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Effects of traumatic dental injuries to primary teeth on permanent teeth – a clinical follow-up study

Lilian de Fátima Guedes de Amorim[1], Carlos Estrela[2], Luciane Ribeiro Resende Sucasas da Costa[1]

[1]Department of Prevention and Oral Rehabilitation, Faculty of Dentistry, University of Goiás, Goiânia, Go, Brazil; [2]Department of Stomatologic Sciences, Faculty of Dentistry, University of Goiás, Goiânia, Go, Brazil

Correspondence to: Lilian de Fátima Guedes de Amorim, Department of Prevention and Oral Rehabilitation, Faculty of Dentistry, Federal University of Goiás, Goiânia, Brazil. Avenida Universitária esquina com 1a. Avenida, s/n, Setor Universitário, 74605-220, Goiânia, GO, Brazil
Tel.: +55 62 40092200
Fax: +55 62 40092200
e-mail: lilianguedes31@terra.com.br

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Abstract – *Aim:* This study evaluated the prevalence of developmental sequelae to permanent teeth (DSP) after traumatic dental injuries to primary teeth (TDI-1) and their association with age, gender, type of injury, recurrence of injury and post-traumatic damage to primary teeth. *Materials and methods*: Dental records of 2725 children treated from February 1993 to December 2008 in a private pediatric dental clinic were examined. A total of 308 records had 412 primary teeth that sustained traumatic injuries. Age at the time of injury ranged from 4 months to 7 years. A chi-squared test and logistic regression were used for statistical analyses. *Results*: One hundred forty-eight children (241 teeth) were followed up until the eruption of the permanent successor. The prevalence of DSP was 22.4%. Discoloration and hypoplasia were the most frequent abnormalities (74.1%), followed by eruption disorders (25.9%). Age at the time of TDI-1 was the only variable significantly associated with DSP. Sequelae were most prevalent among children who suffered an injury between 1 and 3 years of age. *Conclusions*: Children who sustain traumatic dental injuries should be followed up regularly for an early diagnosis and treatment of possible DSP.

Increases in violence, traffic accidents and participation of children and adolescents in sports activities have contributed to making traumatic dental injuries (TDI) an emerging public health problem (1, 2). Moreover, injury to primary teeth becomes a greater risk when the child starts to walk (3).

Epidemiological studies carried out in different countries found a prevalence that ranges from 9.4% to 41.6% (3–9). These variations reflect cultural and environmental differences and the use of different data collection methods in each study (10–12). In primary dentition, the most affected tooth is the maxillary central incisor; falls are the main cause; and the most common location is the home (3–6). TDI to primary teeth (TDI-1) may compromise both primary teeth and their permanent successors. They may lead to physical and emotional changes reflected in the quality of life of both the children and their parents (13).

Recommended treatments of TDI-1 consist of minimizing the possible consequences to the primary tooth and attenuating developmental disorders in the germ of the permanent successor. The permanent tooth germ is separated from the periapical region of the primary tooth by a hard tissue barrier that is less than 3-mm thick and may consist of only fibrous connective tissue (14, 15).

Developmental sequelae to permanent teeth are found in 12–53% of the permanent successors of primary teeth that sustained traumatic injuries (3, 16–23). Severity of sequelae is associated with different factors, such as age at the time of the accident, the degree of root resorption of the injured primary tooth, the type and extent of the traumatic lesion, and the stage of development of the permanent tooth germ (3, 14, 15, 18, 23).

The DSP usually found are: enamel discoloration, enamel hypoplasia, crown or root dilacerations, odontoma-like malformation, tooth-germ sequestration, partial or total interruption of root formation, and eruption disorders (3, 15, 17, 18, 20, 24, 25).

Few epidemiological studies focused on primary tooth traumatic injuries. One of the explanations for the lack of studies in this area is the difficulty of long-term follow-up; another factor is ethical (26). It is difficult to perform randomized studies with victims of traumatic injuries, and most data come from experimental animal studies backed up by clinical observation based on the experience of specialized professionals.

This study analyzed the effect of injuries sustained by primary teeth on permanent successors, and examined the association between sequelae and age, gender, type of injury, recurrence and post-traumatic sequelae to primary teeth.

Materials and methods

This study was approved by the Research Ethics Committee of the Federal University of Goiás (no. 117/2008).

The dental records of 2725 children younger than 7 years old who were treated at a private pediatric dental clinic in Goiânia, Goiás, Brazil, between February 1993 and December 2008 were reviewed. TDI-1 was found in 308 records and affected 412 primary teeth. Inclusion criteria were: TDI that affected periodontal tissue, hard tissues and pulp in primary teeth with follow-up until the complete eruption of permanent successor. Incorrectly filled out dental records, children with TDI-1 only in soft tissue and children who are still being followed up because their permanent teeth have not erupted yet were excluded from the study. A total of 148 children with 241 injured primary teeth were included in the study. TDI and DSP were classified according to the criteria described by Andreasen & Andreasen (14). The teeth that presented more than one type of injury were classified in the 'combined' category, and teeth with a history of injuries on different dates were classified as 'recurrent'.

In the first meeting, the dentist first calmed down the child and the parents, after which the teeth were cleaned with running water or saline solution. The following recommendations were made: pasty diet for 10 days; restricted use of pacifier; tooth brushing with a soft brush after each meal; and topical application of 0.1% chlorhexidine in the affected area with cotton swabs, or mouth rinses twice a day for 10 days. The dental records were reviewed to collect information about gender, age at the time of traumatic injury, type of dental injury, type of treatment recommended for the primary tooth, and type of post-traumatic sequelae to the primary and permanent teeth. The teeth were examined at the time of the traumatic injury and again after 4 weeks, 8 weeks, 6 months, 12 months and once a year until the eruption of the permanent successors. If there were complications, this schedule was changed. The examinations included palpation, percussion and intraoral periapical radiographs. The treatment was performed, and all complications were recorded.

The post-traumatic sequelae analyzed in primary teeth were: changes in crown coloration, pulp necrosis, root canal obliteration, root resorption (accelerated or retarded), dental ankylosis, and changes in root formation.

Statistical analysis of the data was performed using the spss for Windows, 17.0 (SPSS, Inc., Chicago, IL, USA) to evaluate frequency distribution and associations. Statistical significance of associations between variables was determined by the chi-squared test and multiple logistic regression using the backward stepwise method. The level of significance was established at $P < 0.05$.

Results

Of the 148 children with TDI-1 followed up until eruption of the permanent successor, 69 were boys (46.6%) and 79 were girls (53.4%). The maxillary central incisors accounted for 83.3% of the teeth that sustained traumatic injuries, followed by maxillary lateral incisors (11.0%), mandibular central and lateral incisors (3.7%), and canines and molars (2.0%). The most frequent diagnosis was TDIs-1 that affected periodontal tissue (PDL) (163 teeth; 67.6%), and subluxation was the most prevalent PDL injury (94 teeth; 57.7%). TDIs-1 that affected hard tissues and the pulp occurred in 40 teeth (16.6%), and the most prevalent injuries in this category were enamel crown fracture (23 teeth; 57.5%). Combined traumatic injuries were found in seven teeth (2.9%) and recurrent injuries, in 31 teeth (12.9%). Of the 241 permanent teeth that erupted after TDIs-1, 187 (77.6%) did not have DSP. However, 54 (22.4%) had some abnormality: 40 (74.1%) had enamel discoloration, hypoplasia, or both; and 14 (25.9%) had eruption disorders. Intrusion (nine teeth) was the type of traumatic injury that resulted in the highest number of DSP (seven teeth; 77.0%), followed by avulsion (14 teeth), six teeth (42.8%) had DSP. The distribution of types of traumatic injuries according to occurrence of sequelae to permanent teeth is described in Fig. 1.

The time elapsed between the accident and the actual treatment was recorded for 144 TDIs-1 (59.8%); 41 teeth (28.5%) were treated within 2 h (Fig. 2).

The damage to primary teeth after traumatic injury is described in Table 1. No sequelae were found in 134 teeth (55.6%). The treatments of injured primary teeth are described in Table 2. Follow-up was recommended in 97 cases of TDIs-1 (40.2%). Intruded teeth without

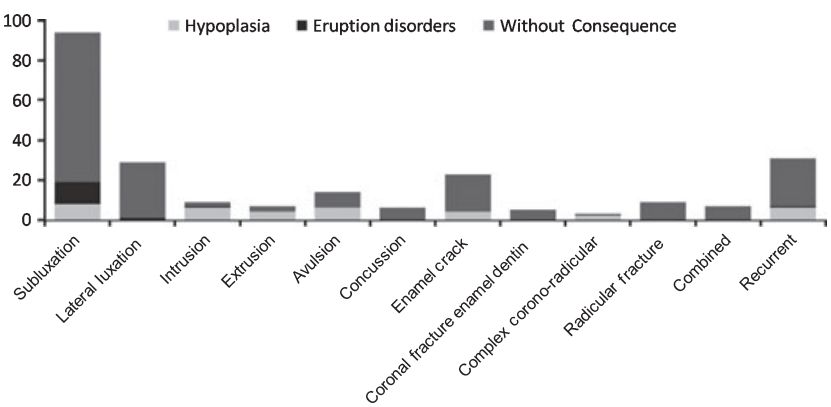

Fig. 1. Permanent teeth with developmental disorders distributed by type of traumatic dental injury.

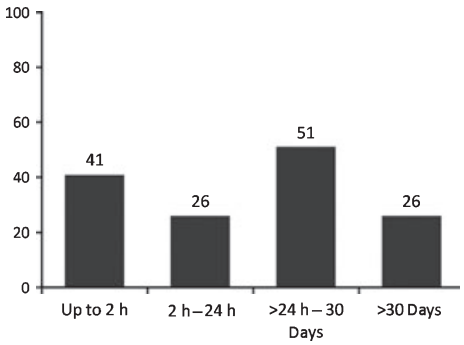

Fig. 2. Distribution of 144 traumatized primary teeth by time elapsed from injury until treatment.

Table 1. Relative and absolute distribution of sequelae in primary teeth after traumatic dental injury (n = 241)

Primary tooth sequelae[1]	*n*	%
No sequelae	134	55.6
Sequelae	107	44.4
Color alteration	46	19.0
Root resorption (accelerated or retarded)	49	20.3
Pulp necrosis	37	15.3
Root canal obliteration	27	11.2
Ankylosis	5	2.0
Interrupted root formation	2	0.8

[1]There were teeth with more than one sequel.

Table 2. Distribution of types of treatment carried out on traumatized primary teeth (n = 241)

Treatment[1]	*n*	%
Examination and follow-up	97	40.2
Await reeruption	8	3.3
Bonding	2	0.8
Splint therapy	75	31.1
Extraction	20	8.3
Polishing and fluoride	18	7.5
Endodontic treatment	32	13.3
Reimplantation	5	2.1
Repositioning and splint	21	8.7

[1]Some teeth had more than one type of treatment.

spontaneous re-eruption, teeth with abscesses and fistulas associated with a radiographic finding of periapical infection and with resorption of more than one-third of the root were extracted. Endodontic treatment was indicated in cases of replantation, bonding and also for teeth with one or more of the following signs: pulp exposure, abscesses, fistulas, increased mobility, color changes in the crown, periapical bone loss, or inflammatory root resorption.

To analyze the association between types of injuries and the occurrence of sequelae to permanent teeth, TDI-1 was classified as: traumatic injury of the hard tissue of teeth and pulp; periodontal tissue traumatic injury; and a combination of the two.

The chi-squared test showed that there was no association between permanent teeth sequelae and gender (P = 0.77), type of TDI-1 and recurrence (P = 0.75) or sequelae to primary teeth (P = 0.09) (Table 3). The chi-squared test (P = 0.03) and logistic regression analysis (OR 1.24; 95% CI 1.02–1.52) revealed a significant association between age and the appearance of sequelae to permanent teeth. A greater prevalence of sequelae was observed in children who experienced traumatic injuries between 1 and 3 years of age; enamel discoloration and/or hypoplasia were more frequent between among 1- and 2-year-old children. Eruption disorders were found in all age groups (Fig. 3).

Table 3. Distribution of sequelae in permanent teeth in relation to gender, age, type of dental trauma, presence of recurrent trauma and sequelae in primary teeth (n = 54)

	Sequelae to permanent teeth, *n* (%)
Gender (P = 0.77)	
Female	27 (11.0)
Male	27 (11.0)
Age (P = 0.03) (years)	
<1	3 (1.2)
1–2	16 (6.5)
2–3	14 (5.7)
3–4	6 (2.4)
4–5	8 (3.3)
5–6	5 (2.1)
6–7	2 (0.8)
Type of TDI (P = 0.75)	
Hard tissue of the tooth and pulp	7 (2.9)
Periodontal tissue	41 (16.8)
Combination	6 (2.4)
Recurrent TDI-1 (P = 0.75)	
Yes	7 (2.9)
No	47 (19.1)
Sequelae of TDI-1 (P = 0.09)	
Present	29 (11.8)
Absent	25 (10.3)

Chi-square test. P value < 0.05 = significant.

Discussion

Sequelae to permanent teeth are frequent after TDI-1 (15, 17). In general, our results were similar to those reported in other studies carried out with different populations (3, 18, 20). However, a few findings and their implications should be stressed out: (i) among 241 primary teeth that were followed-up after a TDI-1 until the eruption of the permanent successor, only 20 (8.3%) had to be early extracted, meaning that a conservative approach to primary teeth injuries is feasible; (ii) repeated injuries in primary teeth did not significantly affect the occurrence of complications in permanent teeth.

Developmental disorders of permanent teeth after TDI-1 are known to be associated with the type of traumatic injury, especially intrusive luxation and avulsion (3, 15, 18, 20–23). In this study, there was no significant association between type of TDI-1 and DSP, as previously reported by Jácomo and Campos (15). The low number of intrusion and avulsion, together with the greater prevalence of subluxation, may explain the prevalence of sequelae found here. Subluxation poses

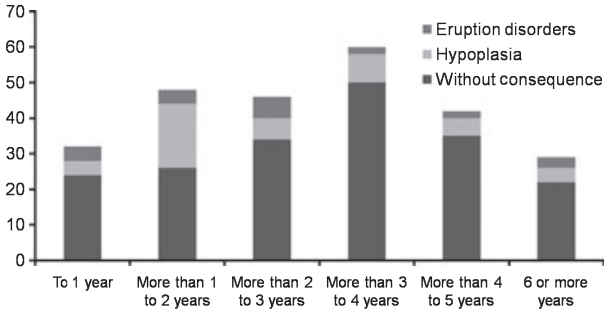

Fig. 3. Relation between age at the time of dental trauma and the type of sequelae observed in the permanent tooth.

little risk to permanent teeth due to the low intensity of the impact force (3, 14). According to Sennhenn-Kirchner & Jacobs (18), subluxation and lateral luxation accounted for only 16% of the cases of odontogenetic disorders.

Age was the only variable significantly associated with DSP ($P = 0.03$). The younger the child, the greater the prevalence and severity of developmental sequelae to the permanent tooth germ (3, 14, 15, 18, 22, 27). Flores (28), however, found 25% of complications after dental injuries in patients younger than 3 years. A high risk of sequelae in this age group may be associated with incomplete bone and permanent tooth-germ mineralization (27).

Enamel discoloration, hypoplasia, or both (3, 15–18, 21) have been described as the most frequent DSP. This was confirmed in our study. Enamel discoloration and hypoplasia were most evident in children between 1 and 2 years of age at the time of TDI, in agreement with other studies (3, 21). This may be explained by the stage of crown formation, which is usually completed at the age of 3 years (23). However, this abnormality was observed in all age groups under study. As reported in other studies (3, 18), eruption disorders were less common and associated with subluxation, lateral luxation and intrusion.

The recurrence of traumatic injury tends to be an aggravating factor in cases of sequelae to injured teeth, and may lead, in most cases, to treatments of greater complexity (29). For this reason, a possible association between TDI-1 recurrence and the occurrence of sequelae to permanent teeth was analyzed. This association was not statistically significant according to the chi-squared test ($P = 0.75$).

No significant associations between the sequelae to primary teeth and injuries in permanent teeth were found. Therefore, the recommendations to extract injured primary teeth to avoid the appearance of primary teeth complications that might increase the chances of sequelae to permanent teeth should be reviewed.

Currently, practically no treatment for traumatic dental injuries is based on evidence. This makes it difficult to analyze the long-term outcome of healing and its association with treatment. Moreover, there is significant disagreement about the best treatment for dental traumatic injuries (30). Rocha & Cardoso (31), however, concluded that endodontic treatment of the injured primary tooth may keep the tooth in acceptable condition until its physiological exfoliation. Coll & Sadrian (32) reported that carefully performed endodontic treatment of primary teeth does not contribute to defects in permanent tooth formation. They may change the pattern of eruption in only 20% of the cases. In a recent article Andreasen et al. (30) demonstrated that one or more dogmas of the treatment of dental injuries might be violated and healing still occurs. However, primary teeth that sustain traumatic injuries should undergo careful, long-term follow-up for the early diagnosis and treatment of pathological disorders.

Cardoso & Rocha (33) and Torriani et al. (34) pointed out that the prognosis of the permanent successor germ after traumatic injury to the primary tooth bears a direct association with the extent of the injuries and not to the precise treatment carried out. Aggressive treatment or subsequent local infection may also hinder the regular formation of tooth tissues. However, when regular follow-up is carried out appropriately after a precise diagnosis, the costs of treatment are lower and the chances of sequelae are minimized (3, 22).

Cone-beam computed tomography (CBCT) has come into use recently and made a major contribution to the diagnosis and treatment planning of traumatic injuries (35). CBCT produces three-dimensional images without enlargement or superimposition of anatomical structures, which facilitates the diagnosis and avoids inappropriate treatment that may increase the chances of damage to primary teeth and their permanent successors. It is important to consider the indication in clinical routine in children the cost-benefits and radiation dose. However, some of the factors that hamper the diagnosis and treatment of TDI-1 and its sequelae in primary and permanent teeth are the low demand for immediate treatment after dental injury (4, 5, 11, 36), the dentist's negligence during the first visit, inadequate follow-up, and overtreatment (14, 37, 38). The short time between TDI-1 and treatment may have affected the prevalence of DSP in our study, as well as the fact that all the cases of TDIs-1 were treated by a specialist.

Educational programs to prevent dental traumatic injuries should be implemented and focus on children younger than 3 years because this is the group with the highest risk for DSP. Dentists in general practice and parents should be made aware of the importance of immediate TDI treatment and long-term clinical and radiographic follow-up. These dentists should be encouraged to treat primary teeth with an emphasis on the early detection and prevention of possible sequelae to the permanent successors. Prospective clinical studies should be conducted to confirm the results of treatment observed in clinical practice.

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