THE INCIDENCE OF THE SECOND MESIOBUCCAL CANAL OF MAXILLARY FIRST MOLAR AMONG LIBYAN SUBPOPULATION: A MICRO-CT STUDY

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ABSTRACT

The objective of the present *ex-vito* study was to investigate the incidence of the presence of second mesiobuccal canal (MB2) of maxillary first permanent molar collected from Libyan population using micro-computed tomography (Micro-CT 1027) and to classify the root canal variation according to vertucci classification. One-hundred twenty extracted intact human maxillary first molars were selected and prepared for Micro-tomographic analysis with skyScan 1072 (SkyScan, Kontich, Belgium) from different private dental clinics. Three-dimensional images were produced and analysed by reconstruction software to verify the incidence of MB2 canal. Overall, 79% of the studied sample showed the presence of MB2 and 20% with one mesiobuccal canal. Only one tooth presented with three mesiobuccal canal. Type IV and II were the most common canal variation which represent 39% and 29% of the studied sample respectively. It was concluded that the incidence of second mesiobuccal canal in the mesiobuccal root of permanent maxillary first molars was high among the Libyan population which is of great importance clinically. The record obtained from this study provides an evidence that help in management of MB2, consequently increase the success rate.

KEYWORDS: Maxillary first molar, Micro-CT, Mesiobuccal root, Libyan population.

INTRODUCTION

Information about canal morphology and its frequent variation is a fundamental prerequisite for endodontic treatment. The European Society of Endodontology stated that the through cleaning and shaping of all pulp spaces and its complete filling with inert filling material as the main objective of endodontic treatment [1].

It is commonly believed that a main reason of root canal treatment failure is an inability to identify and consequently adequately treat all canals of the root canal system [2-5]. Hence, it is very important for the clinician to have precise information of root canal morphology while performing all sorts of endodontic treatment. The maxillary first molar exhibits complex anatomy within its root canal system. Its complexity was first noted by Hess and Zurcher [6]. Later, Weine [2] discovered the different canal classification and from that time, maxillary

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first molar is a focus of many research papers. This complexity is often responsible for the high rate of endodontic failure [7]. The later relates to the presence of MB2 which has been the subject of number of investigations[8].

Challenges always exist with regards to identifying and locating the MB2 canal. Many authors have utilised different methods (clearing, sectioning, radiography, magnification) to find out the number of canals[8]. Other studies had utilised the three-dimensional (3D) imaging systems such as CBCT [9-13] and Micro-CT to identify the presence or absence of MB2 canal[14-17]. The advent of three-dimensional (3D) imaging has offered the practitioners with increased insight into tooth morphology and facilitated the manipulation and enhancement of interactive image. The later is of great importance in visualisation of the area of interest. It also offers a non-invasive and non-destructive approach which make it possible to reproducible method for three-dimensional (3D) evaluation of root canal systems[14,15,17]. Micro-CT employed studies overcome the shortcoming of earlier morphological techniques beside the internal anatomy of teeth could be reconstructed and observed from various angles[15]. There have been limited published researches that have investigated the morphology of the mesiobuccal root of the maxillary first molar using Micro-CT [14-17] showing the viability of the method.

A number of studies[16,18-31] have reported variation in root canal systems owing to racial variance. To date there are no reports on the incidence of MB2 canals among the Libyan population. Hence, the purpose of this in-vitro study was to investigate the incidence of MB2 canal in maxillary first molar using micro-computed tomography and to classify the root canal variation according to vertucci classification.

MATERIALS AND METHODS:

Teeth selection and preparation

The sample teeth comprised of 120 mature maxillary first molars extracted from Libyan patients attending different dental practices in Libya. The teeth were chosen according to the following inclusion and exclusion criteria:

The inclusion criteria

- The tooth was a first molar on the account of it's crown and root morphology.

- The root apices were fully formed on the account of examination by dental operating microscope.

The exclusion criteria

- The tooth had a previous endodontic treatment.

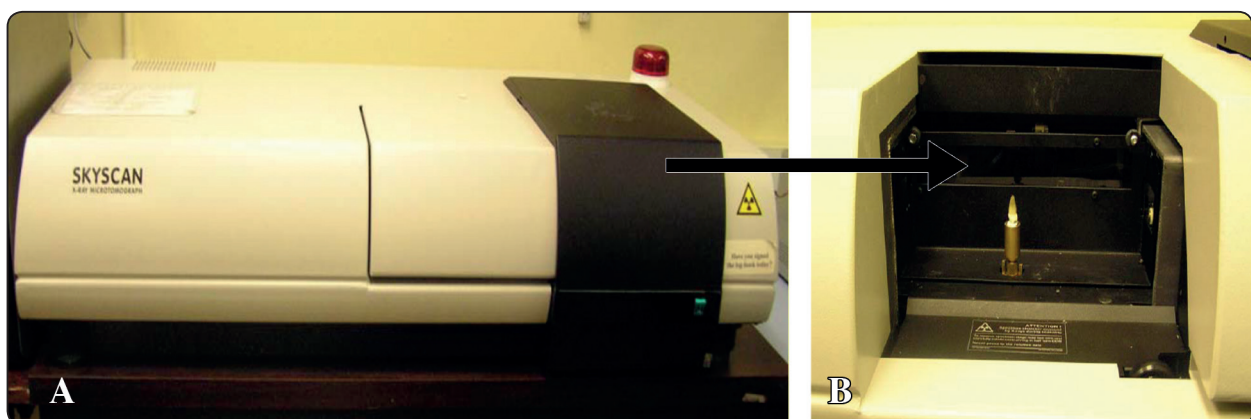- The tooth had a gross decay cavity extending to the mesiobuccal root.

Fig. (1) a) Micro CT 1027,   b) Tooth mounting

■ The tooth had a fractured mesiobuccal root.

Scanning

Each tooth mounted and scanned using skyScan Micro-CT 1027 (SkyScan, Kontich, Belgium) (Fig. 1a &1b) at a slice thickness of 11.6 lm. Three-dimensional images were produced and analysed to record the number of the canals in the mesiobuccal root.

The following parameters were implemented to produce high quality images using Micro-CT acquisition software. The transitional X-ray image was set for 180 degrees of rotation. The system operated at 98μA. The resultant images were fed into TV viewer, which gave 3D consecutive images (Fig. 2).

Fig. (2) 3D of maxillary first molar

These were consequently loaded into attached NRecon reconstruction software, where cross-sectional images were produced as 16 bit bitmap images. The images were produced for all 120 specimens. The following reconstruction parameters were used: Beam hardening: 5; Ring artefact reduction: 13; maximal threshold value: 0.1449; Minimums threshold value: 0.0218; Number of slices: 73. The reconstructed images (Fig. 3 a, b, c) obtained from the NRecon software were analysed by a single observer. The number of mesiobuccal canals was recorded.

After teeth scanning and reconstruction, the root canal systems were classified according to the scheme devised by Vertucci (1984) (Fig. 4) as follows:

Type I. A single root canal extending from the pulp chamber to the apex.

Type II. Separate root canals leave the pulp chamber and join short of the apex to form one canal.

Type III. One root canal leaves the pulp chamber before dividing into two within the root and then merges to exit as one single canal.

Type IV. Two separate root canals extend from the pulp chamber to the apex.

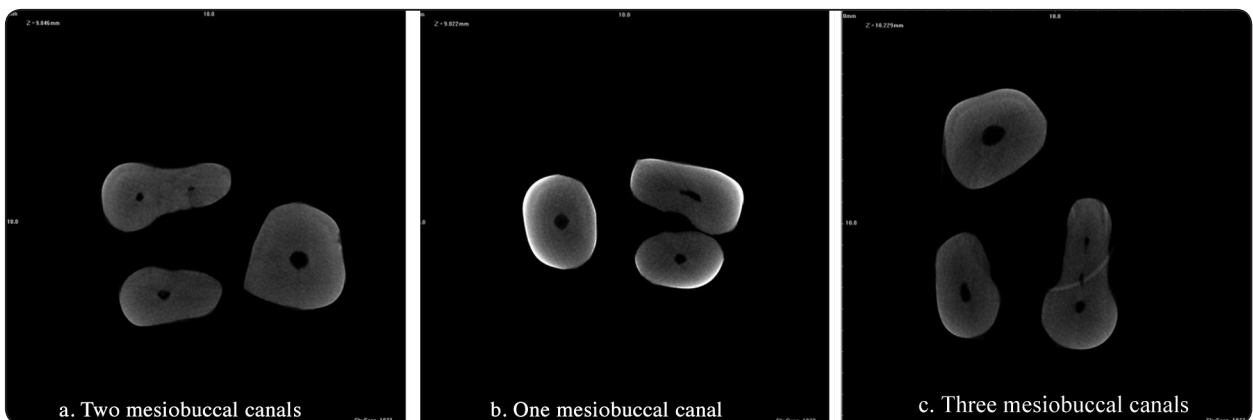Type V. One root canal leaves the pulp chamber

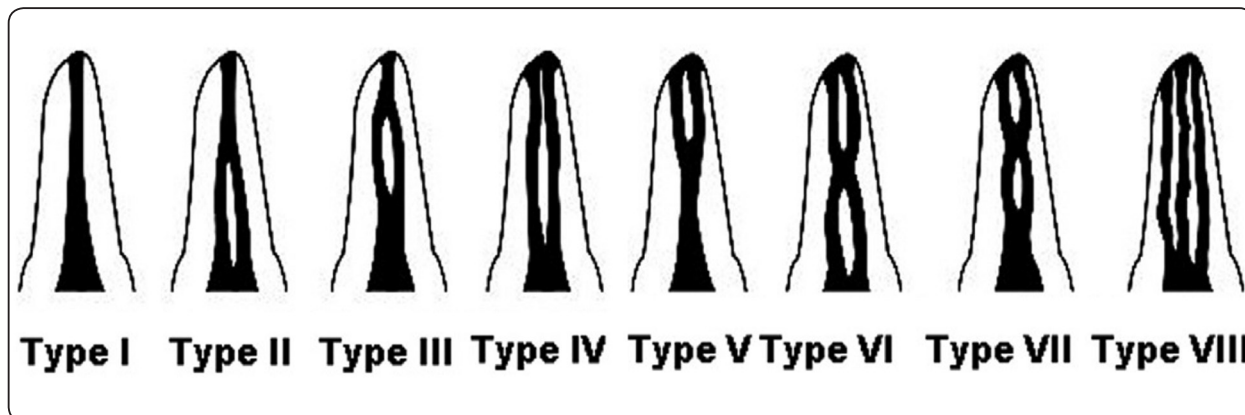Fig. (3) [a,b and c] Reconstructed images of maxillary first molars

Fig. (4) Vertucci classification of the root canal system

and divides short of the apex into two separate and distinct root canals with separate apical foramina.

Type VI. Two separate root canals leave the pulp chamber, merge in the body of the root, and again divide short of the root apex to exit as two separate and distinct canals.

Type VII. One root canal leaves the pulp chamber, divides and rejoins within the body of the root canal and finally redivides into two distinct canals short of the apex.

Type VIII. Three separate and distinct root canals extend from the pulp chamber to the apex.

RESULTS

All the maxillary first molars had three separate roots. Of 120 maxillary permanent first molar teeth studied, 95 (79%) presented with MB2 (Fig. 3a), 24 (20%) showed only one mesiobuccal canal (Fig. 3b). One tooth was found to have three canals in

the mesiobuccal root (Fig. 3c). The percentage distribution of canals in mesiobuccal root is summarised in table 1.

TABLE (1) Number and percentage of canals in mesiobuccal roots

Mesiobuccal root	Number	Percentage
MB1	24	20%
MB2	95	79%
MB3	1	1%
Total	120	100%

Of 120 maxillary first permanent molar teeth studied, the mesial roots with a single canal were of type I and V configuration. Those with two canals were of type II, IV or VI. No type III, VII or VIII canal configurations were found in the roots of these teeth. The number and percentage distribution of canal variation are summarised in Table2..

TABLE (2) Configuration of root canal system

VC	I	II	III	IV	V	VI	VII	V III	Total
Number and Percentages	20 (16.6%)	35 (29%)	0 (0%)	47 (39%)	11 (9%)	7 (6%)	0 (0%)	0 (0%)	120 (100%)

VC: Vertucci classification

DISCUSSION

Wrong assumption regarding the root canal anatomy of teeth might lead to improper root canal preparation, step formation, perforation, transportation and instrument separation[24]. The mesiobuccal root of the maxillary first molar has generated more research and clinical investigation than any other root [8].

A review of literature on the root and root canal morphology of the permanent maxillary first molar demonstrate a broad review of the laboratory and clinical studies published on the anatomy of roots and root canal systems of this tooth[8]. The later reported a wide range of the prevalence of the second mesiobuccal canal of the maxillary first molar. The incidence of MB2 ranges from 18.6%[32] to 96%[33]. It could be argued that the variation of the incidence of MB2 canal may be attributed to various methods employed to identify the extra canal (radiography, sectioning, staining and root clearing) or to the lack of use of magnification (loupes, surgical operating microscope) in clinical studies. In recent years, the development of micro-computed Tomography (MCT) has acquired an increasing significance in the study of tooth structures[14,34,35]. Recently, Domark et al [36] compared the digital radiography and cone-beam and micro-computed tomography. They found that Micro-CT mesiobuccal canal counts were significantly differ from digital periapical radiograph counts but not differ from CBCT counts. They also reported the presence of second mesiobuccal canals in all studied maxillary first molar (100%).

In this study, one hundred twenty extracted maxillary first molars were used. As in common with other studies using extracted teeth, the sample must be regarded as biased because it is not a random selection and consequently may not be representative of the overall population. In the current study the presence of the MB2 canal in the sample of this study was validated by using SkyScan 1027 Micro-CT. This MCT system allowed a clear visualisation of the three-dimensional root canal morphology without sample preparation or using chemical fixation. By using MCT, it was also feasible to achieve a spatial resolution of 5μm corresponding to near 1×10^{-7} Cubic mm voxel size for the resultant image. The later allowed the reconstruction of the internal structure of the root canal and subsequently analyse it fully without destroying its anatomical appearance [37].

The results of the current study on a Libyan population demonstrated a high prevalence of two canals in the mesiobuccal root (79%) of permanent maxillary molar teeth, supporting the view that three roots and four canals are the most common form in fully developed teeth [8]. In addition, the finding of the current study is comparable to the determined prevalence of MB2 canals obtained from many studies carried out on different sub-population; Italian population [80%][14], Indonesian population [68.5%][38] and Korean population [72%][10]. Similarly, Grande et al[17] reported that two canals were present in 80% of mesiobuccal roots of maxillary first molar. Other laboratory studies also reported comparable results [39-44]. Conversely, Singh and Pawar [45] found that the majority of maxillary first molar [69%] had only one mesiobuccal canal. The variation in incidence of MB2 or canal configurations may be owing to the study design, method of canal identification, or to true differences in the sample under investigation according to racial origin [23,46,47].

The high incidence of MB2 canals along with the immense difficulty of identifying those canals should have a great impact on the endodontic treatment. It is extremely significant that practitioners make all effort to locate and negotiate the MB2 canals. Failure of MB2 identification usually end with treatment failure.

While Weine[2] classified the types of one or two canal, Vertucci[46] examined the anatomy of the root

canal and suggested eight different types of canal morphology. In the present study, type IV and II were the most common types of canal configuration, with prevalence of 39% and 29% respectively. The later, varies from the result which was previously reported by Vertucci[46] in which he found a higher prevalence of type II (37%) compared with type IV (18%). In contrast, the incidence of type IV and II canal systems in the current study conforms to those in Burmese, Thai and Jordanian maxillary first molars, where these types were the most common and their prevalence was 33.3%, 44.2% and 35% respectively for type IV, and 25.6%, 17.3% and 28% respectively for type II. It could be argued that the failure rate of treatment of maxillary first molar could be attributed to those specific configuration especially type IV. Yamada and colleagues[16] reported a 44.4% of Japanese maxillary molars had one canal and 55.6% of their sample showed the presence of completely and incompletely separated second mesiobuccal.

CONCLUSION

This study confirmed the anatomical complexity of the maxillary first molar mesiobuccal root canal system. The incidence of second mesiobuccal canal in the mesiobuccal root of permanent maxillary first molars was high among Libyan population. The record obtained from this study provides evidence that help in the management of MB2 canal consequently increase the success rate.

REFERENCES

1. European Society of Endodontology. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. Int Endod J 39, 921-30, 2006.

2. Weine FS, Healey HJ, Gerstein H, Evanson L. Canal configuration in the mesiobuccal root of the maxillary first molar and its endodontic significance. Oral Surg Oral Med Oral Pathol 28, 419-25, 1969.

3. Barbizam JV, Ribeiro RG, Tanomaru Filho M. Unusual anatomy of permenant maxillary molars. J Endod 30, 668-71, 2004.

4. Kontakiotis EG, Tzanetakis GN. Four canals in the mesial root of a mandibular first molar. A case report under the operating microscope. Aust Endod J 33, 84-8, 2007.

5. Witherspoon DE, Small JC, Regan JD. Missed canal systems are the most likely basis for endodontic retreatment of molars. Tex Dental J. 130(2):127-39, 2013.

6. Hess W, Zurcher E. The anatomy of the root-canals of the teeth of the permanent and deciduous dentitions. New York: William Wood and CO. 1-39, 1925.

7. Burns R, Herbranson E. Tooth morphology and cavity preparation. In Cohen S and Burns R (eds) Pathways of the pulp. Mosby: ST Louis. 9th edition, 2002.

8. Cleghorn BM, Christie WH, Dong C. Root and root canal morphology of the human permanent maxillary first molar: a literature review. J Endod 32, 813–21, 2006.

9. Blattner TC1, 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 36(5), 867-70, 2010.

10. Lee JH, Kim KD, Lee JK, Park W, Jeong JS, Lee Y, Gu Y, Chang SW, Son WJ, Lee WC, Baek SH, Bae KS, Kum KY. Mesiobuccal root canal anatomy of Korean maxillary first and second molars by cone-beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 111(6), 785-91, 2011.

11. Zhang R1, 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 44(2), 162-9, 2011.

12. Han X1, Yang H, Li G, Yang L, Tian C, Wang Y. A study of the distobuccal root canal orifice of the maxillary second molars in Chinese individuals evaluated by cone-beam computed tomography. J Appl Oral Sci 20(5), 563-7, 2012.

13. Reis AG, Grazziotin-Soares R, Barletta FB, Fontanella VR, Mahl CR. Second canal in mesiobuccal root of maxillary molars is correlated with root third and patient age: a cone-beam computed tomographic study. J Endod 39 (5), 588-92, 2013.

14. Somma F, Leoni D, Plotino G, Grande NM, Plasschaert A. Root canal morphology of the mesiobuccal root of maxillary first molars: a micro-computed tomographic analysis. Int Endod J 42, 165–74, 2009.

15. Verma P, Love RM. A Micro CT study of the mesiobuccal

root canal morphology of the maxillary first molar tooth. Int Endod J 44, 210–17, 2011.

16. Yamada M1, Ide Y, Matsunaga S, Kato H, Nakagawa K. Three-dimensional analysis of mesiobuccal root canal of Japanese maxillary first molar using Micro-CT. Bull Tokyo Dent Coll 52(2),77-84, 2011.

17. Grande NM1, Plotino G, Gambarini G, Testarelli L, D'Ambrosio F, Pecci R, Bedini R. Present and future in the use of micro-CT scanner 3D analysis for the study of dental and root canal morphology. Ann Ist Super Sanita 48(1), 26-34, 2012.

18. Walker RT (1988). Root form and canal anatomy of mandibular first molar in Southern Chinese population. Endod Dent Traumatol 4, 19–22, 1988.

19. Salwa AY, Abdullah RA, Mohammad FF. Three rooted permanent mandibular first molars of Asian and Black groups in the Middle East. Oral Surg Oral Med Oral Pathol 69, 102–5, 1990.

20. Al-Nazhan S. Incidence of four canals in root-canal-treated mandibular first molars in a Saudi Arabian sub-population. Int Endod J 32, 49–52, 1999.

21. Weine FS, Hayami S, Hata G, Toda T. Canal configuration of the mesiobuccal root of the maxillary first molar of a Japanese sub-population. Int Endod J 32, 79–87, 1999.

22. Gulabivala K, Aung TH, Alavi A, Ng YL. Root and canal morphology of Burmese mandibular molars. Int Endod J 34, 359–70, 2001.

23. Ng Y-L, Aung TH, Alavi A, Gulabivala K. Root and canal morphology of Burmese maxillary molars. Int Endod J 34, 620–30, 2001.

24. Wasti F, Shearer AC, Wilson NHF. Root canal systems of the mandibular and maxillary first permanent molar teeth of South Asian Pakistanis. Int Endod J 34, 263–66, 2001.

25. Alavi AM, Opasanon YL, Ng Y-L, Gulabivala K. Root and canal morphology of Thai maxillary molars. Int Endod J 35, 478-85, 2002.

26. Gulabivala K, Opasanon A, Ng YL , Alavi A. Root and canal morphology of Thai mandibular molars. Int Endod J 35, 56- 62, 2002.

27. Smadi L, Khraisat A. Root canal morphology of the mesiobuccal root in maxillary first molars of Jordanian population. Gen Dent 54(6), 413-6. 2006.

28. Smadi L, Khraisat A. Detection of a second mesiobuccal canal in the mesiobuccal roots of maxillary first molar teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 103(3), e77-81, 2007.

29. Pattanshetti N, Gaidhane M , Al Kandari AM . Root and canal morphology of the mesiobuccal and distal roots of permanent first molars in a Kuwait population – a clinical study. Int Endod J 41, 755–62, 2008.

30. Chen G, Yao H, Tong C. Investigation of the root canal configuration of mandibular first molars in a Taiwan Chinese population. Int Endod J 42, 1044–49, 2009.

31. Keçeci AD· , Ureyen Kaya B, Sener E. Determination of canal orifice co-ordinates and MB2 incidence of maxillary first molars in a Turkish sub-population. Acta Odontol Scand 72(5), 354-61, 2014.

32. Hartwell G, Bellizzi R. Clinical investigation of in vivo endodontically treated mandibular and maxillary molars. J Endod 8, 555-7, 1982.

33. Kulid JC, Peters DD. Incidence and configuration of canal systems in the mesiobuccal root of maxillary first and second molars. J Endod 16, 311-7, 1990.

34. Park JW, Lee JK, Ha BH, Choi JH, Hoi JH, Perinpanayagam H. Three dimensional analysis of maxillary first molar mesiobuccal root canal configuration and curvature using micro-computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 108(3),437-42, 2009.

35. Zhao J, Li Y, Yang Z, Wang W, Meng Y. Three-dimensional computed topography analysis of a patient with an unusual anatomy of the maxillary second and third molars. Int J Oral Sci 3(4), 225-8, 2011.

36. Domark JD1, Hatton JF, Benison RP, Hildebolt CF . An ex vivo comparison of digital radiography and cone-beam and micro computed tomography in the detection of the number of canals in the mesiobuccal roots of maxillary molars. J Endod (7), 901-5, 2013.

37. Skyscan user manual [cited; Available from: http://www. skyscan.be/products/downloads. htm, 2009.

38. Peeters HH, Suardita K, Setijanto D. Prevalence of a second canal in the mesiobuccal root of permanent maxillary first molars from an Indonesian population. J Oral Sci 53(4), 489-94, 2011.

39. Alrahabi M, Sohail Zafar M. Evaluation of root canal morphology of maxillary molars using cone beam computed tomography. Pak J Med Sci 31(2), 426-30, 2015.

40. Spagnuolo G, Ametrano G, D'Antò V, Formisano A, Simeone M, Riccitiello F, Amato M, Rengo S. Microcomputed tomography analysis of mesiobuccal orifices and major apical foramen in first maxillary molars. Open Dent J 6,118-25, 2012.

41. Nance R, Tyndall D, Levin LG, Trope M. Identification of root canals in molars by tuned-aperture computed tomography. Int Endod J 33, 392-96, 2000.

42. Barton DG, Clark SJ, Eleazer PD, Scheetz JP, Farman AG. Tuned-aperture computed tomography versus parallax analog and digital radiographic images in detecting second mesiobuccal canals in maxillary first molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 96, 223-8, 2003.

43. Ramamurthy R, Scheetz JP, Clark SJ, Farman AG. Effects of imaging system and exposure on accurate detection of the second mesiobuccal canal in maxillary molar teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 102, 796-802, 2006.

44. Khraisat A, Smadi L. Canal configuration in the mesio-buccal root of maxillary first molar teeth of a Jordanian population. Aust Endod J 33(1),13-7, 2007

45. Singh S, Pawar M. Rot canal morphology of South Asian Indian maxillary molar teeth. Eur J Dent 9(1), 133-44, 2015.

46. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 58, 589-99, 1984.

47. Vertucci FJ. Root canal morphology and its relationship to endodontic procedure. Endod Topics 10, 3-29, 2005.