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

Xuan HAN¹, Haibing YANG¹, Guoju LI¹, Lin YANG¹, Cheng TIAN¹, Yan WANG²

1- DDS, Department of Endodontics, School of Stomatology, Shandong University; Shandong Provincial Key Laboratory of Oral Biomedicine, Jinan, China.
2- PhD, DDS, Department of Endodontics, School of Stomatology, Shandong University; Shandong Provincial Key Laboratory of Oral Biomedicine, Jinan, China.

Corresponding address: Dr. Yan Wang, DDS, PHD - Department of Endodontics - School and Hospital of Stomatology, Shandong University - 44-1 Wenhua Xi Road - Jinan, 250012 - P.R. China - Phone: +86- 13953165961 - e-mail: wangyan1965@sdu.edu.cn

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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 system². 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 involvement¹,⁶,¹³,¹⁸. 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
films or digital ones. Ozer, et al. (2010) used CBCT to identify the MB2 canals in extracted maxillary first and second molars and concluded that CBCT is a reliable method to detect MB2 canal orifices. When compared with the gold standard of physical sectioning of the specimen, Kottoor, et al. (2011) successfully diagnosed and endodontically treated a tooth with three or four root canals, the DM of 254 (33.29%) concentrated within a field 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 (PDM). DM, the DP and 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 canal orifice of the maxillary second molar 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.
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   | ~6   | ~6.5 | ~7   | total |
|------------------|-------|------|------|------|------|------|------|------|------|------|------|------|-------|
| Number           | 2     | 50   | 166  | 254  | 201  | 68   | 20   | 1    | 1    | 1    | 1    | 1    | 763   |
| Percentage       | 0.26  | 6.55 | 21.76| 33.29| 26.35| 8.91 | 2.62 | 0.13 | 0.13 | 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. 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. (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.

\[ \angle \text{PDM} \] 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 \[ \angle \text{PDM} \], 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.

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

REFERENCES

1- Awawdeh L, Abdullah H, Al-Quadh A. Root form and canal morphology of Jordanian maxillary first premolars. J Endod. 2008;34:956-61.
2- Barbizam JV, Ribeiro RG, Tanomaru Filho M. Unusual anatomy of permanent maxillary molars. J Endod. 2004;30:668-71.
3- Blattner TC, George N, Lee CC, Kumar V, Yelton CD. Efficiency of cone-beam computed tomography as a modality to accurately identify the presence of second mesiobuccal canals in maxillary first and second molars: a pilot study. J Endod. 2010;36:67-70.
4- Durack C, Patel S. Cone beam computed tomography in Endodontics. Braz Dent J. 2012;23:179-91.
5- Fan W, Fan B, Gutmann JL, Fan M. Identification of a C-shaped canal system in mandibular second molars. Part III. Anatomic features revealed by digital subtraction radiography. J Endod. 2008;34:1187-90.
6- Fogel HM, Peikoff MD, Christie WH. Canal configuration in the mesiobuccal root of the maxillary first molar: a clinical study. J Endod. 1994;20:135-7.
7- Hirsch E, Wolf U, Heinicke F, Sliva MA. Dosimetry of the cone beam computed tomography Veraviewepocs 3D compared with the 3D Accuitomo in different fields of view. Dentomaxillofac Radiol. 2008;37:268-73.
8- Kottoo J, Velmurugan N, Surendran S. Endodontic management of a maxillary first molar with eight root canal systems evaluated using cone-beam computed tomography scanning: a case report. J Endod. 2011;37:715-9.
9- Matherne RP, Angelopoulos C, Kulild JC, Tira D. Use of cone-beam computed tomography to identify root canal systems in vitro. J Endod. 2008;34:87-9.
10- Neelakantan P, Subbarao C, Ahuja R, Subbarao CV, Gutmann JL. Cone-beam computed tomography study of root and canal morphology of maxillary first and second molars in an Indian population. J Endod. 2010;36:1622-7.
11- Ozer SY. Detection of vertical root fractures of different thicknesses in endodontically enlarged teeth by cone beam computed tomography versus digital radiography. J Endod. 2010;36:1245-9.
12- Patel S, Dawood A, Whaites E, Pitt Ford T. New dimensions in endodontic imaging: part 1. Conventional and alternative radiographic systems. Int Endod J. 2009;42:447-62.
13- Pattanshetti N, Gaidhane M, Al Kandari AM. Root and canal morphology of the mesiobuccal and distobuccal roots of permanent first molars in a Kuwait population - a clinical study. Int Endod J. 2008;41:755-62.
14- Pauwels R, Beinsberger J, Collaert B, Theodorakou C, Rogers J, Walker A, et al. Effective dose range for dental cone beam computed tomography scanners. Eur J Radiol. 2012;81:267-71.
15- Sberna MT, Rizzo G, Zacchi E, Capparè P, Rubinacci A. A preliminary study of the use of peripheral quantitative computed tomography for investigating root canal anatomy. Int Endod J. 2009;42:66-75.
16- Silva JA, Alencar AHG, Rocha SS, Lopes LG, Estrela C. Three-dimensional image contribution for evaluation of operative procedural errors in endodontic therapy and dental implants. Braz Dent J. 2012;23:127-34.
17- Tachibana H, Matsumoto K. Applicability of X-ray computerized tomography in endodontics. Endod Dent Traumatol. 1990;6:16-20.
18- Weine FS, Hayami S, Hata G, Toda T. Canal configuration of the mesiobuccal root of the maxillary first molar of a Japanese sub-population. Int Endod J. 1999;32:79-87.
19- Zhang R, Yang H, Yu X, Wang H, Hu T, Dummer PM. Use of CBCT to identify the morphology of maxillary permanent molar teeth in a Chinese subpopulation. Int Endod J. 2011;44:162-9.
20- Zheng QH, Wang Y, Zhou XD, Wang Q, Zheng GN, Huang DM. A cone-beam computed tomography study of maxillary first permanent molar root and canal morphology in a Chinese population. J Endod. 2010;36:1480-4.