Analysis of the Root and Canal Morphologies in Maxillary First and Second Molars in a Chinese Population Using Cone-beam Computed Tomography

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Abstract

Introduction: We analyzed and characterized the root and canal morphologies in maxillary first and second molars in a large sample of Chinese patients using reconstructed cone-beam computed tomographic (CBCT) imaging. **Methods:** Maxillary first (n = 1558) and second (n = 1539) molars were collected from Chinese patients (N = 844) who had undergone *in vivo* CBCT imaging. The root canal number and morphology were determined according to Vertucci's classification. **Results:** A single root was found in 0.06% of first molars, which showed type I canal systems. However, second molars with a single root (4.2%) showed widely varied canal systems. The buccal roots of first molars with 2 separate roots showed type I, II, or III canal systems, whereas those of 2-rooted second molars showed widely varied canal systems. The incidence of fused roots was 1.38% for first molars and 23.9% for second molars, whereas canal fusion within fused roots was observed in 4.5% of first molars and 10.6% of second molars. Additional canals were observed in 67.8% and 29.7% of mesiobuccal roots, 1.8% and 0.7% of distobuccal roots, and 0.7% and 0.3% of palatal roots in 1523 and 1017 first and second molars with 3 separate roots, respectively. The mesiobuccal root canal number showed bilateral symmetry between 79% of first molars and 82.3% of second molars, with a concurrence rate of 59.8% between adjacent molars. **Conclusions:** We reported the root and canal morphologic variations in maxillary first and second molars, which have not been reported for Chinese populations. Further studies should focus on canals in fused roots and mesiobuccal roots. *(J Endod 2016;42:696–701)*

Key Words

Canal morphology, cone-beam computed tomography, maxillary molars, root morphology

Recognition of anatomic variations in the root canal morphology is essential to promote successful root canal treatment, which depends on complete debridement, disinfection, and obturation of root canal systems. The inability to detect, debride, and obturate all existing canals is a major cause of root canal treatment failure (1). Meanwhile, root canal morphology is also relevant during post-core and crown restorations because post preparation can result in root canal deviation or root canal perforation. Therefore, clinicians should recognize the common root canal morphologies and possible anatomic variations (2).

Maxillary first and second molars have been investigated because of their complex root and canal morphologies (3–14). According to the reported results, most maxillary first molars exhibit 3 roots and 4 canals (1, 3, 8, 13), including a mesiobuccal root with 2 canals and distobuccal and palatal roots with a single canal each (1, 3, 5, 13, 15). Additional anatomic variations also exist in these teeth. Badole et al (15) reported 3 roots with 7 canals in maxillary first molars (3 in the mesiobuccal root, 2 in the distobuccal root, and 2 in the palatal root). Rouhani et al (11) found 4 roots in maxillary first molars. Meanwhile, it was reported that maxillary second molars showed a higher incidence of variations compared with first molars (14).

Numerous methods have been used to examine root and canal morphologies, including canal staining and tooth clearing (7), sectioning (2), conventional and digital radiography (12, 16), *in vitro* macroscopic examination and root canal treatment with magnification (1), the modified canal staining and clearing technique (10), computed tomographic imaging and contrast medium–enhanced digital radiography (17), and cone-beam computed tomographic (CBCT) imaging (3, 6, 11). Baratto Filho et al (18) used 3 methods to evaluate the root canal morphology in maxillary first molars and found that CBCT imaging was a useful diagnostic tool for this purpose. As a nondestructive tool, CBCT imaging offers not only a higher spatial resolution but also lower effective radiation doses and lower costs compared with computed tomographic imaging. Furthermore, it provides 3-dimensional images of the oral and maxillofacial region for disease diagnosis and root canal morphology assessments.

The internal complexities of root canals are genetically determined and carry definitive importance in anthropology (3, 12); therefore, it is necessary to consider racial differences during clinical treatment. However, although previous studies have reported the number of root canals in maxillary first molars in Chinese populations, few studies have explicitly investigated the root canal morphology in maxillary first and second molars. Therefore, assessment of the root canal morphology in Chinese

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TABLE 1. Number and Morphology of Roots in Maxillary First and Second Molars

	First molar *n* (%)	Second molar *n* (%)
Type 1	1 (0.06)	65 (4.2)
Type 2	11 (0.7)	71 (4.6)
Type 3	3 (0.19)	45 (2.9)
Type 4	1523 (97.8)	1017 (66.1)
Type 5	3 (0.19)	117 (7.6)
Type 6	0 (0)	102 (6.6)
Type 7	14 (0.9)	9 (0.6)
Type 8	2 (0.1)	95 (6.2)
Type 9	1 (0.06)	18 (1.2)
Total	1558	1539

Type 1, 1 root; type 2, 2 separate roots; type 3, 2 fused roots; type 4, 3 separate roots; type 5, fused mesiobuccal and distobuccal roots; type 6, fused mesiobuccal and palatal roots; type 7, fused distobuccal and palatal roots; type 8, 3 fused roots; type 9, 4 separate roots.

populations, which occupy one fifth of the world's population, is essential. The aim of this study was to analyze and characterize the root and canal morphologies in maxillary first and second molars in a large sample of Chinese patients using reconstructed CBCT imaging.

Materials and Methods

Subjects

Digitized CBCT images of the maxillary first and second molars were collected from patients who had undergone CBCT scanning for diagnosis or treatment purposes at the Stomatology Special Consultation Clinic, Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China, from January 2013 to December 2013. The study was exempt from approval by an institutional review board because of the retrospective design. The CBCT images of 844 patients fulfilled the following inclusion criteria: the presence of maxillary permanent first and/or second molars on scans; maxillary molars with fully formed apices; and no root canal fillings, posts, crown restorations, apical periodontitis, or any other odontogenic or nonodontogenic pathology.

Classification of the Root Morphology

Fusion was defined as the deposition of cementum on the root surface from the cementoenamel junction to the apex. We used the following morphologic classification for roots, which was modified from the method of Alavi et al (8): type 1, 1 root; type 2, 2 separate roots; type 3, 2 fused roots; type 4, 3 separate roots; type 5, fused mesiobuccal and distobuccal roots; type 6, fused mesiobuccal and palatal roots; type 7, fused distobuccal and palatal roots; type 8, 3 fused roots; and type 9, 4 separate roots.

Radiographic Evaluations

CBCT images were obtained using a CBCT device (NewTom VG; QR srl, Verona, Italy) with the following parameters: field of view of 500 cm^2 (20 $\times$ 25 cm), a basic voxel size of 0.16 mm, operating parameters of 110 kVp and 10 mA, and a scanning time of 18 seconds. All images were acquired by an experienced radiologist according to the operation instructions. Data were analyzed using NNT software version

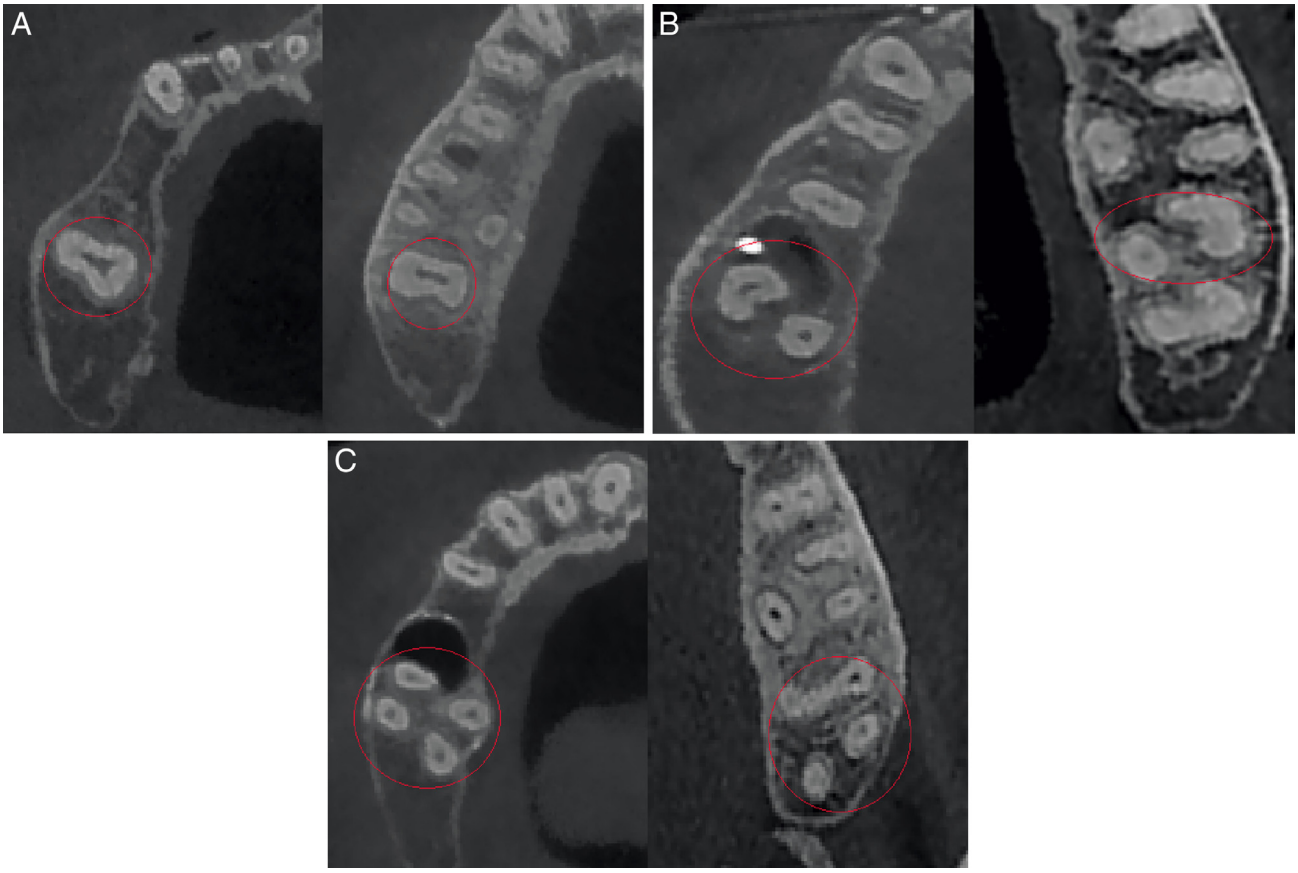

Figure 1. Cases of maxillary (*left*) first and (*right*) second molars with root variations in the axial section. (*A*) One root with a single canal, (*B*) 2 separate roots, and (*C*) 2 buccal roots and 2 palatal roots.