Surgical Endodontic Parameters in the Mandibular Premolars Area: An Anatomic Evaluation with Cone -Beam Computed Tomography

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Introduction: This study aimed to evaluate the relationship between mandibular premolars and the surrounding critical anatomical structures for endodontic surgery using cone-beam computed tomography (CBCT). **Materials and Methods:** In this cross sectional study, 170 CBCT images were evaluated in the sagittal, coronal, and axial planes to measure the buccal bone thickness (BBT) covering each root, the diameter of the premolars in the buccolingual and mesiodistal dimensions, besides the total amount of tissue needed to be resected for endodontic surgery; these measurements were performed at the 3mm level of the apex. Also, the distances from the superior border of mental foramen (MF) to premolars apex and alveolar crest (AC) were measured. Moreover, the position of MF in relation to adjacent teeth was evaluated. Descriptive statistics, independent-sample T-test and Wilcoxon test were used in the SPSS 26 to analysis of the data (α=.05). **Results**: The mean values of BBT for the first and second premolars were measured 1.18 mm and 1.57 mm, respectively. The root diameters of the first and second premolars were measured 4.02 mm and 3.98 mm in the buccolingual dimension, and 2.74 mm and 2.98 mm in the mesiodistal dimension. The total amount of tissue needed to be resected for endodontic surgery in the second premolar has a higher amount with a mean of 5.55 mm. The second premolar was recorded as the tooth with the closest root apex to MF with a mean value of 3.97 mm. The mean distance between MF and AC was measured 13.88 mm, and MFs in most cases (44.11 %) were positioned in line with the second premolar long axis. **Conclusion:** According to findings of the present study, the CBCT imaging evaluation is recommended for each patient before the surgical endodontic operation.

Keywords: Cone-Beam Computed Tomography; Endodontic Surgery; Mandible; Premolar

Introduction

The root canal morphology of the first and second premolar teeth is varied and complex (1). A study has shown that 25.5 % of lower premolars had two canals, and 0.5% of the premolars had three root canal systems (2). Another study found that 22% of first premolars had two root canals, and 18% had C-shape anatomy that often appeared in 3 mm and 6 mm of the apex. Besides, apical delta (a single canal divided into 3 or 4 canals at the apical area) was seen in 6% of cases, occurring just in 3mm of the apex (3). According to the complexity and aberrant configuration of the root canal system in the mandibular premolars, these teeth may have a higher rate of root canal treatment failure that indicates a clinical intervention (4, 5). A surgical endodontic retreatment is a reliable approach that eliminates the pathologies from the peri-apex area and provides a consistent seal at the apical end (6). Apicoectomy, due to a lack of proper instruments in the past, was considered the latest strategy for maintaining teeth (7, 8). With the introduction of the microscope, micro-surgery instruments, and biocompatible root-end filling materials, which provide better access and visibility, endodontic microsurgery gives the chance of survival in the challenging teeth positioned near the critical structures (9, 10). Regarding this issue, Huang *et al.,* (11) investigated long term outcomes of endodontic microsurgery and then reported 78.3% and 95.2% success and healing rate, respectively for this treatment.

In the mandible area, the surgical procedures, such as the insertion of dental implants, surgical extraction of tooth

remains, removal of pathologies, and orthognathic bone fixation, are always likely to damage the critical anatomic structures (12). Many studies reported paraesthesia during or after the nonsurgical root canal treatment in the mandibular premolars due to periapical infections and endodontic therapy failures (13, 14). Also, because of the proximity of premolars to critical neurovascular bundles passing through the MF and the mandibular canal, endodontic surgery in the mandibular premolar region can cause postoperative complications, such as pain and temporary or permanent paraesthesia or numbness of the lower lip; therefore, any damage to the area should be avoided (15, 16). For this purpose, having adequate knowledge regarding the MF anatomy, its relation to premolars, adjacent roots dimensions (diameters and shape), and buccal bone thickness (BBT) before any endodontic surgery is imperative (17, 18).

Conventional periapical radiography is two-dimensional (2D) and comprises superimposition of the structures, distortion, and magnification (19). While, with the advancement of CBCT, it has been possible to examine jawbone, the morphology of teeth, and teeth relation to the adjacent anatomical structures three-dimensionally (3D) without any superimposition and distortion (20). CBCT provides 3D accurate information so that the operator can evaluate structures adjacent to the surgical area and precisely measure parameters that may be required during the operation (21-23).

Identification of anatomical averages in different populations owing to the ethnic variations can effectively help the surgeon in preoperative and intraoperative phases improve the prognosis of the surgical treatment. Also, the positions of MF has been reported in different locations (in the mesiodistal and inferosuperior directions) in the different studies (24). In the sagittal plane, the MF position is reported in a wide range from the mesial of the first premolar to the mesial root of the first molar and in the vertical plane could be found very close or even superior to root apices (25).

In previous articles, the parameters related to endodontic surgery of mandibular premolars were not specifically evaluated. Therefore, it was decided to design a study to examine all these parameters specifically in terms of in the mandibular premolars endodontic surgery. In addition, the methodology of the present article was designed in such a way that the parameters evaluated in the study could be equally comparable on the both sides of the mandible. In other words, this study aimed to evaluate the anatomic parameters that directly affect the success rate of endodontic surgery and play a significant role in reducing complications and help for achieve results that are more predictable.

Materials and Methods

The study was approved by the local ethical committee (code I.R.IAU.B.REC.1398.050). From 621 CBCT images taken in the Faculty of Dentistry, Islamic Azad University, Boroujerd, Iran, between 2018 and 2020, 170 images were included for evaluation. Patients with bilateral CBCT images, the presence of both premolars on both sides, good quality of images, and without artifact were included; patients under 18, with congenital deformity in the mandible, periodontal disease or bone loss, presence of primary or impacted teeth, and root resorption were excluded from the study. All CBCT images were obtained using a single machine (Acteon, Whitefox, Olgiate Olona, Italy) and similar protocol (105.00 KVp, 9.00 Ma, 0.3 mm voxel size, 1 mm slice thickness, 2 mm intervals, and load time of 9 seconds); then, they were examined with Whitefox imaging software (Aceton, Whitefox Imaging Software Version 4.0). The images were evaluated in three planes (axial, sagittal, and coronal), and the parameters were measured on a 16-inch monitor (6930, Acer, USA). Two observers examined all graphs. Both observers first investigated 10% of the samples simultaneously to standardize the measurements. Then, to evaluate agreement in linear and nominal measurements, intraclass correlation coefficient (ICC) and kappa tests were applied, respectively. The results exhibited good reproducibility for both measurements of linear (ICC> 0.88.3, P< 0.0001) and nominal (kappa = 1).

Axial view: Determination of the BBT and root diameters

For this purpose, the long axis of the determined tooth was set parallel with the respective plane (Figure 1a and b) in the coronal and sagittal planes. Next, in the sagittal view along with the tooth, a 3 mm line was drawn, and the point was marked (Figure 1c and d); this point was considered in the axial plane. At this point, measurements of BBT, buccolingual, and mesiodistal diameters of each root were completed. For BBT, the thickness of the cortical plate between the exterior surface of the root and the cortical surface was assessed horizontally (Figure 1e). Also, for the buccolingual and mesiodistal dimensions, the widest part of each root was recorded at the 3mm level of apex (Figure 1f).

The summation of BBT thickness and root diameter in the buccolingual direction can determine the amount of tissue needed to be resected.

Coronal view: Determination of MF distance to premolars apex and alveolar crest

For this purpose, in the axial view, the superior border of MF was determined as point X (Figure 2a); this point was located in the coronal plane (Figure 2b). Then, a section was made through the point X and the middle of the determining tooth (Figure 2c). Next, in the coronal view, the apex was determined as point Y (Figure 2d). The distance between these points was then measured (point X and Y) (Figure 2e). Furthermore, the distance between the AC and point X was measured. The MF-AC distance is valuable because it helps the surgeon predict the anteroposterior extension of the flap (26, 27) (Figure 2f).

Sagittal view: Position of MF in relation to adjacent teeth

To achieve this goal, six positions were considered for MF and adjacent roots relationships. Position 1 (anterior to the long axis of the first premolar), position 2 (aligned with the first premolar long axis), position 3 (between the long axis of premolars), position 4 (aligned with the second premolar long axis), position 5 (between the long axis of the second premolar and mesial root of the first molar), and position 6 (in line with the long axis of the first molar mesial root) (27).

All analyses were conducted using SPSS 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used for analyzing the data. Besides, an independent-sample T-test and Wilcoxon test were applied for determining the possible differences between measurements of the right and left sides of the mandible (α=.05).

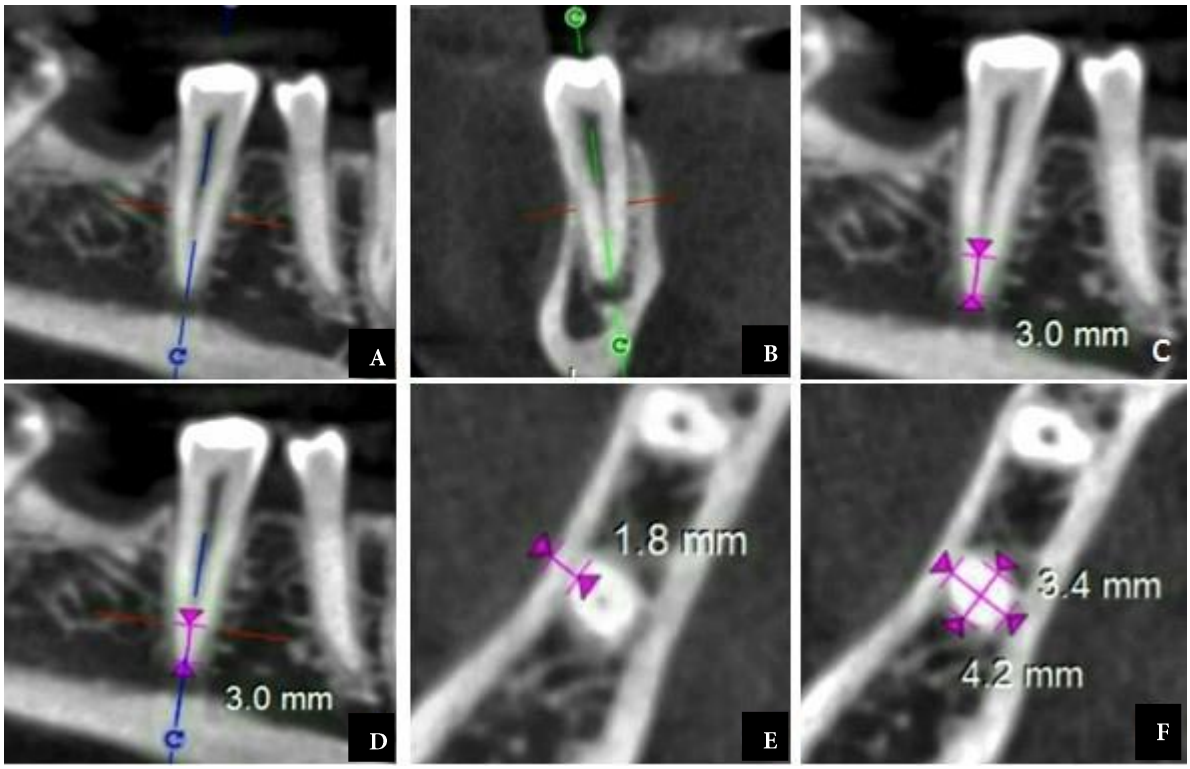

Figure 1. A) A long axis of the tooth was placed parallel with the coronal plane; B) long axis of the tooth was placed parallel with the sagittal plane; C) In the sagittal view, a 3mm line was drawn from the apex in line with tooth long axis; D) Pointer was placed at the marked 3mm level of the apex, and this point was considered in the axial view; **E**) In the axial view, BBT was measured; **F**) The diameter of each root was measured in the buccolingual and mesiodistal dimension

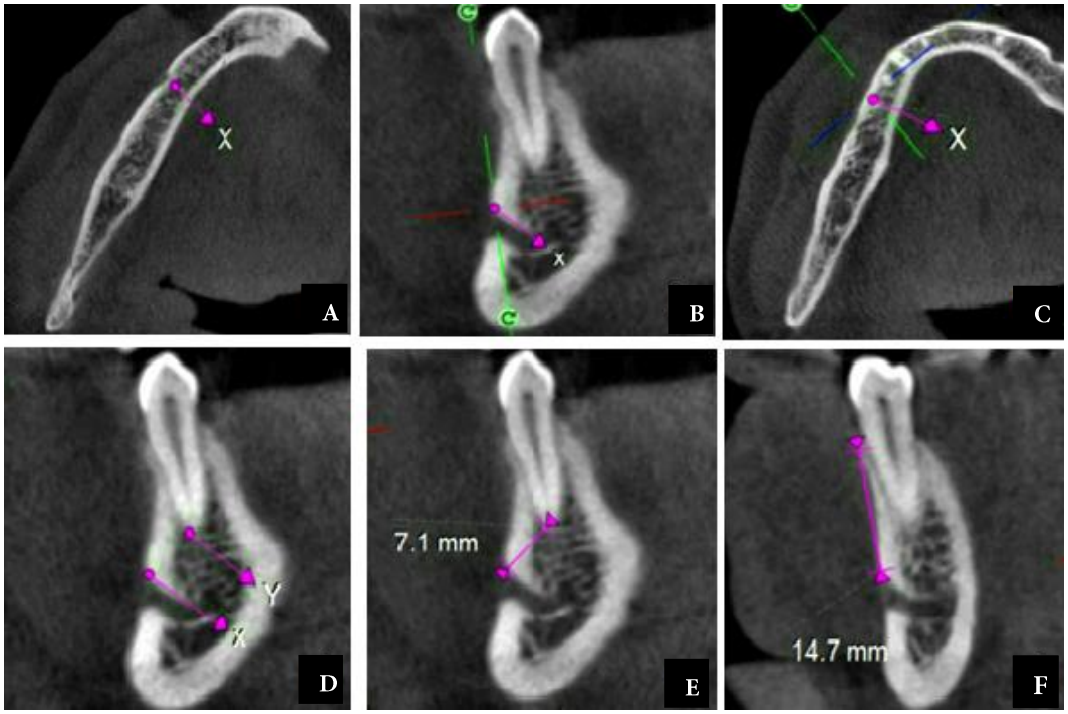

Figure 2. A) In the axial view, the superior border of MF was determined as point X; B) The point X was considered in the coronal view; C) A cross-section was made through the point X and center of the determined tooth; D) The root apex was designated as point Y; **E**) The distance between point X and Y was measured; **F**) The distance between point X and AC was measured in the coronal view

Results

A total of 170 CBCT images, 680 premolar teeth, and 340 MF were evaluated during this study. Of these, 93 (55%) were female, 77 (45%) were male, and the patients were between 18 to 67 years, with the mean age of 43.5 years.

Table 1. Analysis of the BBT covering each of the mandibular premolars

Tooth	Right side	Left side	*P*-value
	BBT Dimension (mm) Mean ± SD (min-max)	BBT Dimension (mm) Mean ± SD (min-max)	
First premolar	1.16 ± 0.68 (0-3.2)	1.19 ± 0.85 (0-3.2)	٠.720
Second premolar	1.55 ± 0.90 (0-4.9)	1.58 ± 0.99 (0-4.2)	٠.770

BBT buccal bone thickness

* independent-sample T-test

Buccal bone thickness

Table 1 shows the BBT in the first and second premolars at the 3 mm level of the apex. The maximum BBT of the first and second premolars were measured 3.2 and 4.9 mm, respectively. The minimum BBT of both first and second premolars were recorded 0 mm.

Table 2. Analysis of the BL and MD dimensions of the mandibular premolars

Tooth	Right side		Left side		*P*-value*	
	BL Dimension (mm) Mean ± SD (min-max)	MD Dimension (mm) Mean ± SD (min-max)	BL Dimension (mm) Mean ± SD (min-max)	MD Dimension (mm) Mean ± SD (min-max)	BL Dimension	MD Dimension
First premolar	4.06 ± 0.72 (2-5.8)	2.85 ± 0.58 (1.6-4.9)	3.99 ± 0.76 (2.2-6.2)	2.79 ± 0.54 (0.5-4.7)	٠.384	٠.324
Second premolar	3.99 ± 0.66 (2.4-5.8)	3.02 ± 0.60 (1.6-4.6)	3.98 ± 0.69 (2.2-5.7)	2.95 ± 0.53 (1.6-4.3)	٠.891	٠.255

BL buccolingual, MD mesiodistal
* independent-sample T-test

Buccolingual and mesiodistal dimension

Table 2 demonstrates the roots thicknesses of the first and second premolars on buccolingual and mesiodistal directions at the 3 mm level of the apex. The maximum and minimum buccolingual dimensions measured 6.2 and 2.2 mm for the first premolar, as well as 5.8 and 2.2 mm for the second premolar. Furthermore, the maximum and minimum mesiodistal dimensions were recorded 4.9 and 0.5 mm for the first premolar, as well as 4.6 and 0.5 mm for the second premolar.

Total amount of tissue needed to be resected

Figure 3 represents the total amount of tissue needed to be resected at the buccal surface during endodontic surgery at the root resection site (3mm of apex). The maximum amounts of resection in the first and second premolars were measured 9.4 and 7.9 mm, respectively. The minimum amounts of resection in the first and second premolars were measured 3.1 and 2.5 mm respectively. Significant differences were showed between the total resection tissue of the first premolar and second premolar (*P*=0.003). No significant differences were found between the mean value of the total resection tissue on the right and left sides of the first premolars (*P*=٠.703) and the second premolars (*P*=0.807).

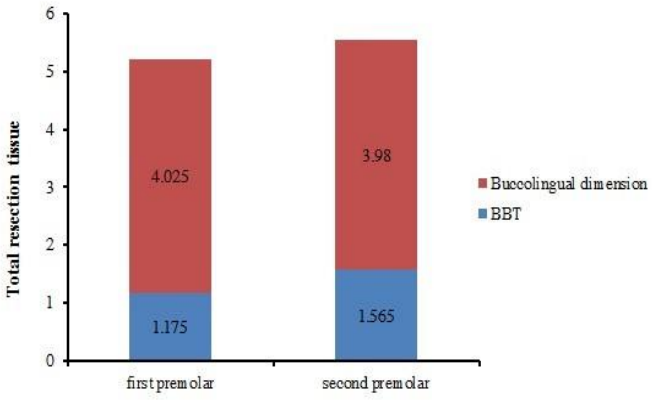

Figure 3. The mean thickness of the tissue needed to be resected during endodontic surgery in mandibular premolars (in millimeters).

Distance between MF and root apices

Table 3 shows the distance between MF superior border and premolars apex. According to results, the maximum distance between MF and the first and second premolars were recorded 12.9 and 9.7 mm, respectively, and the minimum distance between MF and the first and second premolars were recorded 0.8 and 0 mm, respectively. No direct communication was found between MF and the first premolar.

Distance from MF to AC

Table 4 shows the distance between the superior border of MF and AC. Results demonstrated that the maximum and minimum distances were 19 and 7.9 mm, respectively.

Position of MF

Figure 4 demonstrates the distribution of the MFs position to adjacent teeth. Results showed that most of the MFs (44.11%) were placed in line with the long axis of the second premolar (position 4), 37.34% of MFs were positioned between the premolars (position 3), 13.81% of MFs were located between the second premolar and mesial root of the first molar (position 5), and 2,35 %, 1.46%, and 0.87% of the MFs were located in position 6, 2, and 1, respectively.

Table 3. Analysis of the distance between the superior border of the MF and premolars apices

Tooth	Right side		Left side		*P*-value
	Distance to MF (mm) Mean ± SD (min-max)	Direct communication to MF (0mm)	Distance to MF (mm) Mean ± SD (min-max)	Direct communication to MF (0mm)	
First premolar	5.38 ± 2.22 (1.5-12.9)	-	5.12 ± 2.12 (0.8-10.9)	-	٠.270
Second premolar	4.35 ± 1.96 (0-9.7)	N=3	4.15 ± 1.75 (0-8.8)	N=5	٠.322

MF mental foramen

* independent-sample T-test

Table 4. Analysis of the distance between the superior border of MF and AC

Right side	Left side	*P*-value
Distance between MF & AC (mm) Mean ± SD (min-max)	Distance between MF & AC (mm) Mean ± SD (min-max)	0.175
13.62 ± 2.24 (7.9-19)	13.95 ± 2.24 (8.8-19.7)	

MF mental foramen, AC Alveolar crest

* independent-sample T-test

According to the independent-sample T-test, no significant differences were noted between the mean value of BBT, buccolingual and mesiodistal dimensions, and the total amount of root resection for the first and second premolars. Additionally, the distance from MF to adjacent teeth and AC had no significant differences between the right and left side of the mandible. These results demonstrated a good concordance between the mentioned parameters on both sides of the mandible (*P*>٠.05). Also, Wilcoxon tests revealed a good concordance in the position of MF related to adjacent teeth on both sides of the mandible (*P*=0.303).

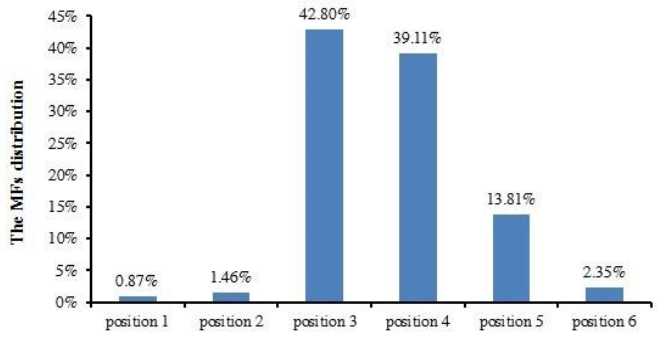

Figure 4. The distribution of the MFs position to adjacent teeth

Discussion

In this radiographic investigation, only bilateral cases with the presence of both premolars in the right and left sides were included. Through this type of case selection, not only the average sizes of a population could be evaluated, but also the concordance of these parameters could be examined. According to results, no significant difference was observed between the right and left side of the mandible (*P*>0.05). Thus, the mean values of the right and left side of the mandible were reported during the present study.

Measurement of BBT and root buccolingual diameter indicated the amount of tissue needed to be resected for endodontic surgery.

The buccal bone thickness

In the present study, the mean value of BBT of first and second premolars was determined by 1.18 mm and 1.57 mm, respectively. Zahedi *et al.,* (28) reported a mean value of 0.86 and 1.23 mm for the first and second premolars, which are very similar to the findings of the present study. Also, Aydin *et al.,* (26), with the same technique, found the BBT of second premolar thicker (2.45 mm) than the first premolar (1.70 mm), which are in agreement with the present study. However, a slight

difference between the results might be attributed to the anatomical variation in different populations. Jin *et al.,* (29) used CT scans for the measurement of BBT and reported the mean value of first and second premolars 3.02 mm and 3.68 mm, respectively. Although the BBT of the second premolar was reported higher than the first premolar, a significant difference was noted in the sizes, which might be attributed to different measurement techniques and reference points of measurements. In the Jin *et al.,* (29) research, measurements were performed from apex of each tooth; however, in the current study, due to endodontic concerns, dimensions were assessed at a 3 mm level of the apex.

Buccolingual and mesiodistal dimension

Due to the majority of anatomic ramifications and lateral canals found in the 3 mm of the apical, for a proper apicoectomy, it is necessary to amputate entire infected tissue to eliminate recontamination possibility (30). Hence, the determination of accurate root dimensions is critical. In the current study, the mean buccolingual dimension (4.02 mm) and mesiodistal dimension (2.82 mm) of the first premolar are similar to the amounts reported in the recently published studies (3.82 and 2.89 mm, respectively) (26), and (3.43 and 2.09 mm, respectively) (28). For the same characters in the second premolar, a mean value of 3.98 mm and 2.98 mm were calculated. These findings are very close to data of similar studies, with a mean of 3.4 mm and 3.75 for the buccolingual dimension and 2.34 mm and 3 mm for the mesiodistal dimension, respectively (26, 28). Tilk *et al.,* (31) assessed the mesiodistal size of 125 extracted first and second premolars in three parts, including coronal, middle, and apical one-third. This assessment reported a mean value of 2.55 and 2.79 mm for the first and second premolars in the apical one-third, respectively, hence supporting the results of the current study.

Total amount of tissue needed to be resected

In the present study, the mean values of the first and second premolars were measured 5.19 and 5.54 mm, respectively. These results are similar to recently published studies (5.50 mm and 6.62 mm, respectively) (26) and (4.29 mm and 4.63 mm, respectively) (28). The data obtained from this analysis not only can effectively help the surgeon in preoperative and intraoperative phases but also by minimizing postoperative complications, makes the surgical outcomes more predictable.

Distance between MF and root apices

In the endodontic surgical treatment, as the root apices are very close to vital structures existing in the MF, this neurovascular bundle should be preserved. In the evaluated images, the nearest tooth to MF was the second premolar with a mean distance of 4.25 mm; following that, the first premolar distance was measured 5.25 mm. Also, in the right and left side of mandible in the 3 and 5 cases, direct communications between MF and the second premolar were noted, which might be a sensitive condition in the apicoectomy procedure. Zahedi *et al.,* (28) reported a mean of 4.62 and 4.81 mm for the distance from MF to the apex of right and left sides of first premolars and 4.23 and 4.32 mm for the second premolars, respectively. These findings are almost similar to the present study results that might be due to a similar population. However, in the report of Zahedi *et al.,* (28), the number of teeth examined on both sides of the mandible was not the same as the present study. Chong *et al.,* (32) assessed the distance of MF to adjacent teeth using 3D software; in the three planes (x, y, z), they reported an average amount of 4.7 and 5.7 mm for first and second premolars, respectively. These data are in contrast with the results of the present study. Aydin *et al.,* (26) found a mean distance of 2.75 mm and 2.74mm for the first and second premolars, which have a significant difference with the present study. The difference might be attributed to different population assessment and measurement techniques used in this study and our investigation. In the present study, the distance between the superior border of the MF was considered as a reference point of measurement. In contrast, in the study of Aydin *et al.,* (33), the nearest point of MF to the tooth in the axial view was considered as the reference point. Moreover, in this study, the closest distance of MF to first and second premolars apices were measured 0 mm, but in the current study, direct communication (0 mm) was not noted with the first premolar apex. Like the previous study, no differences were found in the measurement of this distance on the right and left sides of the mandible (34, 35).

Distance from MF to AC

According to results, on average, MF was located 13.88 ± 2.24 mm below to AC with a wide-ranging from 7.9-19.7 mm. These findings are in agreement with the mean of previous studies ranged from 11.2-14.2 mm (27, 34, 36). No significant difference was observed in this measurement between two sides

(27, 36). This result is also in line with the current study. As the average amount would be influenced by bone loss in the area, some cadaver studies recommended completing the measurement from the cementoenamel junction (37, 38). Moiseiwitsch *et al.,* (37) reported a mean of 16 mm with a range of 8-21mm as a distance between cementoenamel junction and MF.

Position of MF

Khojastepour *et al.,* (12) assessed 156 CBCT images of patients, who had referred to the private maxillofacial radiology clinic in Shiraz, and reported 50.3% of MFs at the apex of the second premolar. In most cases of the present study (44.11%), MFs were located in line with the second premolar, agreeing with the previous study. The slight difference between the two studies may be attributed to separate ethnic origin. Also, most of the cadaver studies reported the MFs frequent position in line with the second premolar with a variety from 50-75% (38-40). In contrast, recent studies reported the common position of MFs, by using the CBCT, between the premolars ranging from 44.4-59.8% (27, 34, 35). According to the results of research conducted by Santini *et al.,* (24), since MFs position may differ in various ethnicities, the determination of exact position should be performed using an appropriate radiographic method before any surgical procedure.

Conclusion

In this CBCT survey, BBT, root diameter on the buccolingual and mesiodistal direction, the total amount of root resection, the position of MF, and its distance to adjacent teeth and upper border of the mandible were assessed. In general, our findings indicated that since all measures in the premolars area are in a millimeter-scale and likewise due to the close proximity of anatomical structures, any minor error during the operation could lead to permanent consequences. Thus, it can be stated that obtaining and assessing the CBCT image for each individual prior to the endodontic surgery is highly recommended.

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Conflict of Interest: 'None declared'.

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