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Dental trauma in patients with maxillofacial fractures

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Abstract – *Purpose*: The purpose of this study was to analyze and evaluate the correlation between dental injuries and the pattern of maxillofacial fractures. The correlation with age, gender, trauma mechanism and type of maxillofacial fracture was also investigated. *Materials and methods*: From January 2000 to December 2009, 1131 patients with facial fractures were registered. Of these, 473 presented with associated dental trauma. The information and data collected and analyzed included: age, gender, mechanism of injury, type of facial fracture, type of dental injury, and the relationship between dental injury and facial fracture. *Results*: Dental injury was sustained by 473 patients (41.8%), with a total of 2215 injured teeth. Of the 2215 injured teeth, 1191 (53.8%) were in the maxilla and 1024 (46.2%) in the mandible. Fall from a height had the highest risk of dental injuries (OR = 4.145, $P = 0.002$). The central incisor was the most injured tooth for both the maxilla (388, 36.2%) and mandible (284, 27.7%). The most common type of dental injury was avulsion (1070, 47.4%). More anterior teeth in the maxilla were of crown fracture, avulsion, and intrusion than that in the mandible, whereas more anterior teeth in the mandible were of subluxation and concussion than that in the maxilla. Dental injuries were more prone to occur in patients who sustained only symphysis fractures (OR = 2.817, $P < 0.001$), only 0.236-fold risk in patients who sustained only mandible angle fracture ($P < 0.001$). *Conclusions*: The occurrence of dental trauma is significantly related to the pattern and position of the maxillofacial fractures.

Dental trauma is usually sudden, circumstantial, unexpected, accidental, and often requires emergency attention (1). Numerous studies have focused on the epidemiologic characteristics of dental injuries. However, the pattern and severity of dental trauma in patients who sustain only the dentoalveolar complex injuries are presumably different from those in patients who present with a combination of dental injury and facial injury (2). Patients with facial fractures have sustained their injuries through high-speed impacts far more than patients who have dental trauma (3). Consequently, it has been assumed that a significant proportion of patients presenting with facial fracture could also have dental trauma (2).

Currently, few articles have been published describing the type and frequency of dental injuries in facial trauma (2–9). However, seldom has consistency been achieved about the most frequent etiologies, incidence, and pattern of teeth injury.

In the past 10 years, authors have disagreed on the most common cause of dental injury in association with facial trauma. Lieger et al. (4) found that traffic accidents were the most common cause, while Thorén et al. (2) reported assault-related injuries as the most common cause. Da Silva et al. (6) found falls as the most frequent cause. Gassner et al. (3, 5) considered sports-related accidents as the most common mechanism of dental trauma in combination with facial injuries.

As far as the patterns of dental injuries are concerned, some authors found most of the injured teeth were of crown fracture (2, 4), while others approved of avulsion (6) or subluxation (3, 5, 7).

The aim of this study was to analyze and evaluate the correlation between dental injuries and the pattern of maxillofacial fractures. Additionally, the occurrence of dental injury in relation to age, gender, trauma mechanism and type of maxillofacial fracture was also investigated.

Materials and methods

The protocol, survey, and consent forms were approved by the Institutional Review Board of Wuhan University. For this retrospective study conducted from January 2000 to December 2009, 1131 patients with facial fractures were registered in our department. Of these, 473 presented with associated dental trauma. The information and data collected included: age, gender, mechanism of injury, type of facial fracture, and type of dental injury.

The mechanism of injury was classified as: assaults, road traffic accidents (motor vehicle accidents, motor-

cycle accidents, and bicycle accidents), fall at ground level or from a height, sports- or work-related accidents, and others.

Facial fractures were divided into: exclusively maxilla fracture, combined fractures of maxilla and mandible, multiple mandibular fractures, and single mandibular fracture (symphysis, condyle, body, angle, ramus, coronoid, or alveolar fracture).

Type of dental injuries was based on the description by Thorén et al. (2) and further improved as: crown fracture, root fracture, crown–root fracture, concussion (marked reaction to percussion but without mobility), subluxation (loose but without displacement), extrusive luxation (partial displacement of tooth out of its socket), intrusive luxation (displacement of tooth into its socket), lateral luxation (displacement of tooth to oral or vestibular area), and avulsion (complete displacement of tooth from the socket). Site of dental injury was classified as mandibular or maxillary and further classified as incisor, canine, premolar, or molar. The incisors and canines were summarized as the anterior teeth, while premolars and molars were summarized as the posterior teeth.

According to age, patients were divided into toddlers (3 years or less), preschool (4–6 years), children (7–12 years), teenagers (13–18 years), and adults (19 years or more). Adult patients were further classified into age groups 19–29, 30–39, 40–49, 50–59, 60–69, and 70 years or more.

To assess relationships between the predictor variables and outcome variables, statistical analysis was performed with SPSS software (version 16.0; SPSS, Chicago, IL, USA). The continuous variables were reported as the mean ± SD and were assessed by *t*-test. The chi-squared test was used when categoric variables were compared. The Fisher exact test was carried out when the observation in any cell of the 2×2 table was expected to be <5. Odds ratio and 95% confidence interval were to assess the risk of sustaining dental injuries. Logistic regression analysis was used to control for confounding variables. Probabilities of $P < 0.05$ were considered significantly different.

Results

In the 10 years period of this study, 1131 patients with facial fractures were registered and analyzed, with male to female ratio of 3.52:1 (881 male and 250 female). Of these, 41.8% (473 patients) presented with associated dental injuries (2215 injured teeth, averaged 4.68 teeth per patient), with male to female ratio of 3.34:1 (364 male and 109 female). The age range of the patients with dental injuries was 1.6–72 years (average 31.86 ± 13.46 years). The largest age group was patients aged 19–29 years (135 patients, 28.5%), followed by 30–39 years age group (124 patients, 26.2%) (Table 1). In the majority of patients, road traffic accidents were the most common mechanism of injury (52.9%), followed by falls (fall at ground level or fall from a height, 29.0%), assault accounted for only 10.4% (49 of 473) of the sample (Table 2).

Table 1. Odds ratio and 95% confidence intervals relating to the risk of dental injuries in different age groups

	Patients with dental injuries					
	Present	Absent	Total	Significance	OR	95% CI
≤3	4	9	13	0.416	0.615	0.188–2.009
4–6	9	16	25	0.551	0.778	0.341–1.777
7–12	18	23	41	0.783	1.092	0.583–2.048
13–18	45	68	113	0.650	0.912	0.614–1.356
19–29	135	212	347	0.186	0.840	0.649–1.088
30–39	124	165	289	0.665	1.062	0.810–1.391
40–49	89	107	196	0.263	1.194	0.875–1.627
50–59	37	46	83	0.597	1.129	0.720–1.771
60–69	9	8	17	0.349	1.576	0.604–4.115
≥70	3	4	7	1.000	1.044	0.232–4.685
Total	473	658	1131	–	–	–

Table 2. Distribution of mechanisms of injury in cases with facial fractures or dental injuries

Etiology	Facial fracture (%)	Dental injury (%)	*P* value
Assault	159 (14.1)	49 (10.4)	0.044
Bicycle	67 (5.9)	31 (6.6)	0.631
MVA	349 (30.9)	139 (29.4)	0.559
Motorcycle	179 (15.8)	80 (16.9)	0.590
Fall ground	136 (12.0)	58 (12.3)	0.894
Fall high	121 (10.7)	79 (16.7)	0.001
Sports	20 (1.8)	10 (2.1)	0.641
Work	27 (2.4)	9 (1.9)	0.550
Others	73 (6.5)	18 (3.8)	0.037
Total	1131 (100.0)	473 (100.0)	–

MVA, motor vehicle accident.

With regard to facial fractures, the largest age group was also the patients aged 19–29 years (343 of 1131, 30.7%), followed by 30–39 years age group (289 patients, 25.6%) (Table 1). Road traffic accidents were also the most frequent mechanism (595 of 1131, 52.6%), followed by falls (257 of 1131, 22.7%), assault accounted for 14.1% (159 of 1131) (Table 2).

The etiology distribution of facial fractures or dental injuries showed that fall from a height more frequently resulted in dental injuries ($P = 0.001$), whereas conversely come to the etiology of assault-related accidents ($P = 0.044$) (Table 2).

The risk of sustaining dental injuries according to age, gender, and etiology is summarized in Table 3. Older patients were at greater risk of dental trauma when compared with younger ($P = 0.007$). Fall from a height had a 4.145-fold risk of dental injuries (OR, 4.145; 95% confidence interval, 1.703–10.087; $P = 0.002$).

Site distribution of dental injuries in upper jaw or lower jaw is shown in Table 4. Maxillary central incisors were the most vulnerable teeth to dental trauma (388, 17.5%), followed by mandible central incisors (284, 12.8%), maxillary lateral incisors (271, 12.2%), and mandible lateral incisors (228, 10.3%). Central incisors in upper jaws were more prone to be injured compared to the lower jaws (32.6% vs 27.7%,

Table 3. Logistic regression analysis: risk of dental injuries in patients by age, gender, and etiology

	Dental injuries					
	Present (n = 473)	Absent (n = 658)	Significance (crude)	Odds ratio (adjusted)	95% confidence interval	Significance (adjusted)
Age	31.86 ± 13.46	30.54 ± 13.41	0.103	0.987	0.978–0.997	0.007
Sex						
Male	364	517	0.518	0.913	0.679–1.227	0.547
Female	109	141				
Etiology						
Assault	49	110	0.002	0.898	0.376–2.143	0.809
Bicycle	31	36	0.447	1.867	0.726–4.803	0.195
Motor vehicle accident	139	210	0.364	1.389	0.604–3.193	0.439
Motorcycle	80	99	0.396	1.755	0.745–4.135	0.198
Fall ground	58	78	0.835	1.555	0.648–3.733	0.323
Fall high	79	42	0.000	4.145	1.703–10.087	0.002
Sport	10	10	0.454	2.336	0.706–7.730	0.165
Other	18	55	0.002	0.670	0.255–1.756	0.415

The variable of 'work' was excluded as 'redundancy' by logistic regression analysis procedure.

Table 4. Site distribution of dental injury in upper jaw or lower jaw

Site	Maxilla (%)	Mandible (%)	Total (%)	P value
Central incisors	388 (32.6)	284 (27.7)	672 (30.3)	0.013
Lateral incisors	271 (22.8)	228 (22.3)	499 (22.5)	0.784
Canines	147 (12.3)	133 (13.0)	280 (12.6)	0.648
First premolars	129 (10.8)	100 (9.8)	229 (10.3)	0.411
Second premolars	84 (7.1)	87 (8.5)	171 (7.7)	0.205
First molars	90 (7.6)	110 (10.7)	200 (9.0)	0.009
Second molars	63 (5.3)	68 (6.6)	131 (5.9)	0.179
Third molars	19 (1.6)	14 (1.4)	33 (1.5)	0.659
Total	1191 (100.0)	1024 (100.0)	2215 (100.0)	

P = 0.013). The first molar was more frequently involved in injuries in lower jaws compared to upper jaws (10.7% vs 7.6%, P = 0.009).

Of the 2215 injured teeth, 2171 teeth were with one diagnosis, 44 teeth were diagnosed twice for different types of injury, with a total of 2259 dental injury diagnosis (Table 5). The most common type of injury was avulsion (1070, 47.4%), followed by subluxation (607, 26.9%), crown fracture (333, 14.7%). When comparing the type of tooth lesion and the location, we found that most teeth injuries were diagnosed in the maxilla (1221, 54.1%). As far as the anterior teeth are concerned, more avulsions (53.2% in maxilla vs 40.9% in mandible, $P < 0.001$), crown fractures (18.9% in maxilla vs 6.1% in mandible, $P < 0.001$), and intrusions (3.7% in maxilla vs 0.3% in mandible, $P < 0.001$) were observed in the maxilla, whereas more subluxation (46.5% in mandible vs 18.5% in maxilla, $P < 0.001$) and concussion (3.9% in mandible vs 1.9% in maxilla, P = 0.031) occurred in the mandible. However, there is no remarkable difference found in injury types of posterior teeth between maxilla and mandible.

Type of dental injuries in anterior or posterior teeth is compared in Table 6. More crown fractures (17.7% vs 13.2%, P = 0.004), crown–root fractures (2.1% vs 0.1%, $P < 0.001$), root fracture (5.9% vs 1.8%, $P < 0.001$), concussion (5.5% vs 2.8%, P = 0.001), and lateral luxation (1.5% vs 0.3%, P = 0.002) occurred in posterior teeth, whereas more subluxation (31.0% vs 19.1%, $P < 0.001$) and intrusive luxation (2.2% vs 0.9%, P = 0.028) were found in anterior teeth.

The risks of sustaining dental injuries in association with different fracture pattern of maxillofacial trauma are summarized in Table 7. Dental injuries were more prone to occur in patients who sustained only symphysis fractures (OR = 2.817, $P < 0.001$): 1.780-fold risk in the pattern of combined fractures of maxilla and mandible ($P < 0.001$), 0.385-fold risk in exclusively maxilla fractures ($P < 0.001$), and only 0.236-fold risk in patients who sustained only mandibular angle fracture ($P < 0.001$).

Discussion

This study analyzed and evaluated the correlation between dental injuries and the pattern of maxillofacial fractures; we mainly found that the occurrence of dental trauma is significantly related to the pattern and position of the maxillofacial fractures.

In this study, the overall prevalence of dental trauma in association with maxillofacial fractures was 41.8%. It is higher than the findings by Lieger et al. (4) (19.5%) and Thorén et al. (2) (16%). However, it is lower than other findings by Gassner et al. (5) (47.9%) and Gassner et al. (3) (49.9%). One study showed a high occurrence (76.3%) of pediatric facial trauma involving dental injuries (7). We found that on average, 4.7 teeth were injured per patient, which was far much more than that reported by other studies. This underscores the importance of a careful examination of the

Table 5. Type distribution of dental injury in upper jaw or lower jaw

Dental injuries	Anterior teeth			Posterior teeth		
	Maxilla (%)	Mandible (%)	*P* value	Maxilla (%)	Mandible (%)	*P* value
Crown fracture	155 (18.9)	40 (6.1)	<0.001	73 (18.3)	65 (17.1)	0.675
Crown–root fracture	1 (0.1)	1 (0.2)	1.000	8 (2)	8 (2.1)	0.917
Root fracture	18 (2.2)	9 (1.4)	0.239	24 (6)	22 (5.8)	0.901
Concussion	16 (1.9)	25 (3.9)	0.031	31 (7.8)	12 (3.2)	0.005
Subluxation	152 (18.5)	306 (46.5)	<0.001	77 (19.3)	72 (18.9)	0.914
Avulsion	437 (53.2)	269 (40.9)	<0.001	181 (45.3)	183 (48.2)	0.416
Intrusion	30 (3.7)	2 (0.3)	<0.001	5 (1.3)	2 (0.5)	0.452
Extrusion	9 (1.1)	4 (0.6)	0.317	1 (0.3)	4 (1.1)	0.206
Lateral luxation	3 (0.4)	2 (0.3)	1.000	0 (0.0)	12 (3.2)	<0.001
Totals	821 (100.0)	658 (100.0)		400 (100.0)	380 (100.0)	

Table 6. Type distribution of dental injury in anterior or posterior teeth

Dental injuries	Anterior teeth (%)	Posterior teeth (%)	Total (%)	*P* value
Crown fracture	195 (13.2)	138 (17.7)	333 (14.7)	0.004
Crown–root fracture	2 (0.1)	16 (2.1)	18 (0.8)	<0.001
Root fracture	27 (1.8)	46 (5.9)	73 (3.2)	<0.001
Concussion	41 (2.8)	43 (5.5)	84 (3.7)	0.001
Subluxation	458 (31.0)	149 (19.1)	607 (26.9)	<0.001
Avulsion	706 (47.7)	364 (46.7)	1070 (47.7)	0.629
Intrusion	32 (2.2)	7 (0.9)	39 (1.7)	0.028
Extrusion	13 (0.9)	5 (0.6)	18 (0.8)	0.545
Lateral luxation	5 (0.3)	12 (1.5)	17 (0.8)	0.002
Total	1479 (100.0)	780 (100.0)	2259 (100.0)	

dental status in every patient presenting with maxillofacial fractures.

The most frequent cause of dental injury was road traffic accidents (motor vehicle, motorcycle and bicycle accidents), comprising 52.9% of the total number of the dental injuries. This figure was 30% in a study in Switzerland (4), 25% in a study in Brazil (6), and only 9.2% in a study in Austria (3). In contrast, assault-related injuries (2), falls (6), or sports-related accidents (3, 5) accounted for the most common etiology in other countries.

We found that fall from a height had the highest risk of dental injuries (OR = 4.145, $P = 0.002$), which is far more than other causes. This gives an impression that a high-energy mechanism may result in a high incidence of dental injuries in patients who sustain maxillofacial fractures. This should warrant public interventions to reduce the risk for dental traumatic injuries when people are working or playing at a height, or above ground level; under these circumstances, they should be encouraged to wear a mouth guard (10–13).

More teeth were injured in the maxilla than in the mandible (1191 vs 1024); this was consistent with other studies in different countries (4, 6). One of the possible reasons for this phenomenon may be the preventive effect of the maxilla on the mandible during occlusion (14, 15). Lieger et al. (4) made the speculation that it could be the fact that the teeth of the lower jaw have better bony anchorage and act like wedges in the case of forceful occlusion. Da Silva et al. (6) revealed that dental trauma and dentoalveolar fractures were most related with maxillary fractures (71.43%), mainly in the anterior region. We too are in agreement with their statements; in this study, an observation that the maxillary central incisor teeth were most commonly injured was made. The occurrence of central incisor injury in the maxillary arch was also much more frequent than that in mandible (32.6% vs 27.7%, $P = 0.013$). This is expected because maxillary central incisors are the most protrusive teeth, and therefore, they are more likely to be struck by an object or hit the ground first (1). Additionally, the incomplete lip soft tissue coverage also increases the risk of the maxillary central incisor injury (16–18).

An interesting finding was that the first molar in the mandible was more frequently injured than in the maxilla (10.7% vs 7.6%, $P = 0.009$). This can be deduced that the first molars in the mandible (6-year teeth) erupt earlier than in the maxilla, the occurrence of pit and fissure caries of the 6-year teeth in childhood complicated the firmness of the hard tissue crown. In addition, the two roots of the first molar in the mandible weakened the resistance to external force compared to maxillary molars with three roots involving a strong palatal root.

Most teeth were dislocated (avulsion, 47.4%) out of the socket. This finding was similar to a study by Da Silva et al. (40.3%) (6), however, contrary to other studies in Switzerland [crown fractures, 47.9% (4) and 47.5% (2)], Austria [subluxation, 50.6% (5), 47.9% (3) and 56.3% (7)]. Da Silva et al. (6) assumed that the high number of dental avulsions and luxation injuries were probably the result of the severity of trauma involving young individuals, who are more susceptible to high-energy impacts.

When statistically comparing and analyzing the type of dental injury in the maxilla and mandible, more anterior teeth in the maxilla were of crown fracture, avulsion, and intrusion, whereas more anterior teeth in the mandible were of subluxation and concussion. These figures parallel the results of Thorén et al. (2). They stated that most crown fractures, root fractures,

Table 7. Odds ratio and 95% confidence intervals relating to the risk of dental injuries in association with maxillofacial fractures

Site of fracture	Patients with dental injuries		Total	Significance	OR	95% CI
	Present	Absent				
Only maxilla	66	195	261	<0.001	0.385	0.283–0.525
Maxilla + mandible	103	89	192	<0.001	1.780	1.302–2.432
Multi-mandible	176	208	384	0.050	1.282	1.000–1.644
Single mandible						
Symphysis	42	22	64	<0.001	2.817	1.658–4.787
Condyle	53	73	126	0.953	1.011	0.695–1.472
Angle	6	34	40	<0.001	0.236	0.098–0.566
Body	23	34	57	0.817	0.938	0.545–1.614
Ramus	0	1	1	1.000	–	–
Coronoid	0	1	1	1.000	–	–
Alveolar	4	1	5	0.168	5.603	0.624–50.294
Total	128	166	294	0.488	1.100	0.841–1.438
Total	473	658	1131	–	–	–

avulsions, intrusions, and concussions were observed in the maxilla, whereas most subluxations/luxations and extrusions occurred in the mandible (2). According to the classification and description of the severity of dental injuries by Oikarinen et al. (19), it can be concluded that dental injuries in the maxilla are more severe than those in the mandible. Several reasons have been attributed to this phenomenon. Owing to the large maxillary overjet (16) and protrusion in the sagittal plane (19), the anterior teeth in upper jaw are more prone to strike against an object (17). In contrast, the anterior teeth in the lower jaw are protected by the maxilla during occlusion (14) and sustain less force; consequently, the mandibular teeth are less seriously injured. However, contrary to the anterior teeth, the injury types of posterior teeth in maxilla and mandible showed no remarkable difference.

We also showed that the injury types between anterior teeth (incisors and canines) differ significantly from posterior teeth (premolars and molars). More hard dental tissue injuries occurred in posterior teeth (including crown fractures, crown–root fractures, and root fractures), which gives an impression that the more cusps or roots in teeth, the greater the likelihood of the occurrence of hard dental tissue injury. More dislocation injuries (including avulsion, subluxation, and intrusive dislocation) were found in anterior teeth; this finding is consistent with the study by Lieger et al. (4).

Regarding specific types of facial fractures, we found that patients with fractures limited to the maxilla had a low risk of teeth injury (OR = 0.385, $P < 0.001$). This finding was consistent with the study by Lieger et al. (4). We attributed this low risk of dental trauma to the resiliency because of the pneumatization of sinus cavities in the maxilla. A high risk of teeth injury was found in patients with the combination fractures of the maxilla and mandible (OR = 1.780, $P < 0.001$); which is also in agreement with Lieger et al. (4). This could be due to the high eternal force leading to impaction of the lower jaw against the upper teeth. In these patients, the chin area most likely hit the ground first, causing forceful closure of the jaws, leading to dental injuries of both jaws (4). When patients sustained exclusively single mandible fracture, we found that dental injuries were associated most frequently in patients with symphysis fracture of the mandible (OR = 2.817, $P < 0.001$). It was in accordance with the findings by Lieger et al. (4). Interestingly, patients who sustained exclusively mandibular angle fracture had the lowest risk of dental trauma (OR = 0.236, $P < 0.001$). Limited literature have reported this phenomenon; the explanation for this is mainly because of few teeth in the region of angle of mandible; most of the wisdom teeth in this area often extracted preventively (8).

In conclusion, the authors observed a significant dental injury rate in patients who sustained maxillofacial fractures. The occurrence of dental trauma is also significantly related to the pattern and position of the maxillofacial fractures. Fall from a height possessed the highest risk of dental trauma. Preventive measures such as wearing mouth guards when working or playing at height or above ground level should be emphasized. A thorough dental examination in all patients with facial injury should be emphasized.

Conflict of interest

None.

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