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Pattern of traumatic dental injuries in the permanent dentition among children, adolescents, and adults

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Abstract – *Background:* Traumatic dental injuries (TDI) comprise six types of luxation and seven types of tooth fractures. The risk of pulp necrosis is increased in teeth with combination injuries where fractures and luxations occur concomitantly. *Aim:* To report and compare the distributions of luxations and fracture types among children, adolescents, and adults, and to analyze the distribution and prevalence of combination injuries. *Material and method:* The study group included 4754 patients (3186 men and 1568 women) with 10 166 traumatized permanent incisors treated at Copenhagen University Hospital, Rigshospitalet. Differences in the distributions of trauma types among age groups (children <12 years, adolescents 12–20 years, and adults >20 years) and distributions of concomitant crown fractures for each luxation type were analyzed with the Chi-square test. *Results:* A total of 7464 teeth (73.4%) had suffered a luxation injury and 5914 teeth (58.2%) a fracture. The overall most frequent injuries were *crown fractures without pulp exposure* (34.9%), *concussions* (24.2%), and *subluxations* (22.2%). The relative frequency of *crown fractures without pulp exposure* decreased across age groups (children 45.2%, adolescents 36.5%, adults 26.3%, $P < 0.001$), whereas the relative frequencies of other injury types increased across age groups : *crown–root fractures* (children 1.8%, adolescents 6.3%, adults 9.2%, $P < 0.001$), *root fractures* (children 2.5%, adolescents 4.6%, adults 8.7%, $P < 0.001$), and *lateral luxations* (children 5.7%, adolescents 10.9%, adults 13.0%, $P < 0.001$). One-third of the traumatized teeth ($n = 3212$) had sustained a combination of a fracture and a luxation injury. The luxation types most frequently presenting with a concomitant crown fracture were concussion (57.9%), intrusion (47.2%), and subluxation (33.4%) ($P < 0.001$). *Conclusion:* The majority of TDI were minor injuries. The relative frequencies of injury types varied among age groups. Combination injuries were observed in one-third of the traumatized teeth and occurred most frequently in teeth with concussion, intrusion, and subluxation.

Dental trauma can result in a number of different injury types involving the tooth and the supporting structures. Six types of luxation and seven types of tooth fracture have been described (1) and used to classify traumatic dental injuries (TDI). The complexity of dental trauma is further increased by the possibility of combination injuries where the trauma has caused both a luxation and a fracture injury in the same tooth.

Recent studies have shown a significantly increased risk of pulp necrosis in teeth with concussion, subluxation, and lateral luxation if they have suffered a concomitant crown fracture (2–5). Minor injury types such as subluxation and crown fracture without pulp exposure carry a low risk of pulp necrosis when they occur as an isolated injury. However, if both occur simultaneously in the same tooth, they have a synergetic effect and involve an increased risk of pulp necrosis (3). A number of epidemiological studies have explored TDI in the permanent dentition (6–17), but little is currently known about the prevalence of combination injuries and how luxations and fractures may occur concomitantly. The extent of damage to the teeth and the supporting structures following dental trauma are determined by the energy and direction of the impact and by the resilience of the involved structures (18). Advancing age is associated with changes in the biological structures like bone (19, 20), teeth (21), and the periodontal ligament (22). It was, therefore, hypothesized that the frequency of luxations and fractures would vary between different age groups.

The aim of this study was to report and compare the distributions of luxation and fracture types among children, adolescents, and adults and to analyze the distribution and prevalence of combination injuries.

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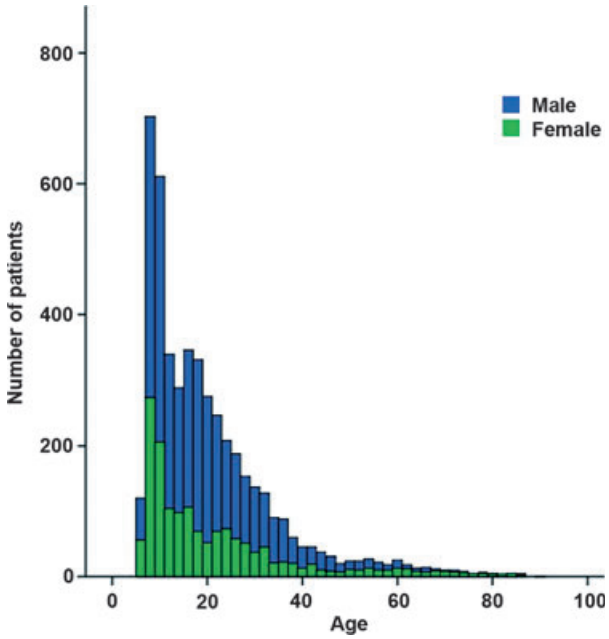

Fig. 1. Age distribution. Age of female patients ranged from 6 years to 86 years (median 15 years, inter-quartile range 9; 27 years). Age of male patients ranged from 6 years to 89 years (median 17, inter-quartile range 10; 25 years).

Materials and methods

Data were extracted from a database containing information on all patients treated for TDI at the Copenhagen Trauma Center (Department of Oral and Maxillofacial Surgery, Copenhagen University Hospital, Rigshospitalet) in the period from 1971 to 1983 (23). The data comprised of 4754 patients (3186 men and 1568 women) with 10 166 permanent incisors. Figure 1 shows the age and gender distributions.

The Copenhagen Trauma Center was the main out-of-hours facility for treatment of TDI in Copenhagen from 1971 to 1983. During office hours, patients with minor trauma injuries received treatment at the community dentistry services for children or by general practitioners. All patients who sought treatment at the University Hospital were received regardless of the severity of their trauma.

Dental trauma was a special focus area at the Department of Oral and Maxillofacial Surgery, Copenhagen University Hospital, Rigshospitalet, during this time period (1971–1983). Oral surgeons and dentists who performed the initial examination and the emergency treatment had received 6 months of supervised training in the clinic.

Observations from the clinical examination were registered on a structured trauma chart, and radiographic and photographic examinations were performed to document soft and hard tissue injuries. The examination procedure has been described in detail previously (24). Trauma entities were defined according to a modification of the WHO classification (1). Enamel fractures and enamel–dentin fractures were grouped as crown fractures without pulp exposure. Crown–root fractures included all crown–root fractures with and without pulp exposure. Patients were included in the study if they had a permanent incisor with at least one of the following diagnoses: *concussion, subluxation, extrusion, lateral luxation, intrusion, avulsion, trauma-related infraction, crown fracture without pulp exposure, crown fracture with pulp exposure, crown–root fracture, or root fracture*. Patients with alveolar fractures and jaw fractures were excluded from this study. Combination injuries were defined as injuries where a fracture and a luxation occurred concomitantly in the same tooth.

Statistical analysis

The relative frequencies of specific luxation injuries and fractures and combinations of these were computed in all age groups separately as the number of teeth diagnosed with the specific injury divided by the number of teeth. The relative frequency of each injury type was compared across three age groups (children, adolescents, and adults). The distribution of concomitant crown fractures was analyzed across luxation types. The chi-square test was used for all comparisons, and the level of significance was set at 1%. The analysis was performed with the statistical software SPSS 18, SPSS Inc., Chicago, IL, USA.

Results

Twice as many men as women received acute treatment for TDI. Among the total number of permanent incisors (n = 10 166), 7464 teeth (73.4%) had suffered a luxation injury and 5914 teeth (58.2%) had suffered a fracture. A combination of a fracture and a luxation injury was seen in 3212 teeth (31.6%). Table 1 shows the distributions of luxation injuries and fractures in relation

Table 1. Frequency distribution of teeth with fractures and luxations by gender (n = 10 166)

	Males n (%)	Females n (%)	P value
Fracture			
No fracture	2830 (41.4)	1422 (42.6)	0.25
Infraction	343 (5.0)	157 (4.7)	0.49
Crown fracture without pulp exposure[1]	2354 (34.5)	1197 (35.9)	0.16
Crown fracture with pulp exposure	451 (6.6)	215 (6.4)	0.76
Crown root fracture[2]	432 (6.3)	191 (5.7)	0.24
Root fracture	420 (6.1)	154 (4.6)	0.002
Total	6830 (100.0)	3336 (100.0)	–
Luxation			
No luxation	1815 (26.6)	887 (26.6)	0.99
Concussion	1663 (24.3)	798 (23.9)	0.63
Subluxation	1505 (22.0)	753 (22.6)	0.54
Extrusion	463 (6.8)	219 (6.6)	0.68
Lateral luxation	670 (9.8)	365 (10.9)	0.08
Intrusion	83 (1.2)	47 (1.4)	0.42
Avulsion	631 (9.2)	267 (8.0)	0.04
Total	6830 (100.0)	3336 (100.0)	–

[1]Including enamel fractures and enamel – dentin fractures.
[2]Including crown – root fractures with and without pulp exposure.

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to gender. A statistically significant difference between the two genders was seen only for root fractures and avulsion injuries. However, the actual differences in the relative frequencies were very small and without clinical relevance. Data for the two genders were, therefore, pooled in the subsequent analysis. The overall most prevalent injury types were *crown fracture without pulp exposure* (34.9%), *concussion* (24.2%), and *subluxation* (22.2%).

Table 2 gives the distribution of luxation types and fracture types for children (below 12 years), adolescents (12–20 years), and adults (more than 20 years). The relative frequency of some injury types decreased across age groups: *crown fractures without pulp exposure* (children 45.2%, adolescents 36.5%, adults 26.3%, $P < 0.001$) and *concussion* (children 27.6%, adolescents 26.0%, adults 20.5%, $P < 0.001$). In other injury types, the relative frequencies were increased across age groups: *crown–root fractures* (children 1.8%, adolescents 6.3%, adults 9.2%, $P < 0.001$), *root fractures* (children 2.5%, adolescents 4.6%, adults 8.7%, $P < 0.001$), and *lateral luxations* (children 5.7%, adolescents 10.9%, adults 13.0%, $P < 0.001$).

One-third of the traumatized incisors had suffered a combination injury ($n = 3212$). Table 3 gives the distribution of luxation types in relation to fracture types in teeth with combination injuries. Enamel–dentin fracture, concussion, and subluxation were the most frequent injury types among the combination injuries. Furthermore, root fractures were often accompanied by displacement or avulsion of the coronal fragment. Figure 2 shows the frequency of a concomitant *crown fracture* for each luxation type. The luxation types most frequently presenting with a concomitant *crown fracture* were concussion (57.9%), intrusion (47.2%), and subluxation (33.4%) ($P < 0.001$). The relative frequencies of different combinations of fractures and luxations varied between age groups (Fig. 3).

Discussion

The results of this study demonstrated that the majority of TDI treated at the Copenhagen University Hospital, Rigshospitalet, between 1971 and 1983 were minor injuries such as concussions, subluxations, and crown fractures without pulp exposure. This is in accordance with previous studies that used a similar classification (6–11). However, other studies have reported very low prevalence of concussions or subluxations (12–17). This may be explained by differences in study designs and trauma classifications. Furthermore, treatment delay may influence the diagnostic result because symptoms of mild luxations such as concussions and subluxations may have subsided if the patient does not appear for treatment until days after the trauma has occurred.

One-third (31.5%) of all TDI in this study were combination injuries. The prevalence was somewhat lower (10–21.7%) in the few previous studies reporting on the occurrence of combination injuries (9–11). The very low prevalence of 10% reported by Borssén & Holm (10) (981 traumatized teeth) may be a consequence of the retrospective study design where there was no particular awareness of combination injuries and where the reported prevalence of concussion was also very low. In a prospective study analyzing the distribution of TDI among 1275 Norwegian school children (9), the reported prevalence of combination injuries was 18%. The dental health system in Norway is comparable to the Danish, and it is noteworthy that the reported relative frequencies of concussion, subluxation, and crown fractures resemble the results of this study. The higher prevalence of combination injuries found in our study, compared with the Norwegian study, may be explained by ascertainment bias as a higher frequency of severe injuries such as avulsions, root fractures, and crown–root fractures may be expected at a hospital emergency clinic

Table 2. Frequency distribution of teeth with fractures and luxations by age groups ($n = 10\ 166$)

	<12 years *n* (%)	12–20 years *n* (%)	More than 20 years *n* (%)	*P* value[1]
Fracture type				
No fracture	1274 (40.6)	1039 (37.3)	1939 (45.7)	<0.001
Infraction	123 (3.9)	184 (6.6)	193 (4.6)	<0.001
Crown fracture without pulp exposure[2]	1418 (45.2)	1017 (36.5)	1116 (26.3)	<0.001
Crown fracture with pulp exposure	189 (6.0)	244 (8.8)	233 (5.5)	<0.001
Crown root fracture[3]	57 (1.8)	175 (6.3)	391 (9.2)	<0.001
Root fracture	77 (2.5)	128 (4.6)	369 (8.7)	<0.001
Total	3138 (100.0)	2787 (100.0)	4241 (100.0)	–
Luxation type				
No luxation	744 (23.7)	813 (29.2)	1145 (27.0)	<0.001
Concussion	866 (27.6)	726 (26.0)	869 (20.5)	<0.001
Subluxation	867 (27.6)	495 (17.8)	896 (21.1)	<0.001
Extrusion	216 (6.9)	154 (5.5)	312 (7.4)	0.01
Lateral luxation	180 (5.7)	304 (10.9)	551 (13.0)	<0.001
Intrusion	60 (1.9)	35 (1.3)	35 (0.8)	<0.001
Avulsion	205 (6.5)	260 (9.3)	433 (10.2)	<0.001
Total	3138 (100.0)	2787 (100.0)	4241 (100.0)	–

[1]Chi-square test of difference among all three agegroups.
[2]Includes enamel fractures and enamel – dentin fractures.
[3]Includes crown – root fractures with and without pulp exposure.

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Table 3. Distribution of teeth with combinations of luxations and fractures (n = 3212)

	Infraction *n* (%)	Crown fracture without pulp exposure[1] *n* (%)	Crown fracture with pulp exposure *n* (%)	Crown root fracture[2] *n* (%)	Root fracture *n* (%)	Total *n* (%)
Concussion	146 (9.8)	986 (66.7)	220 (14.9)	106 (7.2)	21 (1.4)	1479 (100.0)
Subluxation	99 (11.5)	539 (62.4)	62 (7.2)	53 (6.1)	111 (12.8)	864 (100.0)
Extrusion	16 (5.8)	91 (33.1)	6 (2.2)	11 (4.0)	151 (54.9)	275 (100.0)
Lateral luxation	43 (14.1)	149 (48.7)	21 (6.8)	16 (5.2)	77 (25.2)	306 (100.0)
Intrusion	2 (3.1)	53 (82.1)	4 (6.3)	3 (4.7)	2 (3.1)	64 (100.0)
Avulsion	12 (5.3)	79 (35.3)	12 (5.3)	9 (4.0)	112 (50.0)	224 (100.0)
Total	318 (9.9)	1897 (59.1)	325 (10.1)	198 (6.2)	474 (14.8)	3212 (100.0)

[1]Includes enamel fractures and enamel – dentin fractures.
[2]Includes crown – root fractures with and without pulp exposure.

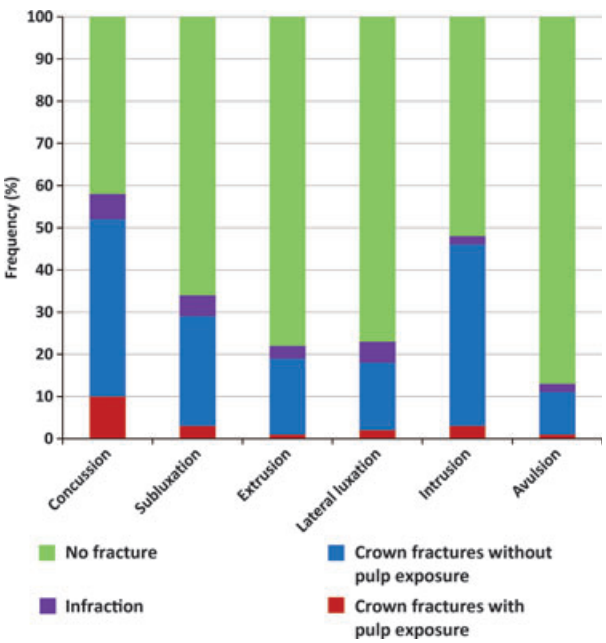

Fig. 2. The frequency of concomitant crown fracture (%) for each luxation type. Crown-root fractures and root fractures are not included.

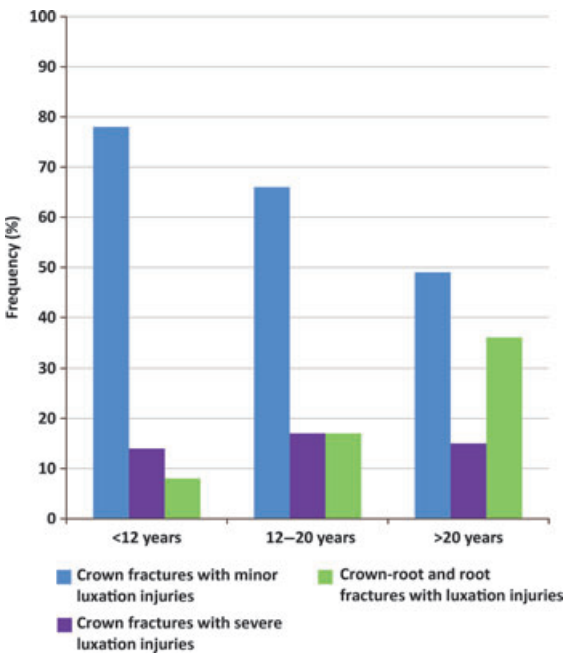

Fig. 3. The relative frequency (%) of different combination injuries by age. Minor luxation injuries include concussion and subluxation. Severe luxation injuries include extrusion, lateral luxation, intrusion, and avulsion.

compared with the public dental health services. These types of injury account for 24.1% of the combination injuries reported in this study.

The extent of damage to the teeth and the supporting structures following dental trauma is determined by the energy and direction of the impact and by the resilience of the involved structures (17, 18). In this study, the relative frequencies of crown–root fractures, root fractures, and lateral luxations were higher among adults than among adolescents and children, whereas the relative frequencies of crown fractures without pulp exposure and concussions decreased across age groups. This observation may be explained by a difference in the cause of injury between children and adults. The main causes for dental trauma in children are falls and injuries sustained during play, whereas in adolescents and adults, more complex traumas may occur caused by sport accidents, fights, and motorized vehicle accidents (16, 25). Local biological factors will also affect the injury pattern (17). The mechanical properties of bone in children are different from those of adults. Children's bone is less mineralized and has a higher resilience (19, 20). Likewise, the continuous deposition of dentin and cementum throughout life will alter the mechanical properties of the tooth and the periodontal ligament (22). An *in vitro* experiment has shown that the transmission of energy in a tooth following an impact to the crown is altered if the damping effect of the surrounding tissues is increased (26). Thus, energy from a trauma which may be absorbed by a flexible bone and a wide periodontal ligament in a child may lead to a root fracture in an adult. Furthermore, the length of the root

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(27) and the protective potential of the soft tissue will also influence the result of a trauma (17). The etiology of TDI is, accordingly, very complex, and a similar impact will manifest itself differently in children and adults. The luxation types most frequently encountered with a concomitant crown fracture were concussion (57.9%), intrusion (47.2%), and subluxation (33.4%).

The mechanism and nature of the energy transmission following an impact to a tooth is more or less without experimental evidence (26, 27). However, we conjecture that a crown fracture will absorb the majority of the energy of the impact and thereby prevent major damage to the periodontal ligament. This may explain why crown fractures were more prevalent in teeth with minor luxation injuries, that is, concussion and subluxation injury. In teeth with extrusion, avulsion, or lateral luxation, the energy of the impact is transferred to the periodontal ligament and the alveolar bone. This may explain why concomitant crown fractures were not as frequently observed in these luxation types. An intrusive luxation is the result of an impact with an axial direction that has forced the tooth into the alveolar bone. In this situation, there is little dampening effect of the periodontal ligament, and a concurrent crown fracture is then a more common finding.

The majority of previous epidemiological studies of TDI have not considered combinations of luxation injuries and fractures (6–8, 12–16). Hence, there may be a lack of awareness of combination injuries. Two-thirds of all combination injuries in this study were observed among teeth with minor luxation injuries such as concussion and subluxation. In a stressful clinical situation, there is a risk of overlooking minor concomitant injuries such as concussions, subluxations, or minor fractures. This may lead to a misinterpretation of the severity of the trauma and of the risk of subsequent healing complications (1–5). A thorough diagnostic procedure where both luxation and fracture injuries are registered is, therefore, important to offer the patient the best treatment.

Conclusion

The majority of TDI were minor injuries. The relative frequencies of injury types varied among age groups. Combination injuries were a common finding among traumatized permanent teeth. Concomitant crown fractures occurred most frequently in teeth with concussion, subluxation, or intrusion. Because teeth with combination injuries have an increased risk of pulp necrosis, it is important to raise the awareness of these injuries and to stress the importance of a thorough diagnostic procedure where both luxation and fracture injuries are registered.

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