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Original Research

Evaluation of Root Canal Morphology of Mandibular Incisor using Cone Beam Computed Tomography

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Abstract:

Background: Successes in dental root canal treatment require a complete knowledge of dental anatomy and root canal morphology. Root has a complicated morphology, and not only it differs in various teeth types but also it differs in the same type of teeth. Anatomical variations especially caused by the presence of lingual canal, which is often missed, may lead to failure in treatment. Considering the importance of canal anatomy and morphology in forming the root canal system and lack of information about the implementation of researches in Iran, we decided to employ the cone beam computed tomography (CBCT) imaging method for the evaluation of canal morphology and anatomy of mandibular incisors in defined groups of Iranian dental patients. Our goal was to improve the treatment rate by gathering more details about the diverse canal types.

Materials and Methods: 81 CBCT images were used to assess the anatomy and morphology of mandibular incisors. Extracted features from the images were used to identify the root type according to Vertucci's and Weine's classifications. A number of roots and root canals, root canal morphology, tooth position, and demographic data were recorded. Further processing and analysis of the results were achieved by Chi-square test, Fisher's exact test, and Kappa coefficient of agreement.

Results: All of the mandibular central and lateral incisors had one root. Based on Vertucci's classifications in mandibular central 63.1% were Type I, 13.1% Type II, 21.2% Type III, and 2.5% Type V and in mandibular lateral 56.9% of canals were Type I, 12.5% Type II, 28.1% Type III, and 2.5% Type V. Based on Weine's classifications in single-rooted central teeth with two canals, a significant difference was seen between male and female patients regarding canal variant ($\chi^2 = 5.98$, $P = 0.050$). No significant difference was seen between male and female patients regarding other parameters evaluated in this study ($P > 0.050$).

Conclusion: CBCT scans are effective tools for identification of root canal morphology.

Key Words: Cone beam computed tomography, mandibular central incisors, mandibular lateral incisors, root canal morphology

Introduction

The main purpose of non-surgical root canal treatment is the elimination of infections from root canal system and prevention of recurrent infection. Dentists should know the complexity of root canal system to understand the principles and complications of cleaning and shaping, determine apical and preparation limit, and prevent procedure errors.[1,2] Morphologic variations of dental pulp anatomy should be taken into account before treatment, especially in teeth that are likely to have a second canal.[3,4] There are a wide variety of *in vitro* methods such as: Direct observation with microscope,[5] root canal dying,[6] clearing,[7,8] horizontal sectioning,[9] and cone beam computed tomography (CBCT).[10]

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. Furthermore, the model can be rotated in any plane in space and analyzed internally and externally, can be sectioned transversally and longitudinally.[11] CBCT in endodontics has a number of advantages. Multiplanar reformation (including oblique and curved) and serial transplanar reformation can improve evaluation of concern region. Fast time in scanning reduces errors caused by subject movement.[12] CBCT can be used to identify the number and shape of the roots and related canals as well as determine the functional length, type, and size.[13] These advantages allow the clinician a more detailed understanding of the factual morphology of root canal systems.[14] Due to the importance of canal anatomy and morphology in cleaning and shaping of root canal system, this study was designed to assess canal anatomy and morphology in mandibular incisors by CBCT images.

Materials and Methods

CBCT images were acquired by Promax 3D CBCT unit (Planmeca OY, Helsinki, Finland). All of the images were observed on the imaging device's software Romexis Viewer by one oral radiologist and two endodontists at the same time until they reached a consensus and the final result was recorded in prepared forms.

A total of 81 CBCT images including mandibular central and lateral incisors were selected for this study. The image selection criteria were: (1) Not endodontically treated teeth, (2) no open apex canals, and (3) CBCT images with high quality.

160 central and 160 lateral teeth were examined. 42.5% (68 cases) of central teeth belonged to men, and 57.5% (92 cases) pertained to women. 43.8% (70 cases) of lateral teeth were related to men, and 56.2% (90 cases) were for women.

Features such as a number of roots and root canals, root canal morphology, tooth position, and demographic data were derived, and Vertucci's[15] classification "Figure 1" and Weine's[16] classification "Figure 2" were the reference for determining the type of root canal morphology.

Chi-square and Fisher's exact tests were used to analyze variants, and Kappa test was used for evaluating the similarity between left and right incisors and central and lateral incisors. SPSS 20 software was used for statistical analysis.

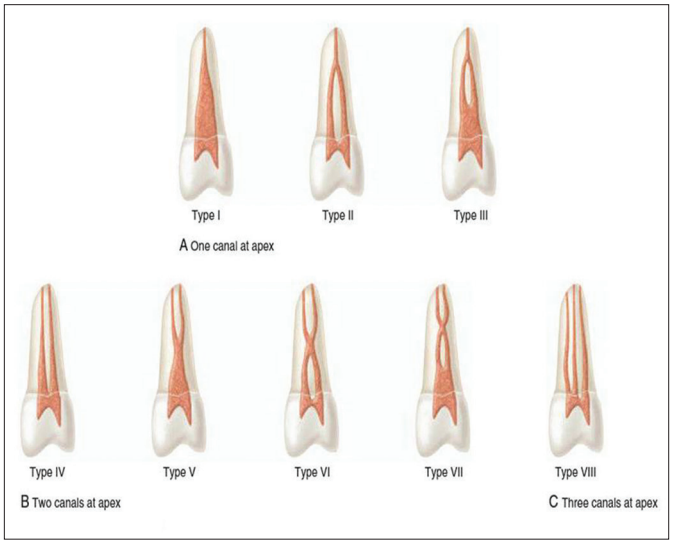

Figure 1: Different types of teeth canal according to Vertucci's classification.[15]

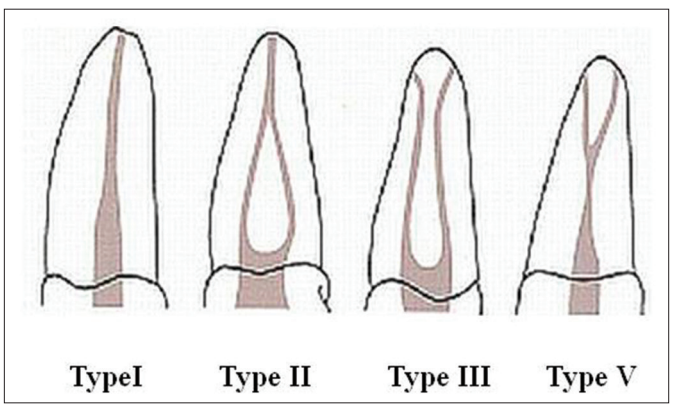

Figure 2: Different types of teeth canal according to Weine's classification.[16]

Results

Central mandibular

Tooth position

50% was at the right and the other half obviously at the left.

Presence of central symmetrical teeth

79 of such teeth were observed from which 33 belonged to men and 46 were for women.

Presence of lateral adjacent teeth

In 158 cases, (98.8%) adjacent tooth was present at the same position.

All 160 of the central mandibular cases had a single root.

Number of canals in central mandibular teeth

Among the 160 teeth, 101 (63.1%) had one canal and 59 of them (36.9%) had two canals, and there was no significant difference between men and women. Number of two canals teeth for men was 27 (39.7%) and for women, it was 32 (34.8%) (Table 1).

Central mandibular canal shape based on Vertucci's classification

According to Vertucci's classification, there was no significant difference between men and women ($P = 0.523$).

Consequently, the most observed root canal type was Type I in both men and women. The second common type was Type III (Table 2).

Central mandibular canal shape based on Weine's classification

The most found type in both men and women was Type I (Table 3).

Table 1: Evaluation of the number of canals in central and lateral mandibular teeth.

Gender	One canal	Two canals	Sum
Men			
Central mandibular			
Count	41	27	68
%	60.3	39.7	100
Lateral mandibular			
Count	34	36	70
%	48.6	51.4	100
Women			
Central mandibular			
Count	60	32	92
%	65.2	34.8	100
Lateral mandibular			
Count	57	33	90
%	63.3	36.7	100
Total			
Central mandibular			
Count	101	59	160
%	63.1	36.9	100
Lateral mandibular			
Count	91	69	160
%	56.9	43.1	100

Table 2: Distribution of morphology and canal numbers of central and lateral mandibular teeth based on Vertucci's classification.

Gender	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII	Type VIII	Sum
Men									
Central mandibular									
Count	41	14	11	0	2	0	0	0	68
%	60.3	20.6	16.2	0	2.9	0	0	0	100
Lateral mandibular									
Count	34	10	23	0	3	0	0	0	70
%	48.6	14.3	32.9	0	4.3	0	0	0	100
Women									
Central mandibular									
Count	60	7	23	0	2	0	0	0	92
%	65.2	7.6	25	0	2.2	0	0	0	100
Lateral mandibular									
Count	57	10	22	0	1	0	0	0	90
%	63.3	11.1	24.4	0	1.1	0	0	0	100
Total									
Central mandibular									
Count	101	21	34	0	4	0	0	0	160
%	63.1	13.1	21.2	0	2.5	0	0	0	100
Lateral mandibular									
Count	91	20	45	0	4	0	0	0	160
%	56.9	12.5	28.1	0	2.5	0	0	0	100

Based on Weine's classification, there was a significant difference in single-rooted teeth with two canals for men and women ($P = 0.050$).

Central symmetrical teeth

There were 79 symmetrical teeth and based on Vertucci's classifications in these symmetrical centrals kappa was 83.5 (perfect agreement) and $P = 0.000$.

Based on Weine's classification in these symmetrical centrals kappa was 80.8 (perfect agreement) and $P = 0.000$.

Mandibular lateral

Tooth position

81 (50.7%) of laterals were at right and 79 (49.3%) at the left side of the mandible.

Presence of Lateral symmetrical teeth

From the 160 laterals, in 79 cases, there were the pair of left and right laterals available and assessable, which were 35 pairs in men and 44 pairs in women.

From the 180 laterals, 180 cases (100%) had one root, 91 (56.9%) of laterals had one canal, and 69 (43.1%) had two canals (Table 1).

Lateral mandibular canal shape based on Vertucci's classification

Based on Vertucci's classifications, the most prevalent canal configuration of lateral was Type I. The second most prevalent type was Type III (Table 2).

There was no significant difference between men and women in terms of canal configuration of mandibular lateral ($P = 0.221$).

Table 3: Distribution of morphology and canal numbers of central and lateral mandibular teeth based on Weine's classification.

Gender	Type I	Type II	Type III	Type IV	Sum
Men					
Central mandibular					
Count	52	14	0	2	68
%	76.5	20.6	0	2.9	100
Lateral mandibular					
Count	57	10	0	3	70
%	81.4	14.3	0	4.3	100
Women					
Central mandibular					
Count	83	7	0	2	92
%	90.2	7.6	0	2.2	100
Lateral mandibular					
Count	79	10	0	1	90
%	87.8	11.1	0	1.1	100
Total					
Central mandibular					
Count	135	21	0	4	160
%	84.4	13.1	0	2.5	100
Lateral mandibular					
Count	136	20	0	4	160
%	85	12.5	0	2.5	100

Lateral mandibular canal shape based on Weine's classification

Based on Weine's classifications the most prevalent canal configuration of lateral was Type I. The second most prevalent type was Type II (Table 3).

There was no significant difference between men and women in terms of canal configuration of mandibular lateral ($P = 0.372$).

There was 79 pair symmetrical lateral. In symmetrical cases, kappa was 1 (complete agreement) and $P = 0.000$, and there was complete agreement.

In 79 pair's adjacent tooth in right side
Based on Vertucci's classifications, variant type in adjacent roots in the right side of the mandible, kappa agreement was 0.613 (average agreement) and $P = 0.000$.

Based on Weine's classifications, variant type in an adjacent canal in the right side of the mandible, kappa agreement was 0.601 (average agreement) and $P = 0.000$.

In 78 pair's adjacent tooth in left side
Based on Vertucci's classifications, variant type in adjacent roots in the left side of the mandible, kappa agreement was 0.589 (low agreement) and $P = 0.000$.

Based on Weine's classifications, variant type in adjacent root in the left side of the mandible, kappa agreement was 0.555 (low agreement) and $P = 0.000$.

Discussion
Root canal anatomy and morphology were affected from many factors. Genetic and racial variations are one of the factors that may affect root and canal anatomy and morphology. There are several tools for evaluation of root and canal anatomy. Using CBCT images has many advantages such as having results comparable to those of direct methods.[17]

In 2013 in Tehran, Amin Sobhani had a study using CBCT. 632 CBCT of mandibular central teeth were gathered, and 614 lateral teeth were investigated. 100% of central teeth and 100% of lateral mandibular teeth had one root. 72.7% of central mandibular teeth had one root, and 27.3% had two. 70.6% of lateral mandibular teeth had one root, and 29.4% had two.

According to Vertucci's classifications, 72.3% of central teeth were Type I and 70.6% of lateral mandibular teeth were Type I. In none of the cases studied, there was no difference between men and women.[14] The results of this study regarding the comparing of root numbers and canal morphology were exactly matched our findings.

In our study, the morphology of central tooth based on Weine's classification was examined, and there was a significant difference between men and women.

Lin *et al*., in 2014, investigated canal morphology and the root of incisor teeth using CBCT method. He examined 1412 mandibular teeth. 10.9% of central mandibular teeth and 25.5% of lateral mandibular teeth had two canals. By applying Vertucci's classifications, it was found that among two canal teeth, Type III incisors were the most and Type II, Type IV, and Type V were next.[18]

In this study, Type I was the most popular in both mandible incisors, which is similar to our study. However, the results of the morphology of two canal teeth were different from ours. This might be related to racial differences and the great number of samples.

Leoni, in 2014, had a research on 100 central incisor and lateral mandibular teeth with the CBCT method. 60% of central and 74% of lateral mandibular teeth had one root and one canal. Regarding Vertucci's classification, 50% of central teeth and 62% of lateral teeth were Type I and 28% of both were Type III also 8 new types, which were not mentioned Vertucci's classification, were observed.[19]

In the present study, anatomy and morphology out of the classification were not observed, which could be because of the genetic and ethnic differences in the populations studied.

Altunsoy, in 2014, performed a study in Turkey using CBCT. 1582 central mandibular and 1603 lateral mandibular teeth were examined. The results showed that 84.5% of central teeth had one canal, and 15.3% of them had two. 80.75% of lateral mandibular teeth had one canal, and 19.25% had two. Based on Vertucci's classification, 84.5% of central teeth were Type I, 0.45% were Type II, 0.8% were Type III, 4.2% were Type IV, and 10.05% were Type V. Besides, among the lateral teeth 80.2% were Type I, 1.2% were Type II, 1% were Type III, 5.4% were Type IV, and 12.1% were Type V.[20]

In this study, similar to our research, most of the mandibular incisor teeth were one canal.

Altunsoy's results show that in central mandibular teeth:
Type I>Type V>Type IV>Type III>Type II

And in lateral mandibular teeth:
Type I>Type V>Type IV>Type II>Type III

While in our study, the results for central mandibular teeth showed that:
Type I>Type III>Type II>Type V

And in lateral mandibular teeth we had:
Type I>Type III>Type II >Type IV

By comparing the results of two studies, differences in the morphology of two canal teeth is evident in the two studied populations.

In the present study, two classification methods were used for investigating the canal's anatomy. Similarities and differences in the anatomy of adjacent and symmetrical teeth can be investigated by CBCT, and it's accomplished in our study. This was not done in any of the researches that we reviewed.

Based on Vertucci's classification, for the right half of the data Kappa coefficient of agreement was 0.613 and based

on Weine's classification it was 0.601. For the left half of the data, according to Vertucci's classification, Kappa coefficient of agreement was 0.589 and based on Weine's classification it was 0.505. These results show that the morphology of teeth was not much correlated.

In the central symmetrical teeth, based on Vertucci's classification, Kappa coefficient of agreement was 0.835 and based on Weine's classification it was 0.808 and the morphology of teeth were similar. 100% of the lateral symmetrical teeth was similar, and Kappa coefficient of agreement was 1 (fully correlated).

With respect to the findings all central and lateral teeth with one root. Most of the central and lateral teeth have a single canal, but the possibility of a second canal should be always taken into account. This possibility is more for lateral teeth compared to central mandibular.

The order of canal anatomy based on Vertucci's classification in central mandibular teeth:
Type I>Type III>Type II>Type V

And for the lateral mandibular teeth, it was:
Type I>Type III>Type II >Type V

The order of canal anatomy based on Weine's classification in central mandibular teeth:
Type I>Type II>Type IV

And for the lateral mandibular teeth, it was:
Type I>Type II>Type IV

Conclusion

This study and similar studies suggest that CBCT radiography is helpful in discovering the anatomy of the teeth.

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