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Assault-related facial fractures: does the injury mechanism matter?

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Abstract. This study clarified the injury characteristics and occurrence of associated injuries in patients with assault-related facial fractures. Data from 840 assault-related facial fracture patients were included; demographic factors, facial fracture type, associated injuries, alcohol use, and injury mechanisms were recorded. Assault mechanisms most often included combinations of different mechanisms (57.5%) and resulted in the victim falling (50.1%). The perpetrator was most commonly a stranger (52.5%) and acted alone (57.7%). A total of 123 patients (14.6%) had associated injuries, with the most common being traumatic brain injury. Associated injuries occurred most frequently in patients with combined fractures of the facial thirds (24.2%) and upper third fractures (42.9%). The most significant differentiating factors for associated injuries were the number of perpetrators, falling, the use of an offensive weapon, and if the events of the assault remained unknown. In adjusted logistic regression analyses, statistically significant associations with associated injuries were found for age (odds ratio (OR) 1.05, 95% confidence interval (CI) 1.03–1.07; $P < 0.001$), falling due to the assault (OR 2.87, 95% CI 1.49–5.50; $P = 0.002$), and upper third facial fractures (OR 6.93, 95% CI 2.06–23.33; $P = 0.002$). A single punch also caused severe injuries and should therefore not be overlooked, as this can be as dangerous as other assault mechanisms.

Key words: physical abuse; maxillofacial injuries; jaw fractures; violence; traumatic brain injuries.

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The burden of assaults is a significant problem on a global scale[1]. Road traffic accidents, falls, and assaults remain the main aetiologies behind facial fractures globally[2]. However, the proportion of assaults in particular has increased strikingly in recent decades[2]. Assaults are distinct from other aetiologies as they entail a unique means of force transmission, as in many cases only the craniofacial skeleton is targeted[3].

According to the World Health Organization, interpersonal violence (IPV) consists of various types of both physical and non-physical violence, ranging from violence between close relations to a community scale[4]. Roughly, these can be divided into domestic violence (DV, including intimate partner violence and violence against family members) and urban violence (UV, including violence between unrelated people and youth violence)[5]. Assault, however, describes only the physical form of violence. In the literature on maxillofacial fractures, the terms 'assault' and 'IPV' have been used interchangeably, despite these slightly differing denotations.

Assaults may involve single or multiple trauma mechanisms, be sharp or blunt by aetiology, and be perpetrated by one or more actors. Although both the events and clinical manifestations of assault victims can be diverse, some frequently occurring factors and predictors have been recognized. Studies examining demographic parameters have shown that assault-related facial fractures are mainly overrepresented in young males living in areas of low socio-economic status[2,6,7]. Additionally, the relationship between IPV and alcohol and other intoxicating substances has been convincingly shown[5–8]. Soft tissue injuries are by far the most common clinical finding, but the significant incidence rates of mandibular fractures should also be emphasized[5,9]. Although the fractures are often isolated[9], the diagnosis of a facial fracture should raise the suspicion of another fracture[10]. Surgeons should also be aware of concealed signs that may affect clinical judgement. For example, women presenting to the emergency department with IPV-related facial fractures are often victims of domestic violence[11]. Additionally, the presence of associated, possibly life-threatening injuries should be thoroughly assessed.

Facial fractures have repeatedly been associated with other concomitant injuries such as traumatic brain injuries (TBI)[12], which are synonymous with intracranial injuries in the literature. Other concomitant injuries include cervical spine injuries (CSI)[13] and blunt cerebrovascular injuries (BCVI)[14]. Associated injuries can also manifest outside the face, including injuries of the limbs, chest, spine, and abdomen[15]. In general, the prevalence of associated injuries in facial fracture patients ranges from 11% to 25%[15,16]. However, few studies have examined the role and severity of associated injuries in assault victims.

The purpose of this study was to clarify the injury characteristics and occurrence of associated injuries in patients with IPV-related facial fractures. In particular, the aim was to assess the specific mechanisms behind these injuries. It was hypothesized that associated injuries correlate with specific mechanisms of violence.

Methods

Study design

Patient data of all facial fracture patients admitted to tertiary trauma centres for paediatric and adult patients (Helsinki University Hospital, Helsinki, Finland) with all types of facial fractures during 2013 to 2018 were reviewed. All facial fractures were diagnosed based on clinical examination and radiological imaging. Patient data including demographic factors, facial fracture type, diagnosed associated injuries, history of alcohol use, and detailed descriptions of injury mechanisms were recorded.

Inclusion and exclusion criteria

All patients who sustained radiologically confirmed facial fractures due to IPV were included in the study.

Study variables

The main study outcome variable was associated injuries. Such injuries were defined as present if any of the following injuries occurred: intracranial injury, cranial fracture, severe eye injury (i.e., permanent loss of vision), CSI, other spinal injury, BCVI, thoracic injury, limb injury, or abdominal injury. Descriptive statistics of associated injury numbers, related mortality, and permanent vision loss were reported.

The primary predictor variable was the mechanism of assault, which was grouped into three categories: a single punch/hit, other, or unknown.

To clarify the specific injury mechanism, secondary predictor variables included the following: use of a weapon/tool (yes/no/not known), falling due to violence (yes/no/not known), violence continued on the ground (yes/no/not known), the number of perpetrators (one/more than one/not known), patient's relationship to the perpetrator (family member/other known/not known), and being under the influence of alcohol/drugs (patient) (yes/no/not known). Alcohol, influence of drugs, or both was verified from blood samples, by use of a breathalyser, or the history provided by the paramedics or patient.

Explanatory variables were sex, age, and fracture type. The latter was categorized as mandibular, zygomatic, maxillary, orbital, nasal, upper third, combined midfacial, combination of facial thirds, and other.

In addition, categorized assault mechanisms were analysed in subgroups. The single punch/hit group was divided into four according to the specific cause: fist, elbow, knee, foot. Mechanisms other than single hits were described as multiple punches, multiple kicks, multiple mechanisms, use of offensive weapon only, and pushed to the ground only.

Statistical analysis

The examination of descriptive statistics included percentages and numbers for categorical variables and the median with interquartile range for age (continuous variable, not normally distributed). To investigate the relationship between associated injuries and the predictor or explanatory variables, the Pearson χ^2 test was used for cross-tabulations. Fisher's exact test was used where cells had ≤ 5 cases. Univariate logistic regression analysis was used to determine the relationship between the outcome variable (associated injuries) and the predictor or explanatory variables to determine the odds. In the multivariable model, variables were included and retained in the model based on $P \leq 1.0$. Odds ratios (OR) were estimated, with the 95% confidence interval (CI). A statistically significant P-value was set at 0.05. The Hosmer–Lemeshow test was used to determine the fit of the model. The final model was found to have a good fit with an estimate of 7.15 and P-value of 0.520 for 10 groups. A test for multicollinearity was performed using the variance inflation factor (VIF) for the final model. The VIF estimate was <5 for each predictor/explanatory variable, suggesting multicollinearity was not an issue. The data analysis was conducted using Stata Statistical Software release 16 (StataCorp, College Station, TX, USA).

Ethical considerations

The study was approved by the Internal Review Board of the Head and Neck Centre, Helsinki University Hospital, Helsinki, Finland (HUS/356/2017). The Internal Review Board of the Head and Neck Centre waived the requirement for informed consent due to the retrospective nature of the study. The guidelines of the Declaration of Helsinki were followed in this study.

Results

A total of 840 patients (753 male and 87 female) fulfilled the inclusion criteria and were included in the analysis. Their median age was 31.8 years (mean 34.1 years, range 14.3–87.4 years). Overall, the most common facial fracture types were mandibular (34.8%), zygomatic (20.1%), and orbital (14.8%). In all, 397 patients (47.3%) received surgical treatment for the facial fracture. Single hits accounted

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for 30.4% of all assaults; other known assault mechanisms (57.5%) included combinations of different mechanisms. The perpetrator was most commonly a stranger (52.5%) and usually acted alone (57.7%). Half of the assaults resulted in the victim falling (50.1%). The use of an offensive weapon was reported in 13.7% of the assaults.

A total of 123 patients (14.6%) had associated injuries (Table 1). The mean age of patients with associated injuries (41.3 years) was significantly higher than that of patients without associated injuries (32.9 years) ($P < 0.001$). The number of perpetrators, falling down, continued violence on the ground, and the use of an offensive weapon were statistically significant injury mechanisms ($P < 0.001$) in predicting associated injuries. In addition, associated injuries were reported more frequently when these aforementioned factors were unknown ($P < 0.001$).

The distribution of assault mechanisms varied significantly between patients regardless of associated injuries (Table 2, $P < 0.001$). The associated injuries cohort was most frequently assaulted using multiple mechanisms (39.0%). The patient or witnesses could not specify the assault mechanism in nearly a quarter (23.6%) of patients with associated injuries. Associated injuries were reported in 17.6% of multiple assault mechanisms and 7.8% of single hits. Associated injuries occurred most often when the patient was pushed to the ground only (33.3%), the mechanism was unknown (28.4%), or multiple mechanisms were used (17.6%).

Associated injuries occurred most often in patients with upper third fractures (42.9%), nasal fractures (30.2%), and combined fractures of the facial thirds (24.2%) (**Supplementary Material** Table S1).

A total of 138 different associated injury types were found in the 123 patients (**Supplementary Material** Table S2). The most common associated injury was an intracranial injury, which occurred as single or combined in 6.9% of all 840 patients. Other common associated injuries were injuries of the chest (24.4% of associated injuries) and upper extremities

Table 1. Associated injuries in 840 patients with assault-related facial fractures[a].

	Patients with associated injury			Patients without associated injury		
	n	%	% of *n*	*n*	%	% of *n*
All	123	14.6		717	85.4	
Age (years)						
Mean	41.3			32.9		
Median	41.4			30.6		
Range	18.6–77.7			14.3–87.4		
$P < 0.001$						
Sex						
Male	107	87.0	14.2	646	90.1	85.8
Female	16	13.0	18.4	71	9.9	81.6
$P = 0.296$						
Alcohol/drugs						
Yes	90	73.2	16.2	465	64.9	83.8
No	32	26.0	11.3	252	35.1	88.7
Not known	1	0.8	100	0	0	0
$P = 0.015$						
Perpetrator of violence						
One of the family	8	6.5	17.4	38	5.3	82.6
Other known	22	17.9	12.4	155	21.6	87.6
Stranger	51	41.5	11.6	390	54.4	88.4
Not known	42	34.1	23.9	134	18.7	76.1
$P = 0.001$						
Number of perpetrators						
One	48	39.0	9.9	437	60.9	90.1
More than one	39	31.7	17.3	186	25.9	82.7
Not known	36	29.3	27.7	94	13.1	72.3
$P < 0.001$						
Falling due to violence						
Yes	77	62.6	18.3	344	48.0	81.7
No	13	10.6	4.9	250	34.9	95.1
Not known	33	26.8	21.2	123	17.2	78.8
$P < 0.001$						
Violence continued on the ground						
Yes	37	30.1	18.2	166	23.2	81.8
No	32	26.0	8.2	356	49.7	91.8
Not known	54	43.9	21.7	195	27.2	78.3
$P < 0.001$						
Use of offensive weapon						
Yes	25	20.3	21.7	90	12.6	78.3
No	74	60.2	11.4	574	80.1	88.6
Not known	24	19.5	31.2	53	7.4	68.8
$P < 0.001$						

[a] The patient population $N = 840$; % is the column percentage (i.e., the percentage of patients within each group with the given characteristic); '% of *n*' is the row percentage (i.e., the distribution of patients with the given characteristic between the two groups).

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Table 2. Distribution of assault mechanisms within the associated injury and no associated injury groups[a].

	Patients with associated injury			Patients without associated injury		
	n	%	% of *n*	*n*	%	% of *n*
Single punch/hit						
$P < 0.001$						
Yes	20	16.3	7.8	235	32.8	92.2
Fist	17	13.8	7.0	227	31.2	93.0
Elbow	0	0	0.0	4	0.6	100
Knee	0	0	0.0	1	0.1	100
Foot	3	2.4	50	3	0.4	50
No	74	60.2	15.3	409	57.0	84.7
Multiple punches (fist)	16	13.0	10.7	133	18.5	89.3
Multiple kicks (feet)	1	0.8	8.3	11	1.5	91.7
Multiple mechanisms	48	39.0	17.6	224	31.2	82.4
Use of offensive weapon only	7	5.7	15.9	37	5.2	84.1
Pushed to the ground only	2	1.6	33.3	4	0.6	66.7
Not known	29	23.6	28.4	73	10.2	71.6

[a] The patient population $N = 840$; % is the column percentage (i.e., the percentage of patients within each group with the given characteristic); '% of *n*' is the row percentage (i.e., the distribution of patients with the given characteristic between the two groups).

(19.5% of associated injuries). Additionally, one patient suffered permanent vision loss and one patient died from multiple intracranial injuries (intracerebral, subdural, and subarachnoid haemorrhages).

In the unadjusted models (univariate analysis, **Supplementary Material** Table S3), single-punch victims were 53% less likely to have associated injuries (OR 0.47, 95% CI 0.28–0.79; $P = 0.004$). In contrast, when an unknown mechanism was recorded, patients were twice as likely to have associated injuries (OR 2.20, 95% CI 1.34–3.61; $P = 0.002$) when compared to those reporting multiple punches. More than one perpetrator (OR 1.91, 95% CI 1.21–3.01; $P = 0.005$) or an unknown number of perpetrators (OR 3.49, 95% CI 2.14–5.67; $P < 0.001$) was associated with an increased risk of associated injuries. Correspondingly, when the use of an offensive weapon was reported (OR 2.15, 95% CI 1.30–3.57; $P = 0.003$) or if it was reported as unknown (OR 3.51, 95% 2.05–6.02; $P < 0.001$) there was an increased risk of associated injuries. Among the fracture types, the highest risk of associated injuries was among patients with upper third fractures (OR 4.54, 95% CI 1.55–13.34; $P = 0.006$).

In the adjusted model (multivariable analysis, **Supplementary Material** Table S4), for every 1-year increase in age, there was a 5% increase in the risk of associated injuries (OR 1.05, 95% CI 1.03–1.07; $P < 0.001$). Victims who fell during the assault were almost three times more likely to have associated injuries than those who did not fall (OR 2.87, 95% CI 1.49–5.50; $P = 0.002$). Consistent with the unadjusted models, the highest risk of associated injuries was among patients with upper third fractures (6.93, 95% CI 2.06–23.33; $P = 0.002$). Statistically significant differences between specific assault mechanisms were not found in the adjusted model.

Discussion

The purpose of this study was to clarify the injury characteristics and associated injuries in patients with assault-related facial fractures. In particular, the aim was to clarify the specific mechanisms behind these injuries. It was hypothesized that associated injuries of facial fracture patients correlate with specific mechanisms of violence. This hypothesis was confirmed. There was a significant increase in associated injuries when multiple perpetrators or falling was mentioned in the anamnesis. However, an unarmed single punch also caused severe injuries (Fig. 1).

Of the patients with assault-related facial fractures included in this study, 14.6% had associated injuries. Nearly half of these were TBIs. In the literature, the incidence of associated injuries varies from 11% to 25% among all facial fracture patients[15,16]. The majority of associated injuries in facial fracture patients are due to motor vehicle accidents, which is expected due to the higher energy mechanisms[2]. In studies focusing specifically on patients with assault-related facial fractures, the incidence of associated injuries has been reported to vary from 3.3% (Japan) to 9.8% (Finland) and 20.3% (Malaysia)[12,15,17]. The present study showed a higher associated injury rate (14.6%) than previously observed in Finland, which can be explained by the study design and the patient groups included. The data included all facial fracture types and reported several types of severe associated injuries. This study focused on trauma unit patients. Minor fractures, such as alveolar ridge or nasal fractures, are treated in non-trauma units by dentists and ENT specialists.

Facial fractures are associated with TBIs and have been observed in 3.2% of maxillofacial fractures[12]. The symptoms of TBI can range from mild nausea and temporary amnesia to seizures and even death[18]. In the present study, TBIs accounted for different types of brain haemorrhages, including intracerebral, subarachnoid, subdural, and epidural. Multiple TBIs in a single patient were not uncommon (22.4% of TBIs). The study findings are noteworthy for clinicians and confirm the hazardous nature of assault-related facial fractures. Accordingly, it is important to exclude intracranial injuries in this patient population, with close collaboration between neurosurgeons and the brain injury unit.

As stated previously, the aim of this study was to clarify specific mechanisms behind assault-related injuries. These can be direct assault mechanisms, for example multiple punches, but they can also include other characteristics that help define the risk of associated injuries. The results revealed that falling due to violence was the most significant injury mechanism that independently increased the risk of associated injuries. Falling as a major risk factor was not an altogether surprising finding; a higher incidence of associated injuries was observed in a study on elderly patients with zygomatico-maxillary-orbital fractures[19], and falls are known to be a major aetiological factor for facial fractures in the elderly[20]. Although these factors can affect assaults individually, a possible predisposing factor could be al-

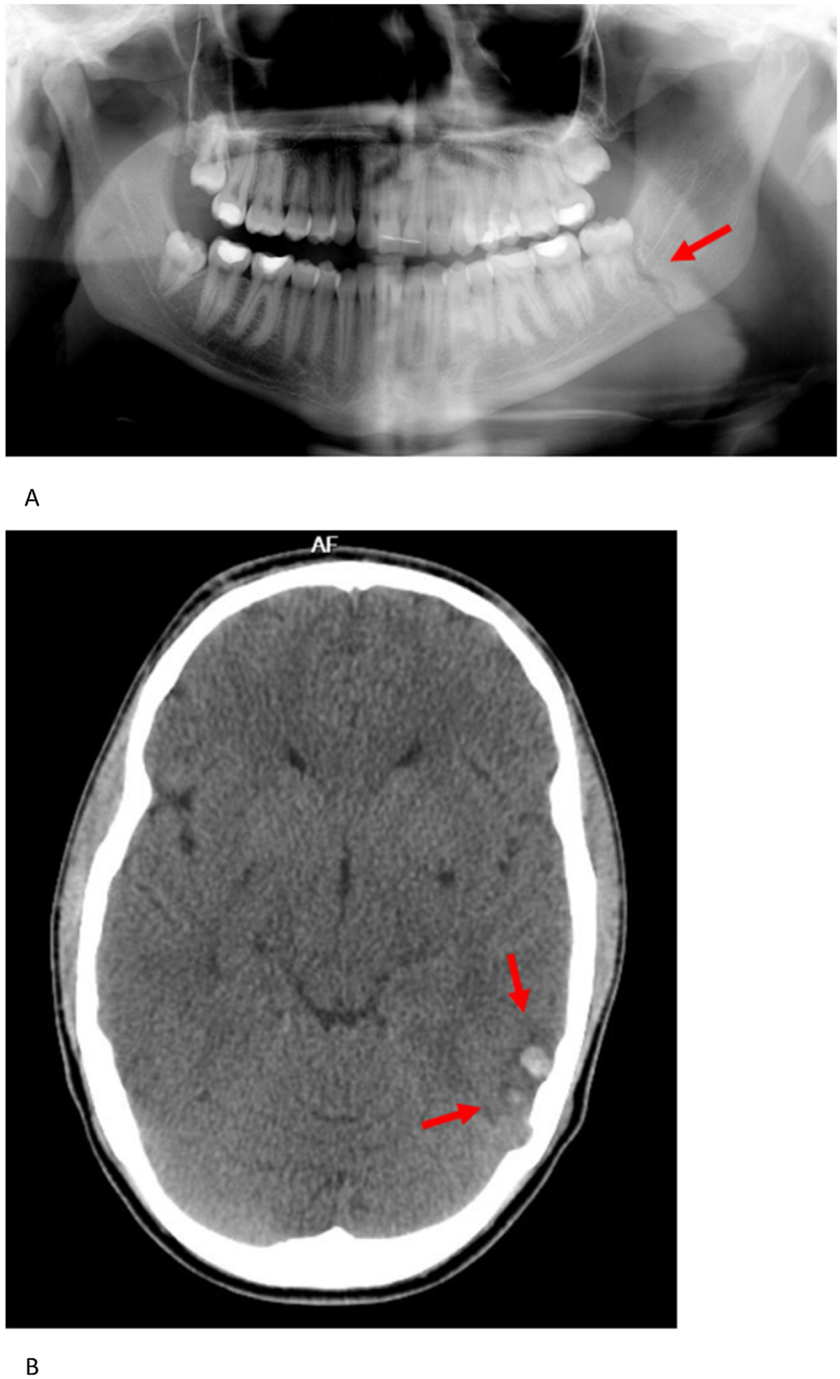

Fig. 1. A 19-year-old male was assaulted by an unknown perpetrator. The patient fell to the ground as a result of a single punch. The assault caused amnesia that lasted a few minutes. The patient was referred to an oral and maxillofacial surgeon the following day due to pain in the lower jaw. A routine examination showed a fracture in the angle of the mandible (A) and intracranial haemorrhage (B) as an associated injury.

cohol. A strong correlation has been established between facial fractures and alcohol[8,9], which was also reflected in the study results (Table 1).

Amnesia can be problematic with assault victims, especially since TBIs are the most frequent associated injury type. The study results showed that unclear events in the anamnesis was a statistically significant factor predicting an associated injury. The risk of an associated injury was greater particularly if the number of perpetrators was unknown. Additional reasons for an insufficient narrative are more challenging, if not impossible, to verify; such reasons include lying, shock, or shame. Nevertheless, if amnesia or alcohol consumption are mentioned in the anamnestic stage, they should be considered as warning signs, as they can be confounding when diagnosing associated injuries.

There is debate in the literature regarding the risks associated with a single-punch assault[21]. The study data showed that single hits accounted for 16.3% of patients with associated injuries compared to 32.8% of patients with no associated injuries. The adjusted OR for associated injuries in single hits did not differ significantly from that of other assault mechanisms, although the distribution between the patient groups varied significantly. However, nearly a fifth (19.0%) of TBI cases in the data resulted from single-punch assaults, and 64.7% of patients with associated injuries who were hit with a single punch had a TBI. Although most single punches do not lead to associated injuries, single punches should not be considered harmless. It is also worth mentioning that the only patient to die was assaulted with a single punch. Thus, even though the results were not entirely conclusive, they show that even a single punch can cause serious intracranial injuries.

While the effect of the direct assault mechanism can offer some insight into the probability of an associated injury, a clear, clinically assessible heightened risk was found in combination fractures (2.02) and in upper third fractures (6.93). In general, the most common fracture types in associated injury patients were mandibular, combined midfacial, and zygomatic. Previous studies support these findings; the most common maxillofacial fractures among assaulted patients are fractures of the mandible[5]. The zygomatic arch, orbit, and nose are also common fracture locations in IPV cases[5,6]. Overall, concomitant injuries in this patient population are associated most frequently with fractures of the upper parts of the face, specifically combination, exclusively upper third, and severe midfacial fractures[15,16,22–24]. It is also worth noting that nasal fractures in particular occur as an additional finding in patients who are being treated at a trauma centre for other injuries.

Due to the retrospective nature of this study, some variables may be inaccurately or incompletely reported. Additionally, radiological examinations of associated injuries were based on clinical considerations. Therefore, associated injuries may even be underrepresented. Furthermore, the precise mechanism of assault could not be obtained from either the patient or the witnesses in a considerable proportion of patients, which also affects the results. It is believed that a major cause of this was incomplete recollection of the events rather than an insufficient anamnesis.

In conclusion, the number of perpetrators and falling are factors that we encourage clinicians to pay special attention to in the anamnesis of assaulted patients. The study results showed that the risk of an associated injury increased if certain events of the assault remained unknown. Combination and upper third fractures coincided most often with an associated injury, increasing the risk two- and sevenfold, respectively. A victim of a single punch should also be examined carefully, as a single punch can be as dangerous as assault with multiple mechanisms.

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Competing interests

None.

Ethical approval

The study was approved by the Internal Review Board of the Head and Neck Centre, Helsinki University Hospital, Helsinki, Finland (HUS/356/2017).

Patient consent

Patient consent was not required for this study.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijom.2021.06.001.

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