A study of the distobuccal root canal orifice of the maxillary second molars in Chinese individuals evaluated by cone-beam computed tomography

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ABSTRACT

As is commonly understood, the root canal morphology of the maxillary molars is usually complex and variable. It is sometimes difficult to detect the distobuccal root canal orifice of a maxillary second molar with root canal treatment. No literature related to the distobuccal root canals of the maxillary second molars has been published. Objective: To investigate the position of the distobuccal root canal orifice of the maxillary second molars in a Chinese population using cone-beam computed tomography (CBCT). Material and methods: In total, 816 maxillary second molars from 408 patients were selected from a Chinese population and scanned using CBCT. The following information was recorded: (1) the number of root canals per tooth, (2) the distance between the mesiobuccal and distobuccal root canal orifice (DM), (3) the distance between the palatal and distobuccal root canal orifice (DP), (4) the angle formed by the mesiobuccal, distobuccal and palatal root canal orifices (∠PDM). DM, DP and ∠PDM of the teeth with three or four root canals were analyzed and evaluated. Results: In total, 763 (93.51%) of 816 maxillary second molars had three or four root canals. The distance between the mesiobuccal and distobuccal orifice was 0.7 to 4.8 mm. 621 (81.39%) of 763 teeth were distributed within 1.5-3.0 mm. The distance between the palatal and distobuccal orifice ranged from 0.8 mm to 6.7 mm; 585 (76.67%) and were distributed within 3.0-5.0 mm. The angle (∠PDM) ranged from 69. 4° to 174.7° in 708 samples (92.80%), the angle ranged from 90° to 140°. Conclusions: The position of the distobuccal root canal orifice of the maxillary second molars with 3 or 4 root canals in a Chinese population was complex and variable. Clinicians should have a thorough knowledge of the anatomy of the maxillary second molars.

Key words: Cone-beam computed tomography. Distobuccal root canal. Maxillary second molar. Root and canal anatomy.

INTRODUCTION

Successful root canal therapy is based on adequate debridement and complete obturation of the root canal system. It is commonly acknowledged that the failure of root canal therapy is caused by the inability to effectively treat all the canals of the root canal system[2]. Revealing the location of all canals has proven to be the most challenging aspect of adequately treating these canals. As is commonly understood, the root canal morphology of the maxillary molars is usually complex and variable. Countless studies focus on the second mesiobuccal root canal (MB2) because of its frequent involvement[1,6,13,18]. However, there are few reports about the other root canal variations. Concerning the second maxillary molar, it is now generally accepted that the most common form involves three root canals, while other conditions also involve 2 or 4 root canals. Because the position of the maxillary second molars is at or near the end of the dentition, it is difficult to detect all the canals and to subsequently finish the cleaning and obturation. For the distobuccal root canal, it was

sometimes not possible to confirm its existence. Even though it exists, the orifice of the distobuccal root canal is difficult to find in some cases, especially when it is covered by excess dentinal growth. It is therefore essential for the clinicians to have a thorough knowledge of the distobuccal root canal associated with the maxillary second molar.

Thus far, the clinical methods used to diagnose and analyze root canal morphology include conventional radiographs, digital radiographic techniques and more recently, computed tomography[5,12]. However, there is no ideal technique because each has its own drawbacks.

The cone-beam computed tomography (CBCT) technique was introduced in the endodontic field in 1990[17]. It uses a cone-shaped beam of radiation to acquire image data in a 180°-360° rotation, which reveals the three-dimensional configuration of an object, thereby helping the clinician to view the morphologic features from three-dimensional perspectives. The ability of CBCT to reduce or eliminate the superimposition of the surrounding structures makes it superior to conventional apical films or digital ones[4,16]. Ozer, et al.[11] (2010) used CBCT to detect the vertical root fractures of different thicknesses in endodontically treated teeth. Blattner, et al.[3] (2010) evaluated the efficiency of CBCT to identify the MB2 canals in extracted maxillary first and second molars and concluded that CBCT is a reliable method to detect MB2 when compared with the gold standard of physical sectioning of the specimen. Kottoor, et al.[8] (2011) successfully diagnosed and endodontically treated a maxillary first molar with eight root canals with the help of CBCT. Compared with conventional medical CT, CBCT allows less scan time, a lower radiation dose and an adequate accuracy of the imaging along with a higher resolution[10,15,19,20].

The purpose of this study was to investigate the position of the distobuccal canal orifice of the maxillary second molars in a Chinese population using CBCT.

MATERIAL AND METHODS

Patient selection

Patients, who were referred to the Hospital of Stomatology at Shan Dong University, Jinan, China from January 2010 to July 2011, were enrolled in this study. The patients included those who required a preoperative assessment for implants or orthodontic treatment. In total, 816 maxillary second molars from 408 patients (181 men, 227 women) with a mean age of 27.3 years (13-57 years) were selected according to the following criteria: (1) maxillary second molar with no caries or defect; (2) no filled materials; (3) no periapical lesions; (4) no root canal treatment; (5) no root

canals with open apices, resorption or calcification; and (6) good quality CBCT images. Informed consent was obtained from each patient, and this study was approved by the Ethics Committee of the Hospital of Stomatology.

CBCT technique

All teeth were scanned by a CBCT scanner, the comfort version of Galileos (Sirona, Bensheim, Germany) according to the manufacturer's recommended protocol. The machine worked at 85 kV and 35 mA (21-42 mA), with an exposure time of 2-6 s. The voxel size was 0.125 mm, and the slice thickness was 1.0 mm. All CBCT images were performed by an experienced radiologist.

Evaluation of images

All the images from 816 maxillary second molars were evaluated. The following information was recorded: (1) the number of root canals per tooth; (2) the distance between the mesiobuccal and the distobuccal root canal orifice (DM); (3) the distance between the palatal and the distobuccal root canal orifice (DP); and (4) the angle formed by the palatal, distobuccal and mesiobuccal root canal orifices ($\angle$PDM). DM, the DP and $\angle$PDM of the teeth with three or four root canals were analyzed and evaluated. Each image was evaluated at the level of the root canal orifice by axial. All the measurements and analyses were performed twice by two experienced endodontists, with a 2-week interval between the assessments. If there was any disagreement between them, a radiologist with endodontic experience helped to make the final decision. The data was then obtained after the final calibration.

RESULTS

Among 816 maxillary second molars, the most frequent pattern was three root canals (57.48%), followed by four root canals (36.03%), then two root canals (6.37%) and five root canals (0.12%). Table 1 shows the frequency of different root canal numbers in the 816 maxillary second molars. The images of the orifices were shown in Figure 1. In total, 763 (93.51%) subjects had three or four root canals; we evaluated the position of the distobuccal root canal orifice in each.

In the 763 maxillary second molars with three or four canals, the DM ranged from 0.7 to 4.8 mm. The DM of 254 (33.29%) concentrated within a field of 2.0 to 2.5 mm, and there were 201 (26.35%) and 166 (21.76%) in the range of 2.5-3.0 mm and 1.5- 2.0 mm, respectively. Other distributions were 68 (8.91%), 50 (6.55%), 20 (2.62%), 2 (0.26%), and 2 (0.26%) within a range of 3.0-3.5 mm, 1.0- 1.5 mm, 3.5-4.0 mm, 0.5-1.0 mm, and 4.0-5.0

mm (shown in Table 2). The majority (81.39%) of the 763 teeth were distributed within a range of 1.5-3.0 mm (shown in Table 2).

Table 3 showed the distributions of DP, which ranged from 0.8 mm to 6.7 mm. The DP of 175 (22.94%) was in the range of 4.0-4.5 mm, 164 (21.49%) in the field of 3.5-4.0 mm, 142 (18.61%) in the field of 3-3.5 mm and 104 (13.63%) in the field of 4.5-5 mm. This accounted for 585 teeth (76.67%), which represented the majority. Other distributions were as follows: 90 (11.8%) in the field of 2.5-3.0 mm, 42 (5.51%) within 5.0-5.5 mm, 31(4.06%) within 0.5-2.5 mm, and 15 (1.97%) within 5.5-7.0 mm.

The angle ($\angle$PDM) ranged from 69.4° to 174.7°. The numbers and percentages of different angles are listed in Table 4. Angles ranging from 110° to 120° were most common in 232 (30.42%) teeth, followed by a group of specimens with angles ranging from 100° to 110° in 198 samples (25.95%). The distribution ranged from 120° to 130° in 124 (16.25%), from 90° to 100° in 114 (14.94%) and from 130° to 140° in 40 (5.24%). Only 36 (4.71%) and 19 (2.49%) teeth exhibited angles ranging from 60° to 90° and from 140° to 180°, respectively; 708 (92.80%) of 763 teeth displayed angles ranging from 90° to 140°.

Table 1- Number and percentage of the separated root canals related to the root canal anatomy of the maxillary second molar

Root canal number	2	3	4	5	total
Number	52	469	294	1	816
Percentage	6.37	57.48	36.03	0.12	100
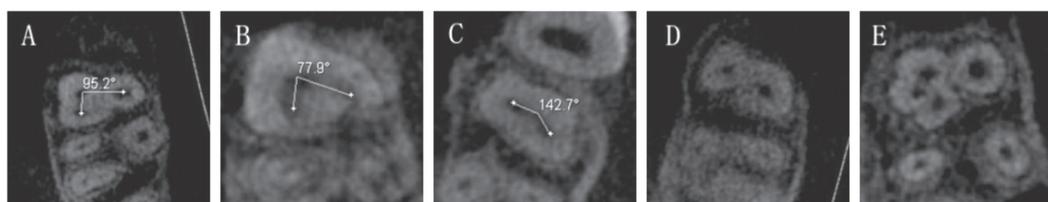
Figure 1- Images of transverse sections of the orifice in different cases. (A) Transverse sections with angle of 95.2°; (B) Transverse section with an angle of 77.9°; (C) Transverse sections with an angle of 142.7°; (D) Transverse section with two orifices; (E) A transverse section with five orifices

Table 2- The variable distance of the DM (the distance between the mesiobuccal and the distobuccal root canal orifice)

DM distance (mm)	0.5~1	~1.5	~2	~2.5	~3	~3.5	~4	~4.5	~5	total
Number	2	50	166	254	201	68	20	1	1	763
Percentage	0.26	6,55	21.76	33.29	26.35	8.91	2.62	0.13	0.13	100

Table 3- DP distance (the distance between the palatal and the distobuccal root canal orifice)

DP distance (mm)	0.5~1	~1.5	~2	~2.5	~3	~3.5	~4	~4.5	~5	~5.5	~6	~6.5	~7	total
Number	1	1	3	26	90	142	164	175	104	42	11	1	3	763
Percentage	0.13	0.13	0.39	3.41	11.8	18.61	21.49	22.94	13.63	5.51	1.44	0.13	0.39	100

Table 4- $\angle$PDM variability (the angle formed by the palatal, distobuccal and mesiobuccal root canal orifices)

The range of the angle	60-70	~80	~90	~100	~110	~120	~130	~140	~150	~160	~170	~180	Total
Number	3	11	22	114	198	232	124	40	8	5	3	3	763
Percentage	0.39	1.44	2.88	14.94	25.95	30.42	16.25	5.24	1.05	0.66	0.39	0.39	100

DISCUSSION

CBCT is widely used in implantology, orthodontics, maxillofacial reconstruction and diagnosis before endodontic treatment as well as in the assessment of the canal preparation, obturation and the removal of root fillings[9]. In this study, CBCT was used as a noninvasive method to evaluate the distobuccal root canal orifice of the maxillary second molar. No information related to the distobuccal root canals of the maxillary second molars has been published. This study provided a detailed report on the distobuccal root canal orifice of the maxillary second molars in a Chinese population by CBCT.

This study showed that the frequency of MB2 in the maxillary second molars was 36.03%, which was higher than that reported by Zhang, et al.[19] (2011). The different methods or the number of samples used may account for the discrepancy. In this study, 93.51% of the maxillary second molars among the Chinese population had three or four root canals, which indicated that the majority had a distobuccal root canal.

The DM of 621 (81.39%) teeth were primarily within 1.5 mm to 3 mm. For these teeth, we had no difficulty in detecting the distobuccal root canals. Although the DM of only 52 (6.82%) teeth ranged from 0.5 mm to 1.5 mm, the orifices were difficult to sometimes locate. Attention should be paid to this situation. The continuous deposition of the dentin over the orifice often tended to conceal its existence. Occasionally, the distobuccal root canal orifice looked like it was in the same position as the mesiobuccal root canal orifice and it was clearly visible after instrumentation. Meanwhile, 22 (2.88%) teeth were presented with a DM larger than 3.5 mm. In this group, the larger the DM was, the more difficult it was to find the orifice. The DP of 585 (76.67%) teeth ranged from 3 mm to 5 mm. We had almost no difficulty during the root canal therapy in each case. Although only a small percentage was out of this field in this study, the difficulty involved in locating the orifices varied. It was therefore important to consider the variations in clinical practice.

∠PDM was presented as an obtuse angle in the majority of the cases. The angles in 708 (92.80%) teeth were in the range of 90° to 140°. Although only 19 teeth exhibited angles over 140°, we should be aware of these cases. In the teeth with larger ∠PDM, the distobuccal orifice would be located closer to the line connecting the mesiobuccal orifice with the palatal orifice. This condition may be caused by the limited bone available in the buccal and distal direction, which forces the distobuccal root to move in the palatal and mesial direction during the development and eruption of the teeth. The orifice of the root canal was difficult to find in the above condition and we should seek along the line formed by the mesiobuccal and palatal root canal orifices. Despite the variation in the distobuccal root canal orifices, the morphology of the occlusal surfaces of the teeth is always helpful in finding the root canal orifice. In the future, a smaller field of view (FOV) should be used for the dental images considering the radiation dose when CBCT presents a routine application in endodontic practice[7,14].

CONCLUSION

The position of the distobuccal root orifice of the maxillary second molars with 3 or 4 root canals was variable. The clinicians should be aware of the likelihood that the distobuccal root canal orifice may be difficult to find. The use of CBCT may facilitate a better understanding of the complex and variable root canal anatomy, which ultimately enables the clinician to look for and locate the distobuccal orifice of the maxillary second molars in the root canal treatment.

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