Cone-beam Computed Tomography Analysis of the Root Canal Morphology of Maxillary First and Second Premolars in a Spanish Population

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Abstract

Introduction: We investigated the root canal configuration of maxillary premolars in a Spanish population by using cone-beam computed tomography. **Methods:** Images of 804 maxillary first and second premolars were obtained from 620 patients who underwent cone-beam computed tomography scanning during preoperative assessment (before implant surgery, orthodontic treatment, dentoalveolar trauma diagnosis, or difficult root canal treatment). We determined tooth position, number of roots, root canal configuration (Vertucci's classification), number of root canals, and number of apical foramina per root and used the χ^2 test to analyze the correlation between root number and tooth position. **Results:** In the maxillary first premolar group (n = 430), 46% (n = 198) had 1 root, 51.4% (n = 221) had 2 roots, and 2.6% (n = 11) had 3 roots. Most exhibited a type IV canal configuration (n = 227, 52.8%). Single-rooted teeth had a more variable canal configuration, whereas most 2-rooted teeth showed a type IV configuration (n = 215, 97.3%). In the maxillary second premolar group (n = 374), 82.9% (n = 310) had 1 root, 15.5% (n = 58) had 2 roots, and 1.6% (n = 6) had 3 roots. The majority of single-rooted second premolars exhibited a type I configuration (n = 147, 47.2%). Overall, type VIII canals were only observed in 3-rooted teeth. No statistical correlation was evident between root number and gender and tooth position. **Conclusions:** There was a high frequency of 2-rooted and single-rooted teeth among maxillary first and second premolars, respectively. The canal morphology of single-rooted teeth was highly variable. *(J Endod 2015;41:1241–1247)*

Key Words

Cone-beam computed tomography, maxillary premolars, root morphology, Spanish population

The root canal system is complex, individual to each tooth, and can harbor a rich microbial flora (1–3). A lack of knowledge of root canal anatomy and/or technical skill may result in a failure to identify all root canals and/or inadequate instrumentation, which can lead to endodontic treatment failure (4, 5). Therefore, a thorough understanding of root canal anatomy and the use of diagnostic imaging are essential before embarking on endodontic treatment (6).

Several studies (7–19) have reported that maxillary premolars have a highly variable internal canal configuration, which can vary according to race and geographic origin (8, 9, 12). The reported prevalence of maxillary first premolars with 1 root ranges from 22% to 66%, with 2 roots from 33% to 84%, and with 3 roots from 0% to 6% (7, 8, 11, 12, 16, 17, 20). Maxillary second premolars usually have 1 root, with either 1 or 2 root canals (10, 12, 20, 21). Significant anatomic variation has also been observed among maxillary second premolars (22–24). Hence, variability in root number and canal configuration in these teeth poses a challenge to the clinician during root canal treatment.

Although intraoral periapical radiography is conventionally used to examine root canal morphology *in vivo* (25), superimposition of structures and image distortion are drawbacks to the use of this technique (26). Changing the horizontal angle of the x-ray tube can sometimes highlight the complexities of the canal system in maxillary premolars (27), but this is not always possible (for example, in patients with a shallow palatal vault). Cone-beam computed tomography (CBCT) imaging allows a 3-dimensional evaluation of teeth and their adjacent structures (26). CBCT has been successfully used to identify second mesiobuccal canals in maxillary molars (28) and distolingual root canals in mandibular first molars (29–31). Neelakantan et al (32) reported that CBCT can detect the root canal system as accurately as the staining and clearing techniques used to study extracted teeth and more accurately than intraoral periapical radiography. Several other studies (33–35) have also concluded that CBCT is more accurate in determining the root canal anatomy of teeth than intraoral periapical radiography.

To date, there has been no detailed examination of the roots and canal systems of maxillary first and second premolars in a Spanish population. In this study, we evaluated the root canal morphology of maxillary first and second premolars in this population by using CBCT.

Materials and Methods

Sample Selection

Images of maxillary premolars were obtained between June 2013 and July 2014 from patients referred to Universitat Internacional de Catalunya (St Cugat del Vallés,

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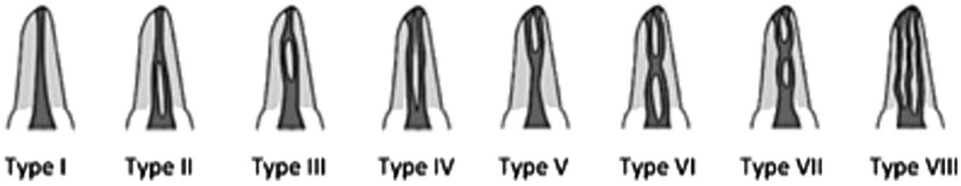

Figure 1. Diagrammatic representation of Vertucci's canal configuration.

Barcelona, Spain) who required CBCT scans as part of the treatment-planning process. The indications for CBCT scanning included the assessment of bone volume for dental implant planning, diagnosis of dentoalveolar trauma, management of impacted teeth before orthodontic treatment, and treatment planning before nonsurgical and surgical endodontic treatment. The Institutional Ethics in Research Committee (Universitat Internacional de Catalunya) approved the design of this study, and all patients gave written informed consent to participate. In accordance with data protection of minors, the Institutional Ethics in Research Committee does not allow the use of CBCT data from persons younger than 18. A total of 804 CBCT images of maxillary premolars (430 first and 374 second premolars) from 620 patients (416 from 362 men and 388 from 258 women) were selected for this investigation, according to the following criteria:

1. Availability of scans of the maxillary first and/or second premolars
2. Complete root formation
3. Absence of root resorption, calcification, or periapical lesions
4. Absence of root canal fillings, posts, or crown restorations
5. Availability of a clear and complete view of the relevant teeth

Image Acquisition

CBCT images were obtained by using a ProMax 3Ds (Planmeca OY, Helsingfors, Finland). The operating parameters were 8 mA and 84 kV, with an exposure time of 12 seconds. The smallest possible field of view was used (5 × 8 cm), and the voxel size was 0.075 mm. All CBCT exposures were performed with the minimum exposure necessary for adequate image quality. The as low as reasonably achievable protocol was strictly followed. Data were reconstructed with slices at 0.2-mm intervals, positioned parallel to the horizontal axis of the alveolar process, and the teeth under examination were placed in the center of the volume.

Image Evaluation

Images were assessed by 2 calibrated endodontists who were trained by using example CBCT images. Before analyzing the experimental material, the 2 examiners were asked to grade 50 sample CBCT images. During the experiment, the examiners assessed the CBCT images independently and then compared readings. They were able to scroll through the axial, coronal, and sagittal views of each tooth. In the event of disagreement, the case was discussed until a consensus was reached. A second session for the analysis of intraexaminer reliability took place 4 weeks after the first assessment.

The following information was recorded and analyzed:

1. Tooth position relative to the left or right side
2. Root number and canal configuration, classified by using Vertucci's criteria (36) (Fig. 1)
3. The number of apical foramina per root

The number of roots detected in the axial plane of the CBCT images was classified in accordance with Pécora et al (9):

1. *Single-rooted teeth:* Teeth with a clear single root and teeth with 2 independent canals that seemed to have 2 roots, which were actually fused
2. *Multi-rooted teeth:* 2-rooted teeth possessing bifurcated roots, regardless of whether they were partial or complete, and 3-rooted teeth, with 3 completely independent roots from the chamber floor, or bifurcations at any position along the buccal or palatal roots

Differences in tooth position (right or left) were determined by using the χ^2 test and were considered significant if the P value was $<.05$. Intraexaminer and interexaminer agreements were calculated by using the Cohen kappa coefficient.

Results

Table 1 shows the number of roots of maxillary first and second premolars according to gender. Of the maxillary first premolars, the majority (52.3%, n = 113) of the 212 teeth from male patients had 2 roots, and the remaining had 1 (43.9%, n = 93) or 3 roots (2.8%, n = 6). The majority (50.5%, n = 108) of the 218 teeth from female patients also had 2 roots, and the remaining presented 1 (48.2%, n = 105) or 3 roots (2.3%, n = 5). Of the maxillary second premolars, most (83.3%, n = 170) of the 204 teeth from male patients had 1 root, and the remaining had 2 (15.2%, n = 31) or 3 roots (1.5%, n = 3). Most (82.4%, n = 140) of the 170 teeth from female patients also had 1 root, and the remaining presented 2 (15.8%, n = 27) or 3 roots (1.8%, n = 3). No significant differences were observed between the number of roots in both maxillary first and second premolars and gender ($P > .05$).

TABLE 1. Prevalence of Roots (% of teeth) According to Gender

Tooth position	One root (%)	Two roots (%)	Three roots (%)	Total
Maxillary first premolars				
Male	93 (43.9)	113 (52.3)	6 (2.8)	212
Female	105 (48.2)	108 (50.5)	5 (2.3)	218
Total	198 (46.0)	221 (51.4)	11 (2.6)	430
Maxillary second premolars				
Male	170 (83.3)	31 (15.2)	3 (1.5)	204
Female	140 (82.4)	27 (15.8)	3 (1.8)	170
Total	310 (82.9)	58 (15.5)	6 (1.6)	374