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W.B. Saunders
2024

Färkkilä, E M, Oksanen, E, Kormi, E & Suojanen, J 2024, 'What Is the Relationship Between Maxillofacial Injury Location and Associated Injuries?', Journal of Oral and Maxillofacial Surgery, vol. 82, no. 7, pp. 800-805. https://doi.org/10.1016/j.joms.2024.03.025

http://hdl.handle.net/10138/590449
10.1016/j.joms.2024.03.025

What Is the Relationship Between Maxillofacial Injury Location and Associated Injuries?

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Background: Patients sustaining maxillofacial fractures are at risk for associated injuries (AIs) to other body regions. The incidence of AIs is reported to be from 20 to 35%. AIs may be life-threatening and play a key role in considering first-line management at the emergency department, as well as planning the definitive treatment of maxillofacial fractures.

Purpose: The study aimed to determine the frequency and risk factors for AIs in patients with maxillofacial fractures.

Study Design, Setting, Sample: The investigators designed and implemented a retrospective cohort study of patients with facial fractures treated at Central Hospital (Lahti, Finland) from January 1, 2009 through December 31, 2019. All adult patients with verified maxillofacial fractures were included. Patients under 18 years of age were excluded from the study.

Predictor Variable: The predictor variable was the location of the maxillofacial fractures grouped into three categories: mandible alone, midface alone, and both midface and mandible.

Main Outcome Variable(s): The primary outcome variable was associated body region injuries coded as present or absent. The secondary outcome variable was the location of the AI categorized as skull, neck, thorax, pelvis, or extremity injuries.

Covariates: Other study variables included demographic data (age, sex, alcohol use), Glasgow Coma Scale, and etiology (fall, traffic- and bicycle accident, assault, pedestrian hit by motor vehicle, work-related, or sports/free-time injuries).

Analyses: Continuous variables were analyzed for normal distribution using the Shapiro-Wilks test and compared with categorical variables using the Mann-Whitney test. The univariate analyses of categorical variables were analyzed by the χ^2 test ($P \leq .05$ was considered statistically significant).

Results: During the study period, 443 adult (≥18) patients had maxillofacial fractures. AIs were present in 88 subjects (20%). The mean age was 47.6 years (range 18-91); 52 years with AIs (range 19-91), and 47 years (range 18-92) without AIs ($P = .03$). Subjects with midface and mandible + midface fractures

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Conflict of Interest Disclosures: None of the authors have any relevant financial relationship(s) with a commercial interest.

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Received August 12 2023

Accepted March 22 2024

0278-2391/24/00207-6

https://doi.org/10.1016/j.joms.2024.03.025

had greater risk to AIs compared to mandibular fractures (relative risk 2.0, P = .002, relative risk 2.8, P = .009).

Conclusion and Relevance: Every fifth maxillofacial trauma patient had an associated injury. Trauma patients should be evaluated in institutions with trauma protocols and imaging modalities before determining and executing the treatment plan for maxillofacial fractures.

J Oral Maxillofac Surg 82:800-805, 2024

Patients sustaining maxillofacial fractures are at a high risk for various concomitant traumatic injuries. The incidence of these associated injuries (AIs) is reported to be from 20 to 35%.[1,2] As AIs may be life-threatening, they play a key role in considering first-line management at the emergency department, as well as planning the definitive treatment of maxillofacial fractures.[3-6] In patients with maxillofacial fractures, certain factors, such as high-energy trauma, severe facial fractures, and advanced age, are reported to increase the risk of concomitant AIs.[1,7,8] Skull fractures, intracranial hemorrhages, and extremities are the most common AIs in patients with maxillofacial fractures,[1,8,9] and advanced age has been reported to increase the risk of having a cervical spine injury (CSI) or rib fractures.[7,10-12] The risk of a head injury is reported to be 3 to 20 times higher in patients with a concomitant maxillofacial fracture.[13] The incidence and pattern of maxillofacial fractures are widely studied.[14-16]

It is important to be aware of the high frequency of concomitant AIs in these patients even with low-energy trauma. Several trauma protocols are used to evaluate patients at the emergency department, and Advanced Trauma Life Support protocols should be followed.[17,18] In large hospitals managing traumatic injuries, trauma surgeons are the first to evaluate patients with maxillofacial fractures. First, the airway is secured, bleeding is controlled, and life-threatening injuries are managed. In outpatient settings and smaller hospitals, oral and maxillofacial surgeons among other reconstructive surgeons might be the first to evaluate maxillofacial trauma patients. To evaluate and document the association between maxillofacial fractures and AIs, we conducted a 10-year retrospective study at Päijät-Häme Central Hospital (PHCH) between 2009 and 2019. As the second largest nonuniversity hospital in Finland, PHCH functions as an acute care unit and a secondary referral hospital, serving a population of 215,000 in the city of Lahti.

The purpose of this study was to determine the frequency and risk factors for AIs in patients with maxillofacial fractures. The investigators hypothesize that there is a set of one or more risk factors that are associated with AI in settings of maxillofacial trauma. The specific aims were *1)* to determine the frequency of AIs in patients with maxillofacial fractures, *2)* to identify the demographic and injury risk factors for AIs, and *3)* to describe specific AIs among maxillofacial fractures.

Material and Methods

STUDY DESIGN/SAMPLE

This was a retrospective cohort study of all patients with maxillofacial fractures treated at PHCH (Lahti, Finland) from January 1, 2009 through December 31, 2019.

The study was approved by the institutional review board (D/18/07.01.04.05/2018 and D/2929/07.01.04.05/2020). Patients were identified from the patient records based on the International Classification of Diseases, Ninth Revision (2007 to 2014) codes 802.0 to 802.99, 805.0 to 805.18, 806.00 to 806.19, and 847.0, and the International Classification of Diseases, Tenth Revision (2015 to 2017) codes S02.2 to S02.04, S02.6 to S026.9, and S07. These codes correspond to fractures involving the nasal bone, orbit, zygoma, maxilla, and mandible. In this study, adult (≥18) patients were included as study subjects if they had a maxillofacial fracture, complete medical records, and complete imaging data. Patients under the age of 18 were excluded, as well as the patients coded with a fracture diagnosis during admission but whose later clinical and/or radiological examination ruled out the diagnosis.

VARIABLES

The primary predictor variable was the location of the maxillofacial fracture(s) and it was grouped into three categories: mandible alone, midface alone, or both midface and mandible. Subjects with mandible fractures had a fracture of one or more of the following regions: symphysis/parasymphysis, body, angle, or ramus-condyle-unit. Subjects with midface fractures had a fracture of one or more of the following bones or locations: nose, zygoma, orbit, maxillary wall, and Le Fort fractures.

The main outcome variable was the associated injury (AI), whereas the secondary outcome variables

were specific AI locations: skull, neck, thorax and pelvis injuries, and injuries in extremities.

Covariates included demographic data (age, sex, alcohol use), Glasgow Coma Scale, and etiology (fall, traffic accidents [including motor vehicle crash, motorcycle accidents, pedestrian hit by motor vehicle], bicycle accident, assault, work-related or sports/free-time injuries).

Patients were evaluated according to the general trauma protocols, which were updated with the best knowledge available, including Advanced Trauma Life Support. In brief, the airway is secured, the bleeding is controlled, and life-threatening injuries are managed.

DATA COLLECTION METHODS

Hospital charts were reviewed for demographic characteristics and injury-related data (bones involved, mechanisms of injury, AIs, and clinical findings). Mandibular fracture sites were categorized based on the radiographs (panoramic and/or computed tomography scans). The sites were defined as follows: *1)* parasymphyseal or symphyseal region, between the canines; *2)* body, from canines to second molars; *3)* angle, third molar area to the angle of the mandible; coronoid, the temporalis muscle attachment area; and *4)* ramus-condyle-unit, as the proximal portion of the mandibular bone. Other maxillofacial fractures and sites also were confirmed on the imaging (computed tomography scans). AIs were divided into 5 categories according to location: *1)* skull, including intracranial hemorrhage, contusion hematoma, and skull and cranial vault fractures; *2)* extremities; *3)* thorax, including lung, and thoracic spine injuries; *4)* pelvis and abdomen, including lumbar spine, kidney, spleen, and liver injuries; and *5)* neck, including CSIs and blunt cerebrovascular injuries (BCVIs).

DATA ANALYSES

Statistical analyses were conducted with JMP pro-15.0 (SAS Institute, Cary, NC) software. Continuous variables were analyzed for normal distribution using the Shapiro-Wilk test and compared with categorical variables using the Mann-Whitney test. The univariate analyses of categorical variables were analyzed by the χ^2 test. The data are presented as a mean (range) or number (%). For all analyses, a P value of .05 or less was considered statistically significant.

Results

During the study period, 443 adult (≥18) patients with maxillofacial fractures and adequate medical records were identified from the hospital records and included as study subjects. Table 1 and Table 2 present covariates, including the demographic data of the study subjects. AIs were present in 88 subjects (20%). The mean age of subjects was 47.6 years (range 18 to 91); 52 years with AIs (range 19 to 91); and 47 years (range 18-92) without AIs. Subjects sustaining mandibular fractures were younger compared to subjects with midface fractures; regarding the subjects with maxillofacial fractures, females were significantly older (female mean age 55.3 vs male mean age 44.1 $P < .0001$). Of the 443 subjects, 302 (68%) were male. The Glasgow Coma Scale for all subjects with maxillofacial fractures was 14.8 and it was statistically significantly lower in subjects with a concomitant AI (14.1 vs 14.9, $P < .001$). Table 1 demonstrates the demographic data and injury etiology between mandible fractures, mandible plus midface fractures, and midface fractures.

In descending order, fall (n = 167), assault (n = 142), sport and free-time injuries (n = 38), and bicycle accidents (n = 39) were identified as the most common mechanisms of injury (Table 2). Subjects injured in traffic accidents exhibited a significantly higher risk to have an AI when compared to other mechanisms. Regarding the maxillofacial fractures, an operative treatment was chosen for 55% (n = 242) of the 443 subjects. Within the group of these subjects, 197 (44%) subjects tested positive for alcohol, 247 tested

Table 1. COVARIATES AND MAXILLOFACIAL FRACTURES

Covariates	Mandible FXs, n = 175 (40%)	Midface Fx, n = 250 (57%)	Mandible + Midface, n = 18 (4%)	*P* Value
Age, mean (range)	45 (18-92)	49 (18-92)	49 (22-86)	.09
Sex (male) (%)	119 (68)	170 (68)	12 (67)	.99
GCS, mean (range)	14.9 (3-15)	14.7 (3-15)	14.8 (14-15)	.17
Alcohol, positive test	66 (38)	123 (49)	8 (44)	.06
Etiology	175 (40)	250 (57	18 (4)	.001

Abbreviation: GCS, Glasgow Coma Scale.

Table 2. DEMOGRAPHIC CHARACTERISTICS AND COVARIATES IN ALL MAXILLOFACIAL FRACTURE PATIENTS WITH ASSOCIATED INJURY STATUS

Demographic Charasterics and Covarietes	All Subjects With Facial Fx, n = 443	Facial Fractures			
		With Associated Injuries, n = 88 (20%)	Without Associated Injuries, n = 355 (80%)	RR (CI)	*P* Value
Age, mean (range)	47.6 (18-91)	52 (19-92)	47 (18-92)	-	.03
Sex	443	88 (20)	355 (80)	-	.33
Male	302 (68)	57 (64)	245 (69)	0.8 (0.8 - 2.1)	.33
Female	142 (32)	32 (36)	110 (31)		
GCS, mean (range)	14.8 (3-15)	14.1 (13.4-14.7)	14.9 (14.9 – 15.0)	-	< .0001
Positive alcohol	197 (44)	39 (44)	158 (45)	1.0 (0.7 - 1.4)	.97
Etiology	443	88 (20	355 (80)	-	<.0001
Fall	167 (37)	33 (38)	132 (37)	1.0 (0.7 - 1.5)	.95
Assault	142 (32)	21 (24)	121 (34)	0.7 (0.4 - 1.0)	.07
Sports and free time	38 (9)	0 (0)	38 (11)	-	.004
Bicycle	39 (9)	13 (15)	26 (7)	1.8 (1.1 - 3.8)	.04
Traffic accident	33 (7)	20 (23)	13 (4)	6.2 (3.2 - 12.0)	< .0001
Work-related	8 (2	1 (1)	7 (2)	0.6 (0.1 - 3.9)	.60
Other	16 (4)	1 (1)	15 (4)	0.3 (0.05 - 2.2)	.19

Abbreviations: CI, confidence interval; GCS, Glasgow Coma Scale; RR, relative risk.

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negative for alcohol, and the data for alcohol consumption were missing in 37 subjects.

Table 3 demonstrates the distribution of maxillofacial fracture sites related to AIs and risk ratio compared to mandibular fracture and concomitant AI (relative risk [RR] = 1). Of all subjects, 175 (40%) had a mandibular fracture alone. Of those, 18 subjects had a simultaneous midface fracture, and 59 (13%) subjects had a bilateral mandibular fracture. Midface fractures were presented in 250 (56%) subjects. In subjects with midface fracture (RR 2.0, 95% confidence interval 1.3 - 3.2, *P* = .002), the risk for an AI was two times greater compared to mandibular fracture and with mandible + midface fracture, the risk was 2.8 (RR 2.8, 95% confidence interval 1.3 - 6.0, *P* = .009).

In descending order, most frequent AIs were skull (n = 48), extremities (n = 44), and thorax injuries (n = 22). Six subjects had neck injury including six CSIs and two BCVIs.

Discussion

The purpose of this study was to determine the frequency and risk factors for AIs in patients with maxillofacial fractures. Regarding this 10-year span retrospective study, the specific aims were *1)* to determine the incidence of AIs in patients with maxillofacial fractures, *2)* to identify the demographic and injury risk factors for AIs, and *3)* to describe specific AIs among maxillofacial fractures. It was hypothesized that patients with high-energy trauma would have the highest risk for AIs.

In this study, 443 subjects had maxillofacial fractures and 20% (n = 88) of those had a concomitant AI. Subjects with AIs were older (mean age 52 vs 47) and more often female (36 vs 31%) when compared to subjects without AIs. A retrospective study from the level one trauma center at Helsinki University Hospital found a similar distribution between the sexes

Table 3. MAXILLOFACIAL FRACTURE LOCATION AND ASSOCIATED INJURY RISK COMPARED TO MANDIBULAR FRACTURE

Fracture Locations		Associated Injury + n (%)	Associated Injury – n (%)	RR (95% CI)	*P* Value
Fracture site		88 (20)	355 (80)	-	.002
Mandible	21 (12)	154 (88)	1		
Midface	61 (24)	189 (76)	2.0 (1.3-3.2)	0.002	
Mandible + Midface	6 (33)	12 (67)	2.8 (1.3-6.0)	0.009	

Abbreviations: CI, confidence interval; RR, relative risk.

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(male 30.8% and female 34.4%) in subjects with maxillofacial fractures and AIs.[19] Kokko et al also found that elderly subjects had at least a 1.6 times higher risk for AIs compared to adults, which was in line with our results. When looking at only the fall etiology in elderly subjects, neither sex showed predominance.[10] In the current study, females were statistically significantly older, which may explain our results.

Mandibular fractures were set as the reference level. The RR of AIs was 2.8 with mandible plus midface fractures. Mandibular fractures were previously found as an independent risk factor for CSIs and BCVIs.[8,20] Every fifth (n = 88/443) subject had an AI. That is a similar result noted in earlier reports.[1,12,21] Some studies have found AIs to be relatively common, occurring in half of the maxillofacial fracture trauma patients.[15,22] Both studies with a high incidence of AIs were from China, where traffic accidents were the most common trauma etiology. This may reflect the different traffic culture in comparison to other studies with a lower incidence of AIs.

In the current univariate model, midface fractures were two times higher risk for an AI compared to mandibular fractures. Similar results have been reported in earlier studies.[1,7,23]

High-energy mechanisms, such as a fall from a high distance, bicycle accidents, and motor vehicle crashes, are known risks for AIs. In the current study, falls, assaults, and sport and free-time accidents were the most common etiologies for maxillofacial fractures, although these etiologies were less associated with AIs. Traffic accidents were statistically associated with AIs in subjects with maxillofacial fractures. This result confirms the findings from previous studies.[1,24,25] Consuming alcohol increases the risk of all types of traumatic accidents.[26] In this study, nearly half (44%) of the subjects consumed alcohol, although alcohol was not associated with AIs.

Skull injuries and extremities were the most frequent AIs in this retrospective study. Neck injury was present in six subjects including six CSIs and two BCVIs. Skull injuries were present in 48 subjects. Previous studies have found an association between maxillofacial fractures and skull injuries, CSIs and BCVIs.[8,11,12,20,27,28] These AIs above the clavicular level usually originate from a direct impact to the craniomaxillofacial region and may be presented in patients sustaining injuries only to the head.

The limitations of this study should be considered and may affect the feasibility of the results regarding the general trauma population. Due to the retrospective nature of this study, some patients had incomplete data and had to be removed from the final analysis. However, the large sample size over a 10-year period likely compensates for this limitation. The long-term consequences of these AIs were not included as part of the study since our objective was to recognize the presence of these injuries and create a high level of suspicion in our comprehensive trauma analysis.

Regarding the strengths of the study, this is a single institution analysis of all maxillofacial trauma patients. Moreover, the data are collected from a single patient record system, limiting data collection errors.

In conclusion, the frequency of AIs is one out of five in maxillofacial trauma patients and meticulous primary trauma evaluations should take place in institutions with proper trauma protocols and imaging modalities before determining and executing the treatment plan for maxillofacial fractures.

Acknowledgments

We would like to thank Harri Pikkarainen (PHCH) for providing information on trauma protocols in the hospital. The funding has been obtained in part from Emil Aaltonen Foundation, Finnish Dental Society Apollonia, Päivikki and Sakari Sohlberg Foundation, Helsinki University Hospital Funds, Ministry of Health (HUS-ERVA VTR) funds, and The Finnish Cultural Foundation.

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