Saudi Dental Journal (2022) **34**, 150–154

King Saud University

Saudi Dental Journal

www.ksu.edu.sa
www.sciencedirect.com

Assessment of the prevalence and configuration of middle distal canals in the mandibular molars in a Saudi subpopulation using Cone-Beam computed tomography

Faisal Alnassar [a], Yousef Aldahman [b], Ahmed Altuwalah [a], Abdullah Aldafaas [c], Ra'ed A-Sadhan [d], Waleed Alnassar [e], Riyadh Alroomy [a,*], Basim Almulhim [f], Badar Alshammari [g], Saad Alnazhan [h]

[a] *Department of Restorative Dental Sciences, College of Dentistry, Majmaah University, Al-Majmaah 11952, Saudi Arabia*
[b] *Endodontist, Department of Endodontics, Eastern Riyadh Dental Center, Second Health Cluster, Ministry of Health, Saudi Arabia*
[c] *Endodontist, King Fahd Security College, Riyadh, Saudi Arabia*
[d] *Associate Professor and Consultant of Oral and Maxillofacial Radiology, Department of Oral Medicine and Diagnostic Sciences, College of Dentistry, King Saud University, Riyadh, Saudi Arabia*
[e] *General dental practitioner, Saudi Arabia*
[f] *Department of Preventive Dental Sciences, College of Dentistry, Majmaah University, Al-Majmaah 11952, Saudi Arabia*
[g] *Department of Dental, King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia*
[h] *Professor, Department of Restorative Dentistry-Endodontics, College of Dentistry, Riyadh Elm University, Riyadh 11681, Saudi Arabia*

Received 9 December 2020; revised 6 December 2021; accepted 9 December 2021
Available online 14 December 2021

KEYWORDS

Dental anatomy;
Mandibular molars;
Middle distal canal;
Root canal anatomy

Abstract *Purpose:* The prevalence of the middle distal (MD) canal in the mandibular molar is significantly low among countries including the USA, Spain, Turkey, and Jordan; however, analysis of its prevalence and configuration has not been performed in Saudi Arabia. Therefore, we aimed to assess the prevalence and configuration of the MD canal in Saudi Arabia.

Methods: A retrospective analysis of 132 cone-beam computed tomography (CBCT) images was performed to evaluate the presence of the MD canal in patients visiting the Radiology Department

* Corresponding Author.
E-mail addresses: F.alnassar@mu.edu.sa (F. Alnassar), yaldahman@moh.gov.sa (Y. Aldahman), A.altowala@mu.edu.sa (A. Altuwalah), dafas.a@hotmail.com (A. Aldafaas), rsadhan@ksu.edu.sa (R. A-Sadhan), Waleed7Alnassar@gmail.com (W. Alnassar), R.alroomy@mu.edu.sa (R. Alroomy), b.almulhim@mu.edu.sa (B. Almulhim), bshammari@kfshrc.edu.sa (B. Alshammari), saadnazhan@gmail.com (S. Alnazhan).
Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.sdentj.2021.12.004

of The College of Dentistry in King Saud University between July 2018 and July 2019. The canal was examined if it was confluent with the distobuccal (DB) or distolingual (DL) canals, fin, or independent. Moreover, the distances from the MD canal to the DL and DB canals and cementoenamel junction (CEJ) were recorded.

Results: One MD canal (0.7%) was observed in 145 teeth. It was confluent with the DL canal. No statistical significance was observed among sex and age. The distances from the MD canal to the DL canal, DB canal, and CEJ were 1.4 mm, 1.9 mm, and 3.1 mm, respectively.

Conclusions: The prevalence of the MD canal was significantly low in a Saudi subpopulation (0.7%). Careful evaluation of CBCT images and the pulpal floor is significantly important to detect the MD canal to ensure a good prognosis.

1. Introduction

The primary purpose of root canal therapy is to shape and clean the entire root canal system before obturating it with a root filling material (Vertucci, 1974). The incomplete removal of pulp tissue and failure in eradicating microorganisms from the root canal systems are considered significant reasons for root canal treatment failure (Ricucci et al., 2009). Therefore, clinicians must have adequate knowledge of the root canal anatomy and its different anatomical variations to obtain a high level of treatment success (Baruwa et al., 2020).

Mandibular molars have a complex and varying root canal anatomy (Mannocci et al., 2005). The mandibular first and second molars generally have two roots (mesial and distal) with two mesial and one or two distal canals (Vertucci, 1984). Secondary dentin deposition has been reported to be a principal determinant in the form and number of root canals that cause a wide variation in root canals, which were primarily in simple form (Thomas et al., 1993).

The presence of an extra root canal in the distal root of the mandibular molars is called the middle distal (MD) canal (Gaêta-Araujo et al., 2019), which is rarely observed, and its occurrence ranges from 0% to 22.5% (Sperber and Moreau, 1998; Sert et al., 2004; Mukhaimer, 2014; Fabra-Compos, 1985; Cunningham and Senia, 1992; Calişkan et al., 1995; Al-Qudah and Awawdeh, 2009; Ahmed et al., 2007; Filpo-Perez et al., 2015; Alashiry et al., 2020). Different methods have been used to detect the presence of MD canals, including radiography (Fabra-Compos, 1985; Cunningham and Senia, 1992), clearing (Sperber and Moreau, 1998; Sert et al., 2004; Calişkan et al., 1995; Al-Qudah and Awawdeh, 2009; Ahmed et al., 2007), cone-beam computed tomography (CBCT) (Fabra-Compos, 1985), and micro-computed tomography (Filpo-Perez et al., 2015; Alashiry et al., 2020).

The prevalence and configuration of MD canals have not been assessed in Saudi Arabia. Therefore, the present study aimed to evaluate the prevalence and configuration of the MD canals in a Saudi subpopulation using CBCT.

2. Materials and methods

2.1. Sample selection and study design

This study was approved by the Ethics Committee of College of Dentistry, King saud university (IRB #E-18–3277). In total, 132 CBCT images were obtained from 132 patients (92 women and 40 men), aged 17 to 70 years who were sent to the Radiology Department for regular dental care between July 2018 and July 2019. The power analysis indicated that 102 cases were at least required to detect a group difference of at least 0.0% vs. 22% MD canal prevalence (Table 1) with a 95% confidence interval and 95% power in a z-test for independent proportions.

Each image included at least one sound mandibular right or left first and/or second molar with fully formed roots. CBCT images that were unclear or blurred, cases with previously initiated root canal treatment or treated teeth, cases with posts or crown reconstruction, periapical lesions, and any clinical or pathological mechanism such as open apex were all excluded. The final sample comprised of 145 mandibular molars (68 mandibular first molars and 77 mandibular second molars).

2.2. Image evaluation

The following data were evaluated and recorded: age, sex, molar type (first or second mandibular molar), presence/absence of an MD canal, and the anatomical configuration of the existing MD canal. The age of the patients was divided into four groups: group 1 (16–25 years), group 2 (26–35 years), group 3 (36–45 years), and group 4 (≥46 years).

A classification similar to the one proposed for middle mesial canals by Pomeranz et al. (1981) has been used for the MD canal by replacing the mesial canal with the distal canal. The classification was described as follows: type I "fin": the file passes freely between the main canals and the extra-canal (transverse anatomies), type II "confluent": the extra-canal originates as a separate orifice but apically joins to one of the main canals, and type III "independent": the extra-canal originates as a separate orifice and terminates as a separate apical foramen. Moreover, measurements for the distance between the orifice of the MD canal and main distal canals and from the cementoenamel junction (CEJ) up to the detection of the MD canal orifice were also recorded (Fig. 1).

Two endodontists analyzed the images of this retrospective CBCT using Planmeca ProMax 3D (PLANMECA, Roselle, IL, USA) with a voxel size of 90–300 μm. The imaging factors were constant for all CBCT scans as follows: field of view 170 × 120 mm, 90 kv, 5–8 mA, and 15 s exposure time. Serial buccolingual, mesiodistal, and coronoapical CBCT sections of the molar were evaluated continuously by moving the toolbar from the pulp chamber floor to the apex to determine the pres-

Table 1 Prevalence of the middle distal canals in the mandibular first and second molars in different populations.

Author	Year	Population	Technique	Number of teeth examined	MD canals (%)
Fabra-Compos, 1985	1985	Spain	Radiography	145 (1st)	0.6
Cunningham and Senia, 1992	1992	United States	Radiography	60 (1st)	1.7
Calişkan et al., 1995	1995	Turkish	Clearing	100	1.7
Sperber and Moreau, 1998	1998	Senegalese	Clearing	480	0.2
Sert et al., 2004	2004	Turkish	Clearing	200	1
Ahmed et al., 2007	2007	Sudanese	Clearing	100 (1st)	3
				100 (2nd)	10
Al-Qudah and Awawdeh, 2009	2009	Jordanian	Clearing	330 (1st)	0.3
Mukhaimer, 2014	2014	Palestinian	CBCT	320 (1st)	0.0
Filpo-Perez et al., 2015	2015	Brazil	Micro-CT	100 (1st)	8
Alashiry et al., 2020	2020	Egypt	Micro-CT	240	22.5%
Current study	2020	Saudi	CBCT	68 (1st)	0.7
				77 (2nd)	0.0

ence or absence of the MD canal and its canal configuration. After determining an MD canal, a maxillofacial radiologist confirmed whether it was a true canal or an isthmus.

2.3. Statistical analyses

To ensure the reliability of the study findings, 10 CBCT images were randomly selected to assess the inter-examiner reliability by reporting the presence and orientation of the MD canals in the mandibular molars. After 1 week, the intra-examiner reliability was tested using the same images. The interclass correlation coefficient (ICC) was used to measure both inter- and intra-examiner reliability (ICC). To achieve data reliability, an intra-examiner calibration based on the anatomical diagnosis of the CBCT images was performed before the experimental reading. Using the Statistical Package for the Social Sciences

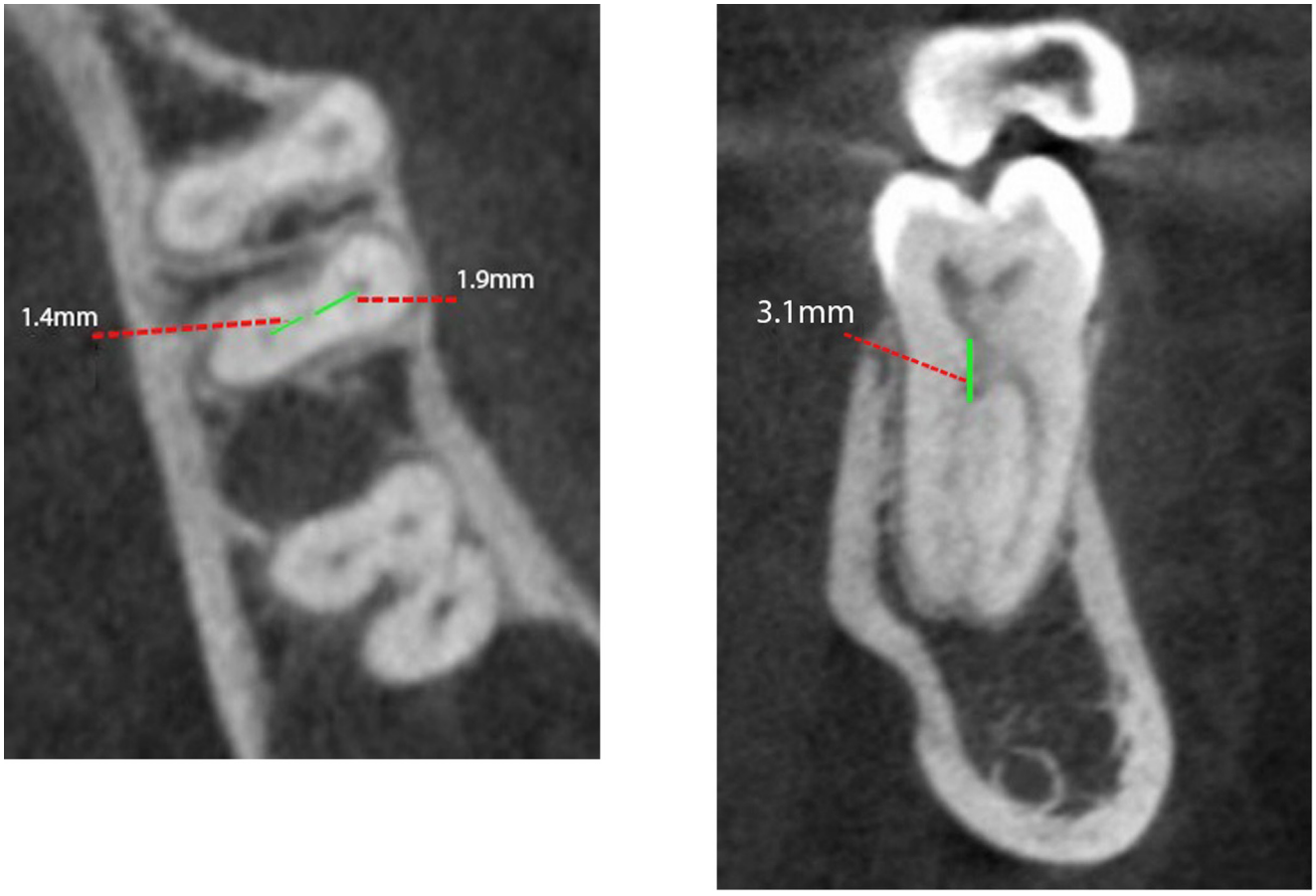

Fig. 1 CBCT of mandibular first molar. (a) Axial view measuring the distance between the orifice of MD canal and main distal canals. (b) Sagittal view measuring the distance from CEJ to the MD canal orifice. CBCT: Cone-beam computed tomography, MD: Middle distal, CEJ: Cementoenamel junction.

(SPSS) program version 22 (SPSS Inc., Chicago, IL, USA), data were evaluated using the Fisher exact and chi-squared tests. $P < 0.05$ was considered statistically significant.

3. Results

The ICC for the inter-examiner reliability was excellent (0.886) for the detection of the MD canal and good (0.625) for the distance measurements. The ICCs for the intra-examiner reliability were 1 for the first examiner regarding the detection of the MD canal and 0.95 for the second examiner.

Out of the 68 teeth evaluated, only one observed tooth presented with an extra MD canal in the mandibular first molar and this was 0.7% of the total sample size (confluent with the distolingual canal), no extra MD canal (0.0%) was found in the second mandibular molars (Table 1). The confluent configuration was observed in an 18-year-old female patient. The distance between the DB and MD canal was 1.9 mm, the distance between the DL and MD canal was 1.4 mm, and the distance from the CEJ to the orifice of MD canal was 3.1 mm. Another MD canal was excluded by the maxillofacial radiologist because it was not a true MD canal.

4. Discussion

Our objective was to investigate the prevalence and configuration of the MD canal in a Saudi subpopulation. The prevalence of the MD canal in Saudi Arabia was found to be significantly low at 0.7%. The canal was closer to the DL canal and away from the CEJ by 3.1 mm.

The root canal system has different anatomical variations; thus, this variation should always be considered at the start of root canal therapy. A thorough clinical and radiographic examination is essential to detect such possible variations. Missed untreated root canals are considered as a major cause that contribute to the failure of the primary root canal treatment (Vertucci, 2005; Allen et al., 1989).

CBCT imaging was reported to be an accurate tool to evaluate the root canal system similar to modified canal staining and tooth clearing techniques (Neelakantan et al., 2010). In the current study, CBCT images were used to evaluate the presence of the MD canals in the mandibular first and second molars. The proportion for the number of root canals in the mandibular first molars in a Saudi subpopulation were reported to be in the range of 1.7% for two canals, 42.23%–73% for three canals, and 25.3%–57.76% for four root canals (Mashyakhy et al., 2019; Al-Nazhan, 1999). The prevalence rate of the MD canals in this study was 0.7%, which was higher than that of a previous study (0.0%) by Mukhaimer (2014) using CBCT. Other studies had varying prevalence rates of the MD canals due to different methodologies and races in these prior studies (Sperber and Moreau, 1998; Sert et al., 2004; Fabra-Compos, 1985; Cunningham and Senia, 1992; Calişkan et al., 1995; Al-Qudah and Awawdeh, 2009; Ahmed et al., 2007; Filpo-Perez et al., 2015; Alashiry et al., 2020).

Different studies have emphasized that the root canal system changes are associated with age as old patients have less number of canals due to dentinal metamorphosis; a better understanding of these changes influences the provision of restorative and endodontic care (Walton, 1997; Smith et al. 1993; Murray et al., 2002; Dammaschke et al., 2003; Basmadjian-Charles et al., 2002). The results of the current study further reinforce these findings and show distinct developmental patterns of canal morphology, especially in young women. It has been reported that women had greater incidence of the presence of five root canals (both roots combined) than men in the mandibular first molars (Kim et al., 2013).

Gupta et al. (2012) have reported that the MD canals were found to be confluent with their respective distobuccal canal at the junction of the middle and apical one-thirds. It is inconsistent with our findings in that the MD canal was closer to the distolingual canal orifice compared to the distobuccal canal orifice (distance = 1.4 mm and 1.9 mm, respectively). It is difficult to determine the possible reason for our recent findings because Gupta et al.'s study was a single case report and we found only one case in a large sample size in our study.

This study has a limitation in that this was a retrospective CBCT study. A study using micro-CT would show a more accurate internal anatomy, and the prevalence of the MD canal might become higher due to its higher resolution (Alashiry et al., 2020). Although the sample size analysis requires at least 102 cases, we cannot perform a statistical analysis on only one case compared to the remaining cases, which would make it statistically biased. Therefore, a multicenter study should be conducted to determine more cases, perform a statistical analysis, and identify associated variables.

5. Conclusion

Considering the limitation of this study, the prevalence of the MD canal in a Saudi subpopulation is significantly low. CBCT is one of the most important tools that can be used to explore the complex root canal anatomy, especially with the use of small field of view with high resolution for dose reduction and accuracy. Careful evaluation of radiographic images and access cavity will provide clinicians with adequate knowledge on the anatomical variations of the root canal of the teeth, which will subsequently improve the outcomes of endodontic treatment.

Ethical Statement

This study was approved by the Ethics Committee of College of Dentistry, King Saud University (IRB #E-18-3277)

Acknowledgements

The authors would like to thank the Deanship of Scientific Research at Majmaah University for supporting this work under Project Number No. R-2021-299.

Funding Sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sdentj.2021.12.004.

References

Vertucci, F.J., 1974. Root canal anatomy of the mandibular anterior teeth. J. Am. Dent. Assoc. 89, 369–371.

Ricucci, D., Siqueira Jr., J.F., Bate, A.L., Ford, T.R.P., 2009. Histologic investigation of root canal-treated teeth with apical periodontitis: a retrospective study from twenty-four patients. J. Endod. 35, 493–502.

Baruwa, A.O., Martins, J.N.R., Meirinhos, J., Pereira, B., Gouveia, J., Quaresma, S.A., Monroe, A., Ginjeira, A., 2020. The influence of missed canals on the prevalence of periapical lesion in endodontically treated teeth: a cross-sectional study. J. Endod. 46, 34–39.

Mannocci, F., Peru, M., Sherriff, M., Cook, R., Ford, T.R.P., 2005. The isthmuses of the mesial root of mandibular molars: a micro-computed tomographic study. Int. Endod. J. 38, 558–563.

Vertucci, F.J., 1984. Root canal anatomy of the human permanent teeth. Oral. Surg. Oral. Med. Oral. Pathol. 58, 589–599.

Thomas, R.P., Moule, A.J., Bryant, R., 1993. Root canal morphology of maxillary permanent first molar teeth at various ages. Int. Endod. J. 26, 257–267.

Gaêta-Araujo, H., Fontenele, R.C., Nascimento, E.H.L., Nascimento, M.D.C.C., Freitas, D.Q., de Oliveira-Santos, C., 2019. Association between the root canal configuration, endodontic treatment technical errors, and periapical hypodensities in molar teeth: a cone-beam computed tomographic study. J. Endod. 45, 1465–1471.

Sperber, G.H., Moreau, J.L., 1998. Study of the number of roots and canals in Senegalese first permanent mandibular molars. Int. Endod. J. 31, 117–122.

Sert, S., Aslanalp, V., Tanalp, J., 2004. Investigation of the root canal configurations of mandibular permanent teeth in the Turkish population. Int. Endod. J. 37, 494–499.

Mukhaimer, R.H., 2014. Evaluation of root canal configuration of mandibular first molars in a Palestinian population by using cone-beam computed tomography: an ex vivo study. Int. Sch. Res. Notices. 2014, 583621.

Fabra-Campos, H., 1985. Unusual root anatomy of mandibular first molars. J. Endod. 11, 568–572.

Cunningham, C.J., Senia, E.S., 1992. A three-dimensional study of canal curvatures in the mesial roots of mandibular molars. J. Endod. 18, 294–300.

Calişkan, M.K., Pehlivan, Y., Sepetçioğlu, F., Türkün, M., Tuncer, S. S., 1995. Root canal morphology of human permanent teeth in a Turkish population. J. Endod. 21, 200–204.

Al-Qudah, A.A., Awawdeh, L.A., 2009. Root and canal morphology of mandibular first and second molar teeth in a Jordanian population. Int. Endod. J. 42, 775–784.

Ahmed, H.A., Abu-bakr, N.H., Yahia, N.A., Ibrahim, Y.E., 2007. Root and canal morphology of permanent mandibular molars in a Sudanese population. Int. Endod. J. 40, 766–771.

Filpo-Perez, C., Bramante, C.M., Villas-Boas, M.H., Duarte, M.A.H., Versiani, M.A., Ordinola-Zapata, R., 2015. Micro-computed tomographic analysis of the root canal morphology of the distal root of mandibular first molar. J. Endod. 41, 231–236.

Alashiry, M., Zeitoun, R., Elashiry, M., 2020. Prevalence of middle mesial and middle distal canals in mandibular molars in an Egyptian subpopulation using micro-computed tomography. Nig. J. Clin. Pract. 23, 534–538.

Pomeranz, H.H., Eidelman, D.L., Goldberg, M.G., 1981. Treatment considerations of the middle mesial canal of mandibular first and second molars. J. Endod. 7, 565–568.

Vertucci, F.J., 2005. Root canal morphology and its relationship to endodontic procedures. Endod. Topics. 10, 3–29.

Allen, R.K., Newton, C.W., Brown Jr., C.E., 1989. A statistical analysis of surgical and nonsurgical endodontic retreatment cases. J. Endod. 15, 261–266.

Neelakantan, P., Subbarao, C., Subbarao, C.V., 2010. 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. 36, 1547–1551.

Mashyakhy, M., Chourasia, H.R., Halboub, E., Almashraqi, A.A., Khubrani, Y., Gambarini, G., 2019. Anatomical variations and bilateral symmetry of roots and root canal system of mandibular first permanent molars in Saudi Arabian population utilizing cone-beam computed tomography. Saudi. Dent. J. 31, 481–486.

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

Walton, R.E., 1997. Endodontic considerations in the geriatric patient. Dent. Clin. North. Am. 41, 795–816.

Smith, C.S., Setchell, D.J., Harty, F.J., 1993. Factors influencing the success of conventional root canal therapy–a five-year retrospective study. Int. Endod. J. 26, 321–333.

Murray, P.E., Stanley, H.R., Matthews, J.B., Sloan, A.J., Smith, A.J., 2002. Age-related odontometric changes of human teeth. Oral. Surg. Oral. Med. Oral. Pathol. Oral. Radiol. Endod. 93, 474–482.

Dammaschke, T., Steven, D., Kaup, M., Ott, K.H.R., 2003. Long-term survival of root-canal-treated teeth: a retrospective study over 10 years. J. Endod. 29, 638–643.

Basmadjian-Charles, C.L., Farge, P., Bourgeois, D.M., Lebrun, T., 2002. Factors influencing the long-term results of endodontic treatment: a review of the literature. Int. Dent. J. 52, 81–86.

Kim, S.Y., Kim, B.S., Woo, J., Kim, Y., 2013. 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. 39, 1516–1521.

Gupta, S., Jaiswal, S., Arora, R., 2012. Endodontic management of permanent mandibular left first molar with six root canals. Contemp. Clin. Dent. 3, S130–S133.