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Original Article

Evaluation of Root Canal Morphology of Mandibular Incisors Using Cone-Beam Computed Tomography in Pakistani Population

Tabinda Shan, Imran Khan, Muhammed Afzal, Zahra Zubair, Samia Rasool, Javeriya Shahid

Department of Operative Dentistry, 28 MDC, Military Dental Center Lahore Pakistan

ABSTRACT

Objective: To investigate the frequency of number of roots, canals, and canal configuration based on gender and symmetry bilaterally of mandibular permanent incisors of Pakistani sub-population.
Study Design: Cross-Sectional study.
Place and Duration of Study: Department of Operative Dentistry, 28 Military Dental Center, Lahore, Pakistan, from Nov 2023 to Jul 2024.
Methodology: Three hundred forty CBCT scans were analyzed, which were recorded for the diagnosis and treatment planning of the patients within the age limits of 18 to 80 years. Number of roots, number of canals and configurations of the canal according to Weine's classification, bilateral symmetry and gender were noted as well.
Results: Mean age of the patients in the study was 44.28 ± 12.84 years. There were 207(60.9%) females and 133(39.1%) males included in our study. Outcome concludes that 65% mandibular central incisors and 63.8% mandibular lateral incisor had two canals. Most common canal configuration was Weine's Type II (65.3%). Frequency of different canal configurations bilaterally was not statistically significant. Occurrence of two canals in lower incisors was slightly higher among males.
Conclusion: Among Pakistani population second canal in mandibular incisors was more prevalent. Dentists performing endodontic treatment of these teeth must be aware of this fact to avoid missed canal.

Keywords: CBCT, Mandibular incisors, Pakistan, Root canal morphology, Weine's Classification system

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INTRODUCTION

Comprehensive knowledge of the anatomy of root canal is essential for effective root canal treatment[1]. Adequate chemomechanical debridement and effective obturation of the root canal depends upon the knowledge of normal root canal anatomy and its variations, this knowledge can be gained from the research literature on this subject.

Mandibular incisors have a quite simple and constant canal anatomy, but the presence of an additional canal, which is usually present ligually, is not infrequently and when undiagnosed and is missed, it is the most common cause of the failure of the treatment [2]. The lingual canal is more difficult to detect on periapical radiographs as compared to the buccal canal because it is frequently concealed below the cingulum, and require undue cutting of the dentinal bulge [3]. Dentinal bridge is located in the pulp chamber of the lower incisors. This cause the formation of two separate, buccal and lingual, canals that ultimately culminate in a single apical foramen i.e Vertucci Type-III. Though, only one canal is present in the apical third of the root, it is usually oval in shape [4]. According to literature 0.3% to 45.3% lower incisors have two canal anatomy [5]. Additionally, canal configurations of mandibular incisors may vary considerably among races, ethnicities and gender [6].

In the modern world of dentistry, CBCT is commonly used as an alternative imaging modality for examination and diagnosis for endodontic therapy. In contrast to the conventional radiography, CBCT provides detail 3-dimensional information of teeth morphology in easy to read cross-sectional views [6].

This study is aimed to assess the root canal morphology of central and lateral mandibular incisors, number of their roots, and frequency of different configurations of canal on the basis of Weine's classification, gender and bilateral symmetry in a population of patients attending the military dental center for treatment purposes using cone-beam computed tomography (CBCT).

METHODOLOGY

The cross-sectional study was performed at 28 Military Dental Centre, Lahore, Pakistan from November 2023 to July 2024 after approval from the

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Ethics Committee of Medical and Dental Corps, (Pakistan Army) (Ref.: No. MDC/R01/24 dated Nov 24th 2023). The sample size was calculated using WHO sample size calculator keeping a 5% margin of error, 95% confidence level and frequency reference of two canals in lower mandibular incisor as 68%7,8. The sample size of 335 was obtained which was rounded of to 340.

Inclusion Criteria: Good quality CBCT scans exhibiting the clear view of the bilaterally present permanent lower incisors that are completely erupted in the mouth were included in the study.

Exclusion Criteria: Teeth that were previous root treated, with canal obliteration, root resorption, root fracture or presence of any artifact that could lead to an incorrect evaluation was excluded.

CBCT scans of 340 patients with ages ranging from 18 to 80 years were analyzed; these scans were taken during the study period for the purpose of dental examination, diagnosis, and treatment planning of these patients. The scans were taken using the CBCT device (CS 9600 CBCT scanner, France) with the X-ray tube head rotating at 360-degree. Manufacturer's standard settings were used for scans reformatting so that the exposure parameters of every scan were the same, the tube voltage was kept at 90 kV, the tube current at 10 mA, and the field of view 80×80 mm, and isotropic resolution was kept at 0.155 mm. To achieve an adequate image quality all scans were exposed with the minimum exposure necessary. Patient's age and gender were also recorded. The scans were exhibited on a Dell laptop screen and evaluated in all the three planes i.e. coronal, axial and sagittal in a room with minimal lighting. All CBCT images were analyzed by two experienced endodontists at different occasions to reach a final consensus for the interpretation of the scan. A final decisive interpretation was managed by a third endodontist with more than 10 years of experience. In this study the following factors were evaluated: 1) Number of roots, 2) Number of root canals, 3) Root canal configuration according to Weines classification, 4) Symmetry of canal configuration of both the incisors with their counterpart, 5) Variation in canal configurations according to gender of the patient. Type of root canal morphology was determined by Weine's classification as shown in Figure-1.

Type I: one canal, one apical foramen, Type II: two canals, one apical foramen, Type III: two different canals and two different apical foramen, Type IV: one canal that divides into two apical foramina.

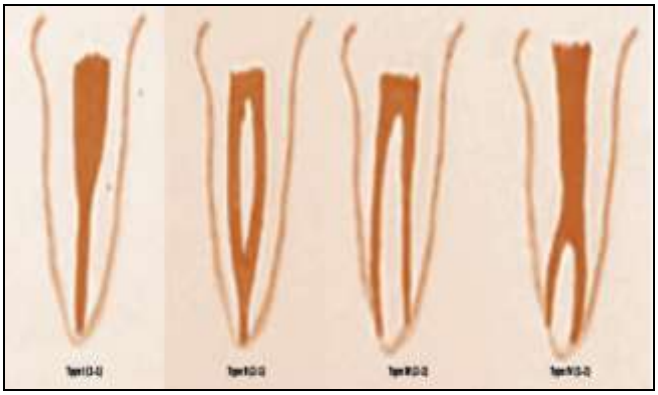


Figure-1: Canal configuration According to Weine's classification.

Data was analyzed using Statistical Package for the Social Sciences version 27.0 (SPSS). Preliminary checks confirmed that the data were approximately normally distributed, as evident from the bell-shaped distribution curve and the absence of significant skewness or kurtosis, making it suitable for parametric statistical analyses. Cross tabulations and chi-square tests were used to examine whether the number of canals, canal configurations, and symmetry varied significantly between male and female participants. Variables with constant values were excluded from statistical testing. The *p*-value of ≤0.05 was considered statistically significant.

RESULTS

A total of 340 scans were included in this study. The mean calculated age of the patients was 44.28 ± 12.84 years. According to gender distribution 207(60.9%) female and 133(39.1%) males were included in the study. A sum of total 1360 mandibular incisor CBCT images were assessed in which, 680 were mandibular CI and 680 mandibular LI. All mandibular incisors had one root. Among the 680 mandibular CI teeth, 238(35%) had one canal and 442 of them (65%) had two canals. Out of 133 male patients, 42(31.5%) had mandibular CI teeth with one root canal and 91(68.4%) had teeth with two canals. In case of female patients 77(37.19%) had one and 130(62.8%) had two canals in their mandibular CI. The *p*- value > 0.05 showing insignificant difference between men and women. Overall, this suggests that the anatomy of central incisors remains fairly consistent, regardless of gender. As for 680 mandibular lateral incisors, 248(36.47 %) had one canal and 432(63.5%) had two canals. Out of 133 male patients, 39(29.32%) right

lateral incisors had one canal whereas 40(30 %) left lateral incisors had 1 canal. There were two canals in right lateral incisor of 94(70.6%) and two canals in the left lateral incisors of 93 (69.9) of men. Out of 207 female patients, 86 (41.5%) and 83(40%) women had one canal in their right and left lateral incisor respectively. Whereas 121(58.45%) and 124 (%) had two canals in their right and left lateral incisors respectively. With *p*-value < 0.05 shows significant difference between men and women in case of mandibular lateral incisors. On the basis of gender, the frequency of Weine's Type I to IV in mandibular incisors identified in this study is shown in (Table-I).

Table-I: Root Canal Configuration based on gender according to Weine's Classification (n=1360)

Gender	Type I n (%)	Type II n (%)	Type IV n (%)	Sum n (%)
Males				
Central incisor	79(29.6%)	183(68.7%)	4(1.5%)	266 (100%)
Lateral incisor	79(29.6%)	183(68.7%)	4 (1.6%)	266(100%)
Females				
Central incisor	152(36.7%)	260(62.8%)	2(0.5%)	414 (100%)
Lateral incisor	169(40.8%)	245(59.1%)	0	414 (100%)
Total				
Central incisor	231(33.9%)	443(65.14%)	6 (0.9%)	680 (100%)
Lateral incisor	248(36.4%)	428(62.94%)	4 (0.8%)	680 (100%)

Weine's Type II (64%; n= 871) was the most common canal configuration, followed by Type I (35.2%; n=479), and Type IV (0.73%; n =10). A variety of canal configurations recorded in our study is presented in Figure-2.



Figure-2: CBCT Sagittal Views With Type-II Canal Configuration

The comparison of symmetry between male and female participants shows that more than 98% of individuals in both groups had symmetrical canal patterns in their central and lateral incisors. In the right vs. left central incisors (RCI vs. LCI), 131 males and 203 females showed symmetry, while only 2 males and 4 females had asymmetrical canals (Table-II). The pattern was nearly identical for the lateral incisors (RLI vs. LLI), with 132 males and 202 females being symmetrical, and just 1 male and 5 females showing asymmetry (Table-III).

Table-II: Symmetry between Right and Left Central Incisor based on gender of the patients (n=340)

Gender	Symmetrical	A Symmetrical	Total	*p*-value
Males	131(39.2%)	2(33.0%)	133(39.1%)	0.770
Females	203(60.7%)	4(66.6%)	207(60.8%)	
Total	334(98.23%)	6(1.76%)	340(100.0%)	

Table-III: Symmetry between Right and Left Lateral Incisors based on genders of the patients (n=340)

Gender	Symmetrical	A Symmetrical	Total	p-value
Males	132(39.7%)	1(16.6%)	133(39.1%)	0.256
Females	202(60.8%)	5(83.3%)	207(60.8%)	
Total	332(98.1%)	6 (1.9%)	340(100.0%)	

These minor differences weren't statistically significant ($p > 0.05$), which suggests that canal symmetry is a consistent anatomical feature that doesn't differ between genders.

DISCUSSION

Mandibular anterior teeth are considered as the simplest of all teeth to be treated endodontically, but unfortunately these teeth are also associated with high failure rates due to lack of knowledge of a frequent presence of a second canal that cannot be appreciated in a 2D periapical radiograph.[10] There are numerous tools to evaluate the root canal morphology of teeth. The methods commonly used are direct observation, plane periapical radiographs, sectioning of extracted teeth followed by microscopic observation or using dyes to visualize root canal morphology, and CBCT.[11]

CBCT provides a 3D examination of the anatomical structures. It is considered as a useful modality to study the root canal morphology. CBCT was found to be analogous to the clearing and staining methods in its accuracy in detecting the number of root canals or even superior to the clearing technique.[12] In the present research, scans were taken from the retrospective radiological records. Consequently, the patients involved in this research project did not undergo unnecessary radiation exposure.

Root canal morphology of mandibular central and lateral incisors has been studied frequently by a lot of researchers.[13,14] and a lot of deviation from the normal has been observed. These deviations and variations can be associated to study design, canal locating technique like radiographs, sectioning and clearing. Geographical and racial differences as well as

the gender of the patient can also lead to canal variations.[15]

In this present study all the mandibular central and lateral incisors examined has one root regardless of the gender of the patient this observation is in agreement with the systemic review done by Dhuldhoya *et al*.[15]

In Jordanian population, presence of second root canal is reported in 26.2% of cases, 16 where as 30% is reported in Saudi Arabian population[17]. Mir HA evaluated the canal anatomy of lower incisors, in Pakistani population, using CBCT and according to their study 26.2% of the examined lower incisors had more than one canal11. In another study done by Moorpani *et al.* on the endodontic anatomy of lateral incisors in Pakistani population, it was found that the frequency of second canal in lower anterior teeth was 33.1%.[18] Yet another research conducted in Pakistan by Sana et al shows the presence of two canals in 28.3% of cases.[19] In this study of a Pakistani population through CBCT, 64.26% of evaluated mandibular incisors were found to have two canals. The finding of this study does not falls within the range reported in the literature in general and in Pakistani population in particular.

In this study, among the 64.26% mandibular incisors with two canals, most commonly found configuration was the Weine type II with two canals exiting from one apical foramen. Whereas, Sana et al in their study on the morphology of mandibular central incisors found Weine type III as the most common presentation[19]. Weines type IV is the most challenging to treat as it exhibit a single canal dividing into two portals of exit. This study, found Weine type IV in 0.73% of cases and this was only in males.

The comparison of symmetry , when the two sides of the mouth were compared, between male and female participants shows that more than 98% of individuals in both groups had symmetrical canal patterns in their central and lateral incisors. Minor differences weren't statistically significant ($p > 0.05$), which suggests that canal symmetry is a consistent anatomical feature that doesn't differ between genders. Ghabbani *et al*. showed the same reults in their study where they found that 98.8% of the mandibular incisors bilaterally in a Saudi subpopulation had symmetrical canal anatomies.[20] Almost same results were found in another study also done in a Saudi subpopulation.[12] Hence, while performing the root canal treatment operator needs to be mindful that canal anatomy can be similar on both sides of the mouth in the same patient. The CBCT scanning is a useful tool for the evaluating the root canal configurations preoperatively and intraoperatively.

As for the gender, the investigations regarding the difference in morphology of mandilular incisors among male and females showed some slight gender-based variation but only in lateral incisors where males had a slightly higher occurrence of two canals in the lateral incisors (RLI and LLI) compared to females. Our results were in disagreement with the findings of the study done by Geduk *et al*.[21] in which the females were found to have higher frequency of two canals. Women were shown to have higher frequency of two canals In an Indian study.[8] Nevertheless, the outcomes of study by Liu *et al* revealed that the frequency of the second canal was comparatively higher in males.[22] The systemic review performed in India also reveal that the occurrence of two canals is higher in lateral incisors as compared to the central incisors.[15]

Though CBCT is a useful diagnostic modality in all areas of dentistry, but, it comes at the cost of high dose of radiation to the patient; hence, it should be considered as a complementary tool when the conventional methods do not suffice and benefits of this form of investigation must outweigh any possible hazards.[23]

CONCLUSION

This study found 64.26% mandibular incisors to have two canals, with Weine's Type-II being the most common and Type IV being the least prevalent. This gender-based analysis shows that the mandibular central incisors have consistent anatomy in both male and female patients as compared to lateral incisors. Males were more likely to have two canals and were the only ones who showed Type 4 canal configurations.

Symmetry between the left and right central and lateral incisors remained very stable across genders. In short, the results highlight the importance of considering gender when assessing root canal anatomy, especially for lateral incisors, where differences may affect how treatment is approached.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

TS & IK: Data acquisition, data analysis, critical review, approval of the final version to be published.

MA & ZZ: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

SR & JS: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree 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 are appropriately investigated and resolved.

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