Journal of Taibah University Medical Sciences (2015) 10(4), 391–395

Taibah University

Journal of Taibah University Medical Sciences

www.sciencedirect.com

Experimental Article

Root canal configurations of the first and second mandibular premolars in the population of north Syria

Adnan A. Habib, Ph.D. [a,*], Mohammad N. Kalaji, Ph.D. [a], Tyseer J. Al saysd, Ph.D. [b] and Khaled A. Al jawfi, Ph.D. [c]

[a] *Restorative Dentistry and Prosthodontics Department, University of Science and Technology, Sana, Yemen*
[b] *Conservative Dentistry Department, Aleppo University, Aleppo, Syria*
[c] *Biological & Preventive Sciences Department, University of Science and Technology, Sana, Yemen*

Received 24 December 2014; revised 13 February 2015; accepted 20 February 2015; Available online 2 April 2015

الملخص

أهداف البحث: يهدف هذا البحث لتقييم تشريحي وشكلي للأقنية الجذرية للضواحك السفلية الأولى والثانية لدى سكان شمال سوريا.

طرق البحث: تكونت العينة البحثية من ١٦٠ ضاحكة سفلية (٩٥ ضاحكة سفلية أولى و ٦٥ ضاحكة سفلية ثانية) مقلوعة حفظت بمادة الكلورامين — ت بنسبة ١٠٪, وحقنت الأسنان بعد فتح الحجرة اللبية بالحبر الهندي ومن ثم جعلت شفافة لتسهيل دراسة عدد، ونموذج، وأنماط الأقنية الجذرية الموجودة في أسنان العينة البحثية.

النتائج: أظهرت نتائج البحث أن ٨٢،١ ٪ من الضواحك الأولى السفلية كانت بقناة واحدة، بينما احتوت ١٧،٩٠٪ من الأسنان على قناتين جذريتين. كما لوحظ أن ٨٣،٠٧٪ من الضواحك الثانية السفلية كانت بقناة واحدة، بينما كان ١٥،٣٥٪ منها بقناتين, وضاحكة ثانية سفلية واحدة (١،٥٣٪) وجد فيها ٣ قنوات.

الاستنتاجات: إن معظم الضواحك السفلية هي أسنان وحيدة القناة مع احتمال وجود قناتين أو أكثر, لذلك يجب على الطبيب المعالج أن يفترض وجود أكثر من قناة جذرية عند علاج هذا النوع من الأسنان.

الكلمات المفتاحية: تشريح؛ شفافية الأسنان؛ تشعبات القناة الجذرية؛ ضاحكة سفلية؛ شكل القناة الجذرية

Abstract

Objective: This study was conducted to assess the canal anatomy and morphology of the first and second mandibular premolars in the population of north Syria.

Methods: One-hundred and sixty permanent fully developed apices of the mandibular premolars (95 first mandibular premolars and 65 second mandibular premolars) were collected and stored in 10% cloramine-T solution. Teeth were stained with India Ink and cleared. The number and the type of root canal were examined in the root of each cleared mandibular premolar.

Results: The results showed that 82.1% of first mandibular premolars had a single canal and 17.9% contained two canals. Eighty three percent of second mandibular premolars had a single canal, 15.3% two canals, and 1.5% three canals.

Conclusion: Most of mandibular premolars have a single canal with the probability of presence of two or more canals. This possibility of the existence of two or more canals in the mandibular premolars should be considered by the dentists while performing endodontic therapy.

Keywords: Anatomy; Cleared tooth; Configuration; Mandibular premolar; Morphology

© 2015 The Authors.
Production and hosting by Elsevier Ltd on behalf of Taibah University. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

* Corresponding address: University of Science and Technology, Sana, Yemen.
E-mail: adnanhabib71@hotmail.com (A.A. Habib)
Peer review under responsibility of Taibah University.

ELSEVIER Production and hosting by Elsevier

1658-3612 © 2015 The Authors.
Production and hosting by Elsevier Ltd on behalf of Taibah University. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/). http://dx.doi.org/10.1016/j.jtumed.2015.02.011

Introduction

Knowledge of pulp anatomy is essential for endodontic treatment success, and a lack of sound knowledge of the pulp anatomy can contribute to treatment failure. The morphologies of the roots and canals of the first and second mandibular premolars can be complex and variable. Due to this varied morphology, the endodontic treatment of mandibular premolars is a challenging task.[1] Slowey indicated that the mandibular premolars are difficult teeth to treat endodontically likely because of the variations in canal anatomy.[2] The distributions of the numbers of roots and canals vary greatly in the literature.[3] The root canal morphologies of the mandibular premolars have been reported based on studies of various population groups (Table 1), including Chinese,[4] Turkish,[5] American,[6,7] Mexican,[8] and African American populations.[6]

Zillich and Dowsen revealed that second or third canals are present in at least 23.1% of first mandibular premolars and in at least 12.1% of second mandibular premolars.[9]

Vertucci found that the mandibular first premolar has one canal in 74.0% of teeth, two canals in 25.5%, and three canals in 0.5% of teeth. The mandibular second premolar has one canal in 97.5% and two canals in 2.5% of teeth.[10]

Lu et al. indicated that 54% of mandibular first premolars in a Chinese population exhibited a single canal, 22% contained two canals, and 18% exhibited a C-shaped configuration.[4]

Baisden et al. found that 76% of mandibular first premolars demonstrated Type I canals, and 24% contained Type IV canals, and the shapes of the canals were predominantly oval or round. Interestingly, C-shaped canals have been found to be predominantly associated with Type IV canal systems; this pattern has observed in 14% of roots.[11]

Jain and Bahugund[12] studied the root canal morphologies of mandibular first premolars in a Gujarati population and concluded that mandibular first premolar teeth predominantly had one root and a Type I canal system (67.39%).

Zaatar et al. found that 95.3% of mandibular second premolars have one canal, and 4.7% have two canals.[13] In France, Geider et al. observed that 86.6% of mandibular second premolars have one canal, and 13.4% have two canals.[14] In Turkey, Sert and Bayirli revealed that 71% of mandibular second premolars have one canal, and 29% have two canals.[5]

The methods that are commonly used to study root canal anatomy include radiography[8], clearing techniques,[15] direct observation with a microscope,[16] 3D reconstruction,[17] and macroscopic sectioning.[4,11] Conventional radiography has the problem of superimposition[18]; moreover, this technique results in a two-dimensional representation of a three-dimensional object. The difficulties encountered with other methods (e.g., cross or longitudinal sections) include disturbance of the pulp space and its surrounding structures during the preparation of the teeth.[19]

Advancements in the field of radiology have drawn upon the use of computed tomography (CT) to image imaging teeth. Eder et al. reported that CT is a viable tool for the evaluation of unclear root canal configurations.[20] Spiral computed tomography (SCT) is also a more useful technique for assessing unusual root canal morphologies compared with routine intraoral periapical radiography.[21,22] A cone-beam computed tomography has also been used to study root canal morphologies because this non-destructive technique provides three-dimensional pictures[23]; however, this technique is expensive and requires complex devices[24]

Until 1982, the clearing procedure was used for anatomical studies of the pulp cavity.[25] In 1983, Tagger et al. put forward an improved method that utilizes methyl salicylate as the clearing agent for three-dimensional studies of apical leakage.[26] The benefits of this clearing technique for creating transparent root canals include the following: it enables three-dimensional assessments[27]; it maintains the original form of the root canal, including minute details[28]; failure in the preparation of the specimen is rare; and the specimen can be preserved for a long time.

The purpose of this study was to investigate the canal configurations of the first and second mandibular premolars of the population of north Syria.

Materials and Methods

This study was approved by the Research Ethics Committee of the College of Medical Science, University of Science and Technology, Yemen.

Totals of 95 extracted mandibular first premolars and 65 mandibular second premolars were collected from various dental clinics within north Syria. All of the teeth belong to people from northern Syria. The teeth included in this study had intact clinical crowns and fully developed apices. Data regarding the age and sex of the donors and the reasons for extraction were not recorded. Any adherent soft tissues, bone fragments or calculus were removed via scaling and polishing. The number of roots was recorded in this stage (Figure 1). Access cavities were prepared with a high-speed handpiece and diamond fissure burs (Komet, Gebr. Brasseler GmbH & Co. KG Germany). After locating the orifices, the pulp tissue was dissolved by immersing the teeth in 5.25% sodium hypochlorite (Clorox, Dammam, Saudi Arabia) for

Table 1: Some studies show number of canals in the mandibular first and second premolar according to population groups.

Study	Teeth in study	Geographic area	1 canal	Results% 2 canals	3 canals
Vertucci1978[10]	First premolar second premolar	USA	74	25.5	0.5
Lu et al2006[4]	First premolar	China	54	22	0
Baisden et al1992[11]	First premolar	USA	76	24	0
Jain and Bahugund2011[12]	First premolar	Gujarati population	67.39	32.61	0
Zaatar et al1997[13]	Second premolar	Kuwait	95.3	4.7	0
Geider et al1989[14]	Second premolar	France	86.6	13.4	0
Sert and Bayirli2004[5]	Second premolar	Turkey	71	29	0

Figure 1: Second lower premolars with two roots.

12 h. Next, the teeth were washed under running tap water for 2 h and dried overnight. India ink (Daler-Rowney Limited, Bracknell, England) was injected into the pulp chamber via a syringe with a 27-gauge needle. Excess ink was removed from the surface using gauze soaked in alcohol. The stained teeth were air-dried and decalcified with 5% hydrochloric acid (ScP, Ltd., England) for three days. The acid solution was changed daily, and the teeth were washed under running tap water overnight and air-dried. The specimens were dehydrated in ascending concentrations of ethyl alcohol (75%, 85%, 96%, and 100%) for 4 h in each concentration. Finally, transparent specimens were obtained by immersing the dehydrated teeth in a methyl salicylate solution (BDA Lap. Supplies, England) in which the teeth were stored until they were examined (Figure 2).

The cleared teeth were examined using a magnifying glass. The root canal systems were classified according to the classification of Vertucci (1984) as follows[7]:

Type I: one single root canal extending from the pulp chamber to the apex.
Type II: separate root canals leaving the pulp chamber and joining short of the apex to form one canal.
Type III: one root canal leaving the pulp chamber before dividing into two canals within the root and then merging to exit as one single canal.
Type IV: two separate root canals extending from the pulp chamber to the apex.
Type V: one root canal leaving the pulp chamber and dividing short of the apex into two separate and distinct root canals with separate apical foramina.
Type VI: two separate root canals leaving the pulp chamber, merging in the body of the root, and again dividing short of the root apex to exit as two separate and distinct canals.
Type VII: one root canal leaving the pulp chamber, dividing and rejoining within the body of the root canal and finally re-dividing into two distinct canals short of the apex.
Type VIII: three separate and distinct root canals extending from the pulp chamber to the apex.

Results

A) *First premolars*

All 95 mandibular first premolars were single-rooted (100%). Among the mandibular first premolars, 82.10% had single canals (Type I), and 17.90% had two canals.

According to Vertucci's classification, the canal configurations of the mandibular first premolars were as follows: Type I, 82.10%; Type II, 1.05%; Type III, 2.10%; Type IV, 2.10%; Type V, 11.57%; and Type VI, 1.05%.

B) *Second premolars*

Of the 65 mandibular second premolars, 2 (3.07%) had two roots.

Among the mandibular second premolars, 83.07% had single canals (Type I), 15.38% had two canals, and 1.54% had three canals (Type VIII).

According to Vertucci's classification, the canal configurations of the mandibular second premolars were as follows: Type I, 83.07%; Type II, 10.76%; Type IV, 4.62%; and Type VIII, 1.54%.

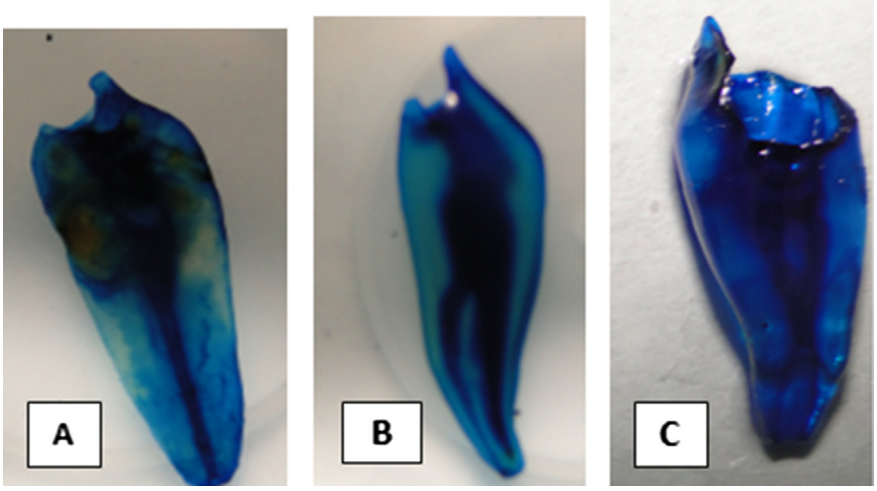

Figure 2: Cleared teeth. **A**: Type I canal configuration, **B**: Type IV canal configuration, **C**: Type VI canal configuration.

Table 2: The number, percentage and canal configuration in mandibular first premolars.

	Roots	Canals	Canal configurations							
	1, 2	1, 2	I	II	III	IV	V	VI	VII	VIII
Number	95, 0	78, 17	78	1	2	2	11	1	0	0
Percent%	100–0	82.10–17.90	82.10	1.05	2.10	2.10	11.57	1.05	0	0

Table 3: The number, percentage and canal configuration in mandibular second premolars.

	Roots	Canals	Canal configurations							
	1, 2	1, 2, 3	I	II	III	IV	V	VI	VII	VIII
Number	63, 2	54, 10, 1	54	7	0	3	0	0	0	1
Percent%	96.93–3.07	83.07, 15.38, 1.54	83.07	10.76	0	4.62	0	0	0	1.53

The results are summarized in Tables 2 and 3.

Discussion

Knowledge of both basic root and root canal morphology as well as possible variation in anatomy of the root canal system is important in achieving successful nonsurgical root canal treatment. This is followed by negotiation, cleaning and shaping, and obturation of the entire canal system in 3 dimensions. Variation in root canal morphology was suggested as the most likely reason for the high frequency of endodontic flare-ups and failures.[3]

Many studies of the root and canal morphologies of mandibular premolars have been conducted because these teeth can present with complex morphologies that often complicate treatment. The majority of these studies have involved complete destruction of the tooth during examination (e.g., hard tissue sectioning) or have acquired only two-dimensional anatomic information (e.g., traditional radiography).[29] Therefore, the current study used the clearing technique because the non-destructive technique is advantageous in the assessment of canal morphology. This technique has been used in several previous studies to visualize root-canal morphologies in detail and to evaluate the sealing abilities of materials or techniques that are used for obturation.[30–33]

The results of this study revealed that 82.10% of the mandibular first premolars exhibited single canals (Type I). This proportion is higher than those reported in many previous studies.[4,10–12] A high prevalence of the Type V configuration (11.57%) of the roots of the mandibular first premolars was also observed in the present study, and this finding is not similar to that reported by Baisden et al.[11]

The results of this study revealed that 83.07% of the mandibular second premolars exhibited single canals. This proportion is lower than those that have been reported in many previous studies,[9,10,13,14] but this proportion is greater than that reported by Sert and Bayirli.[5]

All of the mandibular first premolars and 96.93% of mandibular second premolars in the present study were single-rooted, and these findings are similar to those of many previous studies.[4,13,15]

A great deal of variation has been reported in the literature with respect to the root and root canal morphologies of teeth, and the human mandibular premolar is no exception. This variation in the internal canal morphology of the human mandibular premolar might be due to hereditary and ethnic differences.

Conclusions

1. The majority of mandibular premolars have a single canal, but the presence of two or more canals is not rare; therefore, when administering endodontic therapy to mandibular premolars, clinicians should always assume there are two or more canals in these teeth.
2. This study and previous studies have demonstrated substantial ethnic differences in the internal canal morphologies of human mandibular premolars; moreover, because these studies have been performed in different geographic areas, the findings confirm the influence of hereditary factors on the internal canal morphologies of human teeth.

Authors' contributions

All authors contributed in collecting and classifying the sample, achieving the experiment (clearing of teeth) and testing the cleared teeth. Dr. Adnan Asaad Habib wrote the text of the paper and was the corresponding author. Dr. Kalaji took the pictures and contributed in arrangement of the paper.

Conflict of interest

The authors have no conflict of interest to declare.

Acknowledgements

The authors wish to acknowledge the staff of Aleppo University, the Faculty of Dentistry of Syria University of Science and Technology, and the College of Dentistry of Yemen.

References

1. Lotfi M, Vosoughhosseini S, Zand V, Fatemi A, Shyezadeh V, Ranjkesh B. A mandibular second premolars with three canals and atypical orifices. **J Oral Sci 2008**; 50(3): 363–366.

2. Slowey RR. *Root canal anatomy* : road map to successful endodontics. **Dent Clin North Am 1979**; 23: 555–573.
3. Clegborn BM, Christie WH, Dong CCS. The root and root canal morphology of the human mandibular second premolar: a literature review. **J Endod 2007**; 33(9): 1031–1037.
4. Lu TY, Yang SF, Pai SF. Complicated root canal morphology of mandibular first premolar in a Chinese population using the cross section method. **J Endod 2006**; 32: 932–936.
5. 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: 391–398.
6. Trope M, Elfenbein L, Tronstad L. Mandibular premolars with more than one root canal in different race groups. **J Endod 1986**; 12: 343–345.
7. Vertucci FJ. Root canal anatomy of the human permanent teeth. **Oral Surg Oral Med Oral Pathol 1984**; 58: 589–599.
8. Pineda F, Kuttler Y. Mesiodistal and buccolingual roentgenographic investigation of 7,275 root canals. **Oral Surg Oral Med Oral Pathol 1972**; 33: 101–110.
9. Zillich R, Dowson J. Root canal morphology of mandibular first and second premolars. **Oral Surg Oral Med Oral Pathol 1973**; 36(5): 738–744.
10. Vertucci FJ. Root canal morphology of mandibular premolars. **J Am Dent Assoc 1978**; 97: 47–50.
11. Baisden MK, Kulid JC, Weller RN. Root canal configuration of the mandibular first premolar. **J Endod 1992**; 18: 505–508.
12. Jain A, Bahugund R. Root canal morphology of mandibular first premolar in a gujarati population – an in vitro study. **Dent Res J 2011**; 8(3): 118–122.
13. Zaatar EI, al-Kandari AM, Alhomaidah S, al-Yasin IM. *Frequency* of endodontic treatment in Kuwait: radiographic evaluation of 846 endodontically treated teeth. **J Endod 1997**; 23: 453–456.
14. Geider P, Perrin C, Fontaine M. Endodontic anatomy of lower premolars: apropos of 669 cases. **J Odontol Conserv 1989**; 10: 11–15.
15. Rwenyonyi CM, Kutesa AM, Muwazi LM, Buwembo W. Root and canal morphology of maxillary first and second permanent molar teeth in a Ugandan population. **Int Endod J 2007**; 40: 679–683.
16. Sempira HN, Hartwell GR. Frequency of second mesiobuccal canals in maxillary molars as determined by use of an operating microscope: a clinical study. **J Endod 2000**; 26: 673–674.
17. Mikrogeorgis G, Lyroudia KL, Nikopoulos N, Pitas I, Molyvdas I, Lambrianidis TH. 3D computer-aided reconstruction of six teeth with morphological abnormalities. **Int Endod J 1993**; 32: 88–93.
18. Nattress BR, Martin DM. Predictability of radiographic diagnosis of variations in root canal anatomy in mandibular incisor and premolar teeth. **Int Endod J 1991**; 24: 58–62.
19. Sandhya R, Velmurugan N, Kandaswamy D. Assessment of root canal morphology of mandibular first premolars in the Indian population using spiral computed tomography: an in vitro study. **Indian J Dent Res 2010**; 21(2): 169–173.
20. Eder A, Kantor M, Nell A, Moser T, Gahleitner A, Schedle A, Sperr W. Root canal system in the mesiobuccal root of the maxillary first molar: an in vitro comparison study of computed tomography and histology. **Dentomaxillofac Radiol 2006**; 35: 175–177.
21. Gopikrishna V, Bhargavi N, Kandaswamy D. Endodontic management of a maxillary first molar with a single root and a single canal diagnosed with the aid of spiral CT. **J Endod 2006**; 32: 687–691.
22. Ballal S, Sachdeva GS, Kandaswamy D. Endodontic management of a fused mandibular second molar and paramolar with the aid of spiral computed tomography: a case report. **J Endod 2007**; 33: 1247–1251.
23. Evren Ok, Altunsoy M, Nur BG, Aglarci OS, Çolak M, Güngör E. A cone-beam computed tomography study of root canal morphology of maxillary and mandibular premolars in a Turkish population. **Acta Odontol Scand 2014**; 72(8): 701–706.
24. Low KM, Dula K, Burgin W, von Arx T. Comparison of periapical radiography and cone beam tomography in posterior maxillary teeth referred for apical surgery. **J Endod 2008**; 34: 557–562.
25. Tagger M. *Clearing* of teeth for study and demonstration of pulp. **J Dent Edn 1976**; 40(3): 172–174.
26. Tagger M, Tamse A, Kats A, Tagger E. An improved method of three-dimensional study of apical leakage. **Quintessence Int 1983**; 10: 981–986.
27. Robertson DC, Leeb IJ. Evaluation of transparent tooth model system T. M. for evaluation of Endodontically filled tooth. **J Endod 1982**; 8(7): 317–321.
28. Al Shalabi RM, Omer OE, Glennon J, Jennings M, Claffey NM. Root canal anatomy of maxillary first and second permanent molars. **Int Endod J 2000**; 33: 405–414.
29. Yu X, Guo B, Li K, Zhang R, Tian YY, Wang H, Hu T. Cone-beam computed tomography study of root and canal morphology of mandibular premolars in a western Chinese population. **BMC Med Imaging 2012**; 12: 18.
30. 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 2007**; 103(3): 77–81.
31. Weng XL, Yu SB, Zhao SL, Wang HG, Mu T, Tang RY, et al. Root canal morphology of permanent maxillary teeth in the Han nationality in Chinese Guanzhong area: a new modified root canal staining. **J Endod 2009**; 35(5): 651–656.
32. Wiemann AH, Wilcox LR. In vitro evalution of four methodes of sealer placement. **J Endod 1991**; 17(9): 444–447.
33. Hall MC, Clement DJ, Walker WA. A comparison of sealer placement techniques in curved canals. **J Endod 1996**; 22(12): 638–642.