

ANALYSIS OF ROOT CANAL CHARACTERISTICS OF MAXILLARY INCISORS WITH CONE BEAM COMPUTED TOMOGRAPHY

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I. BACKGROUND

Pulpitis is a common oral disease that greatly affects the health as well as the quality of life of patients. Which if left untreated or poorly treated can lead to inflammation of apical tissues [3]. Root canal treatment (endodontic treatment) aimed at eliminating bacteria, preserving and restoring mechanical function of teeth. Root canal treatment takes time, instrument and depends on doctor's skills and clinical experience. It is clear that the additional information provided by CBCT may increase and/or improve diagnostic accuracy and confidence in decision-making as well as have an impact of treatment planning. More clinical studies are required to assess the long-term impact of CBCT on the outcomes of endodontic treatment [10]. In Vietnam, cone beam computed tomography (CBCT) is a new technology in the field of endodontics with multiple advantageous features such as establishing 3D images of the root canal system with a low dose of X rays, providing more information, true spatial relationships, and image data can be sectioned. Hence, CBCT is highly beneficial and has high value in the field of endodontics, especially in cases of teeth with complex root canal

systems. With the desire to apply science and technology into clinical practice, we carry out this study: "Analysis of root canal characteristics of maxillary incisors with cone beam computed tomography" with the 2 aims:

1. To evaluate the number of root canals in maxillary incisors.
2. To analyze curvature and morphology of the root canal system in maxillary incisors.

II. MATERIALS AND METHODS

2.1. Patient selection

2.1.1. Patient selection

Patients presented at Oral and Maxillofacial Medicine clinic at Can Tho University of Medicine and Pharmacy in 2019 - 2021 with primary endodontic infection

2.1.2. Inclusion criteria included the following:

-Patients whose permanent maxillary central incisors diagnosed with pulp infection according to American association of endodontists criterias [1] and have indications of root canal treatments

- Patient who agreed to participate in the study.

2.1.3. Exclusion criteria were as follows:

- Teeth with previous endodontic treatment, immature apices

- Patients who are pregnant.

- Patient who are incapable of communicating.

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- Patients who have apical periodontitis with large periapical lesion that may required apicoectomy.

2.2. Methods

2.2.1. Research methods

- Descriptive research methods cross-sectional.

- Sample size: 65 maxillary central incisors.

2.2.2. Sampling method

Convenient sampling

2.2.3. Materials and methods

- Numbers of root canal: collected based on reconstructed 3-dimensional images using CBCT. There are 3 values: 1 root canal, 2 root canals, ≥ 2 root canals.

- Tooth length: collected by measuring with the help of software on CBCT image. Tooth length is the length from the incisal edge to the apex of the tooth.

- Curvature of root canals. There are 2 values: straight and curves.

- Root canal curvature orientation. There are 4 values: labial, lingual, mesial, distal.

- Shape of root canal in horizontal cross-sections at coronal one-third, middle one-third and apical one-third. There are 23 values: circle, labiolingual oval, mesiodistal oval.

- Apical foramen positions: collected based on CBCT images. There are 5 values: right in the central, labial aspect, lingual aspect, distal aspect, mesial aspect.

- Classification of the root canal: Qualitative variable, collected based on reconstructed 3-dimensional images and horizontal cross-sections at 3 position, coronal one-third, middle one-third, apical one-third. Evaluation based on Vertucci's classification [1].

III. RESULTS

3.1. Maxillary incisors evaluation and classification

Table 3.1. Maxillary incisor evaluation and classification

Teeth			Root canal	Class
			1	I
	Central incisors	Amount	32	32
		Percentage %	100%	100%
	Lateral incisors	Amount	33	33
		Percentage %	1.0	1.0
Tooth		Amount	65	65
		Percentage %	100%	100%

We examined 65 maxillary incisors, including 32 central and 33 lateral incisors. All maxillary incisors have 1 root canal and belong to type I configuration according to Vertucci's classification.

3.2. Maxillary incisor length

Table 3.2. Maxillary incisor length

Teeth length	Average (mm)	Shortest (mm)	Longest (mm)
Maxillary central incisor	22.8	20.00	25.50
Maxillary lateral incisor	21.8	19.00	25.00

The results of the study showed that average length of maxillary central incisors is 22.8 mm, shortest length is 20.0 mm and the longest length is 25.5 mm. Meanwhile maxillary lateral incisors have an average length of 21.8 mm and the shortest length is 19 mm, the longest length is 25 mm.

3.3. Location of apical foramen

Table 3.3. Location of apical foramens

			Apical foramen location				
			Central	Labial	Lingual	Mesial	Distal
Teeth	Central incisor	Amount	6	0	16	0	10
		Percentage	18.8%	0%	50.0%	0%	31.3%
	Lateral incisor	Amount	10	1	6	1	15
		Percentage	30.3%	3.0%	18.2%	3.0%	45.5%
Total		Amount	16	1	22	1	25
		Percentage	24.6%	1.5%	33.8%	1.5%	38.5%

Of the 65 examined incisors, only 24.6% had apical foramens in the central of the apex. The rate of the incident is 18.8% and in maxillary lateral incisor, the rate is 30.3%.

3.4. Curvature of root canals

Table 3.4. Analysis of root canals curvature

			Curvature		Total
			Straight	Curve	
Maxillary incisor	Central	Amount	24	8	32
		Percentage %	75.0%	25.0%	100.0%
	Lateral	Amount	13	20	33
		Percentage %	39.4%	60.6%	100.0%
Total		Amount	37	28	65
		Percentage %	56.9%	43.1%	100.0%

Analysing coronal and sagittal cross-section of root canal by CBCT showed that: 75.0% of central incisors have straight root canals, 25.0% are curved root canal; In lateral incisors, 39.4% are straight root canals, 60.6% are curve root canals.

Table 3.5. Curvature orientation

			Curvature orientation			Total
			Lingual	Mesial	Distal	
Teeth	Maxillary central incisor	Amount	6	0	2	8
		Percentage %	75.0%	0%	25.0%	100.0%
	Maxillary lateral incisor	Amount	2	2	16	20
		Percentage %	10.0%	10.0%	80.0%	100.0%
Total		Amount	8	2	18	28
		Percentage %	28.6%	7.1%	64.3%	100.0%

Analysing coronal and sagittal cross section of root canal by CBCT showed that: The central incisors predominantly have lingual curvature, accounting for 75% whereas the lateral incisors have distal curvature, accounting for 80.0%.

3.5. Horizontal shapes of root canals

3.5.1. Horizontal cross-sections of coronal one-third

Table 3.6. Horizontal shapes of root canals at coronal one-third section

			Shapes of root canals at coronal one-third			Total
			Circle	Labiolingual oval	Mesiodistal oval	
Teeth	Maxillary central teeth	Amount	21	11	0	32
		Percentage	65.6%	34.4%	0.0%	100.0%
	Maxillary lateral teeth	Amount	11	21	1	33
		Percentage	33.3%	63.6%	3.0%	100.0%
Total		Amount	32	32	1	65
		Percentage	49.2%	49.2%	1.5%	100.0%

Analysing horizontal cross-section of root canal at coronal one-third with CBCT showed that: The coronal one-third of central incisors are mainly circle in shape, accounting for 65.6%. The coronal one-third of lateral incisors are mainly labiolingual oval in shape, accounting for 63.6%.

3.5.2. Horizontal cross-sections of middle one-third

Table 3.7. Horizontal shapes of root canals at middle one-third section

			Shapes of root canals at coronal one-third			Total
			Round	Labiolingual oval	Mesial/distal oval	
Teeth	Maxillary central teeth	Amount	27	5	0	32
		Percentage	84.4%	15.6%	0%	100.0%
	Maxillary lateral teeth	Amount	12	20	1	33
		Percentage	36.4%	60.6%	3.0%	100.0%
Total		Amount	39	25	1	65
		Percentage	60.0%	38.5%	1.5%	100.0%

An analysis of horizontal cross-section of root canal at middle one-third showed that: The middle one-third of central incisors are mainly circle in shape, accounting for 84.4%. The middle one-third of lateral incisors are mainly labiolingual oval, accounting for 60.6%.

3.5.3. Horizontal cross-section of apical one-third:

Table 3.8. Horizontal shapes of root canals at apical one-third

			Shapes of root canals at apical one-third			Total
			Circle	Labiolingual oval	Mesiodistal oval	
Teeth	Maxillary central teeth	Amount	31	1	0	32
		Percentage	96.9%	3.1%	.0%	100.0%
	Maxillary lateral teeth	Amount	30	2	1	33
		Percentage	90.9%	6.1%	3.0%	100.0%
Total		Amount	61	3	1	65
		Percentage	93.8%	4.6%	1.5%	100.0%

Analysis of the horizontal cross-section of root canals at apical one-third canals with CBCT showed that: the apical one-third of central incisors are mainly circle, accounting for 96.9%. The apical one-third of lateral incisors are mainly circle, accounting for 90.9%.

IV. DISCUSSION

4.1. Classification of incisors

From 65 patients, we examined 65 maxillary incisors, including 27 central and 38 lateral incisors. All maxillary incisors have one-rooted anatomy and type I configuration according to Vertucci's classification. This result is similar to that of Martins, J. N. R. et al. (2018) [5], when studying the characteristics of root canal systems in Asians and Westerners using Cone beam CT. According to his research, 100% of the central incisors and incisors on the maxilla have 1 root canal in both Asians and Westerners. Regarding the classification of root canals, in the study, he also showed that the proportion of type I configuration was 100% in both Asians and western. However, many authors also report cases of incisors with more than one root canal with other classification. Calvert, G. (2014) [2], reports 1 case of incisors with class V configuration; Nosrat, A. and Schneider, S. C. (2015) [8], reporting 1 case of incisors with four-rooted anatomy; Thus, 100% of incisors have 1 root and classified type 1 in our study and that of Martins, J. N. R. et al. (2018) [5] is not exactly accurate. This may be due to insufficient sample size (our sample size is 65, by Martins, J. N. R. et al. (2018) [5] is 1147). However, in most cases, maxillary incisors have one root and a type I root canal configuration, only in very rare

occasion that maxillary incisors have other configurations.

4.2. Length of maxillary incisors

The results of the study showed that the incisors between the maxilla have an average length of 22.8 mm, the shortest length is 20.0 mm and the longest is 25.5mm. Meanwhile, the incisors on the upper j have an average length of 21.9 mm and the shortest length is 19 mm, the longest length is 25mm. This result is similar to the study results of Lieu Le Quan (2018)[4], which concluding that the average length of the maxillary central incisors is 23.0 ± 1.1 mm, the maxillary central incisors are 21.9 ± 1.2 mm. Thus, with the help of Cone beam CT, the dentist can predict the length of the teeth which also helps dentists have an estimated working length that facilitates endodontic treatments.

4.3. Locations of the apical foramen

Of the 65 incisors examined, the central incisors had 5 cases of apical foramens located in the central of the apex, accounting for 18.5%; 15 cases of the apical foramens located in lingual aspect, accounting for 55.5%; 7 cases of the apical foramen located on the distal aspect, accounting for 26%. The lateral incisors have 11 cases of the apical foramen located in the middle of the root, accounting for 29%; 1 case of the apical foramen located on the labial aspect, accounting for 2.6%; 7 cases of the apical foramen located in the lingual aspect, accounting for 18.4%, 1 case of apical located on the mesial aspect, accounting for 2.6% and 18 cases of apical foramen located in the distal aspect, accounting for 47.4%. As can be seen, the percentage of apical foramen located right in the central of the root apex is very low, only 24.6% of the maxillary incisors have apical foramens in the middle of the root, most of the maxillary central

incisors have apical foramen located lingually and the maxillary lateral incisors have apical foramens located distally. Compared with the research of Ngan Duong Hoang, Van Dinh Thi Khanh and Khoa Pham Van (2013) [7] about the rate of apical foramens deviating from the apex, our research was higher, reporting a 47.76% of cases that have deviations from the apex. According to the research of Mousavi, S. A. et al. (2018) [6], apical foramen position is 0.847 ± 0.33 mm from apex at anterior teeth and 0.709 ± 0.27 mm at posterior teeth. Based on this result, dentists when performing endodontic treatments may form ideas about positions of apical foramens so that they can explore instruments into the root canals with right directions.

4.4. Long axial cross-section examination

An examination of the coronal/sagittal cross-sections of the root canals with CBCT showed that: there were 19 maxillary central incisors with straight root canal, accounting for 70.4%, 8 teeth with curved root canals, accounting for 29.6%; there were 15 maxillary lateral incisors with straight root canals accounting for 39.5%, 23 teeth with curved root canals, accounting for 60.5%. The ratio of curved root canals in our upper incisors is 52.3%. The rate of curved root canals in our upper incisors is higher than that of Lieu Le Quan (2018) [4], in Le's (2018), the proportion of curved maxillary incisors is 0%. Major differences between studies can be attributed to evaluation methods and tools. In this study, with the use CBCT scans and the support from computer software to evaluate, it was possible to assess the curvature in a more meticulous way than the two studies above [4]. Our results when compared to other studies which included CBCT show similarities. Examples include

the work of Park, P. S. et al. (2013) [9], the study of the curvature of the maxillary teeth, shows that all teeth of the maxilla are curved. A survey of the long axial cross-section of root canals by CBCT showed that the central incisors mainly have lingual curvature, accounting for 75%. The lateral incisors predominantly have distal curvature, accounting for 82.6%. This result helps dentists to explore and shape the root canals properly.

4.1.1. Horizontal cross-section examination

An examination of horizontal cross-sections of the root canals at coronal one-third with CBCT showed that: the central incisors at coronal one-third mainly have circular shape, accounting for 66.7%. The lateral incisors at coronal one-third are mainly labiolingual oval, accounting for 63.2%. Examination of horizontal cross-sections of the root canals at middle one-third with CBCT shows that: central Incisors at middle one-third mainly have circular shape, accounting for 85.2%. The lateral incisors at middle one-third are mainly labiolingual oval, accounting for 60.5%. Examination of horizontal cross-sections of the root canals at apical one-third with CBCT shows that: at apical one-third, the central incisors mainly have circular shape, accounting for 96.3%. At apical one-third, the lateral incisors mainly have circular shape, accounting for 92.1%.

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