

CORRELATION BETWEEN CROWN ROOT RATIO AND PERIOTEST VALUES IN HEALTHY SINGLE ROOTED TEETH

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ABSTRACT

Statement of problem: Unfavorable crown root ratio is linked to mobility, as a result mobile teeth are excluded from serving as abutments which complicates the treatment plan.

Objective: To find if there is true correlation between crown root ratio(C/R) and tooth mobility (TM) by utilizing cone beam computed tomography (CBCT) and periostest.

Materials and methods: The records of 72 patients who attended BAU dental clinics for orthodontic treatment or oral implant placement between 2011 and 2013 were gathered based solely on the availability of CBCT records for single rooted teeth. Only 29 records that fulfilled the inclusion criteria were selected. These records belonged to orthodontic patients with mild occlusal discrepancy who haven't started their treatment yet, and to those requesting tooth replacement with implant retained restoration but having enough posterior stops. All included participants were healthy, aging from 25 to 35 years, having good oral hygiene and acceptable functional occlusion. Patients were asked to participate in the study and 26 subjects recalled (18 males and 8 females). All permanent upper anterior teeth and lower canines and premolars with fully developed roots were assessed for TM and their C/R were measured. The teeth included in the study were 278 single rooted teeth obtained from the 26 CBCTs were included in the study. The data was coded and entered using the statistical package SPSS version 20. The data was summarized using descriptive statistics.

Results: The mean C/R was 0.64 (+ 0.13) and mean periostest reading was -0.61 (+ 3.34). The maximum C/R was 1.51 and the minimum was 0.30, with a median of 0.62 and standard deviation of 0.14. The maximum periostest value was 22.8 and the minimum was -5.90 with a median of -0.93 and standard deviation of 3.35. Using SPSS, we get: $r = 0.616$. Pearson's correlation coefficient revealed a statistically significant moderate and positive correlation between C/R and TM at 0.01 level. **Conclusions:** There was a positive and moderate correlation between crown root ratio and mobility in single rooted teeth with healthy periodontium.

Keywords: Tooth mobility, Crown root ratio, CBCT, Periostest.

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INTRODUCTION

All teeth have two parts, the crown and the root that are demarcated by the cemento enamel junction. In a healthy gingival condition, the roots of teeth are entirely embedded in the alveolar bone which is covered by the soft tissue, while the crown exists entirely outside the surrounding bone.⁽¹⁾

Proper support of the teeth during normal function is due to the fact that the root length which is embedded in bone is considerably longer than the crown length. The crown root ratio (C/R) is a measure of the length of tooth occlusal to the alveolar crest of bone compared with the length of root embedded in the bone.⁽²⁾ It is termed as favorable, if the root existing within the surrounding bone is more than sufficient to support the tooth under normal physiologic stresses.⁽¹⁾

Schillinberg et al, emphasized on the importance of C/R ratio and tied it directly to the abutment selection to support a FPD. They proposed a 2/3 to be the optimum ratio for a tooth to be used as an abutment for a fixed partial denture whereas 1/1 was accepted as the maximum ratio that is acceptable for a prospective abutment under normal circumstances.⁽²⁾

There are three main reasons for unfavorable C/R: (1) Short roots as a result of disturbances during root development, (2) resorption of the originally well-developed roots⁽³⁾, (3) resorption of the crestal bone as in cases of periodontal diseases and epicoectomy.

Tooth mobility is an eventual result of unfavorable C/R ratio. In addition, there are other causes for tooth mobility as inflammatory changes in periodontal ligament, and trauma from occlusion. These two are correctable, but mobility due to alveolar bone loss or root resorption is not likely to be corrected.^(4,5)

Teeth with unfavorable C/R are considered as weak prognosis regardless of their mobility and may affect to complicate the treatment plan,

especially in orthodontics and prosthodontics when estimating the ability of a tooth to carry more than usual masticatory forces. Therefore, reference value for C/R of normal teeth is necessary during these procedures since it affects abutment selection.

The radiographic methods commonly utilized to diagnose and evaluate C/R, root resorption and crestal bone level include panoramic and periapical radiographs. Although they are widely used and readily available, these methods may be limited in their accuracy and/or reproducibility for evaluating C/R due to magnification errors, distortion, superimposition of structures, and improper patient positioning.^(6,7)

The introduction of CBCT in dentistry allowed the clinician to obtain a three-dimensional (3D) image of a patient to evaluate information about teeth, bone support and adjacent structures. Benefits of CBCTs as compared with conventional CTs include rapid scan time, chairside image display, and decreased radiation dose.⁽⁸⁾ In contrast to the popular two-dimensional radiographic techniques mentioned above, linear measurements of structures in the dentomaxillofacial area have been found to be relatively accurate on a CBCT.^(9,10) Recent studies have also shown that CBCT images provide accurate and reliable measurements of root length⁽¹¹⁾ compared with periapical radiographs.⁽¹²⁾

Evaluating tooth mobility (TM) is of interest in daily practice. During a routine dental examination, TM assessment can provide valuable information about the long term prognosis of teeth or indications for treatment strategies. According to Miller's classification, TM is divided into four classes; (class 0) no movement distinguishable, (class I) first distinguishable sign of mobility where tooth can be moved less than 1mm in the buccolingual or mesiodistal direction, (class II) Tooth can be moved 1mm or more in the buccolingual or mesiodistal direction with no mobility in the occlusoapical direction, (class III) mobility is easily noticeable and the tooth moves more than 1 mm in any direction or

can be rotated in its socket.⁽¹³⁾

Methods in which the tooth is deflected between handles of two instruments are very common for categorizing TM into these classes. However, these investigations are subjective and operator-dependent.⁽¹⁴⁾

An objective and highly reproducible method for analyzing TM is the periotest method.⁽¹⁵⁾ The periotest (Gulden-Medizintechnik, Bensheim) is an electronic device that measures the dampening characteristics of the periodontium. A defined impact load is applied to the tooth crown and the mean contact time of 16 reproducible impacts is calculated and converted into a numeric scale ranging from -8 to +50. Low periotest values (-8) indicate a short deflection time and, thus, high stability of the tested object. High values (+50) demonstrate high mobility. The scale correlates with Miller's index, with periotest value (PTV) -8 to +9 being no movement distinguishable, PTV +10 to +19 first distinguishable sign of mobility, PTV +20 to +29 crown deviates within 1 mm of its normal position and PTV +30 to +50 mobility is easily noticeable.⁽¹⁶⁾

To date, there is no clear data of correlation between C/R and TM. Nevertheless, it was assumed before that the teeth with unfavorable C/R (less than 1/1) suffer from mobility as well. In another words, unfavorable C/R is linked to mobility, and as a result teeth suffering from mobility are excluded from serving as abutments which complicates the treatment plan. The question rises, is there true correlation between C/R ratio and TM? The hypothesis of this study is that there is a correlation between C/R and TM.

MATERIALS AND METHODS

Study design and setting

This study was designed as a retrospective, randomized clinical trial, done at Beirut Arab University, Lebanon. The source of population was patients attending BAU dental clinics.

Sample collection

The records of 72 patients who attended BAU dental clinics for orthodontic treatment or oral implant placement between 2011 and 2013 were gathered based solely on the availability of CBCT records for single rooted teeth. The records received for each patient included a CBCT, a diagnostic summary sheet, and a treatment card that provided information about each patient's occlusion, missing teeth, and treatment notes from each visit.

Inclusion criteria for the teeth included in the study were:

- Single rooted teeth with present adjacent mesial and distal teeth
- Vital teeth with fully developed roots and no root resorption
- Absence of periodontal disease as gingival inflammation or pockets
- Absence of widened periodontal ligament space

43 patients were eliminated from the original sample due to the exclusion criteria that included previous orthodontic treatment, periodontal disease, absence of posterior stops in one or in both arches, severe malocclusion, maxillofacial trauma, or orthognathic surgery. Also 4 patients were removed due to poor-quality CBCT images.

Only 29 records that fulfilled the inclusion criteria were selected. These records belonged to orthodontic patients with mild occlusal discrepancy who haven't started their treatment yet, and to those requesting tooth replacement with implant retained restoration but having enough posterior stops. All included participants were systemically healthy, aging from 25 to 35 years, having good oral hygiene and acceptable functional occlusion.

Individual teeth were also eliminated for incomplete image or for poor image quality.

Patients were asked to participate in the study and 26 subjects recalled (18 males and 8 females). All permanent upper anterior teeth and lower

canines and premolars with fully developed roots were assessed for tooth mobility and their C/R were measured.

Measurement of crown root ratio

Measurement of C/R was done on the CBCT records of the available single rooted teeth. For each tooth, the coronal and sagittal planes passing through the most coronal point and through the root apex were defined in the oblique slicing. So, each tooth was oriented so that it was upright in the sagittal and coronal views. The teeth were visualized in three planes (axial, sagittal, and coronal). Following orientation, 4 measurements in the coronal plane were taken on each tooth.

A line was drawn through the alveolar crest mesial and distal to each tooth, and another line passing through the most coronal part of a tooth to the root apex. The crown height and the root length are then measured from the intersection point of these two lines and then the C/R was calculated from these two measurements.

Each periotest value was estimated 3 times for every tooth and the average values were used in the calculations.

Measurement of tooth mobility

The mobility of the teeth was assessed using Miller's mobility index⁽¹³⁾ and the periotest method.^(17,18)

PTV were obtained from all maxillary incisors, maxillary canines, mandibular premolars, and mandibular canines, in a horizontal dimension by the same experienced operator using the periotest device, according to the manufacturer's instructions. The patient's head was placed against the headrest with the actual tooth perpendicular to the floor. Reproducible measurement points (in the mid buccal point of the middle third of the tooth) were marked to the teeth with a waterproof marker. The tip of the periotest was placed, in a horizontal position with the start button on top and at a distance of not more than 4 mm from the

buccal surface of the tooth. The tooth was out of occlusion and percussed perpendicular to the buccal surface.⁽¹⁸⁾ All measurements were made thrice by the same operator. The average values were used in the calculations.

RESULTS

Only 26 healthy Lebanese subjects of both sexes participated in the study. There were 18 male patients (69%) and 8 female patients (30.8%) with age ranging from 25 to 35 (mean age 30 years).

The teeth included in the study were 312 single rooted teeth obtained from the 26 CBCTs, where 26 teeth were excluded as a result of unclear reference points that are due to incomplete root development, caries or restorations, root canal treatment, severe attrition, or blurred radiographs because of diffused images or distortion. Crown root ratio of these teeth were calculated from the CBCTs and their average periotest values were measured by the periotest device. When measuring periotest values, 8 teeth were excluded due to extensive caries or restoration, cracks in the enamel and sensitivity to percussion. So, 278 teeth were included in the study.

The data was coded and entered using the statistical package SPSS version 20. The data was summarized using descriptive statistics. Summary of data is presented in (table 1).

TABLE (1) Descriptive analysis.

Statistics			
		Ratio C/R	Average PerioTest Value
N	Valid	310	292
	Missing	26	44
Mean		.6378	-.60845
Median		.6108	-.93333
Std. Deviation		.13961	3.343607
Minimum		.34	-5.933
Maximum		1.54	22.833

The Pearson's correlation coefficient between the two continuous variables; C/R and TM was used, after testing the normality of data using Kolmogorov-Smirnov test where the P value was 0.0751 indicating normal distribution of the two variables.

Using SPSS, we get: $r = 0.616$. Pearson's correlation coefficient revealed a statistically significant moderate and positive correlation between C/R and TM at 0.01 level.

Scatter Plot (Fig. 1) graphically displays the relationship between the two variables by plotting the values of the dependent variable which is periotest values on the y-axis and the C/R values ratio variable which is the independent variable on the x-axis.

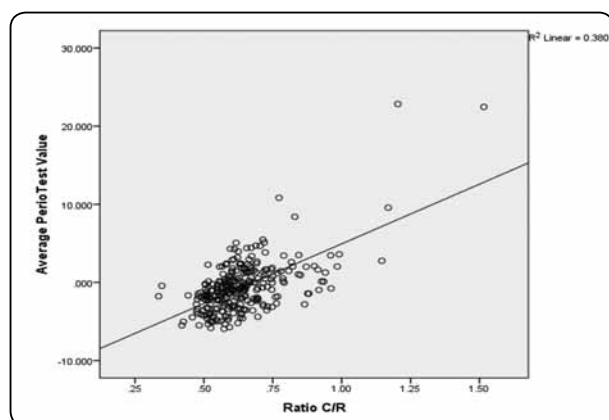


Fig. (1) Scatter plot of C/R ratio to average Periotest value

According to this graph, there appears to be a linear relationship between C/R and TM. High values of crown to root ratio are associated with high values of periotest.

DISCUSSION

The aim of this study was to correlate C/R to mobility in permanent single rooted healthy teeth by utilizing the CBCT and periotest device.

The radiographic methods commonly used to evaluate crown root ratio include panoramic

and periapical radiographs. Although widely available, these methods could be limited in their accuracy and reproducibility due to magnification errors, distortion, and improper patient position.⁽⁷⁾ More recently, Dudic et al, 2009⁽¹⁹⁾ reported that measuring root resorption may be underestimated on panoramic radiographs as compared with CBCT images. Recent studies have also shown that CBCT images provide accurate and reliable measurements of root length⁽¹¹⁾ as compared with periapical radiographs.⁽¹²⁾ In addition, CBCTs, as compared to conventional CTs, have the advantages of rapid scanning time, chairside image display, and decreased radiation dose.⁽⁸⁾

The periotest device was selected to measure mobility because of its widespread use since it was said to be objective and highly reproducible device that is utilized for measurements of the damping characteristics of healthy teeth and evaluating their mobility.⁽¹⁶⁾ The precision of its measurements was reported by Levander and Malmgren, 2000⁽²⁰⁾ and Berthold et al, 2010⁽²¹⁾. The device has some limitations, where it has been reported that the highest reproducibility of the method has been found for teeth with low to moderate TM, whereas measurements on highly mobile (grade III mobility) are less reproducible.⁽¹⁸⁾ The other limitation of the periotest device, and which influence its reproducibility are the angle and the distance of the handpiece from the tooth surface, as well as the use of reproducible measurement points.^(15,21) These aspects were carefully taken into consideration when assessing tooth mobility by the same experienced clinician where reproducible measuring points were drawn on the center of labial surface 4 mm away from the incisal edge, and measuring was only taken in horizontal direction to follow the common protocol.^(22,23)

Previous studies that have attempted to correlate root length with tooth mobility, did not take into consideration the crown height.⁽²⁴⁾ We preferred to consider the crown height and its horizontal

cantilever effect, as well as the crestal bone level by using crown root ratio in our study and correlate it with mobility.

In this study, there was a positive and moderate correlation between crown root ratio and mobility in single rooted teeth with healthy periodontium. This means that as crown root ratio increases, mobility increases where the loss in root length moves the center of resistance more coronally, and the same amount of force will then have a greater impact than on a tooth with less crown root ratio. This result strengthens the earlier findings^(20,24)

Grouping the teeth, revealed that the least mobility was for canine group (mean = - 2.095), and the most mobility was for incisor group (mean = + 0.9474) while for the premolar group it was intermediary (mean = -0.7391). These results were in consistency with Burch 1960⁽²⁵⁾ who reported that teeth normally have a wide range of mobility, with single rooted teeth being more mobile than multirooted teeth and incisors have most mobility of all.

D'Hoedt et al, (1985)⁽¹⁸⁾ determined the PTV for periodontally healthy teeth with normal root length. For central maxillary incisors, the average PTV was 7 and for laterals 6. In comparison, the average PTV in the present study was 0.9474 for the incisor group which is not similar to the results of D'Hoedt. Possible differences may be attributed to errors in measuring tooth mobility or the sample size and its characteristics.

The highest crown root ratio was for the incisor group (0.6799 + 0.6375) and the least crown root ratio was for the canine group (0.5993 + 0.1075) while that of the premolar group was intermediary (0.6338 + 0.1487). These data revealed that teeth with higher crown root ratio (incisor group) had the higher tooth mobility values while those with least crown root ratios (canine group) had the least

mobility values. These results were in agreement with Jonsson (2007)⁽²⁴⁾ who reported that teeth with extreme resorption at the end of orthodontic treatment and a normal crestal bone level had a higher PTV.

Statistical analysis also revealed a positive correlation between crown root ratio within the 3 groups separately, Incisor and premolar groups being moderately correlated while the canine group being weakly correlated. This may be due to the fact that canines had the longest roots among teeth and therefore the least crown root ratio and that this ratio needs more bone loss or root resorption to be altered as compared to the other groups.

Comparing crown root ratio among the 3 groups, revealed statistical difference between the incisor and canine group, with no statistical difference between canine and premolar groups or incisor and premolar group. Concerning mobility, the formerly mentioned tests revealed statistical differences between the 3 groups.

The incisor had the greatest mobility as compared to canines not only due to their shorter roots but also due to the fact that they are labially inclined in their position in the arch and forces of occlusion can be considered as obliquely directed rather than vertically directed.

There were several aspects of this study that one could criticize. The availability of pre- and post treatment CBCTs made this study possible; however, a greater sample size of more than 26 patients could have gained additional strength.

CONCLUSIONS

Within the limitation of the study it could be concluded that, there was a positive and moderate correlation between crown root ratio and mobility in single rooted teeth with healthy periodontium.

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