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Evaluation of Dentin Thickness around Second Mesiobuccal Canal in Maxillary First Molar Using Cone Beam Computed Tomography (CBCT)

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ABSTRACT

Background and aim: Maxillary first molars exhibit a variety of anatomies in the mesiobuccal root, with a concavity on the distal wall limiting the canal's preparation to prevent strip perforation. This study evaluated the dentin thickness around the second mesiobuccal canal (MB2) in the maxillary first molar using cone-beam computed tomography (CBCT).

Materials and methods: The present retrospective descriptive cross-sectional study conducted on 120 CBCT images of patients referred to Radiology Centers of Urmia (Iran) between 2017 and 2019. Samples were collected using a convenience sampling method. A professional radiologist prepared all the CBCT images that had the least exposure required with proper image resolution. The first and second mesiobuccal canals (MB1 and MB2) were both detected. Two endodontists evaluated the dentin thickness around the MB2 canal in the mesial, distal, and palatal walls and its distance to MB1 at coronal, middle and apical cross-sections. Statistical significance level set at 0.05 and all analyses performed using SPSS version 23 software.

Results: In all three sections, the lowest dentin thickness was in the distal wall. The highest was in the palatal wall; this difference was statistically significant in all sections ($p<0.05$). Minimum distances of MB2 from mesial, distal and furcation surfaces and from MB1 canal were significantly different in coronal ($p = 0.008$), middle ($p = 0.004$) and apical ($p = 0.001$) sections.

Conclusion: The low thickness of distal wall indicates more conservative considerations in endodontic and prosthodontic treatments. The CBCT seems to be an effective and non-invasive method in examining root and canal morphology. It may be used as preoperative radiography to assess the dentin thickness in danger zones to prevent iatrogenic errors.

1. Introduction

Successful root canal therapy requires comprehensive knowledge of root canal morphology, which is often highly complex and variable.[1, 2] Various articles have reported a wide range of variation in the number and shape of root canals for each tooth in the system of permanent teeth.[3] The most common variety found in maxillary molars, premolars, and mandibular incisors.[4] The maxillary molars widely studied in different ways because of their varied root morphology. The mesiobuccal roots of these teeth usually contain more than one canal.[5] The second mesiobuccal canal (MB2) prevalence reported being 70.2% in the first molars and 43.4% in the second molars in the Iran population.[6] Failure to fully locate and clear the MB2 can jeopardize the long-term prognosis of the tooth.[7] These complexities make it difficult to achieve endodontic treatment goals, such as 3D cleaning, shaping, and obturation of root canals. Understanding 3D anatomy and canal morphology is a fundamental principle.[8] The root canal morphology can be analyzed using techniques such as canal staining, tooth clearing, plain radiography, digital radiography techniques, and more recently computed tomography techniques.[9] Newer studies have used the Cone-Beam Computed Tomography (CBCT) technique. Recent studies focusing on the MB2 canal of maxillary molars have used pulp casting and cleaning, shaping, radiography, and microscopes.[4, 8, 10] Due to the limitations of conventional methods in the morphological examination of the MB2 canal, an advanced CBCT imaging technique used in this study. Also, the root thickness of the MB in the furcation region is one of the critical factors that must be considered before canal instrumentation to prevent strip perforation in maxillary molars.[8] There are even reports on the cases of strip perforation in the MB2 canal in maxillary molars in routine root preparation.[11] This study aimed to

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investigate the dentin thickness around the MB2 canal in the first maxillary molar.

2. Materials and methods

The current descriptive cross-sectional study conducted on mesiobuccal roots of maxillary first molars in 120 CBCT images prepared from patients referred to Radiology Centers of Urmia City (Iran) between 2017 and 2019. Inclusion criteria were good quality CBCT images. Exclusion criteria included specimens with coronal restoration, periapical lesions, previous root canal treatment, canals with open apices, root canal resorption and calcification, C-shaped canals, three-canalled tooth, caries, and variation of other canals.

The CBCT images were obtained using sordex scauora ® 3D (Helsinki, Filand) with mA = 12, KVP = 90, voxel size=0.2 mm and FOV = 9 * 13 cm, which included maxillary anatomy. A professional radiologist prepared all the CBCT images that had the least exposure required for proper image resolution. The AS LOW AS Reasonably Achievable principles fully applied to all images. All the reconstructions of dental structures and observations were analyzed in Romexis viewer version 3.1.8 software on the LG 17-inch monitor with a resolution of 1024 × 1024 pixels in a dark room. The contrast, brightness, and magnification of the images adjusted to the observers. The teeth structures evaluated in axial cuts of CBCT images with 1mm slice thickness from the pulp-chamber floor to the apex. MB1 and MB2 were both detected, and the distance between these two recorded. Dentin thickness around the MB2 canal measured from mesial, distal, and palatal surfaces of the root up to the canal wall. The coronal one-third was the first place of furcation. The thickness measured from the furcation region, not the root concavity.

In the images taken from the 120 maxillary first molars, the following information recorded:

1- Dentin thickness in mesial, distal, and palatal surfaces of the MB2 canal in coronal, middle, and apical one-third.

2- Distance between the MB1 and MB2 canals in the coronal, middle, and apical one-third.

All images were examined separately by two endodontists. To standardize observations and interpretations, the images of two observers calibrated using 10% of the samples. Two weeks later, 20% of the images re-examined by the two observers. Inter-intraobserver reliability calculated using the intraclass correlation coefficient. Their correlation coefficient was calculated by a 95% confidence interval and an error rate of 0.05 and used as a means of indicating agreement between the two evaluators. Correlation coefficients of 0.5 to 0.75 considered weak, 0.75 to 0.9 as moderate, and 0.9 to 1 as strong understanding. Statistical analysis performed using SPSS version 23 software.

Fig. 1- A sample measurement on the CBCT image in coronal one-third.

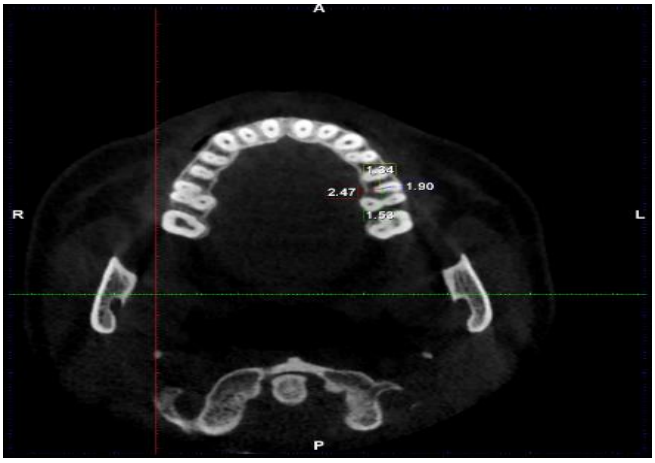

Fig. 2- A sample measurement on the CBCT image in the middle one-third.

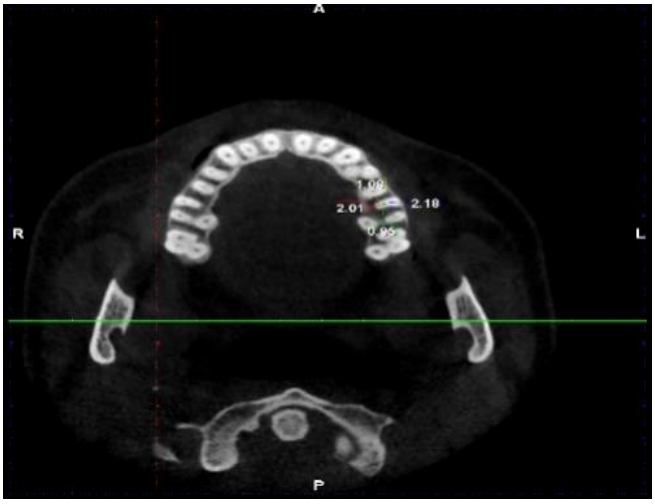

Fig. 3- A sample measurement on the CBCT image in apical one-third.

3. Results

The Kolmogrov-Smirnov test has shown the normal distribution of variables in each coronal, middle and apical groups, so the repeated measurement test with p value=0.05 used for assessing the difference between 3 sectional groups.

The mesial dentin thickness around MB2 in three coronal, middle and apical sections was not equal, and there was a statistically significant difference in these three groups (p = 0.000) (Table 1). The furcal dentin thickness around the MB2 was not equal in three coronal, middle, and apical sections, and there was a significant difference in these three groups (p = 0.000) (Table 1). The palatal dentin thickness around the MB2 was not equal in three coronal, middle, and apical sections, and there was a statistically significant difference in these three groups (p = 0.000) (Table 1).

The distance of MB1 to MB2 in the three coronal, middle and apical sections was not equal, and there was a statistically significant difference in these three groups (p = 0.000) (Table 1).

Table 1. Descriptive and analytical statistics of distances in three coronal, middle and apical sections.

Variables	Value range	Minimum	Maximum	Mean	Standard deviation	Variance	P-value
Dentin thickness in the mesial wall of the second mesiobuccal canal in coronal one-third	1.87	1.08	2.95	1.95	0.44	0.19	0.6
Dentin thickness in the mesial wall of the second mesiobuccal canal in the middle one-third	1.76	1.01	2.77	1.74	0.39	0.15	0.2
Dentin thickness in the mesial wall of the second mesiobuccal canal in the apical one-third	1.19	1.01	2.20	1.52	0.29	0.08	0.1
Dentin thickness of the second mesiobuccal canal to furcation in coronal one-third	1.75	0.9	2.65	1.72	0.35	0.12	0.032
Dentin thickness of the second mesiobuccal canal to furcation in middle one-third	1.49	0.67	2.16	1.49	0.3	0.09	0.00
Dentin thickness of the second mesiobuccal canal to furcation in the apical one-third	0.95	0.67	1.62	1.25	0.21	0.04	0.00
Dentin thickness in the palatal wall of the second mesiobuccal canal in coronal one-third	4	1.13	5.13	2.43	0.46	0.21	0.7
Dentin thickness in the palatal wall of the second mesiobuccal canal in the middle one-third	1.94	1.01	2.95	2.24	0.38	0.14	0.4
Dentin thickness in the palatal wall of the second mesiobuccal canal in the apical one-third	2.06	1.24	3.30	2.04	0.34	0.11	0.1
The Distance of first mesiobuccal canal to the second mesiobuccal canal in coronal one-third	2.34	0.67	3.01	1.96	0.43	0.19	0.1
The Distance of the first mesiobuccal canal to the second mesiobuccal canal in the middle one-third	1.98	1.08	3.06	1.81	0.38	0.14	0.5
The Distance of first mesiobuccal canal to the second mesiobuccal canal in apical one-third	1.82	0.9	2.72	1.61	0.34	0.12	0.8

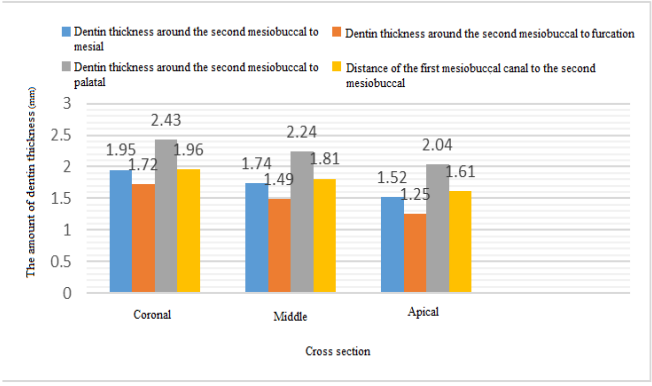

Chart 1. Mean dentin thickness based on the cross-section.

The Related measurement test considering p value= 0.05 used to analyze the difference of four measurement variables in each one-third group. Minimum values for the distance of MB2 from mesial, palatal, and furcation surfaces, and the MB1, in coronal sections, were statistically different (p = 0.008). The minimum values for the distance of MB2 from mesial, palatal, and furcation surfaces and the MB1 in the middle section were statistically significant (p = 0.004). Minimum values for MB2 distance from mesial, palatal, and furcation surfaces, and the MB1 in the apical cross-section were statistically significant (p = 0.001).

According to chart 1, the lowest value in all three sections related to dentin thickness around MB2 to the distal surface, and the highest value related to dentin thickness around MB2 to palatal surface.

4. Discussion

One of the most common teeth requiring endodontic therapy is the maxillary first molar.[12] Canal morphology in the maxillary first molars is complex and variable.[12-14] Many studies have performed on the internal anatomy of the maxillary first molar. These results cannot be generalized to populations in another geographical location because genetic diversity in different racial groups can be as sufficient as other physical differences in the tooth's internal anatomy.[15] The prevalence of second mesiobuccal canals also differs in the nations[15, 16]. A previous study on the Iran population has reported the prevalence of MB2 as 70.2 % in first maxillary molars[6], which indicates the importance of the knowledge improvement about this anatomic variation.

Missing of the canals is one of the common causes of failure in non-surgical endodontic therapy. Many studies have also found that the failure of endodontic treatment in maxillary molars is likely due to failure to find and fill the MB2.[14, 16, 17] Different methods currently used to investigate the diversity of root canal morphology. Some of the in vitro methods are cleaning procedures using decalcification or injection of India ink, Chinese ink, hemotoxin dye, or plastic or metal castings.[7, 9, 11] The disadvantages of these methods are non-usability in the in vivo condition.[17] In recent years, CBCT has been widely used in implants, maxillofacial reconstruction, endodontic diagnostics, as well as in the evaluation of canal preparation, filling, and removal of canal filling materials.[17,18] Also, CBCT is a non-invasive procedure. The specimens studied remain intact and not fragmented and can be directly used to evaluate patients and provide three-dimensional information on the clinician's internal and external root morphology.[18-20] Moreover, CBCT is more accurate than periapical radiography.[20] Abuabara et al.[21] showed that the CBCT is very accurate, and there is no difference between using this approach compared to the microscope and ultrasound. Blattner et al.[22] compared the CBCT with gold standard methods to determine the morphology of dental canals by clinical tooth excision. They found that about 80% of CBCT cases matched with the gold standard of MB2

detection. They introduced the CBCT as a safe and convenient technique to examine and detect the MB2.[21, 22] In this regard, the differences in the prevalence of additional canals in these different studies are due to the racial differences and the sample size of the study (clinical or laboratory)[15,16] In the present study, we measured the distance of MB2 to mesial, furcation, palatal, and MB1 in all three coronal, middle, and apical sections. The results showed that the value of the distances decreased in each variable from coronal to apical, with a significant difference in the three sections. Therefore, the canal morphology and vertical dimension can highly affect the distances, and special attention should be paid to this point during the cleansing and shaping of the canal. The distance of MB2 from mesial, distal, furcation and MB1 were measured once at the coronal section and again in the middle section and finally in the apical section. The results showed that the distance of MB2 to different surfaces of the root was significantly different in each cross-section. This study's findings suggested that the mean mesial dentin thickness at the coronal third was 1.95 ± 0.44 mm, and 42.5% of the specimens were in the range of 1.53 to 2.1mm. The furcal dentin thickness of MB2 was 1.72 ± 0.35mm, and 29.2% of the samples were in the range of 1.82 to 2.1mm. The palatal dentin thickness of MB2 was 2.43 ± 0.46 mm, and 42.5% of the samples were in the range of 1.9 to 2.34mm. So the distal dentin thickness was the least, and the palatal was the greatest. Betancourt reported MB2-P values of 0.49 - 2.68 mm in the coronal third, consistent with the present study.[23] Zhang et al.[24] reported that the distance of MB1 to the palatal surface was higher than that of the distobuccal. The MB1-MB2 distance at the coronal section was about 0.75 to 3.75 mm, which is so near to our finding(0.67 to 3.1mm). They also used the ratio of mesiobuccal-palatal distance to the distobuccal-palatal distance to predict the probability of MB2.[24] A study on the size of grooves on maxillary premolars, showed that the furcation groove always exists in the palatal surface of the buccal root of the maxillary premolars, and the length, depth, location and thickness of dentin in the groove furcation varies depending on the length of the tooth, bifurcation, and CEJ of the tooth, and dentists should consider these parameters to reduce the likelihood of vertical root fracture and perforation.[25] Lammertyn et al. showed that the buccal dentin thickness in the buccal roots of maxillary premolars was higher than the palatal wall at the middle and coronal third. They concluded that the dentin thickness varies in the furcation groove area, causing structural changes in these teeth that must have considered in endodontic and prosthetic applications.[26] According to the presence of such a groove and concavity on the distal surface of the mesiobuccal root in a maxillary first molar,[8] greater care should be taken to prevent root perforation and further dentin removal while using rotary instruments, removing or bypassing the fractured instrument, and also cementing an intracanal post. Therefore, it is necessary to know the minimum dentin thickness in different areas of the canal. Given the genetic and racial differences, this study's results cannot be generalized to other communities.

5. Conclusion

The lowest dentin thickness in all three sections was in the distal (furcal) wall of MB2, and the highest thickness was in the palatal wall of MB2. The small thickness of the distal wall indicates more conservative considerations in endodontic and prosthodontic treatments to prevent procedural errors like perforations, which could compromise the prognosis. The CBCT seems to be an effective and non-invasive method in examining root and canal morphology. It may be used as preoperative radiography to assess the dentin thickness in danger zones to prevent iatrogenic errors.

Conflict of Interest

The authors declared that there is no conflict of interest.

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