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Effects on permanent teeth after luxation injuries to the primary predecessors: a study in children assisted at an emergency service

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Abstract – *Aim*: The purpose of this study is to evaluate the developmental disturbances in permanent teeth as a result of luxation injuries in the primary teeth predecessors. *Material and methods*: A total of 5330 records, corresponding to 10 years attendance at the Emergency Center of Baby Clinic, Londrina State University, Brazil, were analyzed. Three hundred and eighty nine children were involved in this study, totaling 620 traumatized primary teeth. Clinical and radiographic examinations were carried out in the permanent successor teeth. *Results*: In total, 623 permanent teeth were examined and developmental disturbances were detected in 126 teeth (20.2%). The white or yellow-brown discoloration of enamel was the clinical disturbance most observed (78.0%) and the crown alteration most detected through radiographic analysis was hypoplasia (86.0%). Root alterations were rare; root dilaceration was observed in only one case. The age of the children when their primary teeth received damage varied between 6 and 36 months ($P = 0.000325$). Intrusive luxation and avulsion were related with most of the cases of sequelae in the successor permanent teeth ($P = 0.000001$). *Conclusion*: The results of the present investigation emphasize the special attention required for children who suffered dental trauma at an early age, especially in cases of intrusive luxation and avulsion.

Dental traumatic injuries occur frequently in children, especially in those at an early age. Epidemiological studies have shown a frequency of approximately 30% of primary dentition that is affected by trauma (1, 2). These injuries are considered emergency situations and require immediate attention, representing a challenge to professionals as it may have not only a physical component, but a psychological consequence for children and their parents (3, 4).

The close relationship between the apices of primary teeth and germs of the permanent successors can lead to developmental disturbances in the permanent dentition (5). These occurrences are common, varying from 19 to 69%. The consequences in the permanent dentition range from enamel hypocalcifications to an arrest of the permanent bud development (6).

The age of the child at the moment of the accident and the type of trauma in primary teeth can determine the frequency and severity of the alterations provoked in the permanent successor teeth (7). The occurrences of these sequelae are strongly associated with intrusive luxation and avulsion trauma in the primary tooth (8).

Andreasen and Ravn (7) have observed a frequency of alterations to the succedaneous teeth of 63% in children under 2 years; 53% in children between the ages of 3 and 4 years, and 24% in children between the ages of 5 and 6 years. These results associated with the high prevalence of dental trauma in young children emphasize the importance of special attention, including educational and preventive programs as well as urgent care directed to these children (9).

The purpose of this study was to investigate the frequency and types of developmental disturbances in permanent teeth as a result of luxation injuries to the primary teeth in children assisted at the Baby Clinic of the State University of Londrina, Brazil and to identify factors related with these alterations.

Material and methods

The records of 5330 children, corresponding to 10 years attendance of the emergency center of the Baby Clinic, Londrina State University, Brazil, were analyzed. The criteria for inclusion required in this study were: (i) age when trauma occurred was up to 5 years; (ii) trauma was to the anterior primary teeth; (iii) trauma included only subluxation, lateral luxation, intrusive luxation, extrusive luxation, and avulsion. When there was more than one type of trauma, i.e., lateral luxation and intrusive luxation, in the same tooth, it was designated as

association. The patients who met the criteria for inclusion were contacted and the succedaneous permanent teeth were clinically and radiographically examined.

In total, 844 children (15.8%) met the criteria for inclusion. Of these, 409 (48.4%) attended the recall for an examination. Twenty children with recurrent trauma to their primary teeth were excluded, reducing the number of examined children to 389 with 620 traumatized primary teeth. At the time of examination, the age of the children ranged from 5 to 12 years.

The records of these children were studied to obtain information about the history of trauma, i.e., age of the child at the time of the accident, affected primary teeth, and type of trauma. The children were divided according to the age at trauma into the following groups: up to 2 years; 2–3 years; 3–4 years, and 4–5 years.

The clinical assessment of the permanent teeth was performed by one examiner. The evaluation was carried out using artificial light. Prior to the examination, the teeth were subjected to a professional prophylaxis and were dried with cottons rolls and air. All surfaces were examined. All the examined teeth with a general hypoplastic disorder were excluded from this study. The following classification was used to assess the clinical developmental disturbances (6): white or yellow-brown discoloration of enamel, white or yellow-brown discoloration of enamel with circular hypoplasia, crown dialceration, and disturbance in eruption.

Radiographic analysis consisted of determining the following alterations in the permanent teeth (6): crown dilaceration, odontoma-like malformation, lateral root angulation or root dilaceration, root duplication, partial or complete arrest of root formation, vestibular root angulation, sequestration of permanent tooth germs, and disturbances in eruption. All images suggesting hypoplasia were also included in this study. All of the clinical and radiographic alterations were registered in a specific record created for this study. The results were statistically analyzed using a proportion test and the chi-square test, with the level of significance set at 5%.

Results

In the recall examinations, there were slightly more boys than girls; 225 were male (57.8%) and 164 female (42.2%), with a male: female ratio of approximately 1.3:1. The age distribution of the patients at the time of injury is outlined in Table 1. The examined children had a total of 620 traumatized primary teeth. The majority of injuries affected maxillary central (86%) and lateral incisors (13%). The percentage distribution of the different types of trauma to the primary dentition is illustrated in Table 2.

Table 1. Distribution of children's age in the moment of the trauma

Age (in years)	Number of children	%
Up to 2	157	40.4
2–3	113	29.0
3–4	66	17.0
4–5	52	13.4
Unknown	1	0.2
Total	389	100.0

In total, 623 permanent teeth were examined. Development disturbances were detected in 123 of the corresponding permanent teeth and in 3 neighboring permanent teeth, totaling 126 permanent teeth with alterations (20.2%). The frequency and type of clinical and radiographic alterations are outlined in Table 3. The clinical alterations most observed were white or yellow-brown discoloration of enamel (78.0%) (Fig. 1) followed by white or yellow-brown discoloration of enamel with circular hypoplasia (18.0%) (Fig. 2). Hypoplasia was the disturbance most detected through radiographic analysis, with 86% of the cases (Fig. 3) followed by crown dilacerations with 9% of instances (Fig. 4). Only one case of root malformation was observed (Fig. 5) in 15% of the examined teeth, the root was in early development stages at the time of injury.

The association between the age of the child in the moment of trauma and frequency of the sequelae in the permanent tooth is shown in Table 4. The results indicated a high prevalence of disturbances in children under 2 years when the trauma occurred (53.7%) ($P = 0.000325$). In one child, the age at trauma was not registered, excluding their three teeth for this analysis.

The relation between the age of the children in the moment of trauma and types of development of disturbances is provided in Fig. 6. White or yellow-brown discolorations with a circular enamel hypoplasia were most observed in individuals younger than 2 years. White or yellow-brown discolorations without hypoplasia were also observed in older age groups. Crown

Table 2. Distribution of affected primary teeth in relation to different types of trauma

Types of trauma	Number of teeth	%
Subluxation	203	32.7
Intrusive luxation	182	29.3
Lateral luxation	90	14.5
Extrusive luxation	14	2.2
Avulsion	125	20.1
Association	6	1.2
Total	620	100.0

Table 3. Frequency and type of clinical and radiographic alterations among 125 involved permanent teeth

Clinical alterations	Number of teeth *n* (%)	Radiographic alterations	Number of teeth *n* (%)
White or yellow-brown discoloration of enamel	82 (78)	Hypoplasia	18 (86)
White or yellow-brown discoloration of enamel with circular hypoplasia	19 (18)	Crown dilaceration	2 (9)
Crown dilaceration	1 (1)	Lateral root angulation or dilaceration	1 (5)
Disturbance in eruption	3 (3)		
Total	105 (100)	Total	21 (100)

Fig. 1. Discoloration of enamel in tooth 21 following lateral luxation of the tooth 61.

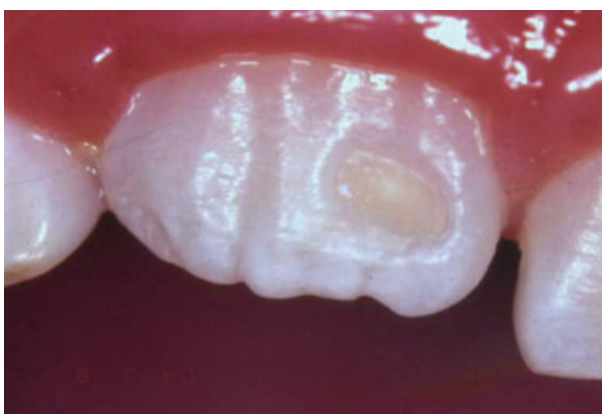

Fig. 2. Discoloration of enamel with hypoplasia in tooth 21 following avulsion of the tooth 61.

dilacerations were only seen in children younger than 2 years. Disturbances in eruption were observed in younger and older age groups. It is important to emphasize that in the case of root dilaceration the child's age at the moment of trauma was not recorded.

The relation between the location of white or yellow-brown discoloration of enamel and white or yellow-brown discoloration of enamel with circular hypoplasia according to patient's age at time of injury is shown in Fig. 7. For all discolorations, the incisal third was the most common location. Discoloration without circular hypoplasia in the incisal third of the crown was commonly observed in children with trauma that occurred up to 2 years and also between the ages of 2 and 3 years; discolorations with hypoplasias in the incisal third of the crown were more evident in children under 2 years.

The association between the type of trauma and the frequency of sequelae is outlined in Table 5. Intrusion luxation was the type of trauma most associated with the presence of alteration in the permanent teeth (52/126), followed by avulsion (48/126); ($P = 0.000001$).

Fig. 3. Hypoplasia detected through radiographic exam in tooth 21 following avulsion of the tooth 61.

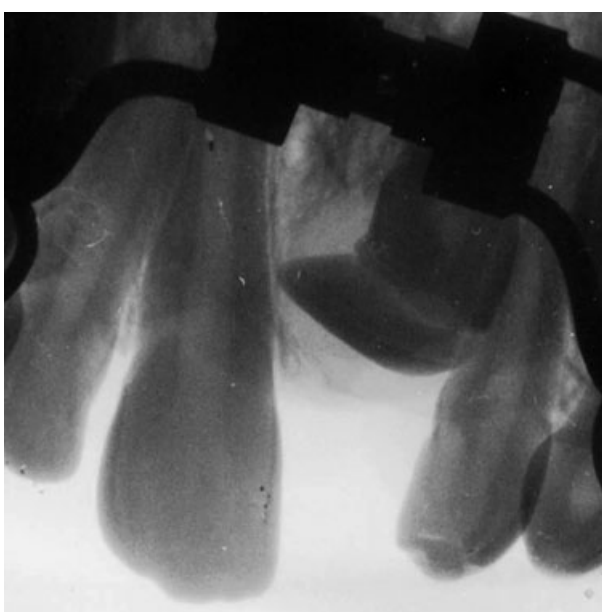

Fig. 4. Crown dilaceration in tooth 21 following intrusive luxation of the tooth 61.

Discussion

This study evaluated the effect of luxation injuries to primary teeth on the successor permanent teeth in children assisted at an emergency center. The protocol for attendance of traumatic injuries at the Emergency Center of the Baby Clinic of Londrina State University

Fig. 5. Root dilaceration in tooth 21 following lateral luxation of the teeth 61 and 62.

Table 4. Relation between age at time of injury and frequency of disturbances in the total of examined permanent teeth

Age (in years)	No disturbances *n* (%)	With disturbances *n* (%)	Total
Up to 2	173 (35.9)	67 (53.7)	240
2–3	145 (28.5)	35 (29.0)	180
3–4	93 (18.5)	11 (7.4)	104
4–5	85 (17.1)	12 (9.9)	97
Total	496 (100.0)	125 (100.0)	621

$\chi^2 = 18.64$; $P = 0.000325$.

includes the follow up of these occurrences until eruption of the permanent teeth. However, this follow-up dental care depends on the cooperation of the parents responsible for the child. This fact could justify the loss of more than 50% of patients for the clinical assessment. A similar situation for recall examinations was observed by Brin et al. (8), relating a low response of the recalls to a lesser severity of dental sequelae of trauma or to dental awareness of the patients. Despite these difficulties, one can consider the number of examined permanent teeth in this study ($n = 623$) as significant.

For this research, only patients who suffered luxation injuries in the primary dentition were selected. Andreasen and Ravn (7) also selected the same type of trauma as this study. Contrary to our results where subluxations were the type of trauma most prevalent, extrusive luxations were the trauma most observed by the authors.

A frequency of 126 (20.2%) permanent teeth with alterations was observed. The frequency of disturbances in the permanent dentition caused by traumatic injuries to the primary antecessor varied from 19 to 69% in previous studies (7, 8, 10–16). The white or yellow-brown discoloration of enamel and the white or yellow-brown discoloration of enamel with circular hypoplasia were the disturbances most observed in the clinical assessments (78% and 18%, respectively). Crown dilacerations were detected in one tooth which were clinically examined and in two teeth through radiographic analysis. Andreasen and Ravn (7) observed a prevalence of 35% discolorations and 3% of crown dilacerations of the examined teeth.

Disturbances in eruption were less frequent, being observed in only 3 of the 126 permanent teeth with alterations. This type of disturbance was related to trauma of avulsion in two primary antecessor teeth and in one case with intrusive luxation. Sennhenn-Kirchner and Jacobs (16) found irregular eruption in 5 of 20 examined permanent teeth with malformations. However, those authors observed a higher association of this type of alteration in cases of subluxations to the primary teeth (3/5).

Developmental disturbances involving the root are reported to be less frequent than disturbances involving the crown (17). This fact is related to the close relation between the roots of primary teeth and the crowns of the

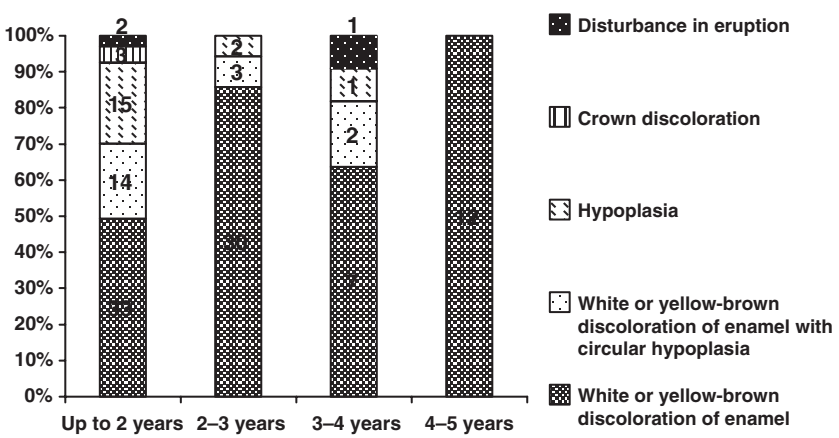

Fig. 6. Relation between age of the children in the moment of trauma and types of development of disturbances.

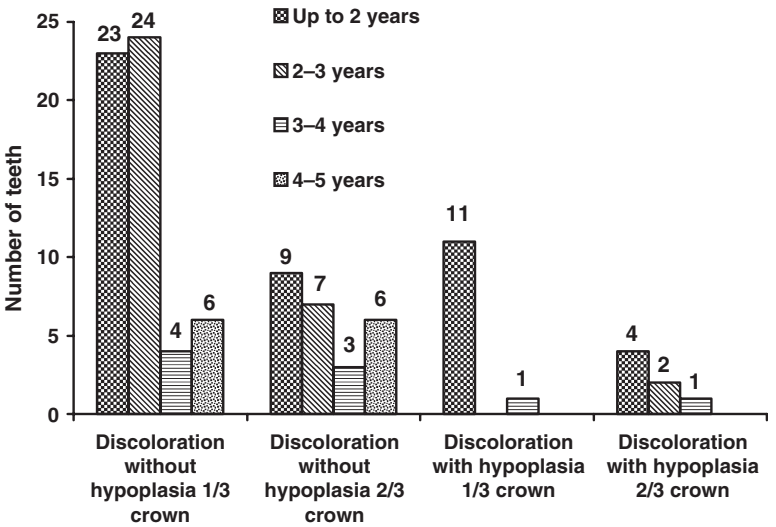

Fig. 7. Relation between localization of white or yellow-brown discoloration of enamel with and without circular hypoplasia according to patient's age at time of injury.

Table 5. Relation between type of injury and frequency of disturbances in the total of examined permanent teeth

Type of injury	No disturbances *n* (%)	With disturbances *n* (%)	Total
Subluxation	191 (38.5)	12 (9.5)	203
Intrusion luxation	132 (26.5)	52 (41.3)	184
Lateral luxation	78 (15.7)	12 (9.5)	90
Extrusion luxation	12 (2.4)	2 (1.6)	14
Avulsion	78 (15.7)	48 (38.1)	126
Associations	6 (1.2)	0	6
Total	497 (100.0)	126 (100.0)	623

Chi-square (χ^2) test = 62.56.
P = 0.000001.

permanent teeth, favoring the predominance of crown malformations (18). These results showed only one case of root malformation in the examined permanent teeth.

This investigation also showed the importance of the radiographic exam, especially to detect more severe disturbances. Andreasen and Ravn (7) stated that serious sequelae, such as disturbances causing alterations in the dental morphology, can be diagnosed 1 year after the trauma. The radiographic image of hypoplasias was in accordance with Andreasen (6), where these defects reveal a transverse radiolucent area corresponding to the coronally placed enamel defect. These disturbances totaled 86% of the alterations which were radiographically assessed.

The results of this investigation show high susceptibility of children younger than 2 years to present alterations in the developing permanent teeth following trauma to the deciduous antecessors. Various studies confirm this association (7, 11, 13, 15, 19–21). Selliseth (11) mentions that the risk of serious damage to the permanent tooth is higher when the age at the time of injury is under 2 years, reasoning that the surrounding bone at this age is less calcified and therefore does not protect the tooth germ.

When the type of disturbances were analyzed in relation to the age of the child at the moment of trauma, the white or yellow-brown discoloration without hypoplasia prevailed in ages up to 3 years. However, these alterations were also observed in older age groups. This is in agreement with previous studies (7, 22, 23). This occurrence is explained by the fact that the maturation of mineralized enamel continues until the time of eruption, therefore, discoloration may affect all age groups (12). The breakdown products of hemoglobin from bleeding can incorporate into the tooth during tooth formation, even after arresting the ameloblast activity (24).

On the other hand, white or yellow-brown discoloration of enamel with circular hypoplasia and also hypoplasias detected through radiographic examination were mostly observed in younger age groups and were not present in children who suffered dental trauma at ages between 4 and 5. This is in agreement with other studies which relate the presence of hypoplasias in children between the ages of 1 and 3 years at the time of injury (7, 22). Diab and Elbadrawy (25) state that as the formation of the crown is usually complete by 3 years, hypoplasias are less frequent in children older than 3 years old. Similarly, crown dilacerations were clinically and radiographically observed in children who suffered trauma up to 2 years.

The incisal third of the permanent crown was found to be the most frequent location of white or yellow-brown discolorations of enamel with or without circular hypoplasia and in children under the age of 3 years at the moment of trauma. Discolorations associated with hypoplasias were most observed in children under the age of 2 years at time of injury. Conversely, Brin et al. (8) have found no apparent correlation between age at the time of injury and location of mineralization defects.

Intrusive luxation was the type of injury most related to the malformation of permanent teeth (41.3%). This is in accordance with previous studies (13, 16, 17, 19, 24, 26). Avulsion was the second most frequent cause of developmental disturbances in the permanent teeth. Andreasen and Ravn (7) attested that the root curvature of the primary tooth provokes a slight rotation movement during avulsion, which can injure the bud of the successor permanent tooth. Differently from the current

results, Ravn (19) reported that the number of disturbances in permanent dentition was lower in cases with intrusion teeth when compared with avulsion.

The results of this investigation emphasize the special attention required for children who suffer dental trauma at early ages (up to 3 years), especially in cases of intrusive luxation and avulsion. Therefore, it is of utmost importance to perform a rigorous clinical and radiographic follow-up examination to detect possible disturbances of the permanent successor teeth and to permit timely adequate intervention.

Acknowledgement

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