Investigation of the root canal configurations of mandibular permanent teeth in the Turkish population

S. Sert[1], V. Aslanalp[1] & J. Tanalp[2]

[1]Department of Dentistry, Gulhane Military Medical Academy Haydarpasa Training Hospital; and [2]Department of Endodontics, Faculty of Dentistry, Yeditepe University, Istanbul, Turkey

Abstract

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Aim To investigate the root and canal morphology of mandibular permanent teeth collected from an indigenous Turkish population.

Methodology A total of 1400 extracted mandibular permanent teeth were evaluated. The teeth were divided into seven groups as central incisors, lateral incisors, canines, first premolars, second premolars, first molars and second molars in order to evaluate their root canal configurations. Access cavities were prepared and pulp tissue removed using 5.25% sodium hypochlorite solution. The teeth were stored in 5% nitric acid solution for 5 days, then rinsed under running water for 4 h and placed in increasing concentrations of ethyl alcohol. The teeth were rendered transparent by immersion in xylene solution for 3 days until complete transparency was achieved. Following this procedure, India ink was injected in the root canal systems and their configurations were examined and compared with the classification of Vertucci. The following observations were made: (i) root canal classification of mandibular teeth; (ii) morphology of the mandibular permanent teeth. The classification of Vertucci was taken as a reference during the evaluation; however additional canal morphological types were evaluated as separate groups.

Results The presence of a second canal was detected in 68% of mandibular central incisors and 63% of lateral incisors. Lateral canals were found in 6.5% of mandibular central incisors and in 13% of lateral incisors. Overall, 62% of mandibular first premolar teeth had a single canal whereas 71% of second premolars had a single canal. The mandibular first and second molar teeth exhibited similar root canal configurations except for a group of second molar teeth that had a single root and canal.

Conclusions The morphological characteristics of teeth in this Turkish population were consistent with those of other studies performed on different populations using similar methodology.

Keywords: mandibular teeth, morphology, root canal.

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Introduction

The study of root and canal anatomy has endodontic (Vertucci 1984) and anthropological (Tratman 1950, Dahlberg 1965, Walker 1988a,b) significance. It is important to be familiar with variations in tooth anatomy and characteristic features in various racial groups as such knowledge can aid location, negotiation and management of canals. Additionally, a number of studies have shown different trends in the shape and number of roots and canals amongst different races (Somogyi-Csimazia & Simmons 1971, Curzon 1974, Reichart & Metah 1981, Walker 1988a, Weine *et al.* 1988, Sperber & Moreau 1998). These variations

Correspondence: Dr Semih Sert, GATA Haydarpasa Egitim Hastanesi, Dis Servisi, 34668 Uskudar, Istanbul, Turkey (e-mail: semihsert@superonline.com).

appear to be genetically determined (Curzon 1974) and are important in tracing the racial origins of populations.

Many investigations have examined the configurations of root canal systems. These have included various methods including the use of polyester resin impressions, creating transparent samples and the use of radiographs in both *in vivo* and laboratory studies (Weine 1982, Vertucci 1984, Weine *et al.* 1988, Bram & Fleisher 1991, Kartal & Yanıkoglu 1992a,b, Calıskan *et al.* 1995).

A number of studies have concluded that the root canal system varies according to race. These studies have been mainly performed on the teeth of North American and Far Eastern populations (Vertucci 1984, Weine *et al.* 1988, Wong 1991). However, some studies have examined a Turkish population (Berna & Badanelli 1985, Kartal & Yanıkoglu 1992a,b, Calıskan *et al.* 1995).

The purpose of this study was to evaluate mandibular permanent teeth within a Turkish population.

Materials and methods

The teeth examined in this study were from Turkish citizens who were referred to the Dentistry Centre at the Gulhane Military Medical Academy for extraction. A total of 1400 teeth were collected. The teeth were divided into seven groups according to tooth type; 200 teeth were included in each group. The seven groups evaluated were: mandibular central incisors, lateral incisors, canines, first premolars, second premolars, first molars and second molars.

The gender and age of the patients was not known. The samples were stored in 5.25% sodium hypochlorite for 30 min (Sultan Chemist's, Istanbul, Turkey) for the removal of organic debris, then in 10% formaldehyde until use. The teeth were cleaned under running water, access cavities were prepared and the coronal pulp tissue extirpated in the canal orifices. The samples were stored in 5% nitric acid solution for 5 days (Aksın Kimya, Istanbul, Turkey). The solution was changed each day. Demineralization was assessed by the insertion of a needle in the crown; radiographs were taken to confirm demineralization. The samples were then rinsed under running water for 4 h. And then placed in 70, 80 and 95% ethyl alcohol (Kimetsan, Ankara, Turkey) successively for 1 day. At the end of this period, no opacity remained. The clearing procedure was completed by placing the samples in xylene (Riedel-de-Haen, Seelze, Germany). At the end of the third day, complete transparency was achieved. India ink was injected into the root canals of the transparented teeth using 22-gauge syringe. After the ink had dried, root canal morphology was examined and compared with the classification of Vertucci (1984). The samples that were not included in the classification (Kartal & Yanıkoglu 1992a,b, Gulabivala *et al.* 2001, 2002, Ng *et al.* 2001) (Fig. 1) were categorized and photographed.

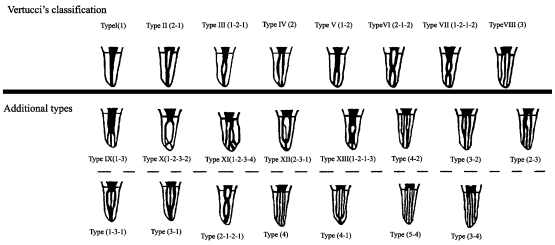

Figure 1 Classification of root canal system types.

Results

The results of the evaluation of the root canal systems in the seven groups are given in Tables 1 and 2 and Fig. 2a–g.

In the present study, variable root canal configurations were found in all of the mandibular teeth except the canine. The percentages of, the number and location of lateral canals, transverse anastomoses and apical foramina and the frequency of apical deltas are presented in Table 2. Lateral canals were found mostly in mesial and distal roots of mandibular first and second molars and in the mandibular second premolars.

Transverse anastomoses between canals were frequently seen in the mesial root of the mandibular first and second molars and mandibular lateral incisors. Lateral canals were found mostly in the apical area. Transverse anastomoses were found mostly in the middle third region.

The apical foramina were mainly localized laterally. Apical deltas were frequently seen in the mandibular central incisor and mandibular second premolar teeth.

Discussion

Although various techniques have been used in studies evaluating canal morphology, it has been reported that the most detailed information can be obtained by demineralization and staining (Vertucci 1984,

Table 1 Root canal classification of mandibular teeth (no. of teeth = 200 in each group; 1400 in total)

Teeth	Mandibular central	Mandibular lateral	Mandibular canine	Mandibular first premolar	Mandibular second premolar	Mandibular first molar		Mandibular second molar	
						M	D	M	D
Type1 I canal	65	74	152	121	142	4	107	25	152
Type 2 2-1 canal	55	54	32	37	14	88	25	63	11
Type 3 1-2-1 canal	54	53	13	21	7	10	42	43	26
Type 4 2 canal	20	19	3	14	18	86	19	56	4
Type 5 1-2 canal	1			5	14	2	5	4	5
Type 6 2-1-2 canal					3	2		2	
Type 7 1-2-1-2 canal					2				2
Type 8 3 canal	4			2		3	2		
Type IX 1-3 canal									
Type X 1-2-3-2 canal	1	1				5		7	
Type XI 1-2-3-4 canal									

Neaverth *et al.* 1987, Sieraski *et al.* 1989) which is regarded as an excellent method for three-dimensional evaluation of root canal morphology.

In most of these studies, the classification of Vertucci (1984) was taken as a reference. In the present study, additional root canal configurations (Kartal & Yanıkoglu 1992a,b, Gulabivala *et al.* 2001, 2002, Ng *et al.* 2001) along with the classification of Vertucci (1984) were taken into consideration.

The literature on mandibular teeth reveals that 11–43% of central incisors possess two canals with 1% having two separate foramina (Pineda & Kuttler 1972, Vertucci 1984, Calıskan *et al.* 1995). Kartal & Yanıkoglu (1992b), who investigated the canal configurations of mandibular central incisors in a Turkish population, reported that 45% of central incisors had a second canal. Calıskan *et al.* (1995) who performed a similar study determined the incidence of a second canal in a Turkish population to be 28%; they also reported that 96% of these two canals joined in the apical area and exited the apex as a single canal. They also determined the presence of three canals in 2% of cases. Moreover, in the two studies, the apical foramina are found mostly on the lateral distal surface (Calıskan *et al.* 1995).

In the present study, a second canal was detected in 68% of mandibular central incisors and 63% of lateral incisors. The large number of teeth examined in the present study may account for this substantially different result. Moreover, regional differences in a country may have an influence on the final outcome of morphological studies. Lambrianidis *et al.* (2001) also, reported that differences between the results of morphology studies may be due to variations of examination methods, classification system, sample size and ethnic background of tooth sources. The Turkish population originates from both Asia and Europe; therefore it is a blend of different races and may exhibit different traits. Although large numbers of teeth were examined in the present study, it must always be kept in mind that the sample must be regarded as biased in studies with extracted teeth as it is not a random selection and may not represent the whole population (Gulabivala *et al.* 2002).

The anatomies of mandibular premolars have been examined extensively (Pineda & Kuttler 1972, ElDeeb 1982, Shapira & Delivanis 1982, Vertucci 1984, Bram & Fleisher 1991, Wong 1991, Kartal & Yanıkoglu 1992a, Calıskan *et al.* 1995). Vertucci (1984) determined the incidence of a second canal in mandibular first premolars to be 26 and 3% for second premolars. The prevalence of lateral canals was 44% for the first premolar, and 48% for the second premolar. The incidence of an apical delta in these teeth was 9% whereas the ratio of apical foramina was 85% for the first premolar, and 84% for the second premolar.

Shapira & Delivanis (1982) reported a case of a mandibular second premolar with three roots and three canals. ElDeeb (1982) reported a mandibular second premolar with three canals, whereas Bram & Fleisher (1991) and Wong (1991) reported cases of mandibular second premolars with four canals.

In their study on a Turkish population, Kartal & Yanıkoglu (1992a) found the incidence of multiple canals in mandibular premolars to be 28% and that completely separate and independent two or three canal variations existed in a single root with a prevalence of 10%. More than 24% of the teeth with two canals had one root canal at the apex.

Table 2 Morphology of the mandibular permanent teeth

Teeth	Root	Number of teeth	No. of lateral canals	Position of lateral canals				Transverse anastomosis of canals	Position of transverse anastomosis			Position of apical foramen		Apical deltas
				Cervical	Middle	Apical	Furka		Cervical	Middle	Apical	Central	Lateral	
Mandibular central		200	13		15,38	84,62		63	26,98	66,66	6,34	65	135	59
Mandibular lateral		200	26	19,23	38,46	42,31		74	13,51	64,86	21,62	94	106	39
Mandibular canine		200	29	17,24	20,68	62,06		9	55,55	44,45		65	135	28
Mandibular first premolar		200	28		28,57	71,43		14	42,85	21,43	35,72	95	105	31
Mandibular second premolar		200	33		72,72	27,28		12	50	50		70	130	51
Mandibular first molar	M	200	55	12,72	20	67,72	22	132	24,24	38,63	37,12	65	135	25
	D	200	45	4,45	31,11	64,45	28	44	29,54	50	20,46	86	124	28
Mandibular second molar	M	200	58	5,18	32,76	62,06		76	19,73	44,73	35,52	47	153	27
	D	200	50	4	26	70	44	11	18,18	54,54	27,28	63	137	25

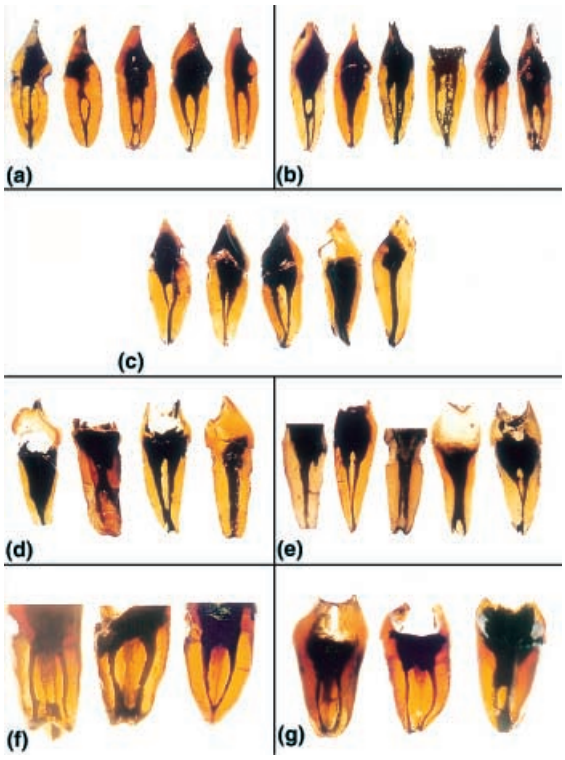

Figure 2 Transparent root canal appearance of mandibular permanent teeth: (a) centrals, (b)laterals, (c) canines, (d) first premolars, (e) second premolars, (f) first molars and (g) second molars.

Calıskan *et al.* (1995) encountered a single canal in 64% of first premolars and 94% of second premolars. They also reported 53 and 39% of these teeth had lateral canals respectively. In the present study, 62% of mandibular first premolars had a single canal whereas the prevalence of a single canal in the second premolars was 71%. In the first premolars, lateral canals existed in 16.5% of the cases whereas in the second premolars, the prevalence was 14%.

Vertucci (1984) reported the prevalence of type 1 (1) canals in the distal root of mandibular first molars to be 70% and type 2 (2-1) canal forms were seen in 28% of the mesial roots and type 4 (2) in 43%. Calıskan *et al.* (1995) encountered type 1 (1) root canal configurations in 61% of distal roots, type 2 (2-1) in 37% of mesial roots and type 4 in 44% of mesial roots. In the present study, most of the mesial roots of the mandibular first molars had two canals (98%) and demonstrated a wide variation of canal configuration. The most common were type 2 (44%) and type 4 (43%). Type 1 was encountered in 54% of distal roots. Thus,

the results of the present study are in agreement with those of Vertucci (1984) and Calıskan *et al.* (1995).

Weine (1982) reported a case where three canals existed in the mesial root of the mandibular first molar. Berna & Badanelli (1985) reported two cases where three separate canals existed in the mesial and distal roots of the first molar. In a study on the mandibular first molars, Gutmann (1978) determined the presence of accessory canals in 10% of the cases.

In the present study, two-rooted mandibular second molars had a single distal canal (76%) and two mesial canals (87.5%) that combined apically (53%). Calıskan *et al.* (1995) determined the prevalence of a single distal canal as 70% and two mesial canals as 90%, 41% of these mesial canals merge at the apex. However, in Vertucci's (1984) study, a single distal was found in 92% of the cases whereas the prevalence of two mesial canals was 73%, 38% of these mesial canals merged at the apex. The results of our study are in agreement with those of Calıskan *et al.* (1995) but differ from those of Vertucci (1984) and Gulabivala *et al.* (2001). This difference in the results may be due to the different populations examined.

Conclusions

The root canal anatomy of 1400 mandibular molar teeth was examined. Overall, 68% of the mandibular central incisors and 63% of the lateral incisors had a second canal. Lateral canals were encountered in 7% of mandibular central incisors and 13% of lateral incisors. Sixty-two per cent of mandibular first premolars had a single canal whereas the incidence of a single canal in the second premolars was 71%. The results of the mandibular second molars were similar to those of the first molar except for a case where a single root and canal existed.

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