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Research Article

Assessment of Root-Crown Ratio for Gender Bias and a Guideline for Abutment Selection Using Panoramic Radiographs- A Retrospective Study

Nikitha Perla[1]*, R Prakash[2] and D Uday Kiran Teja[3]

[1]*Post Graduate Student, Department of Prosthodontics, Anil Neerukonda institute of Dental Sciences, Visakhapatnam, India*

[2]*Professor and Head, Department of Prosthodontics, Anil Neerukonda institute of Dental Sciences, Visakhapatnam, India*

[3]*Reader, Department of Prosthodontics, Anil Neerukonda institute of Dental Sciences, Visakhapatnam, India*

***Corresponding Author:** Nikitha Perla, Post Graduate Student, Department of Prosthodontics, Anil Neerukonda institute of Dental Sciences, Visakhapatnam, India.

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Abstract

The purpose of this study was to use panoramic radiographs to assess the gender-related root-crown relationship of the permanent upper incisors. The precision of the method was also evaluated.

The lengths of the crowns and roots of the central incisors of 75 subjects was measured retrospectively on a panoramic radiographs obtained from the institutional database. A total of 150 samples were studied, of which, 52% (78 subjects) were female and 48% (72 subjects) male. The Modified Linde methodology was utilized. The average root crown ratio for permanent maxillary mid-central teeth was 1.8 in males and 1.7 in females. Although the average root crown ratio for men was higher than for women, using the independent student t-test, no significant difference was found among the comparative ratios between females 0.05 (95% CI: -0.129-0.175) and males 0.04 (95% CI: -0.130-0.176), (p = 0.76) [CI- Confidential Interval] respectively. The research group's evaluation of the ratio of the root to crown of the upper central incisor in the panoramic film has acceptable consistency. The study aims at emphasizing on the significance of understanding the root-crown ratio in the perspective of abutment evaluation. The final decision to use a tooth as an abutment must be based on radiographic interpretation with sound clinical judgement.

Keywords: *Panoramic Radiography; Root-Crown Ratio; Tooth Cervix; Modified Lind Method*

Introduction

It is usually quite difficult to assess the prognosis of teeth that may serve as prosthetic abutments. The clinician must evaluate the abutment teeth carefully as the abutment teeth are subjected to higher than usual occlusal forces transmitted through the prosthesis. One of the primary variables in the evaluation of the suitability of a tooth as an abutment for a fixed or removable partial denture (FPD or RPD) is the root crown ratio [1,2].

The root crown ratio represents the biomechanical concept of a Class I lever for evaluating abutment teeth. The ratio is described in literature as the physical relationship between the alveolar embedded portion of the tooth and the clinically exposed portion based on radiographic evaluation [3]. The fulcrum, or center of rotation, of the Class I lever is in the middle portion of the root that is embedded in alveolar bone [4,5]. The root crown ratio may increase over time, primarily as a result of loss of alveolar bone support; the crown portion of the fulcrum (effort arm) would then increase, and the root portion (resistance arm) would decrease. In addition, the center of rotation moves apically, and the tooth is more prone to harmful effects of lateral forces [2,6].

It is imperative to not confuse the measurements of the anatomical crown with the clinical crown, for determining the root crown ratio. The anatomical crown is that portion of the natural tooth which extends from the cemento-enamel junction (CEJ) to the occlusal/incisal edge, while the clinical crown is the portion of the crown that extends from the free gingival margin to the occlusal/incisal edge [7].

Since most roots have conical shape and the root length is a linear measurement, other criteria should be used to evaluate the total alveolar support of the abutment. The root crown ratio does not express the actual area of bone support and, therefore, might underestimate the severity of bone loss around the abutment [8].

Radiographic evaluation has been the most widely used technique in clinical practice for assessing bone level around teeth. In radiographic research, measuring the root crown ratio is more advantageous than estimation of the absolute linear measurement of crown root, because the change of the radiographic angle will affect the radiographic length of the tooth, but not the root crown ratio. In fact, when a certain range of tilt occurs in the antero-posterior or lateral directions, the ratio remains stable [9]. Even if the dentition is in the focal slot during exposure time, horizontal and vertical distortions may occur. Linear calculations can be useful in the evaluation of radiographs to avoid complete distortion. Also, magnification may vary between different areas of radiographs, such as panoramic radiographs. Since the root and crown are usually in the same vertical plane, the scale does not significantly affect the root crown ratio [10].

In this analysis, panoramic radiographs were used to evaluate the reproducibility of the method of obtaining tooth length and root crown ratio. Panoramic radiographs are very important during the treatment planning phase and patient research as they are reproducible and have low patient exposure. Of significance is that the root crown ratio remains constant in panoramic radiographs and these values are reproducible.

A prosthodontic textbook considers the ratio in terms of crown versus root and a crown root ratio for an abutment of 1:2 is thought to be ideal, but in practice this is rarely observed [7]. Shillingburg., *et al.* [1] suggested a 1:1.5 root crown ratio as optimum or a 1:1 ratio as a minimum ratio for a prospective abutment under normal circumstances. The authors also indicated that if the opposing occlusion is composed of tissue supported prosthesis, a crown-to-root ratio greater than 1:1 might be adequate because of the diminished occlusal forces. Others have suggested that the original 1:2 root crown ratio guideline in the selection of abutments is exceptionally conservative and limits treatment [11].

For the prognosis and treatment planning of dental surgery, short root teeth with a reduced root crown ratio have been proven effective [8]. Generally speaking, the incidence of short root in maxillary centrals is 1% to 10% [12].

There are situations in which a deviation from normal root crown ratio is seen. In the case of bone marrow transplantation, chemotherapy, cleft palate, and trauma, the root crown ratio decreases after root length is reduced [10,13,14]. Increased root crown ratio is seen in trauma with crown fracture, tooth wear and decay. Al-Jamal., *et al.* [13] detailed that the effects of cleft palate on adjacent teeth, mostly on incisors and canines, and incomplete root development could cause an increase in the root crown ratio. However, any size defect or root abnormality as seen in hypodontia impacts all teeth even in the absence of a clinical presentation of any syndrome or an etiology like cleft palate [14].

Several studies have been conducted to investigate the clinical application of root crown ratios calculated from panoramic views. Stramotas., *et al*. [10] conducted a survey to evaluate the accuracy and dependability of crown height, root length, and root crown ratio. They also assessed angulations of teeth relative to each other in the panoramic X-ray, and virtual reference lines of the same segment. They found and supported that tooth length and root crown ratio could be reliably and accurately measured [10].

Holta., *et al.* [9] evaluated the root crown ratio in panoramic radiographs with reliable acceptance and reproducibility and have shown use in determining the rate of apical root resorption in orthodontic and other cases.

In fact, since the tooth is contained in the alveolar socket, the length of the crown and root cannot be measured directly. Thus, the clinician's decisions are primarily based on indirect estimates of length and ratios. This study investigated the root crown ratio of maxillary central incisors and evaluated the reproducibility of the obtained results within the research group [15,16].

Materials and Methods

In this cross-sectional study, non-random sampling was performed on panoramic radiographs of permanent dentate patients. On each X-ray picture, teeth with extensive cavities or restorations, root resorption, incomplete root development, severe crowding, significant wear, intrabony lesions attached to the root, hypercementosis and dilacerations were excluded. X rays of patients with a history of head and neck radiation, chemotherapy, genetic disorders associated with emerging tooth malformations (eg, Down and Turner syndrome), trauma, cleft lip and cleft palate have not been evaluated.

Since the cemento-enamel joint (CEJ) level is not well visible in the panoramic X-rays measuring the height of the crown of each tooth and the length of the root, we adopted the modified Lind method and determine the length between the crown and the root,

that is, the length of each tooth measured accurately [17]. According to this method, the midpoint of the straight line connecting the intersection of the root and the outer profile of the crown was chosen as the point M (Figure 1).

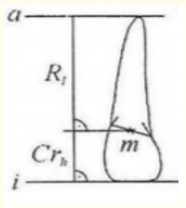

Figure 1: Modified Lind method. i: incisal level, a: apical level, Rtl: Root height, Crh: Crown height, m: Midpoint of a straight line that intersects the points of intersection between the outer contours of root and crown.

Also, the occlusal baseline of the incisor was placed along the incisal edge [17]. A line tangent was placed next to the apex of the longest root and parallel to the incisal baseline and considered the apical baseline. The length of the perpendicular to the incisal baseline at point M is believed to be the same as the length of the root. It is the same as the length of the perpendicular from the height point M of the crown to the apical baseline.

Differences between points and baselines were measured by Digital Calliper Digimizer Version 4.4.4. Measurements done on panoramic X-ray pictures of 75 (out of 100 patients) and 150 teeth of female (52%) and male (48%) patients.

Numerical data were expressed as mean (standard deviation or standard error). Nominal data were expressed as frequency (%). Comparisons of mean root crown ratios between the gender and jaws were evaluated statistically using students t-test. We revisited 60 radiographs to test for method errors (uncertainty associated with observer errors) and a two-tailed $p < 0.01$ matched the data significantly. IBM SPSS Version 20 software application for statistical analysis was used for this evaluation.

Results

The mean root crown ratio was 1.7 among the females and 1.8 in males in the study group.

Descriptive statistics (mean, standard deviation, and 95% confidential intervals) are presented in table 1.

Assessment with Levene's test of homogenicity of variance, depicting the statistical significant difference of mean root-crown ratio between males and females, which was greater in males than females presented in table 2.

Jaw	Tooth	Gender	Mean	Standard Deviation	Confidence Interval Range	Standard Error	P Value
Maxilla	Central Incisor	Females	1.7	0.293	1.29 - 1.81	0.47	0.05
		Males	1.8	0.365	1.29 - 1.76	0.59	0.04

Table 1: Depicts the mean root-crown ratio of permanent maxillary centrals for males and females.

		Levene's Test for Equality of Variances					t- test for Equality of Means		95% Confidence Interval of Difference	
		F	Sig.	T	Df	Sig. (2-talled)	Mean Difference	Std. Error Difference	Lower	Upper
Ratio	Equal variances Assumes	1.428	0.236	-0.301	73	0.05	-0.229	0.7630	-1.755	0.12910
	Equal variances not assumed			-0.300	68.944	0.04	-0.229	0.7653	-1.756	0.12970

Table 2: Levene's test of equality of error variance for root-crown ratio in males and females independent student t test.

$P < 0.05$ – Statistically significant.

Showing a Bar Chart plotted to display mean root crown ratios of the males and females of the permanent maxillary central incisors in figure 2.

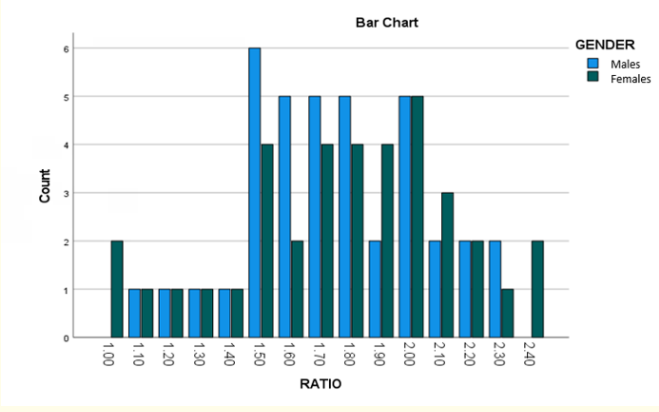

Figure 2: *Showing a bar chart plotted to display the permanent maxillary centrals- mean root crown ratios of the males and females.*

Discussion

The root crown ratios noted on panoramic radiographs are more commonly applied to prognostic assessment of prosthodontic treatment [9]. Root-crown ratio may be an important indicator or predictor of abutment and prosthesis survival, especially when prosthodontic, periodontal and endodontic treatments are planned [18].

Since the root crown ratio is highly dependent on the length of the crown and or the length of the root, a 1mm error to determine the exact intersection of the crown and the root can negatively impact the calculated ratio. Thanyakar., *et al*. [19] and Larheim and Eggen [20] detailed that difficulty in determining the points of reference was the major cause of vertical measurement errors in panoramic X-ray images.

Holta., *et al.* [9] reported a significant difference between the two genders in the root crown ratios for maxillary incisors. In this study, the average root crown ratio of all teeth among the two genders were not statistically significant. This is likely due to the smaller number of samples compared to that of Holta., *et al*. The current investigation shows that the average root crown ratio of maxillary centrals was more in men.

The findings of the study by Holta., *et al.* [9]. who determined the tooth length based on tooth morphology and the present study were more similar than the findings reported by Jackobson., *et al.* [21], Bjorndal., *et al.* [22], Carlson., *et al.* [23] and Midtbo., *et al.* [24], who used cemento enamel junction (CEJ) to determine the midpoint of crown and root. When CEJ is used to determine the midpoint of crown and root, in extracted teeth, the crown part is larger than the clinically measured values of the present study.

The decrease in crown height shortens the corresponding lever arm length, and therefore, less lateral force is applied to the attachment apparatus, with an apparent reduction of the abutment horizontal mobility [25]. Conversely, any increase in the vertical dimension of occlusion (VDO) increases the root crown ratio. Crown lengthening re-establishes the dentogingival junction at a more apical level on the root to accommodate the junctional epithelium and the connective tissue attachment [26]. This procedure increases the root crown ratio.

Current research shows that panoramic radiography is reproducible and reliable in determining root length. Due to the limitations of this technology, unequal magnification before and after panoramic radiographs has always been a challenge faced by researchers and clinicians when evaluating tooth length and position. Because the dimensional change in the horizontal direction is large, the reliability of panoramic radiography is low, but the dimensional change in the vertical direction is much smaller than the dimensional change in the horizontal direction, and is reliable when the patient's head is properly positioned so that the teeth are in focal trough [27,28].

Changes in the occlusal plane (especially the mesio-distal plane) while maintaining the length of the teeth, affect the root crown ratio. Such changes are less important in the patient's occlusal right and left tilts, and wide anterior-posterior rotation and projections of right and left displacement have not been evaluated in current study [27,28].

Also, the tooth inclinations and their effect on root crown ratio are not evaluated in this study. This ratio varies with changes in the bucco-lingual inclination distance from the focal trough, the length of the teeth, and vertical depth of impaction.

Conclusion

The root crown ratio of permanent teeth can be measured on panoramic radiographs with good reproducibilty. Therefore, the degree of root resorption on panoramic X-ray film can be assessed during treatment. This study could not elicit any gender bias nor

was there any statistical significance between values calculated between adjacent quadrants. This goes on to re emphasize on the importance of evaluating root crown ratio on a case to case basis especially for clinical situations like abutment selection.

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