Original Article

Evaluation of the Morphology of Mandibular Incisors using the Cone Beam Computed Tomography

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Abstract

Introduction: Cone beam computed tomography (CBCT) imaging was developed to provide an improved visual representation of hard dental tissues in three dimensions. This *in vitro* study aimed to evaluate the morphology of the roots and canals of the mandibular incisors using CBCT. **Methods:** In total, 100 extracted mandibular central incisors and 100 extracted mandibular lateral incisors were mounted on separate putty blocks, which were completely immobile during imaging. The teeth were imaged using the CBCT unit (kVp=70, mA=8, and exposure time of 12 s). Vertucci's classification was utilized to record the number of roots and the canals in each root, as well as the type of the canals. **Results:** Almost all mandibular incisors were single-rooted. Among the mandibular central incisors, the most common canal morphology proved to be type 1 (51%), followed by type 3 (47%). Totally, 2% of the teeth represented type 2 within Vertucci's classification. Furthermore, mandibular lateral incisors were more varied in terms of anatomical classification. The most common types were recorded as types 3 (55%) and 1 (41%). Moreover, types 6, 2, and 5 comprised 2% of the cases. **Conclusion:** A high percentage of mandibular incisors have two canals, and based on Vertucci's classification, the most common anatomies of these teeth were types 1 and 3.

Keywords: Mandibular incisor, Root canal morphology, Vertucci's classification

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Introduction

One of the most important factors in the success of root canal treatment is the knowledge about the root canal system anatomy. Among the major reasons for the failure of the treatment, one can name the lack of knowledge about pulp anatomy, only the second to erroneous diagnosis, and treatment plan. Although specific anatomy is regarded as the most common form for each tooth in different textbooks, there exists a great anatomical diversity concerning the root canal system (1). Today, radiographic evaluation in endodontics is largely limited to conventional intraoral and panoramic radiographs (2).

Intraoral radiographs provide useful information concerning the presence and location of periapical lesions, root canal anatomy, and proximity to anatomical structures (3). However, the two-dimensional nature of the created images poses certain limitations in terms of anatomic distortions and dislocations (4). Periapical radiographs merely show important features of the tooth and the surrounding tissues in the mesiodistal plane, while many other features remain visible only in the buccolingual plane. Moreover, anatomical structures, such as the zygomatic process and the maxillary sinus, create disturbing noise that makes it difficult to interpret the radiographs (5).

Cone beam computed tomography (CBCT) as a recent technology in radiography has made it possible to observe the dentition and anatomical structures in three dimensions (6). In the imaging process of CBCT, the X-ray beam is conical in shape and divergent, a detector rotates around the patient, and the information is obtained in a cylindrical manner. This information can be processed using a computer, and the images can be reconstructed in all three planes (7). Furthermore, the thickness of the cut can be modified to suit the purpose, and all three planes can be checked simultaneously (8). Complex root canals require great care, which denotes the significant importance of the precise tools and images in the treatment of these cases. The CBCT imaging is not a substitute for conventional panoramic radiography and imaging procedures, rather it is utilized as a complementary tool for specific applications (9, 10).

Mandibular incisors pose certain challenges to endodontic treatment due to the diversity in the number and type of their root canals. Traditionally, mandibular incisors had been considered to have only one canal (11). However, most studies have suggested the existence of more than one canal in a high percentage of incisor teeth (12-15). Accordingly, this study aimed to investigate the morphology of mandibular incisors using CBCT.

Materials and Methods

This *in vitro* study included 100 extracted mandibular central incisors and the same number of extracted mandibular lateral incisors with closed apex. The reason for selecting this size of samples was our limitation in access to extracted mandibular incisors. The exclusion criteria were severe erosion at the incisal edge, severe calcification, internal resorption, previous root canal treatment, and root fracture/crack.

Based on their type, the teeth were separated and numbered so that they could be easily identified if re-examined. At each stage, 20 teeth were mounted on putty blocks for immobilization, and the CBCT image of each category was taken.

The teeth were imaged using a Promax 3D Classic CBCT unit (Planmeca, Helsinki, Finland) with exposure settings of 70 kVp, 8 mA, 12 seconds, and 0.160 mm resolution. CBCT sections were examined using Romexis Viewer software (Ver. 4.4.3), and images of poor quality were excluded.

The review of CBCT images began with the examination of the axial plane views, which were evaluated from the pulp chamber floor to the apex by moving the scroll bar. Other planes were used to ensure the accuracy of the results. In the next step, the second observer, blind to the results achieved by the first observer, examined all the samples. Then, the results were compared. The disputed samples were re-examined until an agreement between the first and second observer was reached. Information about the number of roots and canals as well as the type of canals was recorded based on Vertucci's classification (16) (Fig. 1).

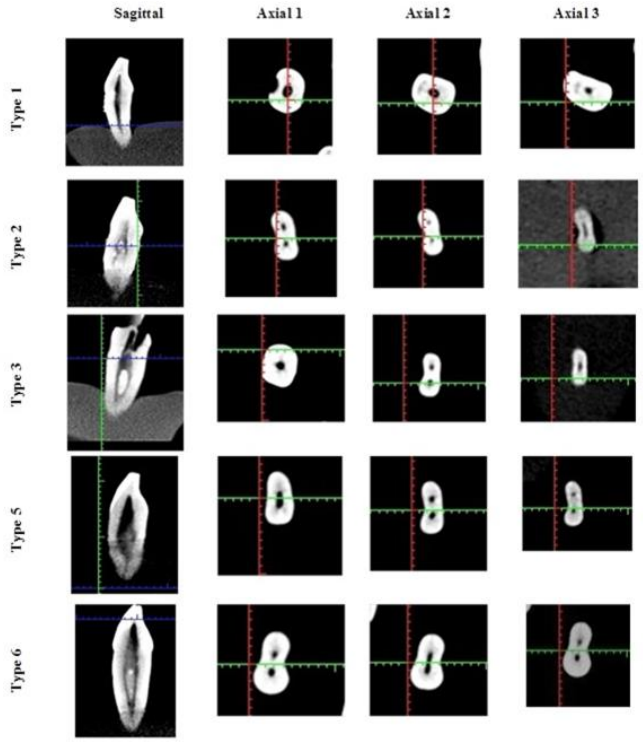

Figure 1: Morphological classification of the studied samples based on Vertucci's classification

The frequency of each type of canal morphology was calculated for each type of tooth. A Chi-squared test was used to compare each of the morphological types between the two groups of teeth. Statistical significance was set at $P<0.05$.

Results

The distribution of the type of canal morphology in the central incisors and the lateral incisors demonstrated in Table I.

The most frequent morphology among the mandibular central incisors was type 1 (51%), followed by type 3 (47%) and type 2 (2%). Concerning mandibular lateral incisors, the frequency of the type order was type 3 (55%), type 1 (41%), type 6 (2%), type 2, and type 5 (1% each). Since the most prevalent morphologies among the central incisors and lateral incisors were types 1 and 3, the Chi-square test was used to evaluate the relationship between tooth type and root canal morphology. The results revealed no correlation of the tooth type with root canal morphology (Table II) (χ^2=2.083, P=0.149).

Table I. Frequency of different types of canal morphology

Tooth type	Canal morphology	Number	Percentage
Central incisor	Type 1	51	51%
	Type 2	2	2%
	Type 3	47	47%
Lateral incisor	Type 1	41	41%
	Type 2	1	1%
	Type 3	55	55%
	Type 5	1	1%
	Type 6	2	2%

Table II: Relationship between tooth type and morphology

		Results		Total
		1.00	3.00	
Tooth Type	Central Incisor	51	47	98
	Lateral Incisor	41	55	96
Total		92	102	194

(χ^2=2.083, P= 0.149)

Discussion

Access to the canals is essential for success in endodontic treatment. Therefore, a clinician must be familiar with the root canal anatomy and its variations in order to prevent treatment failure (17). Since different studies on the anatomy and morphology of mandibular incisors have shown various results, the present study aimed to examine the anatomy and morphology of the root canal in mandibular central and lateral incisors in a local Iranian population. A study on root canal anatomy can be performed both in laboratory format (on extracted teeth) or clinically (on the patient or using the patient's medical documents) (18). Panoramic and periapical radiographs have certain limitations, including superimposition of adjacent structures, presence of distractions, and low resolution. The CBCT has overcome some of these limitations, and therefore, this imaging modality appears to be ideal for the evaluation of the root canal anatomy. Among the various methods for identifying the anatomy of the canal, CBCT seems to be the best choice since it is a non-invasive method that provides sections from all three dimensions, including coronal, sagittal, and axial views (19). However, the patient's movement during this imaging process may result in low-resolution images, thereby increasing the possibility of misdiagnosis. The present *in vitro* study was performed on extracted mandibular incisors, which naturally resolved the problem of motion blurring and decreased resolution.

Moreover, there was no limitation in terms of radiation dose to improve the resolution and quality of the images. However, one limitation of the implemented method was no access to the patients' demographic information, such as age and gender. Most studies on root canal anatomy have employed Vertucci's classification (16). However, classifications introduced by Weine et al. (20) and Gulabivala et al. (21) have also been used in some studies. Recently, Ahmed and Dummer (22) have proposed another classification that requires a very high resolution; however, access to such a resolution is not possible in many situations (23). The current study adopted Vertucci's classification (16), which was believed to be more comprehensive, compared to other classifications.

Some *in vivo* studies that used Vertucci's classification have been conducted on Chinese, Israeli, Indian, Iranian, and Arab populations. It is worth mentioning that in all of whom types 1 and 3 were the most prevalent configurations (13-16, 24). One study on an Iranian population showed that type 1 was the most common configuration based on Vertucci's classification, whereas type 4 represented the lowest frequency in mandibular incisors (12). Another study on an Iranian population concluded that the presence of a second canal in mandibular lateral incisors was more common, compared to the central incisors, and the most common configuration was type 1, followed by type 3 (26).

Similarly, Altunsoy et al. (25) performed a study on the Turkish population and reported that type 1 was the most prevalent configuration, whereas type 5 was the most prevalent configuration among teeth with two canals. In the same line, Federico et al. (23) conducted a study on an Italian population and revealed that types 1 and 2 were more common in mandibular incisors. In all similar studies, mandibular incisors had one root, except for the study conducted by Zhengyan et al. (15), which suggested that 0.3% of the lateral incisors had two roots. In all of the studied teeth, type 1 was the most common configuration. In the present study, the most common configuration of the mandibular central incisors proved to be type 1 (51%), which was consistent with the findings of several studies. However, in mandibular lateral incisors, types 3 (55%) and 1 (41%) were the most common configurations.

The results of the current study indicate that general dentists, as well as endodontists, can use the CBCT to obtain valuable information about the anatomy and morphology of mandibular incisors. The wide variation of root canal configurations observed in this study highlights the importance of taking all these possible configurations into account during endodontic treatment.

Conclusion

The wide range of root canal morphology, which may be observed in mandibular incisors, makes dentists, especially endodontists, pay more attention to probable complications following endodontic treatment of such teeth. They are also advised to order CBCT imaging in cases where there is doubt over the root canal anatomy.

Conflict of Interests

The authors declare no conflict of interest regarding the publication of the study.

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