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Research Article

Pre and Postoperative Change in Dentin Thickness of Danger Zone in Mandibular 1st and 2nd Molars: A Cross-Sectional CBCT Study

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Abstract

Introduction: Adequate knowledge of the internal canal anatomy can help in a considerable reduction of endodontics procedural errors.

Objective: To investigate the dentine thickness in the distal wall of mesial canals of mandibular first and second molars at a level of 2 mm from the base of the furcation, compare endodontically treated mandibular molars with the contralateral sound molars using CBCT.

Materials and Methods: cross-sectional study, conducted by the evaluation of patients CBCT images. 87 CBCT images used to assess the dentine thickness in the distal wall of mesial canals (danger zone) at a level of 2mm from the base of the furcation. Student t-test was used to compare the difference in dentine thickness in the lower first and second molars, in root canal treated tooth and in sound tooth.

Results: The mean thickness of danger zone in MB and ML canals in root canal treated teeth was 0.78 ± 0.30 and 0.77 ± 0.28, while in sound teeth was 1.17 ± 0.25 and 1.19 ± 0.26, respectively. The mean of dentine thickness of the danger zone in both MB and ML roots was significantly reduced after RCT compared to the sound teeth in the contralateral side (P-value = .001).

Conclusion: The outcomes confirm the importance of avoiding over instrumentation to minimis the possibility of strip root perforations in thin areas. The results of this study can be utilized to enhance the decision-making process when selecting the most suitable instrument taper and size for a particular clinical scenario.

Keywords: *CBCT; Danger Zone; Mesial Roots; Mandibular Molars*

Introduction

Endodontics could be defined as "field of dentistry that concentrates on the study of the human dental pulp's physiology, morphology, pathology and their related peri radicular tissues. Its involves the acquisition and application of both fundamental and clinical knowledge, which includes a comprehensive understanding of normal pulp biology and the ability to diagnose, identify the causes of, prevent, and treat diseases and injuries that affect the pulp and peri radicular tissues" [1]. For successful endodontic therapy, it is mandatory to understand root canal anatomy and its variations to minimize procedural such as perforation, zipping and canal transportation, thus it facilitates proper root canal preparation and obturation. The complicated nature of the root canal morphology can give rise to procedural challenges, and these challenges, such as perforations, can potentially cause the failure of root canal treatment [2]. Concerning the Glossary of Terms established by the American Association of Endodontists, strip perforation is known as the full penetration of a root wall due to the excessive instrumentation of the internal wall of the root canal. Therefore, a reduced thickness after canal preparation might lead to fracture or perforation during root canal filling even when strip perforation does not take place [3]. Additionally, the strength and capability of the tooth to withstand unfavorable forces to avoid root fracture are directly proportional to the amount remaining thickness of the root dentine [4]. Hence, to achieve anticurvature debridement of the root canal system on lower molars, it is recommended to perform the procedure away from the furcation, specifically towards the mesial wall of the mesial root [5]. Frequently, midroot perforations occur due to excessive preparation of a thin dentinal wall, which can negatively impact the success of endodontic treatment [6]. In the early 1980s, the 'danger zone' (DZ) concept was introduced as a result of these perforations in the distal area of mesial roots of lower molars [5]. The authors' research findings confirmed the existing knowledge of experienced dentists regarding the positioning of mesial canals in mandibular molars are not centrally located within the root, they observed that these canals are relatively thin towards the furcation (at the distal wall), known as the DZ, which increases the likelihood of strip perforations. In the country, the mesial area of the mesial root was defined as the safety zone as it has a thicker dentinal wall and is often minimally prepared during root canal shaping. The significance of this anatomical area during canal instrumentation was reported by Abou-Rass., *et al*. (1980) [5]. Afterward, multiple studies have evaluated the safety of different techniques for instrumenting the mesial canals of mandibular molars [7-9]. The DZ is positioned below the furcation level by a distance of up to four millimeters, as observed in multiple studies [7,10-14].

Several characteristics of cone-beam computed tomography (CBCT) make it a reliable imaging modality due to its precision and capacity to generate 3D representations of the internal and external tooth structure. In addition, It is a non-invasive method and it has proven to be highly accurate in identifying the complexity of root canal morphology [15,16]. The ability of the CBCT approach to detect root canal configuration is precise and superior to the staining and clearing methods of the root canal and has the advantage of providing a three-dimensional image with full morphologic details [16,17]. As far as we know, no research has been conducted to measure the danger zone in teeth that have undergone endodontic treatment and compare it with sound teeth on the contralateral side in the same patient's mouth.

Aim of the Study

This study aims to evaluate the dentine thickness in the distal wall of the mesial canals of mandibular first and second molars at a level of 2 mm from the base of the furcation, compare endodontically treated molars with the contralateral sound molars using CBCT.

Materials and Methods

This research is a cross-sectional study, conducted by the evaluation of CBCT images, which were collected from the database of Taibah University, College of Dentistry. The research ethics committee of the College of Dentistry-Taibah University has been approved this research (Protocol no.TUCDREC/24042022/TmAqili). The STROBE Statement was used for reporting the current cross-sectional study [18]. The study was conducted on CBCT graphs collected between January 2019 and June 2022.

Design

CBCT was used to assess the dentine thickness in the distal wall of mesial canals (danger zone) at a level of 2 mm from the base of the furcation (Figure 1). Also, comparing the reading of two contralateral mandibular first and second molars, one of them is Endodontically treated tooth and the other tooth is Non-endodontically treated tooth.

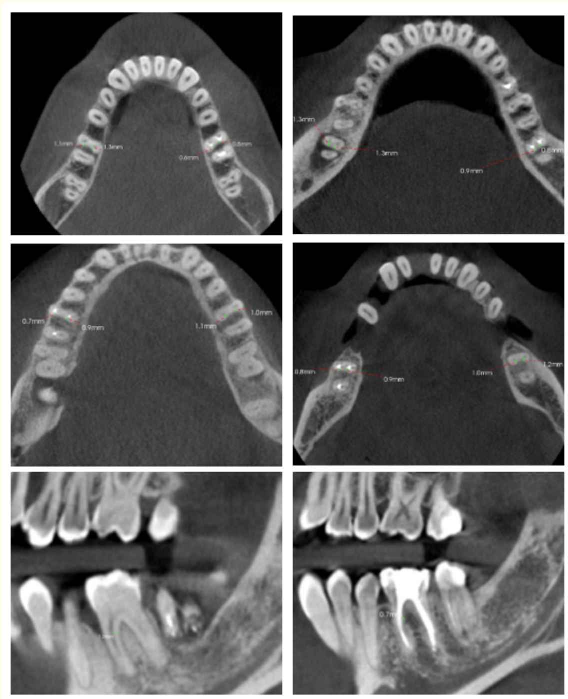

Figure 1: *CBCT images for the measurement of the danger zone (minimum distal dentine thickness).*

Sample

This study included 87 CBCT out of 1483 explored CBCT, the reasons for exclusion are described in figure 2. The exclusion criteria were: unclear or distorted CBCT images, if one of the canals of the RCT tooth is missed; incomplete root formation; root fractures teeth. CBCT was included in the evaluation of this study for the patient seeking dental treatment for other purposes such as missed canal, implant placement or dental surgery who were referred to the College of Dentistry, Radiology Department, Taibah University. CBCT need to have: an intact root structure with complete root formation; at least one sound lower molar on one side and one with root canal treatment on the other side.

The CBCT images were accessed and evaluated at the Radiology Department of the College of Dentistry, Taibah University. CBCT machine (Carestream CS 9300) was used to obtain all CBCT scans used in this study. Parameters of the machine were set to 90 kVp and 4 mA and 8 seconds acquisition time for medium patients. For large patients, the settings were 90 kVp and 5 mA and 8 seconds. When the CBCT is for mandible only, the settings are 90 kVp, 5 mA, 8 seconds acquisition time. G*Power software used T test for sample size calculation. A minimum of 45 participants is required to get a medium-sized effect (dz = 0.5) with a power of 95.

Analysis

The data was imported from the Excel sheet into the statistical package, the Statistical Package for Social Sciences (SPSS) version 26 was used (IBM Corp., Armonk, N.Y., USA) for data analysis. Student t-test was used to compare the difference in dentine thickness in the

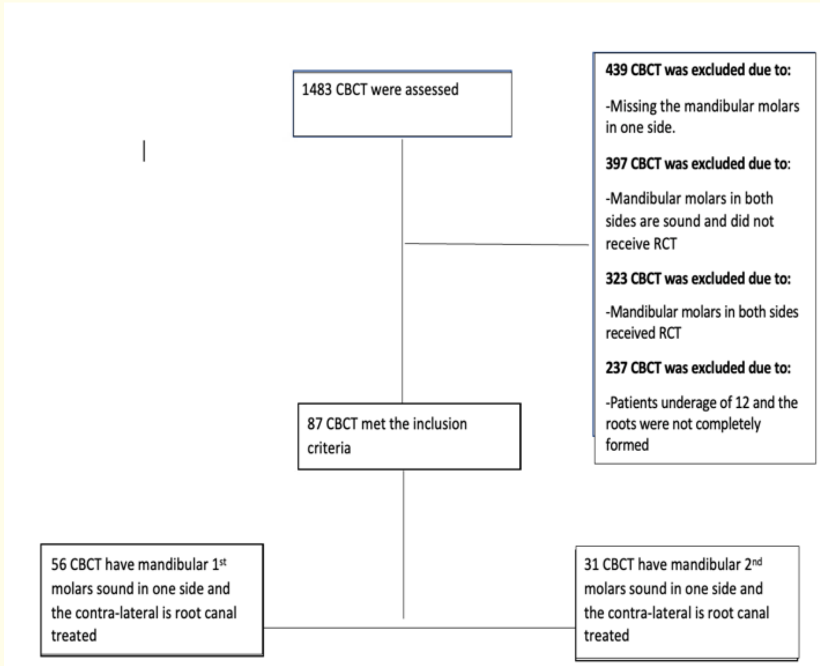

Figure 2: *Flow chart of studied sample.*

lower first and second molar, in root canal treated tooth and sound tooth for each tooth type. Statistically significant difference was defined at $p < 0.05$. The CBCT were assessed by two trained examiners independently according to the previously mentioned criteria. The radiographs were reassessed after 2 weeks to ensure reproducibility; the inter examiner agreement was calculated using Cohen's kappa test.

Results

Table 1 and 2 summarize the mean thickness of dentin in the danger zone for both MB and ML canals of mandibular molars (1st and 2nd), table 1 shows that the mean thickness of dentine in danger zone in mesiobuccal canals in root canal treated teeth was 0.78 ± 0.30, while in sound teeth was 1.17 ± 0.25.

Table 2 shows that the mean thickness of danger zone in mesiolingual canals in root canal treated teeth was 0.77 ± 0.28, while in sound teeth was 1.19 ± 0.26.

The mean thickness of dentine in danger zone in MB roots is significantly reduced due to RCT compared to the sound teeth in the contralateral side (P-value = .001), which is the same findings that can be seen in table 2 for the ML canal (P-value = .001).

Inter-observer reliability test was conducted between the two examiners for 10 CBCTs, it was 92%, which consider high percentage.

Dentine thickness in MB root (mm)	Root canal treated teeth	Sound teeth	t	p
Total	(n = 87)	(n = 87)		
Min. - Max.	0.20 - 1.40	0.60 - 1.60	9.346*	<0.001*
Mean ± SD.	0.78 ± 0.30	1.17 ± 0.25		
First molar	(n = 56)	(n = 56)		
Min. - Max.	0.30 - 1.40	0.70 - 1.60	7.749*	<0.001*
Mean ± SD.	0.84 ± 0.29	1.24 ± 0.24		
Second molar	(n = 31)	(n = 31)		
Min. - Max.	0.20 - 1.30	0.60 - 1.60	5.932*	<0.001*
Mean ± SD.	0.68 ± 0.28	1.06 ± 0.23		

Table 1: *Thickness of danger zone in root canal treated teeth and in sound teeth in MB root.*

*SD: Standard Deviation, t: Student t-test, p: p value comparing between obturated and sound *: Statistically significant at p ≤ 0.05.*

Dentine thickness in ML root (mm)	Root canal treated teeth	Sound teeth	t	p
Total (n = 87)				
Min. - Max.	0.20 - 1.50	0.70 - 1.80	10.121*	<0.001*
Mean ± SD.	0.77 ± 0.28	1.19 ± 0.26		
First molar (n = 56)				
Min. - Max.	0.20 - 1.50	0.70 - 1.80	8.137*	<0.001*
Mean ± SD.	0.83 ± 0.26	1.23 ± 0.26		
Second molar (n = 31)				
Min. - Max.	0.20 - 1.20	0.70 - 1.70	6.490*	<0.001*
Mean ± SD.	0.68 ± 0.28	1.10 ± 0.23		

Table 2: *Thickness of danger zone in root canal treated teeth and in sound teeth in ML root.*

*SD: Standard Deviation, t: Student t-test, p: p value comparing between obturated and sound, *: Statistically significant at p ≤ 0.05.*

Discussion

Throughout a person's life, the pulp-dentinal complex undergoes changes that involve the physiological formation of secondary dentine, this process leads to a decrease in the diameter of the root canal and the size of the pulp chamber [19, 20]. Therefore, the canals were well-defined and narrow, and in some cases too narrow in elderly individuals, whereas younger patients typically have a larger singular canal and pulp chamber [19]. The variation in the thickness of dentin at different levels of the root, supports the need for practitioners to increase their knowledge and awareness about root canal morphology. A lack of comprehensive understanding of the internal canal anatomy can result in significant complications such as instrumentation failures that have the potential to weaken the structure of the tooth and lead to dentinal perforations [21-23]. The most vulnerable part of the root canal shaping process is the dangerous zone, which corresponds to the thinnest section of the root canal wall. This area is highly susceptible to significant reduction in root thickness, and is at a particularly high risk of experiencing unwanted side effects and excessive weakness of the root structure [10], particularly Nickel-titanium (NiTi) instruments are widely utilized in the field of endodontics [24]. During root canal treatment, the potential for stress concentration in the tooth root should be a matter of concern, as it is strongly associated with the occurrence of vertical root fractures. When it comes to stress concentration, the curvature of the canal appears to be more significant than the external shape of the root. Additionally, decreased dentine thickness amplifies the magnitude but not the orientation of the maximum tensile stress [25]. According to Versluis., *et al*. [26] oval canals in the distal and mesial external surfaces of roots exhibited moderate stress concentration that was not considerably influenced by preparations. However, stress concentration was observed to occur in roots with round canals as the size of preparations increased. In order to avoid strip perforations, it is advisable to concentrate the coronal flaring on the thicker and outer portions of the canal walls. However, the minimum amount of coronal enlargement required to facilitate effective irrigation and apical filling has not been determined yet [27]. Lim and Stock [28] have established an arbitrary threshold of 0.3 mm as the minimum thickness of the canal wall that must be preserved after instrumentation to prevent vertical root fracture or perforation. Therefore, comprehending the anatomy of the danger zone better could potentially reduce the occurrence of mishaps.

Different techniques of instrumentation and methods of evaluation used to assess the DZ, including CBCT, periapical radiographs, and micro-CT. Those research that used CBCT to measure the thickness of dentin [14,29-31] used different types and sizes of instruments (hand files, rotary files, and Gates-Glidden) and different distances of the root sites investigated from the furcation to assess their impact on DZ.

In this study, we use the Patients' CBCT to measure the dentin thickness of the sound lower molar teeth on one side compared to root canal-treated molar teeth on the contralateral side. This is a new approach to evaluate the danger zone as most of the previous studies used the CBCT on extracted teeth to assess the danger zone. In mandibular molars, the distal wall of the mesial root has a thin dentin layer close to the furcation, this characteristic is difficult to be specified on a periapical radiograph, so using CBCT is a good technique to assess dentin thickness. Additionally, the 2 mm from the base of the furcation has been chosen as the site for analysis because the distal wall of mesial root in this area has limited dentin thickness with greater root concavity [11,12,32]. In spite of our study, Zhou., *et al*. [33] have shown that the minimum thickness of dentin of the MB and ML canals was below the furcation by 3 to 4 mm, and there was no significant difference between the two canals. The reason for the difference between our findings and Zhou's could be attributed to factors such as variation in sample size and ethnicity. The research conducted by Kessler., *et al*. [10] demonstrated that the danger zone was positioned 4 - 6 mm beneath the canal orifice. However, the disparity observed in their study could be attributed to ethnic differences or the varying locations of the distance measurement origin, which in their study was the canal orifices.

The mean thickness of dentin in the danger zone of the mandibular molars (first and second molars), on sound teeth ranged from 1.17 ± 0.25 in the MB canal and ranged from 1.19 ± 0.26. In the ML canal, while in the root canal treated teeth ranged from 0.78 ± 0.30 in the MB canal and ranged from 0.77 ± 0.28 in the ML canal. The dentine thickness of the danger zone in in both MB and ML roots is significantly reduced due to RCT compared to the sound teeth in the contralateral side. For instance, the danger zone of 200 canals was assessed by Bryant., *et al*. he found that the mean dentin thickness was 0.79 mm [34].

In comparison with other studies, Keles., *et al*. [35] reported that the thinnest canal walls after root canal preparation in ML canals were 1.19 ± 0.18 mm and MB canals were 1.16 ± 0.20 mm, these readings are slightly greater than our findings. De-Deus., *et al*. [36] reported that the danger zone values in sound teeth ranged from 1.13 ± 0.21 mm in MB canals and in the ML canals ranged from 1.10 ± 0.21 mm, these readings are lower than our study. However, in these studies the authors have assessed an extracted teeth at level of 5mm, 7mm respectively. Lack of standardized protocol in the previous published data make the comparison with our results complicated, which confirmed by Puleio., *et al*. systematic review [37]. The present study's outcomes suggest that during root canal preparation in the danger zone, the reduction of dentine should not exceed 0.5 mm. Otherwise, the risk of perforation is likely to increase. In order to prevent strip perforations, caution should be exercised when selecting large-tapered NiTi instruments for the "danger zone," where the dentin thickness of the root canal wall is insufficient. Moreover, it is recommended to limit the amount of coronal flaring and guide the instruments towards the thicker dentine found in the lateral and mesial canal walls, which are situated away from the danger zone [7]. Several limitations could be related to this study. First, the comparison group is the contralateral tooth (not the same tooth), so we can't assess the exact pre and post operative effect of RCT on DZ. However, taking pre and post RCT CBCT for research purposes is un- approved ethically, which explained our method in the current study. Second, no information about the performed RCT (who did it, instruments type, preparation size and techniques).

Conclusion

Within the limitation of our study, the findings suggested that the mesial canals of mandibular molars are more susceptible to complications due to the significant reduction in dentin thickness following RCT. The outcomes confirm the importance of avoiding over instrumentation to minimize the possibility of strip root perforations in thin areas. Hence, it is important to understand the impact of RCT on remaining dentin thickness after mechanical preparation in order to reduce the risk of root perforations. Furthermore, the findings could be used to enhance the decision making of the most suitable instruments taper and size used for each specific clinical condition.

Author's Contributions

In this manuscript, all authors have made significant contributions, and all authors have agreed with its contents.

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Conflict of Interest

The authors have no conflicts of interest relevant to this article.

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