Prevalence and distribution of dental anomalies in a paediatric population based on panoramic radiographs analysis

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Abstract

Aim To evaluate the frequency and distribution of dental anomalies (DA) in a paediatric population.

Material and methods Panoramic digital radiographs of children between 6 and 12 years old performed at a reference centre for radiographic exams were accessed. Two calibrated examiners evaluated the radiographs. The association between variables and outcomes was assessed using non-parametric tests. The significance level was set at 5%.

Results Five hundred and twelve individuals were included and 61.3% presented at least one DA. The mean age of patients with DA (9.35±1.60) was significantly higher compared to patients with no anomalies (7.90±1.58). Patients with supernumerary tooth, however, were significantly younger. The most frequent DA were permanent tooth radicular dilacerations (38.1%), permanent tooth agenesis (29.3%), supernumerary tooth (6.4%) and impacted tooth (6.4%). Anterior teeth and female patients were more affected by radicular dilacerations. Dental agenesis was more frequent in the third molars followed by the upper lateral incisor.

Conclusions DA are quite frequent in the paediatric population and the most common DA observed herein could only be identified through imaging exams. The most appropriate timing to perform an investigation for the detection of dental anomalies appears to be between 9 and 10 years old.

KEYWORDS Disturbances in dental development; Growth and development; Radiology.

Introduction

Dental anomalies (DA) involve abnormalities in the number, size and shape of teeth, structural defects or even eruption pattern disruptions [Altug-Atac and Erdem, 2007]. The precise aetiology of DA is complex and not completely understood. Genetic and epigenetic defects throughout the morpho- or histo-differentiation stages of dental development have been considered to be the main aetiological factors. Variations in the dental morphology and structure, for example, typically result from disturbances during embryological development. Nevertheless, environmental factors that occur during the prenatal and postnatal development period can also trigger the development of DA, particularly positional abnormalities or disorders in the eruption chronology [Vani et al., 2016; Laganà et al., 2017]. The identification of DA is important once they can cause disturbances such as malocclusion, increased susceptibility to caries and aesthetic issues [Mukhopadhyay and Mitra, 2014]. Therefore, an opportune identification can minimise complications by allowing early treatment planning, which is usually associated with less extensive interception and more favourable prognosis [Kapdan et al., 2012]. Moreover, DA can involve isolated events or be part of specific syndromes [Bilge et al., 2017; Stevenson et al., 2015]. Therefore, dentists can contribute to the diagnosis of such syndromes by identifying these abnormalities. Anomalous teeth are typically asymptomatic, and identification by clinicians is frequently made via clinical or radiographic examination [Mukhopadhyay and Mitra, 2014]. Among radiographic examinations, the panoramic radiograph represents an important tool since it provides a general view that allows a more comprehensive diagnosis.

Knowledge of DA prevalence, severity (number of affected teeth) and distribution within the dental arch provides essential information for genetic and phylogenetic studies. Previous analyses have demonstrated some discrepancies in the frequency of DA, probably due to inherent variations of each suited population or to the different diagnostic criteria used by researchers [Altug-Atac and Erdem, 2007; Vani et al., 2016; Laganà et al., 2017; Mukhopadhyay and Mitra, 2014; Kapdan et al., 2012; Bilge et al., 2017]. We believe that it is important to include a representative sample with no significant bias, such as only orthodontic patients, to provide a more accurate estimate of the prevalence of DA in the target population. Furthermore, the establishment of rigid criteria is of paramount importance to allow reproducibility and permit to identify the causes of eventual inconsistencies with previous studies. Concerning the targeted population, studies that focus on paediatric patients are highly desired once the early identification of DA in these patients is more likely to have a larger influence on treatment

	Dental anomaly	Criteria
Size	Macrodontia	Tooth that is far larger than its contralateral homolog, "ovelfills" its space in the dental arch or seems bigger because of exaggerated dimensions (conical, shaped or tapered) (Bilge et al., 2017)
	Microdontia	Tooth that is far smaller than its contralateral homolog, does not "fill" its space in the dental arch or seems small because of the lack of expected shape (conical, shaped or tapered) (Bilge et al., 2017)
Number	Dental agenesis	No sign of crown calcification on the radiograph considering the chronological age of dental eruption. The absence of teeth was classified in hypodontia - agenesis of one to six teeth (excluding the third molars), oligodontia - absence of more than six teeth (excluding the third molars); and anodontia - complete absence of teeth (Gracco et al., 2017)
	Supernumerary tooth	Teeth formed in excess of the normal dentition, regardless of whether they were impacted or in occlusion. A supernumerary tooth located between the central incisors was considered a mesiodens (Pedreira et al., 2016)
Shape	Fusion	Union of two dental germs that would normally be separated resulting in a double tooth. The dental count reveals the lack of a tooth when the anomalous tooth is counted as one (Neville et al., 2015)
	Gemination	Duplication of a single dental germ, resulting in the partial or total formation of two teeth that, however, do not separate completely. Tooth counting is normal when the anomalous tooth is considered as one (Neville et al., 2015)
	Concrescence	Union of two adjacent teeth just by the cement without dentin confluence (Neville et al., 2015)
	Root dilaceration	Abnormal angulation or sharp curvature of the dental root(Neville et al., 2015)
	Hypercementosis	Excessive non-neoplastic cement deposition along the root, leading to root thickening (Neville et al., 2015)
	Taurodontism	Elongated crowns and pulp chamber accompanied by a more apical location of the bifurcation area of a multiradicular tooth (Pedreira et al., 2016; Neville et al., 2015)
	Enamel pearl	Well-defined nodules with enamel-like radiopacity along the root surfaces (Neville et al., 2015)
	Supernumerary root	Increased number of roots, compared to what is classically described in the dental anatomy (Neville et al., 2015)
Eruption	Tooth impaction	A tooth which eruption, in normal functional occlusion, was obstructed by other teeth, bone or soft tissues (Pedreira et al., 2016)
	Ankylosis	Loss of the periodontal ligament space accompanied, usually, by presence of infraocclusion (Neville et al., 2015)
Structural	Amelogenesis imperfecta	Hypoplastic type: thin radiopaque layer of enamel with normal radiodensity Hypocalcified type: enamel thickness is normal but radiodensity is less than that of dentin Hypomaturation type: radiodensity of enamel is similar to that of dentin (Mehta et al., 2013)
	Dentinogenesis impertecta	Presence of bulbous crowns, short roots and obliteration of the pulp chambers and root canals (Neville et al., 2015)

TABLE 1 Dental anomalies evaluated and classification criteria used.

strategies and prognosis. Nevertheless, the literature is not clear concerning the most opportune age to identify DA in children. This information may contribute during childcare, suggesting an ideal timing to identify DA in this population.

The aim of the present study was to evaluate the frequency, severity and pattern of DA distribution, through the examination of panoramic digital radiographs, in a paediatric population that attended a reference centre for radiographic examinations in southern Brazil.

Subjects and methods

Study design and sample

This cross-sectional study was conducted on digital panoramic radiographs performed over a 3-year period (2014–2016) at the Radiology Service of the Federal University of Rio Grande do Sul Dental School. Information concerning age and gender was recovered from the service files. The inclusion criteria included patients aged 6–12 years at the time of radiograph. If more than one panoramic radiograph was available for the same child, only the first one was evaluated. Exclusion criteria were: incomplete records (panoramic radiograph, clinical notes), presence of syndromes that affect tooth development, or a history of previous orthodontic treatment.

Data acquisition

All subjects included in the study had panoramic radiographs taken by an experienced technician using standardised methods with the same x-ray device. The radiographs were taken using a CS 8000C (Carestream Health, Inc., Rochester, NY, USA) panoramic radiographic device, with the following parameters: 90 kVp, 15 mA. The image acquisitions were performed with Trophy Dicom (Trophy Radiologie S.A., Marne la Vallée, France) software and stored in a digital database. Two calibrated examiners manually performed the analysis. The calibration consisted of the study of dental anomalies in 30 panoramic radiographs previously selected by an experienced professional in imaging. Both primary and permanent dentitions were considered. All analyses were conducted under standardised lighting conditions, screen brightness and resolution. A third experienced professional subsequently evaluated cases of disagreement. The DA evaluated in this study and the criteria for identification are detailed in Table 1. In addition to DA, deciduous tooth prolonged permanence and deciduous tooth early loss were evaluated considering the chronological age of dental eruption [Alqahtani et al., 2010]. Information on age and gender were recorded from the patients' files.

Statistical analysis

The agreement between observers was assessed by kappa (k) statistics. The inter-examiner agreement was 0.78, which is considered a substantial value [Landis and Koch, 1977]. SPSS for Windows, version 20.0 (IBM, Armonk, NY) was employed for statistical analyses. Data were expressed as mean and standard deviation values for continuous variables and percentages for categorical variables. The association between variables and dichotomised outcomes was assessed using Fisher exact or Mann-Whitney U tests. A logistic regression model was used to evaluate the strength of the association by determining the odds ratio. Both Chi-square and Kruskal-Wallis tests, followed by a post hoc test (Bonferroni correction) when necessary, were used for non-dichotomised outcomes. The significance level was set at 5% ($p < 0.05$).

Results

Sample

A total of 512 panoramic radiographs of children aged 6–12 years were examined, comprising 276 boys (53.9%) and 236 girls (46.1%). The mean age of the sample was 8.79 (±1.7) years.

Dental anomalies distribution

A total of 314 children (61.3%) presented with at least one DA in their deciduous or permanent teeth. The mean age of patients with at least one DA was 9.35 (±1.60) years, significantly higher compared to patients with no anomaly, who presented with a mean age of 7.90 (±1.58) years (p<0.001; Mann-Whitney U test) (Fig. 1A). Among the patients with a DA, 47.1% were girls, and 52.9% were boys. There was no significant difference between patients with and without DA regarding gender (p=0.56; Fischer exact test) (Fig. 1B).

Concerning the type of dentition, the prevalence of dental anomalies in permanent teeth was 60.5%, considerably higher than the prevalence in primary teeth, which was 3.3%. Thirteen patients presented with anomalies in both primary and permanent teeth. There was a significant association between the presence anomalies in both primary and permanent teeth (p=0.21; Fisher's exact test).

Dental anomalies frequency

Table 2 presents the frequency of all dental anomalies evaluated in the present study. No cases of macrodontia, germination, fusion, concrescence, amelogenesis imperfecta or dentinogenesis imperfecta were observed. The most frequent anomalies were permanent tooth radicular dilacerations (38.1%), permanent tooth agenesis (29.3%), supernumerary tooth (6.4%) and impacted tooth (6.4%). Several anomalies, when present, affected more than one tooth (Table 1). Agenesis of permanent tooth affected from one tooth to thirteen teeth, for example, with a mean of affected teeth of 2.77 (±2.00). We also observed that, excluding third molar agenesis, 20 patients presented with only the absence of one tooth, and 26 patients presented with the absence of 2–6 teeth, leading to a hypodontia frequency of 8.9% in the present sample. Regarding the frequency of oligodontia, we observed that 5 patients (0.9%) presented with more than 6 missing teeth. No case of anodontia was observed. Table 3 demonstrates the distribution of genders within each anomaly. We observed that female patients had a significantly higher frequency of permanent tooth radicular dilaceration compared to male patients (p=0.01; Fisher's Exact Test). Girls had a 1.54-fold higher likelihood (95 CI; 1.08–2.21) of presenting this anomaly compared to boys (p=0.01; logistic regression). Although a significant difference was observed concerning the frequency of radicular dilacerations between genders, when this anomaly was present, the number of affected teeth was similar between girls and boys (p=0.72 - Mann-Whitney U Test). All other anomalies were similarly distributed between genders (Table 3).

Distribution of most frequent dental anomalies by age and gender

A total of 304 (59.3%) individuals presented with at least one of the four more common DA: permanent tooth radicular dilacerations, permanent tooth agenesis, supernumerary tooth or impacted tooth. One-hundred and forty-six (48%) patients were female, and 158 patients were male (58%).

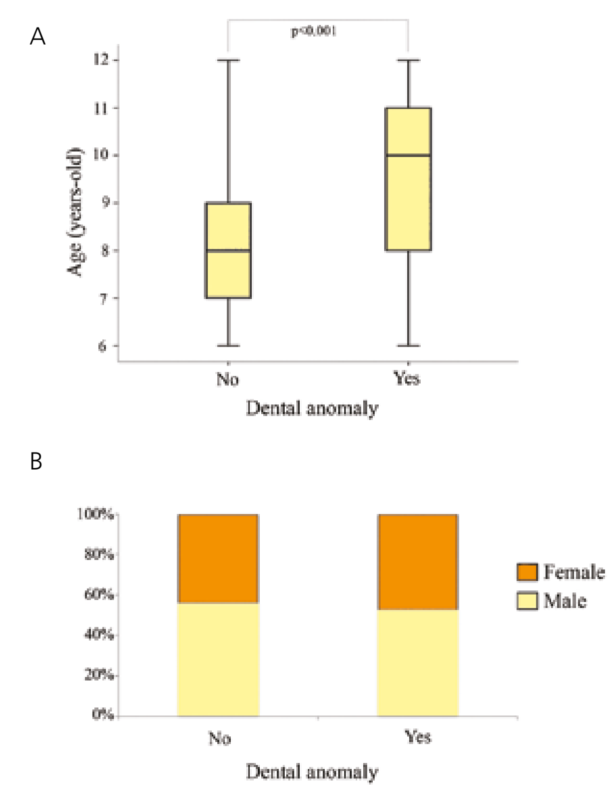


FIG 1 Distribution of dental anomalies.

	Dental Anomaly	Frequency	Number of affected teeth	
			Range	Mean (SD)
Size	Macrodontia	0 (0.0%)	-	-
	Microdontia	3 (0.6%)	1	1 (±0.00)
Number	DT agenesis	3 (0.6%)	1 - 5	2.33 (±2.30)
	PT agenesis*	145 (29.3%)	1 - 13	2.77 (±2.00)
	Supernumerary tooth	19 (3.7%)	1 -2	1.05 (±0.22)
Shape	Fusion	0 (0.0%)	-	-
	Gemination	0 (0.0%)	-	-
	Concrescence	0 (0.0%)	-	-
	DT root dilaceration	2 (0.4%)	1	1 (±0.00)
	PT root dilaceration	195 (38.1%)	1 - 9	2.31 (±1.61)
	Hipercementosis	1 (0.2%)	1	1 (±0.00)
	Taurodontism	5 (1.0%)	1 - 4	2.60 (±1.34)
	Enamel pearl	1 (0.2%)	1	1 (±0.00)
	Supernumerary root	5 (1.0%)	1 - 3	1.60 (±0.89)
Eruption	Impacted tooth	33 (6.4%)	1 - 4	1.45 (±0.71)
	DT ankylosis	12 (2.3%)	1 - 4	1.75 (±0.86)
	PT ankylosis	1 (0.2%)	1	1 (±0.00)
Structural	Amelogenesis imperfecta	-	-	-
	Dentinogenesis imperfecta	-	-	-

*PT – permanent tooth, DT – deciduous tooth, SD – standard deviation - * Third molar agenesis included only for patients above 8 years old*

TABLE 2 Frequency of dental anomalies and number of affected teeth.

	Dental anomaly	Frequency n (%)			Number of affected teeth mean (±SD)		
		Female	Male	p*	Female	Male	p#
Size	Microdontia	0 (0.0%)	3 (100%)	0.25	-	1 (±0.00)	-
Number	DT agenesis	0 (0.0%)	3 (100%)	0.25	-	2.33 (±2.30)	-
	PT agenesis	71 (49%)	74 (51%)	0.23	2.96 (±2.46)	2.58 (±1.85)	0.50
	Supernumerary tooth	11 (57.9%)	8 (42.1%)	0.20	1.00 (±0.00)	1.13 (±0.35)	0.65
Shape	DT radicular dilaceration	1 (50%)	1 (50%)	0.71	1 (±0.00)	1 (±0.00)	-
	PT radicular dilaceration	103 (52.8%)	92 (47.2%)	0.01	2.37 (±1.65)	2.25 (±1.56)	0.72
	Hipercementosis	0 (0.0%)	1 (100%)	0.53	-	1 (±0.00)	-
	Taurodontism	2 (40%)	3 (60%)	0.57	3.00 (±1.41)	2.33 (±1.52)	0.80
	Enamel pearl	1 (100%)	0 (0.0%)	0.46	1 (±0.00)	-	-
	Supernumerary root	2 (40%)	3 (60%)	0.57	1.50 (±0.70)	1.67 (±1.15)	1.00
Eruption	Impacted tooth	12 (36.4%)	21 (53.6%)	0.16	1.67 (±0.98)	1.33 (±0.48)	0.51
	DT ankylosis	8 (66.7%)	4 (33.3%)	0.12	1.50 (±0.53)	2.25 (±1.25)	0.36
	PT ankylosis	1 (100%)	0 (0.0%)	0.46	1 (±0.00)	-	-

*PT – permanent tooth; DT – deciduous tooth; SD – standard deviation; * - Fisher's Exact test; # - Mann-Whitney U test*

TABLE 3 Frequency and number of affected teeth according to gender.

The mean age of patients was 9.37 (±1.59) years, and there was no significant difference between the mean age of boys (9.39±1.6 years) and girls (9.34±1.5 years) (p=0.71; Mann-Whitney U test).

The mean age of patients according to each abnormality is presented in Table 4.

A significant difference was observed for all four DA. Whereas the mean age of patients with radicular dilaceration, dental agenesis and impacted tooth was significantly higher compared with patients that did not present with these anomalies, we observed that patients with supranumerary teeth were significantly younger (p<0.05; Mann-Whitney U test).

Distribution of most frequent dental anomalies in the dental arch

Diagnosis of radicular dilaceration, the most frequent dental anomaly in this study, was obtained when an important root curvature was observed (Fig. 2A). Individually, the lower first molars were the most affected teeth with radicular dilacerations (Fig. 2B). No significant difference was observed between the

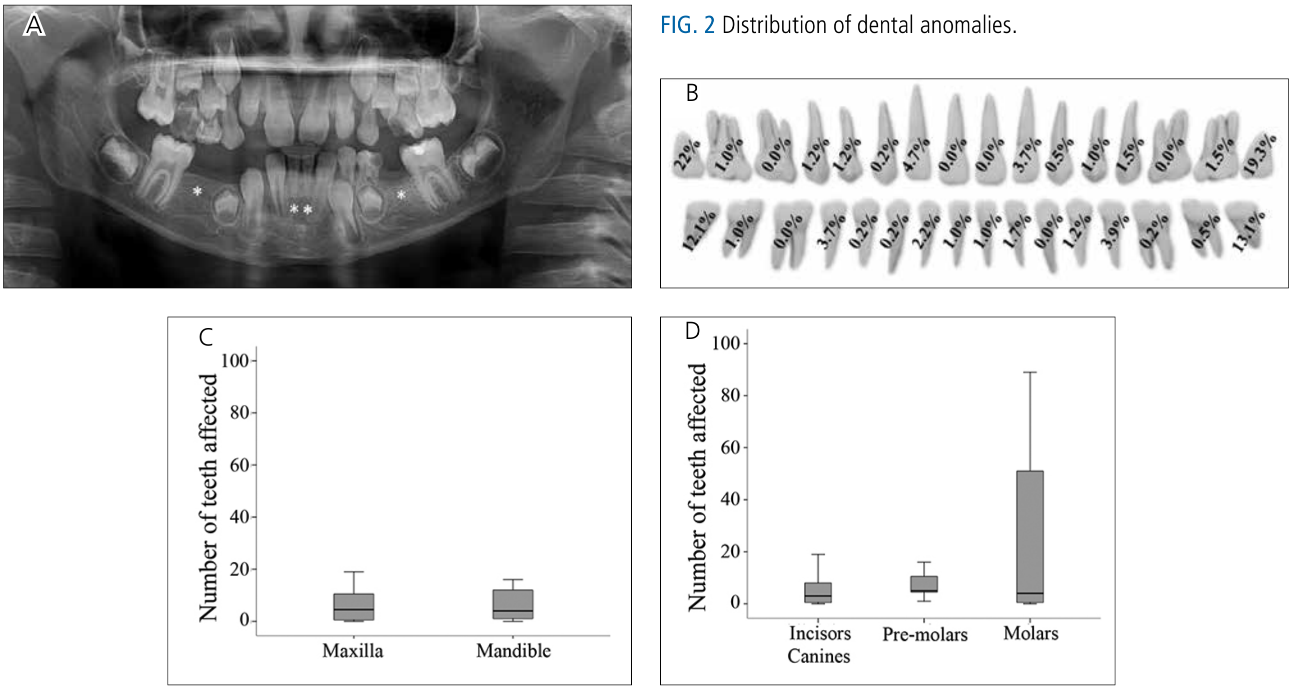


FIG. 2 Distribution of dental anomalies.

Dental anomaly	Age – Mean (±SD)		
	Yes	No	p*
PT agenesis	9.48 (±1.43)	8.52 (±1.78)	<0.001
Supernumerary tooth	7.78 (±1.35)	8.83 (±1.74)	0.01
PT radicular dilaceration	9.55 (±1.55)	8.33 (±1.69)	<0.001
Impacted tooth	9.78 (±1.55)	8.73 (±1.73)	0.001

** Mann-Whitney U test*

TABLE 4 Mean age of patients with the four most common dental anomalies.

frequency of this anomaly in the mandible or maxilla (Fig. 2C). However, we observed that the anterior teeth (incisors and canines) were significantly more affected by this anomaly than premolars (p=0.03; Kruskal-Wallis test; p=0.04; post hoc test) (Fig. 2D).

Dental agenesis was considered in the absence of the permanent tooth or the dental germ, taking into consideration the age of the patient (Fig. 3A). Concerning dental agenesis, the most affected teeth were the third molars, followed by the upper lateral incisor and lower second premolar (Fig. 3B). No significant difference was observed in the frequency of this anomaly within the mandible and maxilla (Fig. 3C) and anterior and posterior teeth (Fig. 3D).

Impacted tooth and supernumerary tooth were the third and fourth most frequent DA. The tooth most commonly impacted was the left central incisor (tooth 21) (21.4%), followed by 11, 12 and 25 (all with the same frequency of 8.9%). Supernumerary teeth were observed in 19 patients. Among these, 12 patients (63.15%) presented with a mesiodens. No supranumerary tooth was observed in the pre-molar or molar area.

Dental eruption disturbances

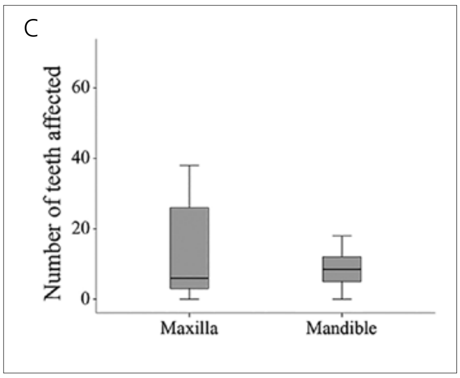
In the present study, the presence of dental eruption disturbance was also evaluated. Within the entire sample, 74 patients (14.5%) presented with early loss of a tooth, and 14 patients (2.7%) presented with primary tooth extended retention. Table 5 presents the frequency and number of affected teeth according to gender. We observed that boys had a significantly higher frequency of teeth early loss compared to girls (p=0.04 - Fisher's exact test). Boys had a 1.58-fold higher chance (95 CI; 0.95–2.64) of presenting with this eruption disturbance compared to girls. The number of affected teeth was similar between genders (p=0.29; Mann-Whitney U test).

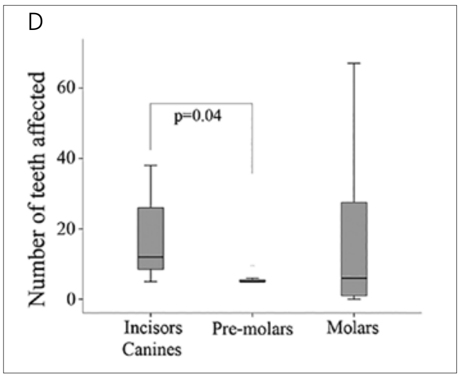
Discussion and conclusion

Abnormalities in tooth size, shape and structure can have significant clinical impact, such as occlusion problems and increased susceptibility to caries and periodontal diseases [Mukhopadhyay and Mitra, 2014]. Moreover, the presence of supernumerary teeth or the absence of a tooth from the normal series can also influence patients' clinical management. The panoramic radiographic examination represents an inexpensive and easy method for identifying some of these anomalies, particularly those that cannot be observed during a physical examination, such as dental agenesis or the presence of supernumerary teeth. As far as we are aware, this is the first study to evaluate the prevalence of DA in both primary and permanent dentition in a large-scale paediatric population from Latin-America with no bias in patients' selection.

Our results demonstrated that more than 60% of evaluated patients presented with at least one DA, revealing an elevated frequency of dental anomalies in this population. The most meaningful result, however, was to observe that the four more common DA observed in this study (radicular dilacerations, tooth agenesis, supernumerary tooth and impacted tooth) cannot be feasibly diagnosed unless an imaging examination is performed. Finally, our results provide insights regarding the most appropriate age to investigate such conditions through panoramic radiography.

FIG. 3 Incidence of dental anomalies.





	Frequency n (%)			Number of affected teeth mean (SD)		
	Female	Male	p*	Female	Male	p#
PT early losses[v]	27 (36.5%)	47 (63.5%)	0.04	2 (±1.14)	1.81 (±1.31)	0.29
DT extended retention	6 (42.9%)	8 (57.1%)	0.51	2.50 (±1.51)	1.13 (±0.35)	0.05

*PT – permanent tooth; DT – deciduous tooth; SD – standard deviation; [v]Causes not evaluated; * - Fisher's Exact test; # - Mann-Whitney U test*

TABLE 5 Frequency and number of affected teeth with eruption disorders.

In recent decades, several studies have been conducted to analyse the frequency of DA in different populations using panoramic radiographs. Discrepancies observed among these studies suggest that inherent variations occur; however, patients' bias selection and differences in the criteria used to establish the presence of DA must be considered. Studies focusing on orthodontic patients have found a frequency of DA from 5.46% [Altug-Atac and Erdem, 2007] to 27.4% [Pedreira et al., 2016], which is expressively lower than the frequency we observed (61.3%). It is possible that patients who seek orthodontic treatment might be more concerned with dental and/or aesthetic problems, and therefore some DA may have been treated at an earlier stage. The more advanced age of patients in both studies supports this possibility (8–14 years old [Altug-Atac and Erdem, 2007] and mean age of 13.34 ± 3.56 years [Pedreira et al., 2016], compared to a mean age of 8.79±1.7 years in the present study). Other studies analysing adult populations with no bias in selection observed a higher frequency of DA, achieving values close to 40% [Vani et al., 2016; Bilge et al., 2017]. A study conducted by Laganà et al., [2017] identified a frequency of DA in a paediatric population (aged 8–12 years) of 20.9%. Despite considering the past history of orthodontics as an exclusion factor, the patient selection site was an orthodontic clinic, which can be considered a bias. Moreover, that study was conducted in Italy, which has a completely different cultural and socioeconomic profile compared to Brazil. Recent data have demonstrated that the percentage of access to oral health in early childhood in the city of Porto Alegre is considerably lower than in other developed countries such as the United Kingdom and Canada [Comassetto et al., 2019]. Thus, it is likely that children in Italy will have access to dental care at an earlier age compared to Brazil, which might explain the discrepancies. Moreover, the centre of radiology where we conducted patients' selection mainly receives children under conventional dental treatment and not only candidates for orthodontic treatment.

An important aspect form the present study is that root dilaceration was included as a DA, which, beyond the other reasons mentioned above, certainly contributed to the elevated frequency of DA we observed. The criteria adopted for diagnosing root dilacerations herein were abnormal angulation or sharp curvature of the dental root [Neville et al., 2015]. We decided to include root dilacerations as a DA mainly because it has clinical impact, such as hampering instrumental introduction during endodontic treatment or increased risk of root fraction during exodontia [Miloglu et al., 2010].

The results from the present study showed no difference between the prevalence of DA among genders, corroborating with some studies [Altug-Atac and Erdem, 2007; Vani et al., 2016; Laganà et al., 2017]. Other groups, however, have observed a higher prevalence of DA in general in female patients [Bilge et al., 2017; Shokri et al., 2014]. An interesting result from the analysis of isolated radicular dilaceration was the significantly higher prevalence of this anomaly in girls. To our knowledge, this is the first time this result has been described in the literature. During childhood, the differences in hormones between genders is not particularly high; hence, a possible hormonal cause for this finding is unlikely. A previous study also identified that changes in sex hormone concentrations during development are not related to different patterns of sexual dimorphism among permanent teeth [Guatelli-Steinberg et al., 2008]. In permanent anterior teeth, root dilaceration is typically a consequence of an indirect trauma to the primary predecessors [Luder, 2015]. Hence, one could expect to observe a higher frequency of this DA in boys, who are significantly more active than girls during childhood [Telford et al., 2016] and thus more prone to traumas; why girls had significantly more root dilacerations remains unclear. Our hypothesis is that other genetic factors associated with gender might play a role in this matter; however, further studies are required to elucidate this issue.

Concerning the age at diagnosis, a remarkable finding was that supernumerary teeth were diagnosed in younger patients, in contrast to all other more prevalent anomalies, which were more common in older children. In most situations, we observed that supernumerary teeth were located between superior incisors (diagnosed as mesiodens). Considering the chronological age of dental eruption, the central upper incisor regularly erupts between the ages of seven and eight years [Alqahtani et al., 2010]. The presence of a mesiodens usually delays the eruption of teeth, which is easily noticed by the child and relatives due to the anterior location [Meighani and Pakdaman, 2010]. Therefore, it is possible to suppose that older children that had this anomaly sought treatment at a younger age when the delay was identified. This might elucidate the lower prevalence of supernumerary teeth in children with more advanced age.

In the present study, we established a criterion for the radiographic diagnosis of each DA (Table 1). This approach allows a better reproducibility of our methods besides offering possible reasons for divergences observed in other studies using different criteria. The more rigid the criterion, the easier its reproduction. In the context of DA, some criteria are more objective and inflexible, such as the absence of teeth germ for dental agenesis. Nevertheless, the diagnosis of some DA, such as root dilaceration and microdontia, are subjected to the examiner's interpretation even in the presence of established criteria. We recognise this as a limitation of this and other studies evaluating DA. However, to overcome this issue, the examiners were previously calibrated and achieved a good inter-examiner agreement. Another important aspect is that the frequency of DA was only evaluated based on panoramic radiographs. Although some anomalies are seen exclusively in imaging exams, others might be better observed in a physical intra-oral examination. For example, no cases of amelogenesis imperfecta or dentinogenisis imperfecta were observed in the present study. These conditions are relatively rare, with the higher prevalence rates reported being 1:700 and 1:6.000, respectively [Barron et al., 2008; Crawford et al., 2007]. It is not clear whether the lack of these DA in the present study is due to a real absence or to the limitations of the panoramic radiograph used to evaluate these conditions. The quality of the panoramic examination can also have a significant impact on the diagnostic capacity. In the present study, we used digital panoramic radiographs. The advantages of digital radiographs go beyond the possibility of enhancing images to achieve a more accurate diagnosis. This method enables less radiation dose exposure and is associated with less environmental contamination compared to conventional films [Sabarudin and Tiau, 2013; Takeshita et al., 2014]. Herein, we excluded patients who had a previous history of orthodontic treatment, which might have contributed to decreasing the selection bias; however, we could not access information concerning other dental treatments. Thus, this issue needs to be pointed out as an additional limitation of this study.

The decision to include third molar agenesis as a DA in the present study had a major impact on the total prevalence of DA in the sample. Third molar agenesis represents a rather typical condition, and some authors suggest that this event should not be considered an anomaly [Gomes et al., 2010]. We decided to include this event during our investigation and perform two different analyses: including and excluding this condition. Yet, we support that it is relevant to evaluate third molar agenesis in paediatric patients. In clinical practice, knowledge of the existence of a third molar germ can, for example, impact on the decision to extract a first permanent molar (FPM). The FPM is the most caries-prone permanent tooth in young children, and in a significant proportion of cases, this tooth is indicated for enforced extraction [Teo et al., 2016]. The guidelines of the Clinical Governance Directorate of the British Orthodontic Society concerning the extraction of FPM in children supports the importance of evaluating the presence of the third molar that can eventually provide suitable replacement along with the second molar [Cobourne et al., 2014]. If the third molar is present radiographically, the extraction may be performed when necessary [Cobourne et al., 2014].

Continuing with the discussion concerning the clinical relevance of our findings, the earlier identification of some DA can provide more conservative interceptions associated with better prognosis [Kapdan et al., 2012], as already mentioned for third molar agenesis. This circumstance also involves other anomalies such as agenesis of other teeth, supernumerary tooth and impacted tooth, which represent some of the most common DA identified in our study. A particularly important aspect concerning these anomalies is that, besides having significant clinical relevance, they can only be diagnosed through imagining examinations. The early identification of other DA, such as radicular dilacerations, might not bring significant benefits to the patient. The main implications of root dilacerations are related to endodontic treatment or exodontia [Miloglu et al., 2010], and both techniques need to be preceded by a periapical radiograph that could identify the dilaceration.

In conclusion, the prevalence of DA in the present paediatric cohort was considered to be particularly high. The most common DA (root dilacerations, dental agenesis, supernumerary tooth and impacted tooth) can only be detected in imaging examinations, evidencing the importance of panoramic radiographs to diagnose these conditions. The majority of patients diagnosed with DA in the present study were 9–10 years of age. We believe that around this age a child might benefit from a panoramic investigation, since the most common anomalies can be identified and, as an advantage, the status of third molar agenesis can also be assessed.

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