Micro–computed Tomographic Analysis of the Root Canal Morphology of the Distal Root of Mandibular First Molar

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Abstract

Introduction: The aim of this study was to evaluate the morphologic aspects of the root canal anatomy of the distal root of a mandibular first molar using micro–computed tomographic analysis. **Methods:** One-hundred distal roots of mandibular first molars were scanned using a micro–computed tomographic device at an isotropic resolution of 19.6 μm. The percentage frequency distribution of the morphologic configuration of the root canal was performed according to the Vertucci classification system. Two-dimensional parameters (area, perimeter, roundness, aspect ratio, and major and minor diameters) and the cross-sectional shape of the root canal were analyzed in the apical third at every 1-mm interval from the main apical foramen in roots presenting Vertucci types I and II configurations (n = 79). Data were statistically compared using the Kruskal-Wallis and Dunn tests with a significance level set at 5%. **Results:** Seventy-six percent of the distal roots had a single root canal. Two, three, and four canals were found in 13%, 8%, and 3% of the sample, respectively. In 13 specimens, the configuration of the root canal did not fit into Vertucci's classification. Overall, 2-dimensional parameter values significantly increased at the 3-mm level ($P < .05$). The prevalence of oval canals was higher at the 1-mm level and decreased at the 5-mm level in which long oval and flattened canals were more prevalent. **Conclusions:** The distal roots of the mandibular first molars showed a high prevalence of single root canals. The prevalence of long oval and flattened canals increased in the coronal direction. In 13% of the samples, canal configurations that were not included in Vertucci's configuration system were found. *(J Endod 2015;41:231–236)*

Key Words

Dental anatomy, mandibular molars, micro–computed tomography, root canal anatomy

The knowledge of the anatomy of the root canal system and its variations play an important role in all steps of endodontic treatment (1, 2). Therefore, the clinician should be able to fully understand the configuration of the root canal, aiming to choose the most appropriate treatment protocol and thereby increasing its success rate (3).

Generally, the morphology of the root canal varies greatly in shape and transversal cross-sections in different groups of teeth (4, 5). In the posterior teeth, the mandibular first molar is recognized as exhibiting a complex and distinct range of variations in the morphology of the root canal system (1,6–9). This tooth usually has 2 roots, but, occasionally, it has 3, with 2 or 3 canals in the mesial root and 1, 2, or 3 canals in the distal root (6, 7, 10). When only 1 distal canal is present, it is usually oval-shaped buccolingually, and untreated surface areas were shown to be as high as 59%–79% when rotary instruments were used for the shaping procedure (11).

Micro–computed tomographic (micro-CT) imaging systems are currently being used for the *ex vivo* study of dental anatomy because they can provide a detailed quantitative and qualitative description of the external and internal anatomy of the teeth (5,12–18), overcoming the limitations of previous methods (19). Despite the fact that a considerable amount of information is available regarding the effect of endodontic procedures on the distal canals of mandibular molars (11, 20, 21), the literature lacks a detailed description of their anatomic configuration using new imagery technology. Thus, the aim of this study was to evaluate the morphologic aspects of the root canal anatomy of the distal roots of mandibular first molars using micro-CT technology.

Materials and Methods

One-hundred extracted 2-rooted mandibular first molars with fully formed apices collected from a Brazilian population were selected based on the appearance of crown morphology. Adherent soft tissue was removed by immersion in 2.5% sodium hypochlorite for 30 minutes. The teeth were then washed under tap water for 30 minutes and stored in 0.1% thymol solution. Patient, sex, and age were unknown. After ethics committee approval (protocol #131-2010), the teeth were mounted on a custom attachment and scanned in a micro-CT device (SkyScan 1174v2; Bruker-microCT, Kontich, Belgium) using 50 kV, 800 mA, a rotation step of 0.8, 360° of rotation, and an isotropic resolution of 19.6 μm. Images of each specimen were reconstructed from the apex to the level of the cementoenamel junction with dedicated software (NRecon v.1.6.9, Bruker-microCT), providing axial cross-sections of the inner structure of the sample.

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TABLE 1. Percentage Frequency Distribution of the Morphologic Configurations of the Root Canal System in the Distal Root of the Mandibular First Molars

Vertucci's configuration system	Vertucci (*N* = 100)	Gulavibala et al (6) (*N* = 104)	Gulavibala et al (7) (*N* = 103)	Harris et al (22) (*N* = 22)	Gu et al (*N* = 25)	Peiris et al (23) (*N* = 177)	Wasti et al (24) (*N* = 30)	Sert and Bayirli (8) (*N* = 200)	Present study (*N* = 100)
1 canal (type I)	70	60.6	67.9	81.8	72	71.8	30	53.5	76
2-1 (type II)	15	15.4	4.8		4	1.1	26.7	12.5	3
1-2-1 canal (type III)	—	2.9	3.9			6.8		21	
2 canal (type IV)	5	13.4	16.5		4	7.9	20.0	9.5	1
1-2 canal (type V)	8	3.8	2.9	9.1	4	10.2	20.0	2.5	7
2-1-2 canal (type VI)	2	2.9			16	1.1	3.3		
1-2-1-2 canal (type VII)						0.5			
3 canal (type VIII)			1.9						
Other configurations									
2-1-2-1 canal									1
2-3 canal		1	1.9						
3 canal								0.5	
1-2-3 canal									4
1-3-1-2 canal									1
3-2-3-2-1 canal									1
1-2-3-2-1 canal									1
1-2-1-2-1-2 canal									1
1-2-3-2-4-2 canal									1
2-1-2-1-2-1-2-3-2-4 canal									1
1-2-3-4-3 canal									1
1-2-1-2-1-3 canal									1

Qualitative Analysis

Three-dimensional (3D) models of the dentin and root canals were reconstructed from the source images by using an automatic segmentation threshold and surface modeling with CTAn v.1.13 software (Bruker-microCT). CTVol v.2.2.1 and Data Viewer v.1.5 software (Bruker-microCT) were used for visualization and qualitative evaluation of the root canal configuration (1).

Quantitative Analysis

Two-dimensional (2D) evaluation (area, perimeter, roundness, major diameter, minor diameter, and aspect ratio) of the canal in the apical third at every 1-mm interval from the apical foramen to the 5-mm level was performed with CTAn v.1.13 software. These parameters were measured only in the distal roots presenting 1 canal at the apical third (n = 79). The area and perimeter were calculated using the Pratt algorithm. The cross-sectional appearance, round or more ribbon

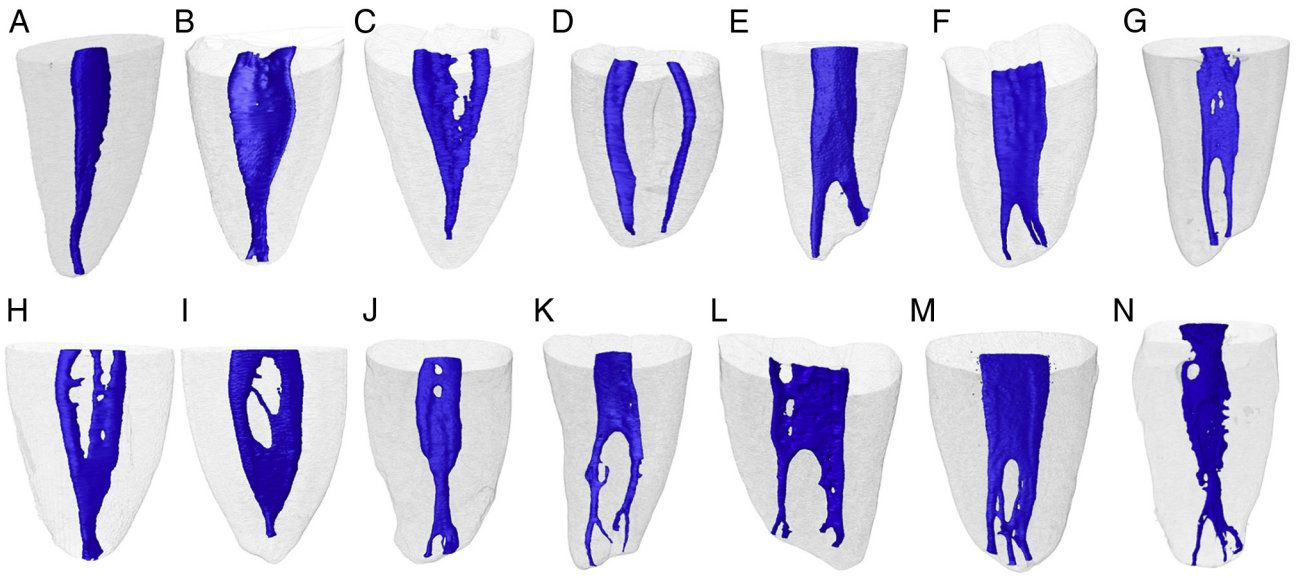

Figure 1. Representative 3D models of the morphologic configurations of the distal canals of mandibular first molars. (*A*) Vertucci type I (a single canal from the pulp chamber to the apex), (*B*) Vertucci type I with an oval-shaped canal, (*C*) Vertucci type II (2-1 configuration, ie, 2 canals leaving the pulp chamber and merging in a single canal), (*D*) Vertucci type IV (2 separate canals from the pulp chamber to the apex), (*E*) Vertucci type V (1-2 configuration, ie, a single canal leaving the chamber and dividing into 2 canals at the apex), and (*F*) Peiris' type XVIII (1-2-3 configuration; ie, 1 canal leaving the chamber, dividing into 2 within the root, and finally redividing into 3 distinct canals short of the apex) (23). Newly defined root canal morphologies are shown in (*G*) 1-3-1-2 configuration, (*H*) 3-2-3-2-1 configuration, (*I*) 1-2-3-2-1 configuration, (*J*) 1-2-1-2-1-2 configuration, (*K*) 1-2-3-2-4-2 configuration, (*L*) 2-1-2-1-2-1-2-3-2-4 configuration, (*M*) 1-2-3-4-3 configuration, and (*N*) 1-2-1-2-1-2-3 configuration.