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Middle Mesial Canal in Mandibular First Molars: A Micro-CT Study

Selen Kucukkaya[1], Emre Nagaş[1], İlkan Tatar[2], Hamdi Celik[2] and M Ömer Görduysus[1,3]*

[1]*Department of Endodontics, Hacettepe University, Turkey*

[2]*Department of Anatomy, Hacettepe University, Turkey*

[3]*Department of General and Specialist Dental Practice, University of Sharjah, United Arab Emirates*

***Corresponding Author:** M Omer Gorduysus, Department of General and Specialist Dental Practice, University of Sharjah, College of Dentistry, United Arab Emirates, Department of Endodontics, Faculty of Dentistry, Hacettepe University, Ankara, Turkey.

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Abstract

Objectives: The aim of this study was to investigate the presence and the incidence of a third canal in the mesial root of permanent mandibular first molars by using microcomputed tomography (micro-CT) and to describe the morphology of mandibular first molar's root canal anatomy.

Methods: A total of 100 extracted mandibular first molars were randomly collected. Teeth were scanned by using micro-CT device (SkyScan 1074, Aartselaar, Belgium). These images were reconstructed three-dimensionally by using software NRecon (SkyScan 1074, Kontich, Belgium). After constructing, three-dimensional images exhibiting the shape of the roots were analyzed by using 3D-Doctor software programme (v.3.5 Able Software Corp, Lexington,MA). Thereafter, the number of the middle mesial canals, were evaluated.

Results: The results of this study indicate that a middle mesial canal present in 12% of mandibular first molars. Among these middle mesial canals two were independent canals, ten were confluent canals.

Conclusion: Micro-CT is a promising research tool for three dimensional evaluation of tooth morphology and provides detailed information on the configuration of root canals. In this study, 12% of mandibular first molars had a middle mesial canal which is significantly important from a clinical point of view. The possibility of additional canal in the mesial root should be anticipated in mandibular first molars.

Keywords: *Dental CT; Accessory canals; Mandibular molars; Micro CT; Root canal morphology*

Introduction

The mandibular first molar is one of the earliest permanent posterior tooth that erupts to mouth and often requires root canal treatment [1]. It is imperative to have a thorough knowledge of root canal anatomy of mandibular first molar teeth in order to improve treatment outcome. Mandibular first molars usually have two roots located one in mesial and one in distal. The usual and widely known canal distribution is two canals in the mesial root and one or two in the distal root [2]. On the other hand, a number of clinical studies reported the presence of more than two canals in the mesial roots of mandibular first molars [3-6]. An independent middle mesial (MM) canal with its own access orifice and apical foramen was first described by Vertucci & Williams [7] and by Barker *et al.* [8]. Various research with different methodologies have shown MM canal has an incidence rate of 0% to 14.8% in the mesial root of mandibular first molars (Table1).

Author	Year	Method	Number of Teeth	%
Skidmore & Bjorndal [2]	1971	*In vitro* (plastic cast)	45	0%
Pineda & Kuttler [9]	1972	*In vitro* (radiographs)	300	0%
Vertucci & Williams [7]	1974	*In vitro* (clearing technique)	100	1%
Pomeranz [10]	1981	*In vivo* (radiograhs)	100	12%
Martinez-Berna & Badanelli [11]	1983	*In vivo* (radiographs)	1418	1.5%
Fabra-Campos [12]	1985	*In vivo* (radiographs)	145	2.1%
Walker [13]	1988	*In vitro* (radiographs)	100	1%
Fabra-Campos [14]	1989	*In vivo* (radiographs)	760	2.6%
Goel [15]	1991	*In vivo* (radiographs)	60	13.3%
Caliskan [16]	1995	*In vitro* (clearing technique)	100	3.4%
Wasti [17]	2001	*In vitro* (clearing technique)	30	3.3%
*Gulabivala [18]	2001	*In vitro* (clearing technique)	139	10.8%
*Gulabivala [19]	2002	*In vitro* (clearing technique)	118	6.8%
Villegas [20]	2004	*In vitro* (clearing technique)	63	5%
*Sert [21]	2004	*In vitro* (clearing technique)	200	4%
Navarro [3]	2007	*In vitro* (CT)	27	14.8%
Navarro [3]	2007	*In vitro* (SEM)	25	12%
*Gu [22]	2010	*In vitro* (micro-CT)	45	2.2%
* Wang [23]	2010	*In vivo* (CBCT)	410	2.6%

Table 1: *Mandibular first molars with three mesial canals.*

**The percentages were calculated according to the root canal classifications given by authors.*

In their study, Vertucci and Williams [7] showed that 1% of specimens had MM canals. Later, Pomeranz *et al.* [10] presented an *in vivo* study identifying 12 MM canals out of 100 mandibular molars and among them eight were fins, two were confluent canals, and two were independent canals [10]. Additionally, Goel *et al.* [15] reported the incidence of the MM canals in mandibular first molars as 13.3% by using radiographs as methodology [15]. Conventional intraoral periapical radiographs provide important details such as the number of roots and root canals, the proximity of roots to the other anatomic structures, the severity of root canal curvatures, root resorptions or the calcifications in the root canal system. Yet, it has limitations to assess the root canal system completely. First of all, conventional radiography compresses three dimensional structures onto a two dimensional image which leads to almost neglecting the third (buccolingual) dimension [24]. Furthermore, geometric distortion and superimposition of structures are the potential negative consequences of conventional radiography [25,26]. Recently, micro-CT has come out as an efficient tool for the evaluation and detection of the root canal morphology. This promising technology provides noninvasive and three dimensional evaluation of the both external and internal morphology of a tooth. Though micro-CT is expensive and time-consuming, it seems to be an effective way to examine the numbers and the morphology of the root canals [27]. The aim of this study was to evaluate the incidence of MM canals in the mesial roots of mandibular first molars by using micro-CT.

Materials and Methods

Specimen selection and preparation

The sample consisted of randomly chosen hundred mandibular first molar teeth belonged to the patients who were Turkish and who were referred to Hacettepe University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery for extractions. Informed consents were obtained from all subjects.

According to the panoramic radiographs, the apices of teeth were fully formed and they had not been endodontically treated previously. Teeth were washed immediately after extraction and were stored in 10% formalin. After the collection was completed, the roots were cleaned to remove adherent hard and soft tissues.

Scanning

Acrylic models were prepared to ensure subsequent and precise repositioning of the specimens into the scanning system each time. Teeth were scanned twice at an isotropic resolution of 21 μm using a micro-computed tomography system (SkyScan 1174; Aartselaar, Belgium) at 60 kV. These images were reconstructed by using the NRecon software Program (SkyScan 1074; Kontich, Belgium) in order to obtain two-dimensional cross-sectional slices of the teeth structure, and they were saved in a TIFF format. NURBS-based 3-D modeling tool Rhinoceros was used for 3D modeling of the root canal system. The images obtained were saved in a STL format and finally the matched 3D images were transferred to Rhinoceros (McNeel, North America, Seattle, USA). The registered images were then processed to generate 3-D rendering of the external surface of the root and the internal root canal by using a 3D-Doctor software program (v.3.5 Able Software Corp; Lexington, MA). Thereafter the presence of the middle mesial canal, were evaluated by three examiners from the research team independently. These three examiners were already trained and experienced on micro-ct and oral radiology one of them was anatomist (PhD and Associate Professor) and two of them were endodontist (one of them PhD, specialist and professor and the other one PhD, specialist and assistant professor). All observations were performed independently after collecting the teeth on the same screen, pc and lighting conditions. Inter observer reliability test was done to statistically measure of inter-rater agreement (Cohen's Kappa coefficients).

Results

The results of this study indicate that a middle mesial canal present in 12% of mandibular first molars. Among these twelve middle mesial canals, two of them were independent canals. The other ten middle mesial canals merged with the mesiobuccal or mesiolingual canals. Figure 1 shows a three dimensional model of one sample which has a confluent middle mesial canal. The slices from cervical to apical of one of the independent canals can be seen in Figure 2. Figure 3 and 4 also show the slices for two other confluent canals of the samples. Inter observer reliability Kappa (K) coefficients was 0.98 and the result showed almost a perfect agreement.

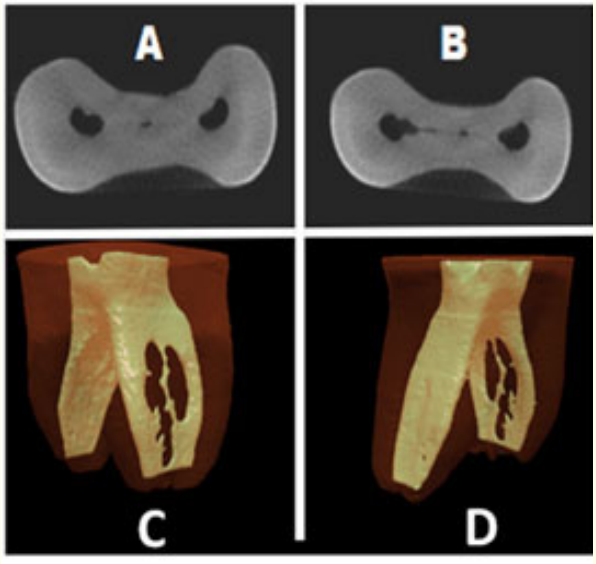

Figure 1: *Micro-CT images of a middle mesial canal A: Cervical, B. Apical. Three dimensional reconstruction C: Mesial aspect, D: Distal aspect of the middle mesial canal.*

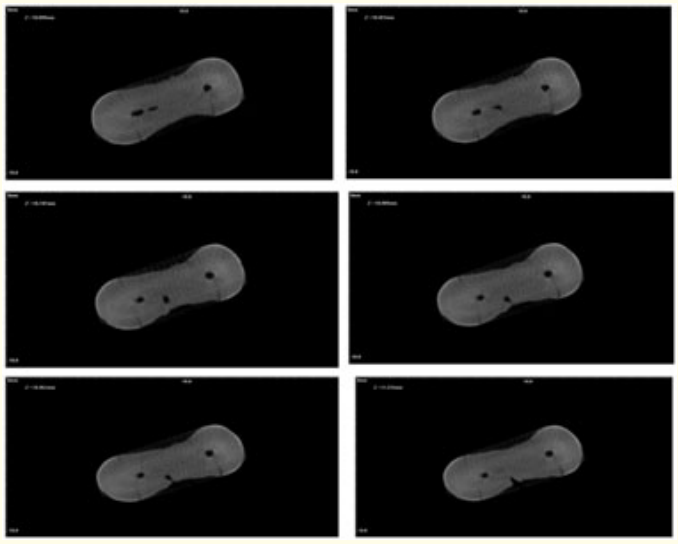

Figure 2: *Micro-CT images of an independent middle mesial canal. Slices from cervical to apical can be seen through A to F.*

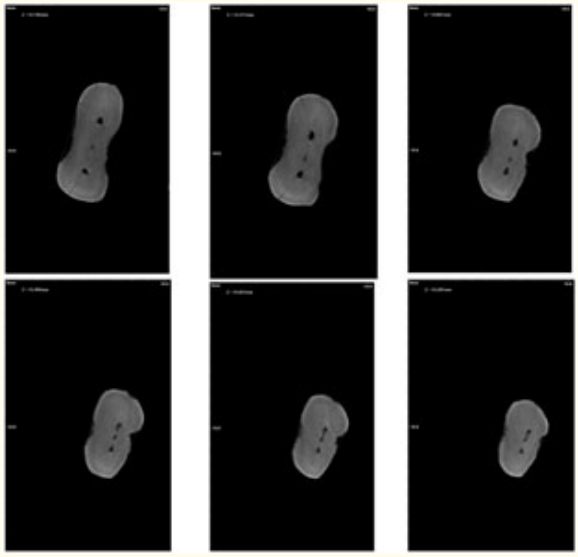

Figure 3: *Micro-CT images of a confluent middle mesial canal. Slices from cervical to apical can be seen through A to F.*

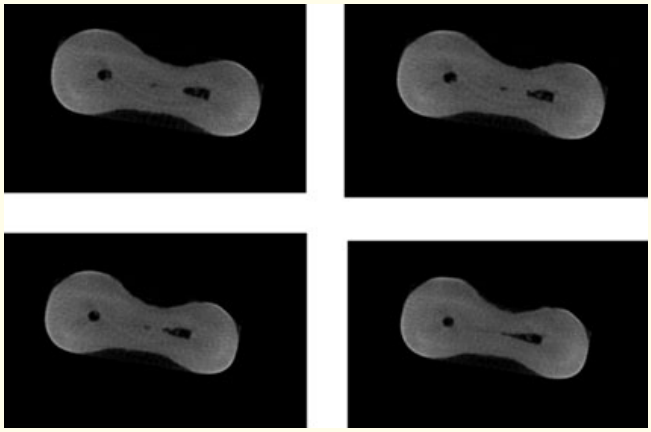

Figure 4: *Micro-CT images of a confluent middle mesial canal. Slices from cervical to apical can be seen through A to D.*

Discussion

The variability of the root canal system represents a challenge for diagnosis and treatment. The identification of the internal morphology as precisely as possible, is the primary step in the root canal treatment. Therefore, preoperative information about configurations and deviations of root canal morphology are crucial. In the present study, the incidence of a MM canal was 12% which is similar to those in previous reports [10,15]. Ethnic divergence, study design or the technique of canal identification may cause the different incidences in literature. For many years, only histology could provide precise information on morphology of root canal system. However, in a recent study it was showed that CT results were identical with histological findings [28]. Owing to CT scans, it is possible to examine samples in three dimensions without giving any damage to them. Micro-CT has gained significant development in this field by reducing the slice thickness from millimeters to micrometers [27]. Also, Micro-CT had showed significantly correlated results with histological sections in an animal study that analyzed the quantification of periapical bone destruction [29]. So far, Micro-CT has been used in anatomy studies to examine the measurements of hard tissues such as enamel, dentin or bone [30-32]. Also the changes after root canal instrumentation techniques has studied by micro-CT in different studies [33-35]. Nevertheless, despite its important role in endodontics the literature is limited for evaluation of MM canals by micro-CT. In 2010, Fan *et al.* [36] studied the isthmuses in the mesial roots of mandibular molars by micro-CT but MM canal was not mentioned in their study. Recently, Gu *et al.* [22] examined the root canal system of three rooted mandibular first molars by Micro-CT. According to them, only one tooth had MM canal out of their 45 mandibular first molar teeth. In the present study, our priority was to evaluate the incidence of the MM canals in mandibular first molars by micro-CT with relatively larger sample size. Despite the detailed images of Micro-CT, its application is limited to experiments. Unfortunately, this technology is not available for clinical use but for this purpose cone beam computed tomography (CBCT) systems can be considered. CBCT was showed to provide accurate measurements with relatively low radiation doses [37] and CBCT systems are commercially available for patient care. Even so, Micro-CT is a promising research tool to study dental anatomy.

In conclusion, we consider that the incidence of 12% for MM canals in mandibular first molars is not rare from a clinical point of view. To negotiate these canals, the area between mesiobuccal and mesiolingual canals should be explored carefully. Unless all canals are cleaned and shaped, the long term success of root canal treatment will be compromised. Therefore, the clinician should be aware of a middle mesial canal while performing an endodontic treatment in mandibular first molars. Consequently, we emphasize the evaluation of micro-CT images may result in better understanding of root canal anatomy which leads the clinician to search for these additional canals to clean, shape and obturate them efficiently.

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