Original Article

Evaluation of Root and Canal Systems of Mandibular First Molars in Taiwanese Individuals Using Cone-beam Computed Tomography

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Background/Purpose: Cone-beam computed tomography (CBCT) can provide valuable data for root canal systems of human teeth. This study used CBCT to evaluate the number of roots and canals in mandibular first molars in Taiwanese individuals.

Methods: We screened 151 patients (76 male and 75 female) scheduled for CBCT scan prior to implantation, or orthodontic, endodontic, or periodontic treatment between June 2006 and March 2009 at the Department of Dentistry, Cardinal Tien Hospital, Taipei, Taiwan. A total of 237 image samples of mandibular first molars were obtained and analyzed for their number of roots and canals.

Results: We found that 177 (74.7%) mandibular first molars had two roots and 60 (25.3%) had three roots. Of the 237 teeth, 133 (56.1%) had three canals, 96 (40.5%) had four, and eight (3.4%) had two canals. Of the 86 patients (43 male and 43 female) with bilateral mandibular first molars, 22 (25.6%, 15 male and 7 female) had bilateral three-rooted mandibular first molars, and six (7.0%, 4 male and 2 female) had unilateral three-rooted mandibular first molars. The $\chi^2$ test showed a significantly higher incidence of three-rooted mandibular first molars in male (44.2%, 19/43) than in female (20.9%, 9/43, $p=0.038$) subjects.

Conclusion: Our results showed a high overall incidence (32.6%) of three-rooted mandibular first molars in Taiwanese individuals. CBCT could be a valuable tool for identifying an extra distolingual root in mandibular first molars.

Key Words: cone-beam computed tomography, molar, root canal

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Successful root canal therapy consists of thorough biomechanical instrumentation and chemical debridement, followed by hermetic obturation of the root canal system. To achieve these goals, an understanding of fundamental root canal anatomy is indispensable for dentists to perform endodontic therapy. Incorrect identification of the number of roots and canals can lead to endodontic failures. In addition, variations in the root canal systems and characteristic features in different races should be recognized before or during endodontic treatment.1

Cone-beam computed tomography (CBCT), using a cone-shaped X-ray beam instead of a fan-shaped beam, has been designed specifically for use in dentistry. The radiation doses required for CBCT are significantly lower than those for conventional CT,2 because the data used to construct the tomographic image are obtained in a single sweep of the scanner. Compared with conventional radiographs that compress the three-dimensional (3D) anatomy into a two-dimensional (2D) image, CBCT produces 3D images with faster image acquisition, doesn’t produce chemical waste, allows for further image manipulation, and has ease of image archiving.3 A cone-shaped beam of X-rays passes through the target area and is detected by an amorphous silicon panel. Subsequently, a personal computer reformats the whole volume of data and processes the images. CBCT has been suggested to assist in evaluating periapical lesions,4,5 conducting periradicular surgery on the palatal root of maxillary molars,6,7 identifying root canal systems,8 and treating external cervical resorption lesions.9

Many studies have examined the root and canal morphology of mandibular first molars in different races.10–16 However, all of these studies have used extracted teeth or retrospective periapical radiographs for analysis. Recently, a study using CBCT to analyze permanent three-rooted mandibular first molars has been reported, but the canal systems of the mandibular first molars were not described.17 Clinically, understanding the root canal system of a tooth using CBCT is very useful for dentists before or during root canal treatment. However, no detailed data of the root canal system of the mandibular first molar in Taiwanese individuals have been found using CBCT for evaluation. The present study used CBCT to analyze the root and canal systems of mandibular first molars in Taiwanese individuals.

Materials and Methods

CBCT images of 500 patients aged 10–90 years old were screened from the files of the Department of Dentistry, Cardinal Tien Hospital, Taipei, Taiwan from June 2006 to March 2009. These patients were scheduled for CBCT (i-CAT; Imaging Sciences International, Hatfield, PA, USA) prior to implantation, or orthodontic, endodontic, or periodontic treatment. Informed consent was obtained from the patients and this study was approved by the Ethical Committee of Cardinal Tien Hospital. Only the permanent mandibular first molars with fully formed apexes were included in this study. Permanent mandibular second molars that had shifted mesially to the position of early lost first molars were excluded by identification of tooth morphology and tilting. According to the above-mentioned inclusion and exclusion criteria, 151 patients (76 male and 75 female) with a total of 237 mandibular first molars were included in this study.

A fast scan model of CBCT was used to minimize the radiation exposure and reduce the chances of patient movement during the scan (scanning time, 40 sec; slices, 0.4 mm; pitch, 0.4 mm). Image reconstruction required <2 minutes. With the patient’s consent, a 20-second, 120-kV, 5-mA CBCT scan was taken. All dental CT images were reconstructed by i-CAT Image System and the images were displayed on a 20-inch, flat-panel, medical liquid crystal display (EIZO FlexScan L887, Ishikawa, Japan) at 1600 × 1200 lines, with a resolution of 0.08 mm. Cross-sectional images through the lower first molars were obtained and analyzed by three endodontists to determine the number of roots and canals in these mandibular first molars. Disagreement...
in the identification of root and canal numbers was further discussed until a consensus was reached. The difference in the incidence of the three-rooted mandibular first molars between male and female patients was analyzed by the \( \chi^2 \) test.

**Results**

Of the 237 mandibular first molars, 177 (74.7%) had two roots and 60 (25.3%) had three (Table 1). When the number of roots was two, the canal number was two (Figure A), three (Figure B), or

<table>
<thead>
<tr>
<th>Case</th>
<th>Male (n = 76)</th>
<th>Female (n = 75)</th>
<th>Total (n = 151)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tooth</td>
<td>119 (50.2)</td>
<td>118 (49.8)</td>
<td>237 (100)</td>
</tr>
<tr>
<td>Two roots(^1)</td>
<td>82 (34.6)</td>
<td>95 (40.1)</td>
<td>177 (74.7)</td>
</tr>
<tr>
<td>Two canals(^2)</td>
<td>2 (0.8)</td>
<td>6 (2.5)</td>
<td>8 (3.4)</td>
</tr>
<tr>
<td>Three canals(^3)</td>
<td>60 (25.3)</td>
<td>73 (30.8)</td>
<td>133 (56.1)</td>
</tr>
<tr>
<td>Four canals(^4)</td>
<td>20 (8.4)</td>
<td>16 (6.8)</td>
<td>36 (15.2)</td>
</tr>
<tr>
<td>Three roots(^5)</td>
<td>37 (15.6)</td>
<td>23 (9.7)</td>
<td>60 (25.3)</td>
</tr>
<tr>
<td>Four canals(^6)</td>
<td>37 (15.6)</td>
<td>23 (9.7)</td>
<td>60 (25.3)</td>
</tr>
</tbody>
</table>

*Data presented as n (%); \(^1\) one mesial root and one distal root; \(^2\) one mesial canal and one distal canal; \(^3\) two mesial canals and one distal canal; \(^4\) two mesial canals and two distal canals; \(^5\) one mesial root and two distal roots.

**Figure.** Cone-beam computed tomography images demonstrate: (A) a mandibular first molar with two roots and two canals (arrow); (B) a mandibular first molar with two roots and three canals (arrow); (C) a mandibular first molar with two roots and four canals (arrow); and (D) a mandibular first molar with three roots and four canals (arrow).
four (Figure C) in 8, 133, or 36 teeth, respectively. However, all three-rooted mandibular first molars had four canals (Figure D).

The distribution of mandibular first molars with three roots was analyzed further in 43 male and 43 female patients with bilateral mandibular first molars (Table 2). Of the 86 patients, 22 (25.6%) had bilateral, three-rooted, mandibular first molars and six (7.0%) had unilateral, three-rooted, mandibular first molars. This gave an overall incidence of 32.6% (28/86) for occurrence of three-rooted mandibular first molars in Taiwanese individuals. The \( \chi^2 \) test showed a significantly higher incidence of three-rooted mandibular first molars in male (44.2%, 19/43) than female (20.9%, 9/43) (\( p = 0.038 \)) patients.

**Discussion**

This study used CBCT to evaluate the root and canal systems of 237 mandibular first molars in 151 Taiwanese individuals. The results showed that the majority (56.1%) of mandibular first molars had three canals, 40.5% had four, and 3.4% had only two (Table 1). These results differed from those of Reuben et al\(^{10} \) who reported that a much higher percentage (85.48%) of the surveyed Indian population had three canals, and a smaller percentage had four (6.45%) or two (6.45%) canals. Our results were more consistent with those of Yew and Chan who found a comparatively higher percentage (62.5%) of Taiwanese patients had three canals, 31.5% had four, and 6% had two.\(^{15} \) Skidmore and Bjorndal\(^{18} \) reported a comparatively lower percentage (28.9%) of male Caucasians had four canals, but a study from Sudan\(^{12} \) found a higher percentage (59%) of teeth with four canals than was seen in the present study. Approximately two-thirds (62.5%, 60/96) of cases in the present study had the fourth canal arising from the distolingual root, which is similar to the rate of 68.3% reported in a Taiwanese study by Yew and Chan.\(^{15} \) However, the percentage (3.4%) with two canals in the present study was lower than that (6.1%) in a study of the Kuwaiti population.\(^{19} \)

The incidence of three- and two-rooted mandibular first molars in our study was 25.3% and 74.7%, respectively (Table 1). This incidence of three-rooted mandibular first molars was higher than that reported in previous studies of Japanese (22.7%),\(^{20} \) Baffin Eskimo (21.7%),\(^{21} \) Taiwanese (21.1%),\(^{11} \) Thai (19.2%),\(^{22} \) Hong Kong (15.0%),\(^{23} \) Burmese (10.0%),\(^{13} \) Caucasian (4.3%),\(^{20} \) Sudanese and Senegalese (3.0%) subjects.\(^{12,24} \) However, the incidence (25.3%) of three-rooted mandibular first molars in the present study was lower than that (33.3%) reported in a previous Taiwanese study using CBCT.\(^{17} \) The discrepancy might have resulted from regional differences; Tu et al\(^{17} \) studied a population in a central city of Taiwan, whereas our study examined a population in a northern city. Three-rooted mandibular first molars have been reported to occur more frequently in the Mongoloid than Caucasoid race.\(^{16} \)

The results of our study support the notion that Taiwanese individuals have a higher prevalence of three-rooted mandibular first molars than other Oriental populations. The incidence of bilateral and unilateral three-rooted molars in Taiwanese individuals in the present study was 25.6% and 7.0%, respectively (Table 2). If the incidence was calculated using three-rooted molars as the
denominator, the bilateral distribution increased to 88.0% (44/50), which was higher than that in two previous studies of Taiwanese individuals (68.6% and 67.0%, respectively), and studies from Hong Kong (61.0%) and Japan (57.0%). In addition to racial differences, another possible reason for the discrepancies between the present and previous studies in Taiwanese individuals is the different methodology used; previous studies used retrospective periapical radiographs to identify three-rooted mandibular first molars. As periapical radiographs are 2D, the number of roots may not be identifiable, even if the images are taken from different angles. The present study showed a significantly higher rate of three-rooted mandibular first molars in male than in female patients; this finding was different from previous studies.

Demineralization and staining has been reported to be the most effective technique for obtaining detailed information regarding canal number and morphology. However, root canal information that is obtained before or during endodontic therapy is more valuable for further dental management. Moreover, it has become more difficult to obtain extracted human teeth for study in Taiwan because the success rate of nonsurgical endodontic treatment has increased in recent decades. CT has been used in previous studies for evaluating root canal systems, but these studies all have used extracted human teeth. A higher incidence of three-rooted and four-canalled mandibular first molars in Taiwanese individuals was found in the present study using CBCT, compared with previous studies using periapical radiographs for evaluation. Further studies are needed to verify whether similar increases in incidence can be obtained using CBCT for evaluation in other populations. Our results indicate that CBCT is an effective adjunctive tool in endodontic treatment of mandibular first molars, because an unidentified extra distolingual root is one of the major factors that contribute to the high extraction rate of molars. Nevertheless, the routine use of CBCT in root canal treatment depends on availability of the equipment and the experience and preferences of the individual dentist. Comparatively poor image quality and contrast resolution compared with conventional films have been cited as the major drawbacks of CBCT in previous studies. However, the potential value of CBCT should be considered when more information is needed for diagnosis or treatment planning beyond that obtained from conventional radiographs.

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References


