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Research Article

Cone-Beam Computed Tomographic Analysis of Middle Mesial Canal and Isthmi in Mesial Root of Mandibular First Molars

Shahzad Ali Shah[1]* and Aamir Mehmood Khan[2]

[1]*Associate Professor and Classified Consultant, Restorative Dentistry, Alrass Dental College, Qassim University, Saudi Arabia*

[2]*Assistant Professor, Department of Operative Dentistry, Khyber College of Dentistry, KPK, Pakistan*

***Corresponding Author:** Shahzad Ali Shah, Associate Professor and Classified Consultant, Restorative Dentistry, Alrass Dental College, Qassim University, Saudi Arabia.

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Abstract

Aim: The aim is to study the prevalence of middle mesial (MM) canal and root canal isthmi (RCI) in the mesial root of mandibular first molar by retrospectively analyzing cone-beam computed tomography (CBCT) images in vivo in selected Pakistani community and to analyze its root canal morphology using Vertucci canal classification.

Methodology: CBCT images of 120 cases with the age group of 13 - 65 years were selected. Findings of MM canals and isthmi were recorded along with variables such as age and sex. Canal morphology was determined using Vertucci canal classification. The CBCT unit used in this study was Planmeca Promax 3D Mid Model 5.1.0.R (Planmeca Oy, Helsinki, Finland) with an isotropic Voxel size of 70 - 400 micrometer and FOV of Ø42 x 50 mm. The data was recorded and analyzed using statistical package of social sciences version 16.0.

The internal anatomy of mesial root of mandibular first molars has been studied in depth in different populations. However, limited information is present in differentiating a true middle mesial (MM) canal from an isthmus.

Results: Of the 120 mandibular first molars, one mesial root with two canals was the most common canal morphology (99.2%). In 1 (0.8%) case, true MM canal was observed in the mesial root. Vertucci canal configuration type IV and type V were the most common configuration in mesial root of mandibular molars consisting of 58.3% and 12.5% of all cases respectively. The RCI were found to be 29.2% of the cases.

Conclusion: Prevalence of MM canal in the mesial root of mandibular molar in this study was significantly low. The presence of root canal isthmi in the main roots of any multi-rooted tooth is one of the major causes of root canal failure. Therefore detecting and cleaning these areas is of prime importance in non-surgical/surgical endodontics.

Keywords: *CBCT; Root Canal Isthmus; Mandibular First Molar; Middle Mesial Canal; Canal Morphology*

Introduction

Endodontics is defined as the prevention and/or treatment of periapical periodontitis. Root canal anatomy is a complex entity. The main objective of root canal treatment is to get rid of the infection and have a good apical and coronal seal with an appropriate coronal restoration. Failure to achieve thorough cleaning and shaping followed by three-dimensional obturation usually causes root canal treatment failure [1]. Clinicians should be aware of the anatomical variations to achieve desired results. Although the etiology of failure in endodontic treatment is multifactorial, inability to identify and debride all the existing canals and/or isthmi is one of the main causes that

can negatively affect a successful outcome [2]. It has been shown that there is a strong relationship between the presence of untreated canal space and apical periodontitis [1,2]. Therefore, a thorough knowledge of the internal root canal anatomy is required to achieve the main objective of endodontic treatment, to prevent or heal apical periodontitis [3]. However, the variability in number and configuration of the canals and hence their clinical identification can pose some challenges and prevent the clinician from achieving this goal.

Many studies have investigated the morphology of the mesial root of first mandibular molars, but the prevalence of the middle mesial (MM) canal and/or isthmi are a subject of controversy till date. Various methods have been used for detection of the MM canal, and the frequency with which the canal was observed ranges between 0% [4] and 46.2% [5]. Pomeranz., *et al.* defined the MM canal as either a fin, confluent, or independent canal between the mesiobuccal (MB) and mesiolingual (ML) canal [6]. However, in this definition, a true canal is not clearly distinguished from an isthmus between the MB and ML canals.

Therefore, the objectives of this study were 2-fold:

1. To identify the prevalence of a true MM canal and root canal isthmi in the mesial root of mandibular first using cone-beam computed tomographic (CBCT) images obtained from Patients visiting Radiology department of Khyber college of Dentistry, Khyber Pukhtunkhwa, Pakistan.
2. To analyze the root canal morphology of the mesial root of mandibular first molars using Vertucci canal classification.

Materials and Methods

The study was reviewed and approved by the institutional review board and the ethical committee of the college. CBCT images of 120 cases were randomly selected from the database of the radiology department between January 1, 2018 to July 2018, as part of a dental examination for diagnosis and treatment planning purposes. All the images were small field of view (FOV). The CBCT unit used in this study was the Planmeca Promax 3D Mid Model 5.1.0.R (Planmeca Oy, Helsinki, Finland) with an isotropic Voxel size of 70 - 400 micrometer and FOV of Ø42 x 50 mm. Exposure parameters were 90 - 120 kVp and 6.3 mA. The CBCT images were viewed with Planmeca Romexis viewer Software model 5.1.0.R (Planmeca OY.) on Lenovo Professional Intel(R) Core™ i5-4200M workstation (Lenovo Inc) using windows 7 ultimate service pack 1 and 43-inch light emitting diode monitor with a resolution of 1920 - 1080 pixels in a dimly lit room. The window/level of the images was adjusted using the image processing tool in the software to ensure optimal visualization. Three observers, an Assistant Professor in operative dentistry, a classified consultant restorative dentist and a consultant in Radiology, were examining the images; results were calibrated based on the criteria and variants established before the evaluation session. All images were analyzed simultaneously to reach a consensus for the interpretation of the radiographic findings. Multiplanar images were examined individually and in a sequential fashion in all 3 dimensions, and findings were correlated across these images to arrive at a conclusion. Based on a previous study [6], a sample calculation was performed using 95% confidence intervals (Figure 1).

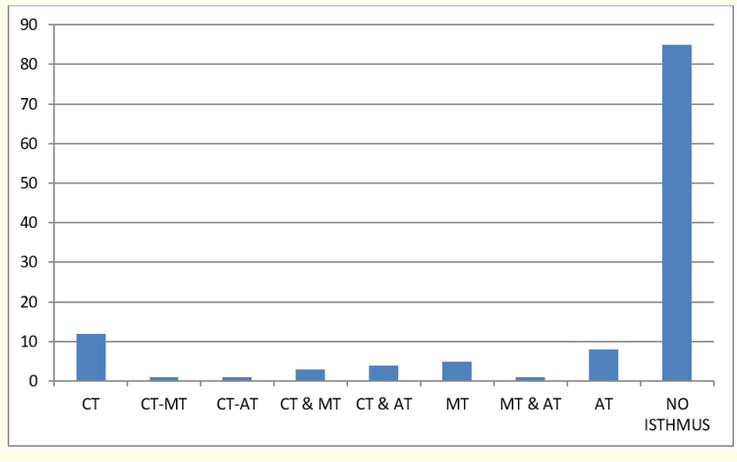

Figure 1: *Frequencies of root canal isthmi in human mandibular first molars (95% confidence interval).*
Mean: 8.41
Std Dev: 3.014
N = 120.

The inclusion criteria consist of asymptomatic, vital first mandibular permanent molars with no previous root canal treatment and/or full-coverage restoration. Teeth with open apices, root resorption, or calcification were excluded from the study. All teeth were analyzed using 3 planes (sagittal, axial, and coronal). During examination of the teeth, the number of roots, the number of root canals in the mesial root, and the configuration of the root canal system in the mesial root were determined according to Vertucci classification of canal configuration and recorded. In addition, patients were classified into 4 age groups: < 20, 21 - 40, 41 - 60, and > 60 years.

Root canal isthmus detection

RCIs were recorded when scanning showed a narrow (ribbon shaped) communication between 2 root canals on an axial image, a mesiodistal or buccolingual projection of a root canal measuring about one-third of the main canal, or a C-shaped root canal. The presence or absence of RCI in each tooth was analyzed by using a modified version of map-reading strategy described in a previous study [7]; examination followed longitudinally in the axial plane from the pulp orifice to the root apex with 0.4 mm slices each (Figure 2).

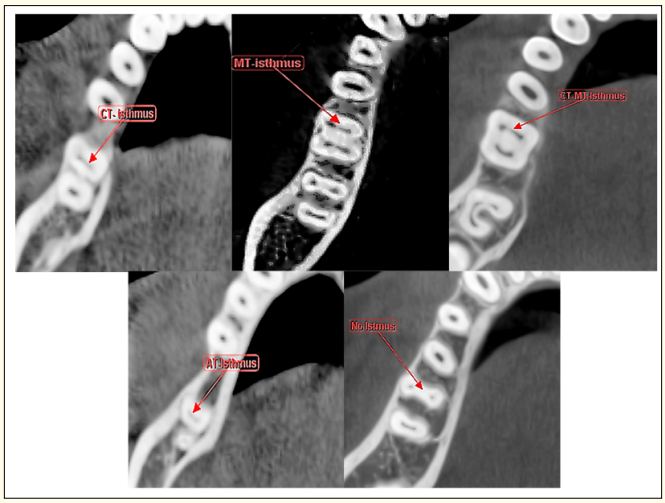

Figure 2: *RCI at different levels of the axial plan (CBCT).*

In the axial view, an isthmus was recorded when a narrow ribbon-shaped communication was visualized between the MB and ML canals. The MM canal was recorded when a radiolucency with a distinct round cross section was visualized between the MB and ML canals regardless of the presence or absence of an isthmus. The presence or absence of root canal isthmus in each tooth was recorded according to its beginning and end, into 10 different categories [7]:

1. At the cervical third only (CT)
2. Begin at cervical third and continuous to middle third (CT-MT)
3. Begin in the cervical third and continuous to apical third (CT-AT)
4. Cervical third and middle third separately (CT and MT)
5. Cervical third and apical third separately (CT and AT)
6. At the middle third only (MT)
7. Begin at Middle third and continuous to apical third (MT-AT)
8. Middle third and apical third separately (MT and AT)
9. At the apical third only (AT)
10. No Isthmus.

After data collection, data entry and analysis was performed with the help of Statistical Package for Social Sciences (SPSS) version 16.0 (SPSS Inc, Chicago, IL).

Result

Of the 120 mandibular first molars, one mesial root with two canals was the most common canal morphology (99.2%). In 1 (0.8%) case, three canals were observed in the mesial root. All the Vertucci Canal configurations were present except I and VII. Age of the patients was divided into three groups (group 1 < 20 years, group 2 21 - 40 years, group 3 41 - 60 years) (Table 1).

Age of the patient	Frequency	Percentage (%)
< 20 years	23	19.2
21 - 40 years	80	66.7
41 - 60 years	17	14.2
Total	120	100%
Mean ± SD = 29.64 ± 10.44		

Table 1: *Distribution of age of the patient.*

Of the 120 mandibular molars, in group 1, 23 (19.2%) teeth had two mesial canals, in group 2, 80 (66%) had two canals and in group 3, 16 (13.3%) had two canals and 1 (0.8%) tooth had three canals. In different age groups, the Vertucci classification was found to be, type II were 21 (17.5%), type III 11 (9.2%), type IV 70 (58.3%) and type V were 15 (12.5%) respectively (Table 2).

Vertucci canal configuration	Frequency	Percent (%)
Type ii	21	17.5
Type iii	11	9.2
Type iv	70	58.3
Type v	15	12.5
Type vi	2	1.7
Type viii	1	.8
Total	120	100.0

Table 2: *Vertucci Classification of canal configuration (mesial root 1st molar).*

The presence of root canal isthmus in mandibular first molars was detected in 29.2% in this study. In cervical third of the mandibular first molars, the RCI observed were about 10%, CT and MT was 2.5%, CT and AT was 3.3%, MT was 4.2% and apical third (AT) was observed 6.7% (Figure 1).

Discussion and Conclusion

Different research techniques were used in the past to evaluate the root canal morphology of mandibular molars with some advantages and drawbacks. The methods which are used in different *in-vitro* studies include casts [8], chemical staining and clearing techniques [9], a DOM [10], different imaging methods [11,12]. Some of these techniques allow a thorough analysis of fine details of the root canal system, but because of the possibility of previous endodontic/periodontal disease, root canal calcifications and pulp stones, extracted teeth may not present a healthy canal system of human teeth. The classification published by Zhang., *et al.* [5] was used for this study because it includes a comprehensive classification that is based on Vertucci [13] combined with modifications to incorporate current 3-dimensional imaging technology. Of the 120 patients, true middle mesial canal was found in 0.8% of cases and the root canal isthmi were found in 29.2% of the cases, which is in sharp contrast to the study conducted by Tahmasbi., *et al*. In which MM canal was detected in 16.4% of the cases and root canal isthmi were detected in 64.7% of the cases [14].

We found in this study that the 0.8% and 11.6% of the true MM canal and RCI are started in the cervical third respectively. Therefore, in total 12.5% of the cases has space between ML and MB canal (either in the form of true canals or isthmus). This finding is significantly low as compared to the study conducted by Azim., *et al.* [15] in which true MM canals were found in 46% of cases under magnification after troughing in the mesial root for up to 2 mm depth.

Due to the complexity of the root canals in the middle and apical third, cleaning and shaping becomes a real challenge. The apical third of the canal is of significant importance in terms of mechanical/surgical therapies and pathological reasons [16]. A finding of this study shows that only 6.7% of the cases has isthmus in the apical third and that may be amenable to separate exit in the apex. The untreated canals and isthmi are covered with biofilm or even further clogged with bacteria in endo treated cases. Also, if not properly accessed mechanically/surgically, these areas cannot be disinfected chemically. Therefore irrespective of the presence of MM canal or isthmus, it is recommended to instrument and irrigate these areas thoroughly.

In addition, the Vertucci classification of root canal morphology, type IV and type V is the most common configuration in mesial root of mandibular molars and consist of 58.3% and 12.5% of all cases which coincides with the previous studies [8-10].

The presence of root canal isthmi in one of the main canal of any multi-rooted tooth is one of the major causes of root canal failure. Therefore detecting and cleaning these areas is of prime importance in non-surgical/surgical endodontics cases.

Acknowledgements

The authors deny any conflict of interest related to this study.

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