BRIEF REPORT

Biomechanical analysis of cervical spine movement on removal of motorcycle helmets

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Objective. To measure cervical spine movement during removal of a motorcycle helmet by health care professionals.

Methods. Observational study using biomechanical inertial sensors to detect movement in the spinal column during removal of helmets.

Results. Thirty-four emergency medicine specialists and nurses participated. The mean (SD) rotation was 1.14° (0.82°) to the left and 3.30° (1.69°) to the right (*P*<.001). Mean flexion was 9.82° (7.46°) and mean extension was 6.23° (6.86°) (*P*<.001). Mean lateral displacement was 5.73° (2.97°) to the left and 5.62° (8.22°) to the right (*P*=.678). The removal maneuvers took a mean of 70 seconds (4 seconds).

Conclusion. Helmet removal was completed in an average of 70 seconds with flexion and rotation mainly toward the side where the professional supporting the head was positioned.

Keywords: Emergency health services. Accidents: motorcycle. Head protective devices: helmets. Injuries: spinal cord.

Análisis biomecánico del movimiento cervical en la extracción del casco en motoristas

Objetivo. Determinar el movimiento cervical durante la extracción de un casco realizada por profesionales sanitarios.

Métodos. Estudio observacional mediante análisis biomecánico con sensores inerciales de los movimientos producidos en la columna durante la extracción de un casco.

Resultados. La muestra final la componen 34 profesionales de servicios de urgencias y emergencias. La rotación fue de 1,14 (DE 0,82)° hacia el lado izquierdo y de 3,30 (1,69)° hacia el lado derecho (p < 0,001). La flexoextensión fue de 9,82 (7,46)° para la flexión y de 6,23 (6,86)° para la extensión (p < 0,001). La lateralización fue de 5,73 (2,97)° para el lado izquierdo y de 5,62 (8,22)° para el lado derecho (p = 0,678). El tiempo medio de realización de la extracción fue 70 (4) seg.

Conclusión. La extracción del casco se realizó en 70 segundos con flexión y rotación hacia el lado donde se encuentra colocado el profesional que sujeta la cabeza.

Palabras clave: Servicios médicos de urgencia. Accidentes de motocicleta. Casco. Lesión médula espinal.

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Article information:
Received: 6-4-2017
Accepted: 4-5-2017
Online: 28-6-2017

Editor in charge:
Agustín Julián-Jiménez, MD, PhD.

Introduction

The World Health Organization pointed out that road traffic accidents cause a high rate of fatalities among motorcyclists[1]. In a Cochrane review[2], they concluded that the helmet reduced the risk of death and cranioencephalic damage. There are many factors that make it necessary to remove the helmet[3,4]: it does not allow a correct evaluation of the airway or possible head injuries, it makes it difficult to restrict movement in the victim during transportation and does not usually allow adequate placement of a cervical collar. The helmet removal manoeuvre, as described by the Pre hospital Trauma Life Support (PHTLS)[5], is performed between two professionals. A professional is placed at the head of the patient stabilizing the helmet with the palms of the hands, the other is placed next to the patient and performs the manual stabilization by holding the jaw and the occipital area of the skull. The person at the head pulls the helmet up and down assuring the release of the nose.

Removal of the helmet can cause secondary injury[6], so it should be carried out by professional experts. To date, there are no studies that determine the degree of mobility of the cervical spine during the manoeuvre nor its effectiveness, so it is based on subjective criteria. The objective of this study was to determine the cervical movement during the removal of the helmet from a motorcyclist made by emergency health professionals.

Method

An observational study in which a biomechanical analysis of the movements produced in the cervical spine was performed while the helmet was extracted from a simulated victim, who was previously placed with inertial sensors (IS) (Figure 1A). It was carried out

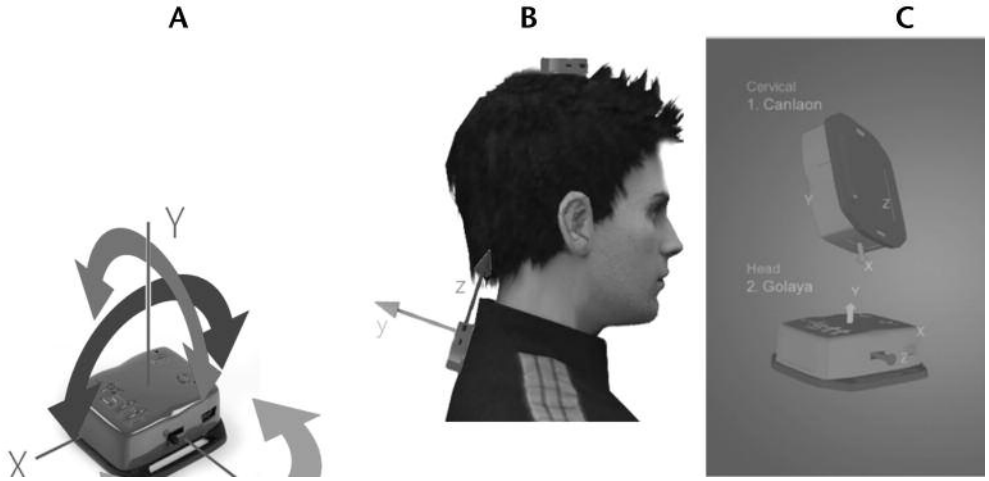

Figure 1. Images of the axes of coordinates of the inertial system (A), location of the sensors (B) and linkage of the sensors (C).

at the Catholic University of Murcia (UCAM), with the collaboration of the Emergency Management 061 of the Region of Murcia, between April and June 2016. It was approved by the UCAM Ethics Committee (code 6118) and all participants signed their consent to participate.

The procedure consisted in a simulation in which two professionals had to remove the helmet of an actor with the role of rider in the supine position, unconscious. Each of the volunteers played the leader role (placed at the head) and were assigned a helper randomly (located to the right of the victim). An open call for a sample of 40 professionals, initially made up of professionals from the Emergency Management 061 of the Region of Murcia (n = 24) and the Spanish Society of Emergency and Emergency Medicine (SEMES) (n = 16). There were 6 participants who did not attend the test, so the final sample was made up of 34 professionals.

Motion analysis was determined using the STT-IBS iSen 3D Motion Analyser (STT Systems) system. These ISs consist of an accelerometer, a gyroscope and a magnetometer, wrapped in a rigid case (36 mm x 15 mm x 46.5 mm), with a total weight of 29 g, with a sending frequency of 250 Hz, precision static (roll, pitch, yaw) < 0.5°, dynamic accuracy (roll, pitch, yaw) <1.5° and latency less than 0.004 secs. The IS determines the angular orientation obtaining the values in the 3 axes of space coordinates (X, Y and Z). The connection was made via a Bluetooth 2.0® system to a computer to which an iSen-Hub signal reception adapter was attached. The biomechanical model of cervical movement analysis was selected. The simulated victim was assigned two ISs (Figure 1B and 1C): one in the head (upper area) and one in the back (between C6 and C7).

For the statistical analysis, we exported the data to the Microsoft Excel® program and analysed it using the SPSS® program version 21. The variables analysed were: age, sex, years of professional experience, years of professional experience in emergencies, qualification and time the manoeuvre. All data of ISs movements were generated during the acquisition of the movements automatically and in real time. Data are presented by frequency, percentage, mean, standard deviation (SD) and range. Rotation, flexion extension and lateralization were analysed using Student's t-test for comparison between the two movements. We also performed the one-way ANOVA study to analyse differences between groups. In order to evaluate the influence of the different variables on the results obtained, a covariance analysis was carried out. The differences were assumed to be statistically significant if $p < 0.05$.

Results

The mean age of participants was 37 (SD 9) years and 23 (68%) were women. Distribution by profession showed that 42% (14/34) were nurses and 58% (20/34) physicians. The average professional experience was 11 (6) years, and the professional experience in emergencies was 4 (3) years. The mean extraction time was 70 (SD 4) secs. Figure 2 shows the overall results for the three axes of motion studied.

The rotation had an average position of -2.74 (3.59)°, with a range of movement of 13°. The rotation movement was 1.14 (0.82)° for the left side and 3.30 (1.69)° for the right side (mean difference 2.16 (95% CI: 1.98° - 2.34°, p <0.001), indicating that the head has been slightly rotated towards the side that the professional is located who holds the head inside the helmet.

The flexo-extension had an average position of 1.62 (12.53)°, with a range of motion of 64°. The flexo-extension movement was 9.82 (7.46)° for flexion and 6.23 (6.86)° for extension (mean difference 3.59 (95% CI: 2.99° -4,18o; p <0.001) which would indicate that the head has had a greater flexion than extension.

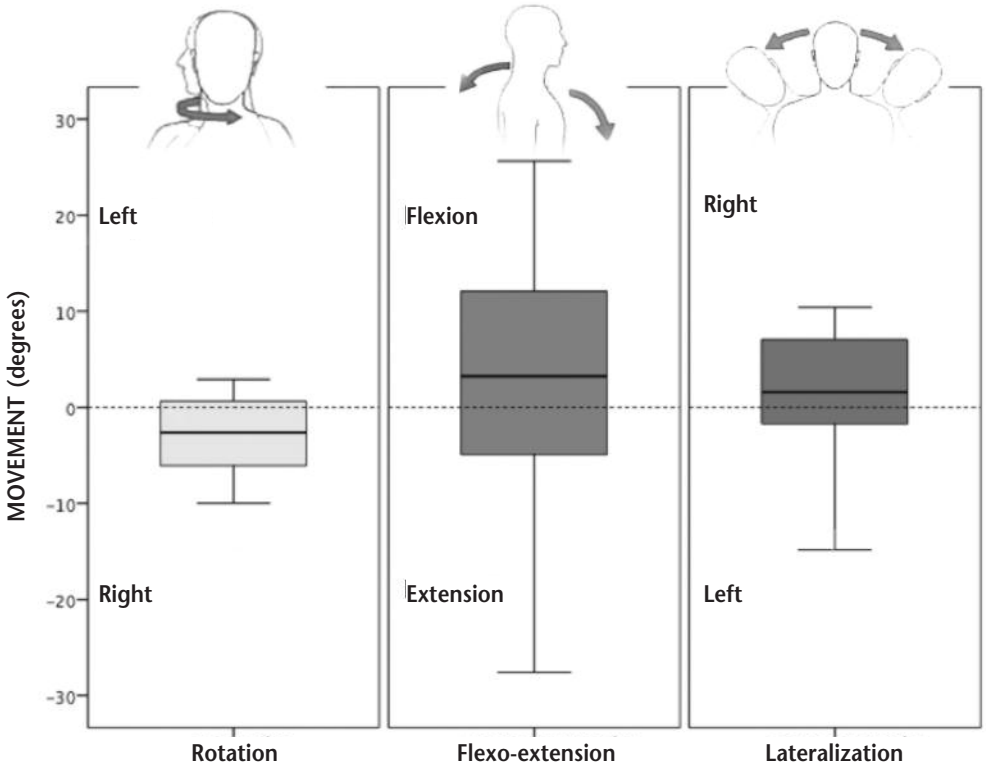

Figure 2. Overall results of the degrees obtained in the biomechanical analysis for the three movements studied.

The lateral position had an average position of 0.05 (9.02)°, with a range of movement of 33°. The lateralization movement was 5.73 (2.97)° for the left side and 5.62 (8.22)° for the right side (difference of means 0.11 (95% CI: 0.41° - 0.63°; p = 0.678); which would indicate that there are no differences between the two movements.

There were no statistically significant differences between the movement results and factors such as sex, age, time of manoeuvre or professional experience, whether hospital or specific in the prehospital emergency area (Table 1).

Discussion

The results of this investigation have determined that the manoeuvre for the extraction of the hull of a motorcyclist has a duration of 70 seconds. To our knowledge, there are no data in the scientific literature regarding the time of accomplishment of this technique, reason why we cannot compare our results with those of other authors. It would be advisable to perform studies to minimize the time until the airway can be opened once the helmet is removed.

Another result of the study is that flexo-extension is the movement with greater range, reaching 64º, with an important preponderance of the flexion on the extension. The rotation of the head has been slightly greater towards the right side, with a range of movement of 13°. The lateralization of the head has not had a side to which it stands out, but it should not be forgotten that up to 33° range of motion has been determined. Although there is no accurate data on the degrees of misalignment during extraction, our results confirm that the helmet can cause difficulty in aligning the head and favour secondary spinal cord injury[3]. The means of movement obtained in our study resembled that determined by Dixon et al.[7] in the extrication of patients of a vehicle or those of Gordillo et al.[8] in the placement of devices such as the spinal board. Therefore, the risk of injury should not be underestimated during helmet in cases of suspected cervical injury.

Table 1. Comparison of results for each of the two groups of professionals

Variable/Professionals	Average	Standard Deviation	Significance*
Time (seconds)			0.261
Hospital	71''	4''	
EMU	68''	3''	
Rotation			0.737
Hospital	2.88º	3.88º	
EMU	2.6º	3,25º	
Flexo-extension			0.794
Hospital	2.44º	15.21º	
EMU	0.73º	9.24º	
Lateralization			0.794
Hospital	0.05º	10.03º	
EMU	–0.2º	8.66º	

* Wilcoxon- Mann Whitney test. EMU: Emergency Mobile Unit

The main limitation of our study is that simulations were performed with a healthy actor without cervical instability. There are studies, such as the one carried out by Prasarn et al.[9] with cadavers that underwent surgical instability at C5 and C6. Their results cannot be compared with ours, since they performed the mobilization with the helmet on; however, in some of the techniques used, the range of motion is greater and would further support the need for removal of the helmet before transferring the patient.

The results of this study allow us to conclude that during the removal of the helmet there is a flexion of the head and a certain degree of rotation towards the side of the professional who holds the head. Although we do not have clinical data, the wide ranges of flexo-extension movement can be very dangerous for a patient with cervical instability

Conflicting interests

The authors declare no conflict of interest in relation to this article.

Financing

Study financed with a grant awarded by the Illustrious Official College of Nursing of the Region of Murcia for the promotion of research projects in the 2016 call.

Ethical Responsibilities

It was approved by the Clinical Research Ethics Committee of the Catholic University of Murcia (code 6118).

All patients gave their consent prior to the participation in the study.

All authors have confirmed the maintenance of confidentiality and respect for patients' rights in the author's responsibilities document, publication agreement and assignment of rights to EMERGENCIAS

Article not commissioned by the Editorial Committee and with external peer review

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