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Dentine Thickness of Second Mesiobuccal Canals in First Maxillary Molars Prepared with Rotary Instruments

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Introduction: The purpose of this study was to evaluate the thickness of the remaining dentine wall in the danger zone of the second mesiobuccal (MB2) canals using cone-beam computed tomography (CBCT) in maxillary first molars following preparation by means of HERO 642 rotary instruments with different tapers. **Methods and Materials:** The study samples included twenty-five mesiobuccal roots of maxillary first molars. A two-step method was employed to prepare the MB2 canals applying HERO 642 instruments: using a 0.02 taper (step 1), and a 0.04 taper (step 2). The roots were scanned before preparation, and after each step. The thickness of the dentine wall was recorded at the CEJ level, as well as 2 mm and 4 mm below the CEJ. The repeated-measures ANOVA in conjunction with the Cochran tests were used to compare the changes in the thickness of the root canal wall. **Results:** There was no area with dentine thickness of <0.5 mm before preparation. A significant reduction in dentine thickness occurred following the preparation with both 0.02 and 0.04 files at all three levels compared with the pre-instrumentation values ($P< 0.05$). However, areas with dentine thickness of < 0.5 mm after preparation using 0.04 files were significantly more than those resulting from the application of 0.02 files both at the CEJ and 2 mm-below-CEJ points, but the differences were not significant at the 4mm-below-CEJ level. **Conclusion:** Within the limitations of the present in vitro study, the use of larger taper instruments in MB2 root canals of maxillary first molars increased the quantity of samples with dentine thickness less than 0.5 millimeter at the coronal level of the root canal. It was concluded that instruments with large tapers, should be used with caution in troughing or preparing such root canals to reduce the risk of strip perforation.

Keywords: Cone-Beam Computed Tomography; Dentine Thickness; Maxillary First Molar; Root Canal Preparation; Second Mesiobuccal Root Canal

Introduction

Root canal preparation is believed to be among the most critical steps in the treatment of root canal, because the effectiveness of the subsequent procedures, such as: adequate mechanical debridement, delivery of intra-canal medicaments, and proper obturation, highly depends on how well this step is performed [1]. Also, it is of paramount importance to preserve the integrity, location and anatomy of the canal after the preparation phase. Overshaping can lead to excessive removal of the dentine wall, thereby reducing its thickness, which in turn undermines the root structure [2].

Maxillary molars account for a high percentage of endodontically treated root canals [3]. The endodontic treatment of maxillary molars is particularly challenging due to their complicated anatomy [4]. The prevalence of a second mesiobuccal (MB2) canal in maxillary first molars has been reported to be as high as 90% in some populations [5]. Generally, the mean dentine thickness of first mesiobuccal (MB1) canals is considerably higher than that of MB2 canals in both the distal and mesial aspects, which means the "danger zone" of the latter is often thinner in most points of the dentine wall [6]. The thickness of the dentine wall may be reduced by up to 33% as a result of MB2 canal preparation [7], and consequently, extreme

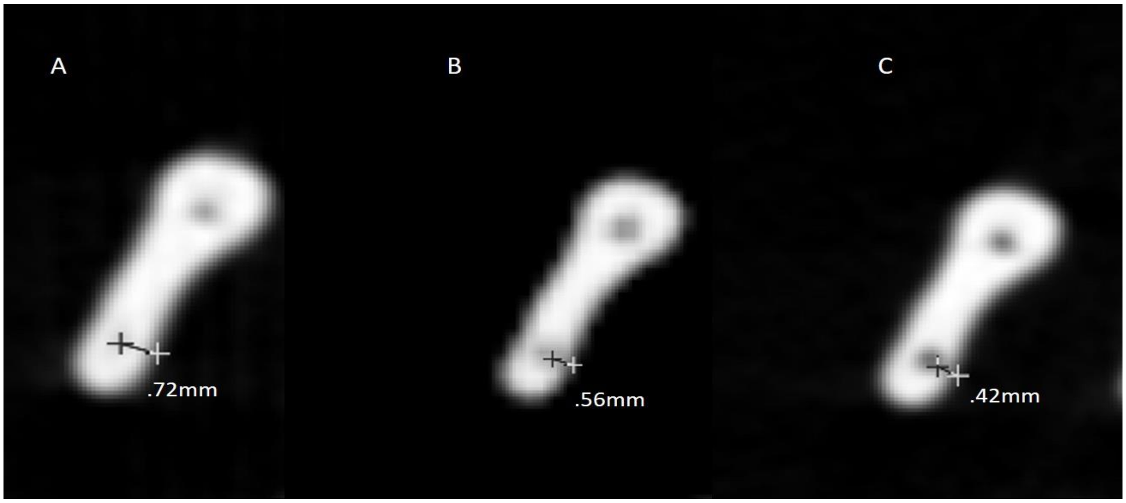

Figure 1. Axial Measurements; *A*) Pre-Instrumentation; *B*) After preparation with .02 files; *C*) After preparation with .04 files

caution should be taken when shaping an MB2 canal during a root canal treatment procedure in maxillary first molars. Therefore, preparing an MB2 canal can be a challenging process [8].

The remaining dentin thickness (RDT) is a key factor affecting the long-term clinical outcome of root canal treatment since it correlates positively with resistance to fracture [9]. It has been found that the measure of RDT following root canal preparation is perhaps the most significant iatrogenic factor that influences the future fracture resistance of the treated tooth [10]. Various methods have been employed to assess RDT following root canal treatment. Cone-beam computed tomography (CBCT) has shown to be a non-destructive technique that provides highly accurate high-resolution images [9], and offers overall acceptable diagnostic accuracy for measuring the thickness of canal wall [11-13].

A number of studies have focused on determining the prevalence of MB2 canals as well as the clinical methods for locating their orifice [14, 15]. However, few researches have been performed to recommend appropriate instrumentation protocols once the orifice of an MB2 canal has been located. The aim of the current study was to determine the remaining dentine thickness at the cementoenamel junction (CEJ), 2 mm below CEJ and 4 mm below the CEJ of MB2 canals in maxillary first molars following preparation using HERO 642 rotary instruments with different tapers, and the aid of CBCT. HERO 642 rotary system is comprised of a NiTi alloy, and incorporates instruments with 0.06, 0.04 and 0.02 tapers in sizes 20, 25 and 30, with additional 0.02 tapers in sizes 35 and 40.

The null hypothesis was defined as follows: there is no difference in the thickness measure of the remaining dentine following preparation of MB2 canals in maxillary molars using instruments with large tapers.

Materials and Methods

Sample selection and imaging

Upon approval from the Ethics Committee (protocol number: 971545), twenty-five human maxillary first molars extracted for reasons not related to this study were collected. None of the samples had root fillings, caries, cracks, fractures, or internal/external resorption. Teeth were standardized in terms of root length; teeth shorter than 17 mm or longer than 21 mm were excluded from the study. The selected teeth were embedded in wax blocks up to the cementoenamel junction, and then mounted on a putty template, which served as a stable guide to reinsert the samples. Preoperative images were acquired using a CBCT machine (Planmeca OY, Helsinki, Finland) at the following parameters: 70 kVp, 5.0 mA, 90 µm voxel size and FOV=8×8 cm. The angle of the mesiobuccal root curvature was measured using CBCT images according to Estrela's method [16]. Roots with curvatures ranging between 25° to 30° which had separate MB1 and MB2 canals extending from the CEJ level up to at least 5 mm towards the apical direction were chosen for the purpose of the current study. The minimum distance from the canal wall to the furcation area at the CEJ, 2 mm and 4 mm below the CEJ was measured on an axial view of the CBCT images with a digital ruler in Adobe Photoshop CC 2015 software (Adobe Systems Inc., San Jose, CA, USA) on the computer monitor. The CEJ was first marked on the coronal or sagittal view, and then the axial cuts were checked.

The teeth were then stored in individually labelled plastic vials containing 10% neutral buffered formalin solution until use.

Root canal preparation

After preparing the access cavity, the MB2 canals were located and explored using a #10 K-file (Mani, Utsunomiya, Japan)

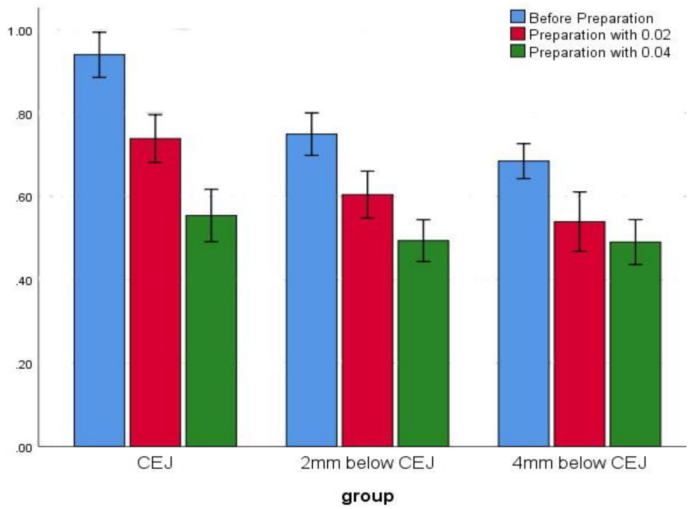

Figure 2. Mean dentine thickness of second mesiobuccal canal at three different levels before preparation, preparation with 0.02 and preparation with 0.04

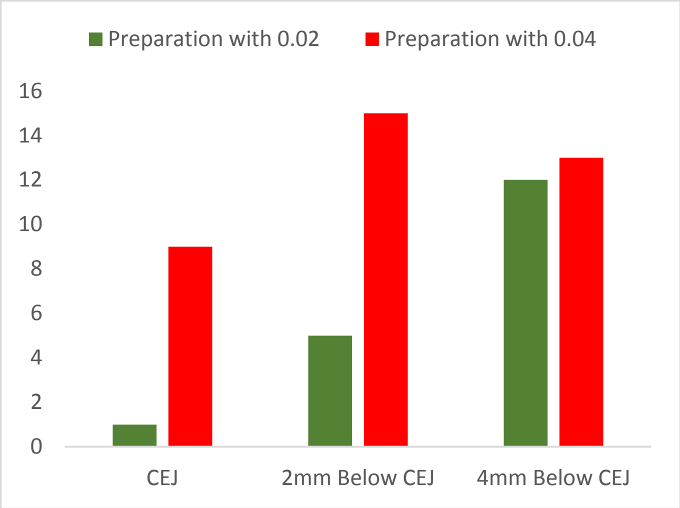

Figure 3. The number of areas with dentine thickness of ≥0.5 mm as well as those <0.5 mm of second mesiobuccal canal at different levels, before and after canal preparation

in all samples. The file was introduced into each canal until the file's tip was visible at the apical foramen. The working length (WL) was defined as 1 mm shorter than this length. No coronal flaring was performed. A #15 K-file was employed to create a glide path to the working length.

Root canals were prepared by means of HERO 642 rotary files (MicroMega, Besançon, France). Preparation was performed in two steps:

Step 1: Initially, a 0.02 taper was used to prepare the canals, and apical preparation was performed to the working length with a size 25/0.02 file.

Step 2: Preparation of the canals was completed to the working length with a size 25/0.04 file.

The instruments were operated sequentially in a continuous clockwise rotation (at 300 rpm and 1 N/cm torque) up to the working length using an endodontic electric motor (Endo-Mate DT; NSK Nakanishi Inc., Tochigi, Japan). Following three gentle in-and-out motion strokes in an apical direction, each instrument was removed from the canal and cleaned. The canal was irrigated during the entire preparation procedure with a total of 10 mL 5.25% sodium hypochlorite. An additional rinse was performed using 5 mL of 17% EDTA, which was followed by a final rinse with 5 mL of distilled water. All canal preparation procedures were conducted by an experienced operator.

Image analysis

Upon completion of preparation Step 1, all canals were dried using paper points, and the samples were submitted to a postoperative CBCT scan (parameters: 70 kVp, 5.0 mA, and 90 µm voxel size). The acquired images were reconstructed using Romexis software (Romexis Viewer, Planmeca). Subsequent to further enlargement of the MB2 canals (step 2 of preparation), the samples were subjected to a final CBCT scan. These images were used to measure and record the thickness of the dentinal wall at the aforementioned areas. All images were analyzed by a calibrated endodontist with standardized training and proficiency in the use of the software (Figure 1).

Statistical analysis

The Shapiro-Wilk test was used to verify normality of data distribution, which showed normal distribution of data ($P>0.05$). Data were analyzed employing the repeated-measures analysis of variance (ANOVA) in conjunction with Cochran statistic tests. A 5-percent significance level was considered in all statistical tests. The Kappa test was used to ascertain intra-examiner reliability.

Results

The overall inter-rater percentage of agreement and kappa statistics were 93% and 0.81 respectively.

Table 1 and Figure 2 demonstrate dentine thickness at three different levels: at the CEJ, 2mm below the CEJ and 4mm below the CEJ. At all three levels, instrumentation using HERO 642 rotary files with both 0.02 and 0.04 tapers resulted in a significant reduction in the values of dentine thickness compared with the pre-instrumentation mean value of dentine thickness ($P<0.05$). Values of dentine thickness following preparation with HERO 642 files with 0.04 taper were significantly lower than those corresponding to 0.02 taper at the CEJ and 2 mm below the CEJ (*P*<0.05). At 4 mm below the CEJ, values of dentine thickness following preparation with HERO 642 files with 0.04 taper were also lower than those related to 0.02 taper, but the difference was not significant (*P*=0.066).

Table 2 and Figure 3 demonstrate the number of areas with dentine thickness of ≥ 0.5mm as well as those < 0.5 mm at different levels, before and after canal preparation.

Before root canal preparation, at the CEJ, 2 mm below CEJ and 4mm below CEJ, there was no area with dentine thickness of <0.5mm. At the CEJ level, there was only one area with dentine thickness of <0.5mm following preparation with 0.02 files, compared with nine areas corresponding to 0.04 files, which represented a significant difference (3.8% *vs.* 34.6%) (*P*<0.05). At 2 mm below CEJ, there were 5 (19.2%) and 15 (57.7%) areas with dentine thickness of <0.5mm following preparation with 0.02 and 0.04 files, respectively, which revealed a significant difference (*P*<0.05). At 4 mm below CEJ level, the number of areas with dentine thickness of <0.5mm were 12 (46.2%) and 13 (50.0%) after preparation with 0.02 and 0.04 files, respectively, which did not mark a significant difference (*P*>0.05).

Discussion

Previous studies have indicated the prevalence of MB2 canals to be as high as 90-96% [17-19]. It has been reported that the dentine thickness of the MB2 canal is significantly less than that of the MB1 canal on both mesial and distal aspects of the root [6]. A critical "strip" perforation may occur as a result of over-instrumentation or over-shaping in an area where the internal dentine wall of the root canal is too thin [20]. Some studies have presented safe protocols for enlargement of the MB1 canal with different rotary systems [21, 22], but to date, very few laboratory studies have examined the remaining dentine thickness following root canal preparation in MB2 canals. The present study sought to compare the thickness measure of dentine wall in MB2 canals before and after root canal preparation. Different tapers of the same rotary file (HERO 642 #25) were used to eliminate the confounding factors affecting the instruments' cutting ability, such as file design, metallurgical properties, *etc.* Furthermore, root canal preparation with 0.02 and 0.04 tapers was performed in 2 steps in each canal to eliminate the interfering factors related to canal anatomy in different roots. Based on the results of the current research, wall thickness of the mesiobuccal root in the coronal thirds of MB2 before instrumentation was approximately within the range of 0.64-1.12 mm. Application of an orifice-opener with large taper may lead to excessive removal of dentinal wall in MB2 canals. Thus, no cervical pre-flaring was performed during the MB2 instrumentation in the present study.

Various methods have been proposed to assess radicular wall thickness, including: serial sectioning, radiographs, cone-beam computed tomographic (CBCT) and micro-computed tomography (micro-CT) [23-25]. A radiograph tends to show a

Table 1. Comparison of mean (SD) values of dentine thickness at different levels

Level	Group	Mean (SD)*	(Min-Max)	Median
CEJ	Before preparation	0.94 (0.13)^{a}	(0.72-1.28)	0.9600
	After preparation with .02 files	0.74 (0.14)^{b}	(0.49-1.01)	0.7300
	After preparation with .04 files	0.55 (0.16)^{c}	(0.31-0.88)	0.5050
2 mm below CEJ	Before preparation	0.75 (0.13)$^{a'}$	(0.64-1.12)	0.7200
	After preparation with .02 files	0.60 (0.14)$^{b'}$	(0.40-0.96)	0.5600
	After preparation with .04 files	0.49 (0.12)$^{c'}$	(0.31-0.84)	0.4850
4 mm below CEJ	Before preparation	0.68 (0.10)$^{a''}$	(0.64-1.12)	0.6400
	After preparation with .02 files	0.54 (0.18)$^{b''}$	(0.31-1.12)	0.5200
	After preparation with .04 files	0.49 (0.13)$^{b''}$	(0.31-0.78)	0.4850

*Min: Minimum, Max: Maximum, *: Similar letters in columns indicate that the groups do not have a statistically significant difference*

Table 2. Number of areas with dentine thickness of ≥0.5 mm and <0.5 mm

Level / Group	CEJ		2 mm below CEJ		4 mm below CEJ	
	≥0.5 mm	<0.5 mm	≥0.5 mm	<0.5 mm	≥0.5 mm	<0.5 mm
Before preparation	26 (100)	0 (0.0) ^{a}	26 (100)	0 (0.0) ^{a}	26 (100)	0 (0.0) ^{a}
Preparation with .02 files	25 (96.2)	1 (3.8) ^{a}	21(80.8)	5 (19.2) ^{a}	14 (53.8)	12 (46.2) ^{b}
Preparation with .04 files	17 (65.4)	9 (34.6) ^{b}	11(42.3)	15 (57.7) ^{b}	13 (50)	13 (50) ^{b}

**Similar letters in columns indicate that the groups do not have a statistically significant difference* greater thickness value than the actual measure, and is, therefore, not a reliable method [12]. Sectioning is an accurate but destructive procedure, which renders the samples unusable for further studies, and in which the samples cannot be used as their own controls [12]. Many studies have successfully used micro-CT to assess the parameters of root canal system [8, 26, 27]. However, using this imaging modality entails a time-consuming process, and generally, micro-CT is not easily accessible for use in the office setting, while posing yet another hazard: high radiation doses [11, 12]. Xu *et al.* [12] have reported that CBCT can accurately measure dentine thickness. In view of the aforementioned, the current study employed CBCT to assess the dentine wall thickness of MB2 canals.

Previous studies have suggested that the MB2 root canal has a danger zone on the distal wall, making it more vulnerable to perforation upon instrumentation [28, 29]. The present study confirmed these findings by showing that there is a high proportion of areas with a dentine wall thickness of 1 mm or less on the MB2 root canal at the CEJ, 2 mm below CEJ, and 4 mm below CEJ levels (76.9%, 96.2%, and 96.2% respectively). The mean values of dentine wall thickness at the three evaluated levels (CEJ, 2 mm and 4 mm below CEJ) were 0.94±0.13 mm, 0.75±0.13 mm and 0.68±0.10 mm, respectively. This information is clinically important since troughing is inevitable in many cases in order to access the MB2 canal orifice, the orifice often being covered by secondary dentine. Therefore, if large instruments are used in the procedure, the integrity of the root structure might be compromised due to deep troughing, as the dentine of the distal aspect of the MB2 canal at the coronal level is usually (too) thin. So, particular caution should be exercised when preparing MB2 root canals in order to avoid strip perforation, and in general, impairing the prognosis of the tooth. In this respect, the application of magnification as well as selective dentine removal can be useful.

In this study, an effort was made to measure the volume of the root structure after each preparation step. As would be expected, dentine wall thickness reduced significantly following root canal preparation at all three evaluated levels. Although no strip perforations were spotted at any of the evaluated levels following root canal preparation with a size #25/0.04 rotary instrument, the number of samples with a dentine thickness of less than 0.5 mm generally increased after additional enlargement of the MB2 canal with larger tapers, and therefore, the null hypothesis was rejected. Similar studies have considered a dentinal wall thickness of 0.5 mm to compare the effect of different preparation methods on the thickness of the remaining root canal dentin [30, 31]. EIAyouti *et al.* [30, 31] noted that the reason why 0.5 mm is chosen in research concerning the remaining dentine wall is that it represents removal of more than 50% of dentine wall in narrow roots. This is true for our samples with an average thickness of 0.68 to 0.94 m. Keles *et al.* [30, 31] observed that additional enlargement of the mid-mesial canal in mandibular molars increased the number of specimens with dentine thickness less than 0.5 mm [31]. In their study, canal preparation was performed in 2 steps. In step 1, MM canals were enlarged using ProTaper Next X1 (size 17, 0.04 taper), and in step 2, they used X2 files (size 25, 0.06 taper).

The number of cross-sections with a dentine thickness of < 0.5mm increased in the apical direction after each preparation step, which was not unexpectable, given the initial dentinal wall thickness at the experimental levels. The present study merely focused on the critical zone of the furcation area, and so, further studies are required to determine the values of remaining dentine thickness in the entire root following the preparation of the canals.

Conclusion

Within the limitations of this study, it was concluded that dentine wall thickness in MB2 root canals of maxillary first molars reduces significantly upon preparation with rotary files. Also, the use of larger taper instruments increased the number of samples with areas having a dentine thickness of < 0.5mm. Thus, instruments with 0.04 taper or higher should be used with caution in these root canals.

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