 20 females, mean age 27 years (range: 19-50 years)) | Ambu® Perfit ACE™ rigid cervical collar | No collar (baseline) | Ultrasound of the internal jugular vein.  The cross-sectional area of the internal jugular vein increased significantly (p < 0.0001) after application of the cervical collar. The mean percentage increase in cross-sectional area was 37% (95% confidence interval [CI] = 20% to 53%). | Authors' conclusions: In healthy volunteers, internal jugular vein cross-sectional area increases after application of a rigid cervical collar. This may provide a possible explanation for the increase in intracranial pressure seen with rigid cervical collar use in victims of head trauma. |
| Stroh 2001 | Observational: Cross-sectional study (retrospective chart review)  USA | 504 patients transported by EMS and subsequently discharged from 5 trauma-receiving hospitals in Fresno County with diagnosis of cervical spinal injury (fracture, dislocation or spinal cord injury without radiographic abnormality) between July 1990 and July 1996 | Arriving in spinal immobilization (probably cervical collar + backboard + straps, but not clearly reported) | Not arriving in spinal immobilization | Of 504 patients transported by EMS with subsequent diagnosis of cervical spinal injury, 495 arrived in cervical spinal immobilization. Of the 9 patients who arrived without cervical spinal immobilization, -2 patients refused immobilization -2 patients could not be immobilized (1 with severe kyphosis, 1 because of extreme combativeness) -3 patients with injuries were missed by protocol criteria (immobilization criteria were absent) -2 patients with injuries were missed because of protocol violations (immobilization criteria were present, but immobilization was not attempted)  Of the 5 patients with cervical spinal injuries that were missed by protocol criteria or because of protocol violations,  -1 had an adverse outcome (residual quadriparesis) -2 injuries were considered unstable -4 patients were >67 years old -1 patient was 9 months old  Of the 2 patients with cervical spinal injuries that were missed because of protocol violations,  - a 73-year-old man was given a diagnosis of stable minor anterior wedge fracture to the body of C6 and a questionable fracture to the right posterolateral arch, after a motor vehicle crash. He was treated with a cervical collar and had no neurologic deficits. - a 76-year-old man was diagnosed with cervical cord dysfunction from a combination of cervical spondylosis, stenosis, degenerative disease, and displacement of an old non-fused unstable C2 fracture, after a chiropractic visit. He was treated with laminectomy, dens removal, and fusion from occiput to C4 and was discharged to a nursing home with residual quadriparesis. However, the extent of neurologic dysfunction did not change between the initial paramedic evaluation and the ED evaluation. Consequently, it seems unlikely that spinal immobilization would have changed the outcome in this situation. | Identified from the list of included studies of the systematic review of Oteir 2014  Protocol: implement spinal immobilization in the following circumstances: 1. Spinal pain or tenderness, including any neck pain with a history of trauma. 2. Significant multiple system trauma. 3. Severe head or facial trauma. 4. Numbness or weakness in any extremity after trauma. 5. Loss of consciousness caused by trauma. 6. If altered mental status (including drugs, alcohol, and trauma) and: • no history available; • found in setting of possible trauma (eg, lying at the bottom of stairs or in the street); or • near drowning with a history or probability of diving. The EMS selective spine immobilization protocol used in this study was 99% (95% CI, 97.7% to 99.7%) sensitive in identifying patients with cervical injuries for immobilization. "Missed" injuries with this protocol were extremes of age and thus the protocol should be used with caution with this population. |
| Szarpak 2018 | Experimental:  Randomized controlled trial (within subjects; cross-over)  Poland | 20 healthy volunteers (firefighters) aged 18-50 years (mean age 34 years, IQR 29-37) without head injury in the 6 months preceding the study and without pathological changes in the cervical sinus | (1) NECKLITE™ collar (2) Patriot® cervical extraction collar | No collar (baseline) | Optic nerve sheath diameter (ONSD) was measured by ultasonography of each eye in both sagittal and transverse planes.  Median ONSD during baseline was 3.6 mm (IQR: 3.58-3.95).   Collar vs no collar When using the NECKLITE™ cervical collar, an increase in ONSD to 3.75 mm was observed (IQR: 3.7-4.2), while the Patriot® collar showed an ONSD of 4.6 mm (IQR: 4.35-4.9). Statistical analysis showed statistically significant differences in ONSD between baseline and Patriot® collar (p = 0.01), and between baseline and NECKLITE™ (p<0.001)  NECKLITE™ vs Patriot® collar Statistical analysis showed statistically significant differences in ONSD between individual collars of NECKLITE™ and Patriot® (p<0.01). | Authors' conclusions: The use of a standard cervical collar caused a significant increase in optic nerve thickness, which is a manifestation of an increase in intracranial pressure. The use of the innovative NECKLITE™ cervical collar was associated with a much smaller increase in the thickness of the optic nerve sheath. Further research is necessary to confirm the results obtained. |
| Tescher 2007 | Experimental: Randomized controlled trial (within subjects; cross-over)  USA | 48 healthy volunteers aged 18-60 years (24 males and 24 women, mean age 38.9 years), stratified into 3 groups by body mass index | (1) Philadelphia® collar (2) Aspen® collar (3) Miami J® collar (4) Miami J® with Occian® Back  Order of collar application was randomized | No collar (baseline) | Cervical range of motion was measured in the seated position without and with collars. Sagittal, coronal and rotatory range of motion was measured with a goniometer. Occipital and mandibular pressures were mapped in upright and supine positions.  All collars produced a statistically significant restriction of movement (p < 0.001). Of the four collars, the Philadelphia® was the most restrictive of cervical range of motion in all movement planes (p < 0.001), followed by the Miami J. The difference in restrictiveness between the Philadelphia® and Miami J® collars in all movement planes was not statistically significant. The Aspen® collar was the least restrictive of flexion and rotation, and the Miami J® with Occian® Back was the least restrictive of extension and lateral flexion movements.  The Aspen® collar had the highest mean pressures on both mandibles and occiput in the upright and supine positions (p < 0.001). The Philadelphia® collar had the highest maximal pressure on the occiput in the supine position (p < 0.001). The Miami J® with Occian® Back had the lowest mean pressure on the occiput in the upright and supine positions, and on both mandibles in the supine position. | Authors' conclusions: The results of our study of uninjured, healthy adults indicate that the Philadelphia® and Miami J® collars effectively reduced cervical movement, and the Miami J® collar with and without the Occian® Back provided superior pressure relief. Consequently, the Miami J® collar may be the orthosis of choice for trauma patients who are admitted to the hospital. Because the Miami J® with Occian® back was the least restrictive in cervical extension, we use it for occipital support for patients with strict spine precautions and patients who are exclusively bedridden. |
| Tescher 2016 | Experimental:  Randomized controlled trial (within subjects; cross-over)  USA | 48 healthy volunteers aged 18-65 years (24 males and 24 females) | (1) Aspen® collar (2) Miami J® collar (3) Aspen Vista® collar (4) Miami J® Advanced collar | No collar (baseline) | Cervical range of motion measurements were performed of flexion, extension and lateral flexion using gravity goniometers, and of cervical rotation in the transverse plane using a goniometer and a shoulder-mounted magnetic yoke. Subjects sat upright for all cervical range of motion measurements.  Tissue interface pressure (over the occiput and anterior mandible simultaneously) were measured with the subjects initially sitting upright in a chair and then lying supine without a pillow on a standard hospital bed.  Collar vs no collar Range of motion: All four collars significantly reduced range of motion in the movements compared to no collar (p<0.001)  Mutual comparison of collars - Range of motion: In 4 of the 6 movement planes (extension, left lateral flexion, right, and left rotation), the Aspen standard collar was more restrictive than both the Aspen Vista® collar and the Miami J® standard collar (P≤0.003 for each), but not the Miami J® Advanced collar. Restriction in flexion was, however, significantly less with the Aspen® standard collar and the Miami J® standard collar compared with the Aspen Vista® collar (P<0.001 and P=0.002, respectively) and the Miami J® Advanced collar (P=0.01 and P=0.02, respectively). - Pressure: The Miami J® standard collar was associated with significantly lower TIPs on both the mandible and the occiput in both the upright and the supine positions compared with the other collars: Aspen® standard (P≤0.001 for each position), Miami J® Advanced (P<0.001 for each position), and Aspen Vista® (P=0.01 for mandible site and upright position and P<0.001 for remaining positions). In contrast, the Miami J® Advanced collar was associated with significantly higher peak TIPs than each of the other 3 collars as measured on the mandible in both upright and supine positions (P<0.001 for each position). Higher occipital peak TIPs were exerted by the 2 Aspen® collars in the supine position (P<0.001 from each pairwise comparison of Aspen® vs. Miami J® collars). The TIP mean pressure values showed fairly similar patterns. | Type of collar is important on risk of pressure injuries. Collars that are more restrictive for movement also have higher tissue pressure and risk of pressure injuries.   Authors conclusions: All collars, compared with no collar, significantly restricted cervical range of motion. Although the collar-to-collar comparisons were statistically significant, the differences may have little clinical significance in the acutely injured trauma patient. The Miami J® standard collar had the lowest overall tissue-interface pressure in both sites and positions. |
| Totten 1999 | Experimental: Randomized controlled trial (within subjects; cross-over)  USA | 39 healthy volunteers (20 males and 19 females, aged 7-85 years (11 aged 7-12 years, 11 young adults and 17 adults >60 years)) | (1) Philadelphia collar + long (wood) backboard immobilization with velcro forehead strap (2) Vacuum mattress + vacuum collar (cervicothoracic immobilization device) | Baseline (seated or lying) | Respiratory function (8 different spirometry measures): six of the eight measures showed respiratory function to be statistically significantly restricted with the collar/backboard and vacuum mattress/collar when compared with baseline, an average of about 17%. Persons in the 20 to 60-year age group, generally, showed better respiratory performance than either the younger or older age groups.  Comfort: Participants rated the comfort level of the wooden board significantly lower (mean 2.8; SD =1.25) than the vacuum mattress (mean = 4.8; SD =0.92). There was no difference between age groups. | Identified from list of included studies of the systematic review of Hood 2015.  Authors' conclusions: Spinal immobilization either by wooden hardboard or by the European vacuum mattress restricts respiration sufficiently that it may be clinically significant for at least some persons. The vacuum mattress was rated as more comfortable than the wooden backboard by participants from all age groups. |
| Uzun 2020 | Experimental: Non-randomized controlled trial  Germany | 3 healthy volunteers without a history of spinal injury or spinal disease, and with a normal BMI (2 females and 1 male, aged 19-28 years) | (1) Straight (0°) vacuum mattress  (2) Straight (0°) vacuum mattress with cervical collar (3) Straight (0°) vacuum mattress with 2 additional Ferno® headblocks (without cervical collar) (4) Straight (0°) vacuum mattress with cervical collar and 2 Ferno® headblocks (5) Inclined (30°) vacuum mattress (without cervical collar or head blocks) (6) Inclined (30°) vacuum mattress with head blocks (without cervical collar) (7) Long spineboard with cervical collar (without head blocks) with Spider straps  (8) Long spineboard (without cervical collar or head blocks) with Spider straps (9) Long spineboard with cervical collar (without head blocks) with Speedclips | [Mutual comparisons of immobilization techniques] | Biomechanical data were measured using various techniques.  For a straight (0°) vacuum mattress, rotation of the cervical spine was reduced from 7° to 3° by additional headblocks. Flexion and extension were reduced from 14° to 3° and from 15° to 6°, respectively. Immobilization was best on a spine board using a headlock system and the Spider Strap belt system; cervical spine extension increased from 1° to 9° with a Speedclip belt system. Use of a cervical collar was not advantageous in reducing cervical spine movement with a spine board or vacuum mattress. | Identified from reference list of Chen 2022.  Authors' conclusions: The remaining movement of the cervical spine is minimal when the patient is immobilized on a spine board with a headblock system and a Spider Strap harness system or on a vacuum mattress with additional headblocks. The remaining movement of the cervical spine could not be reduced by the additional use of a cervical collar. |
| van de Breevaart 2023 | Observational: Retrospective cohort study  The Netherlands | 1,147 trauma patients with a presumed spinal injury transported by EMS to the ED of a level 2 trauma center (59% male, mean age 42 years in pre-period and 44 years in post-period) | After implementation of a new selective preventive spinal immobilization protocol (2017-2018) (n=705)  Main immobilization devices used: - Backboard (n=3) - Backboard + head and/or neck fixation (n=3) - Vacuum mattress (n=256) - Vacuum mattress + head and/or neck fixation (n=22) - Head or neck fixation (n=16) - Unknown (n=9) | Before implementation of this protocol (2013-2014) (n=442)  Main immobilization devices used: - Backboard (n=16) - Backboard + head and/or neck fixation (n=204) - Vacuum mattress (n=18) - Vacuum mattress + head and/or neck fixation (n=4) - Head or neck fixation (n=19) - Unknown (n=3) | Primary outcome: % of records with a non-immobilized spinal fracture (NISF) who had an adverse patient outcome (= need for surgical stabilization, neurological injury, mortality)  The NISF-prevalence was 8% (95%CI [6;11], n = 33) after implementation of the selective protocol vs 10% (95%CI [7;16], n = 19) before the implementation. In both periods, no neurological injuries or mortality due to NISF were found. | Strict protocol:  - criteria: high energy trauma, decreased Glasgow Coma Score, neurological deficits, vertebral pain, intoxication, distracting injuries, facial injuries, and suspicion of a skull base fracture.  - method of immobilization: use of neck collar and backboard  Selective protocol:  - inadequate communication, neurological deficits, vertebral pain, intoxication, distracting injuries, and ‘immobilize the patient when in doubt’  - method of immobilization: not reported/mentioned? But clear shift to use of vacuum mattress.  Authors' conclusions: No difference in neurological injuries or mortality due to NISF were found in a strict and a selective preventive spinal immobilization protocol in a level 2 trauma center. |
| Worsley 2018 | Experimental:  Randomized controlled trial (within subjects; cross-over)  UK | 15 healthy volunteers aged 18-65 years without conditions affecting the cervical spine or skin at the side of collar application (9 males and 6 females, mean age 24 years (range 24-31 years)) | Aspen Vista® cervical collar | Stifneck® cervical collar | Measurements were performed at optimal fit tension (a finger was restricted from sliding between the mandible and collar, without the chin protruding beyond the front piece), high fitting tension (each strap tension increased by 5 mm and increase in collar height) and low tension (each strap tension decreased by 5 mm and decrease in collar height) application. These orders were also randomized.  After having the collars on for 15 minutes, participants were asked to lay supine on a standard viscoelastic hospital mattress without pillow support. After 2 minutes, three interface pressures were recorded from the skin–device interface at the occiput, chin, and bilateral mandibular regions. Interface temperature and humidity measurements were recorded for one minute at the midway point of C-collar application.  Participants were then asked to perform neck flexion, and right and left rotation, stopping when they experienced resistance from the collar. Flexion and rotation were measured with the inclinometer in the sagittal plane on the scalp and in the frontal plane on the forehead.  One minute prior to collar removal, participants were asked to subjectively score their discomfort. Biomarker (cytokine) scores were also obtained.   Interface pressure For each measurement location, there was a significant increase in interface pressures with greater collar tension (p<0.01, for both collar designs). The highest pressures observed from the selected measurement sites were at the occiput, which were significantly higher in each tension for the Stifneck® compared to the Aspen Vista® collar design (p<0.05).  Temperature and humidity Across different test conditions, there were no significant differences for either temperature or relative humidity values (p>0.05). The Stifneck® design produced a 21% increase in relative humidity, compared to a 5.2% increase with the Aspen Vista® design.  Cervical range of motion There were statistically significant differences in the cervical ROM for both flexion and total rotation between all three tensions (p<0.001).  The mean ROM for flexion and rotation both decreased with an increase in collar tension. Greatest mean differences in ROM occurred between optimal tension to high tensions, with a mean decrease of 4° (38.5%) flexion and 14° (39.7%) total rotation.  The Stifneck® (C2) provided slightly more restriction across the three tensions, although these differences were not statistically significant (p>0.05).  Cytokine analysis The ratio of cytokine concentrations from pre- to post-collar application revealed an increase (ratio >2) for all test conditions.  The highest of these ratios were observed during the TH test condition for both collar designs, with a median ratio of 5.8 and 4.7 for the Aspen Vista® and Stifneck®, respectively.  Due to the variance in the data at both optimal and high tension conditions, there were no significant differences between either collar design or tension (p>0.05).  Perceived comfort There were statistically significant differences in subjective comfort scores between different collar fits (p<0.01), with mean discomfort greatest during the high tension fitting condition.  Although a trend was observed that the Stifneck® design was more uncomfortable during optimal and high tension fitting conditions, the differences in the comfort scores between the two collar designs were not statistically significant (p>0.05). | Authors' conclusions: The results revealed that increasing strap tension and collar height generated higher interface pressures at all contact sites, with the greatest values consistently recorded at the occiput. In addition, the material and design of the collars significantly affected both the pressure distribution and microclimate at the device–skin interface. Increased pressures were accompanied by significantly reduced cervical ROM and increased discomfort. Irrespective of tension, all collar applications consistently resulted in the release of the proinflammatory cytokine IL-1α at the skin surface. Therefore, collar application provides an environment conducive to pressure ulcer development that can be influenced by collar design and fit. |
| Woster 2018 | Experimental:  Interrupted time series  USA | 20 healthy adult volunteers (hospital employees) with no history of significant eye injury or malignancy or traumatic brain injury within the past 12 months (5 males and 15 females, mean age 37.1 years) | Rigid cervical collar (unspecified) | No collar (baseline) | Ultrasound was used to measure the optic nerve sheeth diameter (ONSD) in each eye twice, both in the sagittal and transverse planes. Next, a mean binocular ONSD was calculated.  Measurements were done at baseline, 5 minutes and 20 minutes after collar application.  At baseline, mean ONSD was 3.77 mm (95% CI [3.60;3.94]).  At 5 min after placement of the c-collar, mean ONSD was 4.47 mm (95% CI [4.29;4.65]; p<0.001 vs baseline). At 20 min, mean ONSD was 4.53 mm (95% CI [4.33;4.73]; p<0.001 vs baseline). | Authors conclusions: In a cohort of healthy volunteers, placement of a rigid c-collar significantly increased the size of the optic nerve sheath diameter. This increase in size should be considered when using the ONSD as a means of detecting elevated ICP in trauma patients. A future study involving trauma patients will be undertaken to demonstrate if this effect is similar in patients with traumatic injuries. |
| Yard 2019 | Experimental: Randomized controlled trial (within subjects; cross-over)  USA | 30 healthy adult volunteers (emergency medicine residents, faculty of the residency program, and rotating medical students at a level II trauma center) (30% female, mean age 29.7+/-4,57 years, age range: 25-50 years) | Patriot® collar (rigid "no-neck" cervical collar) | No collar | The average ONSD with a cervical collar in place was 0.392 ± 0.081 cm, whereas the average ONSD without a cervical collar placed was 0.365 ± 0.071 cm. The mean change in ONSD for participants with and without the collar was 0.026 ± 0.064 cm (95% CI of difference: 0.015–0.038; P < 0.001), and these differences with the collar placement were essentially the same for each eye. There were no significant differences for the mean change in ONSD irrespective of the order in which the collar was placed on (first 0.20 ± 0.071 cm vs. second 0.033 ± 0.055 cm; P = 0.26). The mean difference between measurements by each examiner was 0.019 ± 0.073 cm. Multiple regression analysis did not identify any participant variables associated with the variation in ONSD observed for collar versus non-collar. | Identified from the reference list of Yazici 2024  Authors' conclusions: We found that cervical collar placement is associated with increased ONSD for healthy volunteers. Future studies should evaluate the utility of this modality for assessing patients with head trauma and other conditions that are associated with elevations in ICP. |
| Yazici 2024 | Observational: Cross-sectional study (retrospective chart review)   Turkey | 169 trauma patients admitted to the emergency department in one hospital between Jan and Dec 2021 (112 males and 57 females, median age 40 years (IQR: 25-55)) | Cervical collar (n=66) | No cervical collar (n=103) | ONSD measurements were performed on CT scans by an emergeny medicine specialist blinded to the intervention. Prior to the study, measurements of this specialist were evaluated by a radiologist, who confirmed the accuracy before starting the study.  The mean ONSD in the axial plane were 5.43±0.50 mm and 5.04±0.46 mm respectively for the right eye and 5.50±0.52 mm and 5.11±0.46 mm respectively for the left eye. The results revealed an association between the presence of a cervical collar and the mean ONSD, which was statistically significant (P<0.001) for both the right and left eyes. | Authors' conclusions: A cervical collar may be associated with increased ONSD. The effect of this increase in the ONSD on clinical outcomes needs to be investigated, and the actual need for cervical collar in the emergency department should be evaluated on a case-by-case basis. |
| Zhang 2005 | Experimental: Randomized controlled trial (within subjects; cross-over)  USA | 20 healthy volunteers with no history of spinal pathology (10 males and 10 females, mean age 24 years) | (1) Aspen® collar (2) Miami J® collar (3) XTW collar (4) Philadelphia® C-Breeze™ collar | No collar | Collar vs no collar All four braces had significantly reduced range of motion in the movements compared to the unbraced conditions (flexion, extension, lateral flexion and rotation, all P<0.05).  Mutual comparison of collars - Flexion: The Miami J® and Philadelphia© C-Breeze™ collars showed significantly greater reductions than the XTW collar.  - Extension: All three collars showed greater reduction than the Miami J®. The XTW collar performed better than the Philadelphia® C-Breeze™ and Aspen® collars.  - Lateral bending: The Philadelphia® C-Breeze™ showed less RoM than the Miami J® in lateral bending (flexion).  - Axial rotation: the Philadelphia® C-Breeze™, Aspen® and XTW cervical orthoses all had less RoM in axial rotation than the Miami J®. This reduction was only statistically significant for the Philadelphia® C-Breeze™ vs the Miami J® collar. | The subjects performed 3 trials in each of the 15 test conditions (5 different collar conditions (including unbraced) and 3 head/neck movements (flexion-extension, left-right lateral flexion, and left-right axial rotation).  Authors' conclusions: The results suggested that the two new cervical orthoses, Philadelphia® C-Breeze™ and XTW collars, along with the two commonly used cervical orthoses in medical practice, Miami J® and Aspen®, are effective in restricting RoMs in the cervical spine. The Philadelphia® C-Breeze™ and XTW cervical orthoses performed either comparably as or better than the Miami J® and Aspen® collars. |