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Prevalence and extent of long oval canals in the apical third

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Objective. The aim of this study was to investigate the canal diameters in the apical roots of human teeth to determine prevalence and extent of long oval canals.
Study design. This investigation was carried out on 180 extracted human teeth, 20 for each tooth group. Each root was horizontally sectioned at 1, 2, 3, 4, and 5 mm from the apex. Canal diameters were measured with a measuring microscope.
Results. In 293 (25%) of the 1181 cross sections investigated, a long oval canal (the long canal diameter was at least 2 times the short canal diameter) was identified. In some tooth groups, the percentage of long oval canals exceeded 50%. In most cases, the long diameter decreased apically; that is, the canal tended toward a rounder cross section. A wide range of diameters existed in all canals.
Conclusion. Long oval canal is common in the apical 5 mm in human teeth. Many long and narrow oval canals would be impossible to instrument completely without perforating or significantly weakening the roots. Care should be taken in cleaning, shaping, and obturating these oval canals.
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During root canal treatment, canals are prepared by hand or by engine-driven instruments. Cutting is achieved by rotation or by a circumferential push-pull movement. Canal preparation is facilitated by irrigation with a solution, such as sodium hypochlorite. Whether the entire wall of the main canal can be safely instrumented depends on many factors, including the morphology of the canal, the thickness of the canal wall, and the size of the instrument used. Anatomic studies on tooth roots and root canals have provided useful treatment information.[1-4]

Canals have different shapes in cross section, including oval shapes, and difficulties have been noted in cleaning these oval canals.[5,6] Recesses in oval canals may not be included in a round preparation created by rotation of instruments, and thus they remain unprepared. One perception is that these recesses could be instrumented by circumferential filing with a small file. However, whether that is really the case in the apical root canals remains to be confirmed because the apical portion of instruments may not be easily controlled.

As reported by Mauger et al,[7] after resecting the apices of mandibular incisors at a 20-degree facial bevel, the average faciolingual diameter of canals was 0.75 mm at 3 mm from the apex. They found that oval canals occupied 42% and long oval canals occupied 40% of the investigated teeth. It seems that most canals of lower incisors were not round in shape; long oval canals may be more difficult to clean, shape, and obturate. In another recent study, apical canal diameter in the first upper molar was investigated.[8] Cross sections of most mesiobuccal canals were found to be oval.

The aim of our study was to investigate the canal diameters in the apical region of human tooth roots of different tooth groups. Also determined were the prevalence and extent of long oval canals.

MATERIALS AND METHODS

One hundred eighty extracted adult human teeth, which had been stored in 10% formalin solution, were randomly selected. Twenty teeth were selected, representing each of the following tooth positions: maxillary incisors and canine, premolars and molars, and

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Table I. Median (range) of canal diameters (in mm) at 1, 2 and 5 mm from the apex

	Buccal/lingual			*Mesial/distal*		
Tooth (canal) position	*1mm*	*2mm*	*5mm*	*1mm*	*2mm*	*5mm*
Maxillary						
Central incisor	0.34(0.15-0.69)	0.47(0.19-0.94)	0.76(0.30-1.20)	0.30(0.14-0.59)	0.36(0.17-0.72)	0.54(0.27-0.99)
Lateral incisor	0.45(0.27-0.83)	0.60(0.30-1.18)	0.77(0.46-1.30)	0.33(0.19-0.54)	0.33(0.17-0.51)	0.47(0.24-0.76)
Canine	0.31(0.16-0.58)	0.58(0.31-0.89)	0.63(0.41-1.26)	0.29(0.11-0.50)	0.44(0.24-0.57)	0.50(0.29-0.67)
Premolar						
Single canal	0.37(0.16-1.35)	0.63(0.27-1.26)	1.13(0.47-2.24)	0.26(0.14-0.37)	0.41(0.23-0.67)	0.38(0.29-0.49)
B	0.30(0.23-0.33)	0.40(0.12-0.67)	0.35(0.29-1.16)	0.23(0.20-0.27)	0.31(0.07-0.52)	0.31(0.20-0.62)
P	0.23(0.17-0.29)	0.37(0.26-0.80)	0.42(0.23-0.67)	0.17(0.17-0.19)	0.26(0.20-0.51)	0.33(0.18-0.50)
Molar						
Single MB	0.43(0.09-0.99)	0.46(0.34-0.96)	0.96(0.34-2.67)	0.22(0.13-0.39)	0.32(0.13-0.53)	0.29(0.15-0.56)
lst MB	0.19(0.12-0.26)	0.37(0.29-0.91)	0.46(0.23-1.11)	0.13(0.08-0.18)	0.27(0.11-0.41)	0.32(0.16-0.50)
2nd MB	0.19(0.14-0.23)	0.31(0.22-0.60)	0.38(0.19-1.21)	0.16(0.15-0.16)	0.16(0.09-0.23)	0.16(0.09-0.35)
D	0.22(0.07-0.73)	0.33(0.18-1.33)	0.49(0.24-1.54)	0.17(0.07-0.39)	0.25(0.15-0.31)	0.31(0.20-0.60)
P	0.29(0.09-0.45)	0.40(0.12-0.59)	0.55(0.31-0.91)	0.33(0.11-0.72)	0.40(0.27-0.94)	0.74(0.31-1.45)
Mandibular						
Incisors	0.37(0.13-0.80)	0.52(0.28-0.98)	0.81(0.29-1.80)	0.25(0.12-0.33)	0.25(0.12-0.51)	0.29(0.19-0.49)
Canine	0.47(0.18-0.75)	0.45(0.28-0.71)	0.74(0.48-1.68)	0.36(0.18-0.72)	0.36(0.28-0.63)	0.57(0.34-0.85)
Premolar						
Single	0.35(0.20-0.80)	0.40(0.29-1.01)	0.76(0.52-1.67)	0.28(0.16-0.54)	0.32(0.17-0.67)	0.49(0.26-0.80)
B	0.20(0.20-0.62)	0.34(0.27-0.62)	0.36(0.20-1.05)	0.23(0.23-0.28)	0.29(0.28-0.48)	0.41(0.30-1.10)
L	0.13(0.12-0.15)	0.32(0.24-0.38)	0.37(0.16-1.08)	0.18(0.10-0.23)	0.21(0.17-0.34)	0.17(0.12-0.54)
Molar						
Single M	0.45(0.06-0.60)	0.80(0.37-1.45)	2.11(0.48-2.89)	0.22(0.11-0.54)	0.30(0.14-0.55)	0.29(0.17-0.50)
MB	0.40(0.20-0.52)	0.42(0.28-0.77)	0.64(0.41-1.26)	0.21(0.19-0.39)	0.26(0.18-0.38)	0.32(0.24-0.42)
ML	0.38(0.32-0.67)	0.44(0.24-1.08)	0.61(0.12-0.89)	0.28(0.23-0.37)	0.24(0.16-0.42)	0.35(0.12-0.63)
D	0.46(0.28-1.69)	0.50(0.23-1.73)	1.07(0.58-2.78)	0.35(0.18-0.69)	0.34(0.18-0.61)	0.59(0.33-0.82)

M, Mesial; *B*, buccal; *D*, distal; *P*, palatal; *L*, lingual.

mandibular incisors and canine, premolars and molars. No information was available as to the ages of these teeth. The patency of each canal was confirmed by inserting a size-08 file through the apical foramen. Teeth with apical foramen that were more than 1 mm away from the apex were excluded.

Each root was horizontally sectioned with a low-speed saw at 1, 2, 3, 4, and 5 mm from the apex for a total of 1181 usable sections. The sections were glued on glass slides. Canal diameters were measured in the 5 cross sections from each tooth with a measuring microscope (Olympus STM, Tokyo, Japan) at ×30 magnification and were determined when the 2 investigators agreed. A canal was identified as long oval when the ratio of long to short canal diameter was ≥2 (ie, when 1 dimension was at least 2 times that of a measurement made at right angles).

Evaluation and comparisons were made descriptively; numbers and percentages of different canal shapes were compiled and reported in a tabular format for the tooth groups and different canal levels.

RESULTS

Canal diameters at 1, 2, and 5 mm from apex for all tooth groups are shown in Table I. The occurrences of the long oval canal are shown in Table II. Overall, in the 1181 cross sections evaluated, a long oval canal was identified in 293 (25%) cross sections. The other 75% were more round or slightly oval in shape. In all tooth groups, the buccal/lingual diameter was longer than the mesial/distal diameter, except for the palatal roots of maxillary molars. Generally, the long diameter decreased apically, meaning the canal tended toward a rounder shape.

Overall, 5 mm from the apex, the occurrence of the long oval canal was ≥50% in some tooth groups (Table II). In Table III these canals (n = 67) are grouped into different oval groups. In 25 (37%) canals, the long:short diameter ratio was ≤2×, that is, more round or slightly oval in shape. In 21 (31%) canals, >2× but ≤4×, there was a long oval shape. In the remaining 21 (31%) canals, there was >4×, that is, a flat shape.

The calculated tapers of apical canals are shown in Table IV. In some tooth groups, the taper in the mesial-distal direction was 0 to 0.02 mm/mm; the most apical portion of root canal was parallel or almost parallel. In all tooth groups, except for the buccal canal in mandibular premolars, the buccal-lingual taper was greater than that in the mesial-distal direction.

Table II. Percentage of long oval canals (ratio of long/short canal diameters ≥ 2) at 1-5 mm from apex

Tooth (canal) position	*1 mm*	*2 mm*	*3 mm*	*4 mm*	*5 mm*
Maxillary					
Central incisor	0%	10%	0%	5%	5%
Lateral incisor	16%	35%	10%	10%	15%
Canine	0%	6%	0%	0%	5%
Premolar					
Single canal	38%	29%	43%	57%	63%
Buccal canal	0%	7%	0%	8%	0%
Palatal canal	0%	15%	7%	0%	0%
Molar					
Single mesial-buccal	33%	13%	60%	75%	60%
1st Mesial-buccal canal	0%	27%	33%	17%	33%
2nd Mesial-buccal canal	0%	73%	80%	58%	60%
Distal-buccal canal	11%	30%	20%	20%	25%
Palatal canal	24%	16%	15%	15%	10%
Mandibular					
Incisors	10%	55%	40%	55%	56%
Canine	11%	5%	5%	5%	5%
Premolar					
Single canal	13%	13%	13%	20%	27%
Buccal canal	33%	0%	20%	0%	20%
Lingual canal	0%	0%	20%	20%	40%
Molar					
Single mesial canal	20%	45%	67%	91%	92%
Mesial-buccal	25%	25%	30%	56%	50%
Mesial-lingual	0%	25%	10%	11%	13%
Distal canal	24%	25%	25%	25%	30%

DISCUSSION

In a previous study, an oval canal was identified when the large diameter exceeded the small diameter.[8] Because there were very few canals in which 1 dimension was equal to that of a measurement made at right angles, many canals were oval. In our study, the prevalence of long oval canals, of which the long canal diameter was at least 2 times the short diameter, was investigated. The general percentage of long oval canal was 25%.

We found that in some tooth groups, cross sections cut at 5 mm from the apex showed a percentage of long oval canal of 50% to 92% (Table II); these cross sections were further used to observe how many canals fell into different oval groups (Table III). It was found that in cross sections, many canals had a flat shape; the long diameter was at least 4 times the short diameter (>4×, Table III). Flat canal occurred in one fourth to two thirds of several tooth groups. Obviously, these long and narrow canals would be very difficult to clean, shape, and obturate.

For these tooth groups, very long buccal-lingual diameters were recorded (Table I). A circular preparation would require instruments of a size that may perforate or significantly weaken the roots in a mesial-distal direction.

The taper of a prepared apical canal is 0.05 mm/mm when the master file is ≤45, as suggested by Weine.[9] However, this taper can be 0.1 mm/mm, according to West and Roane.[10] As shown in Table IV, the average taper of the original canal in the buccal-lingual orientation was 0.10 mm/mm, whereas the taper in mesial-distal direction was much smaller. In some tooth or canal positions the walls were essentially parallel (taper = 0 mm/mm). Instrumenting the canals to a taper of 0.05 mm/mm would leave uninstrumented areas in the buccal-lingual orientation. Increasing the taper from 0.05 to 0.10 mm/mm may be beneficial for the cleaning in the buccal-lingual direction. However, it will increase the diameter of the canal in the mesial-distal direction, thereby reducing wall thickness. To what extent this weakens the root is unknown.

In some teeth, the prevalence of long oval canals is relatively low, for example, ≤5% in maxillary central incisors and in both maxillary and mandibular canines (Table II). These canals were more round in shape. However, the range of canal diameters was wide (Table I). The recommended sizes[11] for the apical enlargement at different tooth positions may be used as references. Instrumenting all canals to a similar size, such as No. 80, would be inappropriate because some canals could be vastly overprepared and the roots weakened, whereas others may not be sufficiently cleaned (Table I). It seems necessary to accurately measure the size of

Table III. Canals that fall into different oval groups at 5 mm from apex

	Number of canals with different long:short diameter ratios							
Tooth (canal)Position	*Total*	*≤l.5x*	*≤2x*	*≤4x*	*≤6x*	*≤8x*	*≤10x*	*>10x*
Maxillary								
Premolar								
Single canal	8	1	2	3	1	1	0	0
Molar								
Single MB	10	1	3	2	0	2	1	1
2nd MB	10	3	1	4	1	0	1	0
Mandibular								
Incisors	19	7	2	5	3	2	0	0
Molar								
Single M	12	0	1	3	3	0	2	3
MB	8	2	2	4	0	0	0	0
	67	14	11	21	8	5	4	4

M, Mesial; *B*, buccal.

Table IV. Taper of root canals

	Taper in mm/mm in 2 orientations	
Tooth (canal) position	*Buccal/lingual*	*Mesial/distal*
Maxillary central incisor	0.11	0.06
Maxillary lateral incisor	0.08	0.04
Maxillary canine	0.08	0.05
Maxillary premolar		
Single canal	0.19	0.03
Buccal canal	0.03	0.02
Palatal canal	0.05	0.04
Maxillary molar		
Single mesial-buccal canal	0.13	0.02
1st Mesial-buccal canal	0.07	0.05
2nd Mesial-buccal canal	0.05	0
Distal-buccal canal	0.07	0.04
Palatal canal	0.07	0.10
Mandibular incisors	0.11	0.01
Mandibular canine	0.07	0.05
Mandibular premolar		
Single canal	0.10	0.05
Buccal canal	0.04	0.05
Lingual canal	0.06	0
Mandibular molar		
Single mesial canal	0.42	0.02
Mesial-buccal canal	0.06	0.03
Mesial-lingual canal	0.06	0.02
Distal canal	0.15	0.06
Average	0.1 ± 0.08	0.04 ± 0.02

any individual canal before deciding on the size of the apical enlargement, rather than simply relying on general recommendations.

Texts have recommended the enlargement of the apical root canal to 3 sizes larger than the first binding file.[9-12] The file is tapered and has its smallest diameter at the tip. This file may not bind at the working length but may bind at any level coronal; thus the size of the first binding file may not provide information for the diameter of the apical canal. A No. 10 file may bind in a variety of canals.[9] Binding by itself does not necessarily indicate the canal diameter (Table I).

It is also recommended that the canal be enlarged to a suitable size, that is, "enough to permit adequate debridement, as well as to permit manipulation and control of obturating materials and instruments, but not so much that the chances of making procedural errors and needlessly weakening the root are increased."[12] These statements are reasonable; diameters at 1 and 2 mm from apex (Table I) are useful in selecting files of suitable sizes for apical enlargement. To prevent occurrence of apical transportation, many authorities have advised preparation of curved canals with small instruments, preferably no larger than No. 25.[12,13] In some cases, a curved canal may have a larger diameter than a straight canal. The curved canals may not be clean after preparation to No. 25 (Table I).[14]

Because of long oval canals, larger canal tapers in the buccal-lingual direction, and a wide range in apical diameters of canals and the lack of technology to measure these diameters, it is very difficult, if not impossible, to adequately debride all canals by instrumentation only. Therefore, steps should be taken to enhance the efficacy of irrigation. Acoustic microstreaming by ultrasonic irrigation may clean the oval canal better.[5] Five percent sodium hypochlorite may be helpful in dissolving organic materials in those uninstrumented recesses.[15,16]

The mean value of apex to apical constriction distance was found to be 0.9 mm.[4] Thus, the diameters at 1 mm from apex shown in Table I are likely the smallest diameters of root canals. It has been suggested that a patency file be used in the apical foramen to remove the debris in the apical 1 to 2 mm of the root canal.[17,18] "The goal is to clean but not enlarge the foramen."[10] Thus, the data in Table I are useful in selecting patency files of suitable sizes for different canals.

With the findings of this anatomic study, it can be concluded that in approximately one fourth of the apical canals, the long canal diameter is equal to or larger than 2 times the short canal diameter; this discrepancy may complicate the root canal cleaning, shaping, and filling procedures.

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