Biomechanical analysis of movements during removal of helmets from motorcycle riders: a comparative study of the efficacy of 2 techniques

Análisis biomecánico de movimiento durante la extricación del casco de motoristas: estudio comparativo de la eficacia de dos técnicas

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Traffic accidents are responsible for 1.2 million deaths per year, 23% of which involve motorcyclists[1]. The full-face helmet protects against multiple injuries[2-4]. The placement of patient immobilization devices is difficult

when a helmet is present[3,5-7] One of the helmet removal techniques, called the "saw-teeth technique," is described in the Prehospital Trauma Life Support (PHTLS) manual.[3] The first rescuer grasps the bottom of the helmet and the victim's chin with both hands, bringing the head to a neutral position. The second rescuer opens the visor and releases the chin strap; he fixes the chin with one hand and holds the back of the head with the other. The objective is to obtain a neutral head position (0º position), maintaining the head-neck-trunk axis. The first rescuer performs up-and-down twisting movements until complete removal.[3,8] Conversely, there is the "continuous traction technique." The beginning is similar. However, the first rescuer removes the helmet with a continuous pulling motion until reaching the victim's nose. At this point, the angle is widened by pulling the helmet posteriorly, and when the partner is ready to maintain the alignment of the head-neck axis, it is fully extracted. Neither technique has been sufficiently investigated. The main objective is to compare the differences in cervical spine misalignment produced by the two techniques.

Cross-sectional, comparative, simulation study to determine by biomechanical analysis with inertial sensors (IS) the misalignment produced in the cervical spine during helmet removal in an injured motorcyclist. The study was approved by the Research Ethics Committee of the Catholic University of Murcia (Registration 6118, 03/06/2016).

The sample consisted of 34 health professionals with more than 3 years of emergency experience and specific training in advanced trauma life support. Each participant acted as the leader of both maneuvers, while another volunteer played the role of the second rescuer. The IS system used was the STT-IBS iSen 3D Motion Analyser (STT Systems) model for motion analysis. The biomechanical cervical motion analysis model was selected. The SIs were placed on the actor (unconscious patient in supine decubitus, with suspected cervical injury), one on the back (between C6 and C7), and one on the top of the head.

The analysis was performed with the SPSS Version 21 program. The data are presented as frequencies, percentages, means, standard deviations (SD), and ranges. The primary variable was neck flexion-extension. The secondary variables were: academic training, years of experience, and time spent performing the maneuver, rotation, and lateralization of the neck. The Mann-Whitney U test for independent variables was used for comparison. Differences were considered statistically significant for a 95% confidence interval ($P < .05$).

No differences were found concerning gender (59% women), professional category, or years of experience in the results. The image of the primary variable, flexion-extension movement, in one of the simulations can be seen in Figure 1. Cervical flexion presents a mean range of 11º (SD ± 7º) with the Saw-teeth Technique, while the Continuous Traction Technique was 8º (SD ± 8º). On the other hand, in cervical extension, with the Saw-teeth Technique, a mean of 14º (SD ± 10º) was recorded, and with Continuous Traction Technique, a mean of 15º (SD ± 8º) was obtained. Therefore, no differences were found for the main variable (flexion $P = .202$; extension $P = .758$). In the qualitative analysis of the curves (Figure 1), several movements can be observed in Saw-teeth Technique, more significant than in Continuous Traction Technique.

Right lateral flexion showed a mean range of 7º (SD ± 6º) with Saw-teeth Technique; meanwhile, with Continuous Traction Technique it was 8º (SD ± 6º). Concerning left lateral flexion with the Saw-teeth Technique, a mean of 8º (SD ± 7º) was noted, and with Continuous Traction Technique, a mean of 7º (SD ± 5º) was achieved. No differences were found for the secondary variable neck lateralization (right $P = .499$; left $P = .646$). Proper rotation exhibited a mean range of 9º (SD ± 5º) with Saw-teeth Technique, while with Continuous Traction Technique, it was 9º (SD ± 5º). Left rotation, using both techniques, showed a mean of 6º (SD ± 5º). No differences were found for the secondary variable neck rotation (right $P = .942$; left $P = .723$).

The mean time employed was 38.9 seconds (SD: ± 11.7) with Saw-teeth Technique; however, with Continuous Traction Technique, it was 33.1 seconds (SD: ± 11.1). For the secondary variable, time to perform the maneuver, differences were found ($P = .01$) with less time employed in helmet removal by Continuous Traction Technique compared to Saw-teeth Technique. The results (Table 1) did not provide significant differences concerning cervical misalignment. It cannot be stated that one maneuver is superior to the other. The maximum and minimum range of cervical motion was analyzed. Although the experience results were similar for both techniques, Saw-teeth Technique caused a more significant accumulation of movements than the Continuous Traction Technique. Our results are similar to other studies.[9] In the future, total cumulative misalignment could be measured to determine if there is greater cumulative motion in Saw-teeth Technique, as the curve drawing indicates. About the time for each maneuver, Continuous Traction Technique seems

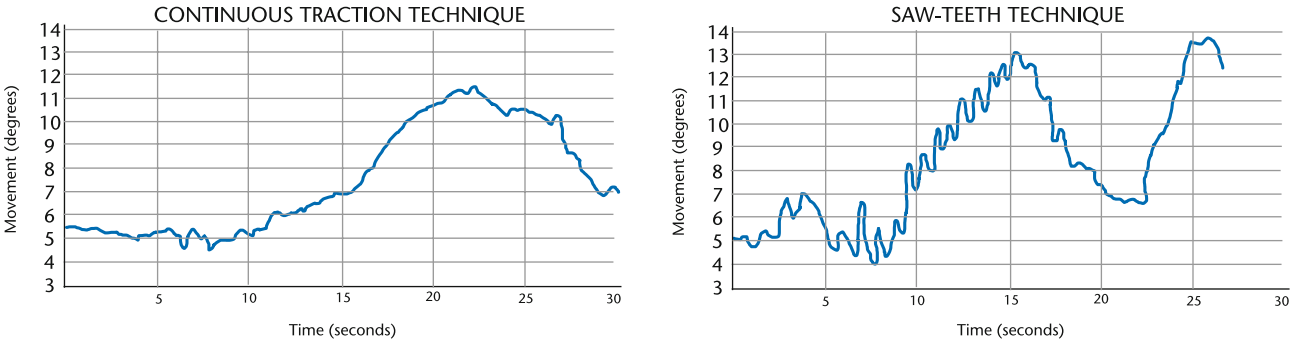

Figure 1. Image of flexion-extension motion during one of the simulations of helmet removal for the two techniques included in this study.

Table 1. Results obtained during the experiment-simulation on the variables studied with respect to cervical movement

Movement	Technique	N	Measure	SD	*P* value
Flexion	Saw-teeth	33	10.97º	7.44º	.202
	Continuous	32	8.85º	7.87º	
Extension	Saw-teeth	33	13.88º	10.26º	.758
	Continuous	32	14.96º	8.47º	
Right lateral flexion	Saw-teeth	33	6.67º	6.20º	.499
	Continuous	32	7.57º	6.37º	
Left lateral bending	Saw-teeth	33	8.41º	7.42º	.646
	Continuous	32	6.71º	4.52º	
Right rotation	Saw-teeth	33	9.08º	4.85º	.942
	Continuous	32	8.83º	5.52º	
Left rotation	Saw-teeth	33	6.42º	5.13º	.723
	Continuous	32	5.90º	4.78º	
Time	Saw-teeh	33	38.9″	11.71″	**.010**
	Continuous	32	33.11″	11.18″	

Bold p values denote statistical significance ($P < .05$).

to be faster and could favor early access to the airway.[3,5-7] The study's main limitation is that it is a simulation involving particular laboratory conditions; spinal stability may differ from results in real victims. However, the use of IS seems reliable according to the results of similar studies.[6,9,11-13] In conclusion, we can state that there are no differences in spinal misalignment during the removal of the motorcycle helmet when comparing Continuous Traction Technique with Saw-teeth Technique. Continuous Traction Technique could provide advantages in patient care due to the shorter time involved in its performance.

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