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Study of anatomical variations in premolars by cone beam computerized tomography in a radiologic clinic in Piauí

Estudo de variações anatômicas em pré-molares por tomografia computadoriza de cone beam em uma clínica radiológica no Piauí

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Abstract
Introduction: *Root canal cleaning is the main objective of endodontic treatment and requires knowledge of the internal anatomy. The premolars are evidenced in the literature with great anatomical variations. In view of this, studies indicate that the use of Cone Beam Computed Tomography helps in the visualization of highly complex anatomy.* ***Objective:*** *to describe the anatomical variations in maxillary and mandibular premolars using cone beam computed tomography in a radiologic clinic in Piaui.* ***Methods:*** *54 cone beam computed tomography scans with 160 premolars were used, produced using the Orthopantomograph OP300 equipment and analyzed by multiplanar reconstructions: axial, coronal and sagittal. Data regarding sex, number of roots and canals were recorded to compare and classify according to Vertucci.* ***Results:*** *the maxillary first pre-molars had 63.5% two roots,83.7% with one root and the mandibular pre-molars mostly with one root. Regarding the number of channels, 92.3% of the first premolars had two channels, most of them maxillary second premolars and mandibular premolars only one channel. Vertucci variations of types I, II, III and IV were verified in single-rooted elements, observing a great variation in superior elements. As for the prevalence of sex, only the first superiors showed greater variation in males.* ***Conclusions:*** *the upper first premolars prevailed with a great anatomical variation in relation to the other premolars with prevalence of Vertucci Type I and in males.*
Keywords: *premolar tooth; computed tomography; endodontics.*

Resumo
Introdução: a limpeza do canal radicular é o principal objetivo do tratamento endodôntico e requer conhecimento da anatomia interna. Os pré-molares são evidenciados na literatura com grandes variações anatômicas. Diante disso, estudos indicam que o uso da Tomografia Computadorizada Cone Beam auxilia na visualização de anatomias de alta complexidade. **Metodologia:** foram utilizadas 54 tomografias computadorizadas de feixe cônico com 160 pré-molares, produzidas no equipamento Orthopantomograph OP300 e analisadas por reconstruções multiplanares: axial, coronal e sagital. Os dados referentes ao sexo, número de raízes e canais foram registrados para comparação e classificação segundo Vertucci. **Resultados:** os primeiros pré-molares superiores apresentavam 63,5% de duas raízes, 83,7% dos segundos pré-molares superiores tinham uma raiz e a maioria dos pré-molares inferiores tinha uma raiz. Em relação ao número de canais, 92,3% dos primeiros pré-molares possuíam dois canais, sendo a maioria segundos pré-molares superiores e pré-molares inferiores apenas um canal. Vertucci variações dos tipos I, II, III e IV foram verificadas nos elementos uniradiculares, observando-se a grande variação nos elementos superiores. Quanto à prevalência do sexo, apenas os primeiros superiores apresentaram maior variação no sexo masculino. **Conclusão:** os primeiros pré-molares superiores prevaleceram com grande variação anatômica em relação aos demais pré-molares com prevalência de Vertucci Tipo I e no sexo masculino.
Palavras-chaves: dente pré-molar; tomografia computadorizada; endodontia.

INTRODUCTION

The objective of endodontic treatment is to obtain complete removal of pulp tissue or debris to achieve adequate disinfection of the root canal system and to perform a three-dimensional obturation within the root canal using a biocompatible material[1,2]. Ignorance of morphological and anatomical variations may result in failure to identify all root canals or may result in inadequate instrumentation, leading to endodontic treatment failure [3,4].

Among the group of dental elements, the premolars present a diverse anatomical variation, mainly in relation to the number of roots and canals. Lower premolars may have one to three roots and a diverse anatomical configuration of canals[5]. According to Vertucci et al.[6] (1984), the lower second premolar has only a single root canal at the apex in 97.5% of the teeth studied, two canals in only 2.5%, and three canals with a lower prevalence[6].

The anatomical structure of maxillary premolars is also complex, including bifurcated roots, large variations

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in root morphology, and multiple canals, thus increasing the difficulties faced by the endodontist[7]. As for channel morphology, Vertucci et al.[6] (1984) reported in their studies that 75% of the maxillary second premolars studied had a single foramen, 24% had two foramina and 1% had three foramina[6].

Vertucci in 1984 observed in his studies an anatomical complexity in general in the dental elements, so to facilitate the study and understanding of these anatomical systems he developed a classification that took into account the relationship of the number of canals in relation to a root. This classification helped in the mastery of these canals, positively impacting endodontic treatments. Using this scientific support, this classification continues to be the most used until today for studies of anatomical variations, being able to classify this relationship into 8 types: root and canal[6,7].

For a long time, two-dimensional radiographs were used to evaluate internal anatomical variations, but with the limitation of image superposition. With this, dental imaging developed Cone Beam Computed Tomography (CBCT) as an evolution of conventional computed tomography focused on the maxillofacial region. Its images are presented in three-dimensional shapes, making it useful in endodontic practice to assess the internal composition of the dental element[1].

In this way, CBCT favors the study of anatomy in vivo by providing details of teeth and adjacent structures with a three-dimensional view. This technology uses isotopic voxels from three planes of space with precise linear geometry and measurements of the images obtained. Thus, it details the root morphology without distortion or overlap, allowing a faithful reproduction of the anatomy and morphology of the dental elements and facilitating the diagnosis in endodontics[8-10].

Thus, the present study aims to describe the anatomical variations in maxillary and mandibular premolars using cone beam computed tomography in a radiologic clinic in Piauí.

METHODOLOGY

This study followed the ethical protocols that ensure compliance with Res. 466/2012 (CNS/MS): patient identification was not attached to the images submitted for analysis, so the data collection instrument did not identify the participant. Being reviewed and approved by the Research Ethics Committee of UNINOVAFAPI of the National Health Council with opinion 4,664,674. This research is characterized as field, quantitative and cross-sectional carried out on the basis of Cone-Beam Computed Tomography files of a radiological clinic in Teresina, Piauí (Brazil) with patients from January to December 2020. The exams were performed using the Orthopantomograph equipment. OP300 from Instrumentarium Dental (Foxel – 61x41mm; Voxel – 85x330um).

66 CBCTs who had at least one premolar in the upper and/or lower arches of male and female patients with no age restriction were included in the study. Twelve CBCTs were excluded because they showed signs of neoplasms, cysts, or other lesions that influenced the identification of anatomical characteristics of premolars, altering the visualization of structures of interest; premolars with evidence of endodontic treatment, prosthetic restorations with intra articular retainers, with incomplete root formation, root resorptions, and calcification of root canals; or they were of poor quality to identify roots and configuration of the premolar root canal system. Thus, totaling 54 analyzed and tabulated CT scans.

The analysis of image scans was performed using the OnDemand 3D software based on a module that allows data storage in DICOM that allows multiplanar reconstructions: axial, coronal, and sagittal, easily accessed on computers. For this stage, two researchers previously trained and calibrated to use the software with an inter-examiner agreement of at least 0.8, according to the Kappa index.

Data were tabulated in relation to: sex; the number of roots; channels; and Vertucci classification (Table 1) in upper right first premolar (14), upper right second premolar (15), upper left first premolar (24), upper left second premolar (25), right lower first premolar (44), right lower second premolar (45), left lower first premolar (34), left lower second premolar (35) in Excel spreadsheet.

Table 1 – *Vertucci classification (1984).*

TYPE	DESCRIPTION
I	*A single channel extends from the pulp chamber to the apical region*
II	*Two separate canals leave the pulp chamber and unite before reaching the apex to form a canal*
III	*One canal exits the pulp chamber, splits in two inside the root, and then merges to exit as a canal.*
IV	*Two separate and distinct canals extend from the pulp chamber to the apex*
V	*One canal leaves the pulp chamber and divides before the apex into two separate and distinct canals with separate apical foramina*
VI	*Two separate canals leave the pulp chamber, merge into the root body, and redivide before the apex to exit as two separate canals.*
VII	*One canal leaves the pulp chamber, splits and then joins within the root body and redivides into two distinct canals before the apex*
VIII	*Three separate and distinct canals extend from the pulp chamber to the apex*

Source: Authors, 2023.

For data analysis, the SPSS statistical package, version 26, was used to tabulate the data and perform descriptive statistics with frequencies and percentages in order to describe the collected data. In addition to chi-square tests to verify the distribution of cases, accompanied by the level of significance ($p < 0.05$).

RESULTS

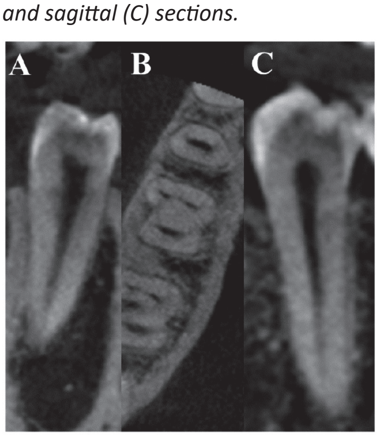
Of the 54 CBCTs, 25 were male and 29 were female. During the analysis, 164 premolars were observed, consisting of 101 maxillary and 63 mandibular premolars. The frequency, followed by the percentage represented in the premolar teeth can be seen in Table 2 regarding the number of roots, canals and the Vertucci Classification.

Table 2 – *Frequency and percentage in premolars.*

Anatomical Variations		Teeth *n*(%)			
		Superior		Inferior	
		1st premolars	2nd premolars	1st premolars	2nd premolars
Roots	1	19 (36,5%)	41 (83,7%)	31 (96,9%)	31 (100%)
	2	33 (63,5%)	8 (16,3%)	1 (3,1%)	0
Chi-square (*p*)		***0,05****	***0,01****	***0,01****	--
Canals	1	4 (7,7%)	29 (59,2%)	30 (93,8%)	31 (100%)
	2	48 (92,3%)	20 (40,8%)	2 (6,2%)	0
Chi-square (*p*)		***0,01****	0,19	***0,01****	--
Vertucci Single Root	Type I	4 (21,1%)	29 (70,7%)	30 (96,8%)	31 (100%)
	Type II	12 (63,2%)	7 (17,1%)	0	0
	Type III	1 (5,3%)	0	1 (3,2%)	0
	Type IV	2 (10,5%)	5 (12,2%)	0	0
Chi-square (*p*)		***0,01****	***0,01****	***0,01****	--
Vertucci Vestibular Root	Type I	33 (100%)	8 (100%)	1 (100%)	0
	Type II	0	0	0	0
	Type III	0	0	0	0
	Type IV	0	0	0	0
Chi-square (*p*)		--	--	--	--
Vertucci Lingual Root	Type I	0	0	1 (100%)	0
	Type II	0	0	0	0
	Type III	0	0	0	0
	Type IV	0	0	0	0
Chi-square (*p*)		--	--	--	--
Vertucci Palatine Root	Type I	33 (100%)	8 (100%)	0	0
	Type II	0	0	0	0
	Type III	0	0	0	0
	Type IV	0	0	0	0
Chi-square (*p*)		--	--	--	--

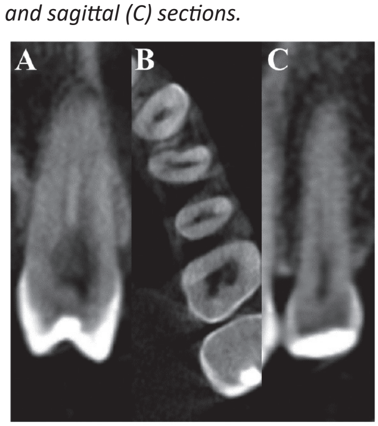
Source: Research Data, 2023.

Figure 1 – *Vertucci classification: Type I in coronal (A), axial (B) and sagittal (C) sections.*



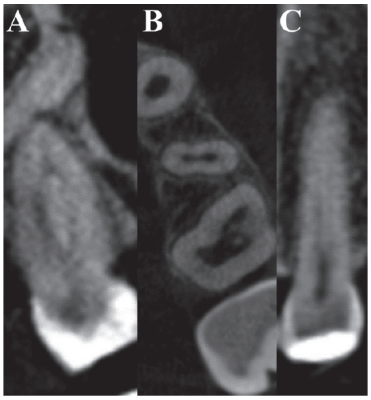
Source: Research Data, 2023.

Figure 2 – *Vertucci classification: Type II in coronal (A), axial (B) and sagittal (C) sections.*



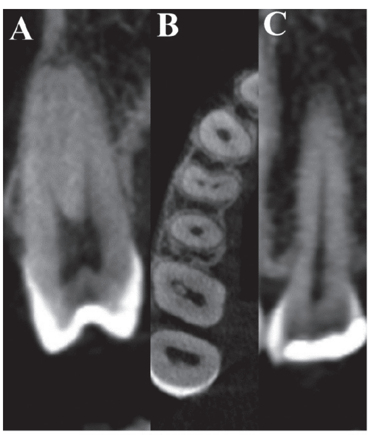
Source: Research Data, 2023.

Figure 3 – *Vertucci classification: Type III in coronal (A), axial (B) and sagittal (C) sections.*



Source: Research Data, 2023.

Figure 4 – *Vertucci classification: Type IV in coronal (A), axial (B) and sagittal (C) sections.*



Source: Research Data, 2023.

It is noteworthy that all these results were accompanied by the level of statistical significance of the chi-square test, safeguarding the character of a non-random distribution. In order to complement the analyses, frequencies of distribution of the numbers of roots were carried out in terms of sex and premolar arches, highlighting the specificity of each tooth (14, 15, 24, 25, 44, 45, 34, and 35), the results are visualized in Table 3, below.

Table 3 – *Variations regarding sex and premolar arches.*

Teeth	Roots	Sex		Dental Arch	
		Masculine	Feminine	Superior	Inferior
tooth14	1	2	8	10	0
	2	8	6	14	0
Chi-square (*p*)		***p = 0,05****		--	
Tooth15	1	7	13	20	0
	2	1	3	4	0
Chi-square (*p*)		*p = 0,69*		--	
Tooth24	1	2	7	9	0
	2	11	8	19	0
Chi-square (*p*)		***p = 0,05****		--	
Tooth25	1	7	14	21	0
	2	3	1	4	0
Chi-square (*p*)		*p = 0,12*		--	
Tooth44	1	5	9	0	14
	2	0	0	--	--
Chi-square (*p*)		--		--	
Tooth45	1	6	8	0	14
	2	--	--	--	--
Chi-square (*p*)		--		--	
Tooth34	1	8	9	0	17
	2	1	0	0	1
Chi-square (*p*)		*p = 0,30*		*p = 0,65*	
Tooth35	1	9	8	--	17
	2	0	0	--	--
Chi-square (*p*)		--		--	

Source: Research Data, 2023.

DISCUSSION

There are several methods for the knowledge of dental anatomy such as root staining, insertion of plastic resins in the canals, scanning microscopy, radiographs use of tomography and microtomography. Given these options, the use of tomography has obtained satisfactory results due to high resolution volumetric records, better manipulation, easy access and lower radiation doses[9].

The results obtained in this investigation provide fundamental anatomical knowledge for the success of endodontic therapies, because the more complex the internal configuration of the roots of these dental elements, the greater the probability of errors during the performance of these therapies[11,12].

The results are in agreement with the study conducted by Burklein et al.[13] (2017) with 62.4% of 644 maxillary first premolars with 2 roots and the second with 82.6% with 1 root13. As in the anatomical evaluation of maxillary premolars by Li et al. (2018) 87.5% of the first with 2 channels and the second with a variation of 50.3% with one channel[12].

On the other hand, the lower premolars had almost a totality with only one root and single canals, and these conclusions can be observed in the study by Corbella et al.[1] (2019) with 90% of mandibular premolars with 1 root3 and Alfawaz et al.[14] (2019) with a large single root rate[14]. Although in this research only 01 lower premolar showed variation in the number of roots, the literature shows a significant percentage of two roots due to flattening in the root formation process [1,9,13].

In addition to the number of roots and channels, studies involving this anatomical analysis approach classify the relationship of channels present in a root according to Vertucci[6] (1984). The present study generally showed that the premolars have a Type I configuration, in addition, this investigation observed Type II, III, and IV configurations, mainly in the single-rooted maxillary first premolars. This is justified by the appearance of these variations in the development of single roots that produce more *flattening, resulting in connections between the canals[11, 12]. The results obtained in this study on the prevalence of the Type I configuration are given by the large proportion relationship between roots and canals showing agreement with individual studies with these elements [12,14].*

In this investigation, we considered the critical analysis in relation to the classification method by Vertucci[6] (1984) as it considers only the main channels. Although the complexity of the canal system is already proven in terms of anatomical findings, it is necessary to create more subtypes considering the particularities of these systems. Since the CBCT images from in vivo studies present in the literature provide the possibility to visualize these anatomical details in greater detail[13,16].

Finally, maxillary first premolars obtained statistically significant results with two roots in males. There is an agreement with two studies that show high rates of anatomical variations in male patients but without a clear relationship with sex[13,17]. Although most studies state that there is no statistical correlation and a consensus in the literature because this information depends more on the number of patients involved in each sex[15,18]. Obtaining that the other premolars in this study presented similar results regarding the variation by sex.

CONCLUSION

It is concluded that in the year 2020 in the radiological clinic data, only the maxillary first premolars were observed mostly with two roots or two canals, the others with only one root or canal. Evidencing a great anatomical variation in the upper arch. Regarding the Vertucci Classification, most roots presented a Type I configuration, followed by Type II, Type III, and IV. It is evident that the last three are more common in single-rooted maxillary premolars. In addition, only the maxillary first premolars showed greater variations between one and two roots per male. And the other elements, most with only one root between both sexes.

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