

Root canal anatomy of the 236 mandibular canines

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Summary

To achieve the effect of mechanical preparation of root canals, transparent specimens of extracted 236 mandibular canines were investigated for canal configuration, thickness and curvature of the root canal, condition of any accessory canals, and location of the apical foramen. Fewer than 25% of the specimens showed accessory canals that were impossible to clean mechanically. The majority of the lateral branches were 0.15 mm \leq 0.20 mm. Although apical foramina located away from the apex were observed in 18% of the mandibular canines. All apical foramina were located within 0.5 mm of the apex. Data on the thickness of the root and main canal in the apical portion and curvature of the root canal suggest that for adequate apical preparation, a #60 file must be able to reach the apical constriction.

Introduction

One of the most important factors in endodontic therapy is the mechanical preparation of root canals. Despite the high success rates seen for appropriate endodontic procedures^{1,2}, a suitable method for cleaning complex root canals such as those with lateral branches or apical ramifications has not yet been established. Furthermore, cleaning narrow flattened canals or roots with a high degree of curvature is extremely ineffective^{3,4}.

Despite a lot of studies that have investigated the anatomy of root canals^{5,6}, researches specifically oriented toward developing a suitable endodontic therapy are scarce. For example, if accurate data on the size of the apex of root canals could be obtained, it might provide reliable standards for the amount of instrumentation normally required in this region. In an attempt to provide such data, Kerekes and Tronstad⁷⁻⁹ measured the diameter of root canals by taking sections of anterior, premolar, and molar teeth at 1, 2, 3, 4 and 5 mm from the apex. Based on these data, they then estimated the smallest size of instruments that would ensure, with 90% probability for each tooth type, adequate preparation of the circular-shaped canals at the various distance from the apex. Due to the small sample size (20 specimens of each tooth type), the reliability of their findings is compromised. Furthermore, as their measurements were obtained from the cross-sections of root canals, the ef-

fects of the curvature of the root canals on measurements could not be assessed in their analysis.

The condition of the accessory canals, such as the lateral branches, is another research field which requires further investigation. Although studies have shown a high incidence of furcation, particularly in the apical portion of the root^{10,11}, the influence of furcation size on the failure of endodontic therapy has not been investigated. Furthermore, data on the incidence of apical ramifications are extremely scarce. The present study investigated macroscopically specimens of extracted canines to determine canal configuration, thickness and curvature of the root canals, condition of any accessory canals, and location of the apical foramina.

The purpose of the present study was to provide clinical data on canal configuration in an attempt to more accurately assess the efficiency of mechanical instrumentation, thus providing better guidelines for the preparation of root canals in endodontic therapy.

Materials and Methods

A total of 236 extracted mandibular canines with no visible abnormalities were examined. Following manual surface cleaning, the teeth were placed in a 10% sodium hypochlorite solution in an ultrasonic cleaner to remove residual organic matter and surface debris. Radiographs of each tooth were taken from the labio-lingual direction, and then dye (India ink) was administered by the vacuum injection method¹². The stained teeth were decalcified using 10% nitric acid for 48 h and then were washed and dried. Transparent specimens were prepared by submerging the dried teeth in methylsalicylate. The specimens were then assessed according to the following categories by the naked eye.

The measurements of the main canals

The thickness of the main root canals, regardless of direction, was measured by determining the largest diameter at locations 0.5, 1, 2, 3, 4, and 5 mm away from the apical foramen toward the crown using the tip of the files as a reference. Measurements were classified into 5 groups with respect to the size of the file: less than 0.20 mm, from 0.20 mm to less than 0.40 mm, from 0.40 mm to less than 0.60 mm, from 0.60 mm to less than 0.80 mm, and over 0.80 mm. The curvature of the main canal was measured as the angle between the axis of the canal (as it extends away from the pulp cavity) and a line the foramen with the point where the canal may be discerned to diverge away from the axis. The curvature was classified in 10-degree increments (0 to 9, 10 to 19, 20 to 29, 30 or greater). The direction of curvature was classified as toward either the labial, lingual, mesial, or distal surface.

The measurements of the apical foramen

The straight line distance of the foramen from the apex was measured and classed according to 0.5 mm intervals. Teeth in which the apical foramen was eccentrically positioned were examined for the orientation of the orifice, using the same criteria described for lateral branch orifices. In cases of apical ramification, when a branch could be judged as the one that a probe would most likely follow, its orifice was defined as the apical foramen, and its distance from the apex and orientation were treated with the above manner.

The measurements of the accessory canals

The number of accessory canals (apical ramification and lateral branches) was counted for each

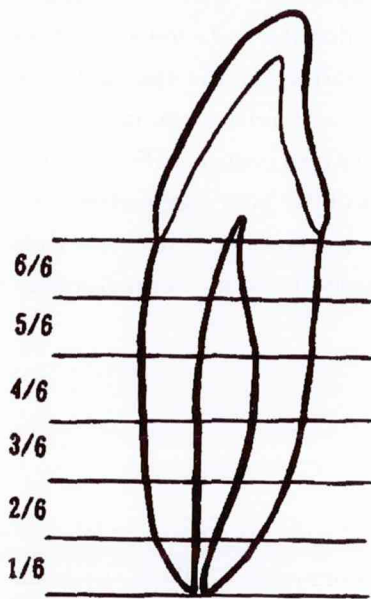


Figure 1 : Levels of lateral branch orifice.

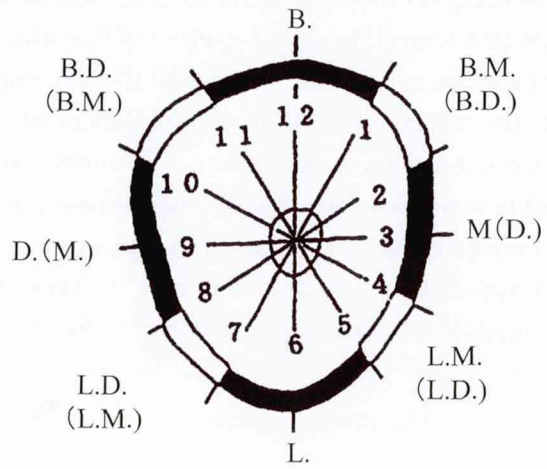


Figure 2 : Orientation of lateral branch orifice



Figure 3 : Teeth having lateral branches. Left, Teeth having lateral branches in the 1/6 portion, whose thickness was classed as roughly equal to 0.10 mm reamer. Right, Teeth having two lateral branches in the 2/6 portion. Thickness of branches, in order going toward apex, was classed as equal to 0.10 mm, and roughly equal to 0.15 mm reamer.

specimen. Each lateral branch was divided for this purpose into sixths, consecutively numbered from the apical (1/6) to the cervical (6/6) portions (Fig. 1). The orientation of each opening was classified according to criteria set forth by Yoshiuchi et al.¹⁹⁾. With the use of a hypothetical cross-section of a root with a lateral branch, the center of the labial surface is defined as 12 o'clock and the center of lingual surface as 6 o'clock. The labial (buccal) surface (B) is defined as the span between 11 and 1 o'clock, the mesio-labial (BM, or disto-labial, BD) between 1 and 2 o'clock, the mesial (M, or distal, D) between 2 and 4 o'clock, and so on. The orientation of each lateral branch orifice was classified according to these divisions (Fig. 2). Furthermore, the thickness of the lateral branches was measured macroscopically and categorized into 7 groups with respect to the size of the files less than 0.10mm, approximately 0.10mm, approximately 0.15mm, approximately 0.20mm, approximately 0.25mm, approximately 0.30mm, and over 0.30mm (Fig. 3).

Results

Main Root Canal

Table 1 shows the thickness of main root canals. At the 0.5mm and 1mm levels, a peak can be seen from 0.20 mm to less than 0.40 mm, and 59.3% at the 0.5mm level, 53.4% at the 1mm level.

Table 2 shows the degree and direction of curvature of the main root canals. Most specimens were straight or almost straight (<10 degrees), and only 1.3% of the specimens had a degree of curvature greater than 20 degrees. Analysis of the direction of curvature showed that the canals were oriented toward all direction.

Table 1 : Thickness of main root canal (Mandibular canine)

Thickness	Distance from Apical Foramen											
	0.5mm		1mm		2mm		3mm		4mm		5mm	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Less than #20 reamer	9	3.8	1	0.4	1	0.4	2	0.8	2	0.8	3	1.3
From #20 to less than #40	140	59.3	126	53.4	104	44.1	69	29.2	38	15.9	19	8.0
From #40 to less than #60	75	31.8	95	40.3	112	47.5	117	49.6	90	37.7	62	26.2
From #60 to less than #80	12	5.1	12	5.1	14	5.9	33	14.0	70	29.3	76	32.1
More than #80 reamer	0	0.0	2	0.8	5	2.1	15	6.4	39	16.3	77	32.5

Table 2 : Degree and direction of curvature of main root canal (Mandibular canine)

Degree	Direction				Total	%
	B	L	M	D		
>30	0	0	0	1	1	0.4
20-29	0	0	1	1	2	0.9
10-19	3	0	1	9	13	5.5
0-9					220	93.2
Total	3	0	2	11	236	
%	18.8	0	12.5	68.8		

Apical Foramen

In the 236 teeth with a distinct apical foramen, 193 (81.8%) teeth had the foramen located at the

Table 3 : Orientation of eccentrically located apical foramen (Mandibular canine)

Eccentricity (mm)	Orientation								Total	%
	B	BM	BD	L	LM	LD	M	D		
2.0mm	-	-	-	-	-	-	-	-	-	-
1.5mm	-	-	-	-	-	-	-	-	-	-
1.0mm	-	-	-	-	-	-	-	-	-	-
0.5mm	21	4	2	3	-	-	11	2	43	18.2
0mm	-	-	-	-	-	-	-	-	193	81.8
Total	21	4	2	3	-	-	11	2	43	
%	48.8	9.3	4.7	7.0	-	-	25.6	4.7		
Eccentrically average (mm)	0.3	0.4	0.4	0.3	-	-	0.4	0.4		
Maximum (mm)	0.5	0.5	0.4	0.3	-	-	0.6	0.5		

center of the root apex. In the 43 teeth remainder (18.2%), the foramen was judged to be approximately 0.5mm away from the apex. Thus, a total of 100% of all foramina were located approximately 0.5mm or less from the apex. Data on the orientation of the eccentrically located foramina are given in Table 3.

Accessory Canals

In the 236 teeth that were assessed, 177 (75.0%) had simply a single main canal (Table 4). Apical ramifications were observed in 20 teeth; these all had only two branches. Lateral branches were observed in 40 teeth; within these 30 had only one lateral branch, 7 had two branches, 3 had three branches (Fig.4). Table 5 summarizes the thickness of the lateral branches. Thicker lateral branches tended to have fewer branches, and none of the branches were larger than a 0.20mm file.

All lateral branches were located in the apical third (1/6, 2/6), and there were no predominant tendencies with respect to the orientation of the lateral branch orifice (Table 6).

Table 4 : Classification of root canal system (Mandibular canine)

Type of canal	No.	Type of root canal system							
		Simple main root canal		Apical ramification only		Lateral branch (es) only		Both apical ramification and lateral branch (es)	
		No.	(%)	No.	(%)	No.	(%)	No.	(%)
Type I	232	174	(75.0)	19	(8.2)	38	(16.4)	1	(0.4)
Type II	4	3	(75.0)	0		1	(25.0)	0	
Total(%)	236	177	(75.0)	19	(8.1)	39	(16.5)	1	(0.4)

Table 5 : Thickness lateral branch (Mandibular canine)

Thickness	No.	%
Less than #10 reamer	24	46.2
From #10 to less than #15	20	38.5
From #15 to less than #20	8	15.4
Larger than #20 reamer	0	
Total	52	



Figure 4 : Teeth having apical ramifications. Left, cleared specimen showing two canals. Right, teeth with three canals.

Table 6 : Orientation and level of lateral branch orifice (Mandibular canine)

Level	Orientation								Total	%
	B	BM	BD	L	LM	LD	M	D		
3/6	—	—	—	—	—	—	—	—		
2/6	5	—	1	—	—	4	4	3	17	32.7
1/6	14	1	4	7	1	1	2	5	35	67.3
Total	19	1	5	7	1	5	6	8	52	
%	36.5	1.9	9.6	13.5	1.9	9.6	11.5	15.4		

Discussion

Pulpectomy and canal debridement have usually been performed only on the main root canal. It has been reported that, despite the existence of untreated accessory canals, good clinical results were obtained on mandibular canines, as well as on other teeth, when these procedures were done properly¹²⁻¹⁴. In this study, almost 40% of the mandibular canines examined had accessory canals that might be impossible to clean. Because most of the lateral branches were extremely small—more than 80% were the size of a 0.15mm file or less—it is likely that they will heal naturally after proper debridement and obturation of the main canal is performed.

In regard to the possibility of adequate mechanical enlargement of the main canal, we could ob-

serve, in the case of mandibular canines, that the root canal generally has a simple cylindrical shape. Moreover, the incidence of curvature severe enough to inhibit mechanical preparation is extremely low. Accordingly, it is possible to estimate the final size required for the apical portion from the basis of measurements on the apical part of the root canal. Data on the thickness of the canal over the first 5mm from the foramen indicate that preparation is normally adequate when the canal is enlarged to a 0.60mm file at within 1mm the foramen.

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抄録：下顎犬歯236歯の根管形態についての検討

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歯内療法における根管形成の際に，より正確な機械的器具操作や根管形成のための評価するために，抜去した下顎犬歯236歯の透明標本において，根管形態，根管の太さと湾曲，副根管の状況および根尖孔の位置について検討を行った．その結果，25%以下の標本において機械的には清掃不可能な副根管が認められた．また，ほとんどの側枝は細く，0.15mm ファイル以下であり，0.30mm ファイルを越える太さの側枝はみられなかった．下顎犬歯の18%で根尖と根尖孔の位置の不一致が観察されたが，下顎犬歯236歯すべての根尖孔が根尖から0.5mm 以内に存在していた．今回の下顎犬歯の根管形態において，歯根の厚さ，根尖付近での主根管の太さ，根管の彎曲度を鑑み十分な根尖の拡大サイズは0.60mm ファイルはであると示唆された．