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Localization of root canal orifices in mandibular second molars in relation to occlusal dimension

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Abstract

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Aim To evaluate the localization and distribution of canal orifices of mandibular second molar teeth in relation to the mesio-distal and bucco-lingual dimensions of coronal tissue.

Methodology Fifty extracted mandibular second molar teeth were embedded into plaster blocks with their vertical axes aligned perpendicular to the horizontal plane. The teeth were photographed digitally from the occlusal aspect under 12 × magnification. Thereafter, the occlusal halves of crowns were sectioned off to expose the root canal orifices. The teeth were than photographed under the same magnification, after which the pre- and post-sectioning images of each specimen were stacked into a single file. To plot the coordinate of each canal orifice, a 0.5-mm grid analytical plane was mounted digitally on the stack so that the *x*- and *y*-axes of the plane were superimposed on the mesiodistal and buccolingual axes (bisectors) of the tooth crowns. Localization and distribution of the coordinates of the canal orifices were evaluated using the chi-square test ($P = 0.05$).

Results Only one tooth displayed a single root canal orifice, located in the mesiobuccal-distolingual 'centre' of the occlusal surface. The majority of mandibular second molars had three orifices (72%), followed by those with two (16%) and four (10%). The distal canal was located lingual to the centre of the occlusal plane.

Conclusion The distal canal was located lingual to the centre of the occlusal plane of mandibular second molars. The possibility of observing more divergent localizations and orifice numbers should not be overlooked in clinical practice.

Keywords: dental pulp cavity, image analysis, mandibular second molar, root canal, root canal therapy.

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Introduction

Many of the difficulties encountered during root canal treatment are due to variations in root canal morphology (Malagnino *et al.* 1997, Soares & Leonardo 2003, Peters 2004). Because the outcome of treatment depends largely on a clear understanding of root canal morphology, clinicians should be aware of the internal morphology of permanent teeth, as well as the possible variations, which might be encountered (Slowey 1974, Christie *et al.* 1991).

Good access of the root canals is the first important phase of root canal preparation (Nallapati 2005). Ideally, an access cavity should facilitate the localization of all root canal orifices; however, it is not uncommon for clinicians to miss a root canal (Weine 1995, Cohen & Brown 2001, Hoen & Pink 2002, Iqbal *et al.* 2005). Missed (unfilled) canals remain as a focus of infection, which in turn can lead to complications (Weine 1995, Cohen & Brown 2001). Hoen & Pink (2002) reported a 42%-incidence of missed roots or root canals in teeth that needed retreatment. They concluded that a thorough knowledge of canal

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anatomy and meticulous attention to treatment details were essential.

Although diagnostic measures are important aids to locate the root canal orifices, a clinician may further improve the access cavity design by correlating the occlusal anatomy with the location of the root canal orifices (Vertucci 2005). As such, preoperative predictors related to detection of root canal orifices are important because they are the only information available before root canal treatment is initiated (Iqbal & Fillmore 2008).

Despite a plethora of publications on the variations of root canal morphology in permanent teeth, relatively few studies have been conducted on the morphology of the root canal system in mandibular second molars (Vertucci 1984, Caliskan *et al.* 1995, Peiris 1998, Peiris *et al.* 2008, Aminabadi *et al.* 2008). These studies have reported that mandibular second molars generally contain three (one distal and two mesial) root canals, but with a considerable degree of variability with regard to the number and localization of their orifices. Those findings also confirm that conventional access cavity design, whose outlines are determined by the occlusal morphology, cannot guarantee detection of all orifices.

The aim of this study was to evaluate the localization and distribution of root canal orifices of mandibular second molar teeth in relation to the mesio-distal and bucco-lingual dimensions of coronal tissue.

Materials and methods

Periodontally involved, freshly extracted mandibular second molar teeth were used. The teeth were obtained under informed consent from Turkish patients aged between 35 and 42 years old. Following removal of all attached soft tissue and calculus, radiographs of the teeth were taken so as to exclude those with calcifications in the pulp chamber or in the root canals. The selected teeth ($n = 50$) were stored in 0.1% thymol solution at room temperature. The teeth were embedded into plaster blocks with their vertical axes aligned perpendicular to the horizontal plane. The teeth were photographed digitally from the occlusal aspect using a stereomicroscope (Wild M3B, Heerbrugg, Switzerland) under standard ($12\times$) magnification (Fig. 1). To expose the root canal orifices, the occlusal portion of crowns were sectioned approximately 3.5 mm from the cemento-enamel junction with a water-cooled, slow-speed diamond saw. This value corresponds to approximately half the occluso-cervical dimension of the mandibular second molar crowns (Ash 1984). Thereafter, the canal orifices were negotiated with a size 10 K-file (Dentsply/Maillefer, Ballaigues, Switzerland) under $6.4\times$ magnification (Carl Zeiss, Oberkochen, Germany). Once again, the teeth were photographed from their occlusal aspect under the same magnification and exposure conditions (Fig. 1).

The digital images of teeth were transferred to a Macintosh workstation, where both the intact and sectioned images of each specimen were combined into a stack using image processing software (Adobe Photoshop CS3 Extended, V. 10.0.1; Adobe Inc., San Jose, CA, USA). Exact alignment of intact tooth images over the sectioned ones was accomplished by superimposing four reference marks (at 3, 6, 9 and 12 o'clock positions) on both images that were placed on the plaster surface before capture the images. To enable visualization of all root canal orifices in the lower layer of stack (post-sectioning image), the region overlying the root canal orifices was deleted from the upper layer (pre-sectioning image) in the form of an endodontic access cavity (Fig. 1). The resultant image was saved as an uncompressed *.TIFF file, and was transferred to an image analysis software (ImageJ Version 1.36 for Macintosh; National Institutes of Health, Bethesda, MD, USA). To enable plotting of the coordinate of each canal orifice, a 0.5 mm-grid analytical plane was mounted digitally on the stack, so that the x- and y-axes of the plane was superimposed on the mesiodistal and buccolingual axes (bisectors) of the tooth crowns (Fig. 1). The coordinates of canal orifices were recorded, and the distribution of orifices with respect to each teeth quadrant (mesiobuccal, mesiolingual, distobuccal and distolingual) was evaluated using the Chi-square test at $P < 0.05$. Additionally, a frequency distribution map was computed.

Results

The number and distribution of root canal orifices in the mandibular second molars are presented in Table 1. One tooth had a single root canal orifice, located in the mesiobuccal-distolingual 'centre' of the occlusal surface. Overall 16% of teeth had two root canal orifices (one mesial and one distal; with a majority of the orifices aligned along their mesiodistal axis), while 72% had three (mesiobuccal, mesiolingual and distal), and 10% had four (mesiobuccal, mesiolingual, distobuccal and distolingual) orifices.

The frequency distribution map with respect to the x–y coordinates of orifices is presented in Fig. 2. The teeth were grouped with respect to the number of orifices,

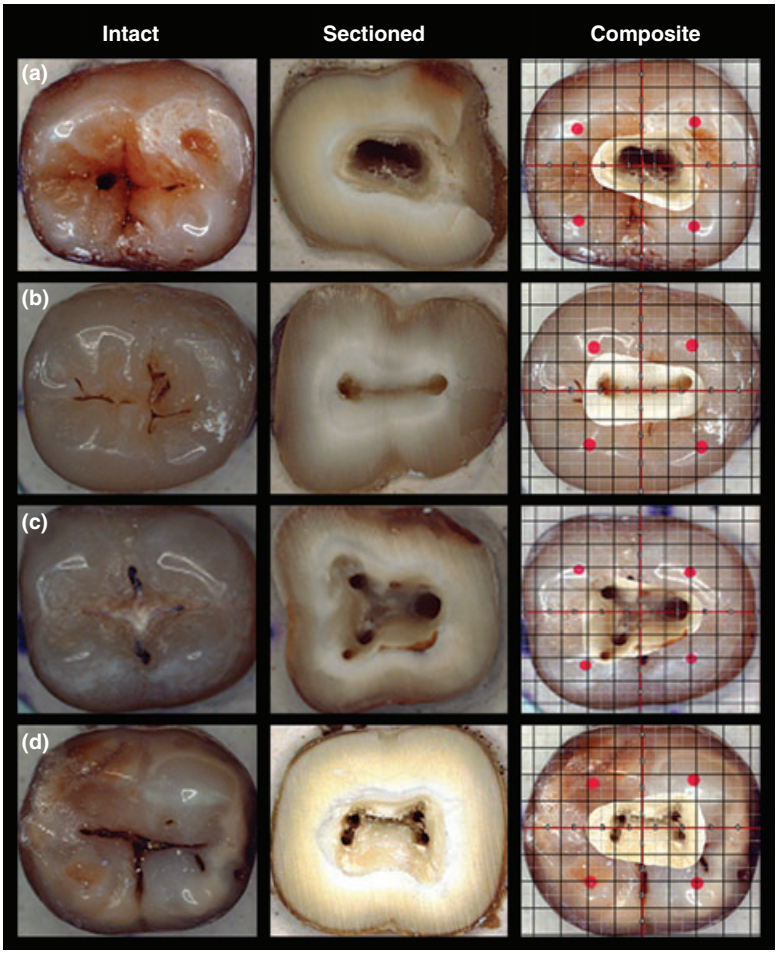

Figure 1 Intact, sectioned and composite (superimposed) representative images of teeth with respect to the number of root canal orifices (a = 1 canal orifice; b = 2 canal orifices; c = 3 canal orifices and d = 4 canal orifices). Cusp tips are marked with dots (left column).

Table 1 Number and distribution of canal orifices in mandibular second molar teeth

Number of root canal orifices	Number of teeth (%)	Mesiobuccal	Mesiolingual	Distobuccal	Distolingual	Centre
1	1 (2)	–	–	–	–	1
2	8 (16)	8	–	8	–	–
3	36 (72)	36	36	36	–	–
4	5 (10)	5	5	5	5	–

after which distribution of orifices was evaluated statistically. In teeth with two orifices, the frequency distributions of the coordinates were not statistically different between the mesial and distal canals ($P = 0.572$ and $P = 0.963$, respectively). When three orifices were present, the number of mesiobuccal orifices located on the coordinate 'x2a, y1b' was significantly greater than those located on other coordinates ($P < 0.001$). This coordinate corresponds to a point that is located 1.5 mm mesial and 1 mm buccal from the 'centre' of the crown (Fig. 2). In the same group, the frequency of mesiolingual orifices that were located on the coordinates 'x1b,–y2a' and 'x2a,–y1b' was significantly higher than those of other orifices ($P = 0.024$ and $P = 0.008$, respectively). However the frequency of these two coordinates did not differ significantly. Despite a greater numerical tendency to accumulate on the coordinate '–x2a,–y1a', there was no significant difference between the frequency of distal canals with respect to their localization ($P = 0.963$).

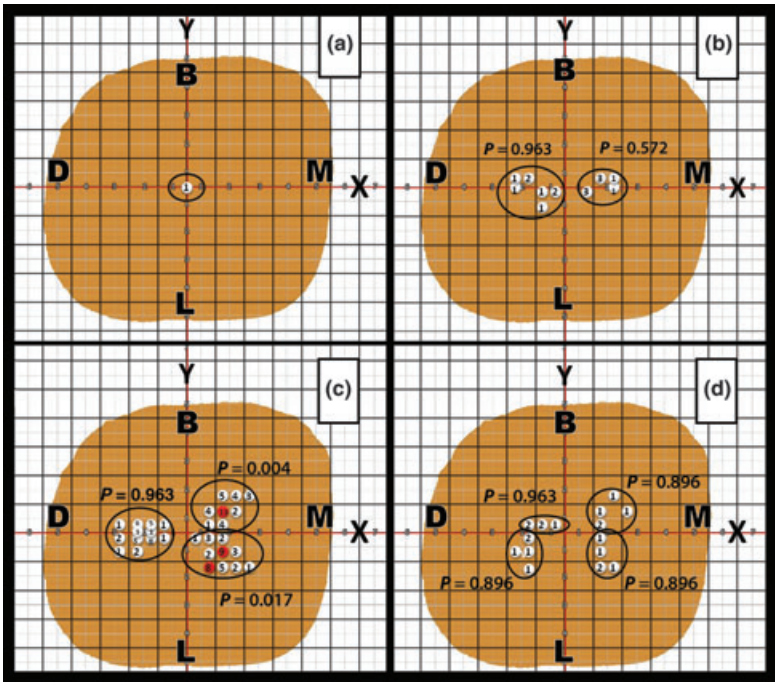

Figure 2 The frequency distribution map with respect to the *x*–*y* coordinates of canal orifices ($P < 0.05$). The teeth have been grouped according to the number of root canal orifices (Insets: a = 1 canal orifice; b = 2 canal orifices; c = 3 canal orifices; d = 4 canal orifices). Areas delineated with ovals demonstrate the regions of the accumulation of root canal orifices in each quadrant. Within each oval, the circles represent the coordinate and number of root canal orifices. The frequency of circles marked with red are significantly greater than those of white circles.

In teeth with four orifices, there was no significant difference between the frequency of orifices within each quadrant (mesiobuccal, $P = 0.896$; mesiolingual, $P = 0.896$; distobuccal, $P = 0.819$ and distolingual, $P = 0.896$).

Discussion

Mandibular second molars with two mesial canal orifices had at least one distal root canal orifice. The prevalence of four canal orifices was 13.8% when a second canal orifice was located in the mesial root. In 10% of the specimens, the orifice of the distal root canal was located on or in close proximity to the mid-bucco-lingual axis, whereas 46% of them were positioned more lingually. Although endodontic access cavities should result in minimum removal of sound tooth structure, these findings indicate that the conservative nature of conventional, triangular-shaped access cavity design may not always reflect the anatomy of the pulp chamber floor (Rahimi *et al.* 2008), and may consequently disguise a more lingually located distal canal orifice and/or the orifice of a second distal root canal. In light of these observations, it may be a reasonable to search for the distal (or second distal) canal orifice which might be located more lingually to the centre of the occlusal plane.

The study utilized image analysis techniques to obtain quantitative results without the need for location of the root canal orifices by separate evaluators, consensus scoring in borderline cases or statistical procedures for determining interexaminer reliability (Nagas *et al.* 2007). To enable plotting of the coordinate of each canal orifice, a 0.5 mm-grid analytical plane was mounted digitally on the stack, so that the *x*- and *y*-axes of the plane were superimposed on the mesiodistal and buccolingual axes (bisectors) of the tooth crowns. The findings suggest that the use of buccolingual and mesiodistal bisectors, which divide the occlusal view into four quadrants, may be a utilized as a simple adjunct in cases where observation of anatomical landmarks on the occlusal surface and the pulp chamber floor cannot verify major and/or supplementary root canal orifices.

Conclusions

A majority of mandibular second molar teeth had three orifices. Nevertheless, the possibility of observing more divergent localizations and orifice numbers should not be overlooked in clinical practice. The distal canal may be located more lingually to the centre of the occlusal plane of mandibular second molars.

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