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Root canal morphology of mandibular first molars: Comparison of the diagnostic accuracy of cone-beam computed tomography and the sectioning technique

Mohammad Yazdizadeh[1], Parniyan Alavinezhad[1], Abtin Sadrishahrezaei[1], Sanaz Sharifishoshtari[2]

Departments of [1]Endodontics and [2]Oral and Maxillofacial Radiology, School of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

ABSTRACT

Background: A successful endodontic treatment requires a comprehensive knowledge of the root canal morphology. This study compared the diagnostic accuracy of cone-beam computed tomography (CBCT) and the sectioning technique for the assessment of mandibular first molar (MFM) root canal morphology.
Materials and Methods: In this *in vitro*, experimental study, 48 eligible MFMs were mounted in 12 blocks (groups of 4) made of acrylic resin and sheep bone powder and underwent CBCT. Next, the teeth were mounted in transparent self-cure acrylic blocks, and their roots were sectioned at three points with 3 mm intervals. Images underwent multiplanar reconstruction in NNT Viewer software and were analyzed by one radiologist with the cooperation of an endodontist. The sections were also evaluated by an endodontist under a stereomicroscope (gold standard). The frequency and percentage of single-canal, and two-canal roots were determined by each technique. The agreement between CBCT and the Gold standard was analyzed by calculating the kappa coefficient ($P < 0.05$).
Results: The diagnostic accuracy of CBCT for the assessment of the MFM root canal morphology was 80% on the mesial surface, 99% in the distal surface, and 96% in total. In the mesial surface, 94.2% of two-canal roots and 66.7% of single-canal roots were correctly detected by CBCT. These values were 100% and 97.4% in the distal surface, and 95.2% and 95.8% in total, respectively. A significant agreement was noted between CBCT and the Gold standard with $\kappa = 0.412$ for the mesial, 0.939 for the distal, and 0.907 for the total surfaces ($P < 0.001$).
Conclusion: CBCT can be reliably used for the assessment of the complex root canal morphology of MFMs when other modalities fall short.

Key Words: Cone-beam computed tomography, mandible, molar, tooth root

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Address for correspondence:
Dr. Sanaz Sharifishoshtari, Department of Oral and Maxillofacial Radiology, School of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
E-mail: kooksysan@yahoo.com

INTRODUCTION

A successful endodontic treatment requires a comprehensive knowledge of the root canal morphology.[1] In addition to the general morphology, some irregularities and hard-to-reach areas are also present in the root canal system that need to be cleaned; if left untreated, these areas can lead to reinfection and treatment failure.[2]

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The morphology of the root canal system is highly complex, and a wide range of anatomical variations exist with regard to root canal anatomy.[1] Thus, knowledge about the root canal anatomy is imperative for a successful endodontic treatment.[3] The root canal anatomy is influenced by a number of factors including the racial and geographical parameters, among others.[3]

Mandibular molars often have one mesial and one distal root. Both roots are wider in the buccolingual than the mesiodistal dimension. The mesial root usually has two canals, which may terminate at one or two apical foramina. The distal root often has one wide canal; however, the presence of two canals has also been reported in one-third of the cases.[1] The possibility of the presence of two canals in the distal root of mandibular first molars (MFMs) is approximately 30%.[2] According to the literature, the possibility of the presence of four canals in MFMs was 31.57% in Urmia, Iran,[4] 45% in South China,[5] 46% in Taiwan,[6] and 59% in Sudan.[7]

Several techniques are used to assess the root canal morphology such as the root canal staining and clearing technique, sectioning, conventional and digital radiographic modalities, and more recently, computed tomography (CT) and cone-beam CT (CBCT).[8] These techniques have different levels of accuracy and complexity and not of all them can be used in the clinical setting, because some of them require destruction of specimens or prevent the use of instruments in the root canal system.[9]

CBCT is a relatively novel technology for maxillofacial imaging, which reportedly has adequate accuracy for the assessment of root canal anatomy.[10-12] CBCT images of root morphology have higher resolution than the CT scans.[11] CBCT has the advantages of higher resolution and lower patient radiation dose than the conventional CT and provides three-dimensional (3D) images of the teeth and their supporting structures, maxilla, mandible, facial skeleton, internal ear, temporomandibular joint, and base of the skull in axial, coronal, and sagittal sections. Despite the advantages of CBCT, it has some limitations with respect to imaging geometry, sensitivity of the detector, contrast, and resolution. Thus, CBCT is often used as a supplement rather than an alternative to panoramic or other conventional radiographic modalities.[13]

Comprehensive knowledge about the root canal anatomy and morphology is important for optimal long-term prognosis of endodontic treatment, and can save time and cost, and result in greater patient satisfaction, and comfort of dental clinician. Furthermore, it is important to assess the root canal morphology in different populations.

Since the anatomical variations of mandibular molars have been less commonly addressed in the literature, compared with maxillary molars, this study aimed to compare the accuracy of CBCT and the sectioning technique for the assessment of the anatomy and morphology of permanent MFMs.

MATERIALS AND METHODS

This *in vitro* experimental study was conducted on 48 MFMs extracted due to poor periodontal prognosis. The study protocol was approved by the Research Ethics Committees of Ahvaz Jundishapur University of Medical Sciences (IR.AJUMS.REC.1397.272). The sample size was calculated to be 48 assuming 95% confidence interval to be 1.96, $P = 0.97$, and d (accuracy) = 0.04.

The teeth had sound roots and closed apices, and were stored in 100% humidity at room temperature during the study. They were mounted in 12 blocks in groups of 4 to the level of their cementoenamel junction. The blocks were made of cold-cure acrylic resin (Marlic Co., Tehran, Iran) and sheep bone powder to simulate the dental arch.

The teeth then underwent CBCT in a NewTom CBCT scanner (Verona, Italy) with the exposure settings of 84 kVp, 63.60 mAs, 5.4 s time, and 8 mm × 8 mm field of view.

For clinical sectioning (Gold standard), each tooth was mounted in transparent self-cure acrylic resin blocks (Dentsply, England). The mesial and distal roots of each tooth were separated from each other; then, each mesial and distal root was cervicoapically divided into three separate sections, including cervical, mid-root and apical, at approximately equal distances with 3 mm intervals. Each section was examined as a study unit under the stereomicroscopy (M400, Wild Heerbrugg, Switzerland) to count the number of canals; Therefore, for each mesial and distal root, 48 multiplied by 3, i.e., 144 sections were studied. The CBCT images were stored in NNT Viewer software (version 8, NewTom, Verona, Italy) and assessed following multiplanar reconstruction. The CBCT images were independently evaluated by one radiologist with the cooperation of an endodontist. They were observed on a 17-inch monitor (LG Corporation, South Korea) with 1024 × 1280-pixel resolution in a dark room. The brightness and contrast of images were adjusted for optimal observation. The sections were also evaluated under a stereomicroscope by an endodontist to assess the root canal morphology (Gold standard).

Data were analyzed using SPSS version 25 (SPSS Inc., Chicago, IL, USA). The frequency and percentage of roots with one and two canals were recorded by using CBCT and the Gold standard. In addition, the agreement between the CBCT and the Gold standard was evaluated by calculating the kappa coefficient.

RESULTS

The findings of the current manuscript are presented in three tables. Table 1 presents the diagnostic accuracy of CBCT for the assessment of the root canal morphology of MFMs in the mesial surface. As shown, the diagnostic accuracy of CBCT for the assessment of the MFM root canal morphology in the mesial surface was 0.80. In other words, it correctly diagnosed 80% of the cases, compared with the Gold standard.

The kappa coefficient indicated significant relative agreement of CBCT with the Gold standard in the assessment of the mesial surface of MFM root canals ($P < 0.001$, $\kappa = 0.412$).

Table 2 presents the diagnostic accuracy of CBCT for the assessment of the root canal morphology of MFMs in the distal surface. As indicated, the diagnostic accuracy of CBCT for the assessment of the MFM root canal morphology in the distal surface was 0.99. In other words, it correctly diagnosed 99% of the cases, compared with the Gold standard. The kappa coefficient indicated significantly high agreement of CBCT with the Gold standard in the assessment of the distal surface of MFM root canals ($P < 0.001$, $\kappa = 0.939$).

Table 3 presents the diagnostic accuracy of CBCT for the assessment of the root canal morphology of MFMs in general. As shown, the accuracy of CBCT for the assessment of the root canal morphology of MFMs was 0.96. In other words, it correctly diagnosed 96% of the cases, compared with the Gold standard. The kappa coefficient indicated significantly high agreement of CBCT with the Gold standard in the assessment of the MFM root canal morphology ($P < 0.001$, $\kappa = 0.907$).

Table 1: Diagnostic accuracy of cone-beam computed tomography for the assessment of the root canal morphology of mandibular first molars in the mesial surface

Diagnosis CBCT	Gold standard		Total, *n* (%)	Accuracy
	One canal, *n* (%)	Two canals, *n* (%)		
One canal	4 (66.7)	8 (5.8)	12 (8.3)	0.80
Two canals	2 (33.3)	130 (94.2)	132 (91.7)	
Total	6 (100.0)	138 (100.0)	144 (100.0)	

CBCT: Cone-beam computed tomography

Table 2: Diagnostic accuracy of cone-beam computed tomography for the assessment of the root canal morphology of mandibular first molars in the distal surface

Diagnosis CBCT	Gold standard		Total, *n* (%)	Accuracy
	One canal, *n* (%)	Two canals, *n* (%)		
One canal	111 (97.4)	0	111 (77.1)	0.99
Two canals	3 (2.6)	30 (100.0)	33 (22.9)	
Total	114 (100.0)	30 (100.0)	144 (100.0)	

CBCT: Cone-beam computed tomography

Table 3: Diagnostic accuracy of cone-beam computed tomography for the assessment of the root canal morphology of mandibular first molars in general

Diagnosis CBCT	Gold standard		Total, *n* (%)	Accuracy
	One canal, *n* (%)	Two canals, *n* (%)		
One canal	115 (95.8)	8 (4.8)	123 (42.7)	0.96
Two canals	5 (4.2)	160 (95.2)	165 (57.3)	
Total	120 (100.0)	168 (100.0)	288 (100.0)	

CBCT: Cone-beam computed tomography

DISCUSSION

Considering the variations in the number and morphology of root canals of permanent teeth,[3] this study aimed to compare the accuracy of CBCT and the sectioning technique for the assessment of the anatomy and morphology of permanent MFMs. The results showed that the diagnostic accuracy of CBCT for the assessment of the root canal morphology of MFMs was 80% in the mesial surface, 99% in the distal surface, and 96% in total, indicating high diagnostic accuracy of CBCT for the assessment of MFM root canal morphology. Torres *et al.*[14] evaluated the root canal morphology of mandibular molars by CBCT in Belgian and Chilean populations. They concluded that CBCT images can help endodontists in precise diagnosis and appropriate endodontic treatment planning. Their results were in line with the present findings. Baratto Filho *et al*.[15] evaluated the internal morphology of maxillary first molars microscopically, clinically, and radiographically by CBCT. They concluded that the microscopic and CBCT assessments had high reliability in detection of root canals, and CBCT can be used as a reliable imaging modality for the primary assessment of the internal morphology of maxillary first molars. Their results were in line with the present findings. Blattner *et al*.[12] used CBCT for identification of the second mesiobuccal canal of maxillary first and second molars. They showed that CBCT correctly detected the presence/absence of the second mesiobuccal canal in 78.95% of the cases, and had no significant difference with the Gold standard (sectioning technique) in this respect. Similar to the present study, they showed that CBCT is a reliable technique for detection of the mesiobuccal canals and yields results comparable to the Gold standard (physical sectioning). Michetti *et al*.[16] evaluated the reliability of CBCT for anatomical negotiation of the root canal system. They found a significant correlation between the CBCT findings and histological analysis of the sections. Kim *et al*.[17] evaluated the morphology of MFMs using CBCT in a Korean population and concluded that CBCT is reliable for the assessment of root canal morphology.

The high reliability of CBCT for the assessment of MFM morphology was also confirmed in the present study. In the mesial surface, 94.2% of two-canal roots and 66.7% of single-canal roots were correctly diagnosed by CBCT. These values were 100% and 97.4%, respectively in the distal surface, and 95.2% and 95.8%, respectively, in total. These findings indicate the optimal diagnostic accuracy of CBCT for the assessment of MFM root canal morphology.

Variations in the results of studies can be due to the different Gold standard techniques, differences in sample size and CBCT scanners, and different levels of experiences of the observers.[8] CBCT can provide high-resolution images in different spatial planes without superimposition of the adjacent structures. It is noninvasive, enables 3D image reconstruction, and has lower patient radiation dose than the conventional CT, and precise geometry due to the isotropic nature of voxels.[18,19] Matherne *et al*.[20] compared CBCT as the Gold standard with digital radiography and showed that CBCT detected a higher number of root canals than digital radiography. These results indicate optimally high diagnostic accuracy of CBCT for detection of root canals in endodontic treatment. Zhang *et al*.[21] stated that CBCT is effective for detection of mesiobuccal canals of maxillary first and second molars.

It should be noted that the observers and their clinical experience level play a role in the results of morphological assessments. Endodontists are probably more acquainted with the root canal morphology, and the results of their observations may be in greater agreement with the Gold standard. Radiologists may have limited expertise in identification of complexities of the root canals unless they acquire greater experience in this field.[22,23]

Image resolution and diagnostic quality depend on the radiographic density, contrast, sharpness, resolution, object density, and type of image receptor.[24] Despite the high diagnostic accuracy of CBCT for the detection of root canal morphology, it should not be routinely used for this purpose since it has a higher patient radiation dose than the conventional imaging modalities. Therefore, CBCT is not indicated in cases where periapical radiography can serve the purpose. However, in cases of abnormal findings on periapical radiographs or clinical examination (where conventional imaging falls short), CBCT may be requested to obtain more accurate results.[10,25-27]

In the present study, clinical sectioning served as the Gold standard. Although some calcifications similar to dentinal bridge may be present in the canals, these calcifications are considered as a canal only when CBCT can differentiate between them and dentinal bridge. CBCT has several applications for the assessment of the internal and external morphology of the root canal system.[28-30] Reuben *et al*.[31] showed a high diagnostic accuracy of CBCT comparable to that of clearing and staining technique for identification of root canal morphology. Rodrigues *et al*.[32] evaluated the anatomy of MFMs in a Brazilian population using CBCT. They found that almost all distal roots had one root canal, which was higher than the rate obtained in the present study (79.2%). Nur *et al*.[33] assessed the root canal morphology of permanent mandibular first and second molars in a Turkish population using CBCT and showed that the mesial roots mainly had more than one canal. Chen *et al*.[6] assessed the root canal morphology of MFMs in a Chinese population and found that 97% of the MFMs had two mesial canals and 46% of them had two distal canals. Variations in the results of the abovementioned studies and the current study may be related to different parameters. Race is an influential factor in this respect.[34] Sert and Bayirli[35] reported that both gender and race should be taken into account in preoperative assessments of the root canal system. Since the current study was conducted on extracted teeth, the age of patients could not be taken into account.

Significant relative agreement was noted between CBCT and the Gold standard with $\kappa = 0.412$ for the mesial, 0.939 for the distal, and 0.907 for the total surfaces ($P < 0.001$). The calculation of the kappa coefficient is a well-accepted technique for qualitative and ordinal assessments.[36] In the present study, all CBCT images were evaluated on the same monitor although evidence shows that the performance of the observer is irrespective of the characteristics of the monitor.[37]

This study had an *in vitro* design. Despite the attempts to simulate the clinical environment by mounting the teeth in blocks made of acrylic resin and sheep bone powder, the actual bone and the surrounding soft tissue can never be accurately simulated *in vitro*. Furthermore, radiographic diagnosis depends on the experience of the observer. Thus, many factors can affect the interpretation of images. Despite the use of the Gold standard in studies conducted *in vitro*, it should be noted that there is no Gold standard in the clinical setting. Moreover, it should be kept in mind that the teeth are fixed during radiography *in vitro*. However, scanning takes 20–40 s and the patients may slightly move during this period in the clinical setting, adversely affecting the sharpness of images, but the difference in distances is insignificant according to recent studies.[38,39] All these parameters should be taken into an account when generalizing the *in vitro* results to the clinical setting.

Future studies are required to ask different groups of the observers such as radiologists and endodontists to interpret the CBCT images regarding the morphology of the root canal system of different teeth. In addition, different exposure settings of CBCT scanners should be compared to find the best protocol for accurate assessment of the root canal morphology of different teeth.

CONCLUSION

The current results supported the optimal diagnostic accuracy of CBCT for the assessment of the root canal morphology of MFMs. Thus, CBCT can be used as a reliable technique for the assessment of the complexities of MFM root canals whenever the conventional radiographic modalities fall short.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

REFERENCES

1. Ingle J, Backland L, Baumgarthner J, Cleghorn B, Goodacre C, Christie W. Morphology of teeth and their root canal system. Hamilton, Ontario, BC Decher. 2008:202-10.
2. Walton RE, Vertucci FJ. Internal anatomy. In: Torabinejad M, editor. Endodontics: Principles and Practice. 4th ed. China: WB Saunders Elsevier; 2009. p. 243.
3. Cohen S, Burns RC. Pathways of the pulp 8th ed St. Louis CV Mosby Co St Louis Misso. 2002;64146.
4. Shahi S, Yavari HR, Rahimi S, Torkamani R. Root canal morphology of human mandibular first permanent molars in an Iranian population. J Dent Res Dent Clin Dent Prospects 2008;2:20-3.
5. Walker RT. Root form and canal anatomy of mandibular first molars in a Southern Chinese population. Endod Dent Traumatol 1988;4:19-22.
6. Chen G, Yao H, Tong C. Investigation of the root canal configuration of mandibular first molars in a Taiwan Chinese population. Int Endod J 2009;42:1044-9.
7. Ahmed HA, Abu-Bakr NH, Yahia NA, Ibrahim YE. Root and canal morphology of permanent mandibular molars in a Sudanese population. Int Endod J 2007;40:766-71.
8. Neelakantan P, Subbarao C, Subbarao CV. Comparative evaluation of modified canal staining and clearing technique, cone-beam computed tomography, peripheral quantitative computed tomography, spiral computed tomography, and plain and contrast medium-enhanced digital radiography in studying root canal morphology. J Endod 2010;36:1547-51.
9. Naoum HJ, Love RM, Chandler NP, Herbison P. Effect of

X-ray beam angulation and intraradicular contrast medium on radiographic interpretation of lower first molar root canal anatomy. Int Endod J 2003;36:12-9.
10. Kottoor J, Velmurugan N, Sudha R, Hemamalathi S. Maxillary first molar with seven root canals diagnosed with cone-beam computed tomography scanning: A case report. J Endod 2010;36:915-21.
11. Neelakantan P, Subbarao C, Ahuja R, Subbarao CV, Gutmann JL. Cone-beam computed tomography study of root and canal morphology of maxillary first and second molars in an Indian population. J Endod 2010;36:1622-7.
12. Blattner TC, George N, Lee CC, Kumar V, Yelton CD. Efficacy of cone-beam computed tomography as a modality to accurately identify the presence of second mesiobuccal canals in maxillary first and second molars: A pilot study. J Endod 2010;36:867-70.
13. Mirzaie M, Torkzaban P, Mohammadi V. Cone-beam computed tomography study of root canals in a Hamadani population in Iran. AJDR 2012;4:25-31.
14. Torres A, Jacobs R, Lambrechts P, Brizuela C, Cabrera C, Concha G, *et al.* Characterization of mandibular molar root and canal morphology using cone beam computed tomography and its variability in Belgian and Chilean population samples. Imaging Sci Dent 2015;45:95-101.
15. Baratto Filho F, Zaitter S, Haragushiku GA, de Campos EA, Abuabara A, Correr GM. Analysis of the internal anatomy of maxillary first molars by using different methods. J Endod 2009;35:337-42.
16. Michetti J, Maret D, Mallet JP, Diemer F. Validation of cone beam computed tomography as a tool to explore root canal anatomy. J Endod 2010;36:1187-90.
17. Kim SY, Kim BS, Woo J, Kim Y. Morphology of mandibular first molars analyzed by cone-beam computed tomography in a Korean population: Variations in the number of roots and canals. J Endod 2013;39:1516-21.
18. Patel S, Horner K. The use of cone beam computed tomography in endodontics. Int Endod J 2009;42:755-6.
19. Peters OA, Laib A, Rüegsegger P, Barbakow F. Three-dimensional analysis of root canal geometry by high-resolution computed tomography. J Dent Res 2000;79:1405-9.
20. Matherne RP, Angelopoulos C, Kulild JC, Tira D. Use of cone-beam computed tomography to identify root canal systems *in vitro*. J Endod 2008;34:87-9.
21. Zhang R, Yang H, Yu X, Wang H, Hu T, Dummer PM. Use of CBCT to identify the morphology of maxillary permanent molar teeth in a Chinese subpopulation. Int Endod J 2011;44:162-9.
22. Omer OE, Al Shalabi RM, Jennings M, Glennon J, Claffey NM. A comparison between clearing and radiographic techniques in the study of the root-canal anatomy of maxillary first and second molars. Int Endod J 2004;37:291-6.
23. Wu DM, Wu YN, Guo W, Sameer S. Accuracy of direct digital radiography in the study of the root canal type. Dentomaxillofac Radiol 2006;35:263-5.
24. PW G. White oral radiology principles and interpretation St. Louis. Mosby. 1987.
25. Lofthag-Hansen S, Huumonen S, Gröndahl K, Gröndahl HG. Limited cone-beam CT and intraoral radiography for the diagnosis of periapical pathology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:114-9.
26. Patel S, Dawood A. The use of cone beam computed tomography in the management of external cervical resorption lesions. Int Endod J 2007;40:730-7.
27. La SH, Jung DH, Kim EC, Min KS. Identification of independent middle mesial canal in mandibular first molar using cone-beam computed tomography imaging. J Endod 2010;36:542-5.
28. Yang H, Tian C, Li G, Yang L, Han X, Wang Y. A cone-beam computed tomography study of the root canal morphology of mandibular first premolars and the location of root canal orifices and apical foramina in a Chinese subpopulation. J Endod 2013;39:435-8.
29. Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic applications of cone-beam volumetric tomography. J Endod 2007;33:1121-32.
30. Scarfe WC, Levin MD, Gane D, Farman AG. Use of cone beam computed tomography in endodontics. Int J Dent 2009;2009:634567.
31. Reuben J, Velmurugan N, Kandaswamy D. The evaluation of root canal morphology of the mandibular first molar in an Indian population using spiral computed tomography scan: An *in vitro* study. J Endod 2008;34:212-5.
32. Rodrigues CT, Oliveira-Santos C, Bernardineli N, Duarte MA, Bramante CM, Minotti-Bonfante PG, *et al.* Prevalence and morphometric analysis of three-rooted mandibular first molars in a Brazilian subpopulation. J Appl Oral Sci 2016;24:535-42.
33. Nur BG, Ok E, Altunsoy M, Aglarci OS, Colak M, Gungor E. Evaluation of the root and canal morphology of mandibular permanent molars in a South-Eastern Turkish population using cone-beam computed tomography. Eur J Dent 2014;8:154-9.
34. Cleghorn BM, Christie WH, Dong CC. Root and root canal morphology of the human permanent maxillary first molar: A literature review. J Endod 2006;32:813-21.
35. Sert S, Bayirli GS. Evaluation of the root canal configurations of the mandibular and maxillary permanent teeth by gender in the Turkish population. J Endod 2004;30:391-8.
36. Thomsen NO, Olsen LH, Nielsen ST. Kappa statistics in the assessment of observer variation: The significance of multiple observers classifying ankle fractures. J Orthop Sci 2002;7:163-6.
37. Cederberg RA, Frederiksen NL, Benson BW, Shulman JD. Influence of the digital image display monitor on observer performance. Dentomaxillofac Radiol 1999;28:203-7.
38. Bauman R, Scarfe W, Clark S, Morelli J, Scheetz J, Farman A. *Ex vivo* detection of mesiobuccal canals in maxillary molars using CBCT at four different isotropic voxel dimensions. Int Endod J 2011;44:752-8.
39. Mahmoudinezhad SS, AryanKia A, Shooshtari SS, Moradi K. The effect of mandibular angulation on preoperative assessment of dental implant insertion at premolar region: CBCT study. Biomed Res Int 2022;2022:7879239.