

Traumatic dental injuries: etiology, prevalence and possible outcomes

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SUMMARY

Objective. The aim was to overview the etiology, prevalence and possible outcomes of dental trauma.

Material and methods. An electronic search of Medline (Pub Med), Cochrane, SSCI (Social Citation Index), SCI (Science Citation Index) databases from 1995 to the present, using the following search words: tooth injuries, tooth trauma, traumatized teeth, dental trauma, dentoalveolar trauma, oral trauma, epidemiology, etiology, prevalence, prevention, pulp necrosis, inflammatory resorption, ankylosis, cervical resorption, was performed.

Results. During last decade traumatic dental injuries were recognized as public dental health problem worldwide. Prevalence of traumatic dental injuries varies between countries. According to the existing data they are more prevalent in permanent than in primary dentition. All treatment procedures in case of dental trauma are directed to minimize undesired consequences despite that treatment of traumatic dental injuries in the young patient is often complicated and can continue during the rest of his/her life. The changing lifestyle and requirements of modern society lead to an emergence of new patterns of dental trauma. A regular update of knowledge in dental traumatology is required.

Key words: dental trauma, etiology, prevalence, pulp necrosis, resorption, ankylosis.

INTRODUCTION

Existing data on prevalence of traumatic dental injuries varies between countries. The differences of design of performed studies could be one of the explanations of such variety of the results. Most of the studies are cross-sectional except few longitudinal (1-6). Registration of traumatic dental injuries in cross-sectional studies has certain degree of subjectivity due to the fact that partly information about the previous traumatic accident is partly taken from interview of child or his/her parents. Possibly not all traumatic injuries are reported. Local environmental, behavioral and cultural diversities of countries could have an influence on the results as well.

Oral traumas are not frequent and make up to 5% of all injured parts of the body of all ages while

in age group of 0-6 years it comprises about 17% (7). Traumatic dental injuries are more prevalent in permanent (58.6%) than in primary dentition where they constitute 36.8% (8, 9). Dental injuries mainly involve front teeth of the upper jaw. The most frequent causes of these injuries are falls, sport activities, bicycling, traffic accidents. Predisposing factors of dental trauma could be related to the person's anatomic features: increased overjet, inadequate lip coverage of the upper anterior teeth etc. (10, 11).

Home and school are places where traumatic dental injuries usually occur. It has been shown that the place of injury was related to gender, i.e. the most frequent location of injury for boys was school followed by home, while for girls this was vice versa (12-14).

Treatment of dental trauma is not an ordinary situation in daily dental practice. Outcome of the treatment is highly related to the knowledge and skills of the dentist as well as to the emergency aid at the place of the injury. So, not only the dentist, but also parents, teachers and coaches must have basic knowledge in emergency management of dental trauma. A person with injured tooth becomes a challenge for the dentist due to the rarity of the situation and uncertainty of the

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treatment prognosis. It is not a routine procedure for the majority of the practicing dentists and it demands precise diagnosis, adequate emergency management and correct treatment with follow-ups. All treatment procedures in case of dental trauma are directed to minimize undesired consequences which might lead not only to the loss of the tooth, but also to the loss of the alveolar bone and in such way impede realization of possible treatment plan. It is important to realize that treatment of traumatic dental injury in the young patient is often unpredictable, complicated, expensive and can continue during the rest of his/her life. Due to the fact that peak of the traumatic injuries in permanent dentition is between 10-12 years of age, consequences of dental traumas may have lifelong impact on person's quality of life. For this reason treatment planning often involves specialists from different disciplines of dentistry.

The aim of this article is to present a review of the etiology, prevalence and possible outcomes of dental trauma.

SEARCH METHODOLOGY

An electronic search of Medline (Pub Med), Cochrane, SSCI (Social Citation Index), SCI (Science Citation Index) databases from 1995 to the present, using the following search words: tooth injuries, tooth trauma, traumatized teeth, dental trauma, dentoalveolar trauma, oral trauma, epidemiology, etiology, prevalence, prevention, inflammatory resorption, ankylosis, cervical resorption and review, was performed. The search yielded 331 titles and abstracts on chosen words. Reading of these articles resulted in the inclusion of 85 publications.

CLASSIFICATION OF TRAUMATIC DENTAL INJURIES

Classification of traumatic dental injuries comprises trauma to the hard dental tissues and the pulp, to the periodontal tissues, to the supporting bone and to gingiva and oral mucosa (Table 1). It reflects the *Application of international classification of diseases to dentistry and stomatology* by World Health Organization (WHO) (15, 16).

It comprises seven types of tooth fractures, six types of luxations, eight types of damage to supporting bone and three to oral mucosa or gingiva (16).

Classification used in clinical practice differs from classification used in epidemiological

studies and comprises six categories: no traumatic dental injury, treated traumatic dental injury, enamel fracture, enamel-dentin fracture, pulp injury and missing tooth due to the traumatic dental injury (16).

ETIOLOGY OF DENTAL TRAUMA. PREDISPOSING FACTORS

Traumatic dental injuries can result from either direct or indirect impact. The extent of the damage is related to such factors as energy of impact, resilience and shape of the impacting object, direction of the impact and the reaction of the tooth surrounding tissues.

Studies show that dependency of type and causes of the traumatic dental injuries to permanent and primary dentition exists. This phenomenon might be related to the features of the underlying bone structure which in primary dentition is less mineralized than in permanent. Therefore trauma in primary dentition more often results in displacement of the tooth. In primary dentition there was a greater range of trauma associated with falls and collisions due to the increase

Table 1. Classification of traumatic dental injuries (15, 16)

Type of injury (code according WHO)
Injuries to the hard dental tissues and the pulp
Enamel infraction (N 502.50)
Enamel fracture (N 502.50)
Enamel- dentin fracture (N 502.51)
Complicated crown fracture (N 502.52)
Uncomplicated crown- root fracture (N 502.54)
Complicated crown-root fracture (N 502.54)
Root fracture (N 502.53)
Injuries to the periodontal tissues
Concussion (N 503.20)
Subluxation (N 503.20)
Extrusive luxation (N 503.20)
Lateral luxation (N 503.20)
Intrusive luxation N 503.21
Avulsion (N 503.22)
Injuries to supporting bone
Comminution of the maxillary alveolar socket (N 502.40)
Comminution of the mandibular alveolar socket (N 502.60)
Fracture of the maxillary alveolar socket (N 502.40)
Fracture of the mandibular alveolar socket (N 502.60)
Fracture of the maxillary alveolar process (N 502.40)
Fracture of the mandibular alveolar process (N 502.60)
Fracture of the maxillae (N 502.42)
Fracture of the mandible (N 502.61)
Injuries to gingiva or oral mucosa
Laceration of gingiva or oral mucosa (S 01.50)
Contusion of gingiva or oral mucosa (S 00.50)
Abrasion of gingiva or oral mucosa (S 00.50)

of independent movements in age group between 0-6 years, while accidents during playing, sport injuries increased in age group between 7-15 years and violence resulted in dental injuries most frequently in age group 21-25 years (17, 18;).

It was revealed that falls were the main common cause of traumatic dental injuries (from 31.7 to 64.2%) followed by sport activities (up to 40.2%), bicycling accidents (up to 19.5 %), traffic accidents (up to 7.8%), physical violence (up to 6.6%) (19-22). From this group of causes traffic accidents constitute a special group of trauma due to predominant multiple injuries including supporting tissues. Moreover, new types of facial trauma occur from airbag explosion in cars during traffic accidents (23, 24). Bicycling accidents are common cause of dental trauma in schoolchildren group. According to the results of the studies if the obligatory wear of bicycle helmets reduced incidence of facial trauma by 65%, incidence of dental trauma incidence by this measure was not reduced (25). Although sport activities is one of the main causes of dental trauma they are classified according to its risk categories: high-risk (American football, hockey, ice hockey, lacrosse, martial sports, rugby and skating) and medium-risk sports (basketball, team handball, diving, squash, gymnastics, parachuting and water polo) (26).

The tendency of increase in the severity of violence among individuals concerning traumatic dental injuries is an alarming factor (19-22). It is important to emphasize that dentists could be the first ones to detect children who had suffered physical abuse. The results from the study performed in United States showed that almost nearly 30% of dentists had a suspicion of child abuse, but only 9-14% claimed that have reported it (27).

Some traumatic dental injuries are of iatrogenic nature and occur during the intubation procedure during general anaesthesia. This type of traumas constitutes from 0.04% to 12% of all cases (28). In UK this complication during anaesthesia is reported to constitute approximately one-third of all claims (29). Dental traumas related to iatrogenic reasons are mainly fractures of crowns and roots and luxation injuries including avulsions.

Piercing of tongue and lips is quite a new category of traumatic dental injuries and may lead to fracturing of teeth and restorations, pulp damage, cracked tooth syndrome (30). The prevalence of chipped teeth among individuals with tongue piercing constitutes 19.2% (31).

It is evident that prevalence of dental injuries differs among studies done in the different countries. The impact of socioeconomic status is discussed and two controversial opinions exist. One of them states that children with low socioeconomic background are more likely to have traumatic dental injuries, while another says that children from high socioeconomic background have higher risk for dental trauma due to their greater access to leisure activities (32, 33).

It is important to remember that some individual anatomical features might serve as predisposing factors to higher incidence of dental trauma. Noori & Al-Obaidi observed that children with class II division 1 malocclusion were more often reported (70%) to have traumatic dental injuries than children with other types of occlusion (13). The most commonly reported factors are large overjet (>3.0 mm), incompetent lips and absence of mouthguards while playing sports (12, 21, 34-36). Children with an overjet with size greater than 3.0 mm were 5.4 times more likely to present with a dental injury than children with an overjet size equal or lower than 3.0 mm (36).

Soriano *et al.* showed that schoolchildren with inadequate lip coverage presented a fourfold higher risk of traumatic dental injuries (35). Gupta *et al.* confirmed this finding and showed that children with inadequate lip coverage were 3.4 times more likely to suffer from a traumatic dental injury than children with adequate lip coverage (36).

Table 2. Prevalence of traumatic injuries

Author	Year of publication	Region	Sample size	Age	Percentage
Sgan-Cohen et al. (34)	2008	Jerusalem	453	5th,6th grade	33.8%.
Fakhrudin et al. (14)	2008	Canada	2422	12;14 year	11.4 %,
Eyuboglu et al. (20)	2009	Turkey	653	1 - 15 years	4.9 %
David et al. (41)	2009	South India	838	12-year old	6 %
Diaz et al. (18)	2010	Chile	–	7-12 year old	66.6 %
Bendo (12)	2010	Brazil	1612	11-14 years	17.1 %
Livny (45)	2010	Palestine	804	6th grade	17.7 %
Navabazam & Farahani (39)	2010	Iran	1440	9-14 years old	27.56 %
Taiwo et al. (21)	2011	Nigeria	719	12-year old	15.2%
Kumar (44)	2011	India	963	12-15 years old	14.4 %
Kelly O. George (46)	2012	Brazil	891	15-19 years old	24.7 %

Repeated trauma episodes are interesting phenomenon. Some people are not affected by dental trauma through whole lifetime while some of them experience them repeatedly and even on the same tooth (37).

DISTRIBUTION BY AGE AND GENDER

Studies have shown that males experienced traumatic dental injuries at least twice as often as females. The male:female ratio varies from 1.5:1.0 to 2.5:1.0 (13, 17, 18, 38, 39). Such ratio could be attributed to a greater participation of boys in contact sports, fights and car accidents (20, 38, 40, 41). Also it could be related to the fact that girls are generally more mature in their behaviors than boys, who tend to be more energetic and active (39). However, some of the studies have shown a reduction in the gender ratio which might be due to increased sports activities among girls (11). Altun *et al.* observed some association between gender and type of injury. Boys more often suffered from dental hard tissue and pulp injury than girls (40). According to the results of the studies for a long time gender had been determined as one of the predisposing factors of dental injuries, while now traumatic dental injuries are more likely to be related to the activities and the environment (42).

Another well-known risk variable of traumatic dental injuries is age. Results of various studies showed the existence of the target groups. According to Lam *et al.* up to 92% of traumatic dental injuries occur before the age of 34 year (17). Distinct age groups are determined and majority of injuries occur in the 0 to 4, 5 to 9 and 10 to 14 years age groups (17). Discrepancies can be seen in the group of 6-14 year-olds in the rate of traumatic dental injuries within smaller subgroups. Altun *et al.* observed that injury rates were highest among children age 6 and ages 8-10 (40). Eyuboglu *et al.* showed the highest frequency of traumatic dental injuries at the age 8-10 (20). While Diaz *et al.* observed that the highest rate of dental injuries in permanent dentition occurred in groups of 7-9- and 10-12- year-olds (18). A study by Navabazam and Farahani identified the 9-10 age range as the period of life when majority of the dental trauma occur (39). In a study by Faus-Damia *et al.* the highest prevalence of traumatized children was at the age of 12.2 years old (22).

PREVALENCE OF DENTAL TRAUMA

Data from many countries showed that one third of all preschool children have suffered traumatic dental injuries involving the primary dentition and

one fourth of all school children and almost one third of adults have suffered a trauma to the permanent dentition (14, 21, 37, 43-46).

Prevalence of dental trauma varies between different countries, age groups, genders, socioeconomic environments etc. (Table 2). The prevalence of traumatic dental injuries among schoolchildren aged 12-15 years varies between 14.4-33.8% (21, 44, 45). Even in the studies from the same country differences are evident. A study by Kumar A. *et al.* in India showed that the prevalence of dental traumas was 14.4% while in another district of South India it constituted 6% and was rather low compared to other studies among 12-year-old schoolchildren (41, 44). Differences observed in prevalence of trauma could be related to the discrepancies of the performed sampling procedures.

The prevalence of dental trauma among 5th and 6th grade schoolchildren in eastern Jerusalem was reported to be 33.8% (34). While in Canada, in a sample of 2422 schoolchildren, aged 12 and 14, traumatic dental injuries were less prevalent (11.4%) (14). In a study of Chilean children and adolescents the group of 7 to 12 year olds had the highest frequency of traumatic dental injuries, i.e. 66.6% (18). Bendo CB *et al.* showed the prevalence of traumatic dental injuries of 17.1% out of 1612 schoolchildren aged 11 to 14 years attending public and private schools (12). A slightly higher percentage of dental traumas was reported in another study from Brazilian population, where the prevalence of traumatic injuries among adolescents aged 15 to 19 years old constituted 24.7% (46).

It should be noticed that there is an increase observed in the prevalence of dental traumas over the last decade which could be attributed to a greater participation in sporting activities (17).

Upper central incisors are the teeth most often damaged during traumatic injury in primary and permanent dentitions. The type of traumatic dental injury differs in different types of dentition, but variations have been also observed between and within countries. The maxillary incisors (66.7%) were the most affected teeth, followed by lateral incisors (17.4%). Enamel fracture is the most frequent type of trauma (63.7-80%) followed by enamel-dentin fracture (15.9-17.2%) (14, 21, 44).

A Palestinian study conducted by Livny reported 17.7% prevalence of traumatic dental injuries. Enamel fractures and injuries involving dentine accounted for 41% and 42.5% of all dental injuries, respectively (45).

In a bigger Iranian study the prevalence of traumatic dental injuries only in maxillary permanent teeth was revealed to be 27.56% (39).

Different types of luxation injuries are more common in primary teeth: subluxation (38.6%), lat-

eral luxation (22.5%), avulsion (16.6%) while enamel dentin fractures predominate in permanent dentition (32%) (17, 18, 20).

The majority of dental injuries in permanent and primary dentitions involve the anterior teeth of upper jaw, especially the maxillary central and lateral incisors, regardless of the type of the study. Traumatic dental injuries usually affect a single tooth, but certain trauma events, such as sports, violence and traffic accidents result in multiple tooth injuries.

TREATMENT OF TRAUMATIC DENTAL INJURIES

The results of surveys performed in USA showed that almost every third child with primary teeth and every fourth adult showed evidence of traumatic dental injuries (37). Low rates of treatment of dental trauma are observed worldwide, however. This phenomenon could be related that uncomplicated injuries to the enamel-dentin are not perceived as a situation which needs immediate treatment. Treatment of dental trauma especially luxation injuries is expensive, time-consuming and involves different specialists and time-consuming, needs long follow-up. The average number of treatment visits in case of dental trauma ranges from 1.9 to 9.1 per 1 year (47, 48).

Results of Glendor study showed that in Sweden a total cost of treatment of dental injuries in the 0–19 years old patients made up US \$ 3.3–4.4 million per one million individuals per year (49). In Denmark the annual cost of treatment of dental injuries irrespective of age per year ranged from US \$ 2 to 5 million per one million inhabitants (50).

Traumatic dental injuries might alter facial appearance of children (51). Cortes with co-authors showed that children with untreated fractured teeth reported 20 times more a negative impact on their daily life than children without traumatic dental injuries (51). Children with dentofacial deviations experienced teasing, embarrassment and lack of social acceptance (52).

OUTCOME OF TRAUMATIC DENTAL INJURIES

The most favorable outcome of traumatic dental injuries is healing of the pulp and surrounding tissues. However, traumatic dental injuries are often accompanied by complications of different types and severities like: pulp necrosis, apical periodontitis, discoloration of tooth crown, fistulas, external inflammatory root resorption. The outcome of dental trauma depends on the type of injury, time prior emergency treat-

ment, and quality of treatment. Consideration has to be given to the fact that complications of dental trauma can occur several months or even years after the injury (53, 54).

Traumatic dental injuries to the hard dental tissues and the pulp such as uncomplicated or complicated crown or root fractures could be accompanied by pulp necrosis. The consequences of traumatic dental injuries to the surrounding tissues of the tooth, in case of avulsion or intrusion injuries, can be even more serious, e. g. various types and degrees of root resorption could be expected.

Traumatic dental injuries like infraction, enamel fracture, uncomplicated or complicated crown fracture represent different possible pathways for bacteria to enter pulp space and to become a cause of pulp inflammation and necrosis as a consequence (55–58). Pulp necrosis as complication following uncomplicated crown fractures is rare and range between 2% and 5% (59). The rate of pulp survival in more severe traumatic injury like complicated crown fractures varies from 63% to 94% (60). If these injuries are treated in an appropriate way, a long-term maintenance of pulp vitality (75.8%) can be expected (60). The chosen treatment method and the time period between the trauma and treatment initiation have a significant influence. Two main methods used in this case are pulp capping and pulpotomy. Pulp capping was less successful in maintaining pulp vitality and pulp necrosis has been found in 45.5% of cases, while partial pulpotomy resulted in considerably higher success rate, i.e. pulp necrosis has developed only in 13.6% of treatment cases (60). Pulp survival was also reported from 60% to 80% in cases of root fractures (61–64).

Pulp necrosis is related to the extent of the damage to the neurovascular supply of the pulp. The severity of it depends on the type of the luxation injury, development stage of the root apex and quality of emergency treatment. Injury to the neurovascular supply could range from minor degree such as stretching, compression of the nerves and blood vessels to a complete disruption of them. Pulp necrosis is frequent in luxated teeth with mature apex and quite rare in immature teeth (65–67). Two types of pulp necrosis are related to traumatic injuries: an ischemic sterile necrosis is caused by disruption of the blood supply at the apical foramen and infection-related liquefactive necrosis (65, 66, 68). The reported prevalence of pulp necrosis in luxated teeth varies from 17 to 100% in accordance with severity of trauma type (66, 69).

It is evident that an isolated crown fracture by itself carries a low risk of pulp necrosis if appropriate treatment is provided (54, 70). If not, fracture line may act as a pathway for bacteria to enter the pulp (56–58). Also

it is important to admit that teeth with vital pulps are more resistant to bacterial invasion into the dentinal tubules than teeth with non-vital pulps. This can probably be explained by the defense mechanisms of the healthy pulp which protects the tissue against bacterial invasion (71, 72). However, if the neurovascular supply to the pulp is compromised or completely disrupted, the defense mechanisms may be less efficient (65).

A subluxation injury is characterized by damage to the periodontal ligament with bleeding and abnormal mobility of the tooth but no displacement (73). However, if these two mild types of injury, i.e. crown fracture and subluxation, occur simultaneously, the defense mechanisms of the pulp will become less efficient (57, 74). A simultaneous luxation injury has been reported to increase the prevalence of pulp necrosis in teeth with crown fractures (53, 54, 75). This is due to the fact that any type of displacement of the teeth results in damage to the periodontal ligament and disruption of the neurovascular supply at the apex of the tooth occurs.

Lateral luxation, avulsion and intrusion are in the group of traumatic injuries commonly associated with more serious complications like external or replacement root resorption. This is due to the severe damage to the surrounding tissues (periodontal ligament, neurovascular bundle) as well as to unmineralized (precement) and hard tissues of the tooth (cement, dentin). Lateral luxation results not only in damage to the periodontal tissues, but also in fracture of the labial bone plate. Avulsion of permanent teeth is seen in 0.5–3% of all dental injuries (76). Avulsion of the tooth is accompanied by severe damage to the periodontal ligament. The cells of the periodontal ligament are predominantly damaged by inadequate storage of the avulsed teeth. Following replantation of avulsed teeth inflammatory root resorption could occur (77). The unique nature of the intrusion injury distinguishes it from other luxations. In this type of trauma the periodontal membrane and root surface are severely disrupted. There is a high risk evident likelihood of external root resorption and long-term survival is doubtful.

Three types of external root resorption, such as surface resorption, replacement resorption/ankylosis and inflammatory resorption are related to the outcome of luxation injuries (76). Inflammatory resorption is associated with the damage of periodontium at the time of trauma, necrosis of the pulp, presence of bacteria within the root canal and dentinal tubules. This type of resorption can be controlled or prevented by efficient root canal treatment (77-79). Replacement resorption/ankylosis appears in teeth where periodontal ligament has been dried due to the long extraoral period or inappropriate treatment handling (80, 81). When ankylosis occurs in a growing patient, infraposition of the tooth is highly likely leading to disturbance in alveolar and facial growth. Previous studies have reported that the prevalence of the root resorption varied between 57% and 80% in avulsed and replanted teeth and between 38–66% after intrusive trauma (82-85).

Proper endodontic treatment is highly effective in management of inflammatory resorption related to infection in the main root canal. Endodontic treatment plays no role in handling teeth where replacement resorption is evident. Another important fact is that both aforementioned types of root resorptions could start in the same tooth at the same time. Therefore endodontic treatment is extremely important in order to prevent root resorption process related to infection and maintain tooth for a longer period of time what is very important in young patients.

CONCLUSIONS

Traumatic dental injuries are recognized public dental health problem worldwide. A tendency of an increase in prevalence of dental traumas due to the higher interest in sport activities can be observed. Moreover, the changing lifestyle and requirements of modern society lead to an emergence of new patterns of dental trauma. To this end, a regular update of knowledge in dental traumatology is required.

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