CORRELATION BETWEEN DIGITAL INTRA-ORAL SYSTEM WITH POCKET SOUNDING IN DETECTION OF BONE DEFECTS

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ABSTRACT

Aim: The aim of this study was to assess the correlation between digital intra-oral radiography with pocket sounding in detection of alveolar bone defect in patients with moderate to severe periodontitis.

Materials & Method: In this cross-sectional study, 52 patients (29 men, 23 women) with 89 angular and horizontal bone defects in maxillary and mandibular premolar and molar teeth, were selected. The vertical distance from Cementoenamel Junction (CEJ) to the margin of alveolar crest was measured by Williams probe and the apical point in interproximal regions were considered as the depth of sounding. Then, digital intra-oral radiographies were obtained, using Photostimulable phosphor Storage Plates (PSP) sensors. The distance in digital intra-oral radiographies were measured in 3 stages of: Original, Inverted, Sharpen1+Noise reduction by a digital ruler. All the data were compared by Paired Samples test, One way ANOVA and Intraclass Correlation Coefficient (ICC).

Results: The mean defect depth determined by Sounding and digital ruler in three groups of Original, Inverted and Sharpen1+Noise reduction were 5.21±1.46, 5.13±1.62, 5.15±1.62, and 5.14±1.61 mm, But no significant differences were found between any two groups of results (P<0.001). The Correlation of Sounding measurements with Original, Inverted and Sharpen1+Noise reduction groups was strong at 98.1%, 98% and 97.9%, respectively.

Conclusion: Digital PSP radiographies can be reliable in measuring the depth of alveolar bone defects compared with the actual measurements (by Sounding). Digital manipulations of radiographic images showed similar results with unprocessed radiographies. Using these filters do not interfere with diagnostic performance of PSP radiographic images.

Key words: Diagnostic Imaging, Dental Radiography, Periodontal Disease.

Introduction

Periodontitis is an inflammatory disease of tooth supporting tissues and is created by a specific group of microorganisms. It is recognized by a vast destruction of periodontal ligament and alveolar bone. The clinical symptom of periodontitis is the destruction of periodontium and the presence of clinical attachment loss (CAL). The most common form of it is the chronic periodontitis which develops through gradual aggregation of microbial plaque.[1]

Generally, diagnosis of periodontitis is through clinical examination, radiographic findings and patient's history. Although panoramic radiography, along with intraoral radiographies, are routinely used for patients with periodontal diseases and a diagnostic method for assessing the alveolar bone height measurement,[2] but the most essential method is clinical probing. In this technique the distance between gingival margin to pocket depth, which is the end of coronal of junctional epithelium, is measured. In this technique probe is used as a parallel to the long access of teeth, since regular probing does not identify the structure and topography of the bone. For doing so, transgingival probing or sounding is used. Transgingival probing is done after topical Anastasia and is a more precise method for analyzing the bone. In this method, the probe is pushed through the depth of pocket and it reaches the bone and thus measures the actual distance of gingival margin to alveolar crest.[1-3] Radiography is a valuable tool for diagnosis and prognosis of periodontal diseases and for evaluation of treatment results.[4]

Radiography has been evaluated in different examinations. For changes in periodontal tissues, specifically alveolar bone recessions, bitewing and periapical radiography (parallel methods) have an indication. Panoramic radiography is not suggested for evaluation of periodontal disease by itself since it magnifies the vast destructions and reduces the small marginal bone destructions.[4] With all the above said, different results have been achieved and there are many factors that make panoramic radiography more common and superior to intraoral techniques. Some reasons are ease of application due to extra-oral film position, lower costs, less exposure to X-ray, and great data on periodontium of both jaws.[5]

The most precise method for crestal bone evaluation is performing flaps and measuring during surgery but this is an intrusive method and can cause discomfort for the patient and a possible damage to teeth supportive tissues. On the other hand, this intrusive method may not be applicable for diagnosis purposes in all patients.[6] Many researchers have tried to find a non-intrusive method with a high accuracy and for measuring in this group of patients; Bone sounding is one possible candidate. Many studies have reported a great correlation between surgery and bone sounding.[7-9] In 1981, Ursell concluded that TGP (transgingival probing) or sounding is a precise method for measuring alveolar bone crest.[9] In another study in Guilan University of Medical Sciences (GUMS) made by Vadiati *et al*., it was shown that bone probing under topical anesthesia shows the depth of vertical defects of alveolar bone close to the one measured in the process of surgery. They realized that because of the strong association between bone probing under anesthesia and surgery procedure, sounding is the best method for estimating bone recession compared to actual amounts. At the same time, digital panoramic computed radiographs showed the measurements less than the actual amount in their study.[10]

Since in digital radiography systems there is neither a film, nor chemical processes of image development and registration; and moreover, x-ray dosage and the number of improper photos are reduced, these systems are popular in both intraoral and extraoral photos.[5]

Diagora Optime® with a PSP sensor (Photo Stimulable Phosphore Storage Plates) is one of the most common intraoral digital systems which allows for calibrating measurements of images; along with Scanora® software. Subjective analysis of intraoral PSP have shown the Diagora® images to be of high resolution.[11,12] This system is the best substitute for the film and is commercially available because it provides all the facilities, image processing and a high accuracy diagnosis.[12,13] Diagora® contains a matt black plastic cover which provides a contamination protection and eradicates the light.[14] Moreover, this system is more adaptable to the intraoral positioning systems.[15] The studies that have compared the PSP quality with CCD and regular film have reported a similar or better quality for PSP.[16,17] and some have shown PSP to have a higher revelation of details in a lower contrast.[16-19]

Since there have not been prior studies on diagnosis value of intraoral PSP digital systems compared to bone sounding in analysis of vertical and horizontal alveolar bone, bone sounding was chosen as the gold standard for bone loss in this research. Moreover, it was compared to intraoral PSP digital radiography (parallel method) and the application of: Inversion filters, Sharpen1 + one-time usage of Noise reduction were checked against original imaging measurement and Sounding. Since probing under local anesthesia is not attainable for all patients due to lack of time, the need for local anesthesia, the method of screening and also imprecision of panoramic radiography for bone loss analysis, this study aimed to compare intraoral digital radiography with probing under local anesthesia. It was also planned to compare the synchronization between the two methods to find out the possibility of gaining a precise analysis of bone loss rate. In the cases where the depth of defect is great, this can affect the future flap design and the need for respective or regenerative periodontal treatments.

Materials and Method

This was a cross-sectional analytic study performed in dental school of Guilan University of Medical Sciences (GUMS). It was conducted from April 2015 to April 2016 and was registered with the code of ethics of IRGums.REC.1394.219. In this study, the patients with moderate or severe periodontitis, who possessed a panoramic radiography, were evaluated in terms of bone loss. In case of a horizontal or vertical bone loss, pocket depth in the area was analyzed using Williams probe and if their measurement was 4 mm or more they would be selected.

Finally, 52 patients (29 men and 23 females) were chosen. In these patients, a total of 89 defects of the alveolar bone in premolars and molars teeth in maxilla and mandible regions with a probing depth equal to, or greater than, 5 mm who had a vertical or horizontal bone defects between their premolar and molar teeth were selected for the review.

After patient selection, the procedure was explained to them and the informed consent was obtained. Scaling was performed, if necessary. After local anesthesia, the vertical distance between CEJ to the alveolar margin bone from the buccal was measured by walking method and using Williams periodontal probe (University of Michigan "0" probe). Pocket sounding was performed by an observer who measured the deepest point in the interproximal area, using inter examiner calibration, and it was recorded as the depth of sounding. In cases where the CEJ were not visible due to restorative treatments or decay, either the apical endpoint of restoration or the decay was used for measuring; and in cases of severe damage, the tooth was excluded from the study. In cases where the measured items fell between the two specified lines of periodontal probe, the final reading was rounded based on the line it was closer to.

Then, for all patients, digital intraoral images were made by using Super-Bite® posterior with ring (Kerr-USA) film holder in parallel technique. For this purpose, the digital sensor PSP (Photostimulated phosphor plate) size 2 was used. Minray® (Soredex-Finland) intraoral radiography was used and it was set at 70 Kvp, 7 mA and 0.20 s. The images on the PSP sensor were scanned by Digora® Optime (Soredex-Finland) using Scanora® software V. 4.3.1 and the images were stored as a DICOM file. Furthermore, In addition to original digital images, three types of digital filters were used in two groups: Inversion, Sharpen1 + Noise reduction. Ultimately, the following three groups were categorized:

1. Original images without filtration [Figure 1]

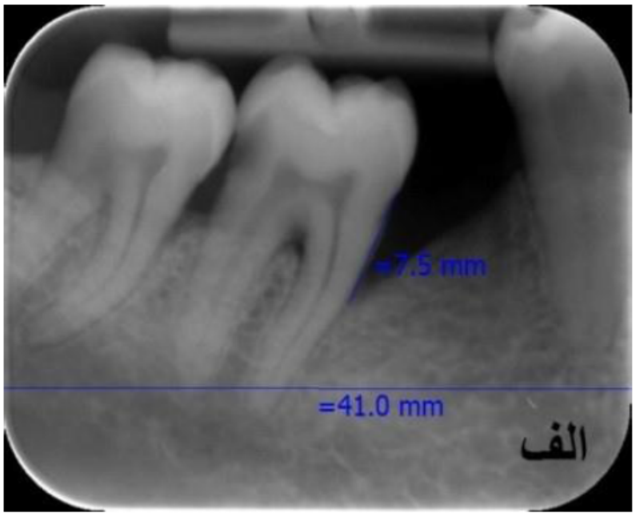

Figure 1: Measurements obtained by digital ruler, no filtration(original image)

2. Inversion filter radiographic images [Figure 2],

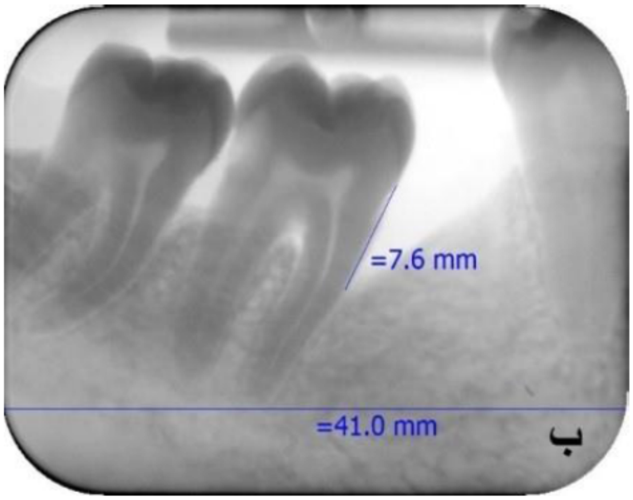

Figure 2: Measurements obtained by digital ruler using inversion filter

and 3. Sharpen1 + one-time Noise reduction filter radiographic images [Figure 3].

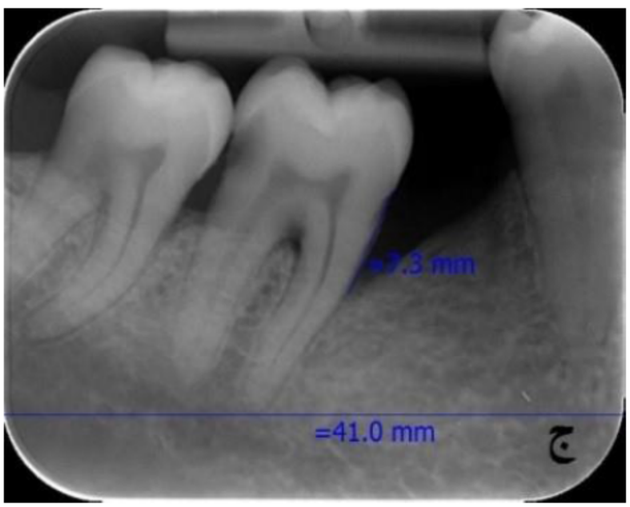

Figure 3: Measurements obtained by digital ruler using sharpen1+Noise reduction

Then, all the measurements of obtained radiographies were analyzed for bone loss depth (for doing so, the linear dimension of number 2 intraoral digital sensor was measured for calibration and it was 41 mm). For matching the measurement, all the intraoral images were analyzed in 100% zoom (true size) condition.0

Afterwards, the connection point of enamel and cement (CEJ) and the most epical part of the alveolar bone crest was determined by an experienced oral-maxillofacial radiologist who was blind to the results. The distances of these anatomic landmarks were measured in 89 zones and in 3 groups (267 altogether) on radiographic images using digital ruler of Scanora® software. The measurements were done in a low light room and on a 16.4” monitor with a screen resolution of 1600×900. There was a two-week interval between the two measurements.

Intra-observer reliability was measured two weeks after digital measurements in all three groups. For doing so, 10 radiographic zones were measured again and they were analyzed by Intraclass Correlation Coefficient (ICC)

Results

After measurement evaluation, the obtained information was put in SPSS 21 software and data normality was analyzed by One-sample Kolmogorov-Smirnov Test.Then, the observer agreement was calculated in each group and for two stages of radiographic image measurement, using Intraclass Correlation Coefficient (ICC): in all the cases it was higher than 0.9. ICC test was employed to determine the correlation between sounding method and radiography: All three groups showed a very high correlation (sounding with original %98.1, sounding with Inverted 98%, and sounding with Sharpen1+Noise reduction stood at %97.9). Then, using Paired Samples test, all three groups of: Original, Inverted, and Sharpen1+Noise reduction were compared to the sounding group. The mentioned three sets were analyzed by One way ANOVA test as well. Based on a meaningful level of more than 0.05 (p=0.058) in table 1, which was obtained by Paired T-test, it can be concluded that there was not a statistically meaningful relation between sounding group and the original group. The mean score in the former was 5.21 ± 1.46 mm, higher than latter (5.13 ± 1.62) however.

Group	Number	SD ± Mean	T	P-Value
Sounding	89	5.21 ± 1.46	1.919	0.058
Original Radiography Images	89	5.13 ± 1.62		

Table 1: Comparing mean scores of sounding and original groups with paired T-test.

Due to a meaningful higher level of 0.05 (p=0.197) in table 2, obtained through Paired T-test, it can be concluded that sounding and inverted groups did not differ significantly. The mean score in the former was 5.21 ± 1.46 mm, higher than latter (5.15 ± 1.62) however.

Group	Number	SD ± Mean	T	P-Value
Sounding	89	5.21 ± 1.46	1.300	0.197
Inverted Radiography Images	89	5.15 ± 1.62		

Table 2: Comparing mean scores of sounding and inverted groups with paired T-test.

In table 3, employing the Paired T-test showed a significant difference of higher than 0.05 (p=0.145) and as a result, the mean score of sounding group with Sharpen1 + Noise reduction group were not significantly different. However, the mean score in the former was 5.21 ± 1.46 mm, higher than latter (5.14 ± 1.61).

Group	Number	SD ± Mean	T	P-Value
Sounding	89	5.21 ± 1.46	1.471	0.145
Sharpen1 + Noise Reduction	89	5.14 ± 1.62		

Table 3: Comparing mean scores of sounding and sharpen1 with one-time application of noise reduction with paired T-test.

Using Intraclass Correlation Coefficient (ICC) statistical test, it was shown in the table 4 that each of the radiography image groups had a high rate of 0.9 agreement with sounding group (p<0.001). In the analysis of observer's agreement within a period of two weeks, the achieved coefficient of agreement in relation to all the scales was more than 0.9 (p<0.001). ANOVA statistical test shows the mean in three groups did not differ statistically in table 6 (p=0.978); no significant divergence was observed in the paired comparisons either (p>0.05).

Group	Correlation Coefficient (α)	95% Confidence Interval		P-Value
		Minimum	Maximum	
Original	0.981	0.971	0.988	0.0001
Inverted	0.980	0.970	0.987	0.0001
Sharpen1 + Noise Reduction	0.979	0.968	0.986	0.0001

Table 4: Determining correlation coefficient of radiographic images of the studied groups with sounding.

Group	Correlation Coefficient (α)	95% Confidence Interval	
		Minimum	Maximum
Original	0.994	0.974	0.988
Inverted	0.998	0.993	1.000
Sharpen1 + Noise Reduction	0.998	0.995	1.000

Table 5: Determining observer's agreement coefficient in two different time period.

Discussion

The results of this study in comparing depth of the bone defect, using sounding and original intraoral digital radiographies showed that although the mean measurement in the original group showed underestimation (5.13 ± 1.62) compared to sounding group (5.21 ± 1.46) but the differences were not significant. In fact, the present

Groups	N	SD ± Mean	95% Confidence Interval		P- Value			
			Min.	Max.	I, II	I, III	II, III	I, II, III
Original (I)	89	5.13 ± 1.62	4.76	5.45				
Inverted (II)	89	5.15 ± 1.62	4.81	5.49	0.978	0.986	0.999	0.978
Sharpen1 + Noise Reduction (III)	89	5.14 ± 1.61	4.81	5.48				

Table 6: Comparing mean scores of all three groups with one-way ANOVA

research reported a very similar measurements of the depth of vertical and horizontal defects of alveolar bone obtained through digital radiographic images (using a PSP sensor) to the sounding method. In the recent study by Vadiati *et al*, there was significant underestimation of panoramic measurements in comparison with actual measurements (sounding and flap surgery).[10] Also, in a research by Moradi *et al*., the distance between Cementoenamel Junction (CEJ) to Alveolar bone crest, measured through periapical and bitewing radiographies, was shown to be less than the actual measurement obtained through flap surgery.[20] A survey conducted by Sairam and Gagan Puri[21] showed the measurements made by digitized bitewing radiographic images to be less than the clinical ones (periodontal probing). Also, Gedik and colleagues in their study, considered the clinical attachment loss (CAL) obtained through probing to be the gold standard and compared the bone crest – that was measured by a ruler – on bitewings, periapical and panoramic with that . Based on their results the mean bone level measured in all three radiographic techniques was less than clinical measurements (CAL). [22]

A study by D. Tihayi *et al*., showed the radiographic measurements to be less than gold standard (flap surgery) ones.[23] According to what has been said up to here, although the results reported in the mentioned studies showed underestimation (similar to the present study), but this difference was not statistically significant in the present study. The differences in various studies could be related to radiographic techniques, the digital sensor, the expertise of radiographic and clinical observer, and even the sample size. In the present study PSP intraoral digital sensor (parallel method) was used, with a higher exposure range than analog films; seemingly, it is the first research using these sensors. Another reason for underestimation in radiographic images could be the cases when the precise measuring of CEJ is not possible in places where gingival enlargement is occurring. Also, when crater decay is present, it is possible that the exact depth would not be diagnosed in radiographies due to facial or lingual bone superimposition. In the present study, interproximal crater defects were excluded as much as possible.

Of course, in the study by Oliveira *et al*., measurements obtained from periapical digital radiographic images were higher (overestimation) than the actual measurements.[24] In another study by Papapanou and his colleagues, the average depth of bone defects in both technique of panoramic and periapical were shown to be more than the actual depth assessed surgically,[3] which is contradictory to this study.

The present research calculated the correlation between sounding measurements and three radiographic groups of: Original, Inverted, and Sharpen1+Noise reduction to be 98.1%, 98%, and 97.9% respectively. In a study by Ismaili *et al*, the correlation between measuring clinical and radiographic lesion depth was calculated to be 88% and it was considered strong.[25]

Although, radiographic measurements tend to show an underestimated bone loss, digital processing and manipulating the radiographic imaging may increase the interpretation ability of radiographs in their accuracy and reliability.[26]

The performance of digital filters in digital radiographic imaging systems has been studied since their introduction. These filters have evolved with the aim of increasing accuracy in the diagnostic process and the quality of digital imaging. Although some filters are only available in certain digital software, most of them have been used for other general purposes. Inversion and Sharpen filters are available in various digital applications. Some studies have shown enhancement filters to be highly popular with observers.[27] However, this is a subjective analysis and it is not always associated with higher accuracy of diagnosis.[28]

In the present study, in order to compare the results of applying filters to the radiography images, the images obtained from 2 filters of Inversion, and Sharpen1 + Noise reduction were compared to the Original images and also to the measurements obtained from sounding. The evaluation showed that the average measurement of a sample through Inversion filter was 1.62 ± 5.15 mm while by applying Sharpen1 + Noise reduction it was 1.61 ± 5.14 mm, but despite the underestimation compared to the Sounding the differences were not significant. On the other hand, although filtered images showed overestimation compared to the Original group, these differences could not be considered meaningful.

Inversion is a very common filter in digital systems and its performance has been evaluated in different diagnostic purposes. In a study by Scaf and his colleagues, the effects of Inversion filtering in digitized radiographic images were evaluated. The results of their study showed that despite overestimation in Inverted images, there was not a significant difference between the original images (without filter) with images obtained through Inversion filters.[26] However, de Molon *et al*. have shown that periodontal bone loss measurements, in gray-scale inverted digital images obtained from CMOS sensors, were less than analog films.[29] However, the procedure was not performed on patients in their study. Moreover, the sensor used in their study was different from the one empolyed in the present study.

In a survey conducted by Tihany *et al*., the effect of brightness and contrast, both individually and simultaneously, were evaluated on radiography and on measurements obtained from distance between Cementoenamel junction to bone defect. Their results showed that a change in brightness and contrast did not increase the accuracy of measurements. And although compared to the non-modified images there was an overestimation of the radiography images, differences were not statistically significant.[23] Also, Oliveira *et al*. applied Perio and Inversion filters using PSP sensors and they compared the results from radiography with the non-filtered actual measurements (on dry mandible). They concluded that all radiographic images overestimated the measurements in comparison with actual measurements, but it was not statistically significant. Also, Perio filters cause underestimation and Inversion filters cause overestimation and simultaneous application resulted in underestimation compared with original images, but none of these differences were not significant.[24] The results of the present study are too close to them, although their research, unlike this one, was not conducted on a patient.

In another study by Eickholz and his colleagues, applications of the following in digitized radiography were assessed: contrast change, Inversion change, changes in gray level, mean value changes, histogram correction, and expansion of gray value. In all cases, the results were underestimated compared to the actual measurements, but none of the groups showed a significant difference with each other.[30]

Based on the results achieved from the measurements in this study, the closest readings to the Sounding (considered as gold standard) were Inverted images. Sharpen 1 + Noise reduction images stood second and the Original images were in the last place. However, the difference between the measurements obtained from any of the radiography images were not statistically significant compared to the Sounding. Furthermore, comparing radiography images with each other was not meaningful either.

Conclusion

As the results of this study showed, intraoral digital images are reliable for measuring the depth of alveolar bone defects compared to the actual values (obtained through Sounding method), and the results of digital intraoral radiography are similar to the ones derived from Sounding method. And by using intraoral digital radiography it is possible to measure the depth of the defects without local anesthesia or sounding, determine the need for surgery and in case of necessity, the type of the required surgery (resective or regenerative). Also, due to the fact that using Inversion and Sharpen1 + Noise reduction filters showed similar results, therefore, in cases where the observer feels the need to apply these filters subjectively, their employment would not create a significant difference in the results and they can be used for vertical and horizontal alveolar bone analysis.

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