



Motor vehicle accidents—related maxillofacial injuries: a multicentre and prospective study

Muhammad Ruslin, DDS, MS,^a Matteo Bruccoli, MD, DDS,^b Paolo Boffano, MD,^b Arnaldo Benech, MD, DDS, PhD,^b Emil Dediol, MD, PhD,^c Vedran Uglešić, MD, PhD,^c Žiga Kovačič, MD,^d Aleš Vesnaver, MD, PhD,^d Vitomir S. Konstantinović, DDS, MD, PhD,^c Milan Petrović, DDS, MD,^c Jonny Stephens, MmedSci,^f Amar Kanzaria, BChD, MFDS, RCS,^f Nabeel Bhatti, MFDS, RCS, MRCS,^f Simon Holmes, FDS, RCS, FRCS,^f Petia F. Pechalova, DDS, MD, PhD,^g Angel G. Bakardjiev, DDS, PhD,^g Vladislav A. Malanchuk, MD, DDS, PhD,^h Andrey V. Kopchak, DDS, PhD,^h Pål Galteland, MD, DDS,ⁱ Even Mjøen, MD, DDS,ⁱ Per Skjelbred, MD, DDS, PhD,ⁱ Helios Bertin, MD,^j Pierre Corre, MD,^j Sigbjørn Løes, DDS, PhD,^k Njål Lekven, DDS,^k Sean Laverick, FDS, FRCS,^l Peter Gordon, MFDS, MRCS,^l Tiia Tamme, MD, PhD,^m Stephanie Akermann, DDS,^m K. Hakki Karagozlu, MD, DDS,^a Sofie C. Kommers, MD, DDS,^a Jan G. de Visscher, MD,^a and Tymour Forouzanfar, MD, DDS, PhD^a

Objectives. The purpose of this European multicenter prospective study was to obtain more precise information about the demographic characteristics and etiologic/epidemiologic patterns of motor vehicle accidents (MVA)—related maxillofacial fractures.

Study Design. Of the 3260 patients with maxillofacial fractures admitted within the study period, 326 traumas were caused by MVAs with a male/female ratio of 2.2:1.

Results. The maximum incidence was found in Zagreb (Croatia) (18%) and the minimum in Bergen (Norway) (0%). The most frequent mechanisms were car accidents, with 177 cases, followed by motorcycle accidents. The most frequently observed fracture involved the mandible, with 199 fractures, followed by maxillo-zygomatic-orbital (MZO) fractures.

Conclusions. In all the 3 groups (car, motorcycle, and pedestrian), mandibular and MZO fractures were the 2 most frequently observed fractures, with some variations. The importance of analyzing MVA-related facial injuries and their features and characteristics should be stressed. (Oral Surg Oral Med Oral Pathol Oral Radiol 2019;128:199–204)

Injuries associated with traffic accidents are a problem faced in several countries, and their prevention is often a

priority for public health authorities.¹⁻¹⁸ In fact, facial injuries, including fractures, may have serious long-term implications for victims of motor vehicle accidents (MVAs) and important socioeconomic consequences.¹⁻⁸ Thus, the knowledge of the factors associated with facial injuries caused by MVAs is important for prognosis, identification of groups at risk, and establishment of measures to minimize the economic, emotional, psychological, and social impacts of these events.¹⁻⁸

Preventing maxillofacial injuries is a valuable pursuit for improving the quality of life of those who suffer such injuries and for decreasing the socioeconomic costs of MVA injuries.¹⁻²¹ Several studies reported in the literature have described the frequency and severity of facial injuries associated with MVAs. However, to our knowledge, no prospective multicentre study on MVA-related maxillofacial injuries has been published. Therefore, several European centers with research experience in maxillofacial trauma^{15-17,22-24} decided to collaborate and initiate a prospective multicentre study on the epidemiology of facial fractures occurring in Europe.

^aDepartment of Oral and Maxillofacial Surgery/Pathology, VU University Medical Center and Academic Centre for Dentistry Amsterdam (ACTA), Amsterdam, The Netherlands.

^bDepartment of Maxillofacial Surgery, University of Eastern Piedmont, Novara, Italy.

^cDepartment of Maxillofacial Surgery, University Hospital Dubrava, Zagreb, Croatia.

^dMaxillofacial Department, UKC Ljubljana, Slovenia.

^eClinic of Maxillofacial Surgery, School of Dentistry, University of Belgrade, Serbia.

^fDepartment of Oral and Maxillofacial Surgery, Royal London Hospital, Barts Health NHS, London, UK.

^gDepartment of Maxillo-Facial Surgery, Medical University, Plovdiv, Bulgaria.

^hDepartment for Oral and Maxillo-Facial Surgery, Bogomolets National Medical University, Kiev, Ukraine.

ⁱDepartment of Maxillofacial Surgery, Oslo University Hospital, Oslo, Norway.

^jService de Stomatologie et Chirurgie Maxillo-faciale, Chu de Nantes, France.

^kDepartment of Maxillofacial Surgery, University of Bergen, Bergen, Norway.

^lDepartment of Oral and Maxillofacial Surgery, NHS Tayside, University of Dundee, Dundee, UK.

^mDepartment of Maxillofacial surgery, Stomatology Clinic, Tartu University, Tartu, Estonia.

Received for publication Apr 26, 2018; returned for revision Oct 17, 2018; accepted for publication Dec 4, 2018.

© 2018 Elsevier Inc. All rights reserved.

2212-4403/\$-see front matter

<http://doi.org/10.1016/j.o.oooo.2018.12.009>

Statement of Clinical Relevance

Most frequently, motor vehicle accidents—related facial injuries are caused by car accidents and involve the mandible.

The purpose of this European multicenter prospective study was to obtain more precise information about the demographic characteristics and the etiologic/epidemiologic patterns of MVA-related maxillofacial fractures.

MATERIALS AND METHODS

The present study was conducted at several European departments of oral and maxillofacial surgery: Department of Oral and Maxillofacial Surgery/Pathology at the VU Medical Center and Academic Centre for Dentistry Amsterdam (Amsterdam, The Netherlands); Department of Maxillofacial Surgery at the University Hospital Dubrava (Zagreb, Croatia); Maxillofacial Department at the UKC Ljubljana, (Ljubljana, Slovenia); Clinic of Maxillofacial Surgery of the School of Dentistry at the University of Belgrade (Belgrade, Serbia); Department of Oral and Maxillofacial Surgery of the Royal London Hospital at Barts Health NHS (London, UK); Department of Maxillo-Facial Surgery at the Medical University (Plovdiv, Bulgaria); Department for Oral and Maxillo-Facial Surgery at the Bogomolets National Medical University (Kiev, Ukraine); Department of Maxillofacial Surgery at the Oslo University Hospital (Oslo, Norway); Service de Stomatologie et Chirurgie Maxillo-faciale at the Chu de Nantes (Nantes, France); Department of Maxillofacial Surgery at the University of Bergen (Bergen, Norway); Department of Oral and Maxillofacial Surgery at NHS Tayside and University of Dundee, (Dundee, UK); and Department of Maxillofacial surgery, Stomatology Clinic, Tartu University (Tartu, Estonia).

This study was based on a systematic computer-assisted database that allowed prospective and continuous recording of all cases of patients hospitalized with maxillofacial fractures in maxillofacial surgery units across Europe, from December 31, 2012, to December 29, 2013.

The following data were recorded for each patient: sex and age of patient, fracture etiology and mechanism, site of facial fracture, Facial Injury Severity Score (FISS), and date of injury. For this study, only patients who were admitted to the hospital for MVA-related maxillofacial injury were considered.

FISS is an injury scale, which is specific for facial trauma and correlates with patient outcome; it aims to provide a practical tool for communication between clinicians and other health care personnel for the management of facial trauma.²¹

MVA-related injuries were analyzed and categorized according to the type of injury: car accident, motorcycle accident, pedestrian, and unknown/other. Bicycle accidents were excluded. Fracture diagnoses were determined on the basis of a combination of physical examination and imaging (computed tomography or conventional radiography)

findings at admission to hospital and classified into mandible, orbito-zygomatic-maxillary complex, orbit, nose, LeFort, frontal sinus, and naso-orbital-ethmoidal (NOE) fractures. Orbital fractures were subclassified on the basis of the involved walls, and Le Fort fractures were subclassified as Le Fort I, II, and III types. Frontal sinus fractures were subclassified on the basis of the involvement of the anterior and/or posterior tables. Mandibular fractures included fractures of the symphysis, body, angle, ramus, coronoid, extra-articular condyle, intra-articular condyle. Associated injuries were classified as orthopedic, brain, abdominal, or thoracic. Patient characteristics were analyzed by using descriptive statistics.

This study was exempt from institutional review board approval. We followed the Helsinki Declaration guidelines.

RESULTS

Of the 3260 patients with maxillofacial fractures admitted within the study period, 326 traumas were caused by MVAs. Of course, in the different centers and countries, the incidence of MVA-related maxillofacial trauma varied, with maximum incidence encountered in the Zagreb (Croatia) center study population (39 patients [18%]) and the minimum in Bergen (Norway) (0 patients [0%]).

On the study population, 225 patients were males, and 101 were females, with a male/female ratio of 2.2:1. Mean age was 36.2 years.

Alcohol addiction was found in 59 patients, and drug use was noted in 4 cases.

The most frequent mechanisms of MVA-related maxillofacial injury were car accidents with 177 cases, followed by motorcycle accidents (91 patients), pedestrian accidents (33 cases), and other/ unknown mechanisms (25 patients). This result was quite uniformly observed in all centers, as showed in [Figure 1](#).

The most frequently observed fracture involved the mandible, with 199 fractures, followed by maxilla-zygomatic-orbital (MZO) fractures (136), orbital fractures (36), Le Fort fractures (32), nose fractures (16 fractures), frontal sinus fractures (15), and NOE fractures (8).

FISS mean score in the whole study population was 2.39 (range 1–12; median 2; standard deviation [SD] 1.99). In the “car accident” group, mean FISS was 2.54; in the “motorcycle” group, the observed mean FISS was 2.47; and in the “pedestrian” group, the mean value of FISS was 1.6.

[Figure 2](#) shows the differences in fracture distribution according to the 3 etiologic categories. In all the 3 groups mandibular and MZO fractures were the 2 most frequently observed fractures, with some variations: In the car and motorcycle groups, mandibular fractures were the main site of injury, whereas in the pedestrian

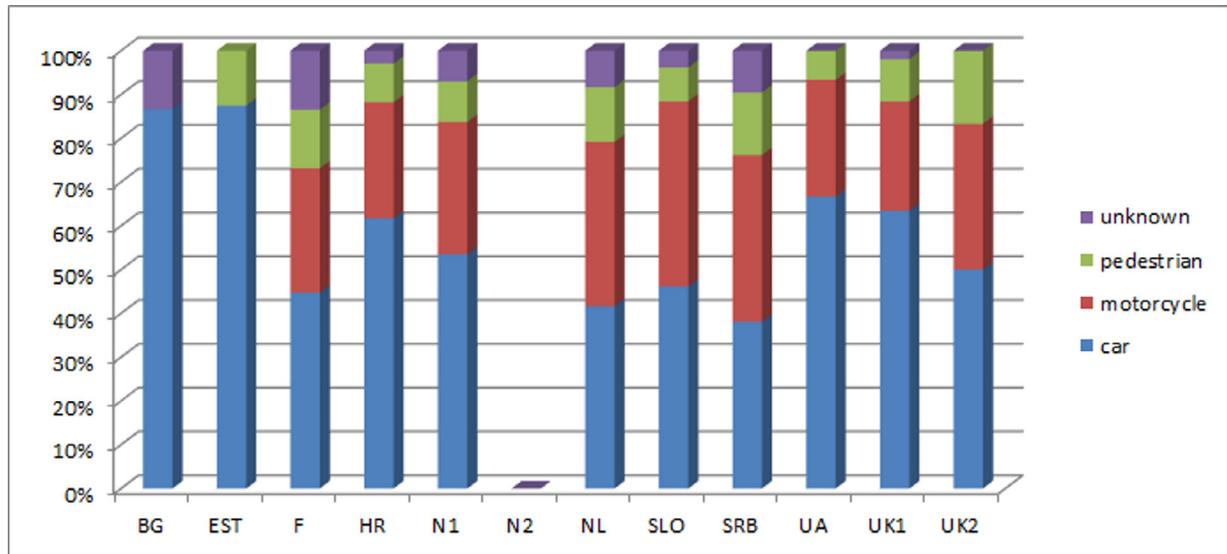


Fig. 1. Percentages of mechanisms of motor vehicle accident (MVA)-related maxillofacial injury in the EUR.MA.T centers. *BG*, Bulgaria; *EST*, Estonia; *F*, France; *HR*, Croatia; *N1*, Oslo - Norway; *N2*, Bergen – Norway; *NL*, The Netherlands; *SLO*, Slovenia; *SRB*, Serbia; *UA*, Ukraine; *UK1*, London – England, United Kingdom; *UK2*, Dundee – Scotland, United Kingdom.

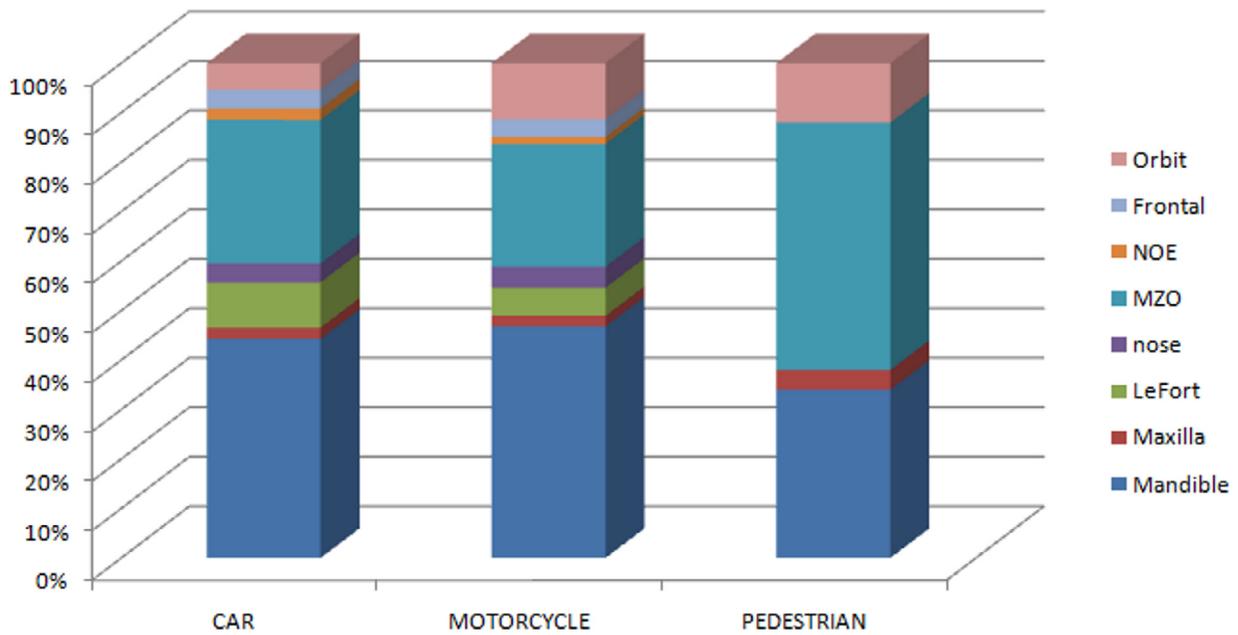


Fig. 2. Distribution of fractures, according to the 3 etiologic categories.

group, MZO fractures were the most frequently observed fractures.

As for associated body injuries, brain and orthopedic lesions were the most frequently observed in all the 3 groups, as shown in Figure 3. A peak incidence of traumatic brain injuries was observed in the motorcycle accident group, whereas a peak incidence of orthopedic lesions was encountered in the car accident group.

Finally, the analysis of the dates of injury showed that the highest incidence of MVA-related

maxillofacial injuries was in the summer and winter months (Figure 4).

DISCUSSION

Analysis of the various patterns of MVAs is crucial, although differences among countries with regard to legislations, regulations, socioeconomic conditions, and road features may represent an important bias in any attempt at assessment.

For instance, in Europe, every country has its own regulations with regard to speed limits, drinking and

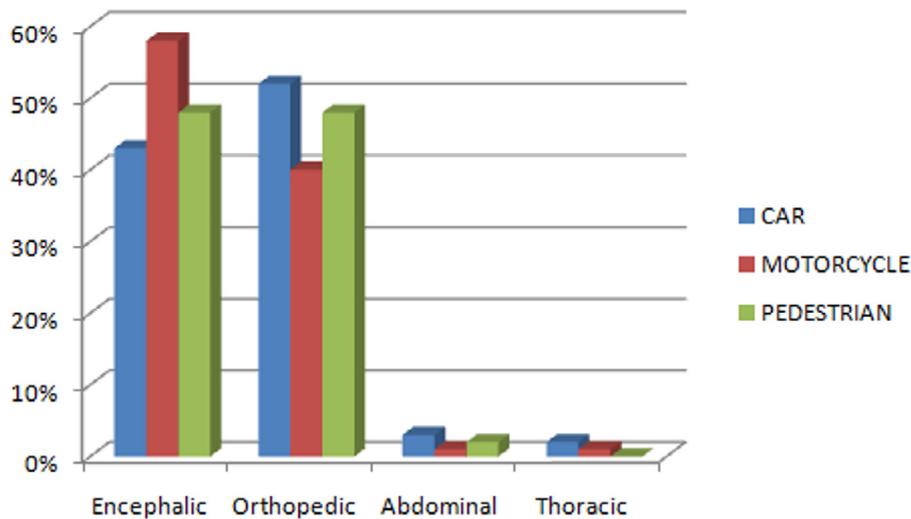


Fig. 3. Associated body injuries, according to the 3 etiologic categories.

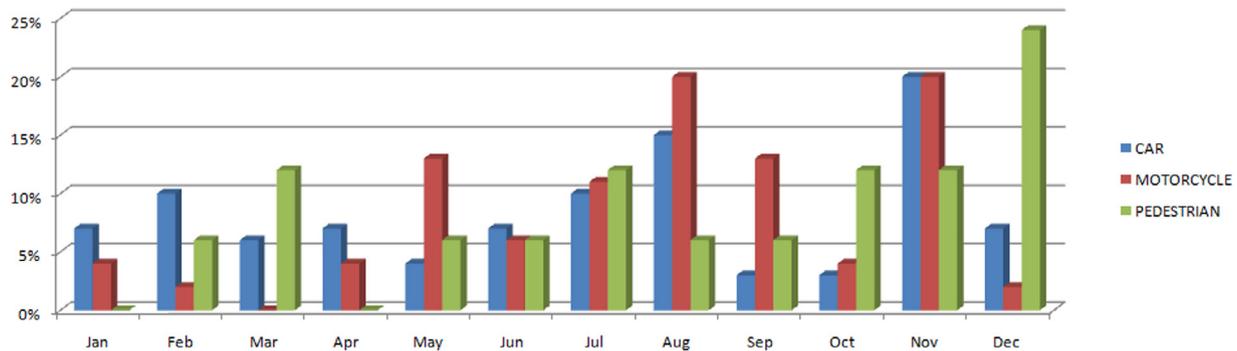


Fig. 4. Monthly distribution of fractures, according to the 3 etiologic categories.

driving, and safety equipment, just to mention some variables. For this reason, a multicenter prospective study seemed to be the most efficient way to collect epidemiologic data on MVA-related facial fractures and to obtain reliable results from an analysis of cases with this peculiar injury.

Demographic characteristics

Of the 3396 patients with maxillofacial fractures admitted within the study period in the different centers, 326 traumas were caused by MVAs. Of course, in the different centers and countries the incidence of MVA-related maxillofacial trauma varied, with the maximum incidence found in Zagreb, Croatia. However, in most centers, the percentage of MVA-related maxillofacial trauma was about 10%. In comparison with other reports in the European literature, this was among the lowest values ever reported. In fact, most recent studies on MVA-related maxillofacial trauma in European countries reported percentages ranging from 25% to 60%. This result may confirm a trend of decreasing incidence of MVA-related maxillofacial

injuries in developed countries. However, recent articles¹⁴ about maxillofacial trauma epidemiology in Africa or Asia highlighted that percentages of MVA-related fractures were often greater than 50%, to reach values of 90% (e.g., in Iran, Turkey, or India).

Of the study population, 225 patients were males, and 101 were females, with a male/female ratio of 2.2:1. The predominance of males in our study agrees with the male/female ratios in European study populations reported in recent articles.¹⁴

Alcohol and MVA

Alcohol addiction was found in 59 patients, and drug use was noted in 4 cases. Unfortunately, a thorough analysis of alcohol addiction is extremely difficult. Although almost 20% of patients/victims of MVAs admitted having an alcohol addiction, strict and precise knowledge of the quantity and type of alcohol consumed would be crucial. This kind of analysis would be extremely difficult because of several factors, such as the unwillingness of some patients to talk about possible alcohol abuse and the different laws relating to this topic. Furthermore, alcohol

intoxication has a close association with the incidence of head and neck injuries, in particular those caused by interpersonal violence and MVAs.¹⁹ Alcohol addiction was associated with a higher proportion of concomitant organ injuries, including injuries to the cervical spine and other organs and fractures in sites other than the facial skeleton.¹⁹ Screening patients for alcohol addiction may offer many potential benefits, providing an opportunity to educate patients about low-risk consumption levels and about the risks of excessive alcohol use.

Etiology and injuries

The most frequent mechanisms of MVA-related maxillofacial injury were car accidents with 177 cases, followed by motorcycle accidents (91 patients), pedestrian accidents (33 cases), and other/ unknown mechanisms (25 patients) (see Figure 1). This result was quite uniformly observed in all centers (see Figure 1). In this study, bicycle accidents were excluded because they are characterized by specific features and populations. Figure 2 highlights the distribution of fractures according to the mechanism: The most evident result is represented by the pedestrian victims of MVAs—MZO or orbital fractures occurred in greater than 60% of pedestrian accidents, in comparison with the 30% to 40% of car/motorcycle accidents. In all 3 groups, mandibular and MZO fractures were the 2 most frequently observed fractures, with just slight variations: In the car and motorcycle groups, the mandible was the main site of injury, whereas in pedestrian accidents, MZO fractures were the most frequently observed fractures.

Of course, further studies on the protective effects of safety equipment (seat belts, airbags, helmets) on the incidence of MVA-related facial injuries are needed, although this could be a challenging investigation.¹⁰⁻¹⁴

The most frequently observed fracture involved the mandible, with 199 fractures, followed by MZO fractures (136), orbital fractures (36), Le Fort fractures (32), nose fractures (16 fractures), frontal sinus fractures (15), and NOE fractures (8). The low number of nasal fractures is probably an effect of a selection bias because in several trauma centers, nasal fractures are treated by ear, nose, and throat surgeons, not by maxillofacial surgeons. An epidemiologic radiologic analysis of MVA-related facial fractures pointed out that nasal fractures were the most frequent facial injuries, followed by orbital fractures.²⁰

Facial Injury Severity Score

FISS mean score in the whole study population was 2.39. In the “car accident” group, mean FISS was 2.54; in the “motorcycle” group, the observed mean FISS was 2.47; and in the “pedestrian” group, the mean value of FISS was 1.6. Therefore, car and motorcycle accidents seemed to result in more severe injuries

compared with “pedestrian accidents.” The reason could be the different mechanism of this last type of injury—the most severe damage to pedestrians may easily result in fatalities, and this may explain the underreporting of such facial injuries. Our results are consistent with those reported in the current literature, with mean FISS values of 2.46 observed in car accidents and 1.65 in motorcycle accidents.¹⁰

Associated body injuries

As for associated body injuries, traumatic brain and orthopedic lesions were the most frequently observed in all the 3 groups (see Figure 3). A peak incidence of traumatic brain injuries has been observed in the motorcycle group, whereas a peak incidence of orthopedic lesions was seen in the car group. The highest incidence of traumatic brain injuries associated with motorcycle accidents was an expected finding because of the high velocity and the lack of protection in the operation of motorcycles in comparison with cars. In spite of the inconvenience of wearing helmets, the compulsory use of such protective equipment remains the only defense against such severe injuries.¹⁰⁻¹⁴

Monthly distribution of injuries

Finally, the analysis of the dates of injuries showed that the highest incidence of MVA-related maxillofacial injuries was seen in the summer and winter months (see Figure 4). The peak incidence of pedestrian injuries was observed in December, whereas the peak incidences for car and motorcycle accidents were in August and November. This monthly distribution of MVA-related facial injuries confirms the acknowledged trend of maxillofacial trauma incidence peaking in the Summer and Winter seasons.

CONCLUSIONS

This European multicenter study on MVA-related maxillofacial injury may represent another important step in our increasing understanding of vehicular accidents and their consequences. The importance of analyzing MVA-related facial injuries and their features and characteristics should be stressed. Further prospective studies about alcohol addiction and driving, as well as about the protective effects of safety equipment, could be fundamental to appropriately assess this socially important phenomenon.

REFERENCES

1. Cini MA, Prado BG, Hinnig Pde F, Fukushima WY, Adami F. Influence of type of helmet on facial trauma in motorcycle accidents. *Br J Oral Maxillofac Surg*. 2014;52:789-792.
2. Cox D, Vincent DG, McGwin G, MacLennan PA, Holmes JD, Rue 3rd, LW. Effect of restraint systems on maxillofacial injury in frontal motor vehicle collisions. *J Oral Maxillofac Surg*. 2004;62:571-575.

3. Fasola AO, Lawoyin JO, Obiechina AE, Arotiba JT. Inner city maxillofacial fractures due to road traffic accidents. *Dent Traumatol*. 2003;19:2-5.
4. Hitosugi M, Mizuno K, Nagai T, Tokudome S. Analysis of maxillofacial injuries of vehicle passengers involved in frontal collisions. *J Oral Maxillofac Surg*. 2011;69:1146-1151.
5. Iida S, Kogo M, Sugiura T, Mima T, Matsuya T. Retrospective analysis of 1502 patients with facial fractures. *Int J Oral Maxillofac Surg*. 2001;30:286-290.
6. Lehto KS, Sulander PO, Tervo TM. Do motor vehicle airbags increase risk of ocular injuries in adults? *Ophthalmology*. 2003;110:1082-1088.
7. Nóbrega LM, Cavalcante GM, Lima MM, Madruga RC, Ramos-Jorge ML, d'Avila S. Prevalence of facial trauma and associated factors in victims of road traffic accidents. *Am J Emerg Med*. 2014;32:1382-1386.
8. Oginni FO, Ugboko VI, Ogundipe O, Adegbehingbe BO. Motorcycle-related maxillofacial injuries among Nigerian intracity road users. *J Oral Maxillofac Surg*. 2006;64:56-62.
9. Ramli R, Abdul Rahman R, Abdul Rahman N, et al. Pattern of maxillofacial injuries in motorcyclists in Malaysia. *J Craniofac Surg*. 2008;19:316-321.
10. Yamamoto K, Matsusue Y, Horita S, et al. Maxillofacial fractures of pedestrians injured in a motor vehicle accident. *Cranio-maxillofac Trauma Reconstr*. 2013;6:37-42.
11. Yokoyama T, Motozawa Y, Sasaki T, Hitosugi M. A retrospective analysis of oral and maxillofacial injuries in motor vehicle accidents. *J Oral Maxillofac Surg*. 2006;64:1731-1735.
12. Salentijn EG, Peerdeman SM, Boffano P, van den Bergh B, Forouzanfar T. A ten-year analysis of the traumatic maxillofacial and brain injury patient in Amsterdam: incidence and aetiology. *J Craniomaxillofac Surg*. 2014;42:705-710.
13. Salentijn EG, Collin JD, Boffano P, Forouzanfar T. A ten year analysis of the traumatic maxillofacial and brain injury patient in Amsterdam: complications and treatment. *J Craniomaxillofac Surg*. 2014;42:1717-1722.
14. Boffano P, Kommers SC, Karagozoglou KH, Forouzanfar T. Aetiology of maxillofacial fractures: a review of published studies during the last 30 years. *Br J Oral Maxillofac Surg*. 2014;52:901-906.
15. Giarda M, Tavolaccini A, Arcuri F, Bruccoli M, Benech A. Surgical approach to isolated bilateral orbital floor fractures. *Acta Otorhinolaryngol Ital*. 2015;35:362-364.
16. Benech A, Nicolotti M, Bruccoli M, Arcuri F. Intraoral extramucosal fixation of fractures in the atrophic edentulous mandible. *Int J Oral Maxillofac Surg*. 2013;42:460-463.
17. Arcuri F, Bruccoli M, Baragiotta N, Benech R, Ferrero S, Benech A. Analysis of complications following endoscopically assisted treatment of mandibular condylar fractures. *J Craniofac Surg*. 2012;23:e196-e198.
18. Bruccoli M, Arcuri F, Cavenaghi R, Benech A. Analysis of complications after surgical repair of orbital fractures. *J Craniofac Surg*. 2011;22:1387-1390.
19. Lee KH, Qiu M. Characteristics of alcohol-related facial fractures. *J Oral Maxillofac Surg*. 2017;75:786.e1-786.e7.
20. Peltola EM, Koivikko MP, Koskinen SK. The spectrum of facial fractures in motor vehicle accidents: an MDCT study of 374 patients. *Emerg Radiol*. 2014;21:165-171.
21. Bagheri SC, Dierks EJ, Kademani D, et al. Application of a facial injury severity scale in craniomaxillofacial trauma. *J Oral Maxillofac Surg*. 2006;64:408-414.
22. Bruccoli M, Boccafoschi F, Boffano P, Broccardo E, Benech A. The Anatomage Table and the placement of titanium mesh for the management of orbital floor fractures. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2018;126:317-321.
23. Bruccoli M, Nestola DF, Baragiotta N, Boffano P, Benech A. Maxillofacial fractures: epidemiological analysis of a single centre experience. *Otorinolaringologia*. 2018;68:132-137.
24. Bruccoli M, Boffano P, Magnano M, Mistretta R, Benech R, Benech A. The management of a high-risk patient with edentulous mandibular fractures. *Otorinolaringologia*. 2019;69:42-44.

Reprint requests:

Paolo Boffano,
Department of Maxillofacial Surgery,
University of Eastern Piedmont,
Novara,
Italy.
Paolo.boffano@gmail.com