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Identification of factors associated with pathological root resorption in traumatized primary teeth

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Abstract – The aim of this study was to determine the factors associated with the development of pathological root resorptions in traumatized primary teeth. Based on Dental Reports on Traumatism from the Assistance Program for the Traumatized Patient, 90 children were selected. Among these children, 45 did not present pathological root resorption, while 45 did (23 replacement root resorptions and 22 external inflammatory root resorptions). Possible factors associated with the development of the pathological resorption include: (i) over 18 months or over 52 months of age, (ii) complicated trauma, and (iii) presence of more than one trauma in the same tooth. Using the chi-squared test, it was verified that trauma recurrence was considered to be a factor associated with the development of pathological root resorption ($\chi^2 = 3.636$; $P < 0.05$). Through the univaried logistic regression test, it was revealed that children with trauma recurrence present a 2.6 times higher chance of developing pathological root resorptions when compared with children that did not report trauma recurrence. Through the univaried logistic regression test, it was also observed that the association of two or three factors caused the chances of pathological root resorption development to increase by 3.8 times in 18-month-old children or older (95% CI: 1.5–9.7) and by 5.1 times in 52-month-old children or older (95% CI: 1.5–17). Trauma recurrence in the same primary tooth is associated with pathological root resorption, and the interaction among two or three factors increases the chance of developing such sequelae.

Dental trauma may impact the stomatognatic system by affecting mineralized tissues (tooth and bone) because of resorption processes. This trauma may damage pulp and periodontal tissues by causing their rupture, hyperemia, or hemorrhage (1, 2).

Among the sequelas that affect traumatized teeth, we can point out the obliteration of the pulp cavity, the development of tooth mobility, sensitivity to percussion, coronal discoloration, pulpal necrosis, and pathological root resorptions (3).

Pathological root resorption is a dental complication that can lead to tooth extraction. There are many classification and terms for different types of root resorption (4). Inflammatory root resorption is diagnosed when there is a loss of root substance combined with a loss of adjoining bony substance and associated radiolucency. Replacement root resorption is diagnosed when there is a loss of root substance with bony replacement and a loss of periodontal ligament space (5).

These, which may or may not be associated with pulpal necrosis (3, 6–9), may in fact lead to the early loss of the traumatized teeth if not treated (4–10). This assumption can be confirmed by clinical cases reported in dental literature, which show, through radiological exams, the early loss of primary traumatized teeth affected by pathological root resorptions (11).

Despite all current knowledge about the presence and types of pathological root resorptions in permanent teeth, such knowledge has not been transmitted to primary teeth (12). It is believed that in many cases pathological root resorptions may be mistakenly treated as physiological root resorptions. There are also case reports in which the dental trauma was not identified, but, upon radiographic examination, atypical radicular resorptions, which may be associated with digital sucking, were observed (13).

Root resorptions (inflammatory and replacement) are diagnosed during longitudinal follow-up procedures, through regular clinical and radiological exams. The diagnosis will become more precise as more radiological exams are performed, as well as by the correct utilization of techniques (14). However, not all patients need several radiological exams during the follow-up period. When considering time, cost, and exposure to radiation, it is necessary that a correct judgment be made with regard to the risk of developing complications during the trauma healing process (15).

By pointing out the factors associated with the development of root resorptions (replacement or inflammatory processes) (16) in primary teeth, it will be possible to determine which patients have a greater potential to develop such sequelaes.

Therefore, the objective of this study is to investigate whether or not gender, the child's age at the moment of the trauma, type of trauma, and recurrence constitute factors associated with the development of replacement or inflammatory root resorptions in traumatized primary teeth.

Methods

The Assistance Program for the Traumatized Patient is part of the Pediatric Dentistry Department of the Federal University of Santa Catarina (UFSC) and has been active since 1998. All patients with traumatized teeth who seek dental assistance at the department are referred to the Program, which maintains an established assistance protocol both for permanent and primary teeth (17, 18).

A retrospective study, which collected data from the dental records of the patients with traumatism assisted by the Program, was conducted, including the collection of information obtained through the analysis of the attached radiological exams. An X-ray viewing box and a magnifying glass were used in the analysis. A set of radiological exams from each patient was analyzed according to the chronological order of the visits until the pathological root resorption was identified. In the cases in which the pathological root resorption was not identified, all the radiological exams attached to the dental records were analyzed. The collected data was copied to three different pre-elaborated charts: absence of pathological root resorption, presence of replacement root resorption, and presence of inflammatory root resorption.

The criteria used for including patients in this study included: being a patient of the Assistance Program for the Traumatized Patient and having traumatized primary teeth. The exclusion criteria included: incomplete data in the traumatism dental records, caries lesion in the traumatized tooth, digital sucking, traumas listed under the categories of avulsion or root fracture, presence of internal inflammatory root resorption, and children presenting a trauma in a tooth other than the maxillary central incisive teeth. Among the cases where pathological root resorptions were not identified, children who had undergone a follow-up procedure period of < 12 months were also excluded from the study.

Three hundred and seventy-one report cards of patients assisted by the Assistance Program for the Traumatized Patient were assessed. From these, 281 patients were excluded from the study, according to the exclusion criteria. Ninety children, from 9 months to 5 years of age, remained in the study. Patients who presented both superior central incisive teeth affected by trauma had just one tooth randomly selected for the sample.

The outcome of the study diagnosed the presence or absence of pathological root resorption, that is, replacement and external inflammatory root resorption. Gender, age at the moment of trauma, type of trauma and trauma recurrence (explanatory variables) were considered as possible factors associated with the development of pathological root resorption. The gender was dichotomized in: 0 = male and 1 = female.

The age at the moment of trauma was assessed in two distinct moments: 18 and 52 months of age. Eighteen months of age is related to the end of the formation of the maxillary central incisive teeth, with: 0 = 18 months of age or younger and 1 = older than 18 months of age (including patients older than 52 months of age). Fifty-two months of age is related to the beginning of the physiological resorption of the maxillary central incisive teeth upon radiographic examination, with: 0 = 52 months of age of younger (including patients younger than 18 months of age) and 1 = older than 52 months of age. All analyses were performed separately for each of the two ages with the aim of verifying if the end of the radicular formation or the beginning of the physiological resorption are in fact determining factors in the development of pathological radicular resorptions in traumatized deciduous teeth.

The types of trauma were classified as 0 = uncomplicated (crown fracture with no pulp exposure, concussion, or subluxation) and 1 = complicated (crown fracture with pulp exposure, luxation, intrusion, and extrusion). Teeth which sustained, uncomplicated, and complicated traumatisms were classified according to the most complicated trauma. The trauma recurrence was dichotomized as: 0 = absent (one trauma) and 1 = present (more than one trauma in the same dental element).

According to the October 1996 National Health Board (CNS) resolution, the present research project was submitted to and approved by the Ethics Committee on Research with Human Beings at UFSC under approval number 174/2003.

Results

According to the inclusion and exclusion criteria, 90 children remained in this case study. Within this sample, 45 patients (50%) did not present primary teeth with pathological root resorption, while the other half showed some type of pathological resorption. Concerning the types of resorptions, 23 children (51.1%) presented replacement root resorption while 22 (48.9%) presented teeth with inflammatory root resorption.

Fifty children were male (55.6%) and 40 were female (44.4%). As regards the cut age of 18 months, 21.1% of the children were 18 months of age or younger while 78.9% were older than 18 months of age. As regards the cut age of 52 months, 88.9% were 52 months of age or younger while 11.1% were older than 52 months of age.

Among the diagnosed traumas types, 65 children (72.2%) presented uncomplicated traumas, while 25 (27.8%) presented complicated traumas. Likewise, 66 children (73.3%) presented just one trauma, while 24 (26.7%) reported more than one trauma in the same primary tooth.

The results showed that 71% of the pathological root resorptions were diagnosed within the 12 months after the onset of the trauma. By analyzing the diagnosis time of the root resorptions separately, it was verified that 66.7% of the replacement root resorptions and 73.7% of the inflammatory root resorptions were identified during the first year.

Possible factors associated with the development of pathological radicular resorption in the traumatized deciduous teeth investigated included: children older than 18 months or older than 52 months of age at the moment of trauma (analyzed separately), complicated trauma, and/or presence of more than one trauma in the same dental element.

Considering the age of 18 months, 10% of the children did not present any of the aforementioned factors, 55.6% of the children presented only one factor, 26.7% of the children presented two possible associated factors, and 7.8% of the children presented all three investigated factors.

Considering the age of 52 months, 34.4% of the children did not present any of the factors, 44.4% of the children presented only one of the possible associated factors, 18.9% of the children presented two of the factors, and 2.2% of the children presented three of the investigated factors. Tables 1 and 2 describe the combination of the patients that presented two or three of the possible factors associated with pathological root resorption.

Considering the factors associated with the development of pathological root resorptions, the chi-squared and Fisher tests were employed. A statistical value regarding trauma recurrence was significant. The results are shown in Table 3.

When associated with the absence of pathological root resorption, with the presence of replacement and inflammatory root resorptions, separately (Tables 4 and 5), it could be observed once again that in the cases with trauma recurrence, there was a statistically significant relevance in the development of inflammatory root resorption (Table 5).

Based on the chi-square test, shown in Tables 3 and 5, the variables with values of $P < 0.25$ were included in

Table 1. Combination of the explanatory variables with absence and presence of pathological root resorption (age of 18 months; $n = 31$)

	Without root resorption		With root resorption	
Combination of the explanatory variables	*n*	%	*n*	%
Age over 18 months and complicated trauma	3	25.0	9	75.0
Age over 18 months and trauma recurrence	3	27.3	8	72.7
Complicated trauma and trauma recurrence	1	100	0	0
Age over 18 months, complicated trauma, and trauma recurrence	2	28.6	5	71.4

Table 2. Combination of the explanatory variables with absence and presence of pathological root resorption (age of 52 months; $n = 19$)

	Without root resorption		With root resorption	
Combination of the explanatory variables	*n*	%	*n*	%
Age over 52 months and complicated trauma	1	16.7	5	83.3
Age over 52 months and trauma recurrence	1	16.7	5	83.3
Complicated trauma and trauma recurrence	1	20.0	4	80.0
Age over 52 months, complicated trauma, and trauma recurrence	1	50.0	1	50.0

Table 3. Association among the patients that presented traumatized primary teeth with and without pathological root resorption and the explanatory variables of gender, age A and age B, type, and trauma recurrence

	Absence of pathological root resorption		Presence of pathological root resorption			
Explanatory variables	*n*	%	*N*	%	χ^2	*P*
Gender					0	1.0
Male	25	50.0	25	50.0		
Female	20	50.0	20	50.0		
Age A					0.600	0.438
≤18 months	11	57.9	8	42.1		
>18 months	34	47.9	37	52.1		
Age B					0.450	0.502
≤52 months	39	48.8	41	51.3		
>52 months	6	60.0	4	40.0		
Trauma type					1.385	0.239
Uncomplicated	35	53.8	30	46.2		
Complicated	10	40.0	15	60.0		
Trauma recurrence					3.636	0.050
Absent	37	56.1	29	43.9		
Present	8	33.3	16	66.6		

Table 4. Association among the patients that present traumatized primary teeth with or without replacement root resorption and the explanatory variables of gender, age A and age B, type, and trauma recurrence

	Absence of pathological root resorption		Presence of replacement root resorption			
Explanatory variables	*N*	%	*N*	%	χ^2	*P*
Gender					0.006	0.939
Male	25	65.8	13	34.2		
Female	20	66.7	10	33.3		
Age A						0.220*
≤18 months	11	78.6	03	21.4		
>18 months	34	63.0	20	37.0		
Age B						0.449*
≤52 months	39	65	21	35		
>52 months	06	75	02	25		
Trauma type					0.126	0.722
Uncomplicated	35	67.3	17	32.7		
Complicated	10	62.5	06	37.5		
Trauma recurrence					0.643	0.423
Absent	37	68.5	17	31.5		
Present	08	57.1	06	42.9		

*Exact test of Fisher.

Table 5. Association among the patients that present traumatized primary teeth with or without inflammatory root resorption and the explanatory variables of gender, age A and age B, type and trauma recurrence

	Absence of pathological root resorption		Presence of inflammatory root resorption			
Explanatory variables	*N*	%	*n*	%	χ^2	*P*
Gender					0.006	0.938
Male	25	67.6	12	32.4		
Female	20	66.7	10	33.3		
Age A					0.024	0.877
≤18 months	11	68.7	05	31.3		
>18 months	34	66.7	17	33.3		
Age B						0.475*
≤52 months	39	66.1	20	33.9		
>52 months	06	75.0	02	25.0		
Trauma type					2.540	0.111
Uncomplicated	35	72.9	13	27.1		
Complicated	10	52.6	09	47.4		
Trauma recurrence					5.761	0.016
Absent	37	75.5	12	24.5		
Present	08	44.4	10	55.6		

*Exact test of Fisher.

the non-conditional, univaried, and multivaried logistic regression analyses (Tables 6 and 7). It was confirmed not only that children with trauma recurrence presented 2.6 times more chance of developing pathological root resorptions (inflammatory and replacement), but also that other factors, such as age over 18 months and complicated trauma, did not interfere in the process (Table 6). When the outcome constituted inflammatory root resorption, it was observed that children with trauma recurrence presented 3.9 times more chance of developing this type of resorption. It was also confirmed that there was no influence from the other factors: age over 52 months and complicated trauma (Table 7).

The chi-squared and Fischer test were also used to verify whether or not the combination among the factors was determinant in the development of pathological root resorptions. This research, therefore, confirmed that the association among two or three of the investigated factors (older than 18 months of age or older than 52 months of age, complicated trauma, and recurrence trauma) were significant enough for the development of pathological radicular resorption in the traumatized deciduous teeth at the ages of 18 and 52 months ($P < 0.005$).

Thus, an analysis of the univaried logistic regression was performed, revealing that, when considering the age of 18 months, children who presented two or three factors showed a 3.8 times greater chance of developing pathological root resorptions when the primary tooth was traumatized (Table 8). When considering the age of 52 months, the children who presented two or three possible factors showed a 5.1 times greater chance of developing pathological root resorptions (Table 9).

When it was affirmed that the combination of the factors produced a separate, relevant factor in the development of pathological root resorptions, the interaction was tested. The aim of such a procedure was to determine which associated variables presented an interdependency in the development of pathological root resorptions. Interactions encompassed both age groups: (i) over 18 months or over 52 months of age and complicated trauma, (ii) over 18 months or over 52 months of age and trauma recurrence, and (iii) complicated trauma and trauma recurrence.

Values with statistical significance for the development of pathological root resorptions (replacement and inflammatory) were observed in the interaction between the factors of age over 18 months and complicated trauma (OR = 3.6; 95% CI: 1.2–11.1; $P = 0.025$) and between the factors of age over 18 months and trauma recurrence (OR = 3.3; 95% CI: 1.0–10.1; $P = 0.041$).

Table 6. Analysis of the univaried and multiple logistic regressions for the presence of pathological root resorption

	OR* (95% CI)	*P*	OR†	*P*
Trauma recurrence		0.61		0.070
0 = absent	1.0		1.0	
1 = present	2.6 (1.0–6.8)		2.5 (0.9–6.8)	

*Rough value (univaried).
†Adjusted according to the complicated trauma and age over 18 months.

Table 7. Analysis of univaried and multiple logistic regressions for the presence of inflammatory root resorption

	OR* (95% CI)	*P*	OR†	*P*
Trauma recurrence		0.020		0.034
0 = absent	1.0		1.0	
1 = present	3.9 (1.2–12.0)		3.5 (1.1–11.2)	

*Rough value (univaried).
†Adjusted according to the complicated trauma and age over 52 months.

Table 8. Univaried logistic regression test for the absence or presence of the association among the explanatory variables (age of 18 months)

	OR* (95% CI)	*P*
Explanatory variables		0.005
0 = none or one variable	1.0	
1 = two or three variables	3.8 (1.5–9.7)	

*Rough value (univaried).

Table 9. Univaried logistic regression test for the absence or presence of the association among the explanatory variables (age of 52 months)

	OR* (95% CI)	*P*
Explanatory variables		0.008
0 = none or one variable	1.0	
1 = two or three variables	5.1 (1.5–17.0)	

*Rough value (univaried).

Statistical significance for age over 18 months and complicated trauma (OR = 4.6; 95% CI: 1.3–16.3; $P = 0.019$) and for age over 18 months and trauma recurrence (OR = 3.7; 95% CI: 1.0–13.6; $P = 0.046$) was also verified in the interaction of possible factors associated with the development of inflammatory root resorptions.

Discussion

The diagnosis of pathological root resorption may be performed by means of follow-up protocols in which the patient is submitted to regular clinical and radiological exams aimed at identifying the presence of resorptions in initial phases. The results of this study showed that it was possible to identify more than 70% of the root resorptions during the first year after the trauma. This period may vary from 1 to 45 months.

When the types of resorptions were analyzed separately, it was observed that the time needed for the diagnosis of replacement root resorptions in primary teeth, within which most of the resorptions were diagnosed after the first year, was different from that reported for permanent teeth (16). According to reports in dental literature, the process of replacement root resorption which commonly develops may occur slowly, when diagnosed long after the trauma, or may occur quickly, when diagnosed within a few weeks after the trauma (19). Once the remodeling process leading to a replacement root resorption has been initiated, it is unknown how long it actually takes for the dental tissue to be completely substituted by the bone (20, 21).

In the cases of inflammatory root resorptions, the time needed for diagnosis (12 months after the trauma) was also estimated in more than 70% of the cases. The results were similar to those from other studies done on primary (12) and permanent teeth (22).

Regardless of the amount of time root resorptions take to be noticed, what may be emphasized is the importance of follow-up procedures for traumatized primary teeth (3, 9, 23–32). The early assistance and the follow-up period can reduce complications occurring because of pulp and periodontal ligament necrosis, which may lead to early tooth loss (1).

The prevalence of pathological root resorptions, as a sequelae present in traumatized primary teeth, was not found in the literature. However, for permanent teeth it was reported that 4.7% of the luxations develop root resorptions caused by substitution (33). In primary teeth, among the sequelae that were investigated by Soporowski et al. (34) and Mortelliti and Needleman (35), replacement root resorptions corresponded to 7.9% and 23.4%, respectively. Inflammatory root resorptions were identified by Borum and Andreasen (12) in 14% of the cases, while Kenwood and Seow (24) identified them in only 7.2% of the cases.

The diagnosis of pathological root resorptions is as important as the determination of the factors that lead to it. Once such factors have been identified, a differentiated protocol can be established for the cases that contain identified factors. Therefore, patients with traumatized primary teeth demand more attention during the follow-up period, with shorter intervals between clinical and radiological exams. On the other hand, children who do not present the associated factors for the development of pathological root resorptions may have a follow-up protocol for these teeth with a greater interval between visits to the dentist.

Based on studies carried out on traumatized permanent teeth, the extent of root formation (9, 12, 31, 36–39) and the trauma type, with or without dental displacement (3, 12, 15, 30, 31, 33, 37–39) were determined as possible factors associated with the development of pathological root resorptions.

According to the extent of its root formation, a tooth may be considered mature or immature. An immature tooth is defined as a tooth whose root presents $\frac{3}{4}$ of its length with open apices or when the root formation is complete, but the foramen is still ample. The authors infer that immature teeth present a greater chance of maintaining pulp vitality or may even present a revascularization of the neurovascular supply when compared with mature teeth in cases of traumatism (10). When the bundle is ruptured or the revascularization does not occur, the pulp tissue necroses and, depending on the degree of damage to the periapical tissues, a pathological root resorption process is initiated. Based on this fact, the age of 18 months was determined, as this is the moment of the apex closure of the primary maxillary central incisors (12, 40). In contrast with the results from the studies on permanent teeth (9, 36–38), there was no association between the age (older than 18 months) and the development of pathological root resorptions. In fact, there was only an association with the presence of pathological root resorption in traumatized primary teeth examined in the present study in the cases in which age interacted with other factors (complicated trauma and recurrence).

In contrast to permanent teeth, primary teeth present physiological root resorption. Therefore, the age of 52 months was also adopted as a possible associated factor, as in this period it is possible to observe, through radiological images, the beginning of the physiological root resorption in the maxillary central incisors (41). However, the findings of the current study showed that there is no relation between age (older than 52 months) and the development of pathological root resorptions, even when age interacted with other factors (complicated trauma and recurrence), which differed from the results obtained by Borum and Andreasen (12). This fact may be explained by the time needed to diagnose the pathological root resorption, which may vary from 1 to 45 months. Thus, the physiological root resorption process may cause the tooth to be exfoliated before the pathological root resorption develops.

Trauma type was also adopted as a possible factor associated with the development of pathological root resorptions in traumatized primary teeth. According to studies on traumatized primary teeth (20, 38, 42), in traumas that cause dental displacement such as luxation, intrusion, and extrusion, the complications are more prevalent than in traumas without displacement, as in the cases of crown fractures, concussion, and subluxations. This most probably occurs, in cases of severe

trauma, because of the irreversible traumas of the vascular supply and periodontal ligament. Additionally, the risk of bacterial infection because of crown fracture with pulp exposition suggests that this type of fracture may also be considered a severe trauma (33).

It was observed in this study that the type of trauma, when considered separately from other variables, did not seem to be related to the pathological resorptions. Similar findings were reported by Soporowski et al. (34). However, in the interaction of complicated trauma with the age over 18 months, statistical association with pathological root resorption was found. This is an essential finding as most dental professionals emphasize both the follow-up and the treatment of teeth affected by severe traumas in detriment of those affected by mild traumas. Cases of avulsion followed by reimplants were excluded from this study because in this type of trauma pathological root resorption is always present, making any such comparison impossible.

Through clinical observations performed during the years the UFSC Protocol for Traumatized Primary Teeth has been used, a great number of trauma recurrences among the assisted children have been observed, with some early traumatized tooth loss. The literature shows that between 4.3% and 68% of children present trauma recurrence in the primary dentition (3, 23). Thus, the surveyed data evidenced that trauma recurrence in the same tooth increased the chances of developing pathological root resorptions, either when considering the recurrence as an isolated factor or when associated with others. Therefore, during the patient interview in the first dentist appointment, it is important to ask the parents or guardians about the occurrence of past traumas. During the follow-up period, the professional must also ask about other traumatisms which may have occurred during the interval. This is an important procedure because of the fact that parents usually forget to inform about other traumas, especially if they occurred but did not result in an aesthetic alteration or bleeding. In cases where the tooth presented more than one trauma, the follow-up procedures may be even stricter when compared with other factors.

More than just identifying the presence of possible factors, it is necessary and essential to determine their combination. Cases in which the combination of two or three factors was detected presented a significant statistical difference as regards the development of pathological root resorption when compared with cases with the presence of only one factor or none at all. Similarly, in the interaction of factors such as age over 18 months and complicated trauma as well as age over 18 months and trauma recurrence, it was verified that the presence of resorptions is greater than when the factors act in isolation. This denotes the interdependency of the factors involved in the development of pathological root resorptions and also, more specifically, in the development of inflammatory root resorptions.

The results obtained in this study may contribute in an important way to clinical decisions as regards traumatized primary teeth, making further alterations in the UFSC Protocol for the Assistance of Traumatized Patients possible. Patients (17) who present factors associated with the development of pathological root resorptions receive a follow-up planning with recall examination intervals which are different from those of patients who do not present the associated factors, implementing a safer and more comfortable assistance for the children.

Conclusions

- Trauma recurrence in the same tooth constitutes a factor associated with the development of pathological root resorptions.
- The identification of two (age over 18 months and complicated trauma; age over 18 months and trauma recurrence) or three (age over 18 months, complicated trauma, and trauma recurrence) factors in the same case is associated with a greater chance for developing pathological root resorptions.

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