Archives of Orofacial Sciences (2011), **6**(1): 21-26.

ORIGINAL ARTICLE

Root-crown ratios of permanent teeth in Malay patients attending HUSM Dental Clinic

Norisa Othman [a], Haslina Taib [a]*, Norehan Mokhtar [b]

[a] School of Dental Sciences, Universiti Sains Malaysia, Health Campus, 16150 Kubang Kerian, Kelantan, Malaysia. [b] Advanced Medical and Dental Institute, Universiti Sains Malaysia, Bandar Putra Bertam, 13200 Kepala Batas, Pulau Pinang, Malaysia.

(Received 16 January 2011; accepted 25 June 2011)

Keywords

Crown height,
Permanent teeth,
Root length,
Root-crown ratio.

Abstract The objectives of this study were to determine the normal mean value of the root-crown (R/C ratios) in Malay patients and their variations by gender and dental arch from orthopantomogram radiographs (OPGs). Two thousand nine hundred and twenty teeth with fully developed roots were measured from 112 OPGs. Subjects with history of maxillofacial trauma or orthodontic therapy were excluded. The mean age of the subjects was 19.1 (SD 2.08) years old for males while females 18.9 (SD 2.19) years old in the range from 15 to 22 years old. The intra-examiner reproducibility of the assessment method was good (Intraclass correlation coefficient 0.81). Results of this study showed that there was no significant difference between R/C ratios of males and females groups. However, the ratios of the antagonist teeth for both males and females were significantly greater in the mandible than in the maxilla ($p<0.05$ for right and left lateral incisors and right first premolars in male; $p<0.001$ for all other teeth). In both gender, the highest R/C ratio was mandibular second premolars and the lowest R/C ratio were maxillary central incisors. The root-crown ratio could be used as a baseline data and reference to help in orthodontic diagnosis, treatment planning and prognosis as well as evaluation developmental root deficiency.

Introduction

All teeth have two general sections, the crown and the root. The crown is covered with enamel and the root is covered with cementum, the line at which these two sections join is called the cementoenamel junction. In a healthy gingival condition, the roots of teeth are entirely embedded in the alveolar bone which covered by the soft tissue. The crown which exists entirely outside of the surrounding bone, is somewhat obscured at the apical millimeter or so. Thus, crown and root can be used as anatomical terms, defining the actual parts of a tooth (Newman *et al*., 2002).

* **Corresponding author:** Dr. Haslina Taib, Tel.: +609-7675812, e-mail: haslina@kck.usm.my

Root-crown ratios (R/C) determine the root length in relative to crown length. Root length is considerably longer than crown length, and this allow for proper support of the teeth during normal function. The normal R/C ratio is thus termed as favorable root-crown ratio, because the root system existing within the surrounding bone is more than sufficient to support the tooth under normal physiologic stresses. Unfavorable (R/C) ratios or short roots may affect the prognosis of the teeth (Newman *et al*., 2002).

Short roots may complicate treatment planning, for instance in orthodontics and prosthodontics when estimating the ability of a tooth to carry masticatory forces. There are two main reasons for short dental roots: (1) disturbances during root development or (2)

resorption of the originally well developed roots (Hölttä *et al.*, 2004). The former can be due to genetic (Lind, 1972; Apajalahti *et al.*, 1999), irradiation of the head and neck and/or chemotherapy of childhood malignancies during tooth development (Näsman *et al.*, 1997), stem cell transplantation during tooth development (Hölttä *et al.*, 2005), Down syndrome (Prahl-Andersen and Oerlemans, 1976), Turner syndrome (Midtbø and Halse, 1994) and dyskeratosis congenita (Atkinson *et al.*, 2008). In some cases an etiology remains idiopathic (Lerman and Gold, 1977).

Causes of resorption of the originally well developed roots are orthodontic induced root resorption (Brezniak and Wasserstein, 1993), dental trauma (Andreasen *et al.*, 1999), squamous cell carcinoma (Kawai *et al.*, 2000), presence of infection, certain systemic diseases, mechanical irritation of tissue or increased pressure in tissue (Tronstad, 1988).

Early detection of small root resorption before orthodontic treatment is essential for identifying teeth at risk of severe root resorption. Reference value for root-crown ratio of normal teeth is necessary when studying root resorption or developmentally short dental root. To date, there is no data of root-crown ratio have been reported for Malay population. Therefore, baseline data for our population is necessary.

The aims of this study were to assess the root-crown ratios of permanent teeth in Malay patients and to determine their variations by gender and dental arch.

Materials and methods

Study design

This is a retrospective record review study done at Dental Clinic, Hospital Universiti Sains Malaysia (HUSM), Kubang Kerian, Kelantan. The reference and source of populations for this study were Malay patients attending HUSM Dental Clinic. The sample size was calculated by using PS Software (Dupont and Plummer, 1990). To detect the difference of 0.15 mm of R/C ratio with standard deviation of 0.27 (Hölttä *et al.*, 2004) in 80% power and alpha 0.05, 52 subjects were needed in each study group. Hundred and twelve OPGs of patients with all teeth present except third molar were retrieved. Fifty male and 62 female Malay patients were chosen by convenient sampling for the age range from 15 year old to 22 year old. All permanent teeth with fully develop roots were measured. Patients who have history of maxillofacial trauma and who had underwent orthodontic treatment were excluded. Poor OPG and teeth which the reference points were not clearly visible were also excluded from the measurement. Ethical approval was obtained from Human Research and Ethics Committee, Universiti Sains Malaysia.

Measurement of root length and crown height

A previously described method (Lind, 1972) was adapted for the measurements. Crown height was measured from the most coronal part of a tooth to the cementoenamel junction and root length was determined by measuring distance from cementoenamel junction to the root apex (Fig. 1).

For assessment of intra-examiner reproducibility, five OPGs were randomly selected. Measurement of root length and crown height was carried out twice within 1 week interval. Intraclass correlation coefficient was calculated and an agreement was achieved.

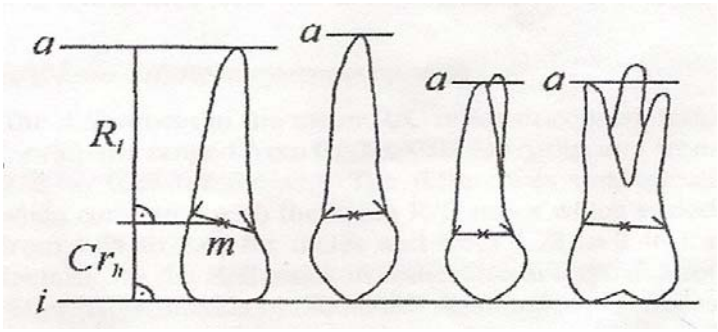

Figure 1 The method for measuring crown height and root length in the assessment of the root-crown(R/C) ratio (Lind, 1972), where; *a* = apical tangent, *m* = midpoints of intersection between the crown and root, *i* = incisal/occlusal reference line, root length (mm) = measured perpendicular from point *m* to point *a,* crown height (mm) = measured perpendicular from point *m* to *i.*

Results

Two thousand nine hundred and twenty two teeth were measured from 112 OPGs of healthy Malay subjects of both sexes. There were 50 males patients (1302 teeth) with mean age of 19.1 (SD 2.08) years old and 62 female patients (1620 teeth) with mean age of 18.9 (SD 2.19) years old. Hundred and seventy two teeth were excluded as a result of (1) indistinct reference points which is due to incomplete root development, extensive caries or restorations, retained root, superimposition, impacted and unerupted teeth, root canal treated, severely attrited dentition, (n=41) and (2) blurred radiographs because of diffused images or distortion (n=131). Intra-examiner reproducibility of the assessment method was good (Intraclass correlation coefficient 0.81; lower bound=0.74, upper bound=0.86).

The mean R/C ratios of contralateral tooth pairs of both males and females in maxilla or mandible shows no significant difference ($p>0.05$). The differences in the mean R/C ratios of contralateral tooth pairs ranged from 0.00 to 0.10 for males and from 0.00 to 0.13 for females. The differences were small when compared with the mean R/C ratio of respective tooth which varied from 1.62 to 2.63 for males and from 1.57 to 2.60 for females. So, the R/C ratios of the antimeres were pooled for further analysis. Detailed descriptive statistics and comparison of R/C ratios for males and females subjects (mean, SD, 95 per cent confidence interval) are presented in Table 1 and 2, respectively.

In both genders, the highest mean R/C ratios were found for the second premolars for both maxillary and mandibular arches. In maxillary arch, the lowest R/C ratios were recorded in central incisors for both genders. However, in mandibular arches, the lowest R/C ratios were found in lateral incisors for males but in females were central incisors. With the exception of permanent maxillary second molars, there were no significant differences between males and females ($p>0.05$). In comparison with maxillary teeth, the mandibular teeth showed higher R/C ratios in both genders ($p<0.05$) (Table 3).

Table 1 Mean root-crown ratios with standard deviations (SD) and 95 per cent confidence intervals (95% CI) for permanent teeth in males (n=50)

Teeth	No. of teeth	Mean	SD	95% CI	*p* Males versus females
11,21	87	1.62	0.25	1.57-1.67	NS
12,22	94	1.79	0.31	1.73-1.85	NS
13,23	96	2.08	0.39	2.00-2.16	NS
14,24	86	2.11	0.42	2.02-2.20	NS
15,25	94	2.20	0.41	2.11-2.28	NS
16,26	95	1.91	0.38	1.83-1.99	NS
17,27	99	1.87	0.32	1.80-1.93	*
31,41	84	1.94	0.40	1.85-2.03	NS
32,42	91	1.93	0.33	1.86-2.00	NS
33,43	95	2.39	0.36	2.32-2.47	NS
34,44	97	2.37	0.43	2.28-2.46	NS
35,45	96	2.63	0.48	2.53-2.73	NS
36,46	92	2.42	0.33	2.35-2.49	NS
37,47	96	2.24	0.33	2.17-2.30	NS

*$p \leq 0.05$; NS=not significant, $p>0.05$

Table 2 Mean root-crown ratios with standard deviations (SD) and 95 per cent confidence intervals (95% CI) for permanent teeth in females (n=62)

Teeth	No. of teeth	Mean	SD	95% CI
11,21	114	1.57	0.25	1.53-1.62
12,22	112	1.75	0.30	1.69-1.80
13,23	114	1.99	0.29	1.94-2.05
14,24	114	2.01	0.39	1.94-2.08
15,25	113	2.19	0.38	2.12-2.27
16,26	119	1.86	0.34	1.80-1.93
17,27	121	1.77	0.30	1.72-1.83
31,41	113	1.90	0.33	1.84-1.96
32,42	114	1.99	0.36	1.92-2.05
33,43	113	2.37	0.36	2.30-2.43
34,44	118	2.39	0.41	2.31-2.46
35,45	119	2.60	0.44	2.52-2.68
36,46	118	2.48	0.35	2.41-2.54
37,47	118	2.20	0.32	2.14-2.26

Table 3 The significant difference of maxillary versus mandibular teeth antagonist mean root-crown ratios in males and females

Teeth	*p* Maxillary versus mandibular antagonist in male	*p* Maxillary versus mandibular antagonist in female
Central incisors	***	***
Lateral incisors	**	***
Canines	***	***
First premolars	***	***
Second premolars	***	***
First molars	***	***
Second molars	***	***

*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$; NS=not significant, $p > 0.05$

Discussion

This study was designed because as far as we are aware no investigation has been conducted on root-crown ratio in Malay population in Malaysia. This study adapted the method by Lind (1972), which was used previously to study the relative amount of root shortening (the root-crown ratios) of permanent maxillary central incisors, using intra-oral radiographs. However, in the present study, quantitative assessment of relative root length was made from OPGs as had been used by Hölttä *et al*. (2004).

We choose to have R/C ratio instead of tooth length linear measurement because in radiographic study, alteration in tooth angulation are known to affect the radiographic tooth length, but does not affect the R/C ratio (Brook and Holt, 1978). Magnification may vary between OPGs taken using different machines, and also between different regions on the same radiographs (Welander *et al.,* 1989). However, Stramotas *et al.* (2000) stated that the R/C ratio can be measured accurately from OPGs and it is reproducible when patient is correctly positioned. The source of error by the observer is the difficulty in recognition of the reference points (Thanyakarn *et al.,* 1992). This can be overcome by the determination of the intersection between roots and crowns (Stramotas *et al*., 2000). Such action would increase the possibility of landmark identification errors. Furthermore, as ratio calculations are dependent on individual root and crown lengths, a difference in locating an R/C intersection may lead to a significant difference in values (Stramotas *et al.,* 2000). A similar difficulty in locating reference points was noted by investigators using the cementoenamel junction (CEJ) to differentiate between the crown and the root (Mavragani *et al*., 2000; Sameshima and Asgarifar, 2001).

The CEJ is more difficult to see in OPGs, making crown or root length determinations from this junction inaccurate compared to intra-oral radiographs (Sameshima and Asgarifar, 2001). Therefore, a reference point based on tooth morphology was chosen (Lind, 1972). Despite this, the inherent problem of the OPG technique could not be overcome, overlapping of teeth, which was maximal in the premolar region (Welander *et al.,* 1989). Maxillary sinuses also may impair the visibility of the apical reference points at the lateral regions of the maxilla. In this study, the most common reason for exclusion was unclear of apical region which encounter about 76 per cent of total excluded teeth. However, the overall measurability of the R/C ratio in the present study was high (95 per cent of total number of teeth).

In this present study, the value of R/C ratio (Table 1 and Table 2) for matured permanent teeth, obtained from OPGs of healthy Malay patients attending HUSM Dental Clinic, were reported. This present results show higher mean R/C ratio in maxillary teeth compared to Finnish population but in the mandibular teeth, the results show lower mean R/C ratio in comparison with Finnish population (Hölttä *et al*., 2004). However, both studies reported the highest mean R/C ratios were found for second premolars for both arches and the mean R/C ratios were higher in mandibular teeth compared to the corresponding maxillary teeth.

Hölttä *et al.* (2004) studied R/C ratios of permanent teeth in Finnish population and found that the mean R/C ratios of permanent maxillary and mandibular central incisors, permanent maxillary lateral incisors and first and seconds molar were significantly larger in males than in females. Tawfik *et al.* (2005) studied R/C ratios of permanent teeth in a sample of Egyptian population found that there were no significant differences between root-crown ratios of right and left teeth for both males and females groups. They also reported that there were high coefficients correlations of the R/C ratios for the teeth in the same arch. In addition they also found that the R/C ratios of upper posterior teeth for males were significantly higher than females. However, this present study found no significant difference between males and females mean R/C ratios. This is in agreement with the other previous studies (Lind, 1972; Jakobsson and Lind, 1973).

Population prevalence for genetic short root anomaly in fully developed dentitions is close to 1.3%. In 70% of the short root anomaly patients, the short-rooted tooth pairs were upper incisors but also involved, were maxillary premolars and lower second premolars. Women were significantly more often affected (Apajalahti *et al*., 1999). Study done by Hölttä *et al.* (2005) shows R/C ratios of patients who underwent stem cell transplantation was affected if compared to normal R/C ratio. Other than described above, the R/C ratios also aid in predicting the prognosis of teeth for fixed prosthesis (Grossmann and Sadan, 2005). So, this present results can be used as a reference of normal R/C ratios.

Conclusion

R/C ratios of permanent teeth can be measured from OPGs with acceptable reproducibility. Therefore, the results from this study can be used as a baseline data for Malay population to help in dental diagnostic and treatment planning.

Acknowledgement

This study is supported by USM Incentive Grant (304/JPNP/600004).

References

Andreasen JO, Andreasen FM, Bakland LK, Flores MT (1999). *Traumatic Dental Injuries. A Manual*. Copenhagen: Munksgaard, pp. 10, 11, 35, 37, 39, 43.

Apajalahti S, Arte S, Pirinen S (1999). Short root anomaly in families and its association with other dental anomalies. *Eur J Oral Sci*, **107**(2): 97-101.

Atkinson JC, Harvey KE, Domingo DL, Trujillo MI, Guadagnini JP, Gollins S, Giri N, Hart TC, Alter BP (2008). Oral and dental phenotype of dyskeratosis congenita. *Oral Dis*, **14**(5): 419-427.

Brezniak N, Wasserstein A (1993). Root resorption after orthodontic treatment: Part 2. Literature review. *Am J Orthod Dentofacial Orthop*, **103**(2): 138-146.

Brook AH, Holt RD (1978). The relationship of crown length to root length in permanent maxillary central incisors. *Proc Br Paedod Soc*, **8**: 17-20.

Dupont WD, Plummer WD, Jr (1990). Power and sample size calculations: a review and computer program. *Control Clin Trials*, **11**: 116–128.

Grossmann Y, Sadan A (2005). The prosthodontic concept of crown-to-root ratio: a review of literature. *J Prosthet Dent*, **93**(6): 559-562.

Hölttä P, Nyström M, Evälahti M, Alaluusua S (2004). Root-crown ratios of permanent teeth in a healthy Finnish population assessed from panoramic radiographs. *Eur J Orthod*, **26**(5): 491-497.

Hölttä P, Hovi L, Saarinen-Pihkala UM, Peltola J, Alaluusua S (2005). Disturbed root development of permanent teeth after pediatric stem cell transplantation. Dental root development after SCT. *Cancer*, **103**(7): 1484-1493.

Jakobsson R, Lind V (1973). Variation in root length of the permanent maxillary central incisor. *Scand J Dent Res*, **81**(4): 335-338.

Kawai N, Wakasa T, Asaumi J, Konouchi H, Kishi K (2000). Radiologic study of tooth root resorption in a case of squamous cell carcinoma. *Dent Radiol (Shika Hoshasen)*, **4**(2): 129-137.

Lerman RL, Gold R (1977). Idiopathic short root anomaly. *J Pedod*, **1**(4): 327-333.

Lind V (1972). Short root anomaly. *Scand J Dent Res*, **80**(2): 85-93.

Mavragani M, Vergari A, Selliseth NJ, Bøe OE, Wisth PL (2000). A radiographic comparison of apical root resorption after orthodontic treatment with a standard edgewise and a straight-wire technique. *Eur J Orthod*, **22**(6): 665-674.

Midtbø M, Halse A (1994). Root length, crown height, and root morphology in Turner syndrome. *Acta Odontol Scand*, **52**(5): 303-314.

Näsman M, Forsberg CM, Dahllöf G (1997). Long-term dental development in children after treatment for malignant disease. *Eur J Orthod*, **19**(2): 151-159.

Newman MG, Takei HH, Carranza FA (2002). *Carranza's Clinical Periodontology*, 9th edn. Philadelphia: WB Saunders Co., pp. 481-483.

Prahl-Andersen B, Oerlemans J (1976). Characteristics of permanent teeth in persons with trisomy G. *J Dent Res*, **55**(4): 633-638.

Sameshima GT, Asgarifar KO (2001). Assessment of root resorption and root shape: periapical vs panoramic films. *Angle Orthod*, **71**(3): 185-189.

Stramotas S, Geenty JP, Darendeliler MA, Byloff F, Berger J, Petocz P (2000). The reliability of crown-root ratio, linear and angular measurements on panoramic radiographs. *Clin Orthod Res*, **3**(4): 182-191.

Tawfik WA, Soliman NL, El Batran MM (2005). Root-crown ratios of permanent teeth in a sample of Egyptian population--panoramic radiographs assessment. *Egypt Dent J*, **51**: 1535.

Thanyakarn C, Hansen K, Rohlin M (1992). Measurements of tooth length in panoramic radiographs. 2: Observer performance. *Dentomaxillofac Radiol*, **21**(1): 31-35.

Tronstad L (1988). Root resorption--etiology, terminology and clinical manifestations. *Endod Dent Traumatol*, **4**(6): 241-252.

Welander U, Tronje G, McDavid WD (1989). Theory of rotational panoramic radiography. In: Langland O, Langlais R, McDavid WD, DelBalso A (eds.) *Panoramic Radiology*, 2nd edn. Philadephia: Lea and Febiger, pp. 38-75.