Cone-beam Computed Tomographic Study of Root Anatomy and Canal Configuration of Molars in a Spanish Population

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Abstract

Introduction: The aim of this study was to identify morphologic peculiarities of roots and analyze the root canal configuration in maxillary and mandibular first and second molars by means using cone-beam computed tomographic (CBCT) imaging in a Spanish population. **Methods:** A total of 284 maxillary molars and 242 mandibular molars from 112 patients were examined *in vivo* by CBCT imaging; only untreated molars with healthy and fully matured apices were included in this study. Details regarding the number of roots, number of canals, and root canal configuration were recorded. **Results:** Maxillary first and second molars had 3 roots in 97.2% and 79%, respectively. In mandibular molars, the frequency of 2 roots was 94% in first molars and 83% in second molars. The canal configuration of the palatal root was 100% Vertucci type I (1-1) in first and second molars. The distobuccal root showed a Vertucci type I configuration in 97% of first and 100% of maxillary second molars. The mesiobuccal root for first molars showed a Vertucci type II configuration (2-1) in 56.5% cases and Vertucci type IV (2-2) in 23.2%. For maxillary second molars, the Vertucci type I configuration reached 52.7%. In mandibular molars, the mesial root showed higher variability. Most frequent was the presence of 2 canals, Vertucci type II for first and second molars. In the distal root, the most common configuration was Vertucci type I in both molars. **Conclusions:** The greater percentage of fused roots was observed in maxillary molars. Vertucci type II configuration was more frequent than type IV in the mesial root of mandibular molars and the mesiobuccal root of maxillary molars. A third canal in the mesial root of first mandibular molars (6.7%) was higher than expected. *(J Endod 2017;■:1–6)*

Key words

Canal configuration, cone-beam computed tomography, mandibular molars, maxillary molars, root anatomy

Significance

The knowledge of the anatomical variability of molars using CBCT is important to improve the treatment outcome.

Predictably successful endodontic treatment depends on the knowledge of the root canal configuration and the variability of its particular anatomy. Molars are especially important because they are often the seat of pulp/periapical disease. The mandibular first molar is the first posterior tooth to erupt; hence, it is more likely to be affected by pathology and seems to be the tooth that most often requires endodontic treatment (1). The maxillary first molar is 1 of the most complex in root and canal anatomy (1), which might contribute to the higher clinical failure rate (2, 3). The second mandibular and maxillary molars also exhibit a high number of anatomic variations (4).

The anatomy of molars appears to be genetically determined by ethnic differences, origins, age, and sex (5, 6). However, findings reported on anatomic variability may have to do with the design of the study and the method of identification applied. Several *in vitro* (7–10), *ex vivo* (11), and *in vivo* (12, 13) methods may be used to inspect the configurations of root canal systems. In recent times, the introduction of cone-beam computed tomographic (CBCT) imaging provides a nondestructive 3-dimensional system for proper information and identification of internal root canal anatomy (14). It offers the advantage of performance in real time during the clinical endodontic procedure and permits low radiation (15). Also, CBCT imaging is more sensitive, identifies higher incidences of anatomic variations (16, 17), and provides much more detail than radiographic images (18).

No publications to date have evaluated the morphology of molars using CBCT imaging in a Spanish population. The aim of the current study was to identify variations in the anatomy of roots and analyze the root canal configuration of first and second maxillary and mandibular molars among a Spanish population using CBCT imaging.

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Materials and Methods

Subjects

The protocol of this retrospective study was approved by the Ethics Committee of the University of Granada, Granada, Spain (UGR-909), and all patients gave written informed consent to participate. CBCT images of maxillary and mandibular molars were obtained between January 2014 and February 2015 from patients who required CBCT scans as part of the diagnosis process and treatment planning from 2 private clinics in Almería (Andalucía, Spain) and 1 in Santiago de Compostela (Galicia, Spain). The CBCT scans were mainly obtained for surgical removal of impacted teeth, implant surgery, facial trauma, or orthodontic treatment.

The study involved 112 patients with almost 2 molars in each hemiarch. There were 56 women and 56 men, with a mean age of 36.8 years (range, 18–62 years), having a total of 284 maxillary molars (142 first and 142 second molars) and 242 mandibular molars (121 first and 121 second molars). Inclusion criteria were as follows: patients had to be 18 years or older with erupted teeth and fully matured apices; absence of crown restorations; and absence of periapical lesions, root resorption, or calcifications.

Image Acquisition and Measurements

All teeth were scanned using the 9300 3D CBCT unit (Carestream Dental, Atlanta, GA). CBCT images implied the following parameters: a field of view of 10 × 10 cm, 90 kV, 4 mA, and a voxel size of 0.18 mm. The imaging time was 8 seconds, and data were reconstructed at a slice interval of 1 mm. Two endodontists, experts in working with CBCT imaging, assessed the images in a dimly lit room on a 27-inch monitor (MX27; EIZO, Madrid, Spain) at a screen resolution of 2560 × 1440 and a 10-bit color depth. To prevent eye fatigue, no more than 3 consecutive scans were completed by 1 examiner without a break. Both experts were previously calibrated with a discussion session and independently graded 30 CBCT images, obtaining interobserver agreement values (kappa for canal system configuration and intraclass correlation coefficient for the number of roots and number of canals) all higher than 0.70, which are considered adequate.

The scans were viewed and evaluated using Carestream software (CS 3D Imaging software 6.1.4). The examiners could magnify images and change viewing settings such as density, contrast, and sharpness to enhance visibility and identification of the examined structures. They were also able to scroll through the axial, coronal, and sagittal views of each tooth.

The features recorded and analyzed were patients' age and sex, number of roots, number of canals, and canal system configuration according to the classifications of Vertucci (19), Gulavibala et al (20), and Al Qudah and Awawdeh (21). A schematic representation is show in Figure 1.

The number of roots and canals, observed by moving the coronal plane, were checked in the axial plane, and canal configurations were evaluated continuously by moving the toolbar from the floor of the pulp chamber to the apex. Figures 2 and 3 show representative images.

Statistical Analysis

SPSS 20.0 for Windows (IBM, Chicago, IL) was used for the descriptive analyses (percentages, means, and standard deviations). SUDAAN 7.0 (Research Triangle Institute, Research Triangle Park, NC) was used for analytical purposes (*P* value calculation and 95% confidence intervals) to account for clustering (ie, multiple molars and roots in patients). We used the DESCRIPT (*t* test) procedure in SUDAAN to estimate the 95% confidence intervals (mean ± 1.96 × standard error) of the number of roots and to analyze the effect of sex on that variable. To evaluate the association between canal configuration and root location, we used the CROSSTAB (chi-square) procedure in SUDAAN.

Results

In this study, maxillary first molars had 3 roots in 97.2%, 2 roots in 0.7% and 1 root in 2.1%. The respective percentages for the maxillary second molars were 79%, 4.2%, and 17%. In mandibular molars, the frequency of two roots was 94% for the first molars and 83% for the second molars, respectively. Sex is not significantly associated with the number of roots in any of the 4 studied molars. The presence of a third root was only detected in mandibular first molars. The number of roots is displayed in Table 1.

Tables 2 and 3 show the canal configuration of maxillary and mandibular molars. Among maxillary molars, there is greater variability for the mesiobuccal (MB) root. The first molars showed a Vertucci type II (2-1) configuration in 56.3% cases followed by type IV and type I. For the maxillary second molar, the Vertucci type I configuration reached 52.7%. The distobuccal (DB) root showed a remarkably high Vertucci type I frequency in the first and second molars. The palatal (P) root was found to be Vertucci type I in both molars. Among the mandibular

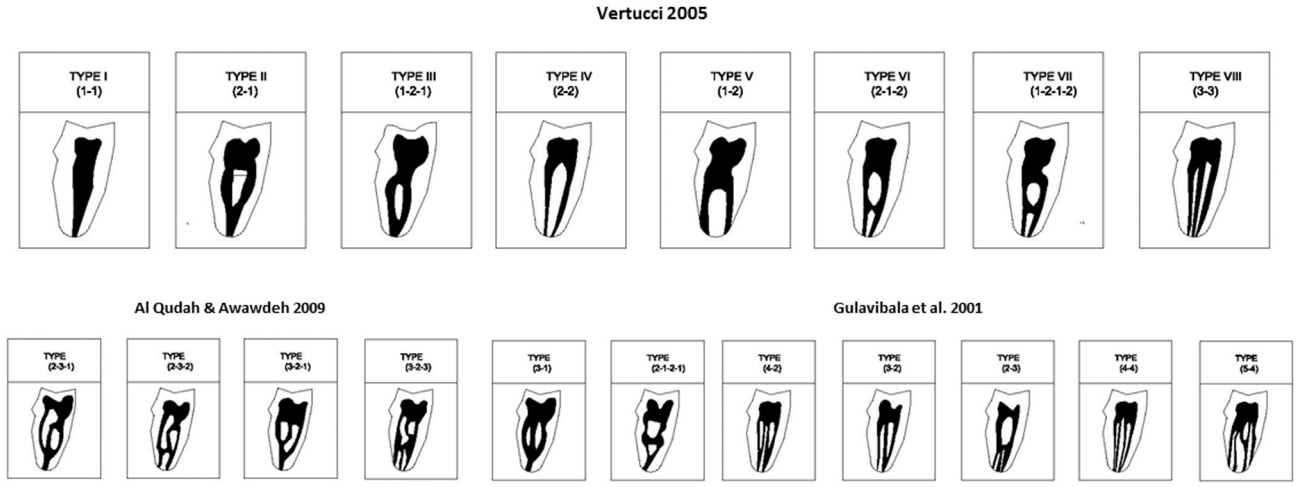

Figure 1. A schematic representation of the root canal configuration.