Original Article

Evaluation of the Root and Canal Morphology of Mandibular Permanent Anterior Teeth in an Iranian Population by Cone-Beam Computed Tomography

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Abstract

Objective: To evaluate differences in the root and canal configurations of mandibular permanent anterior incisors and canines in an Iranian population by means of Cone Beam CT (CBCT) images.

Materials and Methods: Four hundred CBCT images of mandibular permanent incisors and canines that met the inclusion criteria were evaluated. Vertucci´s classification was used to evaluate the number of roots, number of root canals, root lengths, root curvatures and canal types.

Results: Totally 632 central incisors, 614 lateral incisors and 608 canines were evaluated. The average length of the mandibular central, lateral incisors and canines was 21.3±0.10, 21.9± 0.13 and 25.1± 0.11 mm, respectively. All of the mandibular central and lateral incisors had one root, but the incidence of single-rooted mandibular canines and two-rooted mandibular canines was 96.3% and 4.7%, respectively. The majority of mandibular central, lateral incisors and canines had one canal (72.7%, 70.6% and 71.8%, respectively). Five types of Vertucci canal configurations were seen in the evaluated teeth. Type 1 Vertucci configuration was the most prevalent configuration (72.3%, 70.6% and 71.8% for the central, lateral incisors and canines, respectively)), and type 5 Vertucci canal configuration was the least prevalent type seen (3.3%, 3.2% and 2.3% for the central, lateral incisors and canines, respectively). The most frequent root curvatures in these teeth were distally and buccally. No significant difference was seen between male and female patients regarding any of the parameters evaluated in this study ($p>0.05$).

Conclusion: More attention should be given to the detection of additional canals and the recognition of canal curvature in Iranian patients.

Keywords: Cone-Beam Computed Tomography; Morphology; mandibular canines; mandibular incisors; Root canal morphology

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INTRODUCTION

Successful root canal therapy requires knowledge of tooth anatomy and root canal morphology, which may be quite variable within the normal range [1, 2]. For each tooth in the permanent dentition, there is a wide range of variation reported in the literature [1]. For instance, the incidence of two-canal man-

dibular incisors reported by Miyashita et al. was 15% [2] and Ezoddini et al. reported a 55.9% incidence [3]. Vertucci et al. reported a second canal in 27.5% of mandibular incisors [4]. Sert et al. presented that 68% of mandibular central incisors had two canals [5]. In a study conducted by Al-Qudah et al., 26.2% of the mandibular incisors had two canals in the North Jordanian population [6].

There is a wide variety of in vitro and clinical methods used in studies for evaluating the root canal morphology such as decalcification [7], dye injection [4,5,8,9], ex vivo radiography [1], in vitro macroscopic exanimation [10], scanning electron microscope examination of the pulpal floor and grinding or sectioning [1]. Clinical methods include evaluation of endodontic access openings during endodontic treatment using magnification with a surgical operating microscope, or during endodontic treatment where magnification was not specified, or retrospective evaluation of endodontically treated teeth in patient records, or radiography of all teeth and in vivo radiographic examination [1]. Conventional periapical radiographs are valuable diagnostic tools for assessing root canal morphology in vivo [11]. Nevertheless, these radiographs are not absolutely reliable because of inherent limitations such as the distortion and superimposition of bony and dental structures that can occur in the taken images [12].

Recently, cone beam computed tomography (CBCT) has been introduced as an improvement of the diagnostic tools available for dental applications [13]. CBCT provides the clinician the ability to view an area in three different planes and to gain three dimensional information. The combination of sagittal, coronal, and axial views in CBCT images eliminates the superimposition of anatomic structures [12]. Root morphology, the number of root canals and their convergence or divergence from each other can be visualized in three dimensions [14].

These advantages allow the clinician a more detailed understanding of the factual morphology of root canal systems. The permanent mandibular anterior teeth have a wide variety of root canal morphologies [1]. Many studies have pointed out that root canal types may vary according to ethnicity, and a literature search in PubMed and Medline revealed that no studies have evaluated the root anatomy of mandibular permanent anterior teeth in Iranian populations using CBCT. The current study was designed to assess differences in the root and canal morphology of mandibular permanent incisors in an Iranian population by means of CBCT images.

MATERIALS AND METHODS

CBCT images (Planmeca ProMax CBCT; Planmeca, Finland) with device software (Romexis viewer, Planmeca Finland, Ver 2.0.1) of mandibular permanent incisors were collected from patients who visited a radiologic clinic in Tehran, Iran in a time interval of 6 months. The databases of CBCT scans were searched and 400 patient CBCTs that contained at least one mandibular permanent incisor were selected, and the teeth with full-formed apices and no root canal fillings, posts, or crown restorations and no signs of root resorption were evaluated. The number of roots, number of root canals, root lengths, root curvatures and canal types were evaluated, first by a postgraduate of endodontics, and then the results were confirmed by a radiologist (Vertucci´s classification was taken as the main reference for sample evaluation).

RESULTS

Table 1 shows the total number of evaluated teeth in each category. Table 2 shows the average length, minimum and maximum length and the prevalence of Vertucci's canal configurations in the mandibular central and lateral incisors and canines in the evaluated Iranian population.

Table 3 shows the frequency of root curvatures and Table 4 shows the average, maximum and minimum degrees of root curvature in each tooth type.

According to the findings of this study all mandibular central and lateral incisors had one root, but the incidence of single rooted mandibular canines was 96.3% and two rooted mandibular canines was 4.7% in the Iranian population. Most of the mandibular central, lateral incisors and canines had a single-root canal (72.7%, 70.6% and 71.8%, respectively); the prevalence of two root canals was 27.3% for the mandibular central incisors, 29.4% for the mandibular lateral incisors and 28.2% for the mandibular canines. Five types of Vertucci canal configurations were seen in all mandibular central and lateral incisors and canines.Type 1 vertucci configuration was the most prevalent configuration (72.7%, 70.6% and 71.8%, respectively), and the least prevalent vertucci canal configuration was type 5 (3.6%, 3.2% and 2.3%, respectively).

The most prevalent root curvature in mandibular anterior teeth was the distal and consequently the buccal type. In order to confirm the reliability of the results, Kappa for evaluating the curve was 0.97 and the Intra Class Correlation Coefficient (ICC) for quantitative measurements regarding all the factors was more than 0.8.

The independent T-test was used to compare root length and curvatures between the two genders. Statistical analysis was performed by SPSS Ver. 18.0 software. No significant differences were seen between male and female patients regarding any of the parameters evaluated in this study ($p>0.05$).

DISCUSSION

The present study provides a detailed report on the root canal morphology of permanent anterior mandibular teeth in an Iranian population using CBCT. CBCT is currently widely used in implantology, maxillofacial reconstruction, and in endodontic diagnosis before surgical endodontics as well as evaluating canal preparation, obturation, and removal of root fillings. A recent study presented that CBCT was as precise as the modified canal staining and tooth clearing method in determining root canal morphology [14]. The main advantage of CBCT images are nondestructive and 3D reconstruction and visualization of the external and internal anatomy of the teeth and surrounding bony structures [15-18]. The most notable advantages of CBCT are a significantly lower effective radiation dose, a short exposure time (2–5 seconds), its lower expense compared with conventional CT, and its high accuracy. In addition, CBCT measurements are geometrically accurate because the CBCT voxels (3D pixels containing data) are isotropic [17, 18].

Table 1. Number of Teeth Evaluated

	Male	Female	Total
Central Incisor	320	312	632
Lateral Incisor	300	314	614
Canine	298	310	608
Total	918	936	1854

Table 2. The Average Length, Minimum and Maximum Lengths in Millimeters and Prevalence of Vertucci Canal Configuration

Tooth		Average length	Minimum length	Maximum length	% of Type 1 Vertucci	% of Type2 Vertucci	% of Type 3 Vertucci	% of Type 4 Vertucci	% of Type 5 Vertucci
	Overall	21.3±0.10	19.2	23.4	72.7±0.2	11.3±0.2	4.7±0.1	7.7±0.2	3.6±0.1
Mandibular central incisor	**Male**	20.9±0.11	18.9	23.4	35.7±0.1	5.9±0.1	2.4±0.1	3.6±0.1	1.8±0.1
	Female	21.1±0.12	19.2	22.7	37±0.2	5.4±0.2	2.3±0.2	4.1±0.1	1.8±0.1
	overall	21.9±0.13	20.1	24.3	70.6±0.3	7.1±0.3	3.7±0.2	15.4±0.2	3.2±0.1
Mandibular lateral incisor	**male**	21.3±0.12	20.1	24.3	35.1±0.2	3.6±0.2	2.1±0.1	8.0±0.1	1.6±0.1
	female	21.7±0.12	20.0	24.1	35.5±0.2	3.5±0.3	1.6±0.1	7.4±0.2	1.6±0.1
	overall	25.1±0.11	22.1	27.1	71.8±0.2	10.3±0.3	2.8±0.1	12.8±0.2	2.3±0.2
Mandibular canine	**male**	24.9±0.13	22.1	27.1	36.0±0.3	5.1±0.2	1.4±0.1	6.4±0.2	1.3±0.1
	female	25.2±0.13	19.8	26.9	35.8±0.1	5.2±0.3	1.4±0.1	6.4±0.1	1.0±0.2

Table 3. The Frequency of Root Curvatures

Tooth		Straight (%)	Distal (%)	Mesial (%)	Buccal (%)	Lingual (%)	Disto-Buccal (%)	Disto-lingual (%)	Mesio-Buccal (%)	Mesio-lingual (%)
	Overall	68.3	15.1	0.6	5.2	0.8	1	2	4	3
1	**Male**	34.2	7.9	0.3	2.7	0.4	0.5	1.0	2.0	2.0
	Female	34.1	7.2	0.3	2.5	0.4	0.5	1.0	2.0	1.0
	Overall	70.2	19.2	1.4	1.9	1.9	1.9	1.2	1.2	1.1
2	**Male**	35.1	10.0	0.7	1.0	0.9	1.0	0.6	0.6	0.6
	Female	35.1	9.2	0.7	0.9	1.0	0.9	0.6	0.6	0.5
	Overall	71.4	19.6	0.2	5.9	1.1	1.1	0.3	0.2	0.2
3	**Male**	35.1	9.9	0.1	3.0	0.5	0.5	0.2	0.1	0.1
	Female	36.3	9.7	0.1	2.9	0.6	0.6	0.1	0.1	0.1

Table 4. The Average, Minimum and Maximum Degrees of Root Curvatures

	Tooth	Distal			Mesial			Buccal			Lingual			Disto-Buccal			Disto-lingual			Mesio-Buccal			Mesio-lingual		
		average	Min	Max	average	Min	Max	average	Min	Max	average	Min	Max	average	Min	Max	average	Min	Max	average	Min	Max	average	Min	Max
	Overall	11±0.1	5	27	8±0.2	5	22	13±0.3	5	31	12±0.2	5	24	8±0.1	5	21	9±0.1	5	27	13±0.2	5	24	15±0.1	5	28
1	**Male**	10±0.2	5	27	8±0.1	5	22	13±0.1	5	31	12±0.2	5	24	8±0.1	5	20	9±0.1	5	26	14±0.1	5	24	16±0.2	5	28
	Female	11±0.1	5	26	7±0.2	5	20	11±0.2	5	30	10±0.1	5	24	7±0.1	5	21	10±0.2	5	27	12±0.2	5	22	14±0.1	5	27
	Overall	10±0.2	5	22	10±0.1	5	21	13±0.2	5	22	8±0.1	5	27	11±0.2	5	24	17±0.2	5	31	10±0.1	5	21	8±0.1	5	19
2	**Male**	10±0.1	5	22	10±0.1	5	20	13±0.2	5	22	8±0.1	5	26	11±0.1	5	22	17±0.1	5	30	11±0.2	5	20	9±0.1	5	19
	Female	9±0.1	5	22	8±0.1	5	21	12±0.1	5	22	7±0.1	5	27	8±0.1	5	24	15±0.1	5	31	12±0.1	5	21	8±0.1	5	18
	Overall	11±0.1	5	21	8±0.2	5	19	11±0.3	5	23	12±0.2	5	22	13±0.3	5	27	11±0.1	5	22	10±0.2	5	23	11±0.1	5	24
3	**Male**	11±0.1	5	21	7±0.1	5	18	11±0.3	5	21	12±0.1	5	20	13±0.2	5	27	13±0.1	5	20	10±0.2	5	23	10±0.1	5	24
	Female	11±0.1	5	20	8±0.1	5	19	10±0.2	5	23	11±0.1	5	22	11±0.3	5	24	10±0.1	5	22	9±0.2	5	22	11±0.1	5	21

Calikan et al. and Sert et al. used Indian ink and clearing methods and reported that all mandibular central and lateral incisors studied in the Turkish population were single-rooted teeth [5, 9]. All the reviewed anatomical studies reported that 100% of the studied mandibular central and lateral incisors were single-rooted [1]. The results of this study were similar to the for mentioned reports.

Myashita et al. used the clearing method and reported that 85% of the mandibular incisors had a single canal [2]. On the other hand, Boruah et al. cleared mandibular incisors and reported that 63.75% of them had one canal and 36.25% had two canals in the North-East Indian population [19]. Vertucci et al. reported that 27.5% of mandibular incisors had a second canal [4]. In the study conducted by Sert et al., two canals were present in 68% of the mandibular central incisors [5]. Al-Qudah et al. cleared the teeth and reported that 26.2% of the mandibular incisors in the north Jordanian population had two canals [6]. While in the evaluated Iranian population, 72.7% of the mandibular central incisors and 70.6% of the mandibular lateral incisors had one canal, and 27.3% of the mandibular central incisors and 29.4% of the mandibular lateral incisors had two canals. The differences between these morphological studies may be related to variations of the examination methods, classification systems, sample sizes and ethnic background of tooth sources.

The most common form of the mandibular canine is the one with a single root [1, 5]. Some found that 6.2% of the mandibular canines were two rooted [20] and Pecora et al. reported an incidence of 1.7% [10]. This study revealed that the prevalence of single rooted mandibular canines was 96.3%, and 4.7% of the mandibular canines had two roots in the Iranian population.

In the study performed by Pecora et al., the incidence of a single canal was 89.4% in the mandibular canines. In the single-canal system, 96.9% had a single apical foramen [10]. The current study showed a single canal in 71.8% and two canals in 28.2% of the mandibular canines in the Iranian population.

The occurrence of more than two canals in mandibular canines is quite uncommon (0.1%). In some studies, a single apical foramen was found in 97.4% of the teeth and most of the two separate canals joined and exited through a single apical foramen [9].

The average length of the mandibular central and lateral incisors reported in some studies was 20.7 mm [21]. The average length of the mandibular central incisors reported in this study was 21.3 mm (with a maximum of 23.4 mm and a minimum of 19.2mm. In the lateral incisors, the average length was 21.9 mm (with a maximum of 24.3 mm and a minimum of 20.1 mm) [21]. Reported root curvatures in mandibular central and lateral incisors (the most common to the least common) are:straight, distal and labial [21]. Miyashita et al. stated that most of the canals of mandibular incisors (67.9%) were oriented in the labial direction [2]. In the study of Qing-bua Zheng et al., most of the mandibular incisor canals were oriented in the lingual direction [22].

The results of our study showed that 68.3% of the root canals of the mandibular central incisors had a straight orientation, 15.1% had a distal orientation and 5.2% had a buccal orientation, while in the lateral incisor, 70.2% had a straight orientation, 19.2% had a distal orientation and 1.9% had a buccal orientation.

In some studies, the overall reported average length of the mandibular canine was 27 mm [23]. In other studies, the reported average length of mandibular canines was 25.6 mm [21]. In this study, the average length of mandibular canines was 26.7mm.

In a study, the root curvatures in mandibular canines (the most common to the least common) were straight, distal, labial which is similar to the results of this study [21].

Based on the findings of this study and the high incidence of two canals in the lower anterior teeth, the clinician must be alert for

the possibility of a bifurcated root canal or two separate or merging root canals in these teeth.

CONCLUSION

In the studied Iranian population, a high percent of mandibular central and lateral incisors and canines had two canals and root curvatures; therefore more attention should be given to the detection of additional canals and the identification of canal curvatures in patients of the Iranian population.

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