Root Trunk: Types and Dimension and their Influence on the Diagnosis and Treatment of Periodontally Involved First Molars

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ABSTRACT

Objective: To assess the dimension and types of root trunk of mandibular and maxillary first molars and their influence on the diagnosis and management of molars with furcation involvement.

Methods: A total of 105 extracted first molars were used in this study. Included teeth comprised 41 maxillary first molars, and 64 mandibular first molars. For each tooth, the vertical dimensions of the root trunk and root length were assessed with a micrometer caliber. The types of root trunk were classified according to the ratio of root trunk height to root length into types A, B and C. Types A, B and C are defined as root trunks involving the cervical third or less, up to half of the length of the root, greater than the apical half of the root respectively. The length of root trunk and the prevalence of different types of root trunk in maxillary and mandibular molars were analyzed. The percentage of root trunk to root length was also calculated.

Results: Root trunk types A, B and C accounted for 34.9%, 61.8%, and 3.3% of maxillary molars; 62.5%, 37.5%, and 0% of mandibular molars respectively. In maxillary molars, the prevalence of type-A was found to be 39.1% and 41.4% on the buccal and distal root trunks respectively, while less than that on the mesial root trunk (24.4%); the greatest prevalence of type B was found on mesial root trunk (75.6%) while type C was found only on the distal root trunk (9.8%). In mandibular molars, the type-A was found on buccal root trunk and lingual root trunk with a higher prevalence (73.4%, and 51.6%) than type B (26.6% and 48.4%) while no root trunk type C was found in lower molars. The mean root trunk dimension for maxillary molars was 4.9, 4.31, and 3.9mm for the mesial, distal and buccal respectively, while for mandibular molars 3.7mm for the buccal and 4.3mm for the lingual. It was also noted that as the mean root trunk increased, the mean root length decreased.

Conclusion: Awareness of root trunk type and dimension may help the practitioner in the diagnosis, treatment plan, and prognosis of periodontally involved molars.

Key Words: First permanent molar, Furcation involvement, Root trunk

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Introduction

Diagnosis, treatment, and prognosis of furcation involvement (FI) are still challenging problems in the field of periodontal therapy. The unpredictable results of periodontal therapy in furcation-involved teeth is due in part to the complexity of furcation morphology, such as cervical enamel projection,

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Fig. 1. Measurement of the root length using the micrometer caliber

Fig. 2. Measurement of the trunk length using the micrometer caliber

bifurcational ridge, root proximity, length of root trunk (RT), furcation entrance dimension, root fusion, and enamel pearls, for review see Matthews and Tabesh.[1] Of these factors predisposing to periodontal disease, enamel pearls were the only local anatomical factors investigated in the Jordanian population, and were reported to have a prevalence of 4.76%.[2]

The practical application of the anatomical knowledge to clinical dentistry is mandatory to improve the overall dental health service provided either as a preventive or therapeutic measure.

RT can be defined as the part of the root complex that extends between the cemento-enamel junction and the furcation entrance. Its height may be measured in millimeters or given in relation to the maximum length of the root complex.[3] Hou and Tsai in 1997 developed a classification scheme that takes into account the length of the RT compared to total root length. Type A has the shortest RT involving a third or less of the cervical area of the root, type B includes up to half of the length of the root, while in type C the furcation entrance is in the cervical two-third of the root or greater than the apical half of the root.[4]

The height of the RT in addition to the amount of horizontal and vertical bone loss were suggested to supplement furcation classification in order to facilitate the diagnosis, prognosis and treatment planning.[5,6] Tunnel preparation as a part of resective furcation therapy requires a short RT and a wide diameter of the furcation entrance for proper postoperative plaque control management by the patient.[7] In regenerative therapy, RT dimension is considered one of the relevant anatomical factors that may relate to the outcome of therapy.[8]

Furcation morphology of multi-rooted teeth, in particular first molars has been investigated in the literature.[9,10] However, The decision for a specific treatment mode for a periodontitis-affected furcation certainly depends on a careful diagnosis. Novel treatment modalities compel the therapist to acquire the necessary data and to correctly interpret the respective observations. A thorough and detailed diagnosis of all aspects of furcation involvement is demanding in clinical experimentation.[3]

The objective of this study was to assess the dimension and type of RT of mandibular and maxillary first molars and analyze their influence on the diagnosis and management of molars with furcation involvement.

Methods

For the purpose of this study, mandibular and maxillary molars were selected from an extracted teeth collection of a dental practice disposal of three Hospitals (Prince Aysha Medical Complex, Prince Rashed Ben Al-Hassan Hospital, and the Out-patient Clinics of King Hussein Medical Center). Teeth selection was based firstly on having intact roots and furcation regions, secondly on preserved cemento-enamel junction unaltered by loss of tooth substance due to dental caries, fractures, or tooth wear and thirdly on presence of sufficiently intact crowns to facilitate sorting of teeth according to general anatomical characteristics.

Of the 105 teeth retrieved, 41 were maxillary first molars, and 64 were mandibular first molars. To remove any attached soft tissue, all teeth were immersed in 5.25% sodium hypochlorite for 30 minutes, and then sterilized by autoclave. If any calculus obscured the furcation entrances or the root trunk, this calculus was removed gently using a manual curette scaler.

The vertical dimensions of the root trunk and root length were assessed with a micrometer caliber (Fig 1, 2). Measurements of the maxillary molars included the vertical height of the buccal root trunk (BRT), mesial root trunk (MRT), distal root trunk (DRT), mesiobuccal root length (MBRL), distobuccal root length (DBRL) and palatal root length (PRL). Similar measurements were obtained

Table I. The mean ± SD and range for the root and trunk lengths of the investigated teeth

Maxillary First Molar *(n:41)*			Mandibular First Molar *(no:64)*	
Mesiobuccal RL*	**Distobuccal RL**	**Palatal RL**	**Mesial RL**	**Distal RL**
12.88±2.9 (9.9-16.7)	11.95±2.8 (9.1-15.01)	13.09±3.2 (10.01-17.3)	13.96±3.66 (9.98-20.01)	13.54±3.25 (9.97-20.12)
Mesial TL**	**Distal TL**	**Buccal TL**	**Buccal TL**	**Lingual TL**
4.98±1.39 (3.2-7.7)	4.31±1.22 (3.4-7.8)	3.97±0.79 (2.8-7.6)	3.75±2.21 (2.4-6.5)	4.31±1.08 (2.6-6.6)

**RL: root length **TL: trunk length*

Table II. Types of root trunk in relation to the length of root trunk and root length with the percentage of the root trunk / root length in maxillary first molars

Maxillary Molars	Type of root trunk	Root *n (%)*	Length of root trunk *mean±SD (mm)*	Root length *Mean±SD* (mm)	% RT/RL
BRT (41)	A	16 (39.1)	3.48±1.8	13.36±3.0	26.04
	B	25 (60.9.)	4.99±1.2	12.14±1.6	41.1
	C	0	0	0	
MRT (41)	A	10 (24.4)	3.63±0.9	14.4±2.0	25.2
	B	31 (75.6)	5.23±0.8	12.73±2.5	41.08
	C	0	0	0	
DRT (41)	A	17 (41.4)	3.48±1.12	13.18±1.17	26.4
	B	20 (48.8)	4.99±0.1	12.32±1.5	40.5
	C	4 (9.8)	6.1±1.5	10.87±2.12	56.11
Total (123)	A	43 (34.9)	3.51±1.1	13.53±1	25.94
	B	76 (61.8)	5.09±0.1	12.43±3	40.94
	C	4 (3.3)	6.1±1.5	10.87±2.5	56.11

for mandibular molars, including buccal and lingual root trunks (BRT, LRT), mesial and distal root lengths (MRL DRL).

The types of root trunk were classified according to Hou and Tasi (1997)[4] based on the ratio of root trunk height to root length into types A, B and C. Types A, B and C are defined as root trunks involving the cervical third or less, the cervical third to one half and greater than the cervical half of the roots length, respectively. In order to determine the type of root trunk, the mean root length for each aspect of the tooth was measured *e.g.* the type of buccal root trunk of upper molars was determined by measuring the mean length of buccal aspect roots which is the sum of the mesiobuccal root length and distobuccal root length divided by two then this measurement was correlated with the length of the buccal root trunk. The length of root trunk and the prevalence of different types of root trunk in maxillary and mandibular molars were analyzed.

Results

The range and mean values of root trunk and root lengths for the examined teeth are presented in Table I. It can be perceived that, the shortest root dimension of the maxillary molars was the distobuccal followed by the mesiobuccal then the palatal (11.9, 12.8, 13mm). The variation between the mean dimensions of the mesial (13.96) and distal roots (13.54) of the mandibular first molars was less than 0.5mm. Regarding the root trunk dimension, the buccal root trunk was the shortest in comparison with other trunks for both molar types, the mean of the distal trunk of maxillary molars and lingual trunk of mandibular molars were similar (4.31mm). The range of the root trunk for maxillary molars was 2.4-6.6 mm, while for mandibular molars was 2.8-7.8 mm.

Table II and III lists the ranges and mean values of the types of root trunk relative to the dimensions of the root trunk and the root length in maxillary and mandibular first molars respectively. In maxillary molars, the prevalence of type A was found slightly greater on the DRT (41.4%) than the BRT (39.1%) while less than that on the MRT (24.4%). The greatest prevalence of type B was found on MRT (75.6%). In mandibular molars, type A root trunk was found on BRT and LRT with a higher prevalence (73.4%, and 51.6%) than type B (26.6% and 48.4%). No root trunks were classified as Type C except for the distal root trunk of the maxillary molars, in which four trunks were categorized as type C with a mean trunk length of 6.1mm and a mean root length of 10.9mm. It can also be observed that with increasing the mean root trunk there is a decreasing in the mean root length. The above tables showed also the total distribution and prevalence of root trunk types. Root trunk types A,

Table III. Types of root trunk in relation to the length of root trunk and root length with the percentage of the root trunk / root length for mandibular first molars

Mandibular Molars	Type of root trunk	Root *n (%)*	Length of root trunk *mean±SD (mm)*	Root length *Mean±SD* (mm)	% RT/RL
BRT(64)	A	47 (73.4)	3.3±0.21	14.30±0.5	23.07
	B	17 (26.6)	5±0.1	12.73±1	39.27
	C	0	0	0	
LRT(64)	A	33 (51.6)	3.7±2	14.57±3.92	25.39
	B	31 (48.4)	4.83±0.1	12.67±0	38.12
	C	0	0	0	
Total (128)	A	80 (62.5)	3.46±0.2	14.42±1.1	23.99
	B	48 (37.5)	4.89±0.35	12.69±1	38.53
	C	0	0	0	

Table IV. Comparison of root trunk dimension of mandibular and maxillary molars between this study and other studies

Author / year of publication	Maxillary Molars			Mandibular Molars	
	MRT	DRT	BRT	LRT	BRT
This study	**4.98**	**4.31**	**3.97**	**4.31**	**3.75**
Roussa 1998[13]	3.49	4.14	3.46	3.5	2.8
Plagmann *et al*. 2000[15]	4.8	4.5	4.3	4.3	3.3
Gher & Dunlap 1985[16]	3.6	4.8	4.2		
Dunlap and Gher 1985[17]				4.0	4.0
Rosenberg 1988[18]	5.0	3.5	3.0		
Mandelaris *et al*. 1998[19]				4.17	3.14
Kerns *et al*. 1999[20]	4.7	4.7	4.1	4.3	3.3
Porciúncula *et al*. 2007[21]	4.44	4.26	3.50		

B and C accounted for 34.9%, 61.8%, and 3.3% of maxillary molars; 62.5%, 37.5%, and 0% of mandibular molars respectively. It can be noted that the predominant root trunk for mandibular molars was type A while for maxillary molars was type B.

The percentage of root trunk to root length was also calculated (Table II and III). For maxillary first molars, it was found to be approximately 26%, 41% and 56% in case of root trunk type A, B, and C respectively, while for mandibular molars, this percentage was 24% and 38.5% for type A and type B root trunk correspondingly.

Discussion

There has been a significant increase in the knowledge and understanding of the etiology, pathogenesis, and treatment of inflammatory periodontal diseases over the past few decades. However, arriving at a diagnosis and determining the course of treatment are still based largely on basic clinical and radiographic techniques, such as conventional assessment of attachment and bone loss, which both have limitations. Therefore, knowledge of the anatomical and morphological features of roots is necessary to achieve better clinical practice in the field of periodontology. Extracted teeth is the most commonly used method to measure the morphological features of teeth, as this method provide a simple three dimensional insight profile view using different angles. In addition, accurate measurements and re-measurements are easy to perform and re-check at any point in time during the study or even afterwards.

Whilst handling of extracted teeth requires heat-sterilization prior to use for educational or research purposes according to infection control recommendations,[11] it was stated that autoclaving teeth does not appear to alter their physical properties or dimensions.[12] For infection control purposes, teeth used in this study were immersed in 5.25% sodium hypochlorite for 30 minutes followed by autoclave sterilization prior to handling.

Root length is directly related to the quantity of attachment supporting the tooth. Knowledge of root length is a critical element that allows an informed clinical decision regarding diagnosis, prognosis, and choice of treatment option of furcationally involved molars. The mean root length for maxillary and mandibular first molars in the present study was 12.6mm and 13.7mm respectively. For maxillary first molars the mean lengths of the mesiobuccal and palatal roots were closer (12.9, 13mm) and longer than the distobuccal root (11.9mm), while for mandibular first molars, the means of the mesial and distal roots were 14 and 13.5mm respectively. Different results were obtained by Roussa[13] for the maxillary molars who found that the distobuccal is the longest root (12.2mm) compared to 11.3mm and

11.2mm for the mesiobuccal and palatal respectively, while comparable results for mandibular molars in which they found that the means for the mesial and distal roots were 14.2 and 14mm respectively. However, racial variations in tooth morphology are known to exist, particularly with respect to first permanent molars.[14]

The results of this study regarding the mean root trunk height data for both maxillary and mandibular first molars appears within the range of the same measurements in comparison with other studies as shown in Table III.[13,15-21] Both maxillary and mandibular first molars in this investigation had shorter root trunks on the buccal aspects than on lingual, mesial and distal sides, whereby mandibular first molars generally had shorter root trunks than that of maxillary first molars, a finding that is also comparable with others.[13,15,18-21] The length of the mesial and distal root trunks of the maxillary first molar varies between different studies. In the present study, the mean of the mesial root trunk length was greater than the distal, this finding was in agreement with others[15,18,21] while disagrees with some others who found that the distal root trunk was longer than the mesial one.[13,16] Whereas a similar root trunk length for the mesial and distal trunks was found by some studies.[20]

Examination of proximal furcation is more difficult than the buccal and lingual ones in particular when neighboring teeth are present. This is often more difficult in case of long root trunks. Therefore, such teeth may not be identified as furcationally involved without surgical exposure. [20] A detailed knowledge of the length of the variable root trunks in such sites is a fundamental prerequisite for the proper interpretation of clinical data.

This investigation expressed the root trunk not only as an amount measured by millimeters, but also as different types (A, B, and C) and percentages according to its relation with the root length. This information may help the practitioner to evaluate the amount and percentage of attachment loss apical to the cemento-enamel junction required to expose the furcation for the purpose of diagnosis in order to be able to establish a proper treatment plan.

The maximum height of root trunk for mandibular and maxillary molars in the present study was the 6.6mm, and 7.8mm respectively. Dunlap and Gher[17] in their study on maxillary first molars found no tooth had a root trunk longer than 6.0 mm. Hue *et al.* found a significantly higher missing rate, poorer prognosis, and inferior response to periodontal therapy for teeth with a long root trunk length (type C). However, in this study the overall percentage of root trunk type C was 3.3% for the maxillary molars while none among the mandibular molars. Others found a greater percentage of root trunk type C which comprises 11.9% in maxillary first molar and 1% in mandibular first molars.[4]

The measurement of the different types of root trunk relative to the dimensions of both roots and trunks revealed that with increasing root trunk there is a decrease in root length. This finding may influence the treatments choices of furcation involved molars and the determination of treatment plan for the furcationally involved molar. A furcation-involved molar with a long root trunk and short roots may not be a candidate for root resection, since these teeth lose more periodontal support with furcal invasion.[6] Horwitz *et al*.[23] concluded that a long root trunk, a wide furcation entrance and a furcation fornix coronal to the alveolar crest have negative influences on the success of periodontal therapy.

The length and type of the root trunk is one of the key anatomical factors that make molars particularly susceptible to periodontal disease.[24] Mcclain and Schallhorn reported that short root trunks surely influence the pathogenesis of furca involvement, a molar with a short root trunk is more vulnerable to furcal involvement, but has a better prognosis after treatment since less periodontal destruction has presumably occurred.[8] The results of the present study found that, in mandibular molars, the minimum root trunk length at the buccal and lingual aspects was 2mm, so the furcation could be approached even at the 2 mm probing attachment level. This in turn leads to horizontal attachment loss and more progressive furcation involvement. According to Dannewitz *et al*. molars with grade III FI had the highest mortality and leads to a significant deterioration of prognosis.[25] On the other hand, molars with short root trunks and more divergent roots have a more favorable prognosis when root resective therapy is used.[26] A short root trunk and a wide furcation entrance diameter are prerequisites for the indication of the tunnel preparation procedure as a part of resective furcation therapy for the purpose of proper postoperative plaque control management by the patient.[6] To ensure accessibility of the tunnel to plaque control measures after tunnel preparation, the root trunk should reasonably enough not be longer than a third of the total root length, *i.e.,* approximately 4 mm

based on figures by Paolantonio *et al*.[27] However the variation in the lengths of the root trunk between the buccal and lingual sides may interfere with the treatment by tunnel preparation. In the present investigation we also found that lingual root trunks of mandibular molars are on the average longer than the buccal root trunks which might, after tunnel preparation, impede accessibility for plaque control on the lingual furcation entrance.

The length and type of root trunk are not the only factors that need to be considered in treatment planning in case of furcation involvement. The presence of developmental grooves and concavities on the trunk surface[28] is another factor that may contribute to the outcome of regenerative periodontal therapy in case of short root trunk. Lu[29] reported that 94% of the furcations possessed variant depth of developmental concavities on the root trunks. These superficial irregularities at the entrances of furcations may prevent complete adaptation of the coronal microstructure of the membrane along their root surfaces, so they suggested that subgingival application of guided tissue membranes 1-2 mm below CEJ cannot ensure complete adaptation of furcation defects with their coronal microstructures in the majority of molars. Kerns *et al*. found that the mean CEJ to root groove distances ranged from 1.35 to 1.65 mm for maxillary first molars, and from 1.16 to 1.22 mm for mandibular first molars.[20] Therefore regenerative periodontal therapy in case of short root trunk could be compromised especially if developmental concavities and grooves present on the root trunk.

The small number of teeth used in this study can be considered as a limitation. Most of the first molars extracted in our department(s) are badly destructed without a sufficiently intact crown and root structure to facilitate sorting and measurement.

Limitations of the Study

Further prospective studies to compare the effect of different periodontal treatment modalities on molars with different types of root trunk is needed.

Conclusion

Awareness of root trunk type and dimension may help the practitioner in the diagnosis, treatment plan, and prognosis of periodontally involved molars.

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