EFFECTS OF FIXED PROSTHETIC RESTORATIONS ON ALVEOLAR BONE DENSITY

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ABSTRACT

Objective. To determine the effects of fixed prosthetic restorations on alveolar bone density.

Methods. 80 subjects of both genders with fixed prosthetic restorations took part in the research. Retro-alveolar radiovisiography (RVG) images were taken of the abutment teeth with fixed prosthetics and of the homologous (control) teeth for all the subjects. All automatically digitalized RVG images were stored on a computer equipped with the Digora for Windows 2.5 software by which measurements were made in seven regions of interest (ROI), around the tooth root, each of 10-pixel size.

Results. The results of the research were processed by t-test and single factor multivariate analysis of variance (MANOVA) that showed, with a significance level of 5%, that there was no difference in the alveolar bone density between the abutment teeth with fixed prosthetic restorations and the control (homologous) teeth. No statistically significant difference was found either in alveolar bone density between the teeth with different types of restorations (crown, bridge work).

Conclusion. The good quality of fixed prosthetic restorations may be the reason why there is no difference in the alveolar bone density between abutment teeth with fixed prosthetic restorations and the homologous teeth.

Key words: the alveolar bone density, fixed prosthetics

Introduction

The alveolar bone's absorption and apposition are affected by local and system-related factors. A patient's age, gender, body mass index, osteoporotic changes in the entire body, hormonal disbalance, etc. are system factors [1]. Compressive and tensile forces, contacts of antagonists in occlusion, parafunction, hygiene and a properly contoured crown or dental bridge are considered to be local factors contributing to the apposition and absorption of bone tissue around an abutment tooth's root [2, 3]. Some life habits have a major influence on the bone system health such as smoking, alcohol consumption, caffeine, lack of physical activity, frequent diets, unhealthy foods.

Bone mass is built during youth and at the age of sexual maturity. The quantity of bone mass stabilizes in the 30-ies, reaching its highest value, i.e. "bone mass peak", as the maximum mass resulting from the normal growth and development of the body. Skeleton bone mass loss is a physiological process that may begin as early as in the third decade of human life and is marked by a reduction in density and an increase in bone tissue porosity [4]. A lack of estrogen in menopause is the most common cause of bone mass loss in women. In the first 5-7 years after menopause an average of 1-3% of bone mass is lost per year by the age of 70 when this process slows but never stops, as a result of which women lose 35-50% of total bone mass by the time they reach old age [5, 6].

The degree of alveolar bone density may indicate good function, reduced function or the loss of function of the abutment tooth with fixed prosthetic restoration. The most common and straightforward method to determine bone mass density is a routine X-ray. It takes at least 30%, and sometimes even 50 – 60% of bone mass loss before it is possible to detect osteopenia (bone loss) via X-ray [7, 8]. With the progress of IT techniques, numerous methods (software) have been developed for the computer processed RVG imaging, enabling more objective assessment of even minor changes in alveolar bone density, thus they replaced subjective and inadequate methods [9-13].

The goal of this research was to determine whether there is a difference between alveolar bone density around abutment teeth with fixed prosthetic restorations and control (homologous) teeth.

Subjects and methods

A total of 80 subjects took part in the research, aged 20 to 50, of both genders, all with fixed prosthetic restorations (crown or bridge work), who responded for regular check-ups at the Dental Prosthetics Department of the Faculty of Dentistry of the University of Sarajevo. The inclusion criteria for all subjects were as follows: having a fixed prosthetic restoration for at least three months or longer, the edge of the fixed prosthetic restoration is placed sub-gingivally, there is a homologous tooth or a tooth belonging to the same teeth group on the contralateral side as a control tooth for comparison, and both the abutment tooth and the control tooth are in occlusion.

All subjects selected in this way were divided into two groups, depending on their gender: Group A (41 subjects) were female subjects aged 20 to 50; Group B (39 subjects) were male subjects aged 20 to 50. All subjects coincided with the purpose of the research explained and signed the informative consent. Records were created for the purpose of this research into which data on alveolar bone density measurements were entered.

Retro-alveolar radiovisiography (RVGs) images were taken of the abutment teeth with fixed prosthetic restorations and of the homologous (control) teeth for all subjects. The images were obtained with a de.Götzen xgenus® digital device (De Götzen Srl Via Roma, 45-21057 Olgate Olona (VA) – Italy). The X-ray program used in this research was set as LR (low resolution) as the initial standard option due to the lower radiation

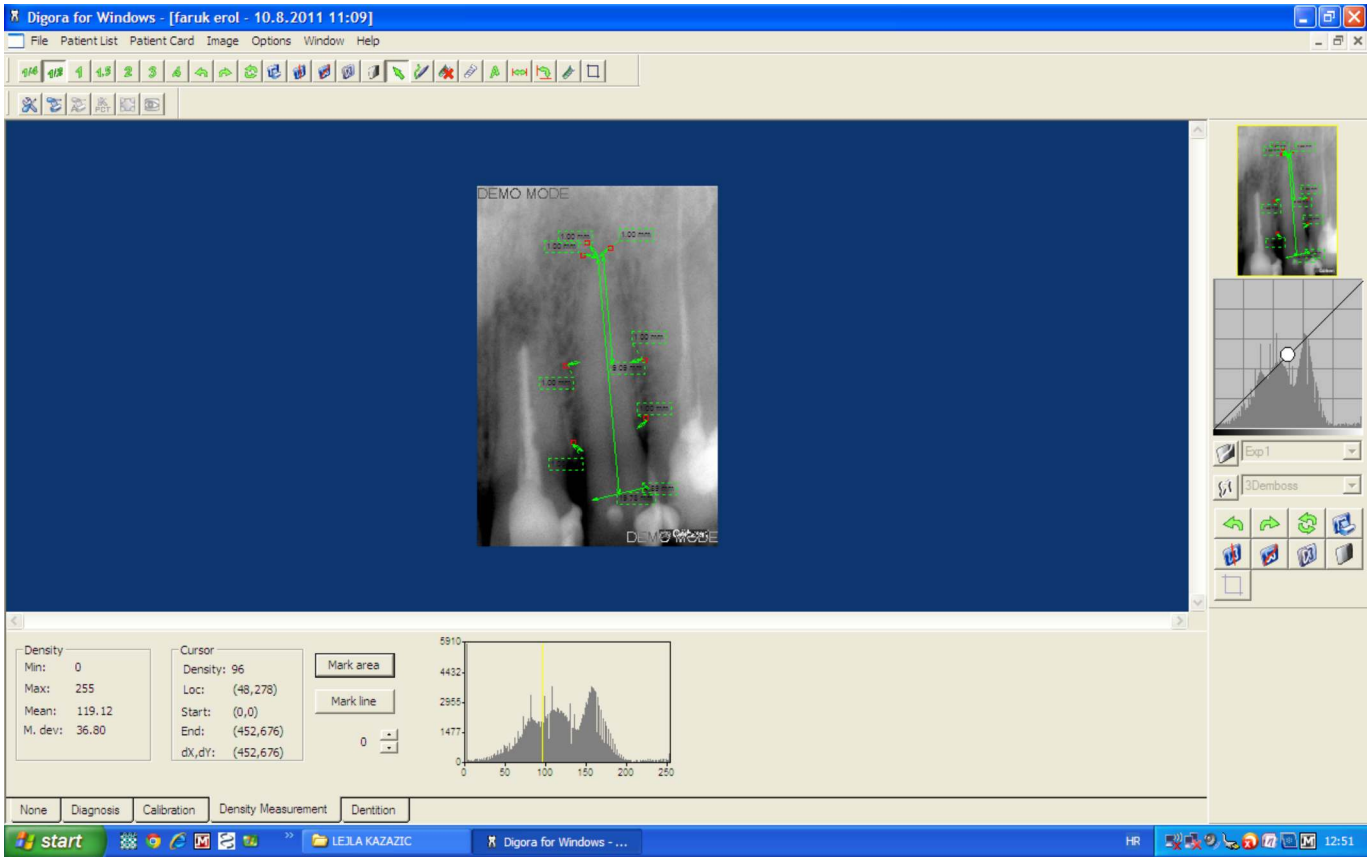

Image 1: ROI Positions

dose the patients were exposed to. Digital sensors were selected and placed as recommended by the manufacturer.

After the scans had been done, all automatically digitalized RVGs were stored on a computer equipped with the Digora for Windows 2.5 (Copyright, Sorodex, 2005) software, which was used for bone density analysis. This density measuring function provides information on the relative values of pixels using 8 – relevant scales, from full black (0) to full white (255).

After the process of image calibration, measuring the alveolar bone density followed. Seven regions of interest (ROI) were selected on each image, surrounding the tooth root, each of 10-pixel size (since the program also has the ability of linear measuring), as follows (**Image 1**):

ROI 1 – 1 mm mesial per alveolar edge from the tooth root

ROI 2 – 1 mm distally per alveolar edge from the tooth root

ROI 3 – 1 mm mesial from the tooth root apex

ROI 4 – 1 mm distally from the tooth root apex

ROI 5 – 1 mm vertically from the tooth root apex

ROI 6 – 1 mm mesial from half the range between ROI 1 and ROI 3

ROI 7 – 1 mm distally from half the range between ROI 2 and ROI 4.

For multi-rooted teeth, one root (mesial) was selected where measurements were taken.

At those points (seven ROIs shaped as small squares having the dimensions of 10x10 pixels) the alveolar bone density was measured as follows: by pointing the cursor to that particular point the density and cursor location were shown, and those values were noted and recorded.

Major advantage of this software is the fact that it enables zoom-in, so that the image can be increased four times. This made the observation of details and the correct positioning of the ROI easier.

Ethics statement

The study was approved by the Ethics Committee of the Faculty of Dentistry of the University of Sarajevo.

Statistical analysis

The parametric statistical techniques applied were the t-test of dependent samples and the single factor multivariate analysis of variance (MANOVA). The alpha significance level was set at 5% (0.05).

Results

The t-test of dependence did not reveal any statistically significant difference between the arithmetic mean of the alveolar bone density in any of the regions of interest (ROI) measured for abutment teeth with fixed prosthetic restorations (FPCT) and the control teeth (CT).

The differences between the arithmetic means, 95% confidence interval of average differences, the t-test values with degrees of freedom and the accompanying alpha value for comparisons of all variables are shown in **Table 1**.

With the single factor multivariate analysis of variance for dependent samples, all the points (ROIs) (1, 2, 3, 4, 5, 6 and 7) of the alveolar bone density were compared for the abutment teeth only. Single factor multivariate analysis of variance showed statistically significant differences in the alveolar bone density of the FPCT between all measured regions, $p<0.000$ (Wilks' Lambda=0.122, F=86.469, n=78). Descriptive statistical values with arithmetic means, standard errors, and the 95% confidence intervals are provided at **Table 2**. From the results obtained it may be observed that the bone is of higher density at the level of the middle root length and apically (ROIs 3,4,5,6 and 7) than at the level of the alveolar saddle (ROIs 1 and 2). Single-factor multivariate analysis of variance only failed to reveal statistically significant differences in the average bone density between the following points: (1 and 2 , p=0.07) , (3 and 4 , p=1) , (3 and 5 , p=1) ,(4 and 5 , p=1) , (6 and 7 , p=1).

Using the single factor analysis of dependent samples variance, all the points of bone density (1, 2, 3, 4, 5, 6 and 7) were compared for the control tooth as well. Single factor analysis of variance revealed statistically significant differences in the control teeth's bone density for all measured

Paired Differences*						
Pair	Mean	Std. deviation	95% CI difference mean	t	df	Sig. (2- tailed)
ROI 1 FPCT - ROI 1 CT	2.40	33.33	2.40±7.39	0.64	77	0.526
ROI 2 FPCT - ROI 2 CT	3.84	29.01	3.84±6.35	1.18	79	0.240
ROI 3 FPCT - ROI 3 CT	-6.16	32.08	-6.16±7.04	-1.72	79	0.090
ROI 4 FPCT - ROI 4 CT	-4.00	29.16	-4.00±6.39	-1.23	79	0.224
ROI 5 FPCT - ROI 5 CT	-6.19	34.61	-6.19±7.59	-1.60	79	0.114
ROI 6 FPCT - ROI 6 CT	-2.44	30.30	-2.44±6.64	-0.72	79	0.474
ROI 7 FPCT - ROI 7 CT	-3.14	29.00	-3.14±6.35	-0.97	79	0.336

* alpha level of significance p<0.05

Table 1. Statistical values of comparisons of alveolar bone density between the ROIs of abutment teeth with fixed prosthetic restorations (FPCT) and the ROIs of control teeth (CT) (paired samples t–test)

95% Confidence Interval				
Points	Mean	Std. Error	Lower Bound	Upper Bound
ROI 1 CT	52.413	3.604	45.237	59.590
ROI 2 CT	59.212	4.333	50.584	67.840
ROI 3 CT	128.212	3.455	121.333	135.091
ROI 4 CT	128.899	3.261	122.405	135.394
ROI 5 CT	130.406	3.383	123.669	137.143
ROI 6 CT	110.888	3.619	103.682	118.094
ROI 7 CT	114.981	3.536	107.940	122.022

Table 2.
Descriptive values of points 1, 2, 3, 4, 5, 6 and 7 on FPCT

95% Confidence Interval				
Points	Mean	Std. Error	Lower Bound	Upper Bound
ROI 1 CT	51.828	3.698	44.468	59.189
ROI 2 CT	57.426	4.084	49.298	65.554
ROI 3 CT	135.373	3.636	128.135	142.611
ROI 4 CT	134.339	3.566	127.241	141.437
ROI 5 CT	138.196	3.650	130.930	145.462
ROI 6 CT	114.881	3.765	107.387	122.375
ROI 7 CT	119.794	3.472	112.882	126.705

Table 3.
Descriptive values of points 1, 2, 3, 4, 5, 6 and 7 on CT

regions p<0.000 (Wilks' Lambda= 0.118, F= 92.06, n=80).

Descriptive statistical values with arithmetic means, standard errors, and 95% confidence levels are shown in **Table 3**. It may be seen from the results presented that the bone is of higher density on the level of the middle root length and apically (ROIs 3,4,5,6 and 7) than at the level of the alveolar saddle (ROIs 1 and 2). Single factor analysis of variance only failed to reveal statistically significant differences in the average bone density between the following points: (1 and 2 p=0.345) , (3 and 4, p=1) , (3 and 5, p=1) ,(4 and 5 , p=0.062) , (6 and 7 , p=0.701).

Table 4 shows the statistical values of *Wilks' Lambda* test obtained through the application of multivariate analysis of variance, showing whether there is a statistically significant difference in the alveolar bone density around the teeth in relation to different types of prosthetic restorations (single crown or bridge work), as a linear combination of all dependent variables of FPCT ROIs (1, 2, 3, 4, 5, 6 and 7). As it may be observed in column Sig. (p=0.497), no statistically significant difference was found between the different types of prosthetics with regard to alveolar bone density, as a linear combination for FPCT ROIs (1, 2, 3, 4, 5, 6, and 7).

Discussion

X-rays represent the most straightforward, cost-effective and accessible means of linear measuring of the amount of bone absorption and calculation of bone density loss. The radiation used is minimum and it may thus be regarded as a non-

	Value	F	Hypothesis df	Eror df	Sig.	Partial Eta Squared
Wilks' Lambda*	0.916	0.919	7.000	70.000	0.497	0.084

* alpha level of significance p<0.05

Table 4. Multivariate test (testing the effect of type of prosthetic restoration on alveolar bone density, with linear combination of FPCT ROI variables)

invasive method. [14]

In the case of radio-visiography imaging the radiation level is up to 90% lower than in the case of ordinary retroalveolar X -raysm thus being utterly negligible when compared to the benefits a patient may have from the information obtained from the X-ray images [15, 16, 17].

Each image in this research was obtained directly in digitalized form, and no RTG film developing or scanning of the image was required, whereby eliminating errors that may occur when developing a film, such as duration of developing, the developer's concentration, the date of production, as well as errors that may occur when scanning images due to non-linearity of the scanner, or glass surface stains [18, 19].

Measurements at the ROIs may be performed using different image processing programs. The Digora for Windows 2.5 (Copyright, Sorodex, 2005) program was used in this research for bone density analysis and for different linear measurements.

Good quality of fixed prosthetic restoration is probably the reason why no statistically significant differences were found in the alveolar bone density between the abutment teeth with fixed prosthetic restoration and the homologous teeth. However, it may be observed from the obtained results that the control teeth had slightly higher alveolar bone density than the abutment teeth. Lower density at the level of the alveolar saddle than in the middle of the root length and apically was also registered, both in teeth with fixed prosthetics and the control teeth. The reason for this is of course the anatomy of the bone, as the bone becomes thicker apically [20]. The reason may also be the proximity of the gingival area where factors are present that may have a major negative impact on bone density, such as plaque accumulation, gingival inflammation, an inadequate crown edge etc. It may be seen from the results of the research that there is a difference in alveolar bone density on the mesial and distal sides along the root for both abutment teeth and control teeth, although it is not statistically significant. The bone is of higher density on the distal side of the tooth's root than on the mesial side. The finding of lower bone tissue density on the mesial side of the tooth's root should not be regarded as a pathological condition, but as a physiological finding. This difference in the density on the mesial and distal sides of the tooth's root is attributed to the thickening of the alveolar process distally. No statistically significant difference was found in alveolar bone density as a linear combination for the FPCT ROIs (1, 2, 3, 4, 5, 6 and 7) regarding the type of prosthetic restoration (single crown, bridge work, appendix bridge). It should be noted that the research mostly involved minor (up to four units) bridges, with a proper unit and inter-unit ratio.

Much researches have dealt with the issue of changes in bone density and absorption below the bases of complete and partial dentures, around the abutment tooth (attachments) and bone density around an implant [21-29]. There are no data to be found in the literature regarding changes in bone density around the abutment teeth with fixed prosthetic restorations.

Conclusions

1. There is no statistically significant difference between the arithmetic means of the alveolar bone density around abutment teeth with fixed prosthetic restorations and control teeth at any of the points, i.e. regions of interest, which may be interpreted as the result of good quality of the fixed prosthetic works. The average alveolar bone density measured around the homologous teeth was insignificantly higher than around the abutment teeth.

2. Higher values of alveolar bone density were found at the level of middle root length and apically than at the level of the alveolar saddle, for both abutment teeth and control teeth, which is explained by the anatomy of the bone.

There is a difference in alveolar bone density on the mesial and distal sides along the root, both for abutment teeth and the control teeth, although it is not statistically significant. The bone is denser on the distal side of the root than on the mesial side, which may be explained by the thickening of bone distally.

3. No statistically significant differences were found between the alveolar bone density as a linear combination of ROIs (1, 2, 3, 4, 5, 6, and 7) for teeth with different types of fixed prosthetic restorations (single crown, bridge work, appendix bridge).

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