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Original Research

The Distribution of Missing Canals in Single-Rooted Teeth with Two Canals

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ABSTRACT

Objective: To determine whether the missing canals in endodontically treated single-rooted teeth with two-canals are present in either buccal or lingual/palatal canals for the Turkish subpopulation.

Methods: High-quality cone-beam computed tomography scans of 1297 endodontically treated single-rooted teeth belonging to 782 adults over the age of 18 were obtained from the archive of a dental clinic. Within this dataset, 129 single-rooted teeth had undergone endodontic treatment and possessed two canals, indicating the absence of one canal. These cases included 73 mandibular anterior teeth, 29 mandibular premolars, and 27 maxillary second premolars. We carefully documented both the tooth type and the location of the missing canal. To classify a missing canal as independent, we required it to have a separate orifice from the other canal or be connected to the other canal within 5 mm of its unsealed apex. The differences between categorical variables were tested with Chi-square analysis. $P \leq 0.05$ was chosen as the statistical significance level.

Results: The buccal canal was missing statistically more often in maxillary second premolars than in other teeth, and mandibular anterior teeth and premolars were statistically similar (p=0.001). The incidence of missing lingual canals was statistically similar in mandibular anterior teeth; and higher compared to maxillary second premolars (p=0.001). Overall, the most frequently missed canal was the lingual canal of the mandibular premolar teeth (96.6%).

Conclusions: The prevalence of a missing lingual canal is higher in mandibular anterior teeth and premolars, whereas a missing buccal canal is more frequently encountered in maxillary second premolars. It is essential for clinicians to be aware of these potential morphological variations to enhance the success of root canal treatment.

Keywords: Cone-beam computed tomography, endodontics, missed canal, prevalence, uninstrumented canal

INTRODUCTION

The success of root canal therapy, which involves the elimination of microorganisms from the infected root canal system, is a crucial factor [1]. Procedural errors during endodontic procedures in teeth with prior unsuccessful endodontic therapy can hinder the control of intracanal infections [2]. One common procedural mistake is the failure to identify a canal during endodontic treatment, typically resulting from a lack of awareness regarding tooth anatomy, the intricate configuration of canals, or inadequate access cavity design [3]. Overlooked canals that remain untreated can serve as reservoirs for sufficient bacteria to sustain or initiate infection, potentially leading to

reinfection [4]. Achieving the best prognosis necessitates the comprehensive identification of all canals within the root canal system. While magnification, conventional radiography, bur or ultrasonic devices, and illumination can be valuable aids in this regard, they do not guarantee the detection of all canals in every case [5-8]. Two-dimensional radiography serves as a valuable diagnostic and treatment tool but is limited in its ability to uncover missed canals due to its operational constraints [5]. In contrast, cone-beam computed tomography (CBCT) has emerged as a leading technique for addressing the shortcomings of traditional radiography, offering improved sensitivity and specificity in aligning images with actual anatomical structures [9]. When compared to periapical radiography, CBCT may offer more information that might affect the treatment planning of endodontic retreatment challenges. It is especially useful in the detection of apical periodontitis, determination of the affected and unaffected roots by the infection, vertical root fractures, and root resorption before apical surgery [10].

The purpose of this retrospective study was to ascertain if the buccal or lingual/palatal canals were seen in the endodontically treated single-root teeth with two canals in a Turkish subpopulation. The null hypothesis was that there was no difference between the tooth groups in terms of missing canal type.

MATERIALS AND METHODS

The ethical committee of the Gaziantep University approved the study (Decision No. 2022/292). This retrospective study included high-quality CBCT images taken from patients referred to a private dental clinic between March 2014 and July 2022 for implant surgery planning purposes. Furthermore, CBCT images were taken for large lesions of jaws such as cyst or other huge pathological structures. Preliminary radiographic evaluations of these patients were made with panoramic radiography, but CBCT was requested because further imaging was needed. CBCT images of 1,297 endodontically treated single-rooted teeth, which belonged to 782 subjects over the age of 18, were examined. Within this dataset, 129 endodontically treated single-rooted teeth featuring two canals (comprising 73 mandibular anterior teeth, 29 mandibular premolars, and 27 maxillary second premolars) representing one missing canal were included in the study. The type of tooth and the location of the missing canal were recorded. CBCT scans that exhibited teeth with root resorption or abnormal development were excluded from consideration. Before the assessment, all data were anonymized, with only the gender and age of the subjects being known.

Main Points;

- Mandibular premolars and anterior teeth with two canals tend to have a lingual canal missing.
- The buccal canals are **missed more often** in maxillary second premolars.
- The most frequently missed canal is the lingual canal of the mandibular anteriors.

CBCT images were obtained using an Orthophos XG 3D unit (Sirona Dental System, Charlotte, North Carolina, USA) configured with an 8x8 cm FOV and operated under standard settings of 85 kV and 7 mA. The voxel size was set at 0.4 mm. DICOM images were captured and displayed in a darkened environment using a 20-inch LED-backlit HP Compaq LE2002x LCD (HP, TX, US) with a resolution of 2560 x 1600 pixels. The images were assessed by two endodontists, each possessing at least 10 years of experience with CBCT, simultaneously. The assessment was carried out using CBCT software (Sirona Galaxis Galileos Viewer Version 1.9.2, Sirona Dental Systems GmbH, Bensheim, Germany) to identify missing canals. Disagreements among the examiners were discussed and resolved until a consensus was reached. Initially, axial views were examined by scrolling to identify unfilled canal spaces. Subsequently, sagittal and coronal views were used to validate the findings. A missing canal was defined as an independent canal if it had a separate orifice from the other canal or if it joined the other canal within 5 mm of the unfilled apex.

Statistical Analysis

Descriptive statistics, including measures such as the mean and standard deviation for numerical variables, as well as frequency and percentage analyses for both numerical and categorical variables, were employed. Furthermore, differences among categorical variables were assessed using Chi-square analysis. The statistical analyses were conducted using the SPSS 22.0 program (IBM, Chicago, USA). $P \leq 0.05$ was chosen as the statistical significance level.

RESULTS

The buccal canal could not be detected in 26 (20.15%) and the lingual canal in 103 (79.85%) teeth. The buccal canal was

missing statistically more often in maxillary second premolars in comparison to other teeth, and mandibular anterior teeth and premolars were statistically similar (p=0.001). Notably, the incidence of missing lingual canals was statistically similar in mandibular anterior teeth and premolars; but it was higher compared to maxillary second premolars (p=0.001). Mandibular premolars and anterior teeth were more likely to have a lingual canal missing (Table 1).

DISCUSSION

Many root canal treatments fail to yield positive outcomes because procedural errors often complicate the management of infections within the root canal system [11]. A critical technical issue in this regard is the inability to locate all of a tooth's root canals, with growing evidence suggesting that missing canals significantly contribute to the failure of endodontic procedures [4, 12]. Identifying all existing canals within the root system is essential for achieving the most favorable prognosis [13]. Even if initially uninfected, an untreated canal within an endodontically treated tooth can lead to permanent apical periodontitis or serve as a potential source of reinfection in the future, necessitating further dental treatment and potentially affecting the prognosis negatively. Therefore, determining the types and prevalence of missing canals can serve as a valuable guide for clinicians in their clinical practice.

Intraoral and panoramic radiographs provide information in only two dimensions, which can limit their ability to identify all root canals [9]. High-resolution CBCT (Cone-Beam Computed Tomography) images of tooth roots, with a relatively low radiation dose, prove beneficial in identifying these canals [5]. However, the effectiveness of CBCT in detecting canals depends on various imaging parameters [14, 15]. Additionally, the presence of restorative materials and metallic posts in the treated tooth can lead to artifacts and make the detection of canals challenging [16].

The prevalence of a second root canal in maxillary second premolars is reported to be 43.9% [17]. In contrast, the literature reports a range of 2.38% to 10.95% for the prevalence of missing canals in maxillary second premolars [3, 11, 13, 18, 19]. This discrepancy could be attributed to the dentists' familiarity with the anatomy of these teeth compared to other single-rooted teeth. Dentists may often assume that maxillary second premolars with two canals have only one canal, especially when the palatal canal is positioned near the center of the access cavity. Our findings suggest a higher probability of missing the buccal canal in these teeth compared to other tooth groups. Employing angled radiography techniques can aid in identifying possible second canals in maxillary second premolars.

The literature reports a prevalence of missing canals in mandibular first premolars ranging from 5.35% to 7.54% [3, 13, 18-20]. The lower incidence of anatomical variations could account for the lower prevalence of missing canals in mandibular premolars. Approximately 75% of mandibular first premolars and 97.5% of second premolars have only one canal in a single root [17].

Our study revealed that mandibular premolar teeth are more likely to have missing canals on the lingual side. While 23.6% of first mandibular premolars and 5.3% of second mandibular premolars featured second root canals, this prevalence was found to be influenced by factors such as ethnicity, age, and gender [21]. The inclination of the crown relative to the tooth root direction can make it challenging for dentists to locate the opening of the lingual canal.

Some studies utilizing CBCT have reported no missing canals in endodontically treated mandibular central incisors [11, 20]. However, a multicenter Portuguese study [3] found that 12.1% of mandibular central incisors had missing canals. This variation may be linked to the high prevalence of second canals, which can reach up to 20.4% in mandibular central incisors [17].

Table 1. Distribution of missing canals according to tooth groups

	Tooth groups			χ^2	p
	Mandibular anterior teeth	Mandibular premolars	Maxillary second premolars		
	N (%)	N (%)	N (%)		
Presence of missing buccal canal	8 (11.0)[a]	1 (3.4)[a]	17 (63.0)[b]	39.611	0.001*
Presence of missing palatal or lingual canal	65 (89.0)[c]	28 (96.6)[c]	10 (37.0)[d]		

*p<0.05; Chi-square test, [a b c d] Numbers followed by different lowercase letters in the same row indicate statistically significant differences.

The prevalence of a second canal in mandibular lateral incisors is reported as 25.3% [17]. Mandibular central and lateral incisors are comparatively smaller in size and have a reduced pulp cavity volume compared to other teeth [22]. These factors may complicate the identification of a second canal using periapical radiographs. Additionally, the small access cavity of mandibular incisors, which opens in the lingual direction due to their shape, can make it difficult to navigate during treatment. As a result, there was a statistically higher occurrence of missing canals on the lingual side of mandibular premolars and anterior teeth in our study. The design of the access cavity may obstruct access to the lingual canal orifices.

In previous studies, the prevalence of missing canals in mandibular canines has been reported to range from 1.6% to 9.5% [3, 11, 19]. This lower percentage may be attributed to the relatively infrequent occurrence of two canals rather than the technical skills of dentists, as only 5.9% of mandibular canines possess more than one canal [17].

Previous research has predominantly focused on the second mesiobuccal canal in maxillary molars when investigating missing canals [3, 11, 13, 18, 19]. To the best of our knowledge, the current study represents the first attempt to assess the prevalence and distribution of missing canals in single-rooted mandibular anterior teeth and premolars featuring two canals. To enhance the success rate of endodontic treatments, it is imperative for dentists to possess awareness regarding the presence of second canals, particularly in teeth with a history of missing canals and those commonly associated with missing canal types [20]. Furthermore, optimizing the access cavity and shaping the pulpal floor in a manner that facilitates the identification of canal openings is crucial. Ultrasonic systems have been recommended for precisely accessing small canal orifices [7]. Moreover, traditional radiographs may superimpose buccal and lingual canals, potentially obscuring their presence. In such cases, angled radiographs and three-dimensional radiographic imaging can offer comprehensive insights into the canal configuration [23]. Utilizing magnification and improved illumination can also aid in creating adequately wide access cavities to locate potential second canals in single-rooted teeth. Additionally, the use of an operating microscope can significantly enhance the identification of internal characteristics that influence canal localization, especially in teeth where external indicators may have been compromised due to prior restorative treatments [24].

Limitations

Several limitations need to be acknowledged in this study. Firstly, the absence of comprehensive data, such as the canal filling technique, type of root canal sealer, number of appointments, pre-treatment conditions of the teeth, and initial diagnoses, represents a limitation. The study's findings and analyses were constrained by the information available in the records. Additionally, this study's reliance on CBCT images from a single center constitutes another limitation. The outcomes may not be entirely generalizable to broader populations or settings. Furthermore, the scarcity of existing literature regarding which canals are frequently missing in single-rooted teeth in Turkiye and globally presented challenges in comparing our study's results. Future investigations involving multicenter and cross-sectional studies on this topic will be invaluable for a more comprehensive assessment of the prevailing circumstances. The final limitation of our study was the use of CBCT to detect missing canals. CBCT's important disadvantage is that the radiation dose is higher than periapical radiographs. As with any radiography device that emits ionizing radiation, the ALADA (As Low As Diagnostically Achievable) principle should be taken into account and the benefits should outweigh the risks when giving an indication for CBCT [25].

CONCLUSIONS

Despite the limitations within which this study operated, the prevalence of a missing buccal canal was primarily observed in maxillary second premolars, whereas a missing lingual canal was predominantly noted in mandibular anterior teeth and premolars. Greater awareness among clinicians regarding potential morphological variations could potentially enhance the overall success of root canal treatments. Future research endeavors may need to place a greater emphasis on this aspect for a more comprehensive understanding.

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Authors' Contributions: All authors contributed equally to this article.

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