Contemporary Orofacial Sciences (2026) 4(1): 29-35
DOI: 10.66224/cofs.4.1.6

ORIGINAL ARTICLE

Evaluation of root number and anatomical configuration of maxillary second molar canals using CBCT

Farnoosh Mobininejad[1], Maryam Zare Jahormi[2]*, Azadeh Torkzadeh[3], Mohammad Hossein Moarefpour[4], Zahra Sadat Mohajer Hejazi[5]

Received: 2025-01-02/ Accepted: 2025-10-12 / First publication date: 2026-003-04

Abstract

Background: The root canal treatment of the maxillary second molar tooth is one of the challenging cases in root canal treatment because it has many anatomical variations. The purpose of this study was to investigate root number and anatomical configuration of maxillary second molar canals using the Cone Beam Computed Tomography method.

Materials and Methods: In this descriptive-analytical study, 165 CBCT images of maxillary second molars from patients aged 18 years or older, available in the archives of the Department of Oral and Maxillofacial Radiology, Azad University of Isfahan were used. CBCT images were evaluated in axial, sagittal, and coronal sections at two separate time points with a defined interval, and the data for each tooth were recorded in specially designed forms. The data were analysed by the Chi-square test (α=0.05).

Results: Most of the maxillary second molars had three roots (81.2%). Two roots were observed in 9.7% of teeth, and single-rooted teeth were found in 6.7% of second molars, and 2.4% had four roots. 63.6% of single-rooted teeth had one canal, and 36.4% had two canals. Most of the teeth with two roots had three canals (81.2%), and 18.8% had two canals. 86.6% of teeth with three roots had four canals, and 13.4% had three canals. A C-type configuration was found in a single-rooted tooth with a single canal.

Conclusion: The most common variations were three-rooted and four-canalled teeth. The least anatomical variety of the root and canal was teeth with two roots and two canals. Mesiobuccal roots in three-rooted and four-canal teeth showed the greatest anatomical diversity according to Vertucci's classification. Only one case of C-type canal was found.

Keywords: anatomical diversity; maxillary second molar; Cone-Beam Computed Tomography

Introduction

In modern dentistry, endodontic treatment is an effective and important method for preserving and maintaining teeth. Dentists' complete knowledge of tooth anatomy and root canal anatomy is definitely a necessary prerequisite for successful root canal treatment (1). Reports of complex anatomy are increasing (2). Therefore, before proceeding to root canal treatment, it is very important to gain sufficient knowledge of the structure of the canal and root. A great variety in the number and shape of canals in each root and the number of roots has been reported for maxillary premolar teeth (3, 4).

Corresponding author: Maryam Zare Jahormi

Department of Endodontics, Faculty of Dentistry, Isf.c, Islamic Azad University, Isfahan, Iran
Email:maryamzare@iau.ac.ir

1. Faculty of Dentistry, Isf.c, Islamic Azad University, Isfahan, Iran
2. Department of Endodontics, Faculty of Dentistry, Isf.c, Islamic Azad University, Isfahan, Iran
3. Department of Oral & Maxillofacial Radiology, Faculty of Dentistry, Isf.c, Islamic Azad University, Isfahan, Iran
4. Department of Endodontics, Faculty of Dentistry, Isf.c, Islamic Azad University, Isfahan, Iran
5. Faculty of Dentistry, Isf.c, Islamic Azad University, Isfahan, Iran

[DOI: 10.66224/cofs.4.1.6]

Weine et al. (5) classified the tooth canals into four types depending on the pattern of dividing the main root canal along its path from the floor of the pulp chamber to the apex of the root. Vertucci (6) also categorized the shape of the root canal more descriptively into eight types. Many researchers use this classification widely in studying the root canal system.

The most observed variation in this tooth is three-rooted, which is known as standard morphology. The roots are mesiobuccal, distobuccal, and palatal, and in each root there is one canal (7-9). Changes in the mesiobuccal root are not uncommon, and the most common type is the presence of a second mesiobuccal root canal; its prevalence ranges from 13.9% to 78.9% (10, 11). On the contrary, changes in the number of canals in the distobuccal and palatal root have rarely been reported (12).

Periapical radiographs are commonly used to evaluate the root canal system prior to endodontic treatment. However, this radiographic method is not able to identify additional roots or canals in a significant number of cases (13). In some cases, this has led to incomplete cleaning and disinfection of the canals due to failure to identify all the patient's roots and canals. Therefore, to facilitate accurate evaluation of the root canal system of patients, clinicians should be aware of common root canal shapes and possible anatomical variations (5).

Several studies have evaluated root morphology and root canal anatomy in different populations using various techniques, including sectioning (5), root canal staining and cleaning (6), periapical radiography (14), and cone computed tomography scanning. However, all these techniques have limitations.

Cone beam computed tomography (CBCT) is a non-invasive method that can provide 3D diagnostic images without overlapping tooth structures. The shape and number of root canals, along with their divergence or convergence, can be seen in 3D images (15).

In Nikoloudaki et al.'s study (16), 3-rooted teeth were the most common in upper second molar teeth. Kim et al. (17) showed that 3-rooted teeth are most common in upper second molars, and 0.49% of the teeth were four-rooted. In Tian et al.'s study (18), the highest prevalence was related to three-rooted teeth. In this study, 1.23% of the teeth were four-rooted, and among three-rooted and four-canaled teeth, the most diversity was observed.

Accordingly, as root canal treatment of the maxillary second molar is sometimes difficult due to morphological differences in root and canal shape and number, the present study aimed to evaluate the canal morphology of the maxillary second molar using CBCT.

Materials and methods

This descriptive-analytical study recruited 165 randomly selected CBCT images of maxillary second molars from patients aged 18 to 60 years (62% female, 28% male) referred to the oral and maxillofacial radiology center of the Faculty of Dentistry, Azad University of Isfahan (Khorasgan) during 2015-2021. These images were taken for other diagnostic and therapeutic purposes. It should be noted that all CBCT images were acquired using a Galileos (Sirona, Bensheim, Germany) with a field of view of 13 × 15 cm (operational parameters: 90 kV, 5 mA, 8.14 s, 0.38 mm voxel size). CBCT images were studied on SIDEXIS 3D software (Fabrikstr 31, Bensheim, Germany) on a computer monitor under standard conditions (semi-dark room with constant light intensity) to view the images in the axial, sagittal, and coronal planes with a slice thickness of one mm to determine the number of roots and root canals (regarding the presence or absence of the second canal) and the type of canals according to Vertucci

[DOI: 10.66224/cofs.4.1.6]

classification (6). The study's inclusion criteria were images of optimal quality, free of motion or foreign-object artifacts, with complete tooth apices and no root canal treatment. Also, they did not have developmental growth problems, latency, calcification, or internal resorption.

The data collection method included observation of CBCT images in three axial, sagittal, and coronal sections by researchers and professors over two time periods, with intervals, and recording the desired information in forms, including pre-prepared tables, for each CBCT image. In the forms, information such as the patient's file number, age, sex, and prescribed CBCT was included. Also, in this form, there were tables for single-rooted, double-rooted, and three-rooted second molar teeth, with the names of the roots listed separately for each tooth. Information for each root, including the number of canals and the type of Vertucci formed by the existing canals, was recorded.

To reduce potential biases, the CBCT stereotypes were randomly observed by two researchers (an oral & maxillofacial radiologist and an endodontist) in two periods with an interval of 2 weeks, and data were recorded and analyzed using Chi-square tests in SPSS software version 22 at a significance level of 0.05.

Results

Among the 165 teeth included in this study, 102 teeth (61.8%) belonged to the group of women and 63 teeth (38.2%) belonged to the group of men.

Table 1 shows that the frequency distribution of the number of roots in the maxillary second molar between women and men had a significant difference ($p = 0.018$) using the Chi-Square test. There were more single-rooted and double-rooted maxillary second molar teeth in women than in men. However, the maxillary three-rooted molar teeth of men were more than those of women. Also, four-rooted teeth were not observed in the male group. However, approximately 3.9% of 102 women's teeth had four roots.

Table 1. Frequency distribution of the number of roots of maxillary second molar teeth in the examined sample (n = 165)

Gender	One	Two	Three	Four	Total
	n (%)	n (%)	n (%)	n (%)	n (%)
Female	10(9.8)	11(10.8)	77(75.5)	4(3.9)	102(100)
Male	1(1.6)	5(7.9)	57(90.5)	0	63(100)
Total	11(6.7)	16(9.7)	134(81.2)	4(2.4)	165(100)

The chi-squared test results in Table 2 show that the number of canals in the second molars of the upper jaw in the investigated samples is presented separately for single-rooted, two-rooted, three-rooted, and four-rooted teeth. The highest prevalence of anatomical variation according to the number of roots and canals, in order from the highest to the least, includes: teeth with three roots and four canals, three roots and three canals, two roots and three canals, one root and one canal, one root and two canals, equal to Four-rooted and four-canaled teeth and the lowest prevalence was related to two-rooted and two-canaled teeth.

Table 2. Frequency distribution of roots and canals of maxillary second molar (n=165)

Number of roots	One		Ywo		Three		Four
Number of canals	one	two	two	three	three	four	four
Number (percentage)	7(63.6)	4(36.4)	3(18.8)	13(81.2)	18(13.4)	116(81.6)	4(100)
total	11(100)		16(100)		134(100)		4(100)

[DOI: 10.66224/cofs.4.1.6]

In the evaluation of roots and canals of maxillary second molars with one root, 11 single-root teeth were observed among the examined teeth. Out of seven single-rooted teeth with one canal, the shape of the canal of the maxillary second molar was identified as C-type, and the anatomical variation of 6 teeth was Vertucci's type I. Also, in single-rooted teeth with two canals, three teeth were Vertucci type II, and one tooth was Vertucci type VI (Table 3)

Table 3. Frequency distribution of roots and canals of maxillary second molars with one root based on Vertucci types (n=11)

Number of canals	C-type	Vertucci types			Total
		I	II	VI	
one	1(14.3)	6(85.7)	0	0	7(100)
two	0	0	3(75)	1(25)	4(100)

In the evaluation of roots and canals of maxillary second molars with three roots and four canals, three teeth had three roots and three canals, with two buccal roots and one palatal root, and one Vertucci type I canal was observed in each root. Among the examined teeth, thirteen teeth had two roots and three canals. One canal was palatal, and the other two were mesiobuccal and distobuccal. Of 13 teeth, eight had Vertucci type II mesiobuccal and distobuccal canals, and five had Vertucci type IV; only Vertucci type I was observed in all 13 palatal canals (Table 4).

Table 4. Frequency distribution of anatomical variations of the root canals in two-rooted maxillary second molars with three canals in patients, according to Vertucci's classification, stratified by patient sex (n = 13).

Root name	Number of canals	Canal name	Vertucci classification	Total
B (Buccal)	Two canals	MB and DB	II	8
			IV	5
P (Palatal)	One canal	P	I	13

Out of 165 examined teeth, 18 had three roots and three canals, and 116 had three roots and four canals. All three-rooted teeth had mesiobuccal, distobuccal, and palatal roots, and each root had one canal, and all canals had Vertucci type I. Of 116 teeth with three roots and four canals, all additional canals were found in the mesiobuccal root (MB2), which showed variations in Vertucci's classification. The most prevalent type observed was Vertucci type II (71.6 percent), and for the distobuccal and palatal canals, only Vertucci type I was observed (Table 5).

Table 5. Frequency distribution of roots and canals of maxillary second molars with three roots and four canals based on Vertucci types (n=116)

Root's name	Canal's name	Vertucci type								total
		I	II	III	IV	V	VI	VII	VIII	
MB	MB_1 & MB_2	0	83 (71.6)	3 (2.6)	25 (21.6)	3 (2.6)	1 (0.8)	1 (0.8)	0	116 (100)
DB	DB	116 (100)	-	-	-	-	-	-	-	116 (100)
palatal	palatal	116 (100)	-	-	-	-	-	-	-	116 (100)

MB: mesiobuccal; DB: distobuccal)

The frequency distribution of the first and second mesiobuccal canals was almost the same between men and women in each of the Vertucci classes. In Vertucci type II (with a frequency of 83 teeth), 56.6% were related to the group of women and 43.4% to the group

[DOI: 10.66224/cofs.4.1.6]

of men. Also, in Vertucci type IV (with a frequency of 25 teeth), women were 0.52%, and men were 0.48%. Two Vertucci type III teeth were in the men's group, and one was in the women's group; the opposite result was observed for Vertucci's V brigade. Types VI and VII of Vertucci each had a single frequency; the first belonged to the female group and the second to the male group.

Four teeth with four roots and four canals were observed in the CBCT images of the investigated samples. All of them had mesiobuccal and distobuccal, mesiopalatal and distopalatal canals. According to Vertucci's classification, all channels were identified as type I. Also, all four teeth belonged to the group of women.

Discussion

According to the results of the present study, 6.7% of teeth were single-rooted, 9.7% were bi-rooted, 81.2% were three-rooted, and 2.4% were four-rooted. Therefore, most of the maxillary second molars were three-rooted ,which is consistent with the results of other studies (19-21).

The number of canals in each root was also assessed, and in single-rooted teeth, 63.6% were single-canal, and 36.4% were double-canal. Among the single-rooted and single-canal teeth (one case), 14.3% of the teeth were C type, and the rest of the teeth, i.e., 85.7%, had Vertucci type I. Between single-rooted and double-rooted teeth, the most observed type was Vertucci type II.

In Tian et al.'s study (18) and Kim et al.'s study (17), single-rooted and single-canal teeth were more common than single-rooted and double-canaled teeth, which is inconsistent with the results of the present study. In Tian et al.'s study (18), type V was the most common among double-canal teeth, whereas in Kim et al.'s study (17), it was the most common among type II double-canal teeth, which is consistent with the results of the present study. However, in the study by Tzeng et al. (22), the number of single-rooted and double-canaled teeth was greater than that of single-rooted and single-canaled teeth, which is consistent with the results of the present study.

In the studies by Kim et al. (17) and Tian et al. (18), no C-type canal was observed, whereas in the present study, one case of C-type canal was observed among the examined samples.

In the two-rooted teeth, 18.8% of the teeth were two-canaled, and 81.2% of the teeth were three-canaled. In double-rooted and double-canal teeth, 100% of buccal and palatal canals were Vertucci type I. In the two-rooted and three-canaled teeth, the most variation observed in the buccal root canals was related to type II. All the palatal canals in the tooth had the type I vertucci. In Kim et al.'s study (17), two-rooted and two-canal teeth were more common than two-rooted and three-canal teeth, and among the two-rooted and three-canal teeth, the most frequent type in the buccal root was type II. In Tian et al.'s study (18), two-rooted and two-canal teeth were more than two-rooted and three-canal teeth, and among the two-rooted and three-canal teeth, the most frequent type in the buccal root was Vertucci type III. In the study by Tzeng et al. (22), two-root and two-canal teeth were more common than two-root and three-canal teeth, which is inconsistent with the results of the present study.

In three-rooted teeth, 13.4% of teeth were three-canal, and 82.6% of teeth were four canals. Therefore, based on the investigations, three-rooted and four-canal teeth were the most common conditions found in upper jaw second molars. The additional canal was found only in the mesiobuccal root, which was the second mesiobuccal canal. In all three-rooted and three-canal teeth (including mesiobuccal, distobuccal, and palatal canals), the only variation observed was Vertucci type I. In the teeth with three roots and four canals, the greatest variation observed in the mesiobuccal root

[DOI: 10.66224/cofs.4.1.6]

was between the first and second mesiobuccal canals of Vertucci type II. 100% of distobuccal and palatal canals were Vertucci type I., which is consistent with the results of other studies (17, 18, 22,23)

In the teeth with four roots (MB, DB, MP, DP), 100% had four canals, and all four were Vertucci type I, consistent with other studies (17, 22). In the study by Kim et al. (17), in four-rooted teeth, all DB, MP, and DP root canals were Vertucci type I, and most MB root canals were Vertucci type I; in one case, Vertucci type II was observed.

In the current study, the difference in the frequency distribution of the number of roots between women and men was also investigated, and the results showed that the frequency distribution of the number of roots between women and men creates a statistically significant difference; Because there were more single-rooted and two-rooted second molars in women than men, and vice versa, more three-rooted molars were observed in men. Four-rooted teeth were observed only in the female group, accounting for 3.9% of all teeth.

The frequency distribution of the number of roots and canals was analyzed by sex within the single-rooted, two-rooted, and three-rooted groups. The statistical results indicated that the distribution of channel frequency between women and men did not show a statistically significant difference.

The frequency distribution of the anatomical diversity of roots and canals in single-rooted teeth by gender was also done. Of the 7 single-rooted teeth, 1 was C type and belonged to the group of women. Among the teeth with type I Vertucci, 83.3% were in women and 16.7% in men.

In the present study, all the two-rooted and two-canal teeth belonged to the female group. In two-rooted and three-channel teeth, 75% of the 8 cases were female, and 25% were male, and 40% were female, and 60% were male out of the 5 cases of type IV teeth. Four-rooted and four-canalled teeth were also examined by gender. These teeth were observed only in the female group. In the study by Kim et al. (17), no difference in the distribution of MB2 canals between women and men was observed, and other variables, including the number of roots and the distribution of canals between women and men, were not investigated.

In the studies by Tzeng et al. (22) and Nad, no significant difference was observed between men and women in the number of roots or the distribution of canals.

In the study by Madfa et al (24), significant variations in root canal anatomy were observed within the Saudi population. The majority of the Saudi Arabian subjects in this study had maxillary second molars with three roots. Approximately half of the sample under investigation exhibited the presence of the four canals.

Conclusion

The most common variation was three-rooted, four-canalled teeth. The least anatomical variety of the root and canal was teeth with two roots and two canals. Mesiobuccal roots in three-rooted and four-canal teeth showed the greatest anatomical diversity according to Vertucci's classification. Only one case of C-type canal was found.

References

1. Rotstein I, Ingle JI. Ingle's Endodontics. 7th ed. Raleigh: PMPH USA; 2019. p. 24-26.
2. Berman LH, Hargreaves KM, Rotstein I. Cohen's Pathways of the Pulp. 12th ed. St. Louis: Elsevier; 2021. p. 136-221.
3. Shekarian M, Majlesi M, Zare Jahromi M. Prevalence of C-shaped canals and three-rooted mandibular molars in the Iranian population by using cone-beam computed tomography. Clin Exp Dent Res. 2023 Oct;9(5):906-912.
4. Ghasemi H, Zare Jahormi M, Torkzadeh A, Mokabberi A. Investigating mandibular anterior teeth root canal configuration diversity using Cone-Beam Computed Tomography. cofs 2024; 2 (1) :26-31

[DOI: 10.66224/cofs.4.1.6]

5. Weine FS, Healey HJ, Gerstein H, Evanson L. Canal configuration in the mesiobuccal root of the maxillary first molar and its endodontic significance. Oral Surg Oral Med Oral Pathol. 1969;28(3):419-425.
6. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol. 1984;58(5):589-599.
7. Neelakantan P, Subbarao C, Ahuja R, Subbarao CV, Gutmann JL. Cone-beam computed tomography study of root and canal morphology of maxillary first and second molars in an Indian population. J Endod. 2010;36(10):1622-1627.
8. Arefifard Z, Zare Jahromi M, Ghaffari R, Mir Sattari S. Evaluation of Prevalence and Quality of Root Resorption of Second Molar Adjacent the Impacted Third Molar in Cone-Beam Computed Tomography J Isfahan Dent Sch 2022; 18(2): 113-20.
9. Zare Jahromi M, Mehdizade M, Shirazizade Z, Poursaeid E. Evaluation of mandibular premolars root canal morphology by cone beam computed tomography. Caspian J Dent Res 2018; 7: 58-63.
10. Betancourt P, Navarro P, Cantín M, Fuentes R. Cone-beam computed tomography study of prevalence and location of MB2 canal in the mesiobuccal root of the maxillary second molar. Int J Clin Exp Med. 2015;8(6):9128-9134.
11. Zeng C, Shen Y, Guan X, Wang X, Fan M, Li Y. Rare root canal configuration of bilateral maxillary second molar using cone-beam computed tomographic scanning. J Endod. 2016;42(4):673-677.
12. Pasternak B Jr, Teixeira CS, Silva RG, Vansan LP, Sousa Neto MD. Treatment of a second maxillary molar with six canals. Aust Endod J. 2007;33(1):42-45.
13. Matherne RP, Angelopoulos C, Kulild JC, Tira D. Use of cone-beam computed tomography to identify root canal systems in vitro. J Endod. 2008;34(1):87-89.
14. Pineda F, Kuttler Y. Mesiodistal and buccolingual roentgenographic investigation of 7,275 root canals. Oral Surg Oral Med Oral Pathol. 1972;33(1):101-110.
15. Tian YY, Guo B, Zhang R, Yu X, Wang H, Hu T, et al. Root and canal morphology of maxillary first premolars in a Chinese subpopulation evaluated using cone-beam computed tomography. Int Endod J. 2012;45(11):996-1003.
16. Nikoloudaki GE, Kontogiannis TG, Kerezoudis NP. Evaluation of the root and canal morphology of maxillary permanent molars and the incidence of the second mesiobuccal root canal in Greek population using cone-beam computed tomography. Open Dent J. 2015; 9: 267-272.
17. Kim Y, Lee SJ, Woo J. Morphology of maxillary first and second molars analyzed by cone-beam computed tomography in a Korean population: variations in the number of roots and canals and the incidence of fusion. J Endod. 2012; 38(8): 1063-1068.
18. Tian XM, Yang XW, Qian L, Wei B, Gong Y. Analysis of the root and canal morphologies in maxillary first and second molars in a Chinese population using cone-beam computed tomography. J Endod. 2016;42(5):696-701.
19. Zheng QH, Wang Y, Zhou XD, Wang Q, Zheng GN, Huang DM. A cone-beam computed tomography study of maxillary first permanent molar root and canal morphology in a Chinese population. J Endod. 2010;36(9):1480-1484.
20. Sert S, Bayirli GS. Evaluation of the root canal configurations of the mandibular and maxillary permanent teeth by gender in the Turkish population. J Endod. 2004;30(6):391-398.
21. Chen G, Yao H, Tong C. Investigation of the root canal configuration of mandibular first molars in a Taiwan Chinese population. Int Endod J. 2009;42(11):1044-1049.
22. Tzeng LT, Chang MC, Chang SH, Huang CC, Chen YJ, Jeng JH. Analysis of root canal system of maxillary first and second molars and their correlations by cone beam computed tomography. J Formos Med Assoc. 2020;119(5):968-973.
23. Namdar P, Molania T, Hoshyari N, Lotfizadeh A, Alimohammadi M, Khojastehfar M, et al. Evaluation of root and canal morphology of maxillary first and second molars by cone beam computed tomography in a northern Iranian population. J Res Dent Maxillofac Sci. 2023;8(4):265-273.
24. Madfa AA, Almansour MI, Al-Zubaidi SM, Alghurayes AH, Aldakhaye SD, Alzoori FI, et al. Cone beam computed tomography analysis of the root and canal morphology of the maxillary second molars in a Hail province of the Saudi population. Heliyon. 2023;9(9):e19477.

[DOI: 10.66224/cofs.4.1.6]