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Original Article

Frequency of C-Shaped Root Canals in Permanent Mandibular Second Molars in a Sample of Pakistani Population using Cone Beam Computed Tomography

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ABSTRACT

C-shaped root tubes have a challenging design that causes issues in the clinic. Endodontic therapy requires careful consideration of the C-shape root canal design in Pakistan due to the country's high carious rate (about 60%). **Objective:** To determine the frequency of C-shaped root canals in permanent mandible second molars among Pakistani adults. **Methods:** At Karachi's Altamash Dental Hospital, cross-sectional study was conducted between March 2021 and January 2022.We used mandibular CBCT images to analyze 302-second molars. The position of the longitudinal groove and the bilateral predominance of C-shaped root canals were also observed. A chi-square test was used for the statistical analysis. **Results:** 47 teeth (15.54%) out of 302 had a "C-shaped canal" configuration. The breakdown was as follows: 31.91% in Category 1 (C1), 14.89% in Category 2 (C2), 6.38% in Category 4 (C4), and 46.80% in Category 3 (C3). There was no appreciable variation in the prevalence of C-shaped canals between the genders; 32.14% of the patients had them unilaterally and 67.85% had them bilaterally. **Conclusions:** "C-shaped canals are found in 15.54% of the mandibular second molars" in the Pakistani sample group, and a high probability of a matching lingual groove (59.57%) is present in these teeth. The most common type of C-shaped root canals observed in this study is C3.

INTRODUCTION

In 1979, Cooke & Cox were the first to provide a detailed "Morphology of the C-Shaped Canal" described [1]. Clinically difficult treatment of C-shaped canals is caused by their complex architecture [2]. For effective endodontic therapy, then, it's crucial to have a solid grasp of the C-shaped root canal design. C-shaped root canals occur when the lingual and buccal sides of a tooth's epithelial root sheath are detached from the root surface [3, 4]. Mandibular second molars are often more closely associated with C-shaped root canals [1, 2]. "Mandibular premolars, mandibular first and third molars and maxillary molars may also have C-shaped root canals. It has been seen in previous data that the occurrence of C-shaped canals root is between 2.7% to 44.5%" [5, 6]. Prevalence studies indicate that C-shaped anatomy has a predilection toward the Asian population. East Asia has a larger frequency of the Asian people than South Asia [5, 7]. Roy A *et al.*, reported an overall prevalence of 37.39% in people of East Asian descent. Contrastingly, these authors reported a much lower prevalence of 6.7% to 7.5% in the South Asian population [7-9]. A few numbers of studies have used CBCT to look at the frequency of C-shaped root canals in the region of the mandible in South Asia [10, 11]. In a Pakistani population, C-shaped root canals in permanent "mandibular second molars" were assessed using CBCT. This imaging technique made it possible to precisely

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identify and assess the three-dimensional root canal form. C-shaped canals, which are complex and challenging to treat, were present in a large proportion of the sample [12, 13]. Endodontic diagnosis and treatment planning should include the following because to its prevalence: sophisticated imaging methods like CBCT, especially in populations with significant anatomical variances. Understanding these prevalence rates may enhance clinical results by guiding more precise endodontic operations.

By use of CBCT, this research sought to determine the frequency of C-shaped root canals in permanent mandible second molars in a sample of Pakistani adults.

METHODS

A cross-sectional research was done at Altamash Dental Hospital Karachi between March 2021 and January 2022. 2019 saw approval of this research by the Altamash Institute of Dental Medicine's ethical review committee (AIDM/ERC/2019/01/010). The formula for calculating the sample size for the research was "n= Z2 P (1-P) / d2. Z (statistic matching to confidence interval) is 2.576 at 99% confidence interval", d (precision) is 5% and P (prevalence) is 13%, where n is the sample size, as the research by Farid H *et al.*, revealed [12]. The estimated sample size was determined to be 302 mandibular second molars. CBCT scans of 151 Patients from Pakistan were sourced from the database of Altamash Dental Hospital. These scans were performed for diagnosis and treatment planning before dental implant placement. The selection of CBCT scans was based on the following criteria. The study includes mandibular second molars with complete root formation and bilaterally present, without previous restoration or endodontic treatment, and free of serious illness or history of head and neck trauma. Participants must have Pakistani nationality and access to standardized, high-quality cone beam computed tomography. Exclusion criteria was patients with known pathologies affecting general development or a history of endodontic treatment. Seventy-four of the 151 CBCT scans were of female patients, and the remaining 77 were of male patients. The patients ranged in age from 20 to 70. The data from these scans included 302 mandibular second molars (151 on the right and 151 on the left). The CBCT scans were performed with a DENTRI scanner. The CBCT images were analyzed using Will-Master image management software. Two clinicians examined CBCT images on two separate occasions with an interval of three months. The categorization of C-shaped root canals was done into four types: C1, C2, C3, and C4. These categories were determined by the presence and orientation of the longitudinal groove within the root canal system. Software used for data analysis was SPSS version 21.0. "The Chi-Squared test was used to look at the prevalence of C-shaped root canals based on age, gender, and tooth position". The occurrences of C-shaped root canals, both unilateral and bilateral, were also detected. "The C-shaped root canal system was categorized by Fan and associates. Statistical significance was set at p- value 0.05".

RESULTS

Total 302 teeth in table 1, 15.54 percent of mandible second molars had C-shaped canals in the roots this group had no C5 variations; 22 (46.80%) were classed as C3, 15 (31.91%) for C1, 7 (14.89%) as C2, and 3 (6.38%) as C4. Eighty-four percent of the 255 teeth preserved in their original state lacked C-shaped root canals.

Table 1: The Root Canal Distribution in Buccal Second Molar with and C-Type Morphology (n=302)

Root Canal Type	C-shaped Present N (%)	C1 N (%)	C2 N (%)	C3 N (%)	C4 N (%)	C5 N (%)	C-shaped Absent N (%)	Total N (%)
Total	47 (15.56%)	15 (31.91%)	7 (14.89%)	22 (46.80%)	3 (6.3%)	0 (0.0%)	255 (84.4%)	302 (100%)

In the table 2 seven teeth (14.89%) had a longitudinal groove; 28 (59.57%) had lingual root surfaces; and 12 (25.53%) had both lingual and buccal root surfaces. Nine (32.14%) patients had C-shaped root canals unilaterally, while 19 (67.85%) had them bilaterally (Table 2). Distribution Characteristics of C-Shaped.

Table 2: Root Canals in Mandibular Molars

Category	Subcategory	N (%)
Location of Longitudinal Groove	Buccal Groove	7 (14.89%)
	Lingual Groove	28 (59.57%)
	Both Buccal & Lingual	12 (25.53%)
	Total	47 (100%)
Unilateral and Bilateral Distribution	Male: Unilateral	3 (27.27%)
	Male: Bilateral	8 (72.72%)
	Female: Unilateral	6 (35.29%)
	Female: Bilateral	11 (64.70%)
	Total Unilateral	9 (32.14%)
	Total Bilateral	19 (67.85%)
	Total Cases	28 (100%)
	Chi-square (X^2)	0.197
	P-value	0.657

Figure 1 illustrated the bilateral incidence of C-shaped root canals.

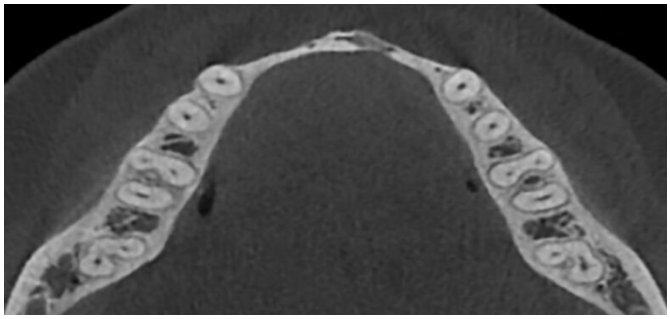

Figure 1: CBCT Axial Cross-Section Showing the Bilateral Occurrence of C-Shaped Root Canal Systems

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Figure 2 showed, meanwhile, that the patient genders did not vary statistically significantly. The bar chart displays the "frequency of C-shaped root canals among patients, both male and female". There were 47 teeth with C-shaped root canals; of them, 28 (89.57%) belonged to women and 19 (40.43%) to males. In contrast, 120 (47.06%) of the teeth in females and 135 (52.94%) of the 255 teeth in males did not have C-shaped root canals. The Chi-square test result (X2) of 2.4875 and the P-value of 0.114 indicate that there is no statistically significant difference in the frequency of C-shaped root canals in men and women. "This is seen by the correlation between the two variables".

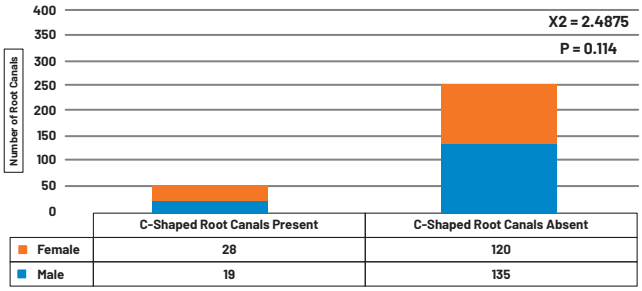

Figure 2: Gender-Specific Distribution of C-Shaped Root Canal Systems.

DISCUSSION

Previous research has shown that the total percentage of roots with C-shaped canals varies from 2.7% to 45.5% [1, 13]. In contrast, a recent research found that the frequency in the Korean population ranged from 31% to 44.5% [14]. The prevalence of c-shaped canals in Chinese may vary from 0.6%-41.27% [15]. Other parts of Asia have observed a lower frequency of this morphology of root canals Especially the South Asian population, including India and Sri Lanka, has shown to have a significantly low prevalence of this morphology. In India, Roy A *et al.*, reported a prevalence of 6.72% whereas, Wadhwani S *et al.*, documented a prevalence of 9.7% [8, 10]. The studies conducted in Sri Lanka report an even lower prevalence ranging from 1.9% - 2.9% as cited by Mazumdar P *et al* [15]. 15.54% of mandibular second molars had C-shape root canals, which is more than previously observed in the South Asian area [11]. Nevertheless, it is far lower than the prevalence in the Korean and Chinese populations. C-shape root canals are classified frequently according to the classifications proposed by a study [16]. The classification of the study does not provide a clear description of the difference between C2 and C3 root canals and their clinical significance. It also does not account for the anatomical changes of the root canal along the length [16]. Rana MA *et al.*, modified this classification using micro-computed tomography. Based on the geometry of their cross-section, they categorized the C-shaped root canals [17]. A more thorough explanation is given in this categorization [17]. The most prevalent C-shaped morphology was C3, which is consistent with studies done on Turkish and Portuguese people [18]. In this study, the tooth with a canal of C-shape had a lingual root and a longitudinal groove which is consistent with the researchers conducted in South Indian and Chinese populations by Yang L *et al* [19]. These findings are consistent with research carried out in India by Singh T *et al* [20]. These researchers found a higher percentage of C-shaped root canals in Indian females. The prevalence of C-shape root canals did not alter with age or position of the tooth in the present study which corresponds with previous studies conducted in different populations [21]. According to a study in 81% of people, a C-shaped root system found on one side is likely to be present on the opposite side. Similarly, C-shape root canals may be bilaterally present in over 70% of the cases [22]. This morphology is observed in 67.8% bilaterally in the present study. However, "there was no difference in bilateral occurrence according to gender". Studies assessing the anatomy of C-shaped root canals used radiography, cleaning procedures, histologic sectioning, and micro-CT scanning of the teeth. Moreover, it is challenging to recognize "C-shaped root canals" alone from radiographs. The tooth-clearing method and histologic sectioning are regarded as the gold standards for researching the anatomy of root canals [19, 20]. These methods permit analysis of the root canal anatomy from all dimensions. However, these methods destroy the specimen and are limited to ex-vivo examination. One such study, done in-vitro, conducted in Pakistan recently has recorded a prevalence of C-shaped canals of 9.5%. Their recoded number is lower than seen in this present study. A reason could be the limitation resulting from in-vitro assessment as the teeth available had to have been extracted previously due to some pathology and hence leading to limitations [16]. In recent years the trend has shifted towards using CBCT for assessment of root canal anatomy. "CBCT is a non-invasive imaging technique that provides three-dimensiona" and geometrically accurate images [19, 24]. Hence, it allows precise in-vivo visualization of the root canal anatomy making its use suitable for a prevalence study [19]. A study compared CBCT with Micro-CT and found two methods equally effective [21]. Studies have also shown that the accuracy of CBCT is greater than that of digital radiography [22]. Two studies conducted on the Pakistani sub population using CBCT show prevalence of 30 (10.2%) and 31 (10%) held in the province of Punjab, while this study held in the Province of Sindh shows a higher prevalence as ethnicity can been seen to cause anatomical variations [20, 21]. Another issue is an increased chance of strip perforation during root canal instrumentation, particularly along the thinner lingual walls [2, 3]. Nickel-titanium rotary instruments effectively debride root canals and reduce the risk of perforation. Anti-curvature filing technique should be utilized during root canal instrumentation to avoid stripping of the thin lingual wall. Avoiding Gates-Glidden burs for the preparation of

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mesiobuccal and buccal isthmus areas further minimizes the chance of perforation. Fine ultrasonic tips are more suitable for the preparation of isthmus areas' [23]. Mechanical instrumentation alone does not eradicate diseased pulpal tissue from the anatomically challenging parts of a C-shaped root canal. Therefore, cleaning the root canals with irrigation is necessary. Sodium hypochlorite is an effective irrigant with excellent antimicrobial and organic tissue-removing properties [24]. It can be ultrasonically activated to enhance effect. In addition, root canals should be irrigated with Ethylene-Di-Amine-Tetra-Acetic Acid (EDTA) dissolve the smear layer and inorganic stuff. Cold lateral compaction may be used for obturation of C-shaped root canals. However, cold lateral compaction produces less dense root canal filling and does not seal the buccal isthmus adequately method for the obturation of C-shaped root canals [25].

CONCLUSIONS

In Pakistanis, "C-shaped root canals in mandibular"second molars are very common (15.54%), and the lingual groove of the tooth is likely to match (59.57%), according to the research. The C-3 root canal is the most often occurring kind in this investigation. Sixty-seven percent of the time, a C-shaped root canal seen on one side was also seen on the contralateral arch.

Authors Contribution

Conceptualization: SNA
Methodology: SNA, SK
Formal analysis: MMM, SK
Writing, review and editing: MMM, MOA

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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