Micro–Computed Tomography Analysis of the Root Canal Morphology of Palatal Roots of Maxillary First Molars

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Abstract

Introduction: A thorough knowledge of root canal anatomy is critical for successful root canal treatments. This study evaluated the internal anatomy of the palatal roots of maxillary first molars with micro–computed tomography (microCT). **Methods:** The palatal roots of extracted maxillary first molars (n = 169) were scanned with microCT to determine several anatomic parameters, including main canal classification, lateral canal occurrence and location, degree of curvature, main foramen position, apical constriction presence, diameters 1 and 2 mm from the apex and 1 mm from the foramen, minor dentin thickness in those regions, canal volume, surface area, and convexity. **Results:** All canals were classified as Vertucci type I. The cross sections were oval in 61% of the canals. Lateral canals were found in 25% of the samples. The main foramen did not coincide with the root apex in 95% of the cases. Only 8% of the canals were classified as straight. Apical constriction was identified in 38% of the roots. The minor and major canal diameters and minor dentin thickness were decreased near the apex. The minor dentin thickness 1 mm from the foramen was 0.82 mm. The palatal canals exhibited a volume of 6.91 mm^3 and surface area of 55.31 mm^2 and were rod-shaped. **Conclusions:** The root canals of the palatal roots were classified as type I. However, some factors need to be considered during the treatment of these roots, including the frequent ocurrence of moderate/severe curvatures, oval-shaped cross-sections, and lateral canals, noncoincidence of the apical foramen with the root apex, and absence of apical constriction in most cases. *(J Endod 2016;42:280–283)*

Key Words

Apical diameter, dental anatomy, maxillary first molars, micro-computed tomography

A detailed knowledge of the anatomy of the root canal system is essential for all phases of endodontic treatment. Regardless of the tooth group, root canal systems have significant anatomic variations that affect the selection and application of treatment protocols (1, 2).

The maxillary first molar is considered one of the most complex teeth in the dental arch. The first molar typically has 3 distinct roots and 3 or 4 canals (1, 3, 4). The complex internal anatomy of the buccal roots of this tooth has been thoroughly assessed with a variety of methodologies, including micro–computed tomography (microCT), which is currently regarded as the gold standard approach for anatomic studies (5, 6). However, microCT investigations of the anatomy of palatal roots and root canals are not complete.

The few microCT studies that examined palatal roots have revealed some anatomic aspects of palatal canals: they are round; their volume and area are approximately 7.0 mm^3 and 30.0 mm^2, respectively (7); the apical constriction is parallel; a constriction is usually not present (8, 9); and the curvature is smooth, gradual, and more frequent in the apical third (10). However, many anatomic parameters of palatal canals are still unknown, and others need to be confirmed with studies with larger sample sizes.

Previous morphologic data indicate that the palatal canals usually have a lower degree of curvature and a larger internal diameter than mesiobuccal and distobuccal canals. Variations in the number, shape, and curvature of palatal canals have been reported, which further indicate the importance of additional investigations with more accurate methods (4, 11). The use of microCT enables the high-resolution radiographic scanning of extracted teeth, which results in detailed 3-dimensional (3D) analyses of their internal anatomy without destroying the specimen (2, 11–13). This study was undertaken to assess the anatomy of the palatal canals of maxillary first molars with microCT.

Materials and Methods

Scanning of the Extracted Roots

A total of 169 maxillary first molars that were extracted from Brazilian individuals for reasons not related to this study were selected. The palatal root was obtained by sectioning the molar at the cementoenamel junction. The roots met the following inclusion criteria: fully formed apex, minimum length of 18 mm, and patent root canals. No information about the sex or age of the individuals from whom the teeth were extracted was available. The study was approved by the Ethics and Research Committee of the Estácio de Sá University.

The roots were scanned with a SkyScan 1174 v2 microCT (Bruker microCT, Kontich, Belgium) with a 50-kV x-ray source and current of 800 mA. The scanning parameters included a rotation step of 1.4, a 360° rotation, and a 60-μm isotropic resolution. The image of each root specimen was rebuilt with NRecon v.1.6.9 software (Bruker microCT), which created axial and transverse slices of the internal structure.

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Qualitative and quantitative analyses of the anatomic parameters were performed. No statistical analyses were performed because of the descriptive nature of the study.

Qualitative Analysis

The following anatomic parameters were assessed: number of canals, classification of the main canal, occurrence and location of the lateral canals according to Vertucci (1), degree of curvature of the main canal according to Schneider (14), position of the anatomic foramen relative to the apex, and presence/absence of the apical constriction. When present, the apical constriction was classified according to Dummer et al (15). These parameters were assessed with CTAn V.1.13 and CTVol v.2.2.1 software (Bruker microCT).

Quantitative Analysis

The root canal measurements included volume (mm^3), surface area (mm^2), minor and major diameters, minor dentin thickness and canal diameter at 1 and 2 mm from the apex and 1 mm from the foramen, minor dentin thickness in these regions, and convexity (structure model index [SMI] from the cementoenamel junction to the apex). The cross sections of the root canals were classified as round, oval, or long oval according to the minor and major diameters of the canals 1 mm from the apex, as previously described by Jou et al (16). For these measurements, the plug-in 3D analysis and morphometric analysis tools of the CTAn software were used.

Results

Qualitative Analysis

The 3D models showed that the specimens exhibited a single main canal from the pulp chamber to the apical foramen. Therefore, 100% of the specimens were classified as Vertucci type I (Fig. 1). Lateral canals occurred in 25% of the roots (n = 42); of these, 88% (n = 37) were present in the apical third, 10% (n = 4) were present in the middle third, and 7% (n = 3) were present in the cervical third (Fig. 1*B*; Table 1). Two specimens exhibited 2 lateral canals, with one in the cervical third and the other in the apical third.

With regard to curvature, 8% of the canals (n = 14) were straight (0°–9°), 48% (n = 81) presented moderate curvature (10°–24°), and 44% (n = 74) had severe curvature (25°–70°), with the latter 2 occurring in the buccal direction. Apical constriction was identified only in 38% of the canals (n = 64), with 64% (41 of 64) classified as simple and 36% (23 of 64) classified as tapering. Four roots ended in apical deltas (Fig. 1*F*). In 95% of the specimens (n = 161), the anatomic foramen was not coincident with the apex (Fig. 1*A*, *C*, and *E*).

Quantitative Analysis

The results of the 2-dimensional and 3D analyses of the root canals are presented in Table 2. The major diameters of the canal 1 mm from the apex and 1 mm from the foramen were 0.44 mm and 0.51 mm, respectively. The minor dentin thickness 1 mm from the foramen was 0.82 mm (0.07–1.48 mm). The volumes of the palatal canals and surface area were 6.91 mm^3 and 55.31 mm^2, respectively. The SMI values indicated that all of the palatal canals exhibited rod-like shapes.

With respect to the cross sections, 29% (n = 46) were classified as round, 61% (n = 99) were classified as oval, and 10% (n = 16) were classified as long oval. No flattened canals were observed.

Discussion

In 1984, Vertucci (1) presented a classification system for the anatomy of root canals, and Vertucci's system has since become the most widely accepted classification system in this field. In the study by Vertucci, the sample of 2400 teeth allowed for the classification of canals into 8 types. In that study, all of the palatal roots of maxillary first molars (n = 100) had only 1 main canal, and the occurrence of lateral canals was high (48%), especially in the apical third (61%).

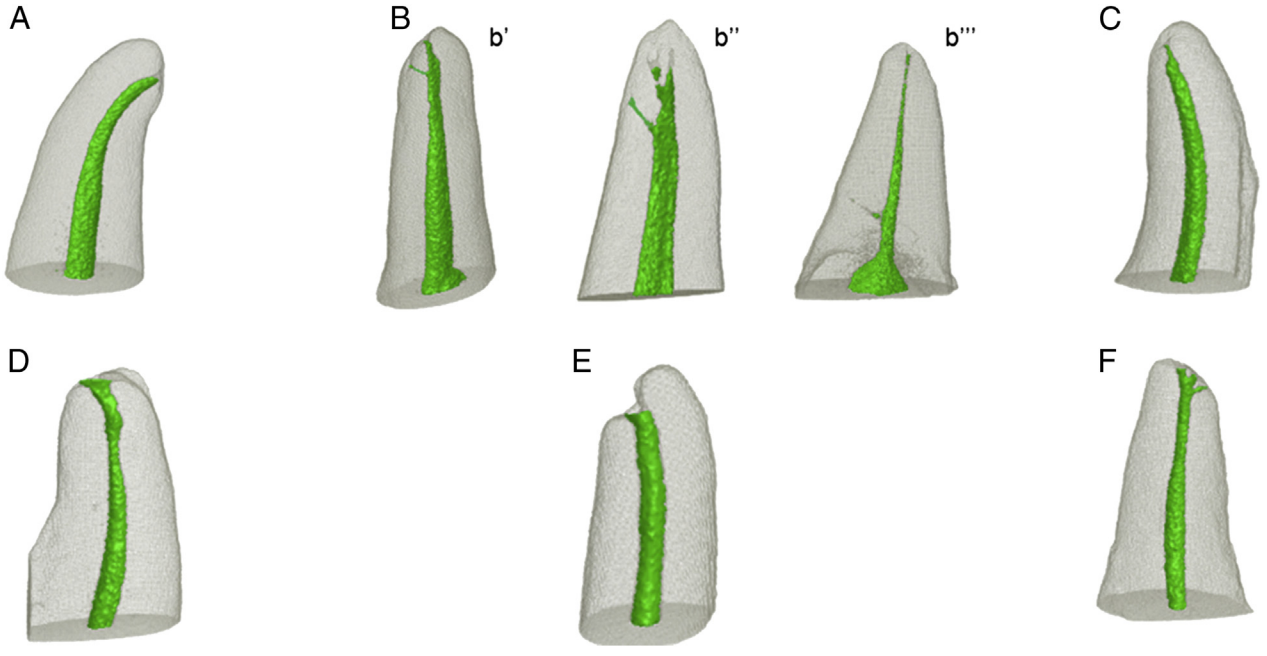

Figure 1. Representative 3D models of the palatal canals of the maxillary first molars (*A*–*F*). Note locations of the lateral canals in the apical, middle, and cervical thirds (b′, b″, and b‴, respectively).