FORMATION OF ROOT-CANALS IN HUMAN TEETH.¹ II

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UPPER FIRST AND SECOND MOLARS

In the upper bicuspid we noticed a wide differentiation in the form of the root-canals, but in the upper molars there is also a variety in the number and form of the root-canals, thus complicating the picture greatly. There are usually three roots present, of which one lies lingually and the other two on the buccal. The lingual root is usually the largest and rounder in form, while the mesio-buccal root is usually wider than the disto-buccal root and externally it not infrequently exhibits a longitudinal groove on the mesial and distal, as well as a flattening mesio-distally and a pointed apex. In rare cases four roots may be found. The fourth root appears to originate from the mesio-distal root and only shows rudimentary development (Moral).

The root-canals leading from the pulp chamber are in conformity with the roots, and in case of a fourth root there is also a separate fourth canal. Since formerly the number of root-canals were described as three, Preiswerk and then Fischer were the first to indicate that the mesio-buccal canal had a wide differentiation. Moral then called attention to a fourth canal, which he also described in its various forms. By means of my own observations I am able to verify the results of Moral.

¹"Zur Anatomie der Wurzelkanäle des menschlichen Gebisses," *Schweizerische Vierteljahrsschrift für Zahnheilkunde*, 1917. Translated by Newton G. Thomas, A.B., M.A., D.D.S., and Herman Redlich, Chicago, Illinois. Part I of this article, which is here concluded, was published in *Jour. Nat. Dental Assoc.*, VIII (September, 1921), 704.

Just as Muehlreiter described the formation of two canals in lower molars by means of the addition of dentin, we must assume the formation of two mesio-buccal canals in upper molars by the physiological addition of dentin, since the origin of the fourth canal from the lingual canal is excluded by this assumption and there is no independent origin (Moral). I am inclined to assume, in the majority of cases, a division of the mesio-buccal canal into two occurs in a physiological manner. Two canals will be found if the two longitudinal grooves are present on the mesial and distal of the root which compresses the root mesio-distally. By means of the grooves walls are driven inward into the lumen of the canal whereby a very fine split or even a complete separation of the canal into two results by the formation of new dentin.

The mesio-buccal canal in half the cases occurs as a simple flattened canal running to the disto-buccal from the pulp chamber to the apex. During youth these canals are simple and undivided (Plate XIII a, 1-17, Plate P 1, 1 and 2). As age advances a division of the mesio-buccal canal becomes noticeable. The division may begin near the pulp chamber and again unite in the apical third, ending as one simple canal at the apex, or the divided canals will again unite and finally end in a forked manner at the apex with independent openings. Numerous divisions of the canal may occur in which the canals at first divide and then reunite at different levels of the root, resulting in a number of connecting canals lying one above the other, similar to conditions found in the upper bicus-

Plate E 1

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Lower First and Second Molars

Plate E 2

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Lower First and Second Molars

Plate E 3

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Lower First and Second Molars

Plate F1

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Upper First and Second Molars

Plate F 2

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Upper First and Second Molars

pids (Plate XIII a, 25-36, Plate XIII b, 27-64, Plate F 1, 1-14).

Besides the various divisions of the mesio-buccal canal, there are also numerous apical ramifications and marrow canals which add to the complications. The finest apical ramifications are most numerous at the apex of the mesio-buccal root and are from four to six in number, arranged tuftlike (Plate d, 8, Plate h, 16, Plate g, 14, Plate i, 9, Plate P 1, 5, 6, 7, 11, 13, Plate XIII a, 28-36). Moral in his observations noticed that 63 per cent of the mesio-buccal canals divided into two, not including the end branches or apical ramifications. He called attention to the fact that the mesio-buccal canal exhibits these divisions into two canals and not the disto-buccal, as Fischer states. I am to verify Moral's results with respect to the statement that the mesio-buccal root is more often found divided than is the disto-buccal, which was already determined by Preiswerk. I was able to find only 53 per cent of the mesio-buccal canals with a division into two; apical ramifications were present in only 60 per cent, which coincides with Fischer's results. I was unable to find a fourth canal which ended in a lingual canal in my specimens, altho the source I often found to lie very near that of the lingual root-canal; it seems to me that the formation of a fourth canal may be explained in most cases as the result of an addition of dentin within the mesio-buccal root.

The disto-buccal canal is built much more simply and its volume is somewhat greater than that of the mesio-buccal canal. Mesio-distally it is somewhat flattened and usually continues to the apex as a simple canal where it splits up into apical ramifications. Here and there are indications of a division of the canal, as for example in Plate F 1, 11. The apical ramifications are least in the distal-buccal canal and never extend above 10 per cent.

The lingual or palatal canal is the largest of the three root-canals of the

upper molars. It has a straight course and gradually tapers toward its apex, giving off marrow canals to the periodontal membrane here and there. Apical ramifications are found in 20 per cent of them. In advanced years the number of marrow canals and apical ramifications decrease in all three root-canals. Here and there a number of fine marrow canals were found on the traylike surface at the base of bifurcation of the pulp chamber, as they were described by Fischer (Plate F 2, 3). Table 10 summarizes the conditions present in the upper first and second molars.

THE LOWER FIRST AND SECOND MOLARS

Just as the upper first and second molars exhibit highly complicated forms of their root-canals, so also the lower first and second molars show a great variety in form and number of their root-canals and awaken our interest in the extensive differentiation in structure of both roots.

The lower first and second molars usually possess two roots which lie one behind the other, the one mesial and the other distal. The distal root is usually somewhat smaller and more round in form, while the mesial root often is quite flattened and grooved longitudinally on the mesial and distal. Only in rare instances do the mesial and distal roots unite to form one compact mass. The occurrence of a third root is rare and, according to Muehlreiter, occurs only in the lower first molars. When present it always lies lingually, usually branching off from the distal root, and corresponds to the root designated as *radix praemolarica* by Bolk. Not infrequently the mesial root occurs with two apices.

According to Bolk there also may occur a splitting of the mesial root of the second lower molars having a *radix praemolarix* so that three anterior roots may persist. There may be a splitting of the mesial and distal roots resulting

in a four-rooted tooth but this is very seldom.

As a rule there are three root-canals in the lower first and second molars of adults, namely two separate mesial canals which may be connected by splits or connecting canals and a larger centrally placed distal canal. In teeth in which the growth of the root has not yet

of the mesial canal into two is explained as follows: During the formation of the mesial root the walls corresponding to the external grooving lie so close to one another at the center that sooner or later the formation of new dentin will separate the canal into two almost completely; however, there are exceptions. In older teeth it is frequently possible

TABLE 10. THE UPPER FIRST AND SECOND MOLARS

Age	Number	Number of Root-Canals					Number of Apical Branchings					Percentage	Number of Marrow Canals					Percentage
		1	2	3	4	5	2	3	4	5	1		2	3	4	5		
15-25	98			48	50		{ Mes. 5 Dist. 2 Pal. 3	5 3 4			10 5 6.5	}	10	1				9
25-35	240			120	120		{ Mes. 40 Dist. 15 Pal. 20	30 4 20	50 5 8	50 10 20	}		32	2				10
35-45	126			50	77		{ Mes. 10 Dist. 8 Pal. 12	30 4 9	25 4 4	51 10 20		}	23	2				11
45-55	48			20	28		{ Mes. 10 Dist. 2 Pal. 2	10 1 3		41 6 10	}		15					12
	512			238	275			129	123	92		67	80	5				16
				46%	53%													

been completed the mesial root will be found to have one large canal running from the pulp chamber to the apex and much compressed at its middle. The distal canal likewise is very wide, having a much rounder form and being slightly compressed mesio-distally (Plate F 1, 1-6, Plate VII a, 1-15).

After a completed formation of the root, differentiations occur in the mesial root which lead to the formation of two mesial root-canals so that three root-canals are present in all (Plates VII b and VIII a, Plate E 1, 7-11).

According to Muehlreiter, the division

to trace a fine microscopic split between the two canals in transverse sections of the root, since a complete fusion of the two walls is seldom and only occurs when an external splitting of the root is present.

The compression of the distal root is so slight and the walls are far enough apart to prevent a fusion which would result in two separate canals, even when the walls have attained their full thickness. However, if this does occur in exceptional cases the tooth concerned would have four root-canals.

Port has verified the results of Muehl-

reiter by sections of 55 young teeth and obtained the results given in Table 11.

In order to verify the results of Muehlreiter and Port, I have examined approximately 80 young lower first and second molars by the "corrosion method" and am able to support the statements

again unite below the separating wall and end either singly or divided, or the canals after once dividing may remain so, each ending separately at the apex. In addition, there are numerous intermediate stages forming anastomoses and bridges between the two separated ca-

TABLE 11. NUMBER OF ROOT-CANALS

Age	Number	Three-Root-Canals	Two-Root-Canals	Apex Open
6.....	1	....	1	1
7.....	4	....	4	4
8.....	7	6	1	7
9.....	8	4	4	6
10.....	12	9	3	9
11.....	12	10	2	3
12.....	5	4	1	2
13.....	6	5	1	--

of Muehlreiter and Port. Between the ages of six and nine, the lower first molars thruout show two canals and likewise in the second lower molars between the ages of twelve and fourteen (Plate VII a, 1-15). In the following years there is a gradual appearance of separating dentinal walls mesio-distally which divide the mesial root-canal into

nals (Plates VIII a, VIII b, IX a, IX b, Plates E2 and E3).

Besides these canal systems there are also numerous apical ramifications and marrow canals which penetrate the mesial root substance in addition to the two main canals and form a grate-like interruption in the apical region (Plates E2 and E3, Plates b, 4, g, 13, i, 18).

TABLE 12. NUMBER OF ROOT-CANALS

	Age	Number	Three-Root-Canals	Two-Root-Canals	Apex Open
First Molar.....	6....	....	....	....	....
	7....	2	....	2	2
	8....	6	....	6	6
	9....	8	2	6	6
	10....	17	10	7	9
	11....	15	9	6	5
Second Molar.....	12....	10	....	10	10
	13....	4	....	4	4
	14....	8	1	7	8
	15....	6	3	3	5
	17....	5	4	1	1
		81	29	52	56

two mesial canals (Plate VII a, 16-27), while the distal canal remains single. Table 12 gives the result of observations between the ages of six and seventeen:

The differentiation of the mesial root-canal continues in the following years by a further separation. The varied stages of division take place. The canals may separate to begin with and

The distal root-canal is much simpler in structure than the mesial, of much rounder form, and without special differentiations. Here and there a tooth may be found in which the distal root-canal shows a division, but in that case there is also an external splitting of the root into two. If similar methods of division take place in the distal root-

Plate G 1

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Upper Third Molars

Plate G 2

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Upper and Lower Third Molars

canal as in the mesial then there will be four root-canals (Plate E 3, 1, 4, 5). There are also numerous apical ramifications and marrow canals in the distal

ber of root-canals by Chauvin and Port. The latter obtained his results upon examining 491 lower molars. (Table 13). According to Port no difference exists

TABLE 13

	Number	Four Canals	Three Canals	Two Canals	One Canal
First Molar.....	137	9	110	17	1
Second Molar.....	125	8	96	17	4
Uncertain	229	8	180	35	6
Total	491	25	386	69	11

root-canal, but less in number compared with the mesial canals (Plate D, 7). The volumes of the root-canals decrease upon the increase of age. Out of 136 lower molars examined by Fischer, 26

between the first and second molars. My statements support the results of Port and therefore I have not sorted out the first and second molars in the summary of my observations. (Table 14).

TABLE 14. LOWER FIRST AND SECOND MOLARS

Age	Number	Number of Root-Canals				Number of Apical Branchings					Percentage	Number of Marrow Canals				Percentage
		1	2	3	4	2	3	4	5			1	2	3	4	
6-17	80	2	36	42	....	5	....	....	....	6						
18-30	210	..	43	157	16	Mes.	60	13	15	26	62	30	5	....	....	16
						Dist.	10	10	9	13	20					
30-40	200	..	19	181	4	Mes.	51	18	25	30	63	24	6	....	....	15
						Dist.	18	10	12	15	27					
40-50	22	..	....	21	1	Mes.	3	5	4	1	60	2	2	....	....	19
						Dist.	1	2	1	2	28					
	512	2	98	401	21		148	55	66	87	73	56	13	....	....	13.5
		0.3%	17.7%	78%	4%											

were free from branchings, the mesial root was branched in 70 per cent and the distal root in 26 per cent. I am able to support these statements of Fischer according to my own observations.

Statements have already been made with respect to the occurrence of a num-

UPPER THIRD MOLARS

The upper third molars may have two or three roots, and four and five-rooted teeth are also numerous. According to Schmidt, the roots of the upper third molar externally may pass thru all stages of development of either one more

or less rudimentary root, or an excess number. The frequency of this irregularity has been stated by various authors, Zuckerkandl, Muehlreiter, Preiswerk and others. Fischer then showed that this great external irregularity is also retained in the differentiation of the inner pulpal cavity and may result in the most complicated formations. The most common form is the result of fusion of the roots into one mass. In this case there will be one single wide root-canals as the result of the fusion of the several canals and the canal will end at the apex as a simple canal without further differentiations (Plate XV a 2, 3, 6, 9). In addition to this more in-

My results, which are based upon 95 molars, verify Fischer's results. Table 15 is a summary of my results according to ages.

LOWER THIRD MOLARS

Normally the lower third molars have two roots; however, there may be three to five present, but usually there is a fusion of the roots into one single root (Zuckerkandl). A splitting of the root is less frequent than in the upper, but according to Port, they show the same manifoldness as the uppers do with reference to position, size, abnormal twists and bends. With reference to branchings, the lower third occupies the lowest rank, which also corresponds to the in-

TABLE 15. UPPER THIRD MOLARS

Age	Number	Number of Root-Canals					Number of Apical Branchings					Percentage	Number of Marrow Canals					Percentage
		1	2	3	4	5	1	2	3	4	5		1	2	3	4	5	
20-30	20	4	12	4	....	....	2	10	....	....	....	60	....	....	....	....	....	....
30-40	33	..	13	20	10	2	22	15	2	2	....	84	8	3	....	....	....	22
40-50	25	..	3	15	4	3	8	7	3	5	....	91	5	3	....	....	....	35
	95	7	30	39	14	5	32	32	5	7	....	80	13	6	....	....	....	20
		6%	32%	41%	15%	5%												

frequent type, there will occur great variations in forms and numbers of root-canals. Besides the simpler forms of two or three canals, which may be connected by numerous anastomoses and canaliculi and in the apical region may break up into fine apical ramifications (Plate D, 8), the four and five-rooted forms offer a most complex network of canals, canaliculi, and apical ramifications, which prove that the upper third molar has the most differentiated root-canals (Plates XV a and XV b, 10-54, Plate G 1, 5-12, Plate G 2, 1-5).

The upper third molars hold the first place with reference to the number of apical ramifications as well as root-canals. Out of 16 examined upper third molars, Fischer found all except 1 branched; 3 had one root-canal, 4 had two canals, 7 had three canals, and 2 had four canals.

ner differentiations according to Fischer, since with respect to the apical ramifications they occupy the lowest rank among all molars.

As a rule, we find one to three root-canals which in general show an absence of the more delicate differentiations. Out of 81 examined, Port found 25 with three canals, 48 with two canals, 8 with one canal; while Fischer, after examining 33, found 7 with one canal, 26 with two canals, of which the mesial canal was found to give off 8 branches. In general the lower third shows simply constructed canals. Next to the relatively seldom occurring form with one wide canal and a fusion of the roots, the two-canal form with a mesial and a distal root-canal is the most numerous. The distal canal usually is round without branches, while the mesial canal shows fine ramifications here

and there. Contrary to the upper thirds, there are very few differentiations of the root-canals in the lower thirds. The anastomoses connecting canals, branchings, and network are almost entirely absent, which corresponds to Fischer's observations (Plate X, 1-27, Plate G 2, 7-11).

Table 16 is a summary of my observations on the lower third molars.

TABLE 16. LOWER THIRD MOLARS

Age	Number	Number of Root-Canals				Number of Apical Branchings				Percentage	Number of Marrow Canals				Percentage
		1	2	3	4	1	2	3	4		1	2	3	4	
20-30	14	3	11	....	....	1	....	....	....	7	....	....	....	....	14
30-40	46	1	35	10	4	....	5	....	....	11.5	....	2	....	....	5
40-50	20	....	10	10	....	....	3	....	....	14	....	1	....	....	5
	80	4	56	20	....	....	9	....	....	10.2	....	5	....	....	6
		5%	82%	13%											

CONCLUSION

1. The inner hollows of the roots of human teeth are usually in conformity with the outer form of the root but may show a more or less far-reaching differentiation according to the type of tooth by the appearance of (a) dentinal walls of division within the root-canals, (b) delicate apical ramifications, (c) marrow canals which pass to the peridental membrane from the main canal thru the dentin.

2. These formations of differentiation normally occur in teeth not externally marked, and are to be regarded as purely anatomical, relatively physiological products of development.

3. The form and number of root-canals are influenced greatly by the dentinal partitions within the pulpal cavity formed by means of a physiological addition of dentin. These occur especially in predisposed types of teeth, having lateral compressions and determine the extensive differentiations within the simple canal, which are characterized by the appearance of spaces, bridge-

like systems, and especially the final division of the canal into two separate canals. This division of the root-canals appears especially in the lower incisors and cuspids, the mesio-buccal root of upper first and second molars, and in the bicuspid.

4. The finer apical ramifications appear regularly in various human teeth and in a different numerical relation for

each type of tooth. They determine a netlike structure formed by numerous fine canaliculi at the root apices, especially in the upper third molars, in the mesio-buccal roots of the upper first and second molars, in the mesial roots of the lower first and second molars, and in the upper and lower bicuspid.

5. The marrow canals likewise occur in various types of human teeth and either represent connecting canals between the separate canals or as canals penetrating the dentin from the main canal to the peridental membrane singly or in numbers.

6. There is also an influence of age upon the form and number of the root-canals, since, in youth, before the closure of the apical foramen, the differentiations are absent generally, and after the closure of the apical foramen the division into two takes place accompanied by other differentiations. With the progress of age, there is a more or less regular increase in formation of dentin and a narrowing of the root-canal which may lead to a complete obliteration of the same.

Upper Central Incisors

1-20, Teeth from the ten-to-twenty-year period with wide root-canals of simple structure, the apical foramen still partly open.

21-41, Teeth from the twenty-to-thirty-year period, canals narrow, the appearance of apical twigs and marrow canals from pulp to periodontal membrane, the latter at varying heights.

Note.—Forms made of Woods metal, one of the eutectic group. Formula: bismuth 4, lead 2, tin 1, cadmium 1; fusing point, $60\frac{1}{2}^{\circ}\text{C}$.

30-40

30-40

40-50

Upper Central Incisors

42-51, Showing root-canal of the thirty-to-forty-year period with various marrow canals which run from the canals to the peridental membrane; also apical branches.

52-60, Teeth of the same period with less voluminous canals and but one marrow canal.

61-69, Teeth of the forty-to-fifty-year period with reduced canal volume, fewer marrow canals, and no apical branches.

Upper Lateral Incisor
 1-11, Root-canals of teeth from twelve-to-twenty-year group of simple but voluminous structure.
 12-20, Teeth of the same period with apical branches and marrow canals.
 21-30, Simple canals with reduced volume.

Age

Plate II b

31-40, Teeth with structure similar to that of Nos. 21-30, with a single marrow canal.
 41-50, Root-canals of teeth of thirty-to-forty-year group with numerous marrow canals exhibiting some apical branches.
 51-61, Strong narrowing of simple canals derived from forty-to-fifty-year-old teeth.

Upper Cuspid

1-9, Teeth from ten-to-twenty-year period with very voluminous root-canals and open apical foramen.

10-18, Teeth from twenty-to-thirty-year period with apical twigs and marrow canals.

19-37, Teeth from twenty-to-thirty-year period with narrow simple canals.

Upper Cusps

38-56, Root-canals of teeth from thirty-to-forty-year period reduced in volume with many marrow canals and apical branches.
 57-67, Root-canals of teeth from forty-to-fifty-year period showing greater reduction in size.
 63-65, Showing beautiful marrow canals.

Lower Central and Lateral Incisors

1-21, Teeth from twelve-to-twenty-year period with wide root-canals and no apical branches.

22-32, Teeth from twenty-to-thirty-year period of simple structure and reduced canal volume.

33-42, Teeth from twenty-to-thirty-year period with part of the canals in varying conditions.

Lower Central and Lateral Incisors

43-64, Teeth from thirty-to-forty-year period, some of simple structure showing narrowed canals, others showing a wider form in the second part of the canal; Nos. 43-45 show a terminal fork.

65-75, Teeth from forty-to-fifty-year period showing reduction of the canal volume.

Age

Plate V a

Lower Cuspid

1-20, Teeth of the twelve-to-twenty-year period with voluminosely built root-canals, some with open foramina; No. 4 has a marrow canal; No. 20 shows the beginning of a division of the canal.

21-30, Teeth of the twenty-to-thirty-year period showing lessening volume in single-compartment canals

Lower Cuspid

31-41, Teeth of the twenty-to-thirty-year period showing the bipartition of the root-canals in various stages with apical twigs.
 42-52, Teeth of the thirty-to-forty-year period with various forms of bipartition of the root-canals; Nos. 44, 45, and 47 present marrow canals.
 53-62, Teeth of the forty-to-fifty-five-year period with simple or divided canals and no apical branches.

Age

Plate VI a

12-25

25-35

35-40

Lower First Bicuspids

- 1-10, Teeth of the twelve-to-twenty-five-year group with open foramina.
- 11-20, Teeth of the twenty-five-to-thirty-five-year group with numerous apical branches and marrow canals.
- 21-24, Teeth of the thirty-five-to-forty-year period with reduced canal volume and with one compartment.

Lower Second Bicuspid

1-10, Teeth of the twelve-to-twenty-five-year group with voluminous root-canals and for the most part with open apical foramen.

11-29, Teeth of the twenty-five-to-thirty-five-year group, some with simple canals and some bipartite canals; Nos. 12, 13, 14, 27, 28, and 29 show two canals; Nos. 24 and 25 show intimation of a split into a third canal.

Age

Plate VII a

5-17

5-17

5-17

Lower First and Second Molars

1-15, Teeth of the five-to-seventeen-year period with wide spacious root-canals and open apical foramina, showing only one canal in mesial and distal root.

16-27, Teeth of the five-to-seventeen-year period which show different stages of division in the mesial root; apical foramina closed with apical branchings of the canals.

Age

Plate VII b

Lower First and Second Molars

28-39, Teeth of the eighteen-to-thirty-year period, part with only two root-canals and part showing the partition of the mesial root-canals.

Age

Plate VIII a

Lower First and Second Molars

40-66, Teeth of the eighteen-to-thirty-year period showing the complete division of the mesial canals as well as more seldom division of distal canals; in addition numerous apical ramifications and marrow canals are demonstrated.

Age

Plate VIII b

18-30

30-40

30-40

Lower First and Second Molars

67-73, Teeth of the eighteen-to-thirty-year period with two mesial canals, marrow canals, and apical branches.

74-86, Teeth of the thirty-to-forty-year period with two mesial canals in different conditions, with marrow canals and apical branches.

Lower First and Second Molars

87-105, Teeth of the thirty-to-forty-year period of simple structure with few marrow canals and apical branches.

106-112, Teeth of the forty-to-fifty-year period with reduced canal volume, the mesial canal divided with numerous anastomoses and apical branches.

Age

Plate IX b

40-50

40-50

30-40

Lower First and Second Molars

113-126, Teeth of the forty-to-fifty-year period with reduced canal volume, the mesial root-canal divided with marrow canals and apical branches.
127-132, Teeth of the thirty-to-forty-year period with divided mesial canals, apical twigs and marrow canals.

Age

Plate X

20-30

30-40

40-50

Lower Third Molars

1-9, Teeth of the twenty-to-thirty-year period with canals confusedly united by anastomoses.
 10-18, Teeth of the thirty-to-forty-year period with simple structure of canals and very few twigs at the apical foramina.
 19-27, Teeth of the forty-to-fifty-year period, canals reduced in volume of simple structure.

Upper First Bicuspids

1-10, Teeth of the ten-to-twenty-year period with very wide canals of single compartments and with open apical foramen.

11-20, Teeth of the twenty-to-thirty-year period showing divided canals in single-rooted bicuspids with marrow canals and apical branches.

21-30, Teeth of the twenty-to-thirty-year period showing two separate canals in double-rooted bicuspids.

30-40

30-40

40-50

Upper First Bicuspid

31-40, Teeth of the thirty-to-forty-year period showing various root-canal forms from a single compartment with an apical forking to a complex bridging between canals.

41-49, Teeth of the thirty-to-forty-year period with two separate canals and numerous marrow canals.

50-59, Teeth of the forty-to-fifty-year period with separate canals presenting numerous marrow canals and apical branches; Nos. 50, 51, 52, and 53 show a division of the buccal canals into two canals.

Age

Plate XII a

Upper Second Bicuspids

1-10, Teeth of the fifteen-to-twenty-year period with closed apical foramina presenting apical twigs and marrow canals.
11-20, Teeth of the twenty-to-thirty-year period, whose canals have less volume, apical divisions, and marrow canals.

30-40

30-40

40-50

Upper Second Bicuspid

21-30, Teeth of the thirty-to-forty-year period having a single-compartment canal ending in a fork which has fine apical divisions.

31-39, Teeth of the thirty-to-forty-year period with divided canals united by bridges in various ways.

40-50, Teeth of the forty-to-fifty-year period with variously formed canals.

Upper First and Second Molars

1-17, Teeth of the fifteen-to-twenty-five-year period with wide root-canals and partially open apical foramina.

18-36, Teeth of the twenty-five-to-thirty-five-year period, showing apical branches and narrow canals, the mesio-buccal root-canal being in various stages of division from a simple canal to fully divided canals with numerous anastomoses.

Age

Plate XIII b

25-85

25-85

25-85

Upper First and Second Molars

37-64, Teeth of the twenty-five-to-thirty-five-year period showing apical branchings and marrow canals with various stages of division of the mesio-buccal canals from a simple structure to a complicated bridging system; also a complete division of the canal.

35-45

35-45

35-45

45-55

Upper First and Second Molars

65-91, Teeth of the thirty-five-to-forty-five-year period with reduced canal volume and numerous apical twigs splitting from the mesio-buccal canal.

92-100, Teeth of the forty-five-to-fifty-five-year period with narrowed canals, the canals being of simple form with few apical twigs.

Upper First and Second Molars

110-130, Teeth of the forty-five-to-fifty-five-year period with reduced canal volume and only a few apical divisions.

Age

Plate XV a

20-30

20-30

30-40

Upper Third Molars

1-9, Upper third molar with one canal of simple form forking at the end, with apical twigs; age, twenty to thirty years.
 10-18, Teeth of the twenty-to-thirty-year period with two canals which divide in the apical region with cross-bridging and side canals.
 19-27, Teeth with three canals with numerous apical twigs and marrow canals beside numerous complicated cross-bridgings; age, thirty to forty years.

30-40

30-40

40-50

Upper Third Molars

28-45, Teeth of the thirty-to-forty-year period with two or three canals, fine apical canals, and marrow canals; Nos. 28, 31, 33 and 34 have youthful form of the twelve-year period.

46-54, Teeth of the forty-to-fifty-year period with four or five canals of complicated structure, apical twigs, marrow canals, and cross-bridging.