INFLUENCE OF AGE AND GENDER ON ALVEOLAR BONE DENSITY IN PATIENTS WITH FIXED PROSTHETICS

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ABSTRACT

Objective: The purpose of this study was to determine the effect of age and gender to the alveolar bone density of the patients having fixed prosthetic restorations.

Methods: 80 subjects of both genders with fixed prosthetics restorations were examined in this research. Retro-alveolar radiovisiography (RVG) images of the abutment teeth and of the homologous (control) teeth were done for all subjects. All RVG images were automatically digitalized and stored at computer equipped with Digora for Windows 2.5 software used for measurements of bone density in seven regions of interest (ROI) around the tooth root, all 10 pixels in size.

Results: The obtained data were processed using statistical method of single-factor multivariate analysis of variance (MANOVA), showing the following: at significance level of 5 %, there was no age and gender dependent difference of the alveolar bone density, except at ROI 6 of the control tooth (with Bonferonni adjustment pursued alpha level 0.007= 0.05/7) where statistically significant gender dependant difference was found. Men had significantly higher average value of alveolar bone density in that region (M=125.81) when compared to women (M=104.49).

Conclusion: No statistically significant effect of age and gender to tooth alveolar bone density as a linear combination of fixed prosthetics abutment teeth ROIs or control teeth ROIs (1, 2, 3, 4, 5, 6 and 7) was found.

Keywords: the alveolar bone density, age, gender, fixed prosthetics

Introduction

The alveolar bone reduction 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 misbalance etc. are system factors [1]. Compressive and tensile forces, contacts of antagonists in occlusion, parafunction, oral hygiene, properly constructed crown or dental bridge are considered to be local factors contributing to apposition and resorption of bone tissue around an abutment tooth's root [2, 3].

Bone mass is being built in younger age and in the age of sexual maturity. The quantity of bone mass stabilizes in 30-ies reaches its highest value i.e. "bone mass peak" as a maximum mass. It is a result of normal growth and development of the body. Bone mass loss is a physiological process that may begin as early as in the third decade of human's life and is marked with a reduction in density and an increase in the bone tissue porosity. [4] A lack of oestrogen in menopause is the most common cause of the bone mass loss in women. In the first 5-7 years after menopause an average of 1-3% of bone mass is lost annually by the age of 70 when this process discontinues, but never stops, due to which women lose 35-50% of total bone mass when they reach old age [5, 6].

Degree of alveolar bone density may indicate a good function, a reduced function, or a loss of function of the abutment tooth.

The most common and straightforward method to determine the bone mass density is through a routine radiographic imaging. It takes at least 30%, and sometimes even 50 – 60% of bone mass loss in order to be able to detect osteopenia (bone loss) via X-ray. [7, 8]. With progress of IT technique, numerous methods (software) have been developed for more objective assessment of even minor changes in the alveolar bone density thus replacing subjective and inadequate methods. [9-13]

The aim of this research is to determine whether there is an age and gender-related difference in the alveolar bone density in patients with fixed prosthetics.

Subjects and Methods

A total of 80 subjects took part in the research, ageing from 20 to 50, of both genders, having fixed prosthetics (crown or dental bridge), during their regular examinations-ups at the Dental Prosthetics Department of the Faculty of Dentistry, University of Sarajevo. Inclusion criteria for the examinees were as it follows: to have a fixed prosthetics for at least three months, to have metal-ceramics fixed prosthetics, subgingival placement of the preparation margins, to have a homologous tooth or a tooth belonging to the same teeth group at the contra lateral side for comparison, both abutment tooth and the control tooth were in occlusion.

All included subjects were divided into two groups, depending on their gender: Group A female subjects ageing from 20 to 50 (41 subjects); and Group B male subjects ageing from 20 to 50 (39 subjects). All subjects were explained the purpose of the research and the benefit they may have from these examinations -up. Ethics Committee of the Faculty of Dentistry approved the research, and all subjects gave their written consents. Data of alveolar bone density measurements were entered into patients' records created for the purpose of this research. For each subject, the weight (in kilograms) and height (in centimetres) were noted in the records for the purpose of calculating BMI (body mass index). The values of plaque index (according to Silness and Loe) and gingival index (according to Loe and Silness) were examined, in order to evaluate oral hygiene, and entered in the records. For each patient, anamnestic data about longevity of fixed prosthetics were noted as well.

Retro-alveolar radiovisiography (RVG) images of abutment teeth and of homologous (control) teeth were done for all subjects with de.Götzen xgenus® digital (De Götzen Srl Via Roma, 45-21057 Olgate Olona (VA) – Italy). Xgenus® digital CCD sensors are equipped with new CsI (Cesium Iodide) scintillator giving best results regarding the noise reduction and the increasing of the spatial resolution of the digital x-ray images thus allowing better utilization of dose exposure. The program used for imaging was LR (low resolution) set as the initial standard option due to lower radiation dose the patients are exposed to. X genus digital sensors are available in two sizes. The size one sensor was used for imaging teeth of intercanine sector, and sensor size two was used for post-canine sector teeth, as recommended by the manufacturer.

After radiographs were made, all automatically digitalised RVGs were stored at a computer equipped with the Digora for Windows 2.5 (Copyright, Sorodex, 2005) software performing the measurements of bone density. This density measuring function provides the information regarding relative values of pixels based on gray scale using 8 – relevant scale, from full black (0) to full white (255). Image calibration was automatic by means of Digora software options according to manufacturer recommendations. It improved the accuracy of measurements and minimised the errors.

After the image calibration process, measuring of the alveolar bone density followed. Seven regions of interest (ROI) were selected at each image, surrounding tooth root, as it follows (**Image 1**):

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

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

ROI 3 – 1 mm mesial from the tooth root apex

ROI 4 – 1 mm distally from 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 only one root (mesial) was selected for measurement in the same manner as described above.

The alveolar bone density was measured at each ROI by pointing the cursor to that particular point and the density and cursor location were shown, and those values were entered into the record card.

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

Statistical analysis

Out of parametrical statistical methods, the single factor multivariate analysis of variance (MANOVA) was applied. The level of 5% (0.05) was taken as pursued alpha level, except in the case of subsequent comparisons at MANOVA where Bonferroni's

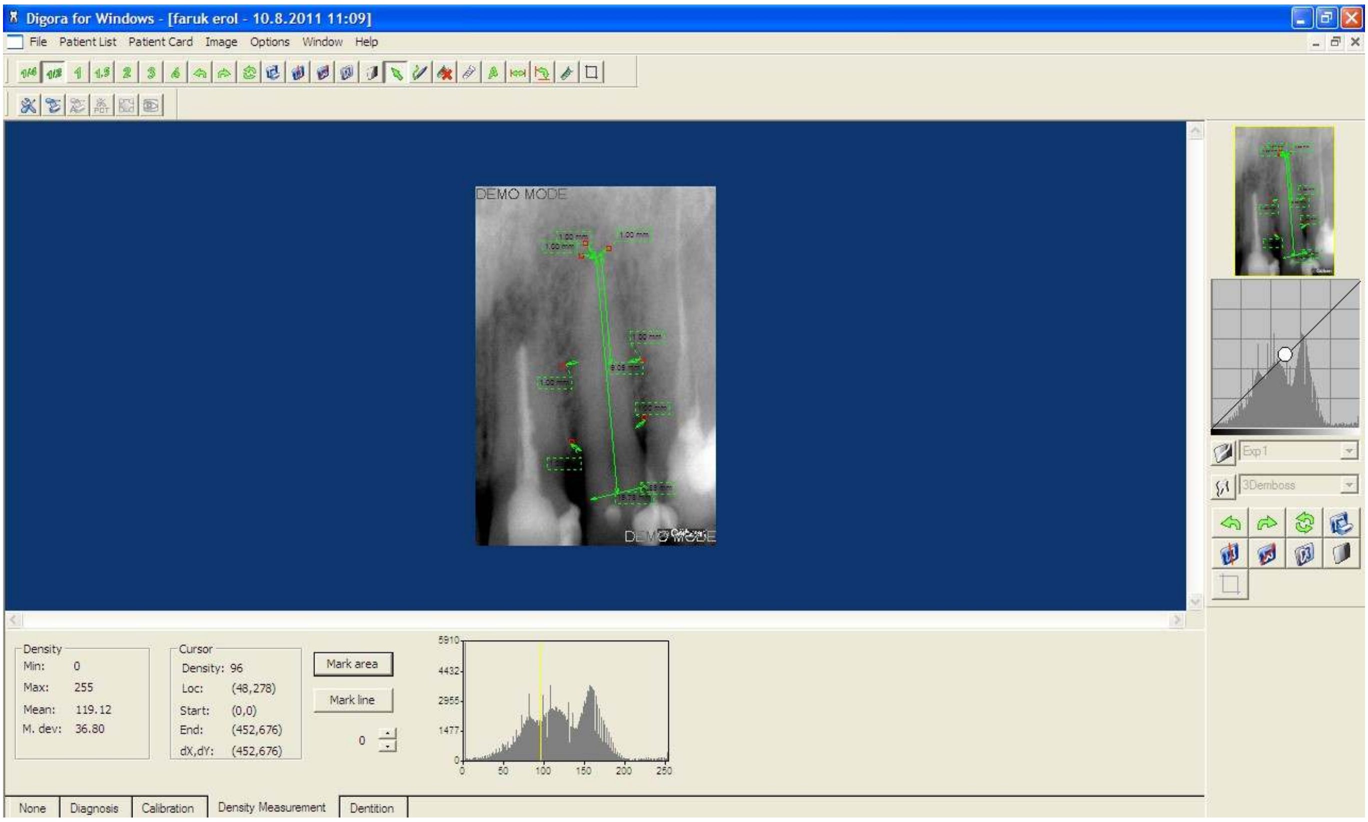


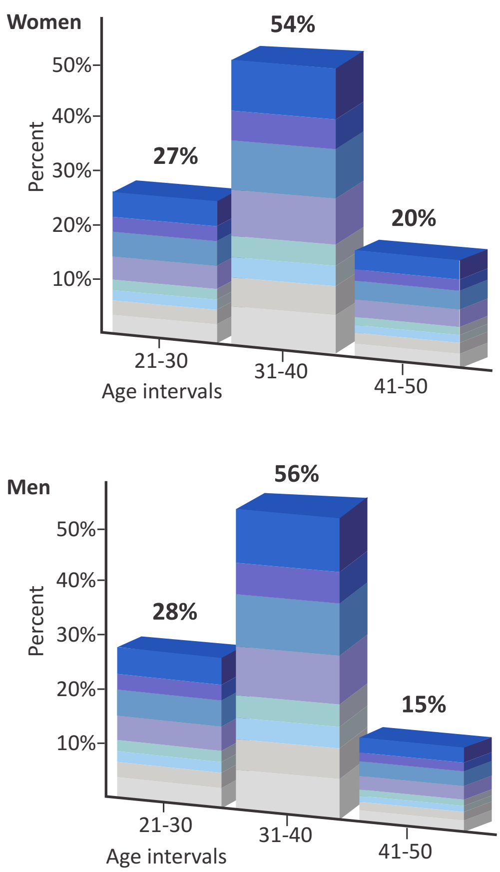
Image 1. Positions of ROIs

adjustment was used in order to reduce the probability (risk) of making the type I error. (i.e. declare the result as significant when it is actually not). It means that we divided the initial alpha level of 0.05 with the number of dependent variables (0.05 / 7=0.007).

Results

Total sample of subjects participating to the research study was n=80. Out of that number, 39 of them were males (48.8%), while 41 were females (51.3%). The mean age of male subjects was 34.56 *(95%CI; 34.56±2.265)* with a standard deviation of 7.22 years, whereas the mean age of female was 35.85 *(95%CI; 35.85±2.101)* with a standard deviation of 6.86 years.

Average values of male and female subjects' age are not statistically different; p= 0,415 (t= 0.819, df= 78). Proportions of gender age intervals in relation to total gender proportions are shown in **Graph 1**.



Graph 1. Gender and age-related interval ratios as opposed to gender ratios

Arithmetic mean of longevity of fixed prosthetics were 53 months for women and 51, 1 months for men respectively.

The single factor multivariate analysis of variance explored the impact of age differences (21-30, 31-40 and 41-50 yrs.) to tooth alveolar bone density at the abutment tooth and the ROI of control tooth. All seven dependent variables of ROI of the fixed prosthetic abutment teeth were included in the first analysis, and all seven dependent variables of the control teeth ROI were included in the second multivariate analysis of variance.

Table 1 shows the statistical values of the *Wilks' Lambda* test through the application of multivariate analysis of variance. As it may be observed in column Sig. (p=0.381), no statistically relevant influence of age to tooth alveolar bone density as a linear combination ROIs for fixed prosthetics abutment teeth (1, 2, 3, 4, 5, 6, and 7) was found.

	Value	F	Hypo-thesis df	Error df	Sig.	Partial Eta Squared
Wilks' Lambda*	0,812	1,08	14,000	138,000	0,381	0,099

** alpha significance level p<0.05*

Table 1. Multivariate test (effects of age onto the tooth alveolar bone density with linear combination of FPAT ROIs' variables)

As shown in **Table 2**, at second analysis pertaining to the variable of the control teeth ROIs, the *Wilks' Lambda* statistical values were presented applying the multivariate analysis of variance. As it may be observed at column Sig. (p=0.365), in this case, no statistically relevant influence of age to tooth alveolar bone density as a linear combination of ROIs for control tooth (1, 2, 3, 4, 5, 6, and 7) was found, either.

	Value	F	Hypo-thesis df	Error df	Sig.	Partial Eta Squared
Wilks' Lambda*	0,814	1,098	14,00	142,00	0,365	0,098

** alpha significance level p<0.05*

Table 2. Multivariate test (effects of age onto the tooth alveolar bone density with linear combination of CT ROIs' variables)

Single factor multivariate analysis of variance explored the influence of gender differences (men/women) to tooth alveolar bone density at fixed prosthetic abutment teeth ROIs and control teeth ROIs. As in the previous analysis, all seven dependent variables of fixed prosthetic abutment teeth ROIs were included in the first analysis, and all seven dependent variables of control teeth ROIs were included in the second multivariate analysis of variance.

Table 3 shows the *Wilks' Lambda* statistical values obtained through the application of multivariate analysis of variance. No statistical relevance was proven of gender to tooth alveolar bone density (p=0.193) as a linear combination for fixed prosthetic abutment tooth ROIs (1, 2, 3, 4, 5, 6 and 7).

In **Table 4**, the *Wilks' Lambda* statistical values are shown for the second analysis with regards to the control teeth ROIs variables, by applying the multivariate analysis of variance. In this case, the multivariate analysis of variance showed a statistically relevant difference of p<0.007 between genders of subjects at the values of linear combination of tooth alveolar bone density for control teeth ROIs (1, 2, 3, 4, 5, 6 and 7) with the effect size of 23.1%.

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Wilks' Lambda*	0,872	1,47	7,00	70,00	0,193	0,128

** alpha significance level p<0.05*

Table 3. Multivariate test
(effects of gender onto the tooth alveolar bone density with linear combination of FPAT ROIs' variables)

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Wilks' Lambda*	0,769	3,094	7,00	72,00	**0,007**	0,231

** alpha significance level p<0.05*

Table 4. Multivariate test
(effects of gender onto the tooth alveolar bone density with linear combination of CT ROIs' variables)

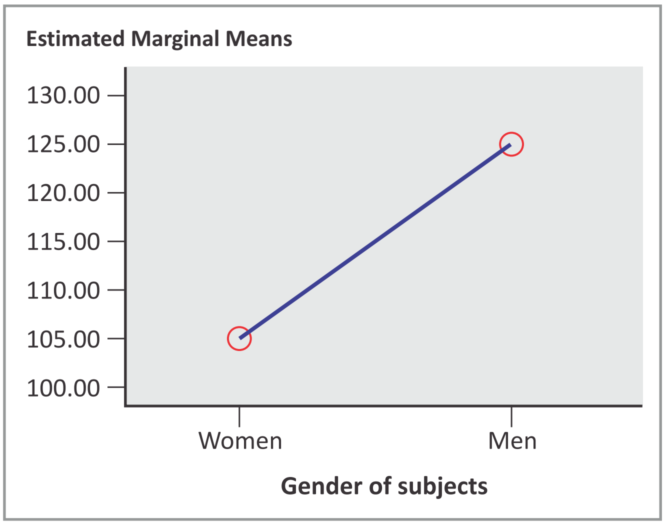
Looking the results of dependent variables in **Table 5** separately, the only difference between genders that reached statistical relevance (with Bonferonni's adjustment pursued alpha level of 0.007= 0.05/7) was in the case of the control tooth ROI 6 (p<0.004), with the effect size of 0.101 i.e. 10.1%.

Source	Dependent variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Gender	ROI 1 CT	207,283	1	207,283	0,188	0,666	0,002
	ROI 2 CT	47,060	1	47,060	0,035	0,852	0,000
	ROI 3 CT	2615,979	1	2615,979	2,521	0,116	0,031
	ROI 4 CT	2228,683	1	2228,683	2,225	0,140	0,028
	ROI 5 CT	741,505	1	741,505	0,693	0,408	0,009
	ROI 6 CT	9086,339	1	9086,339	8,805	**0,004**	0,101
	ROI 7 CT	4908,202	1	4908,202	5,370	0,023	0,064

** alpha significance level p <0.007 (with Bonferroni adjustment)*

Table 5. Tests of Between-Subjects Effects*

Reviewing the arithmetic means of the control teeth ROI 6 in relation to the gender of subjects, it may be seen that men had significantly higher average value of tooth alveolar bone density in this region (M=125.81) than women (M=104.49). The ratio of those differences is shown at **Graph 2**.



Graph 2. Estimated Marginal Means
of ROI 6 CT (subjects' gender)

All patients, both sexes, had equalized average BMI values, with low frequency of extremes (underweight and obese class 1 and 2). There was no statistically significant effect of BMI on alveolar bone density as a linear combination of ROIs for *FPAT (fixed prosthetic abutment teeth)* (1, 2, 3, 4, 5, 6 and 7 (p=0,131)), as shown in **Table 6**.

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Wilks' Lambda*	0,755	1,468	14,000	136,000	0,131	0,131

** alpha level of significance p<0,05*

Table 6. Multivariate test (BMI influence on alveolar bone density in linear combinations of variables ROIs FPAT)

One-factor multivariate analysis of variance did not prove the relation between body mass index of subjects to the alveolar bone density as a linear combination of all dependent variables for the ROIs for CT (control teeth) (1, 2, 3, 4, 5, 6 and 7). (p=0,055), as shown in **Table 7**.

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Wilks' Lambda*	0,726	1,735	14,000	140,000	0,055	0,148

** alpha level of significance p<0,05*

Table 7. Multivariate test (BMI influence on alveolar bone density in linear combinations of variables ROIs CT)

			Plaque Index CT			
			No visible plaque is seen (no scraping plaque)	Plaque can not be seen on the tooth (but by scraping plaque remains on the probe)	Plaque can be seen on the tooth	Total
Plague Index FPAT	No visible plaque is seen (no scraping plaque)	Count	23	38	1	62
		Plague Index FPAT	37,1%	61,3%	1,6%	100,0%
	Plaque can not be seen on the tooth (but by scraping plaque remains on the probe)	Count	6	8	4	18
		Plague Index FPAT	33,3%	44,4%	22,2%	100,0%
Total		Count	29	46	5	80
		Plague Index FPAT	36,3%	57,5%	6,3%	100,0%

** p< 0,006 (Pearson X^2 =10,223 , df=2 , C= 0,337)*

Table 8. Plague index fixed prosthetic abutment teeth in relation to the plaque index of the control teeth*

			Gingival Index CT			
			No inflammation	Mild inflammation	Moderate inflammation	Total
Gingival Index FPAT	No inflammation	Count	4	1	0	5
		Gingival Index FPAT	80,0%	20,0%	0,0%	100,0%
	Mild inflammation	Count	41	2	1	44
		Gingival Index FPAT	93,2%	4,5%	2,3%	100,0%
	Moderate inflammation	Count	22	8	1	31
		Gingival Index FPAT	71,0%	25,8%	3,2%	100,0%
Total		Count	67	11	2	80
		Gingival Index FPAT	83,8%	13.8%	2,5%	100,0%

**p=0,116 (Pearson X^2 =7,410, df=4,)*

Table 9. Gingival Index of FPAT compared to Gingival Index of CT *

No statistically significant differences were found in plaque and gingival index between fixed prosthetics abutment teeth and homologous (control) teeth, which can be seen in **Tables 8 and 9**.

Discussion

X-rays constitute the most straightforward, cost-effective, and accessible mean of linear measuring the resorption amount and density of the bone tissue. Radiation involved is minimal thus it may be regarded as a non-invasive method. [14]

In the case of radio-visiography the radiation level is up to 90% lower than in the case of traditional retroalveolar X –rays meaning that such low level of radiation is utterly negligible when compared to the benefits a patient may have from the information obtained from RVG images. [15, 16, 17]

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

Readings of the levels of gray at the ROIs may be performed through different image processing programmes. The Digora for Windows 2.5 (Copyright, Sorodex, 2005) programme was used in this research to read the average levels of gray within sample and for different linear measurements.

Although no statistically significant difference in the ratio of patient's age was found, we may say that in majority of measured ROIs a higher bone density was observed in subjects of younger age, 21-30 years, than in those aging from 41-50 years. Hence, there is a mild decline in the alveolar bone density in older subjects. It should be emphasized that the upper age limit in this research was 50.

Kovačević et al. did not find in their research a statistically significant difference in the alveolar bone density with regards to patients' age, which is in accordance with this research. [20]

Mazess et al. did not find in their research the age dependant difference in the bone density, either. Women aged only 20-39 participated in their research. [21]

Jager et al. reached a conclusion that there are no age dependent significant changes in the bone density. [22]

Our results showed that females had higher bone density at positions ROI 1 and ROI 2 both in the case of fixed prosthetics abutment teeth and in the case of control teeth in relation to males, which can be interpreted by better oral hygiene in female individuals. In all other measured regions, men have higher bone density both in case of fixed prosthetic carrier teeth and control teeth, although the only statistically significant difference was found at ROI 6 (position: mesial, root middle) of control teeth. We used Bonferroni's adjustment in order to reduce the probability (risk) of type I error (i.e. declaring the result as significant when it is actually not).

Finding in the research (that there is no statistically significant difference in the bone density between genders, except for control tooth ROI 6) may also be explained by the fact that the upper age limit of subjects was 50, and that women have not yet reached menopause when an increasing bone density loss occurs.

Kovačević et al. did not find a statistically significant difference between men and women in the alveolar bone density, which is in accordance with this research. [23]

In their study, Ning et al. did not find statistically significant difference in the alveolar bone density between men and women ageing from 35 to 44. [24]. In their other research the authors did not find difference in the alveolar bone density between men and women ageing from 35 to 54. They found higher alveolar bone density in men than in women ageing from 55 to 64. [25]

In their research, Ulm et al. measured the contents of minerals in the mandible bone (standardised area of the mandible body) with dual photon absorptiometry in 25 toothless lower jaw samples. The results showed that considering gender, there is a statistically significant difference. The values in women decline with age. [26]

In his research Von Wowern determined that the loss of mineral from the mandible bone is more extensive in older women than in older men. [27]

Results related to BMI index can be explained by the fact that most patients in this study had a body mass index within the normal limits. The difference would probably appeared if there were patients with significantly lower body mass index, and in this study, only one patient was underweighted thus having low body mass index.

Rebić et al. examined the effect of BMI on the mandibular bone density. At all points measured from the right and left side of the angulus mandible, mandibular bone density in the group with higher values of body mass index were higher than in the group with lower values of BMI, but there was no statistically significant difference. (28) Those results are in accordance to the findings of our study, because the bone density was higher in almost all ROIs in patients having higher BMI index compared to those with lower BMI values, but there were no statistically significant differences.

Control teeth had higher values of plaque index in relation to the fixed prosthetics abutment teeth (more plaque index 1). All prosthetics in this study were made of metal ceramic which is poorly receptive for plaque, and therefore better results (less accumulation of plaque) were found on prosthetic than on the control teeth.

Lövgren et al. in their research found less plaque accumulation on ceramic crowns than on the control (homologous) teeth. [29] Most of the patients in our research had a plaque index 0 or 1, bringing to the conclusion that the patients had a satisfactory level of oral hygiene. The same results were given by Bentley et al. for their findings. [30]

Conclusion

1. No statistically significant effect of age to the tooth alveolar bone density as a linear combination of fixed prosthetics abutment teeth ROIs or control teeth ROIs (1, 2, 3, 4, 5, 6 and 7) was found. A mild decline in the alveolar bone density was observed depending on age, both with fixed prosthetics abutment teeth and control teeth.

2. There is no statistically significant effect of subjects' age to alveolar bone density as a linear combination for fixed prosthetic abutment teeth ROIs (1, 2, 3, 4, 5, 6, and 7). A statistically significant effect was proven of the gender of subjects to alveolar bone density as a linear combination for control tooth ROIs (1, 2, 3, 4, 5, 6, and 7). The only difference between genders reaching the statistical significance (with Bonferroni adjustment pursued level) occurred in the case of control teeth ROI 6 variable. Women had a higher bone density at the positions ROI 1 and ROI 2 both around fixed prosthetic abutment teeth and around control teeth in relation to men. In all other measured regions, men have higher, although not statistically significant, bone density both around fixed prosthetic abutment teeth and of control teeth.

Declaration of interest

No conflict of interest

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