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Pulp stones following orthodontic treatment: a case-control study

Nódulos pulpares após tratamento ortodôntico: um estudo de caso-controle

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ABSTRACT

The aim of this study was to analyze the incidence of pulp stones (PS) after orthodontic treatment. With a case-control design, 49 patients from a private orthodontic clinic in Curitiba, PR, Brazil, of both sexes, aged between 14 and 26 years, undergoing orthodontic intervention between the years 2000 and 2020, participated. Premolars and molars were analyzed from initial and final panoramic radiographs. Demographic and clinical data were collected from the patients' medical records. After the initial descriptive analysis, followed by the t test for independent samples, the Chi-square test was applied to search for possible associations between the explanatory variables and the outcome of interest (post-treatment PS). Values with a significant difference were those with $p < 0.05$. Nineteen cases and 30 controls participated, namely 26 men and 23 women. There was no difference between groups for the age ($p = 0.114$) and treatment time ($p = 0.204$). Significant differences did not occur between cases and controls in association with the other variables ($p > 0.05$). In conclusion, there was no increase in PS incidence after orthodontic treatment in the sample studied.

Keywords: Endodontics; Orthodontic treatment; Pathology; Pulp stone.

RESUMO

O objetivo deste estudo foi analisar a incidência de nódulos pulpares (NP) após o tratamento ortodôntico. Com um desenho de caso-controle, participaram 49 pacientes de uma clínica ortodôntica privada de Curitiba, PR, Brasil, de ambos os sexos, com idade entre 14 e 26 anos, que passaram por intervenção ortodôntica entre os anos 2000 e 2020. Pré-molares e molares foram analisados a partir de radiografias panorâmicas iniciais e finais. Os dados demográficos e clínicos foram coletados dos prontuários dos pacientes. Após a análise descritiva inicial, seguida do teste t para amostras independentes, foi aplicado o teste do Qui-quadrado para buscar possíveis associações entre as variáveis explicativas e o desfecho de interesse (NP pós-tratamento). Os valores com diferença significativa foram aqueles com $p < 0,05$. Participaram 19 casos e 30 controles, sendo 26 homens e 23 mulheres. Não houve diferença entre os grupos para idade ($p = 0,114$) e tempo de tratamento ($p = 0,204$). Não ocorreram diferenças significativas entre casos e controles em associação com as demais variáveis ($p > 0,05$). Em conclusão, não houve aumento na incidência de NP após o tratamento ortodôntico na amostra estudada.

Palavras-chave: Endodontia; Tratamento ortodôntico; Patologia. Nódulo pulpar.

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INTRODUCTION

Pulp stones (PS) are mineralized structures that organize themselves in the pulp tissue of primary or permanent teeth (SISMAN et al., 2012), with structural and chemical properties similar to dentin (MILCENT et al., 2019). They are usually asymptomatic, detected in radiographic examinations as a finding and represented by radiopaque images inside the pulp chamber (KUZEKANANI et al., 2018). Higher PS prevalence is found in maxillary first and second molars (KUZEKANANI et al., 2018), with a predilection for the right side of the maxilla (KUZEKANANI et al., 2018) and for females (JANNATI et al., 2019). Increase in cases is associated with aging (ERTAS et al., 2017).

In the literature, the possible causes for the occurrence of PS are trauma (LAZZARETTI et al., 2014), chronic irritations due to caries or restorative materials (ERTAS et al., 2017, SEZGIN; SÖNMEZ; KAPLAN, 2021), nanoparticles and nanobacteria (ZENG et al., 2011), systemic diseases (SATHEESHKUMAR et al., 2013; TALLA et al., 2014), and genetic factors (ERTAS et al., 2017). In this context, orthodontic movement seems to be part of the possible causes of occurrence of PS (ERTAS et al., 2017; JENA et al., 2018; KORKMAZ; AYDIN; SARIOGLU, 2019). However, there are still questions regarding the impact of orthodontic treatment on the emergence of PS, since the dental pulp can be affected by the application of force (ABU ALHAIJA; TAHA, 2021) and generate a defense response (LAZZARETTI et al., 2014; ABU ALHAIJA; TAHA, 2021). A recent systematic review revealed that regardless of the type of orthodontic appliance, duration of force, and intensity of force applied, orthodontic treatment does not induce pulp necrosis (WEISSHEIMER et al., 2021). In other studies, it was found that metabolic changes occur through orthodontic movement (VEBERIENE et al., 2010), promoting the development of pulp calcifications (LAZZARETTI et al., 2014).

Several investigations focused on identifying development of PS after orthodontic treatment look into the method used to analyze panoramic radiographs (ERTAS et al., 2017; JENA et al., 2018; KORKMAZ; AYDIN; SARIOGLU, 2019), which is part of the justification for carrying out this research. Therefore, the present study aimed to investigate incidence of PS after orthodontic treatment in patients

attending a private clinic in Curitiba, PR, Brazil. The null hypothesis was that orthodontic treatment would not lead to the incidence of the outcome.

MATERIAL AND METHODS

Ethical aspects

This study was approved by the institutional Research Ethics Committee, under registration No. 2,805,133.

Study design and sampling

This study had a case-control design. Initially, an active search was carried out for panoramic radiographs of patients who were treated at a private clinic specializing in orthodontic treatment, in Curitiba, PR, between the years 2000 and 2020 (n = 2124).

Individuals of both sexes were included, aged between 14 and 26 years at the beginning of treatment (JENA et al., 2018) and who had good quality radiographic examinations in the pre- and post-orthodontic treatment periods (ERTAS et al., 2017; JENA et al., 2018; KORKMAZ; AYDIN; SARIOGLU, 2019). All patients had a record of using fixed orthodontic appliances.

After applying the inclusion criteria, 49 examinations remained. Of these, only premolar and molar teeth, with complete rooting, both arches and facial sides, were assessed. Individuals who had gone extraction of any of the aforementioned teeth and those who had systemic disease recorded in their medical records were excluded (ERTAS et al., 2017; JENA et al., 2018). Teeth with carious lesions or with restorations deeper than 1 mm from the dentin-enamel junction were also excluded (ERTAS et al., 2017; JENA et al., 2018).

Data collected from dental records

Information was collected regarding: sex (male or female), observed skin color (white, yellow, black or brown), age (in years), molar ratio, facial pattern (mesofacial, brachyfacial or dolichofacial), type of accessory appliance used for orthopedic purposes

(maintenance or strength), treatment time (in years), total number of teeth assessed, arch (maxilla, mandible or both) and side (right, left or both) for the presence of PS, condition of each tooth assessed (healthy or filled) and presence or absence of PS per tooth.

For the purposes of statistical analysis, the accessory appliances were dichotomized into: maintenance - appliances the primary function of which is to keep (maintenance) the teeth in position (Nance Button and Lingual Arch) and strength - appliances that exert force on the first permanent molars (Hass, Hyrax, Pendulum, Herbst, Forsus, PowerScope and AEB).

Image analysis and PS diagnosis

Diagnosis suggestive of the presence of PS was made through identification of a defined radiopaque mass inside the pulp chamber, regardless of size (TARIM ERTAS et al., 2014).

This radiographic analysis was performed by only one calibrated examiner (Kappa = 0.88), who was a specialist in Endodontics. A radiology specialist was consulted when there was any doubt regarding diagnosis. The control group consisted of patients who had or did not have PS before orthodontic treatment; and the case group composed of those diagnosed with PS after orthodontic treatment.

Regarding PS incidence, the following was also recorded: arch (maxilla, mandible or both), side (right, left or both) and condition of each tooth (healthy or filled).

Conventional radiographs were digitized and analyzed in the partial darkness of the room, on the same monitor, at a standardized distance of 45 cm (TARIM ERTAS et al., 2014).

The data were tabulated on Excel® spreadsheets and all analysis was performed using SPSS version 23.0. Initially, a descriptive analysis of the variables was performed, including the Kolmogorov-Smirnov normality test. The t test was applied to identify whether there was a difference between mean age and mean treatment time between cases and controls. The Chi-square test was then applied in order to investigate possible associations between the explanatory variables and the outcome (presence of

PS after orthodontic treatment). $p < 0.05$ was adopted as indicating statistical significance.

RESULTS

The t test did not reveal a significant difference between mean age and mean treatment time for the case and control groups. The p-values were 0.114 and 0.204, respectively.

Table 1 shows that there was a balance between males (n = 26; 53.1%) and females (n = 23; 46.9%). People of white skin color accounted for 100% of those surveyed (n = 49). The mean age for the total sample was 20 (±3.5) years and mean treatment time was 3.2 (±1.6) years.

Table 1 - Description of data from 49 patients undergoing orthodontic treatment in a private clinic in Curitiba, PR, from 2000 to 2020.

Variable	**Case** **n = 19 (38.8%)**	**Control** **n = 30 (61.2%)**	**p***	**OR (95%CI)**
Sex				
Male	8 (42.1)	18 (60.0)	0.221	2.06 (0.64-6.63)
Female	11 (57.9)	12 (40.0)		
Skin color				
White	19 (38.8)	30 (61.2)	-	-
Molar relationship				
Class I	9 (42.9)	12 (42.9)		
Class II, Division 1	4 (19.0)	4 (14.3)		
Class II, Division 1, Subdivision right	5 (23.8)	4 (14.3)	0.973	-
Class II, Division 1, Subdivision left	1 (4.8)	1 (3.6)		
Class II, Division 2	1 (4.8)	3 (10.7)		
Class III	1 (4.8)	4 (14.3)		
Facial pattern				
Mesofacial,	10 (52.6)	20 (66.7)	0.310	
Brachyfacial	4 (21.1)	2 (6.7)		-
Dolichofacial	5 (26.3)	8 (26.7)		

Accessory appliance				
Maintenance	11 (57.9)	20 (66.7)	0.535	1.45 (0.44-4.76)
Strength	8 (42.1)	10 (33.3)		
Arch with PS				
Maxilla	5 (26.3)	1 (10.0)		
Mandible	4 (21.1)	2 (20.0)	0.553	-
Both	10 (52.6)	7 (70.0)		
Facial side with PS				
Right	1 (5.3)	2 (20.0)		
Left	9 (47.4)	2 (20.0)	0.238	-
Both	9 (47.4)	6 (60.0)		
	Mean (SD)	**Mean (SD)**	***p*** †	
Age	19.4 (3.5)	20.5 (3.4)	0.114	
Treatment time	3.7 (1.9)	2.9 (1.3)	0.204	

* Kolmogorov-Smirnov Normality Test.

† t Test.

Note: SD, standard deviation.

Source: Data of the study.

Class I was the most prevalent (n = 21; 42.9%), as was the mesofacial facial pattern (n = 30; 61.2%). Accessory appliances intended for keeping the teeth in position were used by 31 individuals (63.3%), while those that exert force were used by 18 (36.7%) individuals.

Regarding PS incidence in the arches, both frequencies observed were the same (n = 6; 20.7%), while with regard to both sides of the face there were 15 (51.7%) on the right side and 11 (37.9%) on the left side.

No significant differences were found between the groups for the variables included in the present analysis ($p > 0.05$). However, in the cases were more frequent females, Class I, mesofacial pattern and who used accessory appliances for maintenance. Despite the lack of a significant difference, the longest mean treatment time (3.7 years) was higher in cases compared to controls (2.9 years).

Table 2 describes the teeth that presented PS. It can be seen that the most affected, in descending order, were: 16 (n = 19), 44 (n = 14) and 26 (n = 10). It is also noteworthy that most of the teeth with PS were healthy (Table 3).

Table 2 - Description of posterior teeth with PS of 49 patients undergoing orthodontic treatment in a private clinic in Curitiba, PR, from 2000 to 2020.

	PS	
Tooth	**Yes**	**No**
17	6	43
16	19	30
15	3	45
14	0	49
24	0	49
25	1	47
26	10	39
27	7	42
37	5	44
36	5	45
35	5	44
34	2	47
44	14	35
45	6	43
46	1	21
47	0	16

Source: Data of the study.

Table 3 - Description of the condition of posterior teeth with PS of 49 patients undergoing orthodontic treatment in a private clinic in Curitiba, PR, from 2000 to 2020.

Tooth	**Healthy**	**Filled**
17	43	6
16	33	16
15	43	4
14	47	2
24	45	4
25	44	1
26	32	17
27	42	7
37	41	7
36	26	23
35	45	3

34	46	2
44	47	1
45	43	3
46	28	21
47	38	11

Source: Data of the study.

DISCUSSION

In this study, orthodontic treatment was not associated with PS incidence. With a varied and not yet fully elucidated etiopathogenesis, orthodontic movement has proven to be a relevant factor associated with the development of PS according to other authors (ERTAS et al., 2017; JENA et al., 2018; KORKMAZ; AYDIN; SARIOGLU, 2019). Assessment of presence of calcifications after orthodontic treatment, by analyzing panoramic radiographs, was performed by Ertas et al. (2017), Jena et al. (2018), and Korkmaz et al. (2019), showed an increase in the incidence of post-treatment PS, which does not corroborate our findings.

Regarding gender, although differences were not found, similar to results of other studies with the same objective (ERTAS et al., 2017; JENA et al., 2018; KORKMAZ; AYDIN; SARIOGLU, 2019) predilection for occurrence of PS in females stands out (JANNATI et al., 2019). As for age, the mean found was 20 years, with no difference between the case and control groups. The mean age of the cases in the present study was 19.4 years. Jena et al. (2018) identified an increase in PS for the 20-22 age group, while Ertas et al. (2017) found the same in individuals aged 18 to 20 years. The present sample was comprised entirely of individuals of white skin color, thus preventing comparison between skin colors. It should be noted, however, that skin color/ethnicity does not appear to have any relationship with PS incidence.

Greater presence of PS in decreasing order of prevalence was found in teeth 16, 44 and 26. When observing teeth according to groups, these findings corroborate those of Korkmaz et al. (2019). However, when the teeth were observed individually, the results found in this study expressed a higher frequency of PS in maxillary molars. This fact coincides with the findings of Ertas et al. (2017) and Jena et al. (2018), who obtained higher values for maxillary molars.

The search for factors not yet associated with orthodontic treatment, resulted in discussion about the molar relationship of those surveyed. In the cases studied here, Class I prevailed, also without significant differences. The literature points out that more complex cases may require the use of greater force and time. Thus, considering that orthodontic force has an immediate effect on pulp tissue blood supply, causing tissue hypoxia, with a 27% to 33% reduction in oxygen supply to the pulp tissue (YAMAGUCHI; KASAI, 2007) the duration of inflammatory responses and the incidence of greater forces tend to provoke pulp calcification (STENVIK; MJÖR, 1970).

As for facial patterns, there were no differences between the groups, but the mesofacial pattern accounted for 61.2% of those surveyed, including a higher proportion of cases. This finding indicates that, in the present sample, this condition did not influence the development of PS.

Also, in search of variables that differed between cases and controls, we investigated data regarding accessory appliances used for maintenance or strength of teeth, specifically supported by molars. No significant association was found with the outcome, but maintenance was more present in the case group. In the same perspective of pulp alterations, Baratieri et al. (2013) analyzed tomographic images performed initially and after one year of the active phase of rapid maxillary expansion. The authors pointed out that it did not induce new calcifications, nor did it interfere with the dimensions of the pulp chamber of the molars used for anchorage.

Differences were not observed here regarding the arch and facial side. Such findings are supported by the literature, where no differences were found between facial sides or arches in relation to the outcome (ERTAS et al., 2017; KORKMAZ; AYDIN; SARIOGLU, 2019). Other authors have indicated higher values for the maxilla (ERTAS et al., 2017; JENA et al., 2018). As for the time factor, the results of this research, even without significant differences, indicate that the duration of exerted force seems to provoke chronic pulp alteration, favouring the development of PS. Although Korkmaz et al. (2019) delimited the maximum duration of treatment with a mean of 3.1 years, in an attempt to exclude the effect of time on the development of PS after orthodontic treatment, relevant results were not revealed by the authors.

Finally, some considerations should be made regarding the method used by some studies mentioned here (ERTAS et al., 2017; KORKMAZ; AYDIN; SARIOGLU,

2019) with a view to comparison. In both studies cited, there was a discrepancy between the sexes, with a predominance of females in the sample, so that stating that PS prevalence was higher in females should be viewed with caution. A positive aspect is that both our study and the other studies mentioned kept the focus of the results on assessing the number of teeth with PS development.

Although the scientific evidence described in the course of this manuscript has its value, it should be noted that the results presented are taken from prevalence studies, which do not serve to establish causal relationships (BELBASIS; BELLOU, 2018) therefore both sample composition and methodological design can influence the relationship between the variables and the outcome.

The limitations of this study derive from the sample chosen and the method used to diagnose PS. As for the sample, inferences and external validations cannot be made. Regarding the method, although histological tests are defined as the gold standard for PS diagnosis (ALEKSOVA et al., 2013) it is an invasive method and therefore unfeasible. On the other hand, cone beam computed tomography is a very reliable method for detecting PS (TASSOKER; MAGAT; SENER, 2018) but the request for complementary exams to patients, with new exposure to radiation, it was not possible. Finally, the literature supports the use of panoramic radiographs for PS diagnosis (ALSWEED et al., 2019; ERTAS et al., 2017; GUNEN YILMAZ et al., 2019; JENA et al., 2018), as well as periodic examinations during orthodontic treatment (JENA et al., 2018; KORKMAZ; AYDIN; SARIOGLU, 2019) which justifies its use in this research.

Given the above, further studies focused on determining the development of PS in larger samples and in different populations are recommended.

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