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Retrospective study on the accuracy of the cone beam computed tomography technique in detecting the mesiopalatal canal in upper second molars

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ABSTRACT. Knowing the anatomy and morphology of the maxillary molar canals and the location of the MV2 are extremely important for endodontist clinics. This study evaluated the morphology of the maxillary second molar and the incidence of the Mesiopalatal canal using cone beam computed tomography. Retrospective secondary data were collected from patients of a reference radiology clinic in Maringá, state of Paraná, undergoing imaging exams in a Prexion 3D scanner. Images were analyzed in the axial, sagittal, and coronal sections. When MV2 was identified, it was categorized according to the Vertucci's Classification. Descriptive analysis was performed for age, gender, the morphology of the maxillary second molar, the presence of the second buccal canal, and classification according to its morphology. A total of 173 patients were analyzed, and 230 maxillary second molars were found, with the presence of the Mesiopalatal in 29.1%. The type IV Vertucci classification was the most frequent (40.3%). The study concluded that there is an expressive occurrence of the second buccal canal in 29.1% of cases, and the most recurrent morphology is type IV, according to Vertucci's classification.

Keywords: Anatomy;root canal; molar tooth; cone-beam computed tomography.

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Introduction

In recent decades, the morphology of the mesiobuccal root of maxillary molars has been more studied due to a higher incidence of anatomical variations. This root commonly has two canals: the first mesiovestibular canal (MV1) and the second mesiovestibular (MV2) or mesiopalatal canal, also known as the "fourth canal" of maxillary molars, resulting in a complex system of root canals (Cleghorn et al., 2006). The presence of MV2 has attracted a lot of attention due to the difficulty of locating, debriding, and filling this canal, which is reported in the literature as one of the biggest causes of endodontic treatment failure (Su et al., 2019).

Studies demonstrate that the presence of the MV2 canal in maxillary second molars can vary between 18% and 47% (4,12,13,14). The clinician must be aware of root canal configuration and the presence of additional canals, which are important for complete instrumentation and disinfection (Cotton et al., 2007). Different methods for complementary evaluation and detection of root canal morphology have been used, including digital radiography, cone beam computed tomography, root sectioning with direct vision, micro-CT, operating microscope, and ultrasonic tips for selective dentin removal (Khosravifard et al., 2018; Manigandan et al., 2020). A technique for this evaluation is considered ideal when accurate, simple, non-destructive, and, most importantly, viable in the in vivo scenario (Neelakantan et al., 2010).

Periapical radiography offers some information in clinical practice; however, it has some limitations as it is a two-dimensional image and the possibility of geometric distortions of the image with a lack of three-dimensional information (Cotton et al., 2007; Patel et al., 2007). CBCT (Cone-beam Computed Tomography) uses an extraoral imaging scanner emitting a fan-shaped beam and multiple exposures around the object to produce 3D images of the maxillary skeleton with considerably less radiation exposure than conventional CT scanning (La et al., 2010). It provides precision, a comprehensive description of root morphology, information for diagnosis and treatment plans before or during root canal treatment and surgical endodontic procedures (Wolf et al., 2017), and pathologies from different three-dimensional perspectives (Patel & Horner, 2009).

Currently, cone beam computed tomography is a reliable method for locating the mesiopalatal canal in maxillary molars (Neelakantan et al., 2010; Parker et al., 2017; Su et al., 2019).

Therefore, the present study aimed to evaluate the morphology of the maxillary second molar and the incidence of the mesiopalatal canal using cone beam computed tomography.

Material and methods

Sample

Retrospective study with secondary data collected from patients undergoing exams for diagnosis and treatment planning using cone beam computed tomography at a reference radiology clinic in the northern region of the state of Paraná, which has a highly accurate device, Prexion 3D scanner (Prexion Inc, San Mateo, CA), required to view fine details. The period collected was six months (December 2015 to May 2016).

Inclusion and exclusion criteria

Inclusion criteria: (a) presence of maxillary molars, (b) maxillary molars with fully formed apex. Exclusion Criteria: (a) presence of an intracanal pin, (b) presence of a fixed prosthesis, (c) open apex, (d) teeth with internal and/or external resorption, (e) calcified canal without canal lumen, (f) residual root, (g) presence of root fracture, and (h) presence of endodontic treatment.

Tomographic image acquisition

Images were obtained using a small volume cone beam computed tomography device, model Prexion 3D (Prexion Inc, San Mateo, CA). This device allows the visualization of small details, such as the fourth canal, and is therefore well suited for this purpose Costa et al., 2014).

The device specifications were operation at 90 kV and 4.0 mA, exposure time of 33.5s, voxel dimension of 0.11mm, and FOV of 5.6 cm x 5.2 cm. Contrast was not used in any of the exams, and all tomographic exams were carried out by an experienced technician under the supervision of a responsible radiologist.

Tomography evaluation

Images were dynamically analyzed in axial, sagittal, and coronal sections. The computed tomography images were read using the CS 3D Imaging Software on a Dell LCD screen with 1,920x1,080 pixel resolution in a dark room by two examiners who were previously calibrated at the same time.

Classification of the mesiovestibular canal morphology:

The classification adopted was that of *Vertucci* (1984), as follows (Table 1):

Table 1. *Vertucci*'s classification.

Classification	Description
I	A single canal from the pulp chamber to the apex
II	Two separate canals from the pulp chamber join as one in the apical third
III	A canal that divides into two smaller ones, which join to become one
IV	Two separate canals from the pulp chamber to the root apex
V	A single canal starting from the pulp chamber, divides into two slightly below the apex
VI	Two separate canals join at the root to form one canal, and then divide at the apex
VII	A canal that divides into two, rejoins after some distance, divides again, and leaves through twoforamina
VIII	Three separate canals in one root

Data analysis

Data were entered in Microsoft Excel 2010 software spreadsheets (Microsoft Corp., USA). Descriptive analysis was performed for age, gender, the morphology of the maxillary second molar, the presence of the mesiopalatal canal, and classification according to its morphology.

Ethical aspects

The work was approved by the Permanent Human Research Ethics Committee (COPEP) of the State University of Maringá (UEM). (CAAE: 56129616.6.0000.0104/Opinion: 1613490/2016).

Results

Of the 173 patients included in the study, 108 (62.4%) were female and 65 (37.6%) were male (Figure 1).

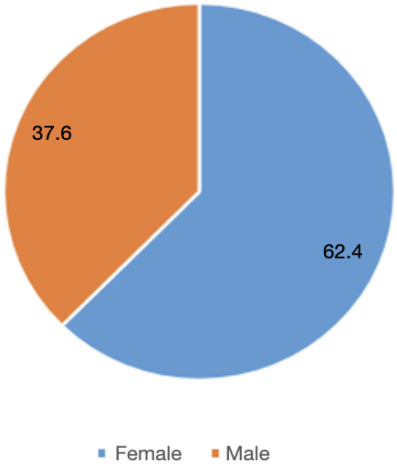

Figure 1. Gender of patients included in the research.

We evaluated 230 maxillary second molars, 113 (49.1%) from the maxillary right second molar and 117 (50.9%) from the maxillary left second molar (Figure 2).

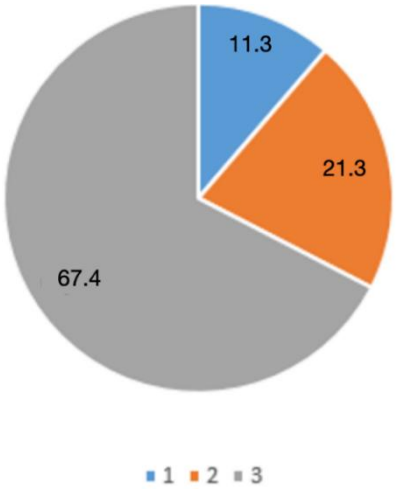

Figure 2. Number of molar roots evaluated.

Of the total of 230 maxillary second molars evaluated, 67 (29.1%) had a mesiopalatal canal (Figure 3).

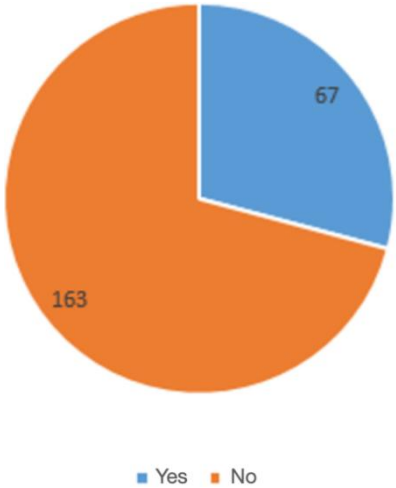

Figure 3. Presence of the fourth canal in the evaluated molars.

In Vertucci's classification, of the 67 molars that presented the fourth canal, 27 (40.3%) were classified as type IV, and 22 (32.8%) were classified as type II (Table 2).

Table 2. Distribution of n and % of individuals who presented the fourth canal according to Vertucci's classification, Maringá, state of Paraná, 2016.

VC*	I	II	III	IV	V	VI	VII	VIII	Total
N	-	22	3	27	8	3	1	3	67
%	-	32.8	4.5	40.3	11.9	4.5	1.5	4.5	100

*VC-*Vertucci*'s classification.

Discussion

The success of endodontic treatment is achieved when the entire pulp system is covered. Variations in root and root canal morphology, especially in multi-rooted teeth, are a constant challenge for diagnosis and treatment. Dentists need to have an in-depth knowledge of root canal configurations and their variations for successful endodontic treatment (Shetty et al., 2016). The mesiovestibular root of maxillary molars has a complex system of root canals. Of the molars analyzed in this study, 29.1% had a mesiopalatal canal, which showed a high percentage compared to the studies by Zhang et al. (2011) with 22% and Khosravifard et al. (2018) with 18%. However, it corroborates Ratanajirasut et al. (2018), who found the fourth canal in 29.4% of cases. Root canal morphology shows distinct configurations between different populations and between groups of teeth, particularly between molars (Razumova et al., 2020). In Zand et al. (2017), the MV2 canal was found in 23.7% of cases, and 156 mesiovestibular roots were evaluated using CBCT and periapical radiography. These authors observed a significant difference in favor of computed tomography compared to periapical radiography in detecting MV2, which shows the low effectiveness of the latter method for a more detailed analysis of the mesiovestibular root.

However, conventional periapical radiographs are essential for preoperative endodontic diagnosis and are the most used method for detecting accessory canals in daily practice; however, periapical radiography can only provide two-dimensional information, which limits its diagnostic effectiveness (Betancourt et al., 2016). Patel et al. (2009) reported CBCT as a non-invasive high-precision three-dimensional technique that increases the percentage of therapeutic success.

The American Association of Endodontics and the American Academy of Oral and Maxillofacial Radiology (AAE/AAOMR) have stated a joint position to determine the effect of CBCT on initial diagnoses and treatment plans. The present study confirmed the importance of CBCT in providing additional information that can alter the initial diagnosis and subsequent treatment plan for complicated endodontic cases, particularly those with post-treatment endodontic disease to determine the need for additional treatment such as retreatment, apical surgery, or extraction. It further pointed out that CBCT is useful in detecting new periapical lesions, missing/extra canals, and vertical root fractures that can significantly alter the treatment plan (Bhatt et al., 2021).

The European Society of Endodontology has also published its position regarding the use of CBCT, in which CBCT imaging has become an essential tool for the diagnosis and/or management of endodontic problems that require three-dimensional imaging; however, it should be used with caution. CBCT should be considered on a case-by-case basis when conventional lower-dose radiography does not provide adequate diagnostic information; as part of this justification, only high-resolution, small FOV (i.e., < min5 cm) is applicable in Endodontics (Patel, Brown, Semper, et al., 2019). A small FOV reduces the volume of exposed tissue and consequently the effective radiation dose, but favorably, this also reduces scatter, which improves image quality (Patel, Brown, Pimentel, et al., 2019).

In this study, regarding gender, 62.4% were women, while 37.6% were men. Previous studies do not corroborate these data, in which most of the sample was male (Patel et al., 2009; Zand et al., 2017). The study by Betancourt et al. (2019) also shows that the MV2 canal was more frequent in males (59.3%) than in females (40.7%), with a significant difference between genders. Likewise, Khosravifard et al. (2018) reported that the majority of the sample is female and found no significant relationship between the presence of MV2 and gender. The differences between the results reported by these authors and the present findings can be explained by divergences that can be attributed to the established evaluation criteria, population differences, inclusion/exclusion criteria, or the large sample size compared to the present study (Magalhães et al., 2022).

According to Vertucci's classification, the most common configuration found in our study on the MV2 canal was type IV (40.3%), in which two separate and distinct canals run to the apex, in agreement with Alavi

et al. (2002), 44.2% and Zhang et al. (2011), 58%. These findings may help the clinician in the treatment of mesiovestibular roots once the authors also found that when MV2 was present, Vertucci type IV was the most common morphology (Neelakantan et al., 2010; Zhang et al., 2011; Ghoncheh et al., 2017; Wang et al., 2017), agreeing with the results of the present study.

Within the scientific community, the existence of MV2 is well known; however, the incidence of this canal strongly depends on the method applied to its location. Different methodologies have been employed to evaluate the incidence of root canals, including root sectioning with direct visualization of the roots, microscopes, micro-CT, and CBCT scans (Magalhães et al., 2022). An in vitro study evaluated the reliability of CBCT exams to detect MV2 canals compared to root sectioning and direct visualization (Wang et al., 2017). This study showed that 68.4% of MV2 canals were detected using root sectioning, and 57.9% of MV2 visualization was obtained with CBCT scans. Despite the authors' conclusion that CBCT is a reliable tool for locating MV2 canals, direct visualization of the root cannot be disregarded. Similar results were reported in a recent in vivo study in which MV2 canals were localized in some cases even when not seen on CBCT scans (Ghoncheh et al., 2017).

Among the limitations of the present study, cone beam computed tomography represents an important tool for three-dimensional analysis; however, it is an imaging exam and sometimes does not present all the details of a clinical exam. Given its ease, as it is a less invasive method, with lower risks for the patient, CBCT can be used safely, being the choice for analyzing the morphology of the mesiopalatal canal in maxillary second molars. Further studies investigating the root canal morphology of permanent maxillary molars are required due to the complexity and different anatomical configurations of these teeth Razumova et al., 2020). Knowledge of these configurations is essential to identify and treat extra canals and increase the chances of successful endodontic treatment (Pan et al., 2019).

Conclusion

The study allowed us to conclude that in the maxillary second molar, there was a prevalence of teeth with three roots (67.4%), and among these cases, 29.1% had the mesiopalatal canal. The most frequent Vertucci classification was type IV.

References

Alavi, A. M., Opasanon, A., Ng, Y.L., & Gulabivala, K. (2002). Root and canal morphology of Thai maxillary molars. *International Endodontic Journal*, *35*(5), 478–485. https://doi.org/10.1046/j.1365-2591.2002.00511.x

Betancourt, P., Navarro, P., Muñoz, G., & Fuentes, R. (2016). Prevalence and location of the secondary mesiobuccal canal in 1,100 maxillary molars using cone beam computed tomography. *BMC Medical Imaging*, *16*(66). https://doi.org/10.1186/s12880-016-0168-2

Bhatt, M., Coil, J., Chehroudi, B., Esteves, A., Aleksejuniene, J., & MacDonald, D. (2021). Clinical decision-making and importance of the AAE/AAOMR position statement for CBCT examination in endodontic cases. *International Endodontic Journal*, *54*(1), 26–37. https://doi.org/10.1111/iej.13397

Cleghorn, B. M., Christie, W. H., & Dong, C. C. S. (2006). Root and Root Canal Morphology of the Human Permanent Maxillary First Molar: A Literature Review. *Journal of Endodontics*, *32*(9), 813–821. https://doi.org/10.1016/j.joen.2006.04.014

Costa, F. F., Pinheiro, L. R., Umetsubo, O. S., Santos Júnior, O., Gaia, B. F., & Cavalcanti, M. G. P. (2014). Influence of Cone-beam Computed Tomographic Scan Mode for Detection of Horizontal Root Fracture. *Journal of Endodontics*, *40*(9), 1472–1476. https://doi.org/10.1016/j.joen.2014.03.001

Cotton, T., Geisler, T., Holden, D., Schwartz, S., &Schindler, W. (2007). Endodontic Applications of Cone-Beam Volumetric Tomography. *Journal of Endodontics*, *33*(9), 1121–1132. https://doi.org/10.1016/j.joen.2007.06.011

Ghoncheh, Z., Zade, B. M., & Kharazifard, J. (2017). Root Morphology of the Maxillary First and Second Molars in an Iranian Population Using Cone Beam Computed Tomography. *Journal of Dentistry*, *14*(3), 115.

Khosravifard, N., Kajan, Z. D., & Hasanpoor, H. (2018). Cone beam computed tomographic survey of the mesiobuccal root canal anatomy in the maxillary first and second molar teeth of an Iranian population. *European Journal of Dentistry*, *12*(03), 422–427. https://doi.org/10.4103/ejd.ejd_60_18

La, S.H., Jung, D.H., Kim, E.C., & Min, K.S. (2010). Identification of Independent Middle Mesial Canal in Mandibular First Molar Using Cone-Beam Computed Tomography Imaging. *Journal of Endodontics*, *36*(3), 542–545. https://doi.org/10.1016/j.joen.2009.11.008

Magalhães, J., Velozo, C., Albuquerque, D., Soares, C., Oliveira, H., Pontual, M. L., Ramos-Perez, F., & Pontual, A. (2022). Morphological Study of Root Canals of Maxillary Molars by Cone-Beam Computed Tomography. *The Scientific World Journal*, *2022*, 1–10. https://doi.org/10.1155/2022/4766305

Manigandan, K., Ravishankar, P., Sridevi, K., Keerthi, V., Prashanth, P., & Pradeep Kumar, A. (2020). Impact of dental operating microscope, selective dentin removal and cone beam computed tomography on detection of second mesiobuccal canal in maxillary molars: A clinical study. *Indian Journal of Dental Research*, *31*(4), 526. https://doi.org/10.4103/ijdr.ijdr_353_20

Neelakantan, P., Subbarao, C., Ahuja, R., Subbarao, C. V., & Gutmann, J. L. (2010). Cone-Beam Computed Tomography Study of Root and Canal Morphology of Maxillary First and Second Molars in an Indian Population. *Journal of Endodontics*, *36*(10), 1622–1627. https://doi.org/10.1016/j.joen.2010.07.006

Pan, J. Y. Y., Parolia, A., Chuah, S. R., Bhatia, S., Mutalik, S., & Pau, A. (2019). Root canal morphology of permanent teeth in a Malaysian subpopulation using cone-beam computed tomography. *BMC Oral Health*, *19*(1), 14. https://doi.org/10.1186/s12903-019-0710-z

Parker, J., Mol, A., Rivera, E. M., & Tawil, P. (2017). CBCT uses in clinical endodontics: the effect of CBCT on the ability to locate MB2 canals in maxillary molars. *International Endodontic Journal*, *50*(12), 1109–1115. https://doi.org/10.1111/iej.12736

Patel, S., Brown, J., Pimentel, T., Kelly, R. D., Abella, F., & Durack, C. (2019). Cone beam computed tomography in Endodontics – a review of the literature. *International Endodontic Journal, 52*(8), 1138-1152. https://doi.org/10.1111/iej.13115

Patel, S., Brown, J., Semper, M., Abella, F., & Mannocci, F. (2019). European Society of Endodontology position statement: Use of cone beam computed tomography in Endodontics. *International Endodontic Journal*, *52*(12), 1675–1678. https://doi.org/10.1111/iej.13187

Patel, S., Dawood, A., Ford, T. P., & Whaites, E. (2007). The potential applications of cone beam computed tomography in the management of endodontic problems. *International Endodontic Journal*, *40*(10), 818–830. https://doi.org/10.1111/j.1365-2591.2007.01299.x

Patel, S., Dawood, A., Whaites, E., & Pitt Ford, T. (2009). New dimensions in endodontic imaging: part 1. Conventional and alternative radiographic systems. *International Endodontic Journal*, *42*(6), 447–462. https://doi.org/10.1111/j.1365-2591.2008.01530.x

Patel, S., & Horner, K. (2009). The use of cone beam computed tomography in endodontics. *International Endodontic Journal*, *42*(9), 755–756. https://doi.org/10.1111/j.1365-2591.2009.01607.x

Ratanajirasut, R., Panichuttra, A., & Panmekiate, S. (2018). A Cone-beam Computed Tomographic Study of Root and Canal Morphology of Maxillary First and Second Permanent Molars in a Thai Population. *Journal of Endodontics*, *44*(1), 56–61. https://doi.org/10.1016/j.joen.2017.08.020

Razumova, S., Brago, A., Barakat, H., & Howijieh, A. (2020). Morphology of root canal system of maxillary and mandibular molars. In *Human Teeth: Key Skills and Clinical Illustrations* (p. 115).

Shetty, H., Sontakke, S., Karjodkar, F., Gupta, P., Mandwe, A., & Banga, K. (2016). A Cone Beam Computed Tomography (CBCT) evaluation of MB2 canals in endodontically treated permanent maxillary molars. A retrospective study in Indian population. *Journal of Clinical and Experimental Dentistry, 9*(1), e51-e55. https://doi.org/10.4317/jced.52716

Su, C.C., Huang, R.Y., Wu, Y.C., Cheng, W.C., Chiang, H.S., Chung, M.P., Cathy Tsai, Y.W., Chung, C.H., & Shieh, Y.S. (2019). Detection and location of second mesiobuccal canal in permanent maxillary teeth: A cone-beam computed tomography analysis in a Taiwanese population. *Archives of Oral Biology*, *98*, 108–114. https://doi.org/10.1016/j.archoralbio.2018.11.006

Wang, H., Ci, BW., Yu, HY., Qin, W., Yan, YX., Wu, BL., & Ma, DD. (2017). Evaluation of root and canal morphology of maxillary molars in a Southern Chinese subpopulation: a cone-beam computed tomographic study. *International Journal of Clinical and Experimental Medicine*, *10*(4), 7030–7039.

Wolf, T. G., Paqué, F., Woop, A.C., Willershausen, B., & Briseño-Marroquín, B. (2017). Root canal morphology and configuration of 123 maxillary second molars by means of micro-CT. *International Journal of Oral Science*, *9*(1), 33–37. https://doi.org/10.1038/ijos.2016.53

Zand, V., Mokhtari, H., Zonouzi, H. R., & Shojaei, S. N. (2017). Root Canal Morphologies of Mesiobuccal Roots of Maxillary Molars using Cone beam Computed Tomography and Periapical Radiographic Techniques in an Iranian Population. *The Journal of Contemporary Dental Practice*, *18*(9), 745–749. https://doi.org/10.5005/jp-journals-10024-2119

Zhang, R., Yang, H., Yu, X., Wang, H., Hu, T., & Dummer, P. M. H. (2011). Use of CBCT to identify the morphology of maxillary permanent molar teeth in a Chinese subpopulation. *International Endodontic Journal*, *44*(2), 162–169. https://doi.org/10.1111/j.1365-2591.2010.01826.x