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Effect of Crestal Bone Level on Mobility of Teeth in the Esthetic Zone

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Abstract: ***Purpose*: Loss of crestal bone is linked to mobility. As a result, mobile teeth with receded crestal bone are not preferred as abutments and therefore are excluded from the treatment plan. The aim of this study is to find if there is real correlation between crestal bone level and tooth mobility by utilizingcone beam computedtomography and periotest. *Materials and methods*: The records of 67 patients who attended the dental clinics of Beirut Arab University for implant placement or orthodontic treatment between 2013 and 2014 were gathered according to the availability of CBCT ofmaxillary anterior teeth. Only 28patients of those who fulfilled the inclusion criteria responded and participated in the study. These participants were orthodontic patients with mild occlusal discrepancy who didn't start their treatment yet, and those requesting single tooth replacement with implant prosthesis. All included participants were healthy, aging from 25 to 35 years and having good oral hygiene with acceptable functional occlusion. All permanent upper anterior teeth with fully developed roots were assessed for tooth mobility and the effect of crestal bone level by measuring thecrown root ratio. The teeth included in the study were 164upper anterior teeth obtained from the 28 CBCTs. The data was coded and entered using the statistical package SPSS version 20. The data was summarized using descriptive statistics. *Results*: The mean crown root ratio was (0.6461) and mean periotest reading was (0.0734). The maximum crown root ratio was 1.52 and the minimum was 0.35, with a median of 0.6159and standard deviation of 0.14710. The maximum periotest value was 22.47 and the minimum was -5.50 with a median of -0.3167and standard deviation of 3.04773.Using SPSS, we get: r = 0.653. Pearson's correlation coefficient revealed a statistically significant moderate and positive correlation between crown root ratio and tooth mobility at 0.01 level.***

Keywords: Tooth mobility, Crestal bone level, Crown root ratio, CBCT, Periotest.

1. Introduction

There are two actual parts of a tooth, the crown and the root that are separated by the cementoenamel junction. In a healthy periodontium, theroots are entirely embedded in the alveolar bone while the crownsare found 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 bonecompared with the length of root embedded in the bone.[(2)] It istermed 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, explained the importance of crown root ratio and tied it directly to the abutment selection to support a FPD. They proposed a ratio of 2/3 to be optimum if the tooth is to be used as an abutment for a fixed partial denture. Whereas, 1/1 wasthe minimum acceptable ratio for a prospective abutment under normal circumstances.[(2)]

There are four main reasons for unfavorable crown root ratio: (1) Short roots as a result of disturbances during root development, (2) resorption of the originally well-developed roots [(3)] (3) resorption of the alveolar bone as in cases of periodontal diseases and (4)root epicoectomy.

Tooth mobility is an eventual result of unfavorable crown root 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)]

The radiographic methods commonly utilized for diagnosis and evaluation ofcrown root ratio, 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 evaluation 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 comparedwith conventional CT scans include rapid scan time, chairside image display, anddecreased radiation dose [(8)] In contrast to the popular two-dimensional radiographictechniques mentioned above, linear measurements of structures in the dento-maxillofacial area have been found to be relatively accurate ona CBCT.[(9,10)] Recent studies have also shown that CBCT images provide accurateand reliable measurements of root length[(11)] compared with periapicalradiographs.[(12)]

Evaluating tooth mobility is of interest in daily practice. During a routine dental examination, mobility assessment can provide valuable information about the longterm prognosis of teeth or indications for treatment strategies. According to Miller's classification, tooth mobilityis 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 tooth mobility into these classes. However, these investigations are subjective and operator-dependent.[14]

An objective and highly reproducible method for analyzing tooth mobility is theperiotest method.[15] The periotest (Gulden-Medizintechnik, Bensheim, Germany) 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]

Teeth with unfavorable crestal bone level are considered as week prognosis regardless of their mobility. Such teeth may complicate the treatment plan, especially in orthodontics and prosthodontics, when estimating the ability of a tooth to carry more than usual masticatory forces.

To date, there is no clear data of correlation between crestal bone position and periotest values in the esthetic zone area. Therefore, reference value for crestal bone level of normal teeth is necessary during these procedures since it affects abutment selection.The question rises, is there true correlation between crestal bone level and tooth mobility? The hypothesis of this study is that there is a correlation between crown root ratio and tooth mobility.

2. Materials and Methods

1-Study design and setting

This was a randomized clinical trial, and a retrospective study done at Beirut Arab University, Lebanon. The source of population for this study was patients attending BAU Dental Clinics.

2-Sample collection

The records of67 patients who attended BAU dental clinics fororthodontic treatment ororal implant placement between 2013 and 2014 were gathered based solely on the availability of CBCT records for maxillary anterior teeth. The records gathered for each patient included a CBCT, a diagnostic summary sheet, and a treatment chart that provided information about each patient's occlusion, missing teeth, and treatment notes from each visit.

32 patients were eliminated from the original sample due to the exclusion criteria that included orthodontic treatment, periodontal disease, absence of posterior stops in one or in both arches, severe malocclusion, maxillofacial trauma,and orthognathic surgery.Also 7 patients were removed due to poor-quality CBCT images.

Only 28 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 thosepatients requesting tooth replacement with implant retained restoration but having enough posterior stops. All included participants were systemically healthy, aging from 25 to 35 years, and having good oral hygiene with acceptable functional occlusion.

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

Individual teeth werealso eliminated for incomplete image orfor poor image quality.

Patients were asked to participate in the study and a total of 163 permanent upper anterior teethwith fully developed roots were assessed for their C/Rand tooth mobility.

3- Measurement of crown root ratio

Measurement of crown root ratio was done on the CBCT records of maxillary anterior 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 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 crown root ratiowas calculated from these two measurements.

4- Measurment 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, and canines, in a horizontal dimension by the same experienced operator using the periotest device, according to the manufacturer's instructions (Fig. 1).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]Each periotest value was estimated 2 times for every toot and the average values were used in the calculations.

Figure 1: Recording tooth mobility using periotest

3. Results

Only 28healthy individualsparticipated in the studywith age ranging from 25 to 35 (mean age 30 years). 168maxillary anterior teeth were obtained from the 28 CBCTs. 4 teeth were excluded as a result ofunclear reference points that was due to severe attritionor blurred radiographs because of diffused images or distortion. 164 teeth were included in the study. Crown root ratio of these teeth were calculated from the CBCTs and their average periotest values were measured by the periotest device.

The data was coded and entered using the statistical package SPSS version 20. The data was summarized using descriptive statistics: mean, standard deviation, median, minimum and maximum values for quantitative variables according to (table 1).

Statistics

Table 1: Descriptive Statistics

		Crown to Root Ratio	Average Perio Test Value
N	Valid	163	148
	Missing	1	16
Mean		.6461	.0734
Median		.6159	-.3167
Std. Deviation		.14710	3.04773
Minimum		.35	-5.50
Maximum		1.52	22.47

The Pearson's correlation coefficient between C/R and mobility was used, after testing the normality of data using Kolmogorov-Smirnov test where the P value was 0.0762indicating normal distribution of the variables

Using SPSS we got: r = 0.653 (Table 2) Indicating a moderate positive relationship between crown to ratio and periotest value. Pearson's correlation coefficient revealed a statistically significant moderate and positive correlation at 0.01 level, (r = 0.653).

Table 2: Correlation Table

Correlations

		Crown to Root Ratio	Average Perio Test Value
Crown to Root Ratio	Pearson Correlation	1	.653**
	Sig. (2-tailed)		.000
	N	163	147
Average Perio Test Value	Pearson Correlation	.653**	1
	Sig. (2-tailed)	.000	
	N	147	148
**. Correlation is significant at the 0.01 level (2-tailed).			

Scatter Plot (Fig. 2) 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 values of the crown to root ratio variable which is the independent variable on the x-axis.

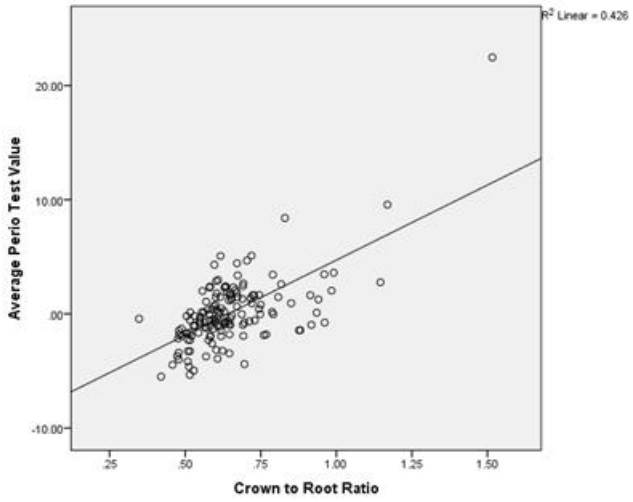

Figure 2: Scatter Plot

There appears to be a linear relationship between crown to root ratio and periotest values. High values of crown to root ratio are associated with high values of periotest. The teeth were then subdivided into 3 subgroups; central incisors, lateral incisors and canines. The correlations were then analyzed within each group. A total of 54 maxillary central incisors, 55 lateral incisors and 55 canines were included. Descriptive statistics for C/R and periotest readingsare summarized in table 3, 4, 5 respectively.

Table 3: Descriptive Statistics of central Incisors

Statistics[a]

		Crown to Root Ratio	Average Perio Test Value
N	Valid	54	50
	Missing	0	4
Mean		.7113	.9787
Median		.6642	.1167
Std. Deviation		.17685	3.90000
Minimum		.52	-3.93
Maximum		1.52	22.47
a. Tooth Name = Central Incisor			

Table 4: Descriptive Statistics of lateral Incisors

Statistics[a]

		Crown to Root Ratio	Average Perio Test Value
N	Valid	55	49
	Missing	0	6
Mean		0.6492	0.9156
Median		0.629	0.9333
Std. Deviation		0.10975	2.06317
Minimum		0.48	-2.3
Maximum		0.99	8.4

a. Tooth Name = Lateral Incisor

Table 5: Descriptive Statistics of canines

Statistics[a]			
		Crown to Root Ratio	Average Perio Test Value
N	Valid	54	49
	Missing	1	6
Mean		0.5778	-1.6925
Median		0.548	-1.6667
Std. Deviation		0.11621	1.97529
Minimum		0.35	-5.5
Maximum		0.98	2.43
a. Tooth Name = Canine			

Histograms of the two variables, showed fairly normal distribution with potential outliers to the right side of the curve for the 3 subgroups.

Using SPSS we got: r = 0.696, indicating a moderate positive correlation in the central incisors group, r = 0.505 and r = 0.430 indicating a weak positive correlation in the lateral incisor and canine groups respectively.

Pearson's correlation coefficient revealed a statistically significant moderate and positive correlation at 0.01 level, for the three groups, Tables 6, 7, 8.

Table 6

Correlations			
		Crown to Root Ratio	Average Perio Test Value
Crown to Root Ratio	Pearson Correlation	1	.696**
	Sig. (2-tailed)		.000
	N	54	50
Average Perio Test Value	Pearson Correlation	.696**	1
	Sig. (2-tailed)	.000	
	N	50	50
**. Correlation is significant at the 0.01 level (2-tailed).			
a. Tooth Name = Central Incisor			

Table 6

Table 7

Correlations			
		Crown to Root Ratio	Average Perio Test Value
Crown to Root Ratio	Pearson Correlation	1	.505**
	Sig. (2-tailed)		.000
	N	55	49
Average Perio Test Value	Pearson Correlation	.505**	1
	Sig. (2-tailed)	.000	
	N	49	49
**. Correlation is significant at the 0.01 level (2-tailed).			
a. Tooth Name = Lateral Incisor			

Table 8

Correlations			
		Crown to Root Ratio	Average Perio Test Value
Crown to Root Ratio	Pearson Correlation	1	.430**
	Sig. (2-tailed)		.002
	N	54	48
Average Perio Test Value	Pearson Correlation	.430**	1
	Sig. (2-tailed)	.002	
	N	48	49
**. Correlation is significant at the 0.01 level (2-tailed).			
a. Tooth Name = Canine			

4. Comparing the groups

Our aim is to test whether the mean mobility and mean crown to root ratio differs across the 3 teeth groups (Group 1 for central incisors, Group 2 for the lateral incisors, and group 3 for the canines). Since mobility is a continuous outcome and we have more than 2 groups and normally distributed as shown in the histograms, analysis of variance or ANOVA will be used (Table. 9).

- Hypotheses:
  - ✓ H0: μ1= μ2 =μ3
  - ✓ H1: at least 2 means are different

Table 9

ANOVA						
		Sum of Squares	Df	Mean Square	F	Sig.
Crown to Root Ratio	Between Groups	.482	2	.241	12.739	.000
	Within Groups	3.024	160	.019		
	Total	3.505	162			
Average Perio Test Value	Between Groups	228.540	2	114.270	14.574	.000
	Within Groups	1136.894	145	7.841		
	Total	1365.433	147			

From SPSS we got p-value= 0.000 which is less than 0.05. The mean mobility and crown to root ratio differed significantly among teeth across the three groups. Our results are significant so we can reject H0 (the null hypothesis) and at least 2 means are different.

In order to specify which groups significantly differ with regard to mean mobility, ANOVA post hoc test will be performed "Bonferroni" (Table 10).

Table 10

Multiple Comparisons							
Bonferroni							
Dependent Variable	(I) Tooth Category	(J) Tooth Category	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Crown to Root Ratio	1	2	.06212	.02634	.059	-.0016	.1258
		3	.13344*	.02646	.000	.0694	.1974
	2	1	-.06212	.02634	.059	-.1258	.0016
		3	.07131*	.02634	.023	.0076	.1350
	3	1	-.13344*	.02646	.000	-.1974	-.0694

		2	-.07131*	.02634	.023	-.1350	-.0076
Average Perio Test Value	1	2	.06302	.56287	1.000	-1.3003	1.4263
		3	2.67118*	.56287	.000	1.3079	4.0345
	2	1	-.06302	.56287	1.000	-1.4263	1.3003
		3	2.60816*	.56571	.000	1.2380	3.9784
	3	1	-2.67118*	.56287	.000	-4.0345	-1.3079
		2	-2.60816*	.56571	.000	-3.9784	-1.2380
*. The mean difference is significant at the 0.05 level.							

Crown to root ratio
P-value with Bonferroni for µ1 and µ3= 0.000 and for µ2 and µ3=0.023 (both areless than 0.05)
The post hoc Bonferroni's test revealed that the teeth groups 1&3, 2&3 significantly differed regard to mean crown to root ratio.

Periotest
P-value with Bonferroni for µ1 and µ3= 0.000 and for µ2 and µ3=0.000 (both areless than 0.05)
The post hoc Bonferroni's test revealed that the teeth groups 1&3, 2&3 significantly differed regard to mean periotest.

5. Discussion

The aim of this study was to correlate crestal bone level to mobility in maxillary anterior teeth by utilizing the CBCT and periotest device.

The commonly used radiographsfor evaluatingcrestal bone level include panoramic and periapical x rays. Although commonly available, these methods are limited in their accuracy and reproducibility due to errors in magnification and distortion. [7] More recently, Dudic et al, demonstrated that measuring root resorption may be misevaluated on panoramic x rays as compared with CBCT images. [19] 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 reduced radiation dose. [8]

The periotest device was selected to measure mobility due to its widespread use due to its highly reproducibility.It is used for measuring the damping characteristics of healthy teeth and evaluating their mobility. [16] The precision of its measurements was reported by Levander and Malmgren[20] and Berthold et al [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 teeth (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 hand piece 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 and correlating it with mobility.

In this study, there was a positive and moderate correlation between crown root ratio and mobility in maxillary anterior 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 of Levander and Malmgren and then with Jönsson et al. [20,24]

Grouping the teeth, revealed that the least mobility was for maxillary canines group (mean = – 1.6925), and the most mobility was for maxillary central incisors group (mean = + 0.9787) while for the maxillary lateral incisors group it was intermediary (mean = +0.9333). 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 0.9787 for the central incisor group and 0.9156 for the lateral 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 C/R was for the central incisor group (0.7113) and the least crown root ratio was for the canine group (0.5778) while that of the lateral incisor group was intermediary (0.6492). These data reveled 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, Central incisorsgroup being moderately correlated while the canines group being weekly 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 crestal bone loss or root resorption to be altered as compared to the other groups.

Comparing crown root ratio and periotest values among the 3 groups, revealed statistical difference between the central incisors and canine group, and between lateral incisors and canines group.

The incisor have 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 28 patients could have gained additional strength.

6. Conclusions

There is a correlation between crestal bone level and mobility of teeth in esthetic zone with central incisors being the most affected and canines being the least affected by crestal bone loss.

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