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ORIGINAL ARTICLE

Maxillofacial injuries in severely injured patients after road traffic accidents—a retrospective evaluation of the TraumaRegister DGU® 1993–2014

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Abstract

Objectives It was the aim of the study to analyse the prevalence of maxillofacial trauma (MFT) in severely injured patients after road traffic accidence (RTA) and to investigate associated factors.

Materials and methods In a retrospective study, data from patients after RTA by the TraumaRegister DGU® from 1993 to 2014 were evaluated for demographical and injury characteristics. The predictor variable was mechanism of injury and the outcome variables were type of injury, severity and hospital resources utilization.

Results During the investigation period, $n = 62,196$ patients were enclosed with a prevalence of maxillofacial injuries of 20.3% (MFT positive). The injury severity score of MFT-positive patients was higher than in the MTF-negative subgroup (27 ± 12.8 vs. 23.0 ± 12.7). If MFT positive, 39.8% show minor, 37.1% moderate, 21.5% serious and 1.6% severe maxillofacial injuries. Injuries of the midface occurred in 60.3% of MTF-positive patients. A relevant blood loss (> 20% of total blood volume) occurred in 1.9%. MFT-positive patients had a higher coincidence with cervical spine fractures (11.3% vs. 7.8%) and traumatic brain injuries (62.6% vs. 34.8%) than MFT-negative patients. There was a noticeable decrease in the incidence of facial injuries in car/truck drivers during the study period.

Conclusions Every 5th patient after RTA shows a MFT and the whole trauma team must be aware that this indicates a high prevalence of traumatic brain and cervical spine injuries.

Clinical relevance Even if sole injuries of the face are seldom life threatening, maxillofacial expertise in interdisciplinary trauma centres is strongly recommended.

Keywords Maxillofacial injury · Trauma · Epidemiology · Road traffic accident

Introduction

Epidemiology of facial trauma was reported to vary across the world and depends on social and economic differences [1, 2]. Traffic accidents contribute to the worldwide deaths in a significant way also leading to moderate as well as serious injuries requiring hospitalization [3]. Even if the introduction of seat belts and the improvement of safety systems led to a significant

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reduction of injury severity and death after traffic accidence, they are still one of the major causes for maxillofacial injuries in adults [2, 4]. Those injuries may result in a loss of function, disfiguration, psychological problems or even disability and death [5]. The assessment of facial injuries is often perceived as difficult by the ambulance. In particular, this is due to the fact that injuries in the maxillofacial area offer special features and that there is often a lack of subject-specific competence [6]. Nevertheless, Esmer et al. found evidence that about 25% of all severely injured patients are suffering from maxillofacial injuries as well [7]. These injuries can be less severe, such as injuries to soft tissue or teeth, or life-threatening, such as bleedings from major arteries [8].

Even in primarily isolated maxillofacial injuries, energy may inevitably be transmitted to other anatomical structures of the head and neck, which can also be involved in a variety of pathological lesions such as spine injury [9]. This impact which is focused toward the body resulting in multiple injuries which varies in severity may be increased in cases of polytraumatised patients after traffic accidents.

In order to develop and implement effective interventions to reduce the medical burden, a better understanding of maxillofacial injuries in severely injured patients after traffic accidents is needed. Though, as the causes of maxillofacial injuries have been shown to vary not only from one country to another but even within the same country depending on the prevailing socioeconomic, cultural, and environmental factors [10], studies with large case numbers are needed in order to allow general conclusions. Therefore, the aims of this study on a large cohort of affected patients were to describe the patterns of the respective injuries and to identify those factors associated with road traffic accidents. As secondary parameter, changes within the patterns of injury within a 20-year period were examined.

Materials and methods

In this retrospective study, data provided by the TraumaRegister DGU® were analysed following the STROBE recommendations [11]. The study has received a positive vote from the Ethics Committee of the Medical School of the University of Ulm, Germany (from 17th of December 2017), and was performed in compliance with the Helsinki Declaration (October 2013).

The TraumaRegister DGU® of the German Trauma Society (TR-DGU) was founded in 1993. The aim of this multi-centre database is the pseudonymised and standardised documentation of care for severely injured patients. Data are collected prospectively from the site of the accident until discharge from hospital. Included are patients who are admitted to hospital via emergency room and subsequently receive intensive or intermediate care and patients who arrive at hospital with vital signs and die before admission to the intensive care unit. The infrastructure for documentation, data management and data analysis is provided by the Academy for Trauma Surgery, which is affiliated to the German Trauma Society. Scientific data analysis is approved according to a peer review procedure established by the Committee on Emergency Medicine, Intensive Care and Trauma Management (Sektion NIS) of the German Trauma Society. The participating hospitals are mainly located in Germany. Currently, approximately 40,000 cases from more than 600 hospitals are entered into the database per year. For hospitals associated with TraumaNetzwerk DGU®, the entry of at least a basic data set is obligatory for reasons of quality assurance [12]. The present study is in line with the publication guidelines of the TraumaRegister DGU® and is registered as TR-DGU Project ID 2014-026.

Study period and population

During the study period from 1993 to 2014, patients who underwent primary treatment at a local (level III), regional (level II) or supra-regional trauma centres (level 1) (as defined by the DGU) were included [12]. The study collective comprised all patients who were involved into a road traffic accident (RTC) and were admitted to the trauma room with at least one "serious injury" (Abbreviated Injury Scale (AIS) 3 or higher). Patients from hospitals other than Germany were excluded due to their potentially other emergency medical services (EMS) systems. Patients who did not undergo immediate surgery or were not admitted to intensive care unit (ICU) were also excluded. Revised Injury Severity Classification II (RISC II) scores were calculated in order to predict mortality and thus to assess the probability of survival at the time of hospital admission [13]. An exclusion on variable level was carried out when values were not available [14].

Procedures and variables examined

Next to demographic details, the type of transportation (car/truck, motorcycle, bike, pedestrian) before trauma was assessed. Patients with an injury to the face (AIS region 2), including orbita, nose, ears, jaw, (inner) mouth, were assigned to the maxillofacial trauma group (*MFT pos*). Patient without maxillofacial injuries belonged to the *MFT neg* group. In *MFT pos*, the respective facial injury pattern was analysed. Furthermore, the different injury combinations in comparison of *MFT pos* and *MFT neg* were investigated. In addition, the association between injury pattern and type of trauma centre was examined. Finally, changes over time have also been analysed.

Statistical analyses

Results are presented in a descriptive manner. Continuous variables are given as mean and standard deviation (SD). Categorical variables were presented with frequency and percentages.

Ninety-five percent confidence intervals (95% CI) were calculated for selected results in order to demonstrate the degree of uncertainty. In order to give a better insight into the distribution of the data, median values were given in addition where appropriate. There was no formal testing (*MFT pos* vs. *MFT neg*) for statistical significance due to the large number of cases. Even small differences without clinical relevance were likely to be statistically significant. For this reason, differences of medical importance were termed "relevant". Data were analysed using SPSS statistical software (version 24, IBM, Armonk, USA).

Results

Demographic and clinical details of all included patients and noticeable differences between MFT pos and MFT neg

During the investigation period, the TR-DGU recorded n = 62,196 patients having suffered from a traffic accident with at least one serious injury. The mean age of all casualties was 42 years (median 42). A total of 71.4% of the casualties were men and 28.6% were women (Table 1). A total of 12,613 patients (20.3%) had a maxillofacial injury and 49,583 patients (79.7%) had not. The mean injury severity score (ISS) was 23.8 points (median 21). The ISS was relevantly higher in MFT pos (27.2 points/median 24) than in MFT neg (23.0 points/median 20). There was also a remarkable higher number of unconscious patients in MFT pos (37.1% vs 20.9%).

In hospital, 6702 (12.1%) of the patients died from the consequences of the accident and the resulting total in-hospital mortality in the collective at hand was 12.1%. The predicted mortality according to RISC II was higher in MFT pos (15.3%) than in MFT neg (11.5%) just as the observed hospital mortality (MFT pos 13.2% vs. MFT neg 11.8%). The highest inhospital mortality was among pedestrians in both groups between 19 and 20% (Tables 1, 2, and 3).

Cyclists showed a mean age of 51.4 (median 54) years and pedestrians of 49.5 (median 52) years. Those were relevant older when compared to car/truck inmates (mean 39.5/median 36 years) and motorcyclists (mean 39.5/median 40 years). A more detailed analysis regarding the type of road accident of patients without and with maxillofacial trauma is displayed in Table 2 and Table 3, respectively.

Injury patterns maxillofacial area (group *MFT pos*)

In *MFT pos*, 5017 (39.8%) patients showed minor (AIS = 1), 4677 (37.1%) moderate (AIS = 2), 2716 (21.5%) serious (AIS = 3) and 203 (1.6%) severe (AIS = 4) injuries in region 2. Most commonly, injuries of the midface were seen (7609 patients (60.3%)). Lower jaw injuries were diagnosed in 2436 (19.3%) and nasal injuries in 2851 patients (22.6%). Injuries of the eyes (6.7%), the mouth (6.3%) and the ear (4.8%) were less common (Fig. 1). Critical or massive bleeding (more than 20% blood volume loss is due to the facial injury) was documented in only 236 patients (1.9%).

Injury combinations

In *MFT pos*, 62.6% of 12,613 cases additionally showed a relevant injury of the neurocranium (Fig. 2). In contrast, *MFT neg* had relevant less lesions in this body region (34.8% of 49,583 cases). In addition, cervical spine injuries were seen in *MFT neg* in only 7.8% of 45,656 cases and *MFT pos* had relevant more respective lesions in this region (11.3% of 10,981 cases; Fig. 3). When comparing cervical spine trauma with AIS = 2 and AIS = 3, higher incidences were seen in *MFT pos* as well (9.8 vs. 6.6% and 1.5 vs. 1.2%) than in the MFT neg group (Figs. 2 and 3). Nevertheless, in *MFT neg*, a relevant increased combination of thoracic, abdominal as well as limb injuries was found.

Primarily chosen level of trauma centres

A total of 55,553 patients (89.3%) were primarily admitted to a trauma centre. The remaining 10.7% were secondary transfers from one hospital to another.

Of these primary admitted patients in the database, in total, 37,411 patients (67.3%) were admitted to a level I trauma centre, 15,318 (27.6%) in a level II trauma centre and in 2824 (5.1%) of the patients in a level III trauma centre. A total of 11,032 (19.9%) of these patients were diagnosed with facial injuries. A total of 8539 of those (77.4%) were treated in a level I, 2271 (20.6%) in a level II and 222 (2%) in a level III trauma centre. In contrast, patients without facial injuries were treated relevant less in a level I trauma centre (64.9%) and relevant more often in level II as well as level III trauma centres (29.3% & 5.8%) (Fig. 4). An accompanying intracranial trauma (AIS head ≥ 3) represents another predictor for admission to a level I trauma centre (Table 4).

Variety of prehospital intubation rates

In the MFT neg group, in 81.2% (20,438) intubation of conscious patients (Glasgow Coma Scale (GCS) > 8) was not performed. A total of 18.8% (4720) was intubated which might depend on preventive or sedation reasons. In contrast, within the MFT pos group, 30.2% (of 4382) conscious patients were primarily intubated. In unconscious patients (GCS $\leq$ 8), the intubation rate increased from 92.3% (MFT neg) to 93.3% (MFT pos) only.

Accordingly, similar results could be found in patients with critical or massive bleeding in the facial region. If such a bleeding occurred, the intubation rate in conscious patients (Glasgow

Table 1 Demographic data and selected figures from the prehospital and inhospital treatment as well as outcome parameters. Continuous data is presented with mean ± standard deviation, median

	Study collective ($n = 62{,}196$)	MFT neg ($n = 49{,}583$)	MFT pos ($n = 12{,}613$)
Demographic data			
Patient age [years]	42.7 ± 20.5, 42	43.1 ± 20.5, 42	41.1 2 20.1, 39
Male gender [%]	71.4% (44,274)	71.1% (35,162)	72.5% (9112)
Blunt trauma [%]	97.8% (59,519)	97.8% (47,416)	97.8% (12,103)
Type of RTA			
Car/truck driver [%]	46,3% (28,798)	45,7%(22,636)	48.9% (6162)
Motorcycle driver (2002–2014) [%]	23.6% (14,709)	25.8%(12,798)	15.2%(1911)
Bicycle driver (2002–2014) [%]	14.0% (8688)	12.8%(6363)	18.4%12325)
Pedestrian [%]	13.5% (8386)	13.1%(6499)	15% (1887)
Two-wheeler (until 2001) [%]	2.6% (1615)	2.6% (1287)	2.6% (328)
Prehospital setting (primary admitted cases only)			
Primary admitted cases	$n = 55{,}553$	$n = 44{,}521$	$n = 11{,}032$
Systolic BP [mmHg]	124 ± 31, 124	124 ± 31, 125	123 ± 31, 120
HR [/min]	90 ± 22, 90	90 ± 22, 90	90 ± 22, 90
GCS ≤ 8 [%]	24.1% (12919)	20.9 (8948)	37.1% (3971)
Intubation and ventilation [%]	43.2% (23745)	39.2% (17249)	59.3% (6496)
HEMS[%]	33.7% (18338)	32.6% (14197)	38.2% (4141)
Transportation to Level I Trauma Centre [%]	67.3% (37411)	52.0% (28872)	77.4% (8539)
Inhospital setting			
Ventilator days (mean ± SD)	5.2 ± 10.0, 1	4.4 ± 9.3, 1	7.1 ± 11.2, 2
ICU days (mean ± SD)	9.1 ± 12.6, 4	8.1 ± 12.1, 3	11.5 ± 13.6, 6
Hospital days (mean ± SD)	22.4 ± 22.5, 17	22.1 ± 22.6, 16	23.3 ± 21.8, 18
Sepsis [%]	7.7% (2364)	7.2% (1722)	9.3% (642)
Any organ failure [%]	40.4% (12,813)	37.9% (9298)	48.9% (3515)
Injury severity and outcome			
155 (mean ± SD)	23.81 ± 12.9, 21	23.0 ± 12.7, 20	27.2 ± 12.8, 24
HISS (mean ± SD)	29.0 ± 14.6, 26	28.2 ± 14.4, 24	31.9 ± 14.9, 27
Predicted mortality according to RISC II[a] [%]	12.2%	11.5%	15.3%
Observed hospital mortality [a] [%]	12.1% (6702)	11.8% (5245)	13.2% (1457)

RTA road traffic accident, *BP* blood pressure, *HR* heart rate, *GCS* Glasgow Coma Scale, *HEMS* Helicopter Emergency Medical Service

[a] Primary admitted cases only

Table 2 Demographic and clinical data of included patients without a maxillofacial trauma

	Demographic data		Prehospital setting			Inhospital setting			Injury severity and outcome	
Type of RTA	Patient age [mean] [years]	Male gender [%]	GCS ≤ 8 [%]	Level 1 trauma centre	Intubation and ventilation	ICU days (median)	Days intubated and ventilated (median)	Hospital days (median)	ISS (mean)	Inhospital mortality [%]
Car/truck driver	41.9	63.9%	19.5%	61.0%	40.0%	3	1	16	23.1	10.6%
Motorcycle driver (2002–2014)	39.6	90.3%	14.8%	63.3%	33.5%	3	0	17	21.8	7.1%
Bicycle driver (2002–2014)	51.0	69.6%	22.9%	63.2%	31.6%	3	0	13	21.1	11.9%
Pedestrian [%]	49.9	56.5%	26.9%	68.4%	39.6%	3	1	16	23.9	19.4%

Table 3 Demographic and clinical data of included patients with a maxillofacial trauma (AIS ≥ 1)

	Demographic data		Prehospital setting			Inhospital setting			Injury severity and outcome	
Type of RTA	Patient age [mean] [years]	Male gender [%]	GCS ≤ 8 [%]	Level 1 trauma centre	Intubation and ventilation	ICU days (median)	Days intubated and ventilated (median)	Hospital days (median)	ISS (mean)	Inhospital mortality [%]
Car/truck driver	35.9	71.0%	36.2%	74.5%	63.7%	7	2	19	27.8	11.3%
Motorcycle driver (2002–2014)	38.8	90.7%	36.4%	77.2%	59.6%	7	2	19	27.8	11.1%
Bicycle driver (2002–2014)	52.5	71.4%	32.6%	74.0%	42.9%	4	1	14	24.0	10.9%
Pedestrian [%]	49.7	60.8%	41.5%	77.1%	54.4%	5	1	18	28.2	19.8%

Coma Scale (GCS) > 8) increased significantly from 20.4% (of 29487 patients) to 54.7% (of 53 patients). In unconscious patients (GCS ≤ 8), the intubation rate increased from 92.6% (of 7484 patients) to 97.2% (of 108 patients) (Fig. 5).

Changes of facial injuries over the investigation period

There was a noticeable decrease in the incidence of facial injuries in car/truck drivers over the years (35.1% of 3108 cases in the years 1993–2001, 24.8% of 6972 cases in 2002–2008 and 17.8% of 18718 cases in the years 2009–2014). The percentage of facial injuries suffered by motorcyclists, cyclists and pedestrians has barely changed over the years (Fig. 6a).

Because of the significant reduction of facial injuries in the group of car/truck drivers, the anatomical regions of the facial injuries were separately analysed for this group. The midfacial injuries decreased from 15.2% of 3108 cases in the years 1993–2001 to 11.9% of 6972 cases in 2002–2008 and 10.6% of 18718 cases in the years 2009–2014. After an increasing incidence of mandibular injuries from 6.9% in the years 1993–2001 to 8.2% in 2002–2008, a marked decline to 2.9% in the latest period of the years 2009–2014 could be recognised. Another reduction could be proven by the incidence of mouth injuries from 2.2% of in the years 1993–2001 to 2.0% in 2002–2008 and 1.3% in the years 2009–2014. There were no relevant changes in the incidences of injuries in the eye, ear and nose region or in the findings of critical bleedings (Fig.6a, b).

Discussion

Over a period of more than 20 years, this study covers all traffic accidents resulting in severely injured patients recorded in the TraumaRegister DGU® and represents the largest

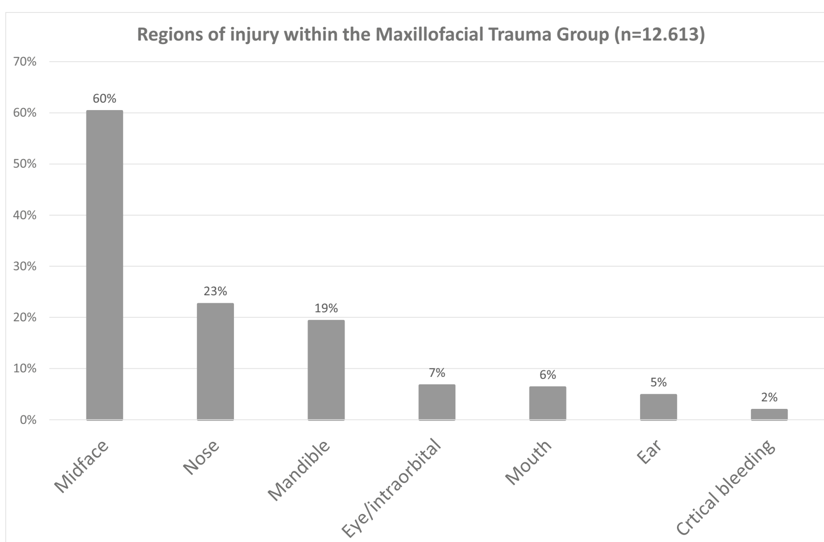


Fig. 1 Affected anatomical regions of the maxillofacial trauma group

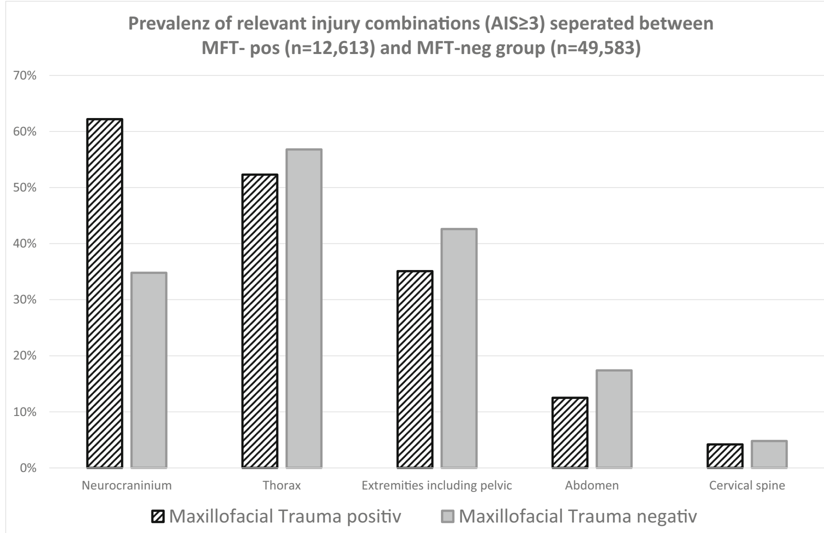


Fig. 2 Associations between maxillofacial trauma and other injuries

cohort published so far. Twenty percent of all patients showed an injury in the maxillofacial area constituting mostly of lesions in the midface, the lower jaw as well as the nose. Predominance of injuries of the midface was described before whereas the mandible, even if an exposed location, was affected less commonly [8]. In accordance, Rashid et al. concluded that most mandibular fractures were associated with interpersonal violence and falls whereas the incidence of fractures associated with traffic accidents became low also reflecting improvements in car safety. Schneider et al. came to the conclusion that only 13% of maxillofacial fractures were result of traffic accidents [4, 15, 16]. Nevertheless, this seems to apply for Germany/Central Europe only as other countries reported different major causes for maxillofacial injuries [10].

The given prevalence is similar if not slightly higher to those reported by others [5, 17] whereas a recent publication showed concomitant injuries to the facial skull in about 39% of cases [8]. The injury pattern of severely injured patients after traffic accidents has changed for car/truck accidents only. For all other types of accident, the combinations of injury patterns have largely remained the same over the years. Some authors reported that accidents involving motorcycles were the most prevalent. For example, in Malaysia, motorcycle-related fatalities are reported to be three times higher than car fatalities, six times higher than pedestrian and 50 times higher than bus passenger fatalities [18]. Nevertheless, others analysed in 2008 that accidents involving automobiles were the most frequent cause [5, 17]. In the developed countries, greater prevalence of facial trauma among victims of automobile accidents than among victims of motorcycle accidents may be due to the use of airbags, which, despite reducing the incidence and severity of injuries in general, may contribute to facial injuries. In contrast to this,

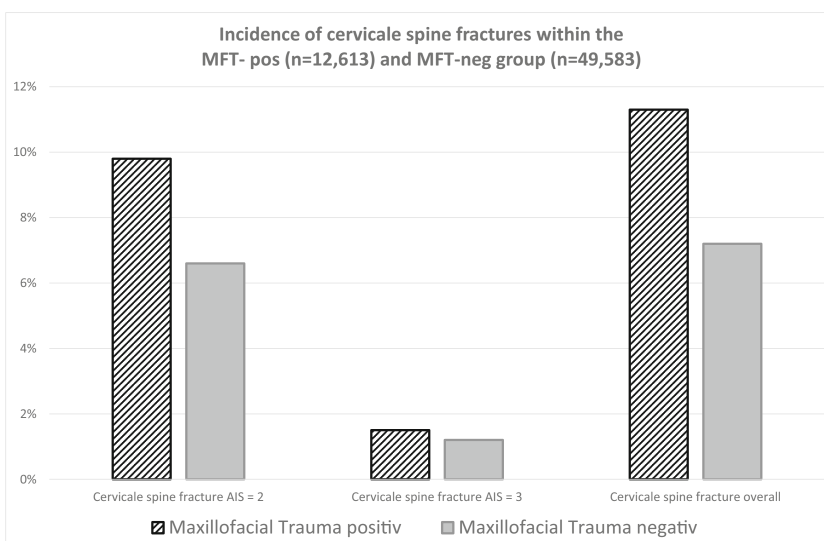
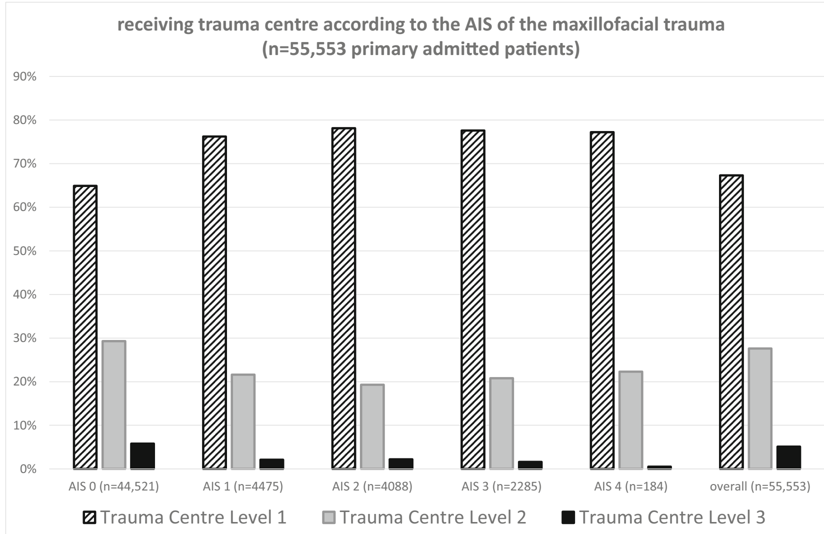


Fig. 3 Associations between maxillofacial trauma and cervical spine fractures

Fig. 4 Place of admission in the various centres according to AIS Region 2 (maxillofacial)



increased education campaigns and monitoring in regard of protection equipment such as helmets may have reduced facial injuries while driving a motorcycle or riding a bike [19, 20]. The predominance of male patients with 71.4% of the casualties is consistent with the literature [4, 5, 21] even if it was not seen as high as the ratio of 13:1 reported by Moafian et al. showing a lack of established cultural patterns [22]. The mean age of 42 years in the study at hand is similar to others [8] whereas in less recent studies, the peak was reported to be between 32 and 40 years [23, 24]. In accordance, a shift towards older patients may be assumed.

Maxillofacial injuries are rarely the leading diagnosis as stabilization and warming of patients on the trauma unit is of paramount importance so facial injuries are often diagnosed later [25]. Nevertheless, they are frequently associated with major trauma of the cervical spine and the neurocranium/head. Analogue to this, a correlation between facial injuries and other injuries of the head has been described to exist in 19–30% of cases [15, 26, 27]. Tsang and Whitfield stated that in 24% of cases with craniofacial fractures, additional fractures in the base of the skull were seen [28]. This could be attributed to transfer of force from the facial skeleton to the cranium. However, some investigations have suggested that the facial skeleton may actually transmit forces directly to the neurocranium, resulting in serious brain injury. An association between injury to the upper and midfacial skeleton and varying severity of brain injury had been suggested [29, 30]. In accordance, at the latest in the trauma room, the entire patient must be re-evaluated in a priority-oriented manner in order not to endanger him or her due to initially unrecognised or underestimated injuries [31]. Though, especially in polytraumatised patients, a delay in correct diagnosis of lesions is evident in 5–14% of cases [32]. For example, the unsuspected comorbidity of the cervical spine as an infrequent but serious risk after maxillofacial injury was illustrated by a recent publication by Reich et al. underlining the results of the study at hand. From a traumatological/orthopaedic point of view, patients with cervical spine injuries present in 6–19% of cases with significant maxillofacial trauma [9, 33, 34] and the probability of a blunt spine injury seem to rise with an increased complexity of the maxillofacial injury (Fig. 3) [35].

Sargent and Rogers formulated that early restoration with anatomic reduction and fixation of the midfacial fractures led to a reduction in oedema formation as well as a better recontouring of facial soft parts [36]. Scholz et al. found the least rate of complications for surgical reduction of midface fractures between the 2nd and the 8th day [37]. In contrary, other authors did not see an increase in complications when using a rather delayed approach for maxillo-facial fractures [6, 24]. Rothweiler et al. even concluded that a delayed approach (> 72 h) led to less complications [8]. Of course, events such as unstable bleeding, exposed cartilage to the nose and ear as well as intra-orbital or intra-canalicular damage to the visual pathway make a therapeutic action necessary within a few hours.

Table 4 Influence of maxillofacial injuries and neurocranial disturbances (AIS ≥ 3) on primary admittance to a level I trauma centre

Primary admission to Level I Trauma Centre (traumatic brain injury)		
TBI neg and MFT neg.	TBI pos. and MFT neg.	TBI pos. and MFT pos.
52 6%	69.0%	77.3%
primary admission to Level I Trauma Centre (Glasgow-Coma-Scale)		
GCS > 8 and MFT neg.	GCS ≤ 8 and MFT neg.	GCS ≤ 8 and MFT pos.
53.9%	73.6%	79.4%

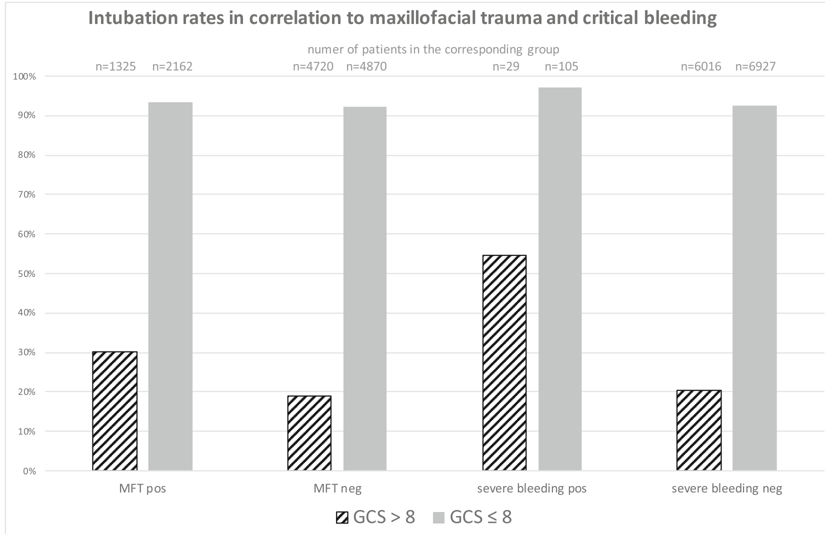


Fig. 5 Varieties in intubation rates between MFT pos and MFT neg group (left side) and in correlation with critical bleeding (right side)

In accordance, basic maxillofacial competence is recommended in all trauma centres, for example in order to immediately detect a retrobulbal hematoma and shift the patient to a centre with maxillo-facial- and/or ophthalmologic expertise as soon as possible. Here, early decompression of the orbita is one major aspect to prevent a permanent loss of function of the optical nerve with otherwise might lead to a consecutive reduced vision or even blindness [38]. Another rare but life-threatening complication of midfacial fractures is a traumatic bleeding of the maxillary artery. This can occur directly after the trauma or delayed after rupture of a traumatic pseudoaneurysm or caused by movement of bony fragments [39]. Therefore, all emergency physicians and trauma surgeons should be aware of this complication and should be trained in stopping the bleeding by using packings, belocq tamponades or expandable local catheters until definitive open surgical ligature or interventional radiological catheter-based embolization can be performed.

A safer and less complication-associated solution might be sufficient availability of maxillofacial surgeons, as well as ophthalmologists and ENT specialists on demand in each trauma centre. On one hand, it appears reasonable that this lack of experts in local and regional trauma centres (level II and III) is due to economic reasons. On the other hand, there will be no second chance for primary reconstruction in some cases. The costs for secondary functional rehabilitation of these patients can be higher if rehabilitation is still possible at all.

In addition, facial injuries often have a disfiguring and extremely stressful effect. Baecher et al. were able to prove a dependence on injury region and post-traumatic stress disorder. The risk to be taken ill by post-traumatic stress disorder (PTSD) significantly increased if injuries of the skull and face region are prevalent compared to other body regions.

Limitations

This secondary data analysis is limited by its retrospective nature. Although efforts are undertaken by the TR-DGU to increase data completeness and data correctness as well as to include all severely injured patients (e.g. regular reports of data completeness, audits of all trauma centres regarding data correctness), up to 10% of all cases likely go unreported [40]. In addition, it must be mentioned that the number of participating trauma centres increased from 5 in the year 1993 to more than 500 in 2014. Furthermore, in the beginning of the TR-DGU,

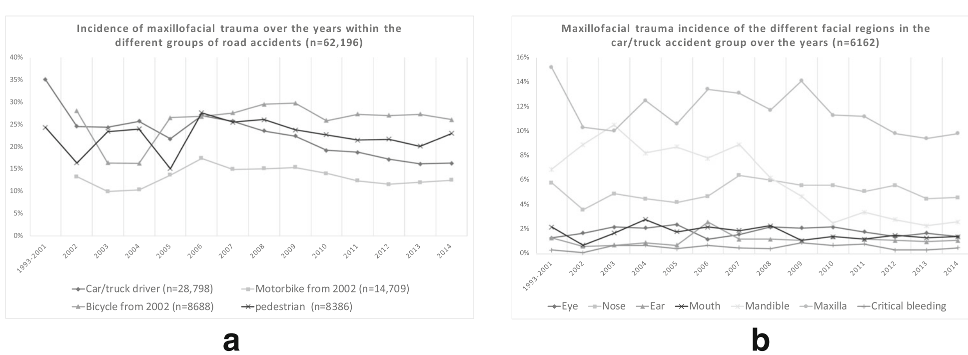


Fig. 6 **a** Incidence of maxillofacial trauma over the years within the different groups of road traffic accidents ($n = 1615$ two-wheeler until 2001 are not included into the diagram). **b** Maxillofacial trauma incidence of the different facial regions in the car/truck accident

most participating hospitals were level I trauma centres which might have influenced the presented results as well.

Also, maxillofacial injuries might be overseen if they were not obvious. In accordance, CT scan of the midface was not always conducted in the past. Though, as several authors showed a positive integration of whole-body CT in the diagnostic assessment of trauma room patients, an increase of the respective detection over the years can be assumed [41, 42]. A further limitation of the study is the absence of details of maxillofacial injuries. Even documentation and especially coding has shown to be not reliable [43] and it can be assumed that this especially applies for maxillofacial injuries if they are primarily documented and coded by trauma surgeons. Moreover, it should be stressed that all data are limited to severely injured patients who arrived alive the emergency department and were treated by a multidisciplinary trauma team.

Conclusion

Data from the study at hand indicate that patients with sustained multiple injuries (including maxillofacial injuries) may benefit from an early multidisciplinary management in a specialised trauma centre wherein close collaboration between trauma-, neuro-, ophthalmology-, ENT- and maxillofacial surgeons can be ensured. On one hand, every 5th patient after road traffic accident needs a maxillofacial expertise and the trauma team must be aware, that maxillofacial trauma indicates a high suspicious of traumatic brain and cervical spine injuries. On the other hand, injuries of the midface are seldom the leading diagnosis of this patient collective—especially a relevant bleeding is rare.

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Compliance with ethical standards

Conflict of interest Sebastian Pietzka declares that he has no conflict of interest. Peer W. Kämmerer declares that he has no conflict of interest. Silke Pietzka declares that she has no conflict of interest. Alexander Schramm declares that he has no conflict of interest. Lorenz Lampl declares that he has no conflict of interest. Rolf Lefering declares that he has no conflict of interest. Dan Bieler declares that he has no conflict of interest. Martin Kulla declares that he has no conflict of interest.

Ethical approval The present study has been approved by the Ethic Committee of the Medical School of the University of Ulm (positive Vote 17th December 2017). All procedures were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent For this type of study, formal consent is not required.

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