STUDY OF ROOT CANAL MORPHOLOGY OF MANDIBULAR PREMOLARS IN AN INDIAN POPULATION

ABSTRACT

AIM: The purpose of this study was to describe the external and internal anatomy of the mandibular premolars. **MATERIAL AND METHODS:** 100 extracted human permanent mandibular first and second premolars teeth were collected. The length of the tooth from the cusp tip to root apex was measured with the help of Vernier calliper. In case of curved roots, ligature wire was adapted to the root and then straightened and measured. Each tooth was examined for the number of roots, curvature of root, presence of root canal invagination. India ink was injected into the pulp chamber through the access opening with a no.27 gauge needle mounted on a disposable syringe. The ink was then drawn through the root canal system by applying negative pressure to the apical end of tooth with the use of central suction system. **RESULTS:** The average (mean) length of mandibular first premolar was 22.25 mm. Average (mean) length of mandibular second premolar was 21.90 mm. Mandibular first premolar had a ribbon shaped root canal orifice in 35% of teeth. Mandibular second premolar had a ribbon shaped of root canal orifice in 44% teeth. Mesial invagination of the root was found in 18% of first and 8% second mandibular premolar teeth. 78% had a Type I canal pattern with Type II, Type IV, Type V, Type VI and Type VII canals being identified in 1%, 2%, 13%, 2% and 1% of the teeth respectively. **CONCLUSIONS:** Complex root canal anatomy frequently found with mandibular premolars among which more common with mandibular first premolars in Indian population.

PATEL, Suhag*
GARG, Sunita*
SABHARWAL, Sumit**
JAIN, Neetika***
ISLAM, Shadabul**
PANDEY, Vineet Kumar**

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Department of Conservative and Endodontics, Ahmedabad Dental College and Hospital Ahmedabad, Gujarat, India*
Department of Conservative and Endodontics, Saraswati Dental College and Hospital, Lucknow, Uttar Pradesh, India**
Department of Conservative and Endodontics, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow, Uttar Pradesh, India***
Correspondence: drsuhagpatel@yahoo.co.in (PATEL S)

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INTRODUCTION

Root canal therapy requires a thorough knowledge of root canal morphology to adequately clean and shape the canal. The internal anatomy of a canal system may demonstrate fins, isthmuses, lateral and accessory canals, or diverse canal shapes which can complicate the cleaning and shaping procedures. An invagination of the lateral surface of the root may separate the canal into multiple canal systems. Incomplete cleaning and shaping of these areas may leave tissue, bacteria, or necrotic debris in the canal. The presence of these irritants can result in persistent periapical inflammation and failure of the root canal treatment.[1]

Anomalous root and root canal morphology can be found associated with any tooth with varying degrees and incidence. Both the mandibular first and second premolars often have a single root and a single canal, however, anomalies of the root and root canal systems aswell as multiple canals have been reported in the literature.[2-4]

The root canal system of the mandibular premolars can be particularly difficult to clean and shape. Ingle[5] stated that the canal anatomy might account for the greater increase in endodontic failure of this tooth. Slowey[6] reported that mandibular premolars are probably the most difficult teeth to treat endodontically due to wide variation in root canal morphology.

The purpose of this study was to describe the external and internal anatomy of the mandibular premolars. External morphological features such as length of the tooth, numbers of roots, root curvature, radicular groove and relationship of root apex to apical foramen; internal morphological features such as shape of the root canal orifice, number of root canal, the type of root canal configuration, lateral canal, intercanal communication, apical deltas were determined.

MATERIAL AND METHODS

It is an in vitro descriptive study, conducted in Department of Endodontic, Government Dental College, Ahmedabad, Gujarat. Ethical clearance was obtained from ethical committee of exempted Government Dental College, Ahmedabad, Gujarat.One hundred extracted human permanent mandibular first and second premolars teeth were collected. The age and gender of the patients were not known. Teeth with carious lesions, cracks, fractured roots, abrasive lesions, calcified root canals and pathological alterations of the roots were excluded from this study. The teeth were rinsed under tap water in order to remove blood and tissue debris. All attached soft tissue and calculus were removed using a hand scalar. The teeth were then preserved in 10% formalin till used. The length of the tooth from the cusp tip to

root apex was measured with the help of Vernier caliper. In case of curved roots, ligature wire was adapted to the root and then straightened and measured. Each tooth was examined for the number of roots, curvature of root, presence of root canal invagination.The relationship of the apical foramen to the root apex was measured using a no. 6 K file under illuminated scale magnifier. In instances where the apical foramen was placed eccentric, the distance and location of the discrepancy was noted.

Access cavities were prepared and the shape of the root canal orifice was noted. Following this, the teeth were placed in 3% sodium hypochlorite for 24 hrs to dissolve all pulpal debris. Thereafter all samples were placed in an ultrasonic bath for ten minutes. Following this, the teeth were washed in running water for 2 hrs for complete removal of pulp debris and then dried overnight. The teeth were placed in 5% nitric acid for 72h, with the acid being replenished every 24h and stirred once every 8h. The end-point of decalcification was checked by taking a radiograph of reference sample teeth, which showed uniform radiolucency with no patches of opaque areas. The teeth were then washed in running water and dehydrated using ascending grades (70%, 80%, 90% and 100%) of isopropyl alcohol for 1 day in each solution. Then finally they were rendered transparent by immersion in methyl salicylate for 2 hours.

India ink was injected into the pulp chamber through the access opening with a no. 27 gauge needle mounted on a disposable syringe. The ink was then drawn through the root canal system by applying negative pressure to the apical end of tooth with the use of central suction system. All samples were observed at 10X magnification under a stereomicroscope for the number of root canals, type of root canals (Vertucci FJ classification[7]), and presence of lateral canals, intercanal communications and apical deltas.

RESULTS

Descriptive analysis was used to quantify the findings.

The average (mean) length of mandibular first premolar was22.25 mm. The smallest first premolar was 17.17 mm while the longest was 26.43 mm. Average (mean) length of mandibular second premolarwas 21.90 mm. The smallest second premolar was 17.10 mm and thelongest was 28.55 mm.

Mandibular first premolar had a ribbon shaped root canal orifice in 35% of teeth followed by oval in 31%, long oval in 22% and round in 12%. Mandibular second premolar had a ribbon shaped of root canal orifice in 44% teeth followed by oval in 23%, round in 17% and long oval in 16%.

Mesial invagination of the root was found in 18% of first and 8% second mandibular premolar teeth. The average

distance of initiation of mesial invagination from the cusp tip was 14.97 mm and 15.45 for first and second mandibular premolar respectively (Table 1 and 2). Buccal invagination of the root was found in both 1% of first and 1% second mandibular premolar teeth in addition to the mesial invagination.

Amongst the 100 mandibular first premolar teeth, 78% had a Type I canal pattern with Type II, Type IV, Type V, Type VI and Type VII canals being identified in 1%, 2%, 13%, 2% and 1% of the teeth respectively. Additional root canal configuration such as Type 1-2-3 and Type 1-3 were also found in 2% and 1% of the mandibular first premolar teeth respectively (Table 3).

Amongst the 100 mandibular second premolar teeth, 89% had a Type I canal pattern with Type III, Type V and Type VII canals being identified in 2%, 7% and 1% of the teeth respectively. Additional root canal configuration such as Type 1-3-4 was also found in 1% of the mandibular second premolar teeth.

There was an increasing prevalence of lateral canals towards the apical part of the root in both first and second premolars (5% and 7%, respectively). While the middle third showed prevalence 4% in first premolar and 3% in second mandibular premolar followed by least numbers in coronal thirds of first and second premolars (1% and 2%, respectively).

Intercanal communications were found in equal number in both first and second premolar that is 6%. These transverse anastomoses were found mostly in the middle third areas of mandibular premolars.Apical deltas were present in 9% of first mandibular premolars and 15% of second mandibular premolars.

DISCUSSION

The configuration of the root canal is important because of their significant impact on the practice of endodontic. The present study was designed to evaluate the canal morphology of mandibular premolar teeth amongst an Indian population using a clearing technique.

There are different methods for studying the morphology of human permanent teeth. These include the use of radiography[8], placing files in the canals to determine the canal configuration, cutting the teeth at different levels[9], making polyester resin cast replicas of the pulp space[10], and clearing and injection of dye[11]. The clearing technique is valuable for studying root canal anatomy because it produces a 3D view of the pulp cavity[9], and instruments are not needed to enter the pulp system[7]. Therefore, this technique helps to maintain the original form of the pulp system[12]. Because of the accuracy of the clearing technique, this method was employed in this study. In addition, the

Vertucci classification[7] and additional classification of Sertet al.[13] were used for classification of the teeth.

Table 1. Canal configuration of mandibular first premolar having mesial invagination and average distance of initiation of mesial invagination.

Type of canal	No. of teeth	Average distance of initiation of mesial invagination from cusp tip
Type I	3	16.12
Type IV	1	13.52
Type V	9	15.74
Type VI	2	16.16
Type VII	1	13.68
Type 1-2-3	1	15.14
Type 1-3	1	14.47

Table 2. Canal configuration of mandibular second premolar having mesial invagination and average distance of initiation of mesial invagination.

Type of canal	No. of teeth	Average distance of initiation of mesial invagination from cusp tip
Type I	1	15.78
Type III	1	15.82
Type V	4	16.06
Type VII	1	14.46
Type 1-3-4	1	15.15

The study found that the mean length of the first and second mandibular premolars were 22.25 mm and 21.9 mm respectively. They were found to be in the range of previous reported studies[14- 17].

The incidence of multiple complex canal morphology occurring in mandibular first premolars was higher than that in second premolars and in agreement with studies reported previously [15, 18-23].

In the teeth with multiple canals, the type V (13% in first and 7% in second premolars) canal system was the most prevalent canal configurations. This is in accordance with the findings of other studies performed in different populations[15, 24]. Type V configurations are rather difficult to treat as one canal is bifurcated into two separate root canals. Direct access to the buccal canal is usually possible, whereas the lingual canal may be difficult to locate, as it tends to diverge from the main canal at a sharp angle. In addition, the lingual inclination of the crown tends to direct the instrument buccally, making location of a lingual canal orifice more difficult. To counter this situation, the clinician may need to extend the lingual wall of the access cavity more towards the lingual. Other canal configuration like type II (1% in first premolar), type III (2% in second premolars), type IV (2% in first premolars), type VI (2% in first premolars), type VII (1% of both first and second premolar) were also found, which are

challenging for complete debridement of canal space.

Table 3. Root canal system (internal morphology) of mandibular premolars.

		Mandibular first premolar(n= 100)	Mandibular second premolar(n= 100)
Type of canals	Type I	78	89
	Type II	1	0
	Type III	0	2
	Type IV	2	0
	Type V	13	7
	Type VI	2	0
	Type VII	1	1
	Type VIII	0	0
	Additional	2	0
	1-2-3 type Additional	1	0
	1-3 type Additional	0	1
	1-3-4 type Present-	10	12
Lateral canals	Absent	90	88
	Cornal 1/3	1	2
	Middle 1/3	4	3
	Apical1/3	5	7
Inter canal communication	Present	6	6
	Absent	94	94
	Cornal 1/3	0	0
	Middle 1/3	3	4
	Apical1/3	2	2
	Middle1/3 +apical 1/3	1	0
Apical delta	Present	9	15
	Absent	91	85

The present study also found three additional canal configurations, which were not included in any of the previous classification of root canal system. They were type 1-2-3 (2% in first premolars), type 1-3 (1% in first premolar) and type 1-3-4 (1% in second premolar) canal configuration [4].

In the present study, lateral canals were observed in 10% and 12% of the first and second mandibular premolars, respectively, and were found most frequently in the apical third of the root. These findings are lower than the results of previous studies[15,4,7]. Intercanal communications observed in the first and second mandibular premolars (6% and 6%, respectively) were also lower than the reported studies, but with similar pattern of distribution which was most common in the middle of the root canals[15, 4, 7].

Apical deltas were observed in 9% of first and 15% of second premolars. Their actual prevalence may be higher, as de calcification in clearing technique might lead to a loss of 0.5 to 1.5 mm of root apex and loss of apical deltas. Other techniques like Cone Beam Computed Tomography (CBCT) and microscopic computed tomography (micro CT) may be more appropriate, non-destructive method to study apical deltas.

The present study included 18 first premolars and 8 second mandibular premolars with mesial invagination (radicular groove) of the root. According to Ash (1999)[25], these are deep developmental grooves found on the surface of the root. These are different than mesial and distal developmental depression on the root, as there is definite in folding of cementum and dentin attempting to divide the canal space also. Out of 26 teeth with radicular groove only 4 teeth had type I and remaining all had complex variable root canal morphology (type III in 1, type IV in 1, typeV in 13, type VI in 2, type VII in 2, type 1-2-3 in 1, type 1-3 in 1 and type1-3-4 in 1).

Amongst the 26 mandibular premolars (18 first premolar and 8 second premolar) having mesial invagination of the root, the teeth with 2 canals (Type IV) had the mesial invagination initiating from the cervical half of the tooth root. The teeth with canal bifurcation (Type V) canal system had the invagination in the apical half of the root. The location of the canal bifurcation varied in accordance with the location of the point of initiation of invagination. There seems to be some anatomical correlation between mesial invagination of the root and the canal pattern confirming that the surface outline of the crown and root reflects the shape of pulp system.

Obviously, to clean, shape and obturate a canal, it must be first located. Use of radiographs of different angulations and CBCT help to give clue about the root canal system of teeth in-vivo and the dental operating microscope and fibreoptic endoscope may allow easier location of such canals. In roots that may contain two more canals, basic rule is to assume that the root contains two canals until proved otherwise.

Complex root canal anatomy frequently found with mandibular premolars among which more common with mandibular first premolars in Indian population. More than one canal was commonly found in the mandibular premolars with root invagination.

CONCLUSION

As premolars are considered as an enigma to endodontic, it is the need of the hour to understand the possible morphological variations of the root canal system to be able to successfully negotiate thereby reducing the failure rates of root canal treatments.

REFERENCES

1. Moayedi S, Lata DA. Mandibular first premolar with three canals. Endod 2004;16:26-9.

2. Baisden MK, Kulild JC, Weller RN. Root canal configuration of the mandibular first premolar. J Endod 1992;18:505–8.

3. Robinson S, Czerny C, Gahleitner A, Bernhart T, Kainberger FM. Dental CT evaluation of mandibular first premolar root configurations and canal variations. Oral Surg Oral Med Oral Pathol Oral Radiol and Endod 2002;93:328–32.

4. Awawdeh LA, Al-Qudah AA. Root form and canal morphology of mandibular premolars in a Jordanian population. Int Endod J 2008;41:240–8.

5. Ingle JI. Endodontics. 3rd ed. Philadelphia: Lea & Febiger; 1985.

6. Slowey RR. Root canal anatomy: road map to successful endodontics. Dent Clin North Am 1979;23:567-70.

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

8. Haddad GY, Nehme WB, Ounsi HF. Diagnosis, classification, and frequency of C-shaped canals in mandibular second molars in the Lebanese population. J Endod 1999;25:268-71.

9. Weine FS, Pasiewicz RA, Rice RT. Canal configuration of the mandibular second molar using a clinically oriented in vitro method. J Endod 1988;14:207-13.

10. Skidmore AE, BjorndalAM. Root canal morphology of the human mandibular first molar. Oral Surg Oral Med Oral Pathol 1971;32:778-84.

11. 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 1969;28:419-25.

12. Barker BC, Lockett BC, Parsons KC. The demonstration of root canal anatomy. Aust Dent J 1969;14:37-41.

13. Sert S, Aslanalp V, Tanalp J. Investigation of the root canal configurations of mandibular permanent teeth in the Turkish population. Int Endod J 2004;37:494-9.

14. Ash MM. Wheeler's Dental Anatomy, Physiology and Occlusion. London, UK: Saunders Company; 1985.

15. Caliskan MK, Pehlivan Y, Sepetcioglu F, Turkun M, Tuncer SS. Root canal morphology of human permanent teeth in Turkish population. J Endod 1995;21:200-4.

16. Kim E, Fallahrastegar A, Hur YY, et al. Difference in root canal length between Asians and Caucasians. Int Endod J 2005;38:149–51.

17. Vertucci FJ, Haddix JE, Britto LR. Tooth morphology and access cavity preparation. In: Cohen S, Hargreaves KM, Pathways of the Pulp, 9th edn. St Louis, MO, USA: Mosby Elsevier; 2006.

18. Pineda F, Kuttler Y. Mesiodistal and buccolingual roentgenographic investigation of 7,275 root canals. Oral Surg Oral Med and Oral Pathol 1972;33:101–10.

19. Green D. Double canals in single roots. Oral Surg 1973;35:689 –96.

20. Zillich R, Dowson J. Root canal morphology of mandibular first and second premolars. Oral Surg Oral Med Oral Pathol 1973;36:738–44.

21. Vertucci FJ. Root canal morphology of mandibular premolars. J Am Dent Assoc 1978;97:47–50.

22. Trope M, Elfenbein L, Tronstad L. Mandibular premolars with more than one root canal in different race groups. J Endod 1986;12:343–5.

23. Sert S, Aslanalp V, Tanalp J. Investigation of the root canal configurations of mandibular permanent teeth in the Turkish population. Int Endod J 2004;37:494-9.

24. Yoshioka T, Villegas JC, Kobayashi C, Suda H. Radiographic evaluation of root canal multiplicity in mandibular first premolars. J Endod 2004;30:73-4.

25. Ash M. Wheeler's Dental Anatomy, Physiology and Occlusion. Philadelphia: W.B. Saunders Company; 1999.