Cone Beam Computed Tomography for Exploring Morphology of Mandibular First Molar

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Authors’ contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

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ABSTRACT

Aims: The root canals have complex morphology and vary widely among individuals variations. The objective of this research was to analyse the morphology of root canals and existence of extra canals in mandibular first molar in subpopulation of Al-Medina Al-Munawwarah.

Study Design: Experimental/Analytical.

Place and Duration of Study: College of dentistry, Taibah University, Madinah Munawwarrah, Saudi Arabia, 2014.

Methodology: This study was conducted using freshly extracted mandibular first molars (n=100). All teeth were examined for morphology of roots, root canals and apical foramen by Cone Beam Computed Tomography (CBCT). The root canals configuration was classified using Vertucci's classification.

Results: All mandibular first molars (100%) had two distinct and clearly separated roots. There was a high probability of two canals (92.5%) in mesial root compared to the distal root that contain two canals only in 20% of teeth. There was no occurrence of more than two roots or more than two canals in any of the roots in the selected teeth. The majority of distal roots (80%) had single canal with type I canal configuration followed by type III (10%), type V (7.5%) and type II (2.5%). The mesial roots presented comparatively complex canals configuration. Type I canal configuration was

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observed in only 7.5% teeth. The incidence of C shaped canals was very low (2.5%).

**Conclusion:** The occurrence of single rooted mandibular first molars as well as supernumerary roots is very unlikely. The incidence of two distinct canals in mesial root is high (>92%), however distal roots mainly represented one canal (80%).

**Keywords:** C shape canals; Vertucci's classification; tooth anatomy.

**1. INTRODUCTION**

The knowledge of tooth roots and canals anatomy is crucial for the successful endodontic treatment. The morphology of root canals of any tooth may vary vastly and differs among different ethnic populations or different individuals within the same ethnic group [1]. Thorough cleansing of the entire root canal system using mechanical and chemical means is an essential requirement for endodontic treatment [2]. Lack of knowledge and information regarding roots anatomy may result in certain canals being undetected and increasing the chances of endodontic treatment failure [3]. The significance of tooth anatomy has been evident since 1902 and details were first published by GV Black [4].

The lower first molar appears in the oral cavity at six years of age [5]; exposing it for earlier decay and operative interventions in dental clinics. The anatomical pattern of tooth root canals represents unique features and has been studied in details [2]. Mandibular first molar has two distinct roots (mesial and distal); the mesial root is widened in buccolingually and likely to contain two canals [6]. However, the distal root may contain either one wider oval canal or two (distobuccal and distolingual) round shape canals [7]. The existence of additional (distolingual) root canal varies remarkably among different subpopulations [8-12]. For example, the incidence of distolingual canal in Caucasians has been reported 0.7-4.2% [8,13] that is remarkably lower than its incidence (5.9-32%) in Mongolians, Chinese and American Indians [10,14]. A lot of research has been published [1,15-22] regarding mandibular first molar root canals morphology in various ethnic groups, using diverse methods, and approaches. Some commonly used methods to analyze the root canal morphology are solution staining [2,23], radiation techniques [24,25] and more recently introduced cone beam computed tomography [15-18,20,26-33].

Cone beam computed tomography (CBCT) was introduced in the field of endodontics in early 1990s [34]. CBCT is a method that uses an exclusive beam to yield three dimensional (3D) images to disclose anatomic details accurately [35,36]. The major benefits of using CBCT are that it is noninvasive and facilitates 3D reconstruction of the complete root canal system [29]. The tooth root morphology differs among various ethnic subpopulations [15-18,37,38].

There are only a few research papers available for tooth root morphology in Saudi subpopulations. The objective of this research was to describe the variants in the morphology of root canal system of the mandibular first molar in Saudi subpopulation residing in Al Madinah Al Munawarah using cone beam computed tomography.

**2. MATERIALS AND METHODS**

**2.1 Sample Selection**

This study was conducted using freshly extracted mandibular permanent first molars (from residents of Al-Medina Al-Munawarah, Saudi Arabia; age; 20-60 years; n=100). The reason for extraction and patient's gender was not recorded. All teeth were examined gently to ensure the presence of intact roots and mature apices. Teeth with incomplete, broken or resorbed roots or obturated canals were excluded from the study. In order to remove any debris or attached tissue remnants, all teeth were cleaned and disinfected using 5% sodium hypochlorite solution for a day and washed using vigorous amount of ultrapure water. Teeth were kept in the normal saline medium while waiting for further experimentation.

**2.2 Image Acquisition**

Cone beam computed tomography (CBCT) acquisition of specimens was operated by Kodak 9000c 3-D system. The extraoral imaging machine and 3-DKodak Dental Imaging software (KDIS; version 1.3) were used. The manufacturer's guidelines were followed throughout the procedure. All images were obtained using parameters set at voltage of 80 kV, exposure time of thirty seconds at 5.0 mA current and using a 14-bit grey scale voxel size (76 x 76 x 76 μm). The entire CBCT imaging
procedure was carried by a registered dental radiologist following the ALARP (As Low As Reasonably Practicable) protocol.

The CBCT data interpretation was performed using an Imaging software (CS 3D; Care stream Health, Inc., 2011) and a 21 inches flat screen (Samsung Seoul, Korea; resolution 1440 x 900 pixels). The contrast function was regulated and the magnifying device was activated when required. The X and Y cursors were used for horizontal and vertical orientation of CBCT images of teeth. In order to survey the anatomy of the roots and canals of mandibular molars from the axial plane, Z cursor was moved slowly (1 mm interval) in cervico-apex direction. All of the images were evaluated distinctly by two operators and any disagreement was discussed until a consensus was reached. All images were analyzed cautiously for roots (number), number and configuration of canals and apical foramina. In order to classify the root canal morphology, Vertucci’s [2] classification (Fig. 1) was used as a reference. Data interpretation was performed using SPSS software (version 19).

### 3. RESULTS

All mandibular first molars (100%) included in this studied had two distinct and clearly separated roots (Fig. 2). There was a high probability of two canals (92.5%) in mesial root compared to the distal root that contain two canals only in 20% of teeth (Table 1).

<table>
<thead>
<tr>
<th>Number of roots</th>
<th>1 root</th>
<th>2 roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distal root</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>Mesial root</td>
<td>7.5</td>
<td>92.5</td>
</tr>
</tbody>
</table>

The majority of distal root presented with only one canal (80%) and only 7.5% of mesial root exhibited one canal. There was no occurrence of more than two roots or more than two canals in any of the roots in the selected teeth. The canal configurations of individual roots of the mandibular first molars were analyzed on the basis of the Vertucci's classification (Fig. 1). The majority of distal roots (80%) had single canal with type I configuration (Table 2). The canal configurations of remaining 20% were type III (10%), type V (7.5%) and type II (2.5%).

The mesial roots presented comparatively complex canals configuration; single canal configuration (Vertucci's type I) was observed in only 7.5% teeth whereas type II, III, IV and type V were observed in 30%, 20%, 27.5% and 12.5% teeth respectively. The type VI was reported only in 2.5% teeth and there was no incidence of type VII and type VIII in either mesial or the distal root. The incidence of C shaped can was very low (2.5%).

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**Table 1. Number of roots and canals (%) in mandibular first molar**

<table>
<thead>
<tr>
<th>Number of roots</th>
<th>1 root</th>
<th>2 roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distal root</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>Mesial root</td>
<td>7.5</td>
<td>92.5</td>
</tr>
</tbody>
</table>

**Vertucci 1984**

<table>
<thead>
<tr>
<th>Type1</th>
<th>Type2</th>
<th>Type3</th>
<th>Type4</th>
<th>Type5</th>
<th>Type6</th>
<th>Type7</th>
<th>Type8</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
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</tr>
</tbody>
</table>

**Fig. 1. Vertucci's criteria for the classification of root canal morphology**
Table 2. Root canal configuration of mandibular molar (%)

<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
<th>Type V</th>
<th>Type VI</th>
<th>Type VII</th>
<th>Type VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distal</td>
<td>80</td>
<td>2.5</td>
<td>10</td>
<td>0</td>
<td>7.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mesial</td>
<td>7.5</td>
<td>30</td>
<td>20</td>
<td>27.5</td>
<td>12.5</td>
<td>2.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C shape</td>
<td>2.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Fig. 2. External anatomy of a typical mandibular first molar and corresponding CBCT images at various corono-apical levels exploring the internal morphology.
4. DISCUSSION

This study provides a detailed report on root internal morphology and anatomy of mandibular first molars in Al Madinah Al Munawarah subpopulation. Mandibular first permanent molars are generally described as two rooted teeth with three canals [2]. In this study, 100% of the first mandibular molars were with two roots (mesial and distal) agreeing with previous studies [39,40]. There was no third root in the sample of this study. The prevalence of supernumerary roots in first lower molar is generally very low. It has been reported below 3% in the African populations, below 5% in Asian and Eurasian populations, 4.2% in whites, and greater than 5% in populations with Mongolian traits [11]. However, in East Asian populations, a high prevalence of an additional distolingual (DL) root or DL canal has been reported in several studies [12,14,41]. Similar results have been reported for the Taiwan’s population and determined the occurrence of a third root to be greater than 20% [12,14,42]. The number of roots in the mandibular molars varies based on the ethnicity of the populations studied. In the Mongoloid, Native American, Eskimo, and Chinese population, the presence of a third root should be considered a normal anatomical variation [43]. The current study reported no mandibular first molar with supernumerary or extra roots.

In this study, the mesial root contains two canals in 92.5% and these findings are in agreement with Al-Qudah et al. [44] and Chen et al. [12]. Many researchers [7,45,46] have reported the occurrence of two canals in the mesial root. We didn’t find middle mesial canal while its incidence has been reported as high as 14.8% [47]. While the distal root contain single canal in 80% of cases and 20% of cases contain two canals. Such variations in the root canals pattern are very much expected. The variation in number of canals in mandibular first molars was reported as following: 61.3% teeth contain three canals, 35.7% contain four canals, and only 1% exhibited five canals [43]. In the current study, the canal configuration for the mesial roots was type II (30%) mainly followed by type IV (27.5%). In contrast, other researchers [48-51] have reported that type IV (~52%) is the most frequent configuration followed by type II (~35%). The canal configurations of mandibular first permanent molars reported in the literature vary on the basis of the different ethnic populations and different methods used [2,12,41]. In a recent systematic review [43], the mesial root of lower first molar has been described to present two canals. Types II and IV were the most frequent configurations. The presence of a third canal, known as middle mesial, was found to have an incidence of 2.6%. Several authors suggest modifications of the access preparation to enhance the diagnosis and exposure of this canal [43].

The root canal morphology of distal root was mainly type I (80%) followed by types III (10%), type V (7.5%) and type II (2.5%). The incidence of type I configuration in the distal tooth was significantly higher than reported in other ethnic populations. The reported root canal system configuration was type I (62.7%), followed by types II (14.5%) and type IV (12.4%) [48,49,52]. The most common configuration in the distal root is type I with 62.7%, followed by type II with 14.5% and type IV with 12.4% [43]. The incidence of C shape canals in the lower molars varies depending on ethnic origin and remains 2.7% to 8.0% [53]; however, it’s more frequent in Asian population than other races [54-56]. The use of a dental operating microscope has proved to be another important aid because it has helped tremendously in locating additional canals [57].

5. CONCLUSION

The occurrence of single rooted mandibular first molars as well as supernumerary roots is very unlikely in the subpopulation of Al Madinah Al Munawarah. The incidence of two distinct canals in the mesial root is high (>92%), however distal roots mainly represented one canal (80%). A very low incidence of C shaped canals (2.5%) was observed.

CONSENT

Not applicable.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.
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