Anatomic Study of the Buccal Root with Furcation Groove and Associated Root Canal Shape in Maxillary First Premolars by Using Micro–Computed Tomography

Jun Li, DDS, MSc, Ling Li, DDS, MSc,† and Yihuai Pan, DDS, PhD**

Abstract

Introduction: The purpose of this study was to investigate the buccal root anatomy of bifurcated maxillary first premolars with furcation grooves and to determine the correlation between the groove depth and the buccal root canal shape by using micro–computed tomography. **Methods:** Thirty-six bifurcated maxillary first premolars with furcation grooves were obtained from native Chinese individuals aged 17–25 years and scanned by micro–computed tomography. Basic parameters including the groove length, depth, and location were recorded. The wall thickness at different portions of the buccal roots was measured by using a customized application framework in MeVisLab software. The root canal shape was quantified by the form factor, and the correlation between the mean form factor and the maximum groove depth was analyzed. **Results:** The minimum wall thickness was less on the palatal aspect (<1 mm) than on the buccal aspect of the coronal two thirds of the buccal roots. The mean form factor value ranged from 0.72–0.91 and correlated negatively with the maximum groove depth ($\rho^2 = -0.641$, $P < .001$). **Conclusions:** The irregular wall thickness of buccal roots of bifurcated maxillary first premolars with furcation grooves and the related changes in the root canal shape should be considered during endodontic and prosthetic treatment. *(J Endod 2013;39:265–268)*

Key Words

Form factor, furcation groove, maxillary first premolars, micro-CT, minimum wall thickness

From the Departments of *Endodontics and †Oral Prophylaxis and Hygiene, School and Hospital of Stomatology, Wenzhou Medical College, Wenzhou, China.

Address requests for reprints to Dr Yihuai Pan, Department of Endodontics, School and Hospital of Stomatology, Wenzhou Medical College, 113 West Xueyuan Road, Wenzhou 325000, China. E-mail address: yihuaipan72@yahoo.com.cn

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A thorough knowledge of roots and root canal morphology is the foundation for successful root canal therapy. Maxillary first premolars have a complex anatomy and are therefore considered challenging to treat. Although the number of roots, canal types, canal shape, canal diameter, and number of apical foramina of maxillary first premolars have been reported (1–4), the presence of a groove on the palatal aspect of the buccal roots of bifurcated maxillary first premolars has been less noticed. This groove extends from just below the bifurcation to the apex and has been described as a furcation groove (5, 6). Investigations indicate that the presence of such a groove may increase complications during root canal instrumentation and dowel space preparation (5, 7). Nevertheless, quantitative assessment of the correlation between the buccal root canal shape and the furcation groove depth has not been reported.

In previous studies of maxillary first premolars with furcation grooves, different methodologies such as radiographic (8) and sectioning (5–7) techniques were used. However, these techniques are invasive or allow only 2-dimensional (2D) analysis. Recently, micro–computed tomography (micro-CT) has been used to investigate the morphologic features of roots and root canals. Because of its noninvasiveness and extremely high resolution, enabling 3-dimensional (3D) evaluation of teeth, this method has proved to be a valuable tool in experimental endodontics (9, 10).

The purpose of this study was to investigate the buccal root anatomy of bifurcated maxillary first premolars with furcation grooves and to determine the correlation between the groove depth and the buccal root canal shape by using micro-CT.

Materials and Methods

Preparation of Specimens and Micro-CT Scanning

Forty-two bifurcated maxillary first premolars extracted for orthodontic treatment were collected from a native Chinese population aged between 17 and 25 years. Immediately after extraction, the teeth were stored in 10% neutral-buffered formalin solution until use. All the teeth showed complete root formation and were not endodontically treated. After calculus and attached soft tissues were removed, every tooth was inspected under a stereomicroscope (Carl Zeiss Microscopy GmbH, Göttingen, Germany) with ×6 magnification to confirm the presence of a furcation groove. Six teeth were excluded because of the absence of a furcation groove, and the final sample comprised 36 teeth.

A commercially available micro-CT system (μCT-80; Scanco Medical, Bassersdorf, Switzerland) with an isotropic voxel size of 36 μm was used to scan the specimens according to the manufacturer's instructions. Scanning was performed perpendicular to the long axis of the teeth. After calibration and segmentation of the scanned cross-sectional images, 3D images of each tooth were reconstructed by using the MeVisLab 2.0 software package (MeVis Medical Solutions AG, Bremen, Germany). Volumes of interest extending from just below the furcation to the apex of the buccal roots were selected.

Furcation Groove Measurements

Measurements of the furcation grooves were taken vertically (Fig. 1*A*) and horizontally (Fig. 1*B*). Five planes were selected for the vertical measurements: (1) furcation plane (FP), the cross-sectional plane at the furcation level; (2) apex plane (AP), the

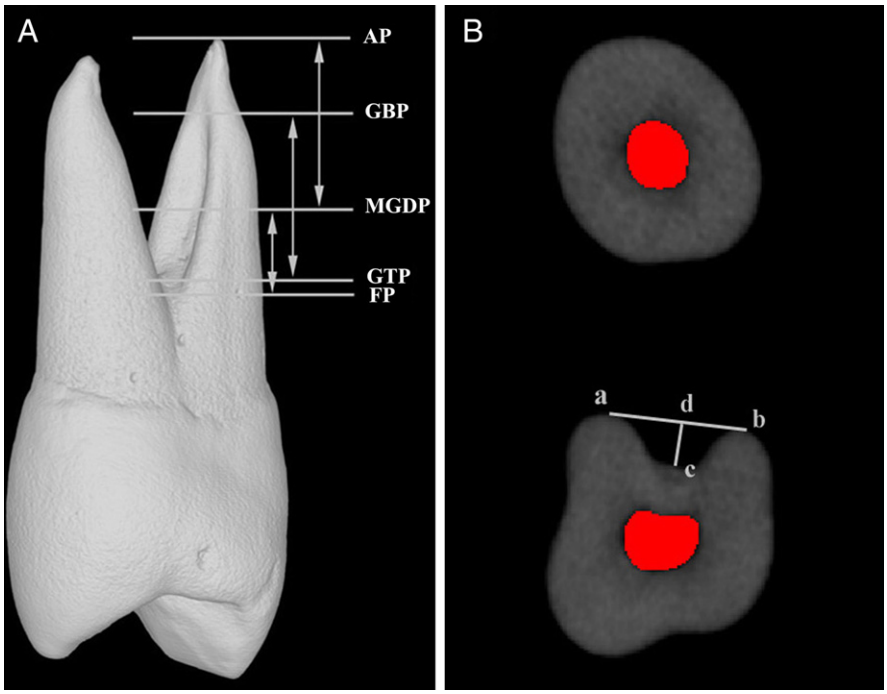

Figure 1. Vertical and horizontal measurements of the furcation groove. (*A*) Planes for the vertical measurements: FP, GTP, MGDP, GBP, and AP. (*B*) Reference points and lines for the horizontal measurements: ab line, groove tangential line; point c, groove vertex; cd line, line perpendicular to the ab line (ie, MGD).

cross-sectional plane at the anatomic apex of the buccal root; (3) groove top plane (GTP), the cross-sectional plane at the coronal top of the groove; (4) groove bottom plane (GBP), the cross-sectional plane at the apical bottom of the groove; and (5) maximum groove depth plane (MGDP), the cross-sectional plane at the deepest part of the groove. The distances from MGDP to FP, MGDP to AP, and GTP to GBP were then measured. Horizontal measurement was taken in the MGDP to determine the maximum groove depth (MGD).

Wall Thickness Measurements

The wall thickness of the buccal roots was expressed as color-coded reconstructions by using the customized application framework in MeVisLab software according to the method of Gao et al (11). The reconstructed images showed the distribution of the minimum distance between the root external surface and the root canal surface, ie, the wall thickness distribution of the buccal roots (Fig. 2). The roots were divided into 3 equal portions: coronal, middle, and apical portions. Then the minimum wall thickness (MWT) on the buccal and palatal aspects at each portion was recorded.

Root Canal Shape Analysis

Cross-sectional images of interest were analyzed with Image-Pro Plus 6.0 software (Media Cybernetics, Inc, Bethesda, MD). For every cross-sectional image, the boundary of the buccal root canal was automatically segmented, and its perimeter and area were automatically calculated. The form factor (FF) of the buccal root canal at every cross section was calculated by the following equation:

$$FF = \frac{4 \times \pi \times Area}{Perimeter^2}$$

Then the mean form factor (MFF) of the whole buccal root canal was calculated and recorded.

Statistical Analysis

The furcation groove data were subjected to descriptive statistics. The MWT on the buccal and palatal aspects at different portions of the buccal roots was compared by the paired-samples *t* test. The correlation between MFF and MGD was analyzed by using Pearson correlation coefficients (ρ^2). The level of significance was established at $P < .05$. All statistical analyses were performed with SPSS 13.0 (SPSS Inc, Chicago, IL).

Results

The prevalence of furcation grooves in this study was 85.7% (36 of 42 teeth). Most of the furcation grooves (69.4%) were located in the coronal two thirds of the buccal roots; only 11 extended to the apical third.

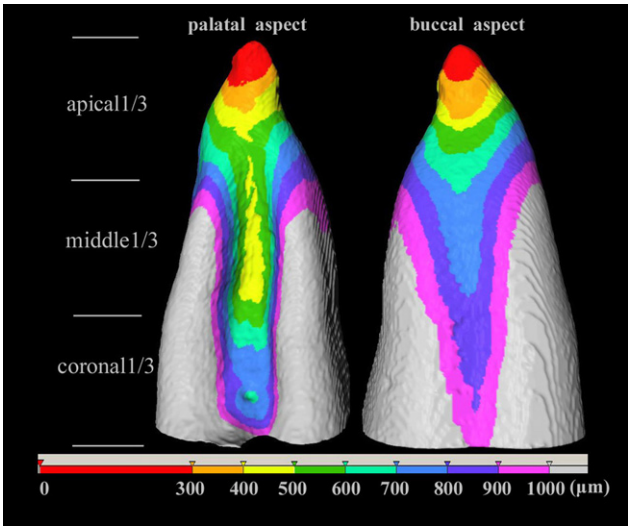

Figure 2. 3D color-coded images showing the wall thickness distribution on the buccal and palatal aspects of the buccal root.