Radix mesiolingualis and radix distolingualis in a collection of permanent maxillary molars

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Two lingual root structures are occasionally found on human permanent maxillary molars. One of these is the normal lingual root, which is always present, the other is a supernumerary structure which can be located either mesiolingually (radix mesiolingualis (RML)) or distolingually (radix distolingualis (RDL)). The available literature refers only to the existence and location of RML and RDL. Very small materials have, quite simply, hitherto precluded a more detailed description of these roots. The large collection of extracted teeth at the School of Dentistry in Copenhagen now includes a non-random subcollection of 145 permanent maxillary molars, the root complex of which contains 2 lingual root structures. Based on this material it was possible to undertake a modern, systematic analysis of the macromorphological variation of RMLs and RDLs. In this study, which was mainly non-metric, criteria for the identification of RML and RDL were established. The analysis also showed that the lingual supernumerary roots were only rarely found on the first molar, but with increasing frequency on the second and third molars. Both separate and non-separate RML and RDL were observed. In the material, degrees of separation greater than 0.9 were registered, degrees of divergence up to approximately 45°, an apical bend of approximately 90°, and extreme apical slenderness. Even though the supernumerary roots described here do not occur very often, knowing about them is nevertheless clinically relevant in for example endodontic and surgical contexts.

☐ *Maxillary molars; permanent teeth; supernumeraray roots*

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It is well known that there is usually only 1 lingual/palatinal root on human permanent maxillary molars, but occasionally maxillary molars with 2 lingual root structures are found. Since one of these macrostructures is the normal lingual root that is always present, the other must necessarily be a supernumerary structure, which can be located either mesiolingually or distolingually. The authors propose to designate the former as *radix mesiolingualis* (RML) and the latter as *radix distolingualis* (RDL).

In some textbooks of normal macroscopic dental morphology (1–9), and in a very few similar works of pathological dental morphology (10–12), attention is directed towards permanent maxillary molar variants with 2 well-developed lingual root structures. Comments on or illustrations of such variants are also found in a few dental morphology theses, review articles, and debate contributions (13–21). Permanent maxillary molars with 2 lingual root structures have occasionally been observed during dental population studies (22–24). Furthermore, in recent years, endodontists have shown significant interest in permanent maxillary 1st and 2nd molars with similar root morphology and the consequent root canal configurations (25–35).

It is characteristic of the above-mentioned publications (1–35) that none of them adequately describes RML and RDL seen from a modern macromorphological point of view. Basically, only the existence and location of the roots are mentioned. The very small materials, often only a single tooth or a few teeth, have made it impossible to conduct a more extensive survey.

The large collection of extracted teeth at the School of Dentistry in Copenhagen now includes a significant number of permanent maxillary molars, the root complex of which contains 2 lingual macrostructures. On the basis of this material/subcollection, it has now become possible to conduct a systematic analysis of RML's and RDL's morphological variation.

In the light of the above, a study was planned, the purpose of which was: (i) to establish criteria for the identification of RML and RDL on permanent maxillary molars, (ii) to map the occurrence of these supernumerary roots on 1st, 2nd, and 3rd molar in the subcollection of permanent maxillary molars with 2 lingual root structures, and (iii) to register other clinically relevant macromorphological variables regarding RML and RDL, e.g. frequency of separation, degree of separation, degree of divergence, apical bend, and apical slenderness. The results obtained in the present study can later be related to the root canal conditions in RML and RDL, thus accentuating the clinical relevance of this article.

This article is part of a larger research project about supernumerary roots in human permanent molars. The results of three earlier surveys have already been published (36–38).

Materials and methods

Materials

The Department of Dental Morphology and Forensic Odontology at the School of Dentistry in Copenhagen has a substantial collection of extracted teeth: The Copenhagen Tooth Collection. These teeth have been sent unsorted to the Department by practicing dentists in Denmark between 1963 and 2000. On receipt, the teeth are properly cleaned. Up to March 2000 the major collection contained a subcollection of 145 permanent maxillary molars with root complexes having *2 lingual* root structures; 71 are from the right side, 74 from the left side. These teeth, which were identified by both authors, constituted the material for the present study.

Definitions and dental symbols

This publication presupposes a knowledge of the following dental macromorphological definitions and dental symbols.

Root cone. Constantly present macromorphological unit or element involved in the build-up of the root complex.

Supernumerary root. Inconstantly present macromorphological element.

Root component. Root cone combination that contributes to the build-up of the root complex of molars.

Root structure. Joint designation for root cone, supernumerary root, root component, etc.

Separation. The phenomenon that root structures are separate.

A root structure that at a given level is separate from one or several other root structures is designated as separate. A root structure that at a given level is connected to one or several other root structures is designated as non-separate.

Furcation. The part of the root complex that is located between separate root structures.

Frequency of separation. The frequency with which 2 root structures are separate in a population/sample.

Degree of separation. The maximal furcoapical extension in relation to the maximal cervicoapical extension.

Degree of divergence. The angle formed by the height axes in the cervical two-thirds, approximately, of 2 root structures.

The degree of divergence may be greater than zero, i.e. positive, equal to zero, or smaller than zero, i.e. negative. A positive degree corresponds to divergence between the above-mentioned height axes. A degree at zero corresponds to parallelism between the axes mentioned. Negative degree corresponds to convergence between the axes.

Apical bend. The phenomenon that the apical third, approximately, of a root complex or a root structure deviates from the direction of the corresponding, cervical two-thirds.

Apical slenderness. The phenomenon that the apical part of a root complex or a root structure is especially slender.

Symbols. The common symbol *M1 sup* is used for teeth 16 and 26, *M2 sup* for 17 and 27, and *M3 sup* for 18 and 28. For M1 sup, M2 sup, and M3 sup the common symbol *M sup* is used.

Methods

All the records were made in agreement with the relevant definitions presented above. The observations were made on completely dry teeth, chiefly in a stereomicroscope with a maximum magnification of ×15. All the permanent maxillary molars with 2 lingual root structures were first examined by both authors independently. It was necessary to include structures on the crowns in order to establish definitive criteria for identifying the lingual roots, after which both authors were able to classify all the teeth with identical results.

Results

Identification

It must be emphasized, by way of introduction, that on permanent maxillary molars three root components are a *constant* part of the build-up of the root complex: 1 lingual and 2 buccal, i.e. a mesiobuccal and a distobuccal component (39). By paying careful attention to these three root components, though primarily the *lingual* one, it was possible to determine the presence of a lingually located supernumerary root. Efforts were also made to identify the 2 lingual root structures using the criteria described below.

Radix mesiolingualis. The *lingual* part of the root complex is made up of 2 macrostructures, which are in principle cone-shaped and located mesially and distally. The structures are either separate or non-separate in relation to each other (Figs 1 and 2). The mesial of the 2 lingual root structures has direct affinity to the *mesiolingual* part of the crown, which is very pronounced (Fig. 3). Under these conditions, the mesial root structure is identified as RML, while the distal structure is identical with the lingual root component.

Radix distolingualis. The *lingual* part of the root complex is made up of 2 macrostructures, which are in principle

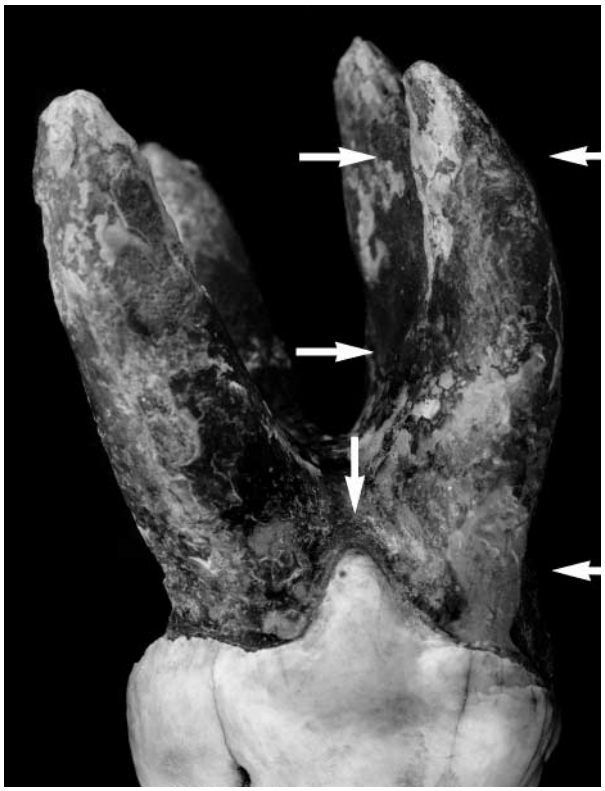

Fig. 1. M1 sup, lingual aspect; mesially to the right; ultra-violet exposure. Radix mesiolingualis and lingual root component are separate. Horizontal arrows indicate RML. Degree of divergence between the 2 mentioned root structures is approximately 45°. Vertical arrow marks a voluminous enamel extension between the same root structures.

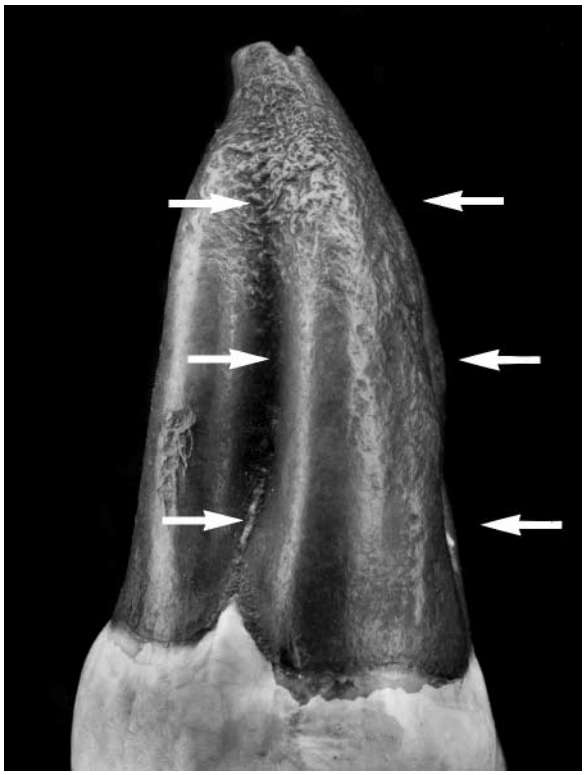

Fig. 2. M3 sup, lingual aspect; mesially to the right; ultra-violet exposure. Radix mesiolingualis and lingual root component are non-separate. Arrows indicate RML. The dividing groove between the 2 root structures is distinct.

cone-shaped and located mesially and distally. The structures are either separate or non-separate in relation to each other. The distal of the 2 lingual root structures has direct affinity to the *distolingual* part of the crown, which is very pronounced (Fig. 4). Under these conditions, the distal root structure is identified as RDL, while the mesial structure is identical with the lingual root component.

Radix mesiolingualis/distolingualis. The *lingual* part of the root complex is made up of 2 macrostructures, which are in principle cone-shaped and located mesially and distally. The structures are either separate or non-separate in relation to each other. The mesial of the 2 lingual root structures has direct affinity to the *mesiolingual* part of the crown, while the distal of the lingual root structures has direct affinity to the *distolingual* part of the crown. Both the mesiolingual and the distolingual part of the crown are very pronounced (Fig. 5). Under these conditions, the 2 current root structures *cannot* be identified with complete certainty. There are 2 possible structure combinations: it is either the RML and the lingual root component which are present, or it is the RDL and the lingual component.

Under the conditions mentioned, where the structures

Table 1. Distribution of 81 radix mesiolingualis in a collection of permanent maxillary molars according to root types

	M1 sup		M2 sup		M3 sup		Total	
	*n**	%	*n*	%	*n*	%	*n*	%
Separate	4	4.9	9	11.1	37	45.7	50	61.7
Non-separate	2	2.5	9	11.1	15	18.5	26	32.1
Separate/non-separate	1	1.2	0	0.0	4	4.9	5	6.2
Total	7	8.6	18	22.2	56	69.1	81	100.0

* Absolute frequency.

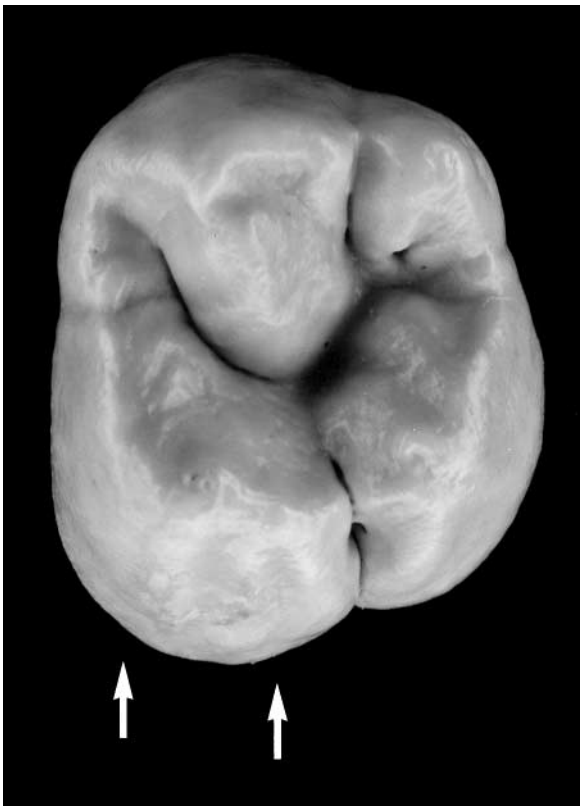

Fig. 3. M3 sup, occlusal aspect; lingually downwards, mesially to the left; ultra-violet exposure. Mesiolingual part of the crown is very pronounced. Arrows indicate the part of the crown concerned.

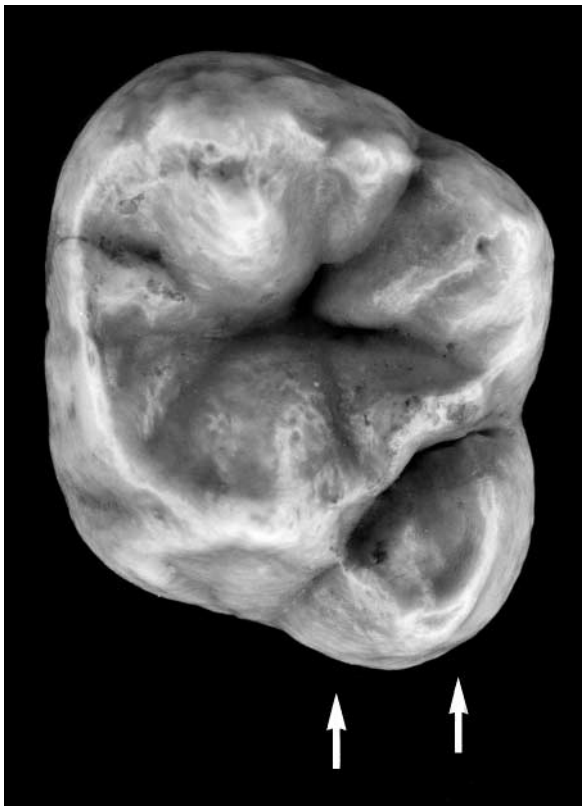

Fig. 4. M3 sup, occlusal aspect; lingually downwards, distally to the right; ultra-violet exposure. Distolingual part of the crown is very pronounced. Arrows indicate the part of the crown concerned.

Table 2. Distribution of 7 radix distolingualis in a collection of permanent maxillary molars according to root types

	M1 sup		M2 sup		M3 sup		Total	
	n	%	*n*	%	*n*	%	*n*	%
Separate	0	0.0	0	0.0	5	71.4	5	71.4
Non-separate	0	0.0	1	14.3	1	14.3	2	28.6
Separate/non-separate	0	0.0	0	0.0	0	0.0	0	0.0
Total	0	0.0	1	14.3	6	85.7	7	100.0

Table 3. Distribution of 57 2L variants in a collection of permanent maxillary molars according to root types

		M1 sup		M2 sup		M3 sup		Total	
		n	%	*n*	%	*n*	%	*n*	%
2LM	Separate	2	3.5	4	7.0	35	61.4	41	71.9
	Non-separate	0	0.0	0	0.0	6	10.5	6	10.5
	Separate/non-separate	0	0.0	0	0.0	10	17.5	10	17.5
Total		2	3.5	4	7.0	51	89.5	57	100.0
2LD	Separate	2	3.5	3	5.3	31	54.4	36	63.2
	Non-separate	0	0.0	1	1.8	10	17.5	11	19.3
	Separate/non-separate	0	0.0	0	0.0	10	17.5	10	17.5
Total		2	3.5	4	7.0	51	89.5	57	100.0

Fig. 5. M3 sup, occlusal aspect; lingually downwards, mesially to the right; ultra-violet exposure. Mesiolingual and distolingual part of the crown are very pronounced. Arrows indicate the parts of the crown concerned. A deep groove is visible between them.

cannot be identified with certainty, the mesial (M) of the 2 lingual (L) root structures is neutrally termed *2LM,* while the distal (D) structure is neutrally termed *2LD.* The following common neutral designation is used for the teeth concerned: *2L variants.*

The distribution in the material (subcollection) of RML, RDL, and the 2L variants on M1 sup, M2 sup, and M3 sup is given in Table 1, Table 2, and Table 3, respectively.

In Table 1, *separate* includes the variants on which RML was separate in relation to both the lingual and the mesiobuccal root component; *non-separate* covers the variants on which RML was non-separate in relation to one or both of the components just mentioned. Similarly, Table 2, *separate,* comprises the variants on which RDL was separate in relation to both the lingual and the distobuccal root component; *non-separate* includes the variants on which RDL was non-separate in relation to one or both of the adjacent components. In Table 3, 2LM *separate* covers the variants on which 2LM was separate in relation to both 2LD and the mesiobuccal root component; *non-separate* includes the variants on which 2LM was non-separate in relation to one or both of the root structures just mentioned. In the same table, 2LD *separate* lists the variants on which 2LD was separate in relation to both 2LM and the distobuccal root component; *non-separate* includes the variants on which 2LD was non-separate in relation to one or both of the neighboring root structures.

Under certain conditions it was impossible to decide whether an observed supernumerary root should be registered as separate or non-separate. This was the case for variants on which large cement deposits apically in the root complex had blurred the original macromorphology totally. Nor was it possible on root-open teeth with a demonstrated non-separate supernumerary root to decide whether the root would have remained non-separate, or whether separation would have occurred later in the root formation period. The RML, RDL, and 2L variants in question were therefore registered as *separate/non-separate.* Nor was it possible on such teeth to observe, for example, degree of separation, apical bend, and apical slenderness for the supernumerary roots concerned. Fracture of a root structure affected the same conditions.

Macromorphology

The location, principal shape, separation, or non-separation of RML, RDL, 2LM, and 2LD are discussed in the section "Identification". An account is given below of other clinically relevant conditions regarding the macromorphology of the supernumerary roots mentioned.

Relative size. On the individual tooth, radix mesiolingualis could have a larger or a smaller cervicoapical extension than both the mesiobuccal and the lingual root component. Variants were also observed on which RML was larger than one of the components just mentioned, but smaller than the other one. The smallest RML had a cervicoapical extension which was approximately two-thirds of the corresponding extension of the neighboring root structures.

Radix distolingualis could have a larger cervicoapical extension than both the distobuccal and the lingual root component; there were also variants on which RDL was smaller than the distobuccal root component, but larger than the lingual component. The differences in size were minimal in all cases.

On the individual tooth, 2LM could have a larger or a smaller cervicoapical extension than both the mesiobuccal root component and 2LD. Variants were also observed on which 2LM was larger than one of the neighboring structures, but smaller than the other one. The smallest 2LM had a cervicoapical extension which was approximately two-thirds of the corresponding extension of the mesiobuccal root component and of 2LD.

On the individual tooth, 2LD could have a larger or a smaller cervicoapical extension than both the distobuccal root component and 2LM. Variants were also observed on which 2LD was larger than one of the neighboring root structures, but smaller than the other one. The smallest observed 2LD had a cervicoapical extension which was

Fig. 6. M3 sup, lingual aspect; mesially to the left; ultra-violet exposure. Degree of separation between the 2 lingual root structures, 2LM and 2LD, is greater than 0.9, registered directly at the enamel line.

approximately three-fourths of the corresponding extension of the distobuccal root component and of 2LM.

Frequency of separation. As a supplement to the data presented in Tables 1, 2, and 3, it is worth noting the following.

Radix mesiolingualis non-separate was found on 26 teeth: RML was non-separate with both the mesiobuccal and the lingual root component on 11 of these teeth; on 10 teeth RML was separated from the mesiobuccal root component, but non-separate in relation to the lingual component; in addition, RML was non-separate in relation to the mesiobuccal root component and separated from the lingual component on 5 teeth.

On 1 of the 2 radix distolingualis non-separate, RDL was non-separate with both the distobuccal and the lingual root component; on the other tooth, RDL was separated from the distobuccal root component and non-separate in relation to the lingual component.

On 3 of the 6 2LM non-separate, 2LM was separated from the mesiobuccal root component, but non-separate in relation to 2LD; on 2 teeth, 2LM was non-separate in relation to the mesiobuccal root component and separated from 2LD; on the last tooth, 2LM was non-separate with both the mesiobuccal component and 2LD.

The total of 11 2LD non-separate variants was distributed as follows: 2LD was non-separate in relation to the distobuccal root component and separated from 2LM on 7 of the teeth; 2LD was separated from the distobuccal root component, but non-separate in relation to 2LM on 2 teeth; 2LD was non-separate in relation to both the distobuccal root component and 2LM on the last 2 teeth.

Degree of separation. The degree of separation between the following root structures was registered: (i) RML and the mesiobuccal root component, (ii) RML and the lingual root component, (iii) RDL and the distobuccal root component, (iv) RDL and the lingual root component, (v) 2LM and the mesiobuccal root component, (vi) 2LM and 2LD, and (vii) 2LD and the distobuccal root component.

The minimum for all degrees of separation was 0.0. The maximum for the degree of separation between RML and the lingual root component and between 2LM and 2LD was greater than 0.9 but less than 1.0 (Fig. 6), which is the absolute maximum for degrees of separation in the permanent dentition. For the other degrees of separation the maximum was 0.8.

On one and the same tooth, the degree of separation between RML and the lingual root component was often greater than the degree of separation between RML and the mesiobuccal root component. On one and the same tooth, the degree of separation between 2LM and 2LD was very often greater than the degree of separation between 2LM and the mesiobuccal root component. The degree of separation between 2LD and 2LM was very often greater than the degree of separation between 2LD and the distobuccal root component. A corresponding distribution pattern could not be demonstrated for the relatively few RDLs.

Degree of divergence. The degree of divergence was registered between the same root structures as listed under "Degree of separation".

All the degrees of divergence varied from slightly negative to relatively highly positive. The minimum was approximately −5°, the maximum approximately +45°. Maximal divergence was registered between RML and the lingual root component (Fig. 1) and between 2LM and 2LD; the percentage occurrence of a positive degree of divergence was greatest between the same root structures.

It should be added that on almost 70% of the studied M sup with 2 lingual root structures, a very characteristic, voluminous enamel extension was observed between them (Fig. 1). Its height and breadth varied somewhat. The high frequency of separation, high degree of separation, high degree of divergence of the lingual root structures, and the presence of a voluminous enamel extension are noteworthy. Enamel extensions of this nature only appear on M sup with 2 lingual root structures. This type of extension can accordingly—just like the macromorphological structural changes in the crown—be considered as a marker variable for this root constellation: a clinical clue.

Apical bend. RML, RDL, 2LM, and 2LD often presented apical bend, especially when the root structures were

separate. Bends of around 90° were identified. The direction of the bend varied.

Apical slenderness. RML, RDL, 2LM, and 2LD appeared frequently with apical slenderness, especially the separate roots. The degree of slenderness was occasionally extremely pronounced.

Discussion

The Copenhagen Tooth Collection, from which the teeth studied stem, consists of extracted teeth. The composition of this material may be affected by various, to some extent uncontrollable, factors; for instance, those connected with extraction and collection. Therefore the tooth collection cannot be regarded as quantitatively representative. Consequently, it is not possible to state any frequencies for the occurrences of RML and RDL in a population context.

Most of the teeth comprising the collection have probably been extracted from Danes, but a small proportion may well stem from immigrants. Accordingly, there is no guarantee that the macromorphological variants found in the collection are exclusively Danish.

The available material, consisting of M sup with an RML or an RDL, is so large, though, that it is highly probable it is *qualitatively* representative. From the point of view of variation there are hardly any significant RML or RDL variants—even when considered globally—that are not exemplified in the material. Even though the subcollection of permanent maxillary molars with an RML or an RDL must be regarded as a not particularly large non-random collection statistically speaking, the collection at the present time—considered from the viewpoint of dental morphology—must be characterized as probably the largest of its kind in the world.

Since there is no information available as to whether the individual teeth in the Copenhagen Tooth Collection were extracted from male or female patients, it was not possible to determine potential gender differences.

Apparently, 2 lingual root structures on the permanent maxillary molars does not arise by an apical division to a lesser or greater extent of the lingual root component. Such variants were not found in the material studied. On all the maxillary molars with 2 lingual root structures, these had been present already when root formation had started, i.e. they were recognizable in the cervical part of the root complex. At the same time, a remarkably strong development of certain macromorphological coronal structures on the lingual part of the crown, both occlusally and on the middle and cervical part of the lingual surface, was seen. The observed tight relationship between a root structure and a heavily manifested crown structure located in close proximity to one another has therefore been used to distinguish between the types of lingual supernumerary roots.

In a dental context, the names of dental structures are given according to their location on the tooth in situ. This is the case for both crown and root structures. The type division in this study is, therefore, related to the *location* of the supernumerary roots, to how well developed the occlusal structures are mesiolingually and/or distolingually, and to how well-developed the lingual cingulum is.

Supernumerary lingual roots have previously been discussed in the literature as anomalies or curiosities. In our non-random collection of permanent maxillary molars supernumerary lingual roots appeared only rarely on M1 sup, but with increasing frequency on M2 sup and M3 sup. Interest in supernumerary roots on the permanent maxillary molars has been rising in recent years because of the growing need for endodontic treatment of these teeth. This has created a need to diagnose variants with more root canals than usual, and to know the frequencies and ranges of variation for the total number of root structures and root canals found on the maxillary molars. Knowledge of the separate supernumerary roots is obviously also of relevance to the extraction of the molars in the upper jaw.

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