Evaluation of Canal Configuration and Frequency of Second Canal in Mandibular Lateral Incisor Using Cone Beam Computed Tomography (CBCT)

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ABSTRACT

Objective: To categorize root canal configuration according to Vertucci's classification and determine the frequency of second canal in mandibular lateral incisors of Pakistani subpopulation (Karachi based) by using Cone Beam Computed Tomography.
Study Design: Cross sectional study.
Place and Duration of Study: Out-patient department of Oral and Maxillofacial Surgery and the department of Radiology at Dow University of Health Sciences, Karachi Pakistan, from Jan to Jul 2019.
Methodology: Study was conducted on 160 extracted permanent mandibular lateral incisors. After extraction, teeth were randomly arranged in wax models and imaged via CBCT. Each tooth sample was analyzed in axial and sagittal sections. The images were investigated by two blinded examiners and data on canal morphology was recorded.
Results: The frequency of single canal mandibular incisors was recorded as 107 (66.9%) whereas 53 (33.1%) of teeth showed two canals. Females presented with a higher frequency of two canalled incisors, although the results were statistically insignificant. The most prevalent canal anatomy detected was Type I (105, 65.6%) followed by Type III (33, 20.6%), Type II (12, 7.5%) and Type V (10, 6.3%). Mandibular lateral incisors presenting with two canals anatomy, Type III (32, 97%) morphology was most commonly detected followed by Type II (12, 100%) and Type V (9, 90%).
Conclusion: CBCT scans are an effective tool for identification of root canal morphology. Mandibular lateral incisors most frequently presented with Type I canal anatomy whereas incisors with two canals most frequently presented with Type III configuration.

Keywords: Cone beam Computed tomography, Mandibular lateral incisors, Second canal, Vertucci canal configuration.

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INTRODUCTION

A thorough understanding of the complexity of root canal anatomy and its variations plays a fundamental role in performing a successful endodontic treatment. Many authors investigating tooth morphology have postulated that canal anatomy varies according to age, gender and ethnicity; and may also be determined genetically, therefore it should be researched amongst different populations.[1] Literature presents a wide range of anatomical variations regarding all teeth in permanent dentition.[2] Mandibular incisorstypically present with one root and a single canal system, although studies have shown that other anatomical variations also exists within its morphology. Rankine-Wilson and Henry were the first to investigate the canal morphology of double rooted mandibular incisors, they reported that 40.5% of the teeth showed canal bifurcation.[3] Since then numerous ex-vivo and in-vivo studies have been conducted to analyze the morphological variations within mandibular teeth. These studies have reported a range of anatomical variance from 10.6-63% for lateral mandibularincisors.[4-6] This wide range in anatomical variations presented in the literature can be attributed to difference in methods of investigations, sample size and donor ethnicity.[6]

Research on tooth morphology has employed a vast number of destructive and non-destructive methods such as decalcification, conventional radiography, vertical and cross-sectional cutting, histological evaluation, stereomicroscopy, surgical microscopy, plastic casts, scanning electronic microscopy, cone beam computed tomography (CBCT) and micro-computed tomography (mCT).[7-10] The most commonly used conventional radiographic technique presents a major limitation by portraying a 2-dimentional image of a 3-dimentional structure, which results in obliteration of vital anatomical information regarding canal anatomy.[7-10] For this reason, nowadays CBCT has been chosenover conventional radiography as an accurate diagnostic tool for evaluation of tooth morphology in many studies,[2-7] With the introduction of CBCT imaging in dentistry, it is possible to perform 3D evaluation and extract detailed information about the complex canal anatomy,

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which aids in treatment planning and increases the prognostic outcome of the treatment.

The objectives of the present study were to evaluate canal configuration and the frequency of second lingual canal in mandibular lateral incisors in a sample of Pakistani supopulation using CBCT.

METHODOLOGY

This in-vitro, cross sectional study was conducted in the out-patient department of Oral Maxillofacial Surgery and department of Radiology, from January to July 2019 at Dow University of Oral Health Sciences (DUHS), Karachi, after obtaining ethical approval from Institutional Review Board (Ref: IRB-1194/DUHS/Approval/2019/20). One hundred and sixty extracted permanent mandibular lateral incisorswere selected for the study using non-probability purposive sampling technique. Sample size was calculated using PASS V.[11] software with 95% confidence level, 80% power of the testusing an estimated population size 200 (extracted teeth) within one year with 30.1% prevalence of second canal using CBCT6. The total sample size determined was 155 teeth. To compensate for observational errors, 5% sample size was added to the study; hence final sample size was calculated to be 160 mandibular lateral incisors.

After obtaining a written informed consent from the patients, 160 permanent mandibular lateral incisors were collected from the Oral and Maxillofacial Surgery department of Dow University of Health Sciences (DUHS), Karachi, Pakistan.

Inclusion criteria: The inclusion criteria was; permanent mandibular lateral incisors with fully developed roots and mature apices of patients of both genders aged between 18-65 years.

Exclusion criteria: Teeth presenting with fractures, previous endodontic treatment/intervention, root caries, calcification, and resorption (internal/external) were excluded from the current study.

The selected extracted teeth were cleaned of calculus and soft tissue debris using an ultrasonic scaler (Wood-pecker Dte-D5, China) at a power setting of 03 with continuous water spray and then stored in 0.9% normal saline until use.

Following completion of sample collection, they were randomly divided into groups of 10 teeth and arranged in a wax model for CBCT imaging procedure at the department of Radiology at Dow University of Health Sciences (DUHS), Karachi.

CBCT Imaging Protocol: Each wax model was imaged by a CBCT device (Care stream 9000 3D) with the exposure parameters of 70kV and 10mA. The 7.5cm×3.75 cm field of view (FOV), a voxel size 0.18mm and duration of exposure 10 seconds was selected in imaging protocol.[1] The volumetric data set of each imaging procedure was converted into study images via CS 3D imagingsoftware, each sample image was sliced into axial and sagittal views and evaluated by two blinded investigators to determine canalmorphology (Figure).

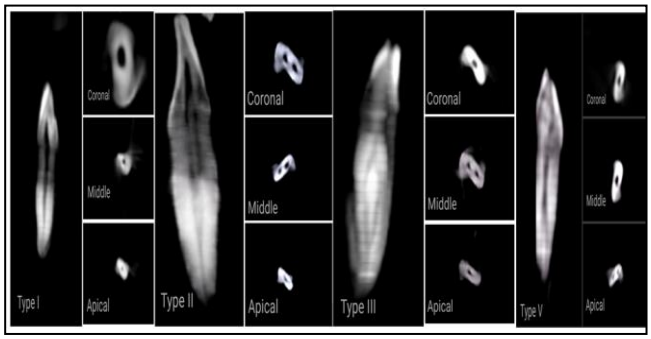

Figure: Representative CBCT images of different canal morphologies observed in mandibular lateral incisors evaluated in current study.

The following observations were recorded in the proforma:

1. Number of canals present.
2. Canal configuration in accordance to Vertucci's method.

The following Vertucci canal configuration was used in the study to categorize canal anatomy.

Type-I (1-1): A single canal present from the pulp chamber tothe apex.

Type-I (2-1): Two separate canals leave the pulp chamber andjoin each other to form one canal at the apex.

Type-III (1-2-1): One canal leaves the pulp chamber, divides intotwo canals joining each other to form one canal at theapex.

Type-IV (2-2): Two separate and distinct canals present fromthe pulp chamber to the apex.

Type-V (1-2): One canal leaves the pulp chamber, divides intotwo separate canals with two apical foramina.

SPSS version 23 was used for data analysis. Descriptive statistics were used to calculate mean and standard deviation for age; frequencies were calculated for the presence of second canal and variants of canal configuration. Chi-squared test was used to calculate

associations between variables. A *p*-value ≤0.05 was considered significant.

RESULTS

A total of 160 CBCT images of mandibular lateral incisors were evaluated in the present study. The arch side distribution was as follows: right side 78 (48.8%) and left side 82 (51.2%). The mean age range was recorded as 43.6 ± 7.6 years with a gender distribution of 83 (51.9%) males and 77 (48.1%) female patients.

The frequency of mandibular incisors with a single root canal was recorded as 107 (66.9%) whereas 53 (33.1%) of teeth showed the presence of a second root canal in the lingual aspect of the root (table-I).

Table-I: Distribution of number of canals within the mandibular lateral incisors.

No. of Canals	Frequency (n)	Percentages (%)
Single Canal	107	66.9%
Two Canals	53	33.1%

The frequency of second canal according to arch side was recorded as 23 (29.5%) right side and 30 (36.6%) left side respectively. In regards to gender; females presented with a higher Frequency of second canal (30, 39.0%) as compared to males (23, 27.7%), but the results were statistically insignificant (table-II).

Table-II: Distribution of number of canals within genders.

Gender	No. of Canals		*p*-value
	Single Canal n (%)	Two canals n (%)	
Males	60 (72.3%)	23 (27.7%)	0.131
Females	47 (61%)	30 (39%)	

**p≤0.05 was considered significant.*

The most commonly observed Vertucci configuration in mandibular lateral incisors was Type I (105, 65.6%) followed by Type III (33, 20.6%), Type II (12, 7.5%) and Type V (10, 6.3%). Type IV was not observed in any of the samples of the present study (table-III).

Table-III: Frequency of different canal morphologies in permanent mandibular lateral incisors.

Vertucci Classification	Frequency (n)	Percentage (%)
Type I (1-1)	105	65.6%
Type II (2-1)	12	7.5%
Type III (1-2-1)	33	20.6%
Type IV (2-1)	-	-
Type V (1-2)	10	6.3%

In mandibular lateral incisors presenting with two canals morphology the most commonly detected was Type III (32, 97%) followed by Type II (12, 100%) and Type V (9, 90%). Type I and Type IV canal configura tion were not observed in samples with two canal morphology (table-IV).

Table-IV: Frequency of different Vertucci variants in permanent mandibular lateral incisors with two canal morphology.

Total no. Lateral incisors with two canals, n (%)	Vertucci Classification n (%)*				
	Type I (1-1)	Type II (2-1)	Type III (1-2-1)	Type IV (2-2)	Type V (1-2)
53 (33.1%)	-	12 (100%)	32 (97%)	-	9 (90%)

** % shown are within Vertucci Classification of two canalled mandibular lateral incisors.*

DISCUSSION

In clinical practice, failure to locate a second canal in the mandibular lateral incisors, is regarded as one of the main reasons for failure of root canal treatment.[11,12] The inability to identify and locate additional canals leads to incomplete cleaning and shaping and formation of an inapt obturation seal. It is generally assumed that mandibular incisors are associated with a single root and a single canal system, however multiple studies have shown different configurations with special regards to ethnicity and race.[7-13] To understand and identify different anatomical variations within the human dentition, CBCT has been chosen as the tool of choice in many morphological studies.[14,15] As variations in morphologies exist amongst populations, the present study aims to provide a comprehensive report on canal morphology and configuration of mandibular lateral incisors in Pakistani subpopulation using CBCT.

The present study revealed that 107 (66.9%) of mandibular incisors presented with a singlecanal, whereas 53 (33.1%) showed the presence of a second canal. The results of the present study are in agreement with a local study conducted on Hyderabadi population by Shaikh *et al*.[12] They reported 61% of mandibular incisors presented with a single canal whereas in 39% of teeth a second mandibular canal was detected. Similar percentages were presented by Boruah *et al*,[16] they conducted a similar study on North-East Indian population and reported 63.75% of mandibular incisors presented with single canal and 36.25% had two canals. On the contrary, a similar CBCT study conducted by Aminsobhani *et al*,[2] reported lower percentages (29.4%) of two canalled mandibular incisors. Similar results were reported by Al-Qudah *et al*,[17] they studied the Jordanian population, using clearing technique and concluded that only 26.2% of the mandibular incisors presented with two canals. The differences in between

these morphological studies may be related to variations of the evaluation methods, sample sizes, racial and ethnical background of donor tooth population.

According to the current study on the basis of gender higher percentages of second canal was found in females although the results were statistically insignificant. Similar inferences were drawn by Haji-Hassani *et al,*[18] and Aminsobhani *et al,*[2] on their studies on Iranian population and Verma *et al,*[11] on their study on Indian population. Although the results did not prove to be statistically significant, the observed higher Frequency of second canal in females provides valuable clinical data for endodontists while performing root canal procedures.

In the present study the most commonly detected Vertucci configuration was Type I (105, 65.6%) followed by Type III (33, 20.6%), Type II (12, 7.5%) and Type V (10, 6.3%). This observation is in agreement with other studies by Aminsobhani *et al,*[2] Haghanifar S *et al,*[19] and Haji-Hussani *et al,*[18] on Iranian population, Verma *et al,*[11] and Prita *et al,*[7] on Indian population, Sert *et al,*[5] and Arslan *et al,*[20] on Turkish and Valenti-Obino *et al,*[21] on Italian population, where type I anatomy was found most prevalent amongst mandibular incisors. On the contrary, Kalaitzoglou *et al,*[6] demonstrated that type III configuration was most prevalent amongst Greek population. Furthermore, it also important to observe that Type IV canal configuration anatomy was not detected in any of the samples of the present study. This finding of the current study is also remarked by other researches.[6,22-25] where type IV anatomy was not observed in their sample population as well.

It was also observed in the present study, that the mandibular lateral incisors presenting with two canals morphology the most frequently detected canal anatomy was Vertucci Type III (32, 97%) followed by Type II (12, 100%) and Type V (9,90%) whereas, Type I and Type IV canal configurations were not observed in any of the samples. Similar observations were reported by Kalaitzoglou *et al,*[6] they observed high percentage of type III (77.3%) configuration which is similar to the results of our study; type I and type IV canal configurations were not detected in mandibular lateral incisors in their study population as well. Contradictory, Verma *et al,*[11] reported Vertucci classification type V to be the most frequently observed canal anatomy within their study population.

Based on the findings of this study it can be deduced that a substantial percentage of mandibular lateral incisors within the sample population presented with a second canal with a variable Vertucci canal configuration. Therefore, the clinician should pay due-diligence to canal anatomy and morphology while performing an endodontic treatment to increase the probability of prognostic success.

CONCLUSION

A total of 33.1% of the observed mandibular lateral incisors presented with a second canal. The higher frequency was noted in females, although the results were statistically insignificant. The most observed Vertucci classification amongst the mandibular lateral incisors was Type I (105, 65.6%) whereas, Type III (32, 97%) canal anatomy was found to be most prevalent amongst two canalled incisors. Furthermore, CBCT proved to be an excellent imaging modality tool for the identification of different canal morphologies.

Conflict of Interest: None.

Authors' Contribution

PM: Substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data, and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work ae approprately investigated and resolved, FUEQ: Drafting the article or revising it critically for important intellectual content, SA: Final approval of the version to be published, HA: Drafting the work, MS: Design the work, MA: Interpretation of data for the work.

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