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Assessing peculiarity of molar root trunk dimensions in a sample of Saudi population – A radiographic analysis

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KEYWORDS

Molar;
Root trunk;
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Abstract Objective: To assess the dimensions of root trunk lengths (RTL) in maxillary and mandibular molars and evaluate their correlation with the mesio-distal (MD) width of the tooth at the level of cemento enamel junction and Inter-Radicular Angle (IRA) at the point of roots separation.

Materials and methods: Radiographic measurements of a total of 955 molars from 120 study subjects satisfying the inclusion criteria were analyzed. The sampling frame consisted of radiographs from the outpatient dental clinic of the College of Dentistry, King Saud University, Riyadh, Saudi Arabia. The linear measurements, including the width, length and depth of the root trunks under investigation were made using flexible translucent plastic grid while; the angles were measured by rotary German caliper protractor.

Result: The mean RTL dimension for molars were 4.31 mm (3–8 mm). The mean MD width of the molars was 10.02 mm and the mean measured IRA was 34.12°. The longest RT was observed in maxillary 1st molar (4.40 mm) while the shortest radiographic RT length was recorded for the mandibular 2nd molars (4.13 mm). Statistically insignificant correlation ($p = 0.090$) was observed between RTL with the MD width of the tooth, whereas appreciable significance resulted between RTL and IRA ($p < 0.001$).

Conclusion: Knowledge about the molar teeth RT length of the study population will aid the dental clinician in better decision making during management of periodontal disease conditions.

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1. Introduction

Dimensional assessment of root trunks (RT) is of vital importance while diagnosing and planning periodontal disease management (McClain and Schallhorn, 2000). The prognostic value of any periodontitis treatment protocol is greatly influenced by the furcal dimension and its morphology (Santana

et al., 2004). Nevertheless, periodontal management of multi-rooted teeth has always remained an enigma. To overcome the challenges in periodontal treatment planning, accurate measurement of ideal RT parameters of the study population including the attachment levels and vertical heights of the teeth under investigation becomes essential.

Adequate knowledge about the morphological variances and their effective practical application in clinical dentistry are recognized as mandatory for preventive and therapeutic health care delivery. As part of the root complex, RT can be defined as part extending between the cement enamel junction and the entrance of the furcation (Muller and Eger, 1999). It is most commonly measured in millimeters or related to the root complex length. As early as 1997, Hou and Tsai compared the length of the RT with the total root length and proposed a classification. According to this classification,

- Type-A – RT length involving the cervical one third or less of the root,
- Type-B – RT involving from cervical third to one half of the root length,
- Type-C – RT measures from the cervical two-third of the root or more than the apical half of the root (entrance of the furcation) (Hou and Tsai, 1997).

Further, the study results also enumerated that in maxillary molars the long RT was found mesially in par with the shorter RTs observed buccally (Hou and Tsai, 1997). In addition, the long RTs were mostly associated with lingual surfaces of mandibular molars, short root length depicting a strong correlation among the variables like vertical length, type of RT and furcation involvement investigated. Hence appreciating the RT morphology will greatly influence the diagnosis, management and prognosis of furcation involvement in multi rooted teeth (Hou and Tsai, 1997). Moreover, the amount of vertical or horizontal bone loss also dictates the proposed periodontal procedures (Hou et al., 1998, Al-Shammari et al., 2001).

Previous studies and clinical reports reveal that the complex anatomical features of the multi-rooted teeth pose difficulties in diagnostic approaches, especially with the pathology around the furcation. divided the furcation into 3 parts; the first part is the root trunk and defined it as the area which extends apically from the cement-enamel junction (CEJ) and ends in the area of root separation, the second part is the furcation roof and the third is the area of root separation (Grant, 1988). Considering the mandibular first molar, presence of furcal concavities on the mesial and distal surfaces and their narrow entrances often results in compromised manipulation and indefinite results. In addition, other anomalies like enamel projections, enamel pearls, bifurcation ridge, dimension of furcation entrance and fused roots are also considered as predisposing factors for periodontal diseases (Dababneh, 2011).

Gaining adequate access and complete instrumentation of the root surface facilitated by a clear knowledge of the root trunk dimension ensures positive outcome measures. Invasive procedures like resective furcation therapy normally has better prognosis with short RT facilitating improved postoperative plaque control (Rudiger, 2001). Furthermore, RT is considered as one of the major determinant for promising results in regenerative surgeries (McClain and Schallhorn, 2000).

A comprehensive approach to the analyzing the various aspects of the root complex is clinically demanding (Muller

and Eger, 1999). Radiographic examination forms an essential part of oral and perioral evaluation. Conventional dental radiographs (periapical and bitewing films) till date remains the most preferred radiographic tool utilized by dental care providers universally (Santana et al., 2004). Primarily characterized by minimal technique sensitivity, low financial costs and minimum radiation risk intraoral radiographs are reliable for diagnosis, planning and therapeutic management of periodontal patients.

Literature reveals the significance of RT dimensions as an indispensable part of currently available periodontal management modalities prioritizing accuracy and maximal treatment outcomes (Paolantonio et al., 1998). Interestingly, most of these studies used the direct method of measurements on collected extracted teeth to report the length for the different types of RT (buccal, lingual, mesial and distal). Scarcity of research to measure RT length using measurements on conventional dental radiographs which are frequently available as part of more routine and basic diagnostic tools in dental practice. Therefore, the principal objective of this study was to determine the mean and range of RT length in radiographic measurements of molars' and to explore the possible correlation between root trunk length with the width of the tooth mesio-distally at the level of the CEJ and with the inter-radicular angle at the point of furcation entrance.

2. Material and methods

2.1. Ethical approval: ethical approval

The Institutional Research Board and the Institutional Ethics Committee, (CDRC. NO. IF 1958) at the college of dentistry research center (CDRC), King Saud University, Riyadh, Saudi Arabia after analyzing the credibility, approved our research proposal (CDRC. No. 1958).

2.2. Study sample

For the purpose of this study, 20 complete mouth radiograph (20 CMS) of 120 Saudi patients taken as part of their regular dental examinations at the clinics of the College of Dentistry, King Saud University, Riyadh, Saudi Arabia; were surveyed. The sampling frame included radiographs of male patients with age ranged from 18 to 30 years. The total numbers of radiographed teeth obtained in this convenience sample were 960 molars teeth (240 maxillary 1st molars, 240 maxillary 2nd molars, 240 mandibular 1st molars, and 240 mandibular 2nd molars).

2.3. Inclusions criteria

Inclusions criteria were molars with intact furcation, unaltered by caries or fractures, and with complete radiographic root formation. Exclusion criteria were molars with external root resorption or with obscured restoration that could obstruct identification of the CEJ, presence of radiographic periapical pathosis, molars with root canal treatment and/or with severe root dilacerations and radiograph with severe length distortion.

2.4. Test-retest reliability

All the radiographic measurements were done by one examiner who was well equipped with the technical implications. The intra-examiner reproducibility of the measurements was done in randomly selected 5 different sets of 20 CMS with a total of 40 molars before proceeding with the study sample measurements. The measurements were done twice in two week interval to make sure that the examiner was consistent in his measurements.

2.5. Variables under investigation

The following parameters were measured for each target molar:

- 1- Radiographic Length Distortion (LD); defined as the length of the radiographic shadow located between the tips of the buccal and lingual or palatal cusp, (if it exceeded 3.5 mm; the film was excluded);
- 2- Radiographic Root Trunk Length (RTL); defined as the vertical distance from line A to line B; the line A is a horizontal line which connected the mesial and distal points of radiographic CEJ and the line B is a horizontal line parallel to line A and tangent to the fornix of the furcal entrance
- 3- Mesio-Distal (MD) width; defined as the horizontal distance between the mesial and distal points of radiographic CEJ along with line A;
- 4- Inter-Radicular Angle (IRA); defined as the angle of roots separation at the furcal entrance (Figs. 1 and 2). For LD, RTL and MD the unit of measurement was millimeter (mm); while for IRA was measured in degrees.

All the measurements were obtained from the bitewing films and done in a dark room using radiographic viewer with good light condition. All the linear measurements were made using flexible translucent plastic grid while; the angles were measured by rotary German caliper protractor.

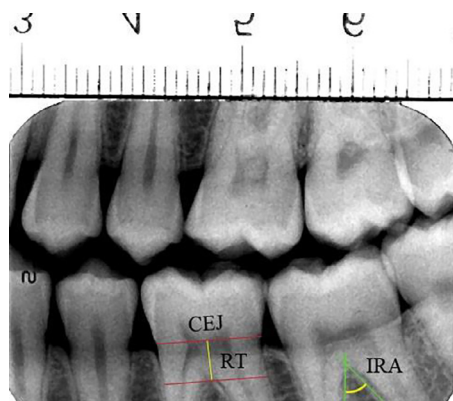


Fig. 1 Measurement of Inter-radicular angle (IRA).

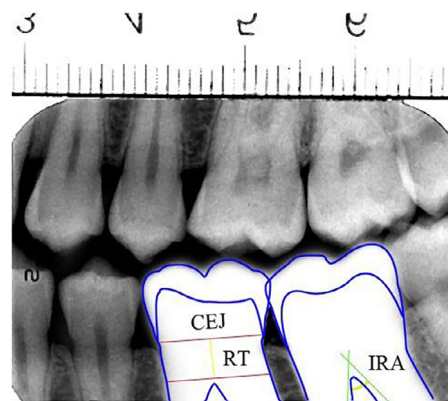


Fig. 2 Measurement of Root trunk (RT).

3. Results

A high degree of intra-examiner reproducibility was obtained for the measured variables, as shown in Table 1; Cronbach's alpha correlation test showed excellent reproducibility for the assessed variables LD, RTL, MD and IRA with coefficient values ranged from 0.99 to 1. Length distortion of the radiographic films was within an acceptable range; with a mean value of 1.43 mm. In addition five molars that showed LD value more than 3.5 mm teeth were totally excluded from the study and data analysis and resulted in reduction of the sample size to 955 teeth as shown in Table 2.

Table 3 shows the means, standard deviations, ranges, and the actual teeth numbers for all radiographic variables which were measured. The mean radiographic RT length for all the molar teeth analyzed together was 4.31 mm and ranged from 3 mm to 8 mm. The mean mesio-distal width of the molars at the level of CEJ was 10.02 mm and ranged from 7.5 mm to 13 mm. The mean inter-radicular angle was 34.12° with angles of roots separation that ranged from 27° to 45°. Table 3 highlighted different "n" values from one variable to another. The reason for this heterogeneity was that during measurements; the target anatomical landmark for one specific variable was not clear but at the same time; it was appreciable for another variable in the same radiographic film. Another contributing factor was the difference due to the study exclusion criteria, which excluded one variable from measurements but included the other in same radiograph; for example molars with severe dilacerated roots were excluded for the measurements of inter-radicular angle but not for the length of RT.

Table 4 show the detailed descriptive statistics for the radiographic root trunk length for the individual molar type and arch specific respectively; the maxillary 1st molar recorded the longest radiographic root length with mean of 4.40 mm,

Table 1 Reproducibility test.

Variable	Cronbach's alpha
LD	0.99
RTL	1.00
MD	0.99
IRA	0.99

Table 2 Radiographic Length Distortion (LD) Measurement in mm.

	LD
Minimum	0
Maximum	3.5
Mean	1.43
Standard deviation	0.74
N	955

Table 3 Descriptive analysis for RTL, MD and IRA.

Variable	Minimum	Maximum	Mean	Std. deviation	N
RTL	3	8	4.31	0.76	949
MD	7.5	13	10.02	1.06	955
IRA	27°	45°	34.12°	2.93°	933

Table 4 Descriptive statistics for RTL by tooth and arch specific type.

	Max. 1st molar	Max. 2nd molar	Mand. 1st molar	Mand. 2nd molar
Mean	4.40	4.32	4.38	4.13
Std. deviation	0.71	1.05	0.61	0.58

Table 5 Correlations between RTL with IRA and MD respectively.

	RTL	IRA
Pearson correlation	1.000	0.151 (*)
P value		0.000
	RTL	MD
Pearson correlation	1.000	-0.055
P value		0.090

* Correlation is significant at the 0.01 level (P value).

followed by mandibular 1st molars. The shortest radiographic RT length was recorded for the mandibular 2nd molars with mean value of 4.13 mm.

Pearson correlation test showed insignificant negative correlation between the radiographic RT length with the width of the tooth mesio-distally. However, the correlation between the radiographic root trunk length with the angle of roots separation was statistically significant but with low Pearson correlation values to be of clinical relevance (Table 5).

4. Discussion

The term Radiographic RT as introduced in this study indicates the radiopaque area of molar teeth that extend from the CEJ coronally to the beginning of the root separation apically as visible in the bitewing radiographs (Svardstrom and Wennstrom, 1988; de los Rios et al., 2002). This definition

implied that not all types of root trunks such as the mesial and distal root trunks of maxillary molars can be seen in the two dimensional radiographs were not a part of the inclusions (Abdallah et al., 1987). This study selected the bitewing radiographs that had been taken at dental college setting under supervision of the dental and maxillo-facial radiology division; which allowed radiographs to be taken by well trained staff using standardized radiographic films and equipment resulting in minimal distortion and allowing more accurate measurement.

The data concerning the RT length for the maxillary molars reflected the length of the buccal root trunk since the palatal trunk was not visualized in the radiographs with a lack of possible overlap. In contrast, the mandibular molars anatomically has two RTs, buccal and lingual which may overlap with each other even in the two dimensional radiographic films (Shiloah and Kopczyk, 1979). Nonetheless, majority of the morphometric studies which used direct measurements on extracted teeth confirmed that the lingual root trunk was longer than buccal root trunk (Ochsenbein, 1986; Hou and Tsai, 1997; Kerns et al., 1999; Marcaccini et al., 2012). In a similar study, examining the RT measurements of mandibular molars reported that the lingual root trunk was approximately 1 mm longer than buccal root trunk (Santana et al., 2004). Effectively, based in these findings, the current study assumed that the data concerning the mandibular root trunk reflected the length of lingual root trunk rather than the buccal root trunk.

The 4.31 mm mean RTL for all molars obtained from this study was similar to the one reported by Paolantonio et al. an average mean of 4 mm obtained through examination of 414 extracted teeth RTs (Paolantonio et al., 1998). For individual molar types the mean RTL for maxillary first molars was 4.40 mm which was slightly longer than the mean RT length reported by Gher and Dunlap. The calculated mean buccal RT length of 4.2 mm from a sample of 20 extracted maxillary first molars was measured. This is to be greater than the mean of 4.11 and 4.13 reported by a similar anatomical studies with extracted molar teeth (Hou et al., 1998; Kerns et al., 1999). Similar trend was observed for other molars teeth measured in this study; the mean RTL for the maxillary 2nd molars was 4.32 mm compared to 4.29 mm mean buccal root trunk of maxillary 2nd molars reported by Kerns et al. (1999).

For mandibular 1st molars our study reported a mean RTL of 4.38 mm compared to 4.28 mm, 4.03 and 4.08 mm reported by previous studies (Hou et al., 1998; Mandelaris et al., 1998; Kerns et al., 1999) for the lingual RT. Whereas, for mandibular 2nd molars this study reported mean RTL of 4.13 mm compared to 3.83 mm reported by Kerns et al. for lingual root trunk length (Kerns et al., 1999). This trend of slightly longer measurements of the mean RTL for all molar types could be explained by the slight radiographic length distortion reported as a limitation of the study (mean of 1.43 mm). In comparison, other studies used direct measurements on extracted teeth which allowed more precise measurements (Dababneh, 2011). Nevertheless, this difference was very minimal to be clinically significant; therefore; the radiographic assessment method to measure RT length seem to be a reliable tool to be used clinically to have an idea about the approximate length of RT particularly for maxillary buccal and mandibular lingual root trunk.

The reported correlation between the radiographic root trunk lengths with the width of the tooth at the level of CEJ

and the degree of the roots separation had insignificant correlation, which implied the complex anatomical features of the multirrooted teeth particularly the molars. These findings were in agreement with the one reported by Paolantonio et al.⁵, where they found very weak correlation between the different anatomic features of the molars root furcation region using direct measurements on extracted molars (Paolantonio et al., 1998).

Careful observation of the RT length from the bitewing radiograph will help the dental clinician and specialist to predict the prognosis for multi rooted teeth before interventions particularly for procedures like crown lengthening (Dibart et al., 2003). The radiographic critical distance determined from the furcation entrance before crown lengthening called CDF value when measured and monitored avoids the long term development of radiographic furcation involvement after final crown delivery. The CDF value should be at least > 4 mm after crown lengthening procedure; is strongly related to the anatomy of the involved teeth and especially to the length of the root trunk (Gher and Vernino, 1980).

Since the present study lack the true positive control to compare the obtained radiographic measurements; future studies are recommended. A more accurate comparative analysis of the radiographic measurements of the different anatomical features of the molars RT regions to the one from the direct measurements using the same teeth (Siaili et al., 2018).

5. Conclusion

Within the limitations of this study, the following conclusions can be drawn. Knowledge about the molar teeth RT length of the study population in this particular geographic location will aid the dental clinician in better decision making during management of periodontal disease conditions.

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Conflict of interest

The author certifies that he has no affiliation with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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