Available online at www.sciencedirect.com

ScienceDirect

Biomedical Journal

journal homepage: www.elsevier.com/locate/bj

Original Article

Evaluation of the root and canal systems of maxillary molars in Taiwanese patients: A cone beam computed tomography study

Yu-Hua Lin [a], Hsiu-Na Lin [a,*], Chien-Chih Chen [b], May-Show Chen [c]

[a] Department of Dentistry, Chang Gung Memorial Hospital, Taipei, Taiwan
[b] Department of Dentistry, Cardinal Tien Hospital, New Taipei City, Taiwan
[c] Department of Dentistry, Taipei Medical University Hospital, Taipei, Taiwan

ARTICLE INFO

Article history:
Received 20 April 2016
Accepted 23 May 2017
Available online 27 July 2017

Keywords:
Cone beam computed tomography
Maxillary molars
Root canal system
Taiwan

ABSTRACT

Background: This study evaluated variations in root canal configuration in the maxillary permanent molars of Taiwanese patients by analyzing patients' cone beam computed tomography (CBCT) images. Comparisons were made among these configurations and those previously reported. This information may serve as a basis for improving the success rate of endodontic treatment.

Methods: The root canal systems of 114 Taiwanese patients with bilateral maxillary first or second molars were examined using CBCT images. The number of roots, canals per root, and additional mesiobuccal (MB) canals, as well as the canal configuration were enumerated and recorded.

Results: Of the 196 maxillary first molars examined, three (1.5%) had a single root, two (1.0%) had two roots, and 191 (97.5%) had three separate roots. Out of all first molar roots examined, 44% of mesiobuccal (MB) roots had a single canal and the remainder had a second MB (MB2) canal. Of the 212 maxillary second molars examined, 16 (7.1%) had a single root, 51 (24.2%) had two roots, 143 (67.8%) had three roots, and two (0.9%) had four separate roots. For the MB roots, 92.3% of three-rooted maxillary second molars had a single canal and the remainder had an MB2 canal. In all three-rooted maxillary first and second molars, each of the distal and palatal roots had one canal.

Conclusions: The root canal configurations of the MB roots of maxillary molars were more varied than those of the distobuccal and palatal roots, and the root canal configurations of maxillary second molars were more varied than those of the first molars. These findings demonstrate CBCT as a useful clinical tool for endodontic diagnosis and treatment planning.

The thorough and complete debridement, disinfection, and obturation of the root canal system are essential for achieving successful root canal treatment. However, currently available imaging systems do not allow for three-dimensional visualization of the patient's root canal configuration during these procedures. This has resulted in incomplete debridement, disinfection, and obturation in some cases due to the failure to detect all of the patient's roots and canals. Therefore,

* *Corresponding author*. Department of Dentistry, Chung Gung Memorial Hospital, 199, Dunghua N. Rd., Taipei, Taiwan.
E-mail address: tiffanylin1214@gmail.com (H.-N. Lin).
Peer review under responsibility of Chang Gung University.
http://dx.doi.org/10.1016/j.bj.2017.05.003

At a glance commentary

Scientific background on the subject

The elucidation of the second mesiobuccal canal (MB2)'s anatomical structure in clinical practice is complex due to anatomical variations between individuals, as well as the excessive dentin deposition at the opening of the canal and the difficulty in visually accessing maxillary molars.

What this study adds to the field

In recent years, CBCT has made it possible to visualize the difficult-to-get-to anatomical structure in three dimensions, and it has now become a valuable tool for facilitating endodontic diagnosis and enabling treatment using a lower dose of radiation when compared to conventional computed tomography.

to facilitate an accurate assessment of patients' root canal systems, clinicians should be aware of common root canal configurations and possible anatomical variations [1].

Because root canal anatomy is genetically determined, there may be similarities as well as variations in the patterns of root canal configuration among different populations. Ethnicity-related differences in root canal anatomy have been reported in many studies. Therefore, characterizing the root canal anatomy of a specific population and comparing the findings with those of other populations would be conducive to enhancing clinicians' understanding of population trends in the anatomy of the root canal system.

Maxillary molars are known to have the highest clinical failure rate in root canal treatment [2,3], likely because of their complex root anatomy and canal morphology [1,4–9]. According to published studies, most maxillary molars have three roots and four canals [4–9]. The incidence of a second mesiobuccal (MB2) canal in the mesiobuccal (MB) root is higher than 50% [8–11]. Other anatomical variations that have been reported include a third canal in the mesial root [12], more than one canal in the distobuccal and palatal roots [10,11], and C-shaped canals [13].

Commonly used methodologies for evaluating the inner morphology of root canal systems include sectioning techniques, canal staining and tooth clearing [4,14,15], and acquisition of conventional and digital radiographs [16–18]. A recently developed imaging method, cone beam computed tomography (CBCT), has been shown to provide accurate high-resolution three-dimensional anatomical images for diagnosis and treatment planning before endodontic treatment [19,20]. Therefore, this imaging method has potential as a superior preoperative assessment for improving root canal treatment outcomes and avoiding further complications.

Numerous studies have used the CBCT method to investigate the canal morphology of maxillary molars. However, the root canal morphology of maxillary permanent molars in the Taiwanese population has not been investigated in this manner. This *in vivo* study therefore used CBCT imaging to analyze the number of roots and canals of maxillary first and second molars to categorize the presence of MB2 canals in the Taiwanese population.

Methods

Patients

A total of 67 women and 47 men were included in this study, with a mean age of 24.63 years (range: 18–64 years). CBCT images of 196 maxillary first molars and 212 maxillary second molars were obtained from these 114 participants between July 2014 and July 2015 at Chang Gung Memorial Hospital, Taipei, Taiwan. The images were taken as part of routine examination, diagnosis, and treatment planning for patients requiring orthodontic or orthognathic treatment or during preoperative assessment for dental implants. Patients' identities were not revealed; only information regarding gender and age was acquired. This study was approved by the institutional review board of the Chang Gung Medical Foundation (protocol number: 201602003B0).

Teeth were selected according to the following criteria: (1) fully erupted permanent maxillary first molars or second molars bilaterally; (2) maxillary first or second molars with fully formed apexes and no previous root canal treatment. Exclusion criteria were as follows: (1) CBCT images that were unclear or had artifacts; (2) maxillary first and second molars with root resorption or calcification, or crown restorations interfering with image analysis.

Image acquisition

All CBCT images were acquired using the i-CAT Cone Beam 3D Dental Imaging System (Image Sciences International, Hatfield, PA, USA). The image parameters were as follows: pixel size, 0.25 mm; slice thickness, 0.25 mm; tube voltage, 120 kVp; tube current, 36.12 mA/s; and acquisition period, 40 s. CBCT imaging was carried out by four licensed radiologists according to the ALARA radiation safety principle.

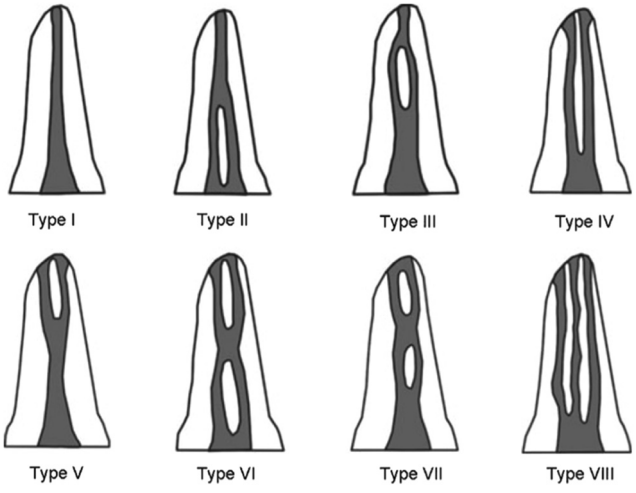

Fig. 1 Vertucci's (1984) classification of the root canal system.