ENDODONTIC CONFIGURATION OF MANDIBULAR PREMOLARS: A CONE-BEAM COMPUTED TOMOGRAPHY STUDY

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ABSTRACT

Aim. The aim of this study was to assess the endodontic morphology of mandibular bicuspids in a Romanian population, by means of cone-beam computed tomography (CBCT). **Material and method**. 507 mandibular premolars were analysed on CBCT scans. We observed: number of roots and prevalence of C-shaped configurations, number and configuration of root canals, position of the bifurcation. **Results**. For first premolars, Vertucci I (1-1) was the most frequent configuration 66%; 32.8% had 2 canals and 1.2% presented 3 canals; C-shaped first premolars was found in 12.8% of the cases. For second premolars, Vertucci I was prevalent, in 94.55%, two canals were in 5.06% and 3 canals in 0.39% of the cases; C-shaped in 3.11%. The average bifurcation depth was 12.88 mm. **Conclusions.** Our study found that mandibular premolars are mainly single-rooted and most of the cases present Vertucci type I canal morphology. The finding of variations in this study was not low, compared with other studies. Knowledge and understanding of root canal morphology is paramount for a successful endodontic treatment.

Keywords: mandibular premolars, endodontic anatomy, C-shaped, prevalence, CBCT

Introduction

The success of endodontic treatment depends on its ability to address the entire endodontic system [1]. Endodontic anatomy is extremely complex, in addition to the usual configurations, there are multiple variants, but also anatomical structures secondary to the pulp chamber and root canals, of small dimensions, such as lateral canals or isthmuses [2]. Failure to identify and treat a main canal during endodontic treatment is one of the causes of endodontic treatment failure and post-treatment apical pathology such as apical periodontitis [3].

Mandibular premolars usually have a single root and a single canal, wider, oval in two-thirds or in the coronal half; towards the apical third this canal becomes round in horizontal section and of a suddenly smaller diameter [4]. These teeth can also have two canals, either in a single root, or in two roots or even three canals [5]. The endodontic anatomy of these teeth varies with gender and ethnicity [6]. To locate all the canals of a tooth, knowledge of the usual anatomy is essential, as well as any anatomical variations, no matter how rare they may be [7].

Unfortunately, common imaging methods, such as preoperative periapical radiography, do not always reveal complex endodontic anatomy, as they are 2D [8]. Of course, there are also situations when the radiograph indirectly shows that there are multiple canals in a lower premolar.Thus, the sudden disappearance of the radiolucency specific to the root canal somewhere in the middle third of the root could be a sign of a bifurcation or even trifurcation of the root or root canal [9,10].

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CBCT is the imaging tool of choice to understand and visualize complex endodontic anatomy, being a 3D rendering [11]. Thus, in addition to the number of canals, we also have information regarding the level where the root canal bifurcates, but also the angle of emergence of the lingual canal. Depending on these aspects, we will decide on the treatment plan and how much it is necessary to remove the root dentin and at which level, to remain minimally invasive. This aspect is vital for the subsequent resistance of the tooth to mechanical forces. Another essential aspect that CBCT highlights is the C-shaped aspect of the root; this feature is completely omitted on a periapical radiograph, as it is only highlighted on the axial, horizontal section of the CBCT [12]. Why is this anatomical detail important after all? Because, in this case, the 2 or 3 canals are no longer symmetrically located, but slightly off centric and, as a result, their identification is much more difficult, especially if their bifurcation occurs deep apically. Equally important, this C-shaped anatomical feature presents thin walls towards the concave part of the root and any invasive search for the canals can lead to either dangerous thinning of the root walls or even perforations. There is a reduced root thickness in relation to the mesial invagination, 0.8-0.3 mm, as opposed to root thickness of teeth without mesial invagination, 1.09-1.85 mm [13,14]. This C-shape is in the middle third of the root, rather than the cervical or apical [15]. Although this type of configuration is more commonly found in mandibular molars, it has also been observed in maxillary molars, but especially in mandibular premolars [16,17].

The aim of this study was to establish the endodontic anatomy of the lower premolars using CBCT scans from patients who visited two dental offices in Romania.

Material and method

CBCT scans of 253 patients (93 male and 160 female patients, mean age 44, age range 18-88) were retrieved from two dental private offices in Romania databases over a period of 3 years (2020-2023). The scans were recommended for diagnosis purposes and treatment planning. The CBCT images were acquired with Veraviewepocs 3D P (R100) equipment (J. Morita MFG Corp., Kyoto, Japan). The scan parameters were 90 kV, 5 mA, 9.4 s exposure time, 125 μm spatial resolution and 40×40 mm field of view (FoV). All CBCT exposures were performed with the minimum exposure necessary for adequate image quality.

The selection of CBCT scan followed as inclusion criteria the good quality of radiographic images of mandibular premolars, with fully developed roots and closed apices. There were excluded the cases with insufficient field of view, bone abnormalities, root resected teeth. After applying these criteria, there were a total of 507 CBCT analysed teeth.

CBCT scans were viewed with the software provided with the CBCT unit. The images were analysed on a 27 inches Dell LCD screen with a resolution of 2560 × 1440 pixels in a darkroom. We adjusted the brightness and contrast of the images using the image processing device in the software to ensure optimal image. The CBCT imaging assessment methodology involved orienting the long axis of the tooth under examination with the reference lines within the visualization software, followed by an anatomical interpretation performed across the coronal, sagittal and axial planes. The CBCT scans were analysed twice by an experienced with a 1-month interval in-between.

We collected the following information: number of roots, number of root canals, C-shaped configuration (in the presence of a radicular groove along the root) (Figure 1), root canal bifurcation level, level and

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location of the radicular groove, Vertucci type [18].

For data analysis we used Microsoft Excel and MedCalc Software Ltd. 23.0.2.

Results

There were 507 scanned mandibular premolars, 250 first premolars (FP) and 257 second premolars (SP).

For FP, Vertucci I was the most frequent configuration 66%, followed by V, 26%. C-shaped FP was found in 12.8% of the cases.

For SP, Vertucci I was prevalent, in 94.55%, followed by V, 4.67%; C-shaped in 3.11%.

Males were significantly associated with C-shaped condition and non-single root canal configuration in FP ($p<0.05$).

12.88 mm (8-18 mm) was the mean bifurcation depth for mandibular premolars.

No significant differences were found regarding the presence of radicular grooves; they were observed in the middle third (53.12% for FP and 50% for SP) and apical third of the root (46.87% in FP and 50% in SP). Most of these grooves were located on the mesiolingual surface of the root (87.5% for FP and 50% for SP), and on the lingual surface (12.5% for FP and 50% for SP).

The detailed results are displayed in tables 1-5.

		n	%
Gender	female	159	63.60
	male	91	36.40
Roots	1	216	86.40
	2	2	0.80
	C	32	12.80
Canals	1	165	66.00
	2	82	32.80
	3	3	1.20
Vertucci	I	165	66.0
	II	7	2.80
	III	3	1.20
	IV	5	2.00
	V	65	26.0
	VII	1	0.40
Non Vertucci		4	1.60

Table 1. Sample characteristics first mandibular premolar

		C	non-C	p	
Gender	Female	15	144	0.0356	
	Male	17	74		
	Category	Reference	OR	CI	p
C	Male	Female	2.2054	1.0430-4.6632	0.0384
Canals >1	Male	Female	2.4955	1.4515-4.2906	0.0009

Table 2. Statistical associations First mandibular premolar

		n	%

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Gender	female	160	62.26
	male	97	37.74
Roots	1	249	96.89
	2	0	0.00
	C	8	3.11
Canals	1	243	94.55
	2	13	5.06
	3	1	0.39
Vertucci	I	243	94.55
	II	1	0.39
	V	12	4.67
Non Vertucci		1	0.39

Table 3. Sample characteristics second mandibular premolar

		C	non-C	p	
Gender	Female	3	157	0.143	
	Male	5	92		
	Category	Reference	OR	CI	p
C	Male	Female	2.8442	0.6643-12.1778	0.1589
Canals >1	Male	Female	1.70	0.5776-5.0036	0.3353

Table 4. Statistical associations second mandibular premolar

	Category	Reference	OR	CI	P
	FP	SP			
C	32	8	4.5688	2.0615-10.1255	0.0002
non-C	218	249			
> 1 canal	85	14	8.9416	4.9126-16.2747	<0.0001
1 canal	165	243			

Table 5. Comparative results FP versus SP

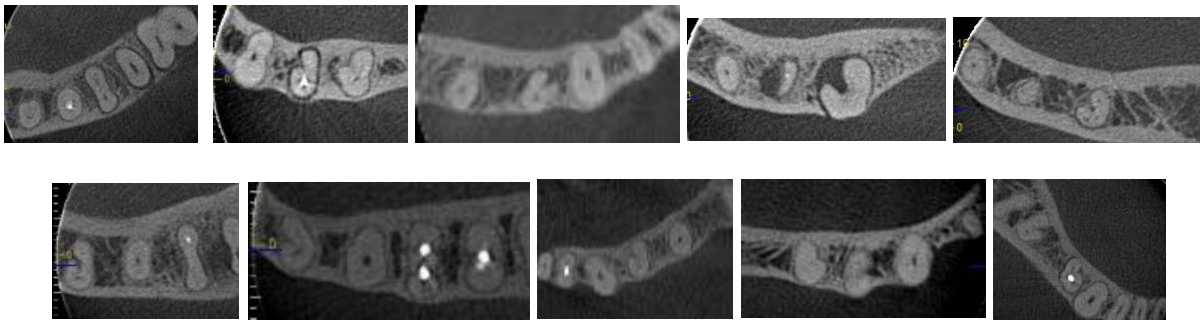

Figure 1. Axial view of different C-shaped mandibular premolars

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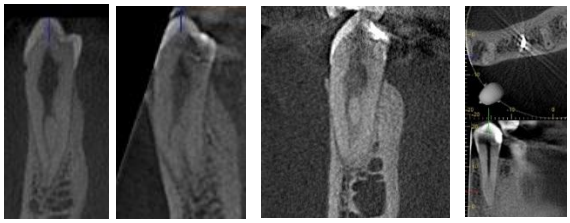

Figure 2. Vertucci Class II, V, VII and three canals (Non-Vertucci)

Figure 3. Bifurcation level

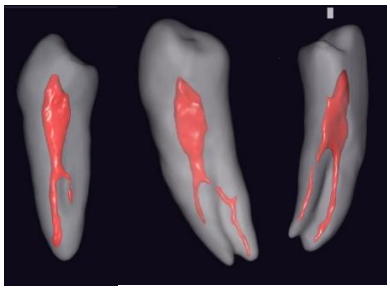

Figure 4. 3D Standard Tessellation Language (STL) segmentation generated by the Diagnocat software (LLC Diagnocat, USA), showing angle of bifurcation of lingual canal and the radicular groove of mandibular premolars included in our study

Discussion

Our study was based on the examination of CBCT. This is clinically used in preoperative anatomical evaluation and faithfully reproduces endodontic anatomy [19]. In vivo CBCT studies enable higher sample sizes and have the major advantage of accurately identifying the tooth type, compared to studies performed on extracted teeth. In addition, it allows the inclusion of important variables for morphological studies, such as age, gender and ethnicity, all of which are parameters that can be associated with endodontic anatomical variability. In studies on extracted teeth, there is uncertainty in identifying the type of premolar [20,21]. Micro CT, although it reproduces very fine details, is not clinically available, and on the other hand it is also expensive for studies on large groups of teeth [22].

Our research had balanced sample size for each premolar studied group. Morphological diversity is a common feature of these teeth, but the frequency with which these anatomical variations occur is considerably different. Most of FP had 1 root canal, 66%, but the prevalence of 32.8% for the 2-canal variant is not small at all and is necessary to keep this aspect in mind when such a tooth needs to be treated endodontically. The prevalence of C-shaped (Figure 1) was 12.8%, a higher

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value compared to other similar studies, as we will show later. Special attention should also be paid to Vertucci type V (Figure 2), which represents a bifurcation of the canal and the most difficult class to manage endodontically. The second premolar more frequently presents only 1 canal, 94.55%, the other variations being less common, including C-shaped, 3.11%. 3-root canal configuration was a rare occurrence for both premolars, 1.2% and 0.39% respectively, similar with other studies [23,24,25].

The depth of bifurcation (Figures 3) in teeth with 2 canals, shows the difficulty of these cases, 12.88 mm being below the cemento-enamel junction, towards the apical. These cases can only be treated endodontically with magnification means, such as the dental operating microscope. The radicular groove (Figure 4) was found in the middle and apical third of the root and predominantly located on the mesiolingual surface of the root, similar with other study. [26].

Our study obtained a statistically significant association between the type of configuration with more than 1 canal, as well as C-shaped in FP, and male gender. Thus, there is an OR of 2.4 and 2.2 respectively for male patients to present these variations ($p<0.05$). FP presents OR of 8.9 and 4.5 for non-single root canal endodontic and C-shaped configurations compared with SP ($p<0.05$).

A worldwide study of endodontic anatomy of mandibular premolars showed that the proportion of a lingual root canal was 23.6% and 5.3% for the first and second premolars, respectively. Africans, younger groups and males were associated with higher odds of presenting a lingual root canal [27].

A study on a German population found that one root was predominantly in the first and second mandibular premolars, (90.76% and 98.16%, respectively) and one canal (77.9% and 96.0%), whereas two canals were less common (21.9% and 3.6%) [28].

A micro-CT study of mandibular second premolar showed that most of these teeth had one physiological foramen in 57.8% of the samples, while they reported two physiological foramina in 32.4%, three in 7.8%, and even four or five each in 1% [29].

A large study on a Portuguese population (2012 mandibular premolars) found a prevalence of 2.3% and 0.6% in mandibular first and second premolars of C-shaped morphologies respectively; this configuration was observed mostly unilateral. Its prevalence was higher in first mandibular premolars and males [30].

A CBCT study in a Chinese population established a prevalence of 10.25% for C-shaped configuration in mandibular first premolars, and 0.25% for second mandibular premolars. They found a higher prevalence of this type in first mandibular premolars of males than in females [31].

A CBCT study on an Argentine population showed C-shaped canal system in first premolars 10%, and 2% in second premolars [32], while a micro-Ct study on a Brazilian subpopulation found C-shaped canal configuration in 67% of extracted first mandibular premolars with radicular grooves [33].

As can be seen, these teeth show not only large anatomical variations within the type but also depending on ethnicity and gender. Our research therefore shows the endodontic anatomical complexity of these teeth, but also the frequency with which they can be encountered in current practice, with a particular focus on the mandibular first premolar, often underestimated from this point of view.

Conclusions

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Our study found that mandibular premolars are mainly single-rooted and most of the cases present Vertucci type I, followed by type V canal morphology. C-shaped configuration was found in 12.8% and 3.11% for FP and SP respectively. The variations in this study were not low, compared with other studies. Knowledge and understanding of root canal morphology is paramount for a successful endodontic treatment.

CBCT is a reliable imagistic tool in assessing the endodontic anatomy of root canal both in clinical trials and preoperatively.

References

1. Siqueira JF Jr, Rôças IN. Present status and future directions: Microbiology of endodontic infections. Int Endod J. 2022 May;55 Suppl 3:512-530. doi: 10.1111/iej.13677. Epub 2022 Jan 13. PMID: 34958494.
2. Wolf TG, Basmaci S, Schumann S, Waber AL. Internal Morphology of Mandibular Second Premolars Using Micro-Computed Tomography. J Imaging. 2023 Nov 23;9(12):257. doi: 10.3390/jimaging9120257. PMID: 38132675; PMCID: PMC10743552.
3. Siqueira JF Jr, Silva WO, Romeiro K, Gominho LF, Alves FRF, Rôças IN. Apical root canal microbiome associated with primary and posttreatment apical periodontitis: A systematic review. Int Endod J. 2024 Aug;57(8):1043-1058. doi: 10.1111/iej.14071. Epub 2024 Apr 18. PMID: 38634795.
4. Mashyakhy MH, Chourasia HR, Jabali AH, Bajawi HA, Jamal H, Testarelli L, Gambarini G. C-shaped canal configuration in mandibular premolars and molars: Prevalence, correlation, and differences: An In Vivo study using cone-beam computed tomography. Niger J Clin Pract. 2020 Feb;23(2):232-239. doi: 10.4103/njcp.njcp_335_19. PMID: 32031099.
5. Jang YE, Kim Y, Kim B, Kim SY, Kim HJ. Frequency of non-single canals in mandibular premolars and correlations with other anatomical variants: an in vivo cone beam computed tomography study. BMC Oral Health. 2019 Dec 4;19(1):272. doi: 10.1186/s12903-019-0972-5. PMID: 31801495; PMCID: PMC6894311.
6. Almeida JC, Candemil AP, Bertolini GR, Souza-Gabriel AE, Cruz-Filho AM, Sousa-Neto MD, Silva RG. Cone-beam computed tomographic evaluation of the root canal anatomy of the lower premolars and molars in a Brazilian sub-population. Imaging Sci Dent. 2023 Mar;53(1):77-82. doi: 10.5624/isd.20220204. Epub 2023 Feb 1. PMID: 37006788; PMCID: PMC10060753.
7. Pérez-Heredia M, Ferrer-Luque CM, Bravo M, Castelo-Baz P, Ruíz-Piñón M, Baca P. Cone-beam Computed Tomographic Study of Root Anatomy and Canal Configuration of Molars in a Spanish Population. J Endod. 2017 Sep;43(9):1511-1516. doi: 10.1016/j.joen.2017.03.026. Epub 2017 Jul 20. PMID: 28735786.
8. Fava LR, Dummer PM. Periapical radiographic techniques during endodontic diagnosis and treatment. Int Endod J. 1997 Jul;30(4):250-61. doi: 10.1046/j.1365-2591.1997.00078.x. PMID: 9477811.
9. Vertucci FJ. Root canal morphology of mandibular premolars. J Am Dent Assoc. 1978 Jul;97(1):47-50. doi: 10.14219/jada.archive.1978.0443. PMID: 277575.
10. Xu M, Ren H, Liu C, Zhao X, Li X. Systematic review and meta-analysis of root morphology and canal configuration of permanent premolars using cone-beam computed tomography. BMC

DOI : 10.62610/RJOR.2025.2.17.9

Oral Health. 2024 Jun 4;24(1):656. doi: 10.1186/s12903-024-04419-y. PMID: 38835024; PMCID: PMC11149329.

11. Patel S. New dimensions in endodontic imaging: Part 2. Cone beam computed tomography. Int Endod J. 2009 Jun;42(6):463-75. doi: 10.1111/j.1365-2591.2008.01531.x. Epub 2009 Mar 2. PMID: 19298576.
12. Patel S, Durack C, Abella F, Shemesh H, Roig M, Lemberg K. Cone beam computed tomography in Endodontics - a review. Int Endod J. 2015 Jan;48(1):3-15. doi: 10.1111/iej.12270. Epub 2014 Apr 2. PMID: 24697513.
13. Sandhya R, Velmurugan N, Kandaswamy D. Assessment of root canal morphology of mandibular first premolars in the Indian population using spiral computed tomography: an in vitro study. Indian J Dent Res. 2010 Apr-Jun;21(2):169-73. doi: 10.4103/0970-9290.66626. PMID: 20657082.
14. Gu YC, Zhang YP, Liao ZG, Fei XD. A micro-computed tomographic analysis of wall thickness of C-shaped canals in mandibular first premolars. J Endod. 2013 Aug;39(8):973-6. doi: 10.1016/j.joen.2013.04.039. Epub 2013 May 31. PMID: 23880261.
15. Sierra-Cristancho A, González-Osuna L, Balanta-Melo J, Cafferata EA, Rojas C, Melgar-Rodríguez S, Carvajal P, Vernal R. A micro-CT analysis of radicular dentine thickness in mandibular first premolars presenting C-shaped root canals: Identification of potential danger zones. Int Endod J. 2022 Jun;55(6):672-684. doi: 10.1111/iej.13740. Epub 2022 Apr 10. PMID: 35344612.
16. Yilmaz Z, Tuncel B, Serper A, Calt S. C-shaped root canal in a maxillary first molar: a case report. Int Endod J. 2006 Feb;39(2):162-6. doi: 10.1111/j.1365-2591.2006.01069.x. PMID: 16454798.
17. Roy A, Astekar M, Bansal R, Gurtu A, Kumar M, Agarwal LK. Racial predilection of C-shaped canal configuration in the mandibular second molar. J Conserv Dent. 2019 Mar-Apr;22(2):133-138. doi: 10.4103/JCD.JCD_369_18. PMID: 31142981; PMCID: PMC6519192.
18. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol. 1984 Nov;58(5):589-99. doi: 10.1016/0030-4220(84)90085-9. PMID: 6595621.
19. Venskutonis T, Plotino G, Juodzbalys G, Mickevičienė L. The importance of cone-beam computed tomography in the management of endodontic problems: a review of the literature. J Endod. 2014 Dec;40(12):1895-901. doi: 10.1016/j.joen.2014.05.009. Epub 2014 Oct 3. PMID: 25287321.
20. Khedmat S, Assadian H, Saravani AA. Root canal morphology of the mandibular first premolars in an Iranian population using cross-sections and radiography. J Endod. 2010 Feb;36(2):214-7. doi: 10.1016/j.joen.2009.10.002. Epub 2009 Dec 6. PMID: 20113777.
21. Trope M, Elfenbein L, Tronstad L. Mandibular premolars with more than one root canal in different race groups. J Endod. 1986 Aug;12(8):343-5. doi: 10.1016/S0099-2399(86)80035-8. PMID: 3462297.
22. Jonker CH, Lambourn G, Oettlé AC, Foschi F, Theye C, L'Abbé EN. A New Methodology to Determine the Orifice for Root Canal Configurations in First Permanent Molar Root and Canal Morphologies Using Micro-Computed Tomography. J Clin Med. 2023 Dec 22;13(1):71. doi: 10.3390/jcm13010071. PMID: 38202078; PMCID: PMC10779853.

DOI : 10.62610/RJOR.2025.2.17.9

23. Trope M, Elfenbein L, Tronstad L. Mandibular premolars with more than one root canal in different race groups. J Endod. 1986 Aug;12(8):343-5. doi: 10.1016/S0099-2399(86)80035-8. PMID: 3462297.
24. Ebrahimi A, Aminzadeh N, Gharechahi M. Endodontic Treatment of a Mandibular Second Premolar with Type XVII Sert and Bayirli's Canal Anatomy. Iran Endod J. 2019 Winter;14(1):75-78. doi: 10.22037/iej.v14i1.23186. PMID: 36879599; PMCID: PMC9984825.
25. Zoya-Farook A, Abhishek P, Shahabadi A. Cone-beam Computed Tomographic Evaluation and Endodontic Management of a Mandibular First Premolar with Type IX Canal Configuration: Case Report. J Endod. 2017 Jul;43(7):1207-1213. doi: 10.1016/j.joen.2017.01.011. Epub 2017 Apr 25. PMID: 28389073.
26. Fan B, Yang J, Gutmann JL, Fan M. Root canal systems in mandibular first premolars with C-shaped root configurations. Part I: Microcomputed tomography mapping of the radicular groove and associated root canal cross-sections. J Endod. 2008 Nov;34(11):1337-1341. doi: 10.1016/j.joen.2008.08.006. Epub 2008 Sep 12. PMID: 18928842.
27. Martins JNR, Zhang Y, von Zuben M, Vargas W, Seedat HC, Santiago F, Aguilar RR, Ragnarsson MF, Plotino G, Parashos P, Ounsi HF, Nole C, Monroe A, Kottoor J, Gonzalez JA, Flynn D, Chaniotis A, Cassim I, Boveda C, Berti L, Altaki Z, Alkhawas MAM, Alfawaz H, Silva EJNL, Versiani MA. Worldwide Prevalence of a Lingual Canal in Mandibular Premolars: A Multicenter Cross-sectional Study with Meta-analysis. J Endod. 2021 Aug;47(8):1253-1264. doi: 10.1016/j.joen.2021.04.021. Epub 2021 Apr 24. PMID: 33901542.
28. Bürklein S, Heck R, Schäfer E. Evaluation of the Root Canal Anatomy of Maxillary and Mandibular Premolars in a Selected German Population Using Cone-beam Computed Tomographic Data. J Endod. 2017 Sep;43(9):1448-1452. doi: 10.1016/j.joen.2017.03.044. Epub 2017 Jul 22. PMID: 28743430.
29. Wolf TG, Basmaci S, Schumann S, Waber AL. Internal Morphology of Mandibular Second Premolars Using Micro-Computed Tomography. J Imaging. 2023 Nov 23;9(12):257. doi: 10.3390/jimaging9120257. PMID: 38132675; PMCID: PMC10743552.
30. Martins JNR, Francisco H, Ordinola-Zapata R. Prevalence of C-shaped Configurations in the Mandibular First and Second Premolars: A Cone-beam Computed Tomographic In Vivo Study. J Endod. 2017 Jun;43(6):890-895. doi: 10.1016/j.joen.2017.01.008. Epub 2017 Apr 25. PMID: 28389074.
31. Chen C, Zhu T, Wu H, Zhao X, Leng D, Wang J, Yang L, Wu D. Prevalence and correlation of C-shaped root canals of mandibular premolars and molars in Eastern Chinese individuals. Sci Rep. 2022 Nov 17;12(1):19779. doi: 10.1038/s41598-022-24381-5. PMID: 36396689; PMCID: PMC9671964.
32. Chaintiou Piorno R, Consoli Lizzi EP, Gualtieri AF, Rodríguez PA. C-Shaped canal system in mandibular premolars evaluated by cone-beam computed tomography in a population of the Autonomous City of Buenos Aires, Argentina. Arch Oral Biol. 2021 Mar;123:105040. doi: 10.1016/j.archoralbio.2021.105040. Epub 2021 Jan 8. PMID: 33454421.
33. Ordinola-Zapata R, Monteiro Bramante C, Gagliardi Minotti P, Cavalini Cavenago B, Gutmann JL, Moldauer BI, Versiani MA, Hungaro Duarte MA. Micro-CT evaluation of C-shaped mandibular first premolars in a Brazilian subpopulation. Int Endod J. 2015 Aug;48(8):807-13. doi: 10.1111/iej.12380. Epub 2014 Oct 10. PMID: 25244658.

DOI : 10.62610/RJOR.2025.2.17.9