Root canal morphology of mandibular incisors in a Jordanian population

A. A. Al-Qudah & L. A. Awawdeh
Faculty of Dentistry, Department of Restorative Dentistry, Jordan University of Science and Technology, Irbid, Jordan

Abstract

Aim To investigate the root canal morphology of mandibular incisors in a Jordanian population using a canal staining and tooth-clearing technique.

Methodology Four hundred and fifty extracted mandibular incisors were collected from dental clinics within north Jordan. Following pulp tissue removal and staining of the canal systems, the teeth were decalcified with 5% nitric acid, dehydrated with ascending concentrations of alcohol and rendered clear by immersion in methyl salicylate. Cleared teeth were examined by eye and the following features were evaluated:

(i) number and type of root canals; (ii) presence and location of lateral canals and intercanal communications; (iii) location of apical foramina; and (iv) frequency of apical deltas.

Results The majority of mandibular incisors had a single canal (73.8% of teeth possessed a Type I canal system). Although 26.2% of the roots possessed two canals, only 8.7% had two separate apical foramina.

Conclusions The prevalence of two canals in this group of mandibular incisors was 26.2% and is within the range of previous studies performed on populations of different racial origin.

Keywords: mandibular incisors, morphology, root canal.

Introduction
A clear knowledge of the anatomy of root canal systems is an essential prerequisite to carrying out root canal preparation. Many of the problems encountered during root canal treatment occur because of inadequate understanding of the pulp space anatomy. This applies to mandibular incisor teeth as many dentists fail to recognize the presence of a second canal.

Current knowledge of pulp space anatomy is based on research findings and individual case reports. Many studies have examined the root canal systems of mandibular incisors. Rankine-Wilson & Henry (1965) filled the root canals of mandibular anterior teeth with radio-opaque material, sectioned them in a horizontal plane, and exposed radiographs. They reported two canals in 40.5% of mandibular incisors. Later, Vertucci (1974) used the clearing technique to study the root canal morphology of 300 extracted mandibular anterior teeth. Two canals were found in 30% of mandibular central incisors and in 25% of mandibular lateral incisors. Mauger et al. (1998) evaluated the canal morphology at different root levels in one hundred mandibular incisors and reported that 98–100% of the teeth had one canal in the area 1–3 mm from the apex.

There is a lack of consistency in the reported prevalence of second canals in mandibular incisors (Vertucci 1974, Kaffe et al. 1985, Walker 1988, Mauger et al. 1998, Sert et al. 2004). The differences may be related to study design (in vivo versus ex vivo), technique of canal identification (radiographic examination, sectioning and clearing) or to racial divergence. Many studies have reported that root canal systems vary according to race (Walker 1988, Haddad et al. 1999, Weine et al. 1999, Sert & Bayirli 2004).
Descriptions of the frequently occurring root canal systems of permanent teeth are based largely on studies conducted in Europe and North America, and relate to teeth of mainly Caucasoid origin. These descriptions may not be fully applicable to teeth of non-Caucasoid origin. There are no published reports on the root canal anatomy of mandibular incisors in Jordan or other Middle Eastern countries. Jordan is in the Middle East with an estimated population of 5.8 million. Approximately, 92% of people living in Jordan are Jordanian and 98% are Arabs.

The purpose of this study was to examine the root canal morphology of mandibular incisors in a Jordanian population using a canal staining and root clearing technique.

**Materials and methods**

Four hundred and fifty extracted mandibular incisors were randomly collected from general dental clinics within north Jordan. The gender and age of patients was not known and no attempt was made to differentiate between central and lateral incisors. The teeth were placed in 3.25% sodium hypochlorite (Hypex Bleach, Jordan Chemical Industries Co., Amman, Jordan) for 1 h, after which any remaining soft tissue or calculus was removed by scaling. Access cavities were prepared and the pulp tissue removed by immersion in 3.25% sodium hypochlorite overnight, before placement in an ultrasonic bath. The teeth were then rinsed in running tap water for 2 h and dried overnight. An endodontic irrigation syringe with gauge 27 needle (BU Kwang Medical Inc., Seoul, Korea) was used to inject Indian ink (Sanford rotring GmbH, Hamburg, Germany) into the root canal system. The root apex was then immediately placed over small vacuum holes, connected to a central suction system, until the ink exited at the apical foramen.

The teeth were demineralized by immersion in 5% nitric acid for 4 days at room temperature (21 °C). The acid solution was changed every day. The teeth were washed under the running tap water for 4 h, dried and dehydrated using ascending concentrations of ethyl alcohol (70%, 96% and 99%) for 12 h each. Finally, the dehydrated teeth were placed in methyl salicylate, which rendered them transparent after about 2 h.

The transparent specimens were examined by the naked eye, and the following observations were made: (i) number and type of root canals; (ii) presence and location of lateral canals and intercanal communications; (iii) location of apical foramina; and (iv) frequency of apical deltas. The canal configurations were categorized into the first five types of Vertucci’s classification (2005) as follows:

- **Type I.** A single canal is present from the pulp chamber to the apex.
- **Type II.** Two separate canals leave the pulp chamber, but join to form one canal to the site of exiting.
- **Type III.** One canal leaves the pulp chamber, divides into two within the root, and then merges to exit in one canal.
- **Type IV.** Two separate and distinct canals are present from the pulp chamber to the apex.
- **Type V.** Single canal leaving the pulp chamber but dividing into two separate canals with two separate apical foramina.

The five canal configurations are shown in Fig. 1.

**Results**

Results are summarized in Tables 1–3. All teeth had one root. Table 1 shows the number and percentage of each canal type in the mandibular incisor teeth. Of 450 teeth, 332 (73.8%) had a single canal. Although 26.2% of the roots possessed two separate canals, only 8.7 had two separate apical foramina (Types IV and V). Figure 2 shows transparent teeth specimens, demonstrating the five canal configurations observed.
Table 1 Number and percentage of canal system types in mandibular incisors \( (n = 450) \)

<table>
<thead>
<tr>
<th>Type of root canal</th>
<th>Type I (332, 73.8%)</th>
<th>Type II (49, 10.9%)</th>
<th>Type III (30, 6.7%)</th>
<th>Type IV (23, 5.1%)</th>
<th>Type V (16, 3.6%)</th>
</tr>
</thead>
</table>

Table 2 Number and percentage of roots with lateral canals and intercanal communications \( (n = 450) \)

<table>
<thead>
<tr>
<th>Roots with Lateral canals</th>
<th>Position of lateral canals</th>
<th>Intercanal communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
</tr>
<tr>
<td>4 (0.9)</td>
<td>6 (1.3)</td>
<td>18 (4.0)</td>
</tr>
</tbody>
</table>

Table 3 Number and frequency of roots with central and lateral foramina and roots with apical deltas \( (n = 450) \)

<table>
<thead>
<tr>
<th>Position of apical foramina</th>
<th>Central (235, 52.2%)</th>
<th>Lateral (215, 47.8%)</th>
<th>Apical deltas (8, 1.8%)</th>
</tr>
</thead>
</table>

Discussion

A variety of techniques have been used to study root canal morphology including radiographic examination (Kaffe et al. 1985), root sectioning (Mauger et al. 1998) and staining and clearing techniques (Robertson et al. 1980). It has been reported that fine details of the root canal system can be visualized by staining and clearing (Gulabivala et al. 2002) and this method was used in the present study.

The literature on mandibular incisors reveals that 11–68% of mandibular incisors possess two canals, although many merge into one canal in the apical 1–3 mm of the root (Madeira & Hetem 1973, Vertucci 1974, Kartal & Yankikoglu 1992, Miyashita et al. 1997, Mauger et al. 1998, Sert et al. 2004). Vertucci (1974) examined the root canal morphology of 300 mandibular anterior teeth and reported a second canal in 27.5% of mandibular incisors. Miyashita et al. (1997) reported that 12.4% of mandibular incisors contained two canals, but only 3% had two foramina. Sert et al. (2004) noted that two canals were present in 68% of mandibular central incisors. The differences between these morphology studies may be related to variations of examination methods, classification systems, sample sizes and ethnic background of tooth sources.

This study examined the root canal morphology of extracted mandibular incisors collected from dental
clinics within north Jordan. Therefore, the sample may not be fully representative of the Jordanian population. However, root canal morphology may not vary in a young nation of the same ethnic origin. Therefore, the data presented in this paper is expected to apply to the Jordanian population.

It was found that 73.8% of the mandibular incisors possessed a single root canal. Although two canals were found in 26.2% of teeth, 67% of these canals joined and exited in a single foramen. Only 8.7% of canals in the teeth exited in two separate foramina (Types IV and V). Therefore, the frequency of two canals in the present study was within the range of previous reports.

The results of this investigation indicate that two canals occur in about one-fourth (26.2%) of mandibular incisors. This proportion is not found clinically by practitioners during root canal treatment (Neo & Chee 1990). This is due to failure of the dentist to recognize the presence of the second canal and the need for access cavities to have appropriate inciso-gingival extension to facilitate the location of lingual canals.

Of the teeth with two canals, the Type II configuration was most prevalent, followed by Types III, IV and V. Preparation and filling of Types I and IV canal systems is relatively straightforward because each of the canals in these configurations is separate and distinct between orifice and apex. However, Type II, III and V systems are different because there are areas in the root where the two canals share space and others where the canals are separate. This requires an individualized procedure for preparation and filling in each of these conditions to obtain the most desirable results.

In the present study, lateral canals were observed only in 6.2% of teeth and were found most frequently in the apical third of the canal. This is consistent with the findings of Miyashita et al. (1997) but much lower than that reported by Vertucci (1984). Intercanalar communications were observed in 18.4% of all teeth and in 70.2% of teeth with two canals. The high percentage of intercanalar communications in teeth with two canals may be of clinical significance, because it may be difficult to debride and fill these communications adequately. The apical foramen was found to coincide with the apical root tip in 52.2% of teeth. This is higher than reported in previous studies that demonstrated that the apical foramen coincided with the anatomical apex in 17–46% of cases (Pineda & Kuttler 1972, Caliskan et al. 1995, Sert et al. 2004, Vertucci 2005). This finding may be of significance in working length determination which often depends on the average position of apical constriction relative to root apex. If the position of the foramen is more apical than previously reported, then the position of the apical constriction and working length determination may vary accordingly.

Conclusions

Overall, 26.2% of mandibular incisors in this north Jordanian population had two canals. In the teeth with two canals, the Type II canal system was the most prevalent and Type V was the least prevalent.

The high percentage of intercanalar communications and centrally located apical foramina is of clinical relevance.

Acknowledgements

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References


