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Original Article

Factors associated with pulp canal obliteration due to traumatic injuries in deciduous teeth: a retrospective study

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Abstract: Pulp canal obliteration (PCO) presents itself as a frequent pulp complication in traumatized primary teeth, characterized as a progressive deposition of hard tissue in the root canal. In this context, this study aimed to evaluate the association between PCO due to the occurrence of traumatic dental injuries (TDI) in deciduous teeth and specific factors. For this, a retrospective study was carried out through 210 medical records selected from the Dental Trauma Care Program from 2012 to 2019. After applying the eligibility criteria, 371 deciduous teeth were included. Statistical analysis was performed using chi-square and Fischer's exact test. The occurrence of PCO was observed in 4.9%. Associated factors such as age (P=0.63), sex (P=0.47) and search for care (P=0.87) did not influence the occurrence of PCO. Concerning the type of TDI and development of PCO, the injury of subluxation showed a statistically significant association (P=0.01). There was an association of PCO with other TDI complications such as crown discoloration (P<0.01) and acceleration of physiological root resorption (P=0.01). No statistically significant association was found regarding the development of sequelae in permanent successors and PCO (P>0.05). Based on this study, PCO was not a frequent complication of TDI in deciduous teeth in the population evaluated. PCO was associated with subluxation, crown discoloration, and acceleration of physiological root resorption. However, it did not show association with any related factor (age, sex, and seeking care) and the development of clinical or radio graphical sequelae in permanent successors.

Keywords: Tooth injuries, dental pulp calcification, tooth, deciduous, complications

Introduction

Pulp canal obliteration (PCO) is considered a pathological process that occurs such as Traumatic Dental Injuries (TDI) circumstances [1, 2]. There is a higher prevalence of PCO during the first and second decades of life, which is the most pulp complications present in traumatized teeth and the diagnosis appears about three months after the traumatic injury [1, 2].

The most considered complications related to PCO are dental crown discoloration [3] and the lack of pulp response to vitality [4]. Uncontrolled deposition of dentin, which affects the light transmission trough the tooth, results in opacity, characterizing the clinical discoloration observed [5]. The type of injury and the patient's age at the time of the trauma can influence the PCO development [5].

The prevalence of PCO in traumatized deciduous teeth can vary. While some authors observed a high prevalence [6-9], others observed a low prevalence [10] or even no relationship found [11]. For trauma subtypes, there is a greater association between PCO and the following types of injuries: luxations, subluxation, and concussion [8, 10, 12, 13].

Therefore, the knowledge about this modality of pulpal healing in a population is important to support clinical decisions during the follow-up of TDI in the primary dentition. Based on such,

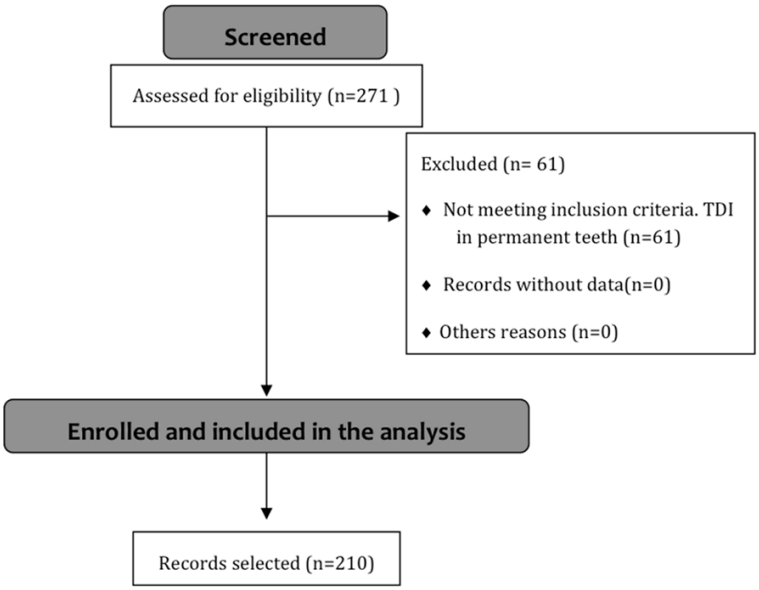

Figure 1. Records included in the analysis.

this study aimed to evaluate the association between PCO due to TDI occurrence in deciduous teeth and associated factors.

Material and methods

This retrospective study was based on file records of children treated at the Dental Trauma Care Program (DTCP) of the Health Institute of Nova Friburgo, Fluminense Federal University, Brazil, during a period of 7 years (from 2012 to July 2019). This project was approved by the ethics committee of the Fluminense Federal University, CAAE nº 70872117.8.00-00.5626/protocol nº 2.320.329.

The DTCP offers access, treatment, and follow-up for TDIs affecting the primary dentition. All patients treat in this Program are routinely follow-up until complete root formation of their succeeding permanent teeth. Parents or legal guardians are initially interview regarding the child's medical history and history of dental trauma. Subsequently, clinical findings are documented, and radiographs and photographs are taken. Dental trauma diagnosis is based on clinical examination and radiographic findings, using the Andreasen and Andreasen classification: concussion, subluxation, extrusive luxation, lateral luxation, intrusive luxation, avulsion, enamel fracture, enamel and dentine fracture with or without pulpal exposure, crown-root fracture with or without pulpal exposure, root fracture [14]. A professional with large experience in pediatric dentistry makes the diagnostics. The protocol of care is based on recommendations of the International Association of Dental Traumatology Guidelines [15].

All cases of injury with complete TDI documentation (clinical photos, radiographs, and trauma data sheet) from children who suffered traumatic dental injuries in deciduous teeth were included in the study. The following items were excluded: patients that used interceptive orthodontic or prosthesis, patients with special needs such as lack of motor and/or mental ability, or carrier of some type of syndrome, cases of children in whom the evaluation type of TDI was inconclusive due to collaboration problems and incomplete records or without a consent form signed by the patients' parents or caregivers.

Clinical details such as gender, age at the time of TDI, number of traumatized teeth, the type of TDI, clinical and radiographic sequelae in the primary dentition and sequelae in the permanent successors and the time elapsed between the dental injury and care were also recorded. The pulp condition with PCO was evaluated in periapical radiographs and was positive when it had deposition of hard tissue along the walls of the root canal and in the coronal pulp chamber [16].

The data were tabulated in a statistical program (SPSS 19.0), for the quantitative analysis of the results and the frequency of the data of interest was obtained. The Chi-square and Fisher's exact tests were applied for the association between variables collected from the child (sex, age), type of TDI [14, 16], type of tissue affected by TDI, search for care (mediate/immediate) with PCO. Statistical differences at the level of 5% were considered.

Results

From a total of 271 records, 61 were excluded from the study and the final sample consisted of 210 records (**Figure 1**). Among 210 patients'

Table 1. Relationship between sex, age, search for care, and PCO

Variables	Pulp canal obliteration			
	Total n (%)	No n (%)	Yes n (%)	*P*-value
Age				
n<3 years	189 (100%)	181 (95.8%)	8 (4.2%)	
n>4 years	182 (100%)	172 (94.5%)	10 (5.5%)	0.63**
Sex				
Female	157 (100%)	151 (96.2%)	6 (3.8%)	
Male	214 (100%)	202 (94.4%)	12 (5.6%)	0.47**
Search for care				
Mediate	294 (100%)	280 (95.2%)	14 (4.8%)	
Immediate	77 (100%)	73 (94.8%)	4 (5.2%)	0.87*

*Chi-square test; **Fisher's exact test. P<0.05. Bold denotes statistical association.

records selected, 55.2% were boys and 44.8% were girls. The mean age was 3.51 years (SD 1.52). The immediate time for search for care was recorded in 17.6%. Among the 210 selected records, 371 deciduous teeth were included. The PCO was observed in 18 teeth (4.9% of the total sample of 371).

Considering associated factors, no statistically significant association was found between sex, age, seeking care, and PCO (P>0.05) (**Table 1**).

The type of tissue affected (support or dental) and the presence of displacement had no statistical association with the presence of PCO (P>0.05). Regarding the type of TDI, subluxation injury showed a statistically significant association with PCO (P=0.01) (**Table 2**).

Considering the association of clinical and radiographic complications in the primary dentition and PCO, other conditions such as accelerated physiological root resorption (P=0.01) and crown discoloration (P<0.01) presented statistically significant association (**Table 3**).

The sample of permanent successors already erupted during the data collection period consisted of 148 teeth. Among the successors available for the evaluation, 36 (24.3%) presented sequelae resulting from dental trauma in the primary dentition. **Table 4** shows the absence of a statistically significant association between PCO in primary dentition and the presence of clinical and radiographic sequelae in the permanent successors included in the present study (P>0.05).

Discussion

Traumatic dental injury (TDI) is caused by an unexpected event resulting from any activity of daily living and is considered with some diseases, such as dental caries and periodontal disease as a problem of public health of great importance [17]. The occurrence of TDI in childhood and adolescence is common [18]. In the primary dentition, this involvement can lead to pulp damage in addition to the possibility of reaching and generating sequelae of formation in permanent teeth [19, 20].

PCO is a sign of pulpal healing and stands as one of the most common pulp complications in traumatized teeth, presenting as its main mechanism a rapid formation of mineralized tissue within the root canal, radiographically observed as a reduction in the thickness of the lumen of the canal [1, 5]. This study showed no statistical relationship between gender and the presence of PCO and age and PCO, as also demonstrated by another study in the literature [21].

It was observed that the prevalence of PCO was low. This result differs from those found by some authors who observed a prevalence ranging from 25.3% to 54% [6-8, 13, 21]. However, the present finding coincides with the results of another study [10] that also observed a low prevalence of PCO in primary teeth (2.5%). This low prevalence could to some extent be explained by the low occurrence of displacements of the tooth at the time of injury (severe luxations) in this study. Several studies [8, 10, 11, 13, 22, 23] that featured a higher frequency of TDI with displacements were associated with a high prevalence of PCO. The low sample size can also be a factor related to the lower prevalence of PCO. A similar study with a larger sample [21] presented a four times higher prevalence of PCO.

PCO showed a statistically significant association with the occurrence of subluxation injury, in agreement with the results of another study [24]. However, other authors have shown a possible association between PCO and TDI with displacements, such as extrusive luxation, intrusive luxation, and lateral luxation [6, 7],

Table 2. Relationship between the type of affected tissue, the type of trauma, and PCO

Variables	Pulp canal obliteration			
	Total n (%)	No n (%)	Yes n (%)	*P*-value
Affected tissue				
Support tissue	327 (100%)	310 (94.8%)	17 (5.2%)	
Dental tissue	44 (100%)	43 (97.7%)	1 (2.3%)	0.70**
Displacement				
Presence	82 (100%)	81 (98.8%)	1 (1.2%)	
Absence	289 (100%)	272 (94.1%)	17 (5.9%)	0.14**
Type of traumatic injury				
Concussion				
Yes	100 (100%)	92 (92%)	8 (8%)	
No	271 (100%)	261 (96.3%)	10 (3.7%)	0.08*
Subluxation				
Yes	38 (100%)	33 (86.8%)	5 (13.2%)	
No	333 (100%)	320 (96.1%)	13 (3.9%)	**0.01***
Lateral luxation				
Yes	23 (100%)	22 (95.7%)	1 (4.3%)	
No	348 (100%)	331 (95.1%)	17 (4.9%)	1.00**
Extrusive luxation				
Yes	4 (100%)	4 (100%)	0 (0%)	
No	367 (100%)	349 (95.1%)	18 (4.9%)	1.00**
Intrusive luxation				
Yes	23 (100%)	23 (100%)	0 (0%)	
No	348 (100%)	330 (94.8%)	18 (5.2%)	0.61**
Enamel Fracture				
Yes	67 (100%)	64 (95.5%)	3 (4.5%)	
No	304 (100%)	289 (95.1%)	15 (4.9%)	1.00**
Enamel-dentin fractures (with no pulp exposure)				
Yes	70 (100%)	69 (98.6%)	1 (1.4%)	
No	301 (100%)	284 (95.1%)	17 (5.6%)	0.21**
Enamel-dentin fractures (with pulp exposure)				
Yes	14 (100%)	14 (100%)	0 (0%)	
No	357 (100%)	339 (95%)	18 (5%)	1.00**
Root Fracture				
Yes	1 (100%)	1 (100%)	0 (0%)	
No	370 (100%)	352 (95.1%)	18 (4.9%)	1.00**

*Chi-square test; **Fisher's exact test. P<0.05. Bold denotes statistical association.

which suggests a greater association of this sequel with TDI in supportive tissue. Contrarily, some authors did not observe any relationship between PCO and the different types of TDI [8-10].

When it refers about the association between the presence of PCO and crown discoloration, it was observed a statistically significant association. Several studies in the literature have suggested and shown an association between both conditions [8, 9, 25-28]. Although it was not found a relationship between obliteration and periapical lesion development in the present study, some authors observed secondary necrosis in deciduous teeth with PCO [25, 29]. Although it is not clear how this process occurs, a possible justification, according to Cleen [30] and Bastos and Cortes [5] would be that necrosis observed after the obliteration of the root canal, would be the result of a new TDI able to disrupt the vascular supply, already vul-

Table 3. Relationship between PCO and clinical and radiographic complications in the primary dentition

Variables	Pulp canal obliteration			
	Total n (%)	No n (%)	Yes n (%)	*P*-value
Crown discoloration				
Yes	81 (100%)	70 (86.4%)	11 (13.6%)	
No	290 (100%)	283 (97.6%)	7 (2.4%)	**<0.01****
Loosening				
Yes	19 (100%)	19 (100%)	0 (0%)	
No	352 (100%)	334 (94.9%)	18 (5.1%)	0.61**
Internal root resorption				
Yes	2 (100%)	2 (100%)	0 (0%)	
No	369 (100%)	351 (95.1%)	18 (4.9%)	1.00**
External root resorption				
Yes	22 (100%)	21 (95.5%)	1 (4.5%)	
No	349 (100%)	332 (95.1%)	17 (4.9%)	1.00**
Thickening of the periodontal ligament				
Yes	24 (100%)	22 (91.7%)	2 (8.3%)	
No	347 (100%)	331 (95.4%)	16 (4.6%)	0.412**
Physiological root resorption acceleration				
Yes	37 (100%)	32 (86.5%)	5 (13.5%)	
No	334 (100%)	321 (96.1%)	13 (3.9%)	**0.01***
Periapical lesion				
Yes	3 (100%)	3 (100%)	0 (0%)	
No	368 (100%)	350 (95.1%)	18 (4.9%)	1.00**
Tooth ankylosis				
Yes	3 (100%)	3 (100%)	0 (0%)	
No	368 (100%)	350 (95.1%)	18 (4.9%)	1.00**
Pulp necrosis				
Yes	0 (0%)	0 (0%)	0 (0%)	
No	371 (100%)	353 (95.1%)	18 (4.9%)	---

*Chi-square test; **Fisher's exact test. P<0.05. Bold denotes statistical association.

nerable, in the apical foramen. They also consider the possibility of necrosis being the result of the presence of caries and/or restorations that can cause irreversible damage to the dental pulp. For this reason, follow-up is still necessary since the evolution to necrosis in the deciduous tooth with PCO is not viable for endodontic treatment requiring the extraction of the tooth. In deciduous teeth, physiological root resorption is a genetically programmed process [31]. The study of Jacobsen and Sagnes [25] aimed to observe the influence of PCO in the process of physiological root resorption. The authors did not observe any influence of PCO on the process of physiological root resorption in deciduous traumatized teeth. In addition, the study of Borum and Andreasen [6] did not demonstrate a relationship between PCO and any disturbance in the speed of physiological root resorption in primary teeth. Differently, the present study presented a statistically significant relationship between PCO and the acceleration of physiological root resorption, contrasting the statement by Jacobsen and Sagnes and Borum and Andreasen [6, 25] regarding the expectation of normal physiological resorption in cases of PCO due to the occurrence of dental trauma.

The development of sequelae in permanent successors depends on several factors, such as the type of TDI in the primary dentition and the patient's age at the time of the trauma [32]. PCO showed no statistically significant associa-

Table 4. Relationship between PCO and sequelae in permanent successors

Variables	Pulp canal obliteration			
	Total n (%)	No n (%)	Yes n (%)	*P*-value
Demarcated opacity				
Yes	22 (100%)	21 (95.5%)	1 (4.5%)	
No	126 (100%)	121 (96%)	5 (4%)	0.89*
Hypocalcification				
Yes	8 (100%)	8 (100%)	0 (0%)	
No	140 (100%)	134 (95.7%)	6 (4.3%)	1.00**
Deviation in the eruption path				
Yes	5 (100%)	5 (100%)	0 (0%)	
No	143 (100%)	137 (95.8%)	6 (4.2%)	1.00**
Enamel Hypoplasia				
Yes	3 (100%)	3 (100%)	0 (0%)	
No	145 (100%)	139 (95.9%)	6 (4.1%)	1.00**
Root angulation				
Yes	3 (100%)	3 (100%)	0 (0%)	
No	145 (100%)	139 (95.9)	6 (4.1%)	1.00**

*Chi-square test; **Fisher's exact test. P<0.05. Bold denotes statistical association.

tion with the development of sequelae in permanent successors. Although it has already been proven that long-term complications can cause damage to permanent successors [1, 13, 26, 33]. There is still a need for studies that associate PCO and its direct association with the development of sequelae in the permanent successors.

The results observed were based in the patients from the Dental Trauma Care Program (DTCP) and cannot be extrapolated to other populations, since the present sample was not representative, but a convenience sample. However, it is extremely important for directing the protocols of management of the population who seeks care at the DTCP. In addition, the methodology used can be replicated by other researchers wishing to deepen the topic or in other populations. Since the study showed a statistically significant relationship between PCO and subluxation, this information can influence the extending the follow-up of the traumatized element due to the possible expectation of this outcome.

The low prevalence of PCO in the sample can present itself as a limitation of the study, even though sufficient methodology was used for the correct diagnosis of the condition. This fact can be justified by the different patterns of the methodology of studies available in the literature, the use of different types of TDI in the sample in question, and the different follow-up times in the consulted works.

Based on the findings, it is possible to highlight the association of crown discoloration and acceleration of root resorption with PCO. Those are important findings for the conclusion of the clinical diagnosis of any of the conditions and the correct approach to the sequel. This information demonstrated a causal relationship between the presence of crown discoloration, and acceleration of the physiological root resorption and the presence of PCO in deciduous teeth. This clinically implies closer monitoring of the patient for the intervention of the consequences this early loss may cause. In addition, the fact that the tooth has a color change in the crown and/or accelerated root resorption, often leads the clinician to the idea of the need for endodontic treatment. Therefore, to know that the relationship of pulp necrosis and PCO in primary teeth is rare [25, 29] is especially important to demystify the relationship of color change with endodontic treatment. However, even if it does not evolve into more serious sequelae, it does not rule out the need for follow-up. This is also true to finding the absence of a relationship between PCO and the development of sequel in the permanent successors. Follow-up is still justified, and even more, studies are needed to assess this causal relationship.

Another fact that denotes the clinical relevance of this study is the association of subluxation injury with the PCO. This finding reinforces others in the literature that TDI can affect Oral Health Related Quality of Life (OHRQoL) [34] and emphasizes the importance of monitoring TDI, the importance of treatment and follow-up for a better outcome in OHRQoL [35]. In addition, PCO it is not related to large displacements, is underdiagnosed and occasionally,

sub-treated. The well-performed follow-up can guide parents by decreasing the implementation of mistaken treatments and improving the quality of life of these patients.

Conclusion

PCO was not a frequent complication of TDI in deciduous teeth in the population evaluated. PCO was associated with subluxation injury, coronary discoloration, and acceleration of physiological root resorption, but it did not show association with any related factor (age, sex, and search for care) and the development of clinical or radiographic sequelae in permanent successors.

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Disclosure of conflict of interest

None.

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