Root form and root canal system of maxillary first premolar teeth in North Indian subpopulation of Sundernagar, district Mandi Himachal Pardesh.

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Abstract
Introduction: Knowledge of both normal and unusual configurations of the pulp is critical for the success of endodontic treatment. Clinicians performing endodontic therapy must know the size, location of the pulp chamber, and expected number of roots and root canals.
Objectives:The purpose of this study was to evaluate root form and root canal system of human maxillary first premolars in the North Indian subpopulation of Sundernagar, Himachal Pradesh using Clearing technique.
Methods: A total of two hundred fifty extracted human maxillary first premolars from the population of Sundernagar were collected. After cleansing of samples, access cavities were prepared, pulp tissue was extirpated, then immersed in 5% nitric acid for 5-7 days. These were rinsed, dried, and dehydrated using ethyl alcohol in increasing concentrations (70, 80, 90, and 100%). Then the teeth were rendered transparent by immersing in methyl salicylate. India ink was injected and specimen were evaluated for root canal system under 5X magnifying glass.
Results:76% were two root form followed by fused roots 73.6%, followed by one root form 21% and three root form 3% which had majority non-fused roots. The majority of samples were straight (60%). Majority of samples (40%) showed curvature in apical third and towards the mesial surface. 72% of the samples had two root canals. Type IV was most prevalent (47%) followed by Type II, Type I, Type III, Type VI. Lateral canals were present in 5%, accessory canals in 8%, apical delta in 7%, and intercanal communications in 22% samples.
Conclusion: It was concluded that in the Sundernagar population, Type IV is the most prevalent followed by Type II, Type I, Type III, Type VI. Two root form is common with fused root pattern.
Keywords: *clearing technique, maxillary premolars, unusual configuration of pulp, Vertucci's classification, endodontic therapy, root canal anatomy*

I. Introduction

In the study of human anatomy, root canal morphology often is most captivating and difficult to classify. The relative simplicity and uniformity of the external surfaces of roots often mask their internal complexity[1]. Numerous factors contribute to variations in root canal studies including ethnicity[2], age[3], gender[4,] etc. Other factors like the number of canals, direction, and depression of roots, pulp cavity configuration, and difficulty in visualizing apical extent by periapical radiographs complicate endodontic treatment[5].

Knowledge of both normal and unusual configurations of the pulp is critical for the success of endodontic treatment. Clinicians performing endodontic therapy must know the size, location of the pulp chamber, and expected number of roots and root canals. The chances of missed canals during root canal therapy are high leading to endodontic failures.

Human maxillary first premolars have been of great concern because of a lot of variations like the number of roots, canal configurations, direction and longitudinal depression of roots, twisted buccal root, short roots with two buccal roots with bifurcation, short roots with two fused buccal roots, three fused roots etc[5]. The literature conveys a divergence of opinion as to the anatomy of the pulp cavity of maxillary first premolars[6].

In earlier studies prevalence of one root varies from 15.5% to 60%, two roots 40-80.9%, three roots 0.5-9.2%[5,7]. In previous Indian studies, there was an increased propensity of Type I, II, III, and IV canal morphology in maxillary first premolar Thus, it is evident that the anatomy of these teeth tends to have racial variations.

A variety of techniques have been proposed to permit visualization of the root canal system. The methods most commonly used in analyzing the root canal morphology are clearing and staining[6,8], conventional radiographs[7], digital and contrast medium enhanced radiographic techniques, radiographic assessment enhanced with contrast media[9,10,] and more recently computed tomographic techniques[11]. Current literature shows that in case of suspicion of unusual anatomies modern radiographical techniques like spiral computed tomography are highly helpful in making a proper diagnosis as they offer non-invasive reproducible techniques for three-dimensional assessment of root canal system[5]. But these modern radiographical techniques involve expensive equipment, so canal clearing and staining are generally considered the gold standard for the in-vitro studies. O.E.Omar[12,13]in 2001 reported the advantage of using this technique as it demonstrates three dimensional, morphologically accurate, dyed pulpal spaces of a tooth that would be correctly positioned within a transparent tooth structure. Moreover, not much instrumentation is needed to enter and study the pulp system[14]and thereby this technique helps to maintain the original form of the pulp system[15]

There are very few clinical studies in Himachali population like finding the prevalence of Radix entomolaris in mandibular first molars[16,17] but Information on root and canal morphology of maxillary first premolars in the subpopulation of Sundernagar is not available and published yet; therefore this study aimed to evaluate root form and root canal system of human maxillary first premolarsin the north Indian population of Sundernagar.

II. Materials And Methods

A total of 250 extracted human maxillary first premolars collected from patients who came to the Oral Surgery department of Himachal Dental College, Sundernagar. Teeth with intact roots and fully formed apices were included whereas teeth with fractured roots, immature apices, root canal treated, post and core and with resorbed teeth, roots were excluded. Samples were cleansed of blood, debris by immersing in 5% sodium hypochlorite(Avarice Industries). Teeth were preserved by soaking in 10% formalin till used for further study. Visual inspection of root morphology was made and findings were recorded.

Access cavities were prepared using diamond point round bur no.2 and pulp tissue was extirpated. Samples were immersed in a 5% nitric acid solution (Nice chemicals Pvt. Ltd.) which was changed daily for five days. Decalcification was confirmed and assessed by the insertion of the metal pin. Samples were rinsed, dried, and immersed in ethyl alcohol (Suzhou Laboratories,) in increasing concentrations 70, 80, 90, and 100% for 24 hours, 12 hours, 1 hour, and 1 hour respectively for dehydration. Finally, teeth were rendered transparent by immersing in methyl salicylate (Aggarwal pharmaceuticals). After complete transparency India Ink (Speed balls encre de Chine) was injected into root canals of transparent samples using a syringe.
Root canal morphology was examined under 5X Magnifying glass and then again preserved in methyl salicylate for future references.
The following observations were made:
1. Root form.
2. Location of furcation.
3. The number of root(s) and root canal(s).
4. Root canal configurations in each root.
5. Presence and location of intercanal communications.
6. Lateral canals.
7. Apical delta.

Vertucci's[14] classifications[1] and Sert&Byralli's[4] classification was used for the identification and classification of root canal anatomy in this study.
- Type I (1-1): Single canal runs from orifice to apex.
- Type II (2-1): Two canals arise from the pulp chamber which unites in its course into one.
- Type III (1-2-1): One canal arises from the pulp chamber and during its course splits into two. These two canals again unite into one before exiting from the apex.
- Type IV (2-2): Two canals run separately from orifice to apex.
- Type V (1-2): One canal arises from the floor of the pulp chamber and during its course divides into two.
- Type VI (2-1-2): Two canals start from the pulp chamber, during its course; they unite into one and then again divide into two before exiting from the root apex.

- Type VII (1-2-1-2): One canal leaves the pulp chamber, which divides and again unite into in its course and finally divide into two before exiting from the apex.
- Type VIII (3-3): Three canals leave the pulp chamber and run independently towards the apex.

III. Observations And Results

Out of 250 extracted maxillary first premolars 76% samples were observed two root forms majority fused 73.6% followed by one root form 21%. Only 3% samples had three root form with non fused pattern of the root but all samples had fused buccal roots. (Table 1)

On visual observation the majority of samples were observed to be straight (60%) and remaining were curved (40%) among which curvature was observed in the apical third of root and also towards the mesial surface. (Table 1)

Mesial depression was observed mostly in the cervical third of the crown (51%), the middle third of the crown (33%), and the remaining 16% were not defined. (Table 1)

Out of all samples, 52% showed two separate foramina followed by 47% one foramen majority of which had a central location (72%). (Table 1)

Among all the samples level of furcation is in the Cervical third of root (62%) followed by middle third (36%), only 3% of samples had furcation in the apical third. (Table 1)

72% of samples showed two root canals followed by a single canal in 27% samples. (Table 2)

Accessory canals were present in 8% of the samples; lateral canals in 5%; apical deltas in 7% and intercanal communications in 22% samples. (Table 2) According to Vertucci's root canal configurations (Figure1) Type IV was most prevalent (47%), Type II(22%), Type I (20%), Type III(5%) and Type VI (4%). Type V, Type VII, and Type VIII were not found in study samples.(Table 2) Two teeth showed additional configuration: Sert and Bayirli's (Figue2) Type XVI(2-3) and Type XIX (2-1-2-1).(Table 2)

IV. Discussion

There have been many studies on root canal morphology and root canal systems from more than 100 years. Success of endodontics depends on thorough knowledge of root canal anatomy not only its basic anatomy, but also variations. Numerous techniques have been approached to study root canal systems including visual examination and digital radiography (Erdal et al 2012)[18], root sectioning and radiographic examination (Atieh et al 2008)[19], cone beam computed tomography (S Magfuri et al 2019)[20] clearing techniques (Robertson et al 1980)[21]. It has been reported that fine details of root canals can be studied by staining and clearing technique (ShahriarShahi et al 2008)[22].

Sufficient sample size is very important consideration in studies, so that results are descriptive of population of Sundernagar, Himachal Pradesh. Samples were identified before access opening and external morphology was studied. Human maxillary first premolars always have been the source of lots of variations like number of roots, canal configuration, direction and longitudinal depression of roots, twisted buccal roots, short roots with two buccal roots, short roots with fused buccal roots, three fused roots etc.(Pecora et al 1991)[5]. After extraction teeth were placed into 5% solution of sodium hypochlorite for 48 hours to dissolve organic matter. The effectiveness of sodium hypochlorite in cleaning and disinfection is because of concentration of available chlorine and the pH of the solution (Fukuzaki S 2006)[23]. Samples were placed in 5% nitric acid at room temperature which was changed after every 24 hours. Some agents for decalcification process remove calcium ions completely and rapidly, which can result in irreversible damage to organic components, hence for this reason the percentage of nitric acid to be used is of utmost importance. Next the samples were dehydrated using 70% of ethyl alcohol for 12 hours, 80% for 12 hours, 90% and 100% for 1 hour each. There occurs loss of water via process of dehydration. After dehydration, the teeth were placed in a container containing methyl salicylate for 2 days to make them translucent (Vertucci 1984)[14]. Methyl salicylate tolerates more water as compared to other clearing agents and is not noxious. Following this the India Ink dye was injected into pulp chamber with the help of 26 gauge needle.

Of the 250 maxillary first permanent premolars studied, 76% were found to have two roots, 21% had single root and 3% samples had three roots and observation is similar to previous studies like Carns & Skidmore[24](72% two root form, 22% one root form and three root form 6%), Ugandan population[25] (73.3% two root, 26.7% one root and no three root form) and Pomeranian population[26](74.3% two root,15.5% one root and 9.2% three root form) . Whereas few populations have different trend like Brazilian population[5] (55.8% one root, 41.7% two roots and 2.5% three root form) and Indian study by Gupta et al[27] (53.6% one root, 21.6% two root form and 0.4% three root form) showed higher percentage of single rooted followed by two rooted and three rooted samples.

Among two root form 73.6% samples had fused root pattern and 26.3% had non fused roots. In three root samples 33.3% had fused and 66.6% had non fused root samples. In previous studies pattern of roots are different as majority of root patterns in two root form were non fused like Carns and Skidmore[24] (57%),

Vertucci[14](56.5%) and Pomeranian population[26] (49.3%). Among three root form Pomeranians[26] showed same pattern of maximum samples with fused buccal roots and separate root pattern was more prevalent as compared to all fused roots.

In present study 60% samples were found to be straight and remaining 40% curved majority in apical third deviated to mesial whereas other studies have not documented data only observation mentioned like in Singaporeans[28] single roots were found to be straight and curvature found in apical third deviated to distal.

Mesial depression on crowns of premolars were found in cervical third (51%) and in middle third (33%). Level of furcation was found in 62% samples in cervical third followed by 36% in middle third and 2% in apical third. No other studies showed any data regarding these two features.

Presence of multiple foramina, accessory canals, lateral canals, apical deltas and intercanal communications are important part of root canal system. It is very important for clinician to have proper knowledge and familiarization with above mentioned features of internal morphology. The outcome of endodontic treatment can be influenced by presence of lateral and accessory canals as these can act as avenues for extension of disease from pulp to periodontium. Similarly presence of intercanal communications in teeth may be of clinical significance as these are difficult to debride and obturate adequately.

Accessory canals were present in 8% samples, lateral canals were present in 5% and intercanal communications were present in 22% samples. Other studies like Pineda & Kuttler[7] (41.2%), Awawdeh[8] (19.3%) and Gupta et al[27] (34.8%) showed lateral canals with higher prevalence as compared to present studies. Accessory canals in Indian studies had 15.6% prevalence higher than our present study. Intercanal communications were of higher incidence if compared to previous studies like Awawdeh[8] (7%) and Indian study by Gupta et al[27] (16%).

Apical delta is a branching pattern of small accessory canals and minor foramina seen at tip or apex of root. Presence of apical deltas may affect long term prognosis of root canal therapy because of incomplete debridement. Apical delta in previous studies showed prevalence like Pineda and Kuttler[7] (1.9%), Vertucci[14](3.2%), Awawdeh[8] (4.3%) and Sert and Bayirli[4] (30.4%) whereas in present studies only 7% samples were found with apical deltas.

Location and number of apical foramina is of clinical significance during working length determination. This depends upon the average position of apical constriction relative to root apex. Presence of multiple foramina in Himachali population were 52%(two)and 1%(three) and single foramen in 47% samples and majority samples were showing central location(72%).Our result was different from other studies like lesser than Kuttler (1972)[8](68%), laterally Vertucci(1984)[14] (88%), Awawdeh (2008)[8](40%) and Indian studies by Gupta et al (2015)[27] (50.8%+0.8%) multiple and (48.4%)single.

We found 47% of samples had Vertuccci's[14] Type IV most prevalent quite similar to Pineda and Kuttler[8] (41.7%), whereas other studies like Awawdeh[8] showed higher prevalence (62%).Type II in our studies showed 22% lower than Pineda and Kuttler[8] and higher than Vertucci[14].

Thus, we can say that root and canal morphology of Himachali population of Sundernagar maxillary first premolars is highly variable.

V. Conclusion

Within limitations of this study it was concluded that in Sundernagar population Type IV root canal configuration is most prevalent followed by Type II, Type I, Type III, Type VI in human maxillary first premolars. Additional classification Sert and Bayrili followed was rare Type XVI (2-3) and Type XIX (2-1-2-1), but clinician should keep it in mind while doing root canal treatment for premolars

Acknowledgement

Conflicts Of Interest

All authors of present study declare no conflict of interest.

References

[1]. Gurkirat Singh Grewal, Ajay Chhabra, Varun Jindal.Root canal morphology of mandibular premolars in North Indian population using Tooth Clearing Technique- An In Vitro Study, Dental Journal of Advance Studies 2015;.3 (3) :140-147.
[2]. Gulabivala K, Anug TH, Alavi A.Root and canal morphology of Burmese mandibular molars. IntEndod J 2001; 34(5):359-70.
[3]. Neaverth EJ, Kotler LM, Kaltenbach RF. Clinical investigation (in vivo) of endodontically treated maxillary first molars. J Endod 1987; 13(10):506-12.
[4]. Sert S, Bayirli GS. Evaluation of root canal configurations of mandibular and maxillary permanent teeth by gender in Turkish population. J Endod 2004; 30(6):391-8.
[5]. Pecora JD, Saquy PC. Root canal morphology of maxillary first premolar. Braj Dent J 1991; 2: 87-94.
[6]. Vertucci FJ.Root canal morphology of maxillary first premolar. J Am Dent Assoc 1979; 99(2):194-8.

[7]. Pineda F, Kuttler Y. Mesiodistal and buccolingualroentgenographic investigation of 7275 root canals. Oral Surg, Oral Med, Oral Pathol, 1972;33(1): 101-11.
[8]. Awawdeh L, Abdullah H, Al-Qudah A. Root form and canal morphology of Jordanian maxillary first premolars. J Endod 2008; 34(8):956-61.
[9]. Thomas RP, Moule AJ, Bryant R. Root canal morphology of maxillary permanent first molar teeth at various ages. IntEndod J 1993; 26(6):257-67.
[10]. Naoum HJ, Love RM, Chandler NP. Effect of X-ray beam angulation and interradicular contrast medium on radiographic interpretation of lower first molar root canal anatomy. IntEndod J 2003; 36(1):12-19.
[11]. Plotino G, Grande NM, Pecci R.Three dimensional imaging using microcomputed tomography for studying tooth macromorphology. J Am Dent Assoc 2006; 137(11):1555-61.
[12]. Omer Grduysus. Operating microscopes improves negotiation of canals in maxillary molars. Journal of Endodontics 2001; 27(1):683-6.
[13]. Omer OE, AI Shalabi RM, Jeenings M, Gleenon J, Claffey NM.Comparison between radiographic and clearing technique in the study of root canal anatomy in maxillary first and second molars: IntEndod J 2004; 37(5):291-6.
[14]. Frank J. Vertucci .Root canal anatomy of the human permanent teeth. Oral Surg, Oral Med, Oral Pathol, 1984; 58(5):588-99.
[15]. Barker BCW, Lockett BC, Parsons KC.The demonstration of root canal anatomy. Aust Dent J 14, 1969;14(1):37-41.
[16]. Verma, S., Goel, M., Singh, M., Mandhotra, P., & Kumar, V. Prevalence of Radix Entomolaris in Mandibular First Molars of North Indian Population of Sunder Nagar, Himachal Pradesh. JAMMR, 2018; 27(5), 1-6.
[17]. Verma S, Aggarwal R, Aggarwal R, Aggarwal S, Bala S, Goel M. Locating The Hidden Treasures In Endodontics: Radix Entomolaris: An Overview & A Case   Report. IndJ DentSci 54 (1), 713-719.
[18]. **ErdalOzcan, HakanColak, Mehmet Mustafa Hamidi.** Root and canal morphology of maxillary first premolars in a Turkish population. Journal of Dental Sciences 2012;7: 390-394.
[19]. **Momen A. Atieh.** Root and canal morphology of maxillary first premolars in a Saudi population. J Contemp Dent Pract , 2008;9(1):46-53.
[20]. **ShadiaMagfuri, Husain Keylani, Hitesh Chohan.** Evaluation of root canal morphology of maxillary first premolars by Cone Beam **c**omputed tomographic in Saudi Arabian southern region subpopulation: An In Vitro Study, International Journal OF Dentistry, vol 2019,Article ID 2063943, 6 pages..
[21]. **Robertson D. Leeb, J. Mckee.**A clearing technique for study of root canal systems. J.Endod ;1980;6(1):42-4
[22]. **Shahi S, Yavari HR, Rahimi S, Ahmadi A.** Root canal configuration of maxillary first permanent molars in an Iranian population. J Dent Res Clin Dent Prospect 2007;1 (2):59-64.
[23]. **Fukuzaki S**. Mechanism of sodium hypochlorite in cleaning and disinfection processes. Biocontrol Sci. 2006 Dec; 11(4): 147-57.
[24]. **E. J. Carns, A.E. Skidmore.** Configurations and deviations of root canals of maxillary first premolars; Oral Surg Oral Med Oral Pathol, 1973; 36(6):880-886
[25]. **Charles Mugisha, AneetKutesa, Louis Muwazi, William Buwembo.** Root and canal morphology of maxillary first premolars teeth in a Ugandan population. Open Journal Of Stomatology, 2011;1: 7-11.
[26]. M. Lipski, K. Wozniak. Root canal morphology of human maxillary first premolar Durham Anthropology journa, 2005;12:2-3.
[27]. Gupta S, Sinha DJ, Gowhar O. Morphology of maxillary first premolar. J Conserv Dent 2015; 18(3)232-236.
[28]. Loh H S. Root morphology in Singaporeans; Australian dental journal.1998;43(6):399-402.

Tables –

Table 1

s.no.	External root morphological features			
1	Number of roots	Single 21%	Two roots 76%	Three roots 3%
2	Root pattern (fused/Nonfused)	-	73.6%(Fused)	33.6%(Fused)
3	Root Curvatures(Straight/ curved)	Straight 60%	Curvature 40%	
4	Apical foramen	1 47%	2 52%	3 1%
5	Mesial Depression (crown)	Middle third 33%	Cervical third 51%	
6	Level of Furcation (root)	Cervical third 49%	Middle third 28%	Apical third 2%

Table 2

S.no.	Root canal system	Percentage		
1	Root canals	1 27%	2 72%	3 1%
2	Accessory canals	8%		
3	Lateral canals	5%		
4	Intercanal communications	22%		
5	Apical Delta	7%		
6	Vertucci's canal classification			
	a.Type I	20%		
	b. Type II	22%		
	c. Type III	5%		
	d. Type IV	47%		
	e. Type VI	4%		

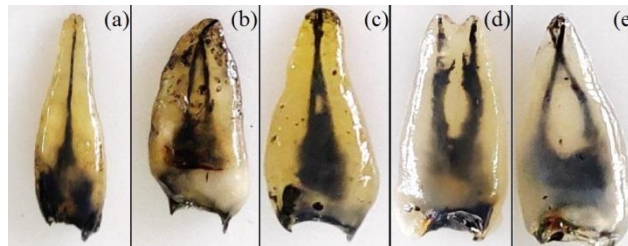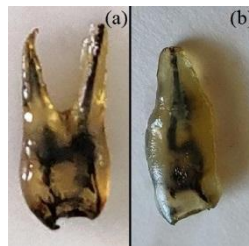| Sert and Bayirli's canal classification	
a. Type XVI	1%
b. Type XIX	1%

Figure 1

Figure 2

Legends –
Figure 1: Vertucci's Canal Classification a. Type I(1-1) b. Type II(2-1) c. Type III(1-2-1) d. Type IV (2-2) e.Type VI (2-1-2)
Figure 2: Sert and Bayirli's classification a. Type XVI(2-3) b. Type XIX (2-1-2-1)