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RESEARCH ARTICLE

Root Canal Morphology of Maxillary Second Premolars for patients attending Ajman University

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ABSTRACT:

Background: The internal anatomy is a complex system and root canal morphology varies between teeth, especially in maxillary second premolars. **Objective:** The purpose of this present study is to identify the variations in root and root canal morphology of the upper second premolar. **Methods:** A retrospective study on 197 maxillary second premolars, which have had an endodontic treatment in Ajman University in the Academic Year 2018/2019. Intraoral periapical (IOPA) radiograph was reviewed for identifying the number of root canals. **Results:** The incidence of two canals in the maxillary second premolars was very high 78.7%, and the internal anatomy is complex and highly variable. **Conclusion:** A straightforward message to the clinicians to be careful in their evaluation and to take care whenever an upper maxillary second premolar is to be treated endodontically.

KEYWORDS: Maxillary second premolar, Root Morphology, Canals Configuration, Vertucci Classifications, Root Canal Treatment, Parallax technique.

INTRODUCTION:

A key objective of an effective nonsurgical endodontic root canal treatment is a proper and clear understanding of root morphology and canal configurations due to the highly complex internal and external anatomical variation present in teeth.¹⁻⁸ In order to ascertain the effectiveness of root canal treatment, the success of the treatment is higher if infection is eradicated effectively from all allocated canals before the root canal system is obturated.⁹⁻¹⁰

Overall, anatomical variation in dental morphology could be due to several exogenic and endogenic factors, for instance diet and fluoride intake, that may cause a significant irregularity in the predentine and unmineralized area in the dentin or they may alter tooth-bud growth in maturation in the sensitive process of odontogenesis.^{1,11-14}

On the other hand, the formation of dentine may cause variations in root canals after the completion of their development, thus, the outline and proportions of previously formed canals may alter; the pulp space is then reduced and root canals become tightened.^{1-2,14-16}

Deposition of dentine in the isthmus zone may divide the root into two distinct canals, ending in one or two different foramina. Apart from the main root canal, lateral and accessory canals are also encountered, which formed from the core canal and terminate in dentin with a dead end or with an addition foramen in the periodontal membrane.^{1,14,17-20}

All root canals must be tightly sealed with a filling that reaches to an optimum working length to eliminate the possible bacterial growth in the unfilled spaces, which usually lead to a development of a periapical inflammatory lesion.^{1,24}

Even with intraoral periapical (IOPA) radiographs, which are important in diagnosing and treatment planning, these variations may present clinical difficulties that might often lead to unfavorable

treatment consequences. Thus, we sometimes need to take a Cone Beam Computed Tomography (CBCT) which gives a 3D image of a 3D object, hence, a better reading.^{5,19,25}

The only tooth that displays the eight likely configurations of the Vertucci's classification is maxillary 2nd premolar. This tooth's complex and changeable canal morphology makes it very challenging to treat endodontically.^{4-6,8,18,21,26}

The intent of this current study is to detect radiographically as well as clinically the variations in root morphology and number of the canals of the upper second premolars and the most commonly observed Vertucci Classification among patients attending Ajman University for routine endodontic treatment.

MATERIALS AND METHODS:

Ethical approval for this in vivo cross-sectional observational study was approved from the local ethical committee, college of Dentistry, Ajman University, United Arab Emirates on December 11, 2019.

The database of the endodontic patients in the college of dentistry was accessed from December 15 until the 29th of the same month in 2019. One-hundred ninety-seven patients who came for routine treatment were referred to the Restorative Department of the College of Dentistry for Root canal treatment of maxillary second premolars. Pre-operative x ray was taken to evaluate the number of the roots, canal configuration, and periapical status. The sampling process were targeting the presence of fully developed upper second premolar roots. 197 teeth were carefully chosen for this study according to the inclusion criteria, in which all clear undistorted radiographs, lack of root resorption, absence of calcification and periapical lesion as well as absence of root canal filling, post or crowned teeth were included in our study.

IOPA radiographs of high quality of all patients visited fourth year students for root canal treatment (RCT) of the maxillary second premolar for the academic year 2018/2019 were included in the present study regardless of race, age, or sex. The reason for choosing fourth year students only is that the fifth-year students are only allowed to do RCTs on molars in this department. In addition, all treated cases done by the students were checked, approved and followed up during the endodontic treatment by two endodontists. The assessment was throughout the IOPA radiographs from the patient's records. As a rule, in the endodontic department at the college of dentistry in Ajman University, Ajman, UAE. A mesial/distal shift IOPA radiographs (Same Lingual Opposite Buccal "SLOB" technique) must be taken for all upper premolars and lower molars going for RCTs. These will reveal the

presence of overlapping or even additional canals and sometimes an idea about some root canal morphological complexity, which are not clear in paralleling technique. Since IOPA radiographs give a 2D image of a 3D object. Therefore, all students are obligated to take IOPA radiographs in SLOB technique for these teeth. Moreover, since the students take the radiographs by their own, the expectance of many radiographs (more than 5) per RCT present in the database is normal.

Following the routine patients' preparation after establishing the correct diagnosis, and placing rubber dam, then access cavity into the pulp space through an oval outline bucco-lingually is made. Canals were explored with the aid of endodontic explorer. Furthermore, Copious irrigation with saline and 2.5% of sodium hypochlorite and a periapical radiograph was taken for the assessment of the number of roots, canals as well as confirmation of the Estimated working length after inserting size 15 or 20 K files (Mani Inc., Japan), subsequently, examination of the floor of the pulp chamber to trace canals' orifices in difficult cases was through the use of 3.5 high resolution magnification loupes (Heine, Germany).

Two specialists within the Restorative department with more than 15 years of experience in endodontics examined the included teeth with both clinical and radiographical methods. The data was recorded specifically for number of canals, roots and lastly type of canal configuration in accordance to Vertucci's classification was distinguished.

Furthermore, radiographic assessment after final treatment was done by two clinicians, which were reviewing the cases separately, and writing down the number of canals, roots and apices of each case. As an average, two to three IOPA radiographs per case were checked from the pre-operative and working length stages. Out of the 197 cases, the two clinicians had different results in 77 cases. A third clinician was involved for assessment and along with the other two clinicians reviewed the 77 cases once again as a group. Then, a group decision was taken after an agreement on the 77 cases made between the three clinicians.

The results were presented using descriptive statistical measure (frequency and percentage) after the data collected were transferred and completed using the SPSS Statistics software for Windows Desktop V. 26.0 (IBM Corp., Chicago, USA).

Data evaluated with one-sample Chi-Square test and one-sample Binomial test to define the distribution of the data within the whole sample, while Fisher's Exact test to obtain the significance differences between the

number of canals and roots of the upper second premolars and to clearly state if there is variation within the same tooth or not. The statistically significant level (p-Value) was set at below 0.05 with 95% confidence interval.

RESULTS:

Among the 197 patients registered, regardless of their sex, age or race, the maxillary second premolar showed a significant variation in the number of the roots besides number of canals (P<0.000) in which one root was observed in one-third of the cases (31.5%) while almost two-thirds seen with two roots (68.5%). Overall, one canal was seen in 21.3% whereas two canals in 78.7% of the included teeth. Furthermore, one apex was seen in 28.9%, two apices in 70.6%, whilst three apices in only one case having a 0.5% of the total number. (Figure 1) (Table 1)

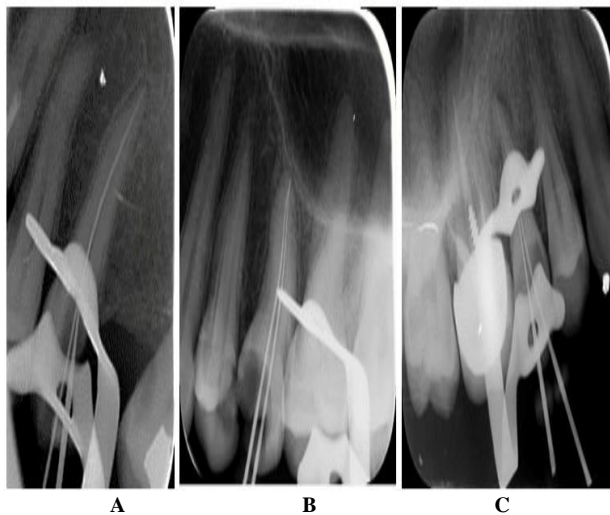


Figure 1: Different Canal Configurations seen in Maxillary Upper Second Premolars, A) one canal ending in one apex, while B and C) two canals ending in two apices.

Table 1: Overall distribution of the upper 2nd premolars within the study

	Frequency (Percentage)	One-Sample Binomial Test (P-value)
One Root	62 (31.5%)	.000 ^a
Two Roots	135 (68.5%)	
	Frequency (Percentage)	One-Sample Binomial Test (P-value)
One Canal	42 (21.3%)	.000 ^b
Two Canals	155 (78.7%)	
	Frequency (Percentage)	One-Sample Chi-Square Test (P-value)
One Apex	57 (28.9%)	.000 ^c
Two Apices	139 (70.6%)	
Three Apices	1 (0.5%)	

a. Test Statistics=62.000, Standard Error = 7.018, Standardized Test Statistics = -5.130.
 b. Test Statistics=155.000, Standard Error = 7.018, Standardized Test Statistics = 7.980.
 c. Test Statistics=146.721, df = 2.

When you come into a close-up picture, when one root present, one canal and two canals end in one apex in 19.8% and 9.1% of the total cases, respectively. While the cases end in two apices where 1.5% and 1% in one canal and two canals, respectively. Moreover, in the presence of two roots, two canals were seen in 68% which ends in two apices and only one case 0.5% ends in three apices. Statistically significant difference (P<.000) was seen when maxillary second premolars were evaluated collectively to determine the variability of the canals present in the included teeth (Table 2).

Focused on Vertucci's root canal morphology classification (one root), a total of 62 teeth had one root. Accordingly, the most commonly observed type was type I, in which 39 teeth (62.9%) demonstrate Type I canal configuration (in which one canal end in one apical foramen), while 18 upper second premolars (29%) had Type II configuration (two canals terminate in one apical foramen) comparing to only 3 teeth (4.8%) showed Type V configuration (one canal with two isolated apical foramina). Lastly, the least observed configuration was type IV with only 2 teeth (3.2%) two canals with two isolated apical foramina (Figure 2).

Table 2: Common Root Canal Morphology of the upper 2nd premolars

	One Apex		Two Apices		Three Apices	Fisher's Exact Test
	One Canal	Two Canals	One Canal	Two Canals		
One Root	39 (19.8%)	18 (9.1%)	3 (1.5%)	2 (1%)		.000
Two Roots			Two Canals	Two Canals		
			134 (68%)	1 (0.5%)		

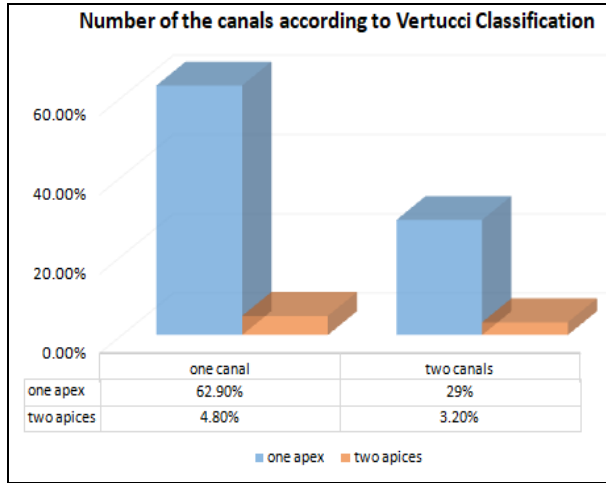


Figure 2: Root Canal Morphology of Vertucci Classification (the percentage taken as one root included only).

DISCUSSION:

Comprehensive information of a root as well as canal morphology and its variation is very important to a successful root canal treatment and cannot be overemphasized.^{21-23,28-29}

Maxillary second premolar is the unique tooth that demonstrates all Vertucci's canal configurations (8 Types). In addition, it shows an extensive variation in the number of roots and canals as showed in the literature. These variances may be owing to method of canal detection (IOPA radiographs, CBCT, etc.), study design or racial variation.²¹⁻²³

Even though in real dental practice, it may be challenging to distinguish these multi-morphological variations from IOPA radiographs that give a two-dimensional image of a three-dimensional object, an adequate knowledge and two IOPA radiographs taken at mesial angulation to one another (SLOB technique) will display a better image of canal morphology and hence a better treatment outcome.^{23,28,30}

The current study investigated the root canal configuration of the upper second premolar in patients attending Ajman University for RCT in term of number of the roots and canals. An attention-grabbing remark is that our study revealed that 31.5% of teeth exhibited a single root while 68.5% had two roots, which is at variance with the study of Muna et al. in 2014 who found that 55.3% of teeth possessed one root, whereas 44.2% possessed two roots.²³ Another study in 2016 by Mutasim et al. found in his research that 67% of teeth exhibited a single rooted morphology, 30% had dual roots, and lastly 3% had three roots.⁴

Interestingly, there have been many conflicting observations in relation to the root morphology of the upper 2nd premolar. In Mahmoud Torabinejad's textbook "Endodontics: Principles and Practice", he found that a single root is seen in 88% of the possessed teeth, of which one canal is dominant in about 53%,³¹ which does not coincide with the current study that documented significantly high incidence rate of two roots in the maxillary second premolar.

Analysis of current study reveals that most of the upper 2nd premolars reported with two canals (78.7%) comparing to only (21.3%) reported with one canal. Which coincides with earlier studies in which the frequency of two canals in an upper second premolar varies between 57% and 85.7% (Khurram et al. 2007, Udayakumar et al. 2010, Mutasim et al. 2016, A. Oginni 2004, Muna et al. 2014).^{4,23,28-29,32}

The commonness of the existence of apical deltas in permanent teeth showed a wide variation.³¹ Deltas are frequently present in mandibular and maxillary second premolars as well as mandibular lateral incisors.⁵ The frequency of apical deltas in the current study was only one premolar that had three apices (0.5%), which is much lower than that reported by Mutasim et al. who observed apical deltas in 7% of teeth in the a previous study.⁴

Moreover, a number of articles stated the likelihood of getting three separated canals in a maxillary upper premolar, with numbers ranging from 0 to 2% of examined upper 2nd premolars (Vertucci et al. 1974; Weng et al. 2009; Pecora et al. 1993; Jayasimha Raj and Mylswamy, 2010).³²⁻³⁵ A more recent analysis done by Mutasim et al. in 2016 reported a 5% incidence of three canals,⁴ which is greater than results that reported in past studies.²³⁻³⁵ However, in our study, we did not find three canals in any of the 197 cases we have checked. Plentiful factors contribute to the inconsistencies in all the present results may be described by the variations in sample size selection, ethnic population, and analysis techniques and methods among the former studies.³⁵

Regarding canal configuration, in the current investigation, and based on the classification of Vertucci, four different canal configurations were observed,³³ most of the observed patients had Type I configuration, followed by Type II, V, IV, respectively. This result comes in agreement with a study done in Nigeria²⁸ in which they clearly stated the four types of Vertucci classification, comparative evaluation of the classification observed by other study in a Saudi population, in which most patients observed had Type IV configurations, followed by Type I, then Type II, and lastly Type VII.³⁶ In contrast to further similar work

included in the literature in Saudi population as well,³⁷ although Type IV root canal configuration still stated to be 65.3% in Saudi population, the incidence of the remaining classification were difference in which type IV followed by Type II configuration (19.7%), then followed by Type I (7.6%), Type III (3.3%), Types V, VI, and VII, respectively, and lastly Type VIII (0.8%).

An exhaustive understanding of a root canal morphology and its normal variations is an important prerequisite for endodontic treatment success.²² Occasionally endodontically treated tooth might be unsuccessful for the reason that the Dentist fails to identify all the canals existing in the accused tooth.³⁸

Moreover, the variances of the total number of canals and roots of the upper second premolar displays in the literature may be owing to the study proposal (clinical studies as opposed to lab work), mode of each canal discovery (radiographical presentation, extracted tooth sectioning and investigation under the microscope or Scanned Electron Microscope (SEM), using canal staining elements and root clearing, or for more clinical accuracy the use of cone-beam computed tomography techniques (CBCT)), or actual differences in the selected population to represent a specific study (ethnic variation).²¹⁻²²

CONCLUSION:

Clinicians should put on mind while doing RCT of the upper second premolar that the majority of this tooth has two canals, and the internal anatomy is highly complex and variable. The eight likely configurations of Vertucci's classification is quiet common, and once spotted or suspected while evaluating the mesial/distal shift IOPA radiograph, a CBCT radiograph is advised as it will provide a definitive image of the internal complexity of that tooth. Therefore, a careful evaluation is to be considered each time root canal treatment is planned for those teeth. Moreover, further investigations with more sample sizes and more variability (gender, age range and ethnic variation) are recommended to insure the validity of our results.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE:

The current Study was permitted by Ethical Committee of Ajman University, Ajman, United Arab Emirates on December 11, 2019. (Reference Number D-F-H-2019-Nov-28)

HUMAN RIGHTS:

All research procedures on humans were followed in agreement with the ethical standards of the committee responsible for human experimentation, and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

All the participants of the study signed a general dental consent form.

CONFLICT OF INTEREST:

The authors state no conflict of interest, financial or otherwise.

AVAILABILITY OF DATA AND MATERIALS:

The datasets analyzed during the present study are available from the corresponding author upon request.

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