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Effects of Nonsurgical Periodontal Treatment on the Alveolar Bone Density

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The aim of this study was to evaluate the effects of nonsurgical periodontal treatment on alveolar bone density (ABD) and bone height (BH) using direct digital radiography. Nineteen patients (mean age: 36±7.3 years) with generalized chronic periodontitis were examined at baseline, 90 (90AT) and 180 (180AT) days after nonsurgical periodontal therapy. Radiographs were taken from two sites with specific characteristics: 39 sites with probing pocket depth (PPD)≤3 mm and clinical attachment level (CAL)≤1 mm (shallow sites); and 62 sites with PPD≥5 mm and CAL≥3 mm (deep sites). The ABD was assessed considering the bone regions of interest at the alveolar bone crest (ROI I) and at the medullar bone (ROI II). The BH was assessed considering the distance from the alveolar bone crest to the cementoenamel junction. Mann-Whitney test was used for the overall demographic data, Wilcoxon test was used to compare the baseline, 90AT and 180AT data as well as to compare the groups and subgroups within the same evaluation period. The significance level was set at 5%. The deep sites showed a significant increase of ABD in ROI I at 90AT (p<0.007) and at 180AT (p<0.005). ABD decrease was seen in ROI II at 180AT (p<0.04) while BH reduced only in shallow sites at 90AT. In conclusion, an increase in ABD was observed in deep sites of patients with generalized chronic periodontitis. However, no significant change in alveolar BH was observed in these sites.

Key Words: periodontitis, non-surgical periodontal treatment, alveolar bone density, linear bone measurement, digital radiography.

Introduction

Periodontitis is characterized by a hyperreactive inflammation against a bacterial load in the gingival sulcus. Such inflammation leads to an irreversible tissue destruction characterized by collagen destruction, alveolar bone loss and consequently an apical migration of the junctional epithelium (1). Although several studies have analyzed the clinical improvements after periodontal therapy, information about changes in the alveolar bone density (ABD) are very scarce (2,3).

Bone is a dynamic tissue undergoing constant remodelling. In healthy adults, maintenance of bone mass is achieved by coupling the bone formation and bone resorption processes, named bone turnover, and indicates the mineralization degree of the alveolar bone tissues (4). The risk factor for alveolar bone loss and alteration of ABD is based on the deficit in bone turnover. The decreased bone mass in periodontitis may result in sites with accelerated progression of bone loss, in the presence of oral biofilm infection and host immunological responses, due to the fragility of the bony housing of the teeth. Dense trabeculation was a strong indicator of high bone mineral density, and sparse trabeculation may be used to predict low bone mineral density (5).

Intraoral radiographs are a non-invasive important source of information about the alveolar bone conditions and the periodontium (1,6), such as the ABD (7-9), and linear radiographic measurements, which gives an idea of the high bone changes around the teeth (10,11). The use of digital radiographic technique allows for detecting minimal bone changes, which could not otherwise be detected on conventional radiographs (12,13). Furthermore, digital radiography offers some advantages, such as reduction of the radiation dose in a calibrated exposure, elimination of film processing, better visualization and standardization of the images, possibility of image filling and recovery in addition to the fact that fact that digital systems provide tools to study and interpret the images (14-16).

The aim of this study was to assess the effects of nonsurgical periodontal treatment on the ABD and alveo;ar bone height (ABH) using direct digital radiography.

Material and Methods

Sample Selection

Nineteen patients (mean age 36.7±7.3 years) with generalized chronic periodontitis diagnosed following the criteria of the American Academy of Periodontology 1999 (17) participated in this study after signing an informed consent form. Ethics Committee approval for the study was obtained (Protocol number: CEP/HUPE 2481/2010).

The patients filled out a questionnaire about their age, gender and ethnic background, level of education, medical history, smoking habits and use of medication. The inclusion criteria were patients with at least three sites with probing pocket depth (PPD) ≥5 mm and , clinical attachment level (CAL) ≥3 mm on the proximal sides of different teeth, who had not undergone periodontal therapy in the last 12 months, or used antibiotics in the previous 6 months or antiinflammatory medications 3 months prior to the study. Patients who were smokers, diabetics, hypertensive, pregnant or breast feeding, those diagnosed with autoimmune diseases or AIDS, and also those with bone metabolism diseases such as osteoporosis, vitamin D deficiency and hyperthyroidism, were excluded.

Clinical Measurements

The patients were evaluated at baseline, and at 90 and 180 days after nonsurgical periodontal treatment (NSPT) (90AT and 180AT, respectively). The selected patients had at least 18 teeth. Acetate 0.5 mm molds were used to standardize the probing position at different moments of measurement. The clinical data were assessed by the same examiner using a North Caroline periodontal probe (PCΔ15; Hu-Friedy, Chicago, IL, USA). The 6 sites (mesiobuccal, buccal, distobuccal, distolingual, lingual and mesiolingual) around each tooth, except for the third molars, were examined, except for the third molars. The clinical data consisted of PPD, CAL, bleeding from probing (18) and plaque index (19). The examiner calibration had an agreement of 94% within ±1 mm for the measurements of PPD and CAL with the North Carolina periodontal probe.

All patients received a periodontal treatment comprising instruction on oral hygiene; scaling and root planing using hand instruments and ultrasound (Cavitron Select; Dentsply, New York, NY, USA), followed by pumice prophylaxis. The treatment was performed in 45-min sessions following the radiological examination and consisted of 1-2 sessions of supragingival scaling and 4-5 sessions for subgingival scaling under local anesthesia. After the clinical examination, 101 proximal sites were selected and divided in two groups: Group 1, with 39 sites with PPD≤3 mm and CAL≤1 mm; and Group 2, with 62 sites with PPD≥5 mm and CAL≥3 mm. Sites with proximal restoration above the cementoenamel junction were excluded from the study.

Radiographic Measurements

Periapical radiographs were taken by the same examiner using the parallelism technique at baseline, 90AT and 180AT, using KODAK 2200 Intraoral X-ray System unit (Kodak® Company, Trophy, France) calibrated to 70 kV and 7 mA. Exposure time was 0.092 s for maxillary incisor and canine teeth; 0.077 for mandibular incisors and canines; 0.117 for maxillary premolars; 0.082 for mandibular premolars; 0.138 for maxillary molars and 0.092 for mandibular molars.

The radiographs were analyzed by Kodak® digital RVG 6100 software (Kodak® Company). The regions of interest (ROIs) were established in 1 mm^2 and were positioned on two regions lateral to the root of the selected site, one placed at the alveolar bone crest (ROI I) and another 3 mm below the first, at the medullar bone (ROI II) (Fig. 1) (adapted from Rosa et al. 2008). To demarcate the ROIs, a standard 1 mm^2 square radiopaque net was placed in the digital sensor, used for calibration together with the radiographic system when evaluating the image. ABD was established by the average intensity measured on the diagonal line drawn from the upper left corner to the lower right corner of the square. The ABD given by the system was calculated by pixels using a scale of grey that varies from 0 to 256, where 0 represents black and 256 white. Linear measures (mm) were made as follows: (1) distance from the alveolar bone crest to the cementoenamel junction (Crest-CEJ) of the tooth of interest; (2) distance between the CEJ of the of the tooth of interest to the CEJ of the adjacent tooth (CEJ-CEJ); and (3) a point in the middle of the line between the two adjacent CEJs (mCEJ-Crest) to the bone crest. ABH was considered as the distance between the CEJ and the alveolar bone crest.

Calibration for image analysis was made using 30 radiographs and reached a 94% agreement for linear measurements with a maximum error range of ±0.1 mm and 97% agreement for the ROIs with maximum error range of ± three pixels.

Statistical Analysis

After the application of the Kolmogorov Zmirnov Z normality test, the normally distributed data were displayed as mean and standard deviation, whereas non-normally distributed data were displayed as median and quartile range. The Mann-Whitney test was used to analyze the overall demographic data. The Wilcoxon test was used to compare the data from the three periods of evaluation (baseline, 90AT and 180AT) expressed as median and

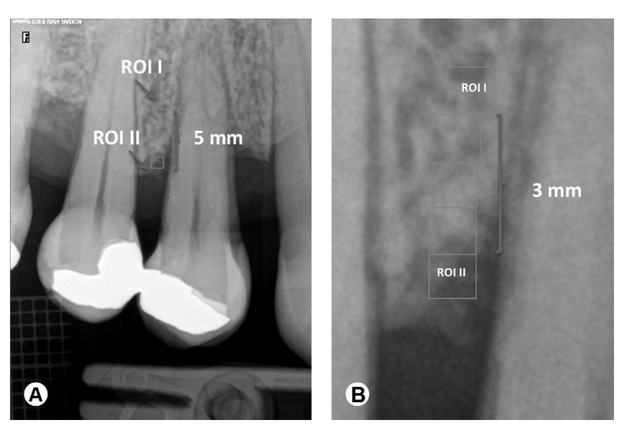

Figure 1. A: Regions of interest I and II (ROI I and ROI II) of approximately 1 mm^2 each were positioned on two regions to the side of the root of the selected site, and the distance between them was 3 mm. B: Detail of the location of the ROIs and the distance between them.

variation interval. The same test was used to compare the groups and subgroups within the same evaluation period, i.e., sites with PPD≤3 mm *versus* PPD≥5 mm, sites with single-rooted *versus* multirooted teeth and sites with vertical defects *versus* horizontal defects. The level of significance of 5% ($p<0.05$) was established. Pearson's correlation coefficient was used and the correlation that attained an r value of 0.6 with $p<0.01$ was considered relevant. SPSS statistical software version 19.0 (SPSS Inc., Chicago, IL, USA) was used for data calculation. The significance level was set at 5%.

Results

None of the patients was Caucasian, 15 were females (78.8%), a high school degree was the maximum educational level, and all patients had 24 (±10) teeth and 144 (±60) sites for examination.

The clinical and radiographic data are presented in Table 1. The period between baseline and 90AT was named δ1 and the period between baseline and 180AT was named δ2. Group 1 had a significant reduction for PPD (p=0.01), CAL (p=0.02), and ABH (p=0.05) only between baseline and 180AT. However, there was no significant change in ABD. The ABD in ROI I showed significant bone gain both in δ1 (p=0.007) and in δ2 (p=0.005). On the other hand, the ROI II showed a significant fall in ABD at 180AT (p=0.04), and the ABH did not change in these sites. The plaque index at baseline was 99.6%; while at 90AT it was 54.6% and at 180AT was 47.9%. The values of bleeding on probing were reduced from 97.3%, at baseline, to 58.6% and 54.3%, at 90AT and 180AT, respectively. The decrease was significant in δ1 and δ2 for both indexes (p<0.001) (data not shown).

Group 2 was further divided in sites of single-rooted or multirooted teeth and sites with horizontal or vertical bone defects. All clinical measurements showed decrease. Also, the ROI I showed a significant increase in ABD both for δ1 (p=0.02) as for δ2 (p=0.004*)* in sites of multirooted teeth. When the sites were grouped by bone defects, the horizontal sites showed a significant gain in ABD in δ2 (p=0.02), while vertical sites showed a significant density loss at 90AT (p=0.04) (Table 2). The ROIs of the sites with PPD≥5 mm and CAL≥3 mm in single-rooted teeth were compared with the ROIs of the sites of multirooted teeth, and there was no significant difference between them. The same occurred when sites with PPD≥5 mm and CAL≥3 mm in horizontal defects were compared with the ROIs of the vertical defects (data not shown).

Discussion

This study observed an increase of ROI I density in sites with PPD≥5 mm and CAL≥3 mm in the multirooted teeth. Few papers evaluated the results of NSPT on the ABD using computer analysis of the radiographs. Dubrez et al. (7), Okano et al. (8) and Hwang et al. (9) reported that ABD increased significantly after NSPT, while Schmidt et al. (6) did not find significant difference in the ABD after 2 years of observation. Hwang et al (9) were the authors whose method most closely resembled the one used in this study,

Table 1. Median (interval of variation) in millimeters for the clinical measurements: probing pocket depth (PPD), clinical attachment level (CAL), distance from the alveolar bone crest to the cementoenamel junction (Crest-CEJ) of the tooth of interest, distance between the CEJ of the of the tooth of interest to the CEJ of the adjacent tooth (CEJ-CEJ), and a point in the middle of the line between the two adjacent CEJs (mCEJ-Crest) to the bone crest; and for the radiographic measurements in pixels: bone region of interest I (ROI I, at the alveolar bone crest) and II (ROI II, at the medullar bone), at day 0(b) and 90(90AT) and 180(180AT) days post-treatment

Group	Period	PPD	CAL	Distance Crest-CEJ	Distance mCEJ-Crest	Distance CEJ-CEJ	ROI I	ROI II
PPD≤3mm (n=39)	Baseline	3.0(1.0)	1.0(1.0)	2.4(5.4)	2.3(5.2)	2.3(4.8)	166.0(104.0)	174.0(138.0)
	90AT	2.0(2.0)	0.0(1.0)	2.0(5.2)	2.3(5.0)	2.4(4.4)	166.0(121.0)	177.0(171.0)
	180AT	2.0(2.0)	0.0(3.0)	2.6(4.6)	2.3(5.0)	2.4(3.8)	164.0(97.0)	177.0(99.0)
	δ1	0.01	0.02	0.05	0.53	0.66	0.59	0.61
	p 2	0.08	0.19	0.35	0.74	0.79	0.45	0.71
PPD≥5mm (n=62)	Baseline	6.0(5.0)	5.0(11.0)	4.2(13.3)	4.9(12.4)	2.9(7.1)	158.0(113.0)	181.5(82.0)
	90AT	4.0(5.0)	4.0(10.0)	4.2(15.1)	4.6(13.8)	3.0(7.8)	162.0(156.0)	184.0(134.0)
	180AT	3.0(6.0)	4.0(10.0)	4.1(14.9)	4.2(13.8)	2.9(7.8)	161.5(118.0)	175.0(134.0)
	Δ 1	<0.001	<0.001	0.29	0.71	0.07	0.007	0.35
	Δ 2	<0.001	<0.001	0.83	0.32	0.82	0.005	0.04

Wilcoxon test was used to calculate the p value. δ1 demonstrates statistically significant difference between baseline and 90 days post treatment (90AT); δ2 demonstrates statistically significant difference between baseline and 180 days post treatment (180AT).

because they collected the radiographs by direct digital technique. This suggests that new research considering the radiographic density of the alveolar bone should be performed using direct digital imaging technologies so that the benefits the currently available tools in the software may help in the diagnoses of bone loss for a better progress follow-up of the periodontal treatment.

ROI II showed change in the ABD of sites with PPD≥5 mm in δ2. Previus studies (9,20,21) have suggested the use of control ROIs, but the authors did not use the same standard of positioning, also there is still no definition as to which would be the most specific control region. Maybe this region should be located even further from the defect and the treated area, as described by the Hwang et al. (9) and Toback et al. (21). However, those authors observed, respectively, an increase in the density of the apical and middle region of the defect, showing that both areas may have the density changed. Therefore, apparently the ROI II area was not a good choice for ROI control. Thus, the behavior of ROI in medullar bone should be further investigated and perhaps justifications are encountered by enlightening treatment remodeling and bone activity and/or hormone associated with the presence of bone biomarkers and inflammation of the tissue of this region. It is also important to consider that in the current study, no change took place at ROI II when the compared PPD≥5

Table 2. Median (interval of variation) in millimeters for the clinical measurements: probing pocket depth (PPD), clinical attachment level (CAL), distance from the alveolar bone crest to the cementoenamel junction (Crest-CEJ) of the tooth of interest, distance between the CEJ of the of the tooth of interest to the CEJ of the adjacent tooth (CEJ-CEJ), and a point in the middle of the line between the two adjacent CEJs (mCEJ-Crest) to the bone crest; and for the radiographic measurements in pixels: bone region of interest I (ROI I, at the alveolar bone crest) and II (ROI II, at the medullar bone), at day 0(b) and 90(90AT) and 180(180AT) days post-treatment

Subgroup	Period	PPD	CAL	Distance Crest-CEJ	Distance mCEJ-Crest	Distance CEJ-CEJ	ROI I	ROI II
Single-rooted teeth (n=32)	Baseline	6.0(3.0)	5.0(11.0)	4.8(12.9)	6.2(11.6)	2.7(7.1)	161.0(94.0)	182.0(54.0)
	90AT	3.0(5.0)	5.0(10.0)	5.5(15.1)	5.4(13.6)	3.0(7.8)	164.0(102.0)	180.5(124.0)
	180AT	3.0(8.0)	1.0(9.0)	4.1(14.6)	5.3(13.0)	2.9(7.8)	169.0(105.0)	181.0(128.0)
	δ1	<0.001	0.007	0.456	0.914	0.048	0.173	0.347
	δ2	<0.001	<0.001	0.456	0.724	0.431	0.203	0.211
Multirooted teeth (n=30)	Baseline	6.0(5.0)	4.5(6.0)	3.0(10.4)	3.6(8.5)	3.1(5.8)	145.5(113.0)	180.0(82.0)
	90AT	4.0(4.0)	3.0(9.0)	3.0(10.1)	3.2(10.5)	3.1(3.7)	156.0(156.0)	186.0(98.0)
	180AT	4.0(8.0)	2.0(7.0)	2.8(10.1)	3.3(10.5)	3.0(38.0)	159.0(118.0)	169.0(95.0)
	δ1	<0.001	0.001	0.39	0.37	0.65	0.02	0.58
	δ2	<0.001	<0.001	0.63	0.28	0.57	0.004	0.07
Horizontal defect (n=28)	Baseline	5.0(2.0)	4.0(5.0)	3.2(9.2)	3.6(8.8)	2.2(5.1)	156.5(99.0)	171.0(71.0)
	90AT	3.0(3.0)	2.0(7.0)	3.1(9.3)	3.1(8.3)	2.9(4.5)	165.0(130.0)	177.0(134.0)
	180AT	3.0(6.0)	1.0(6.0)	3.1(8.2)	3.1(7.8)	2.9(5.0)	161.5(109.0)	169.0(134.0)
	δ1	<0.001	<0.001	0.59	0.17	0.36	0.08	0.58
	δ2	<0.001	<0.001	0.66	0.09	0.35	0.02	0.28
Vertical defect (n=34)	Baseline	6.0(5.0)	5.5(11.0)	5.4(12.1)	6.6(11.4)	3.1(6.3)	162.5(113.0)	187.0(77.0)
	90AT	4.0(5.0)	4.5(9.0)	6.1(14.0)	6.2(13.1)	3.3(7.5)	161.0(111.0)	186.0(68.0)
	180AT	4.0(9.0)	3.0(9.0)	5.0(14.0)	5.6(13.3)	3.0(7.5)	161.5(114.0)	183.0(89.0)
	δ1	<0.001	0.029	0.30	0.20	0.14	0.04	0.39
	δ2	0.001	<0.001	0.53	0.93	0.64	0.09	0.07

Wilcoxon test was used to calculate the p value. δ1 demonstrates statistically significant difference between baseline and 90 days post treatment (90AT); δ2 demonstrates statistically significant difference between baseline and 180 days post treatment (180AT).

mm sites were single-rooted, multirooted, horizontal or vertical defects, although the multirooted and the vertical defects sites are near the statistical 95% cut.

The results of the analysis of the ABH showed a significant decrease only in the sites with PPD≤3 mm, in the δ1 interval. Although this represents an improvement for the initial bone repair, it does not last for the 180 days of the assessment. Hence, the findings of this study seem to corroborate with those of other authors (22,23) who affirm that NSPT influences minimally the ABH. However, Nibali et al. (11) showed an increase in the bone level in sites with infra-bone defect treated with NSPT. These authors affirmed that the greatest reduction of the defects occurs in sites with deep probing pocket and with patients who associated antibiotic therapy. It is relevant to state that in this group there was a large number of smoker patients who had a lower reduction in the radiographic height. Matchei et al. (22) also included smokers in their sample and came to the conclusion that in this group, the probing pockets were initially deeper and their response to the NSPT had a minimal gain in attachment level and with loss of ABH. It is important to emphasize that the data used in this work represent the behavior of NSPT in a sample without exposure to risk factors such as smoking, and also without the interference of additional therapies other than the NSPT so as to avoid possible confusing factors.

Another interesting method to study the bone structure is to digitize conventional radiographic images and then subtract them. Longlois et al. (24) showed that although the use of software allows manipulating images, storing them in compact discs, measuring both linear and angular distances and determining gray levels at a specific point, there is no difference among the measurements obtained with conventional radiographs, digitized radiographs and dry specimens.

Other studies stated that the linear bone measure sub-estimates the real ABH when radiographic measures is compared to surgical methods (10,21). Although surgical intervention was included in the present study, it is important to point out that such procedure, despite being considered standard for bone assessment, is obviously invasive and the scar of the defect cannot be anticipated (21). Therefore, the bone changes revealed by direct digital radiography show that this is a safer and more reliable technique that deserves more research. It is worth noting that systems with the same image acquisition principle, like charge coupled device-based or storage phosphor systems, tend to present certain similarities in their general characteristics, although all of the direct digital systems present good performance in producing acceptable images for diagnosis (25).

In conclusion, a significant increase in ABD was observed in the bone crest of deep sites in patients with periodontitis. In addition to the significant reduction in the probing depth and increased attachment level, no significant change in ABH was observed on these sites.

Resumo

O objetivo desse estudo foi avaliar os efeitos do tratamento periodontal não cirúrgico na densidade do osso alveolar e na altura óssea alveolar usando radiografias digitais diretas. Dezenove pacientes (média de idade 36±7,3 anos) com pacientes com periodontite crônica generalizada foram examinados no tempo 0 e aos 90 (90AT) e 180 (180AT) dias após o tratamento periodontal não cirúrgico. Dois grupos de sítios foram radiografados, 39 com profundidade de bolsa a sondagem (PBS)≤3 mm e nível de inserção clínica (NIC)≤1 mm (sítios rasos) e 62 com PBS≥5 mm and NIC≥3 mm (sítios profundos). A densidade foi avaliada considerando as regiões ósseas de interesse na crista óssea alveolar (ROI I) e no osso medular (ROI II). A altura óssea compreendia a distância entre a crista óssea alveolar e a junção cemento-esmalte. Os sítios profundos mostraram um significante aumento na densidade óssea na ROI I tendo p<0,007 em 90AT e p<0,005 em 180AT. Uma redução na densidade óssea foi vista na ROI II 180AT (p<0,04) enquanto a altura óssea reduziu somente nos sítios rasos 90 AT. Como conclusão, um aumento na densidade foi observado na crista óssea alveolar de sítios profundos em pacientes com periodontite. No entanto, nenhuma alteração significante na altura óssea alveolar foi observada nesses sítios.

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