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A cone-beam computed tomography study of the mesial cervical concavity of maxillary first premolars

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ABSTRACT

Objective: To investigate the mesial cervical concavity of maxillary first premolars and its relationship with root and canal configuration using cone-beam computed tomography (CBCT).
Design: Images of maxillary first premolars (n = 1056) were collected from patients (n = 601) who had undergone*in vivo* CBCT scanning. The root and canal number and morphology were evaluated. The following measurements of the mesial cervical concavity of the maxillary first premolars were evaluated in section images: dentine thickness (in concavity at the cemento-enamel junction), concavity angle, depression depth (distance from mesial dentinal surface at concavity to mesial proximity), concavity position (distance from mesial dentinal wall at invagination to the top of the mesial marginal ridge). The reliability of the data was analyzed with an unpaired Student's *t* test and Fisher's exact test.
Results: The percentages of maxillary first premolars with one root, two, and three roots were 55.5%, 43.7%, and 0.8% respectively. Mesial cervical concavity was recorded in 64.5% of single-root maxillary premolars. The prevalence of two-root maxillary first premolars with mesial cervical concavity was 73.8%. The means of the aforementioned four measurements were 1.705, 147.9, 1.640, and 5.247 mm. The values of dentine thickness (mm), depression depth (mm), and concavity position (mm) of the mesial cervical concavity were largest in two-root maxillary first premolars. The smallest concavity angle of the mesial cervical concavity was found in three-root maxillary first premolars.
Conclusions: There is a high prevalence of mesial cervical concavity among maxillary first premolars. The mesial root concavity is more prevalent in single-rooted maxillary first premolars when there are two canals present, and its prevalence and degree of concavity increase with the number of roots.

1. Introduction

The root morphology of the maxillary first premolars differs from other premolars. It presents a variety of configurations and shapes throughout the dentition. The unique anatomical features commonly described include bifurcated roots, narrow furcation entrance, multiple canals, and deep mesial concavities (Bellizzi & Hartwell, 1985). Several studies have reported a high incidence of mesial concavities of the maxillary first premolars (Lammertyn, Rodrigo, Brunotto, & Crosa, 2009; Li, Li, & Pan, 2013; Zhao, Wang, Pan, Pan, & Jin, 2014). According to the position of root concavities, Ong and Neo classified them into five groups (Ong & Neo, 1990). Type I: no concavity on the root; Type II: concavity starting at the enamel; Type III: concavity starting at the cemento-enamel junction; Type IV: concavity starting at the cervical third; Type V: concavity starting at the apical third. The mesial cervical concavities (Types II and III) are the uppermost and communicate with the oral cavity. These root concavities of the first premolars lead to plaque accumulation and are associated with periodontal disease (Zhao et al., 2014). They also are the first concavities met in root canal procedures, which might lead to unfavorable endodontic outcomes without a thorough knowledge of their morphology (Lammertyn et al., 2009).

Successful endodontic treatment relies on a thorough knowledge of tooth root configurations and shapes (Lammertyn et al., 2009; Paul & Dube, 2015; Versiani et al., 2016). The number of roots, the canal types, and the diameter of Type IV and Type V concavities of maxillary first premolars have been reported (Booker & Loughlin, 1985; Lammertyn et al., 2009; Li et al., 2013; Tamse, Katz, & Pilo, 2000), and there is a need to study the location, depth and the dimensions of the canal walls

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of the cervical concavities (Types II and III) to enrich the anatomical data.

Radiographic investigation is central to the diagnosis and treatment process in endodontics (Ok et al., 2014). Conventional intraoral images, whether film-based or digital, cannot accurately represent the complete three-dimensional (3-D) information of the cervical concavities, because the anatomy of the region is obstructed by tooth structures in a two-dimensional image. Cone beam computed tomography (CBCT), a noninvasive method, is now widely used to observe tooth anatomy in axial, sagittal, and coronal sections with a high resolution (Chang, Lam, Shah, & Azarpazhooh, 2016; Ozcan, Sekerci, Cantekin, Aydinbelge, & Dogan, 2015; Scarfe, Levin, Gane, & Farman, 2009). Tooth root and canal anatomy and morphology, the number of canals, and their divergence or convergence from each other can be visualized and measured in three-dimensions (Kaya, Yavuz, Uysal, Akkus, & 2012; La, Jung, Kim, & Min, 2010; Ozcan et al., 2015).

Consequently, the aim of this study was to conduct a morphometric analysis and establish baseline data of the mesial cervical concavity of maxillary first premolars using CBCT.

2. Materials and methods

This study was conducted in the Ninth People's Hospital, Shanghai Jiao Tong University, School of Medicine (Shanghai, China). Between February 2015 and September 2016, 1056 CBCT images of maxillary first premolars were collected from 601 patients aged 18 to 80 years who were subjected to CBCT scanning as a preoperative assessment for maxillofacial, implant or orthodontic treatment.

The samples were selected according to the following criteria:

1 Available CBCT images of the maxillary first premolars with complete root anatomy
2 Absence of root canal treatment
3 Absence of coronal or post-core restorations
4 Absence of root resorption or periapical lesions
5 CBCT images of high quality (able to distinguish between enamel and dentin)

The CBCT images were acquired using a CBCT scanner (i-CAT, Imaging Sciences International, Hatfield, PA, USA) at 85 kV and 35 mA by an experienced radiologist. The entire acquisition process was performed according to the manufacturer's recommended protocol. The exposure time was set at 2–6 s, the voxel size of the images ranged from 0.125 to 0.3 mm, and the slice thickness was 1.0 mm.

The first plane, beneath the cemento-enamel junction, was selected for measurement and evaluation. The contrast and brightness of the images were adjusted to ensure optimal visualization. Measurement accuracy was 0.001 mm and 0.1°. The long axis (L0) was from the central groove to the root apex. The parallel line of L0 (L1) along the mesial proximity in the section was defined as the reference line (Fig. 1a, b). The mesial cemento-enamel junction was used as the reference section for concavity measurements. All the images from the 1056 maxillary first premolars were evaluated to acquire the information: Gender, age, number and type of roots and canals; and in order to position the mesial cervical concavity of maxillary first premolars, the following values were measured (Fig. 1a, b):

A: Dentine thickness (in concavity at the cemento-enamel junction)

B: Concavity angle

C: Depression depth (distance from mesial dentinal surface at concavity to mesial proximity)

D: Concavity position (distance from mesial dentinal wall at invagination to the top of mesial marginal ridge).

All data were evaluated a further two times at an interval of 1 month; no significant difference was found among replicate measurements using one-way analysis of variance.

Student's unpaired *t* test was used to compare the A values. Fisher's exact test with two-tailed significance was used to evaluate the statistical significance of differences between teeth with or without concavity. The difference was considered statistically significant when $P < 0.05$. Collected data were statistically analyzed using SPSS 15 for Windows software (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Number of roots and root canals in maxillary first premolars

Table 1 shows the frequency distribution of the root canals of maxillary premolar teeth. The percentages of maxillary first premolars with one, two, and three roots were 55.5%, 43.7%, and 0.8%, respectively. Most maxillary first premolars had two-root canals (74.2% of the 1056 teeth studied). Among the 586 single-rooted maxillary first premolars, 54.9% had two canals and 45.1% had one canal. All (n = 462) of the two-rooted maxillary first premolars had two canals. Only eight of 1056 maxillary first premolars had three roots: a mesiobuccal root, a distobuccal root, and a palatal root. Each of the three-rooted maxillary first premolars had a single canal in each root. There was no statistically-significant difference between right and left, or male and female in the number of roots and root canals.

3.2. The mesial cervical concavity in maxillary first premolars

Of the total, 727 maxillary first premolars exhibited mesial cervical concavity. Mesial cervical concavity was recorded in 64.5% of single-root maxillary premolars. Of 264 single-canal one-root premolars, 100 had this feature (37.9%). Two-root maxillary first premolars with mesial cervical concavity were more commonly present (73.8%). There was a statistically-significant difference between the prevalence of one-root and two-root maxillary first premolars. In this study population, all three-root maxillary first premolars had mesial cervical concavity (Table 2).

3.3. Measurements of the mesial cervical concavity in maxillary first premolars

The dentine thickness in the concavity at the cemento-enamel junction in teeth with mesial cervical concavity was smaller than that in teeth without (Table 3). The mean and standard deviation of each measurement and its relationship to the number of roots are presented for maxillary first premolars with mesial cervical concavity (Table 4). The values of dentine thickness (mm), depression depth (mm), and concavity position (mm) of the mesial cervical concavity were largest in two-root maxillary first premolars, second largest in one-root, and smallest in three-root premolars. The minimum concavity angle (º) of the mesial cervical concavity was in three-root maxillary first premolars, followed by two roots, and one root.

4. Discussion

Cervical concavity commonly exists at the mesial cemento-enamel junction in maxillary first premolars, and is often connected to the occlusal fissure by a groove (Macha Ade, Vellini-Ferreira, Scavone-Junior, & Ferreira, 2010). The anatomic structure is capable of retaining plaque and substances which may not be biologically compatible with periodontal tissues, which may influence periodontal treatment and removal of plaque, calculus and other substances (Ok et al., 2014). A previous study reported that the concavities of the first premolars were important in contributing to local periodontal disease of the first premolars (Zhao et al., 2014). The presence of cervical concavity may lead to inconsistent wall thickness on different aspects of the tooth at the cemento–enamel junction (Katz, Wasenstein-Kohn, Tamse, & Zuckerman, 2006). Endodontic therapy and post preparation may reduce the dentin more on this aspect of the tooth at the