Avicenna J Dent Res. 2014 December; 6(2): e21952. DOI: 10.17795/ajdr-21952
Published online 2014 October 14. **Research Article**

Comparison the Accuracy of the Cone-Beam Computed Tomography With Digital Direct Intraoral Radiography, in Assessment of Periodontal Osseous Lesions

Janet Moradi Haghgoo [1]; Abbas Shokri [2]; Amin Khodadoustan [1]; Masoumeh Khoshhal [1]; Nazli Rabienejad [1,*]; Maryam Farhadian [3]

[1]Department of Periodontics, School of Dentistry, Hamadan University of Medical Sciences, Hamadan, IR Iran
[2]Department of Radiology, School of Dentistry, Hamadan University of Medical Sciences, Hamadan, IR Iran
[3]Department of Epidemiology and Biostatistics, School of Public Health, Hamadan University of Medical Sciences, Hamadan, IR Iran

*Corresponding author: Nazli Rabienejad, Department of Periodontics, School of Dentistry, Hamadan University of Medical Sciences, Hamadan, IR Iran. Tel: +98-8138381085, Fax: +98-8138381085, E-mail: nazlirabi@yahoo.com

Received: July 11, 2014; **Revised:** August 20, 2014; **Accepted:** August 23, 2014

Background: Radiography is as a part of periodontal examination. Early detection of periodontal disease is important in the prevention of tooth loss and patient's general health.
Objectives: The objective of this study was to compare diagnostic accuracy of cone-beam computed tomography (CBCT) with digital direct intraoral radiography, in assessment of periodontal osseous lesions.
Materials and Methods: Fifty interproximal bone losses were evaluated in this study. First, direct digital intraoral radiography (Sopro-La Ciotat-France) was taken, and then CBCT (Newtom 3G, Verona. Italy) was carried out. Periodontal flap surgery was done to achieve the gold standard. The distance between cementoenamel junction (CEJ) and the bottom of the vertical pattern of bone loss or the most coronal level of bone in horizontal pattern was measured. These measurements were analyzed by paired t test. The intraclass correlation coefficient (ICC) was used to evaluate the degree of agreement between observers.
Results: Accuracy is higher with CBCT in evaluating vertical dimension of periodontal bony defects (0.53 ± 0.59 to 0.56 ± 0.45) ($P < 0.001$). ICC shows high level of agreement between observers in two image modality.
Conclusions: We conclude that CBCT and digital images can be used in periodontal bone assessments; each modality should be chosen based on defect type and patient's specific characteristics.

*Keywords:*Periodontal Bone Loss; Cone-Beam Computed Tomography; Dental Digital Radiography

1. Background

Nowadays, it is obvious that early detection of the periodontal disease is important in the prevention of tooth loss and accordingly, patient's general health (1). The goals of periodontal therapy are to preserve the natural dentition and to maintain and improve periodontal health (2). Radiography is valuable in diagnosis, severity estimation, evaluation of prognosis, and treatment outcome. Radiography is a part of periodontal examination (3). Although radiography is a proper way to detect calculus and defective restorations, main goal of radiographic examination is to evaluate alveolar bone height considering cementoenamel junction (CEJ), which helps us in periodontal diagnosis (4, 5). However, radiography has some shortcomings. It usually underestimates the amount of bone loss (3). Superimposition of anatomic structures in 2D images often hides true dimensions between buccal and lingual cortical plates, especially in intraosseous lesions (4).

In conventional radiographic methods, (because of X-ray angulation) only interproximal bone surfaces are detectable with different levels of assurance (5). Achieving high quality by chemical compounds and processes are proved to be problematic in dentistry radiography. These reasons directed the system of conventional radiography toward digital systems. Digital radiography eliminates dangerous waste agents in the form of processing chemical materials and lead foils. Digital radiography provides electronic transfer and reduces exposure (6). It has several other advantages over conventional radiography, including faster image acquisition and image enhancement (7).

When clinical examination raises concerns, CBCT (cone-beam computed tomography) can add to the diagnostic value. CBCT lacks the problems of geometric superimposition and unpredictable magnification (3). CBCT is much cheaper than medical CT units, imparts a relatively low dose to the patient and is rapidly becoming available to the dental profession (8). Dentists usually use linear

Copyright © 2014, Hamadan University of Medical Sciences; Published by Hamadan University of Medical Sciences. This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (http://creativecommons.org/licenses/by-nc/4.0/) which permits copy and redistribute the material just in noncommercial usages, provided the original work is properly cited.

measurements such as distances between anatomic landmarks or thickness of the bone to facilitate diagnosis and determination of presurgical strategies (9). CBCT overcomes the problems by axial cuts, but it has some disadvantages such as high radiation dose, high cost, and low resolution (10).

Nowadays, we see increased demand for dental implants, and many advances have occurred in diagnosis and treatment. Diagnostic imaging helps the team for implantology to provide a perfect and comprehensive treatment plan. Radiography has applications in presurgical, surgical and postsurgical stages; it evaluates the amount of bone, its relation with anatomic structures and amount of crestal bone loss. Amount of crestal bone loss after implant insertion, is important in determination of the implant failure (11). Although there are few studies about application of CBCT in the evaluation of periodontal defects, its combination with 2D digital intraoral radiography may improve periodontal diagnosis and treatment plan (12, 13).

Radiography is so valuable in the diagnosis and treatment of periodontal diseases that outweighs its limitations and innate shortcomings. Considering rapid advances and availability of the new imaging technologies, it is obvious that we need studies to compare efficacy, accuracy, and application of them in measuring lesion dimensions and overcome limitations of anatomic structures.

2. Objectives

In this study, we compared accuracy of CBCT with direct digital radiography; the achieved result can be used as an aid in different clinical diagnosis or treatments like implant dentistry. It is useful to mention that our aim was not to determine the defects depth.

3. Materials and Methods

3.1. Patients Selection

The participants were selected from the patients referred to the Periodontology Department of Hamadan Dental School. We evaluated 50 sites of osseous defects. The patients who had all the inclusion criteria were selected. Inclusion criteria were as follows:

1) Interproximal osseous defects (horizontal or 3 wall vertical),

2) Indication for periodontal surgery at the site of the defect,

3) No contraindication of periodontal surgery,

4) No contraindication to radiography.

3.2. Radiographic Evaluation

After enrolling the patients in the study, direct digital intraoral radiography (Sopro CCD- France) and CBCT (Newtom 3G- Verona CBCT Italy) were taken at the site of the bone defect. De Gotzen dental radiography machine was used to take intraoral direct digital radiography (kvp = 60, mA = 7, s = 0.2). In direct digital intraoral radiography, one technician took all the radiographies to reduce interfering factors. Images were seen and measured by Sopro software and saved as JPEG format. We calibrated the machine before taking images using a human skull mandible to estimate the measurement bias. Therefore, the machine was calibrated and reliable (Figure 1).

For CBCT radiographs, images were taken by New Tom 3G (Verona, Italy) at kvp = 110, mAs = 10.65, FOV = 6 and pixel size of 200 μm. NNT software was used in coronal and sagittal plans to reconstruct observation images.

3.3. Radiographic Measurements

CCD images were saved as JPEG files to measure by observers, and then by CCD machine special software ruler. These specifications were considered for CBCT: slice interval = 1 mm, slice thickness = 0.5 mm, and step = 0.5 mm. Regarding these two radiographic modalities, two persons evaluated images at 2-week intervals. A 14-inch monitor (Sony corporation flat 7 panel-LCD) was used to see images. Vertical dimension of the periodontal bone defects was measured under standard conditions and constant environment (same monitor, without changes in contrast and resolution, same lightness of room, and equal distance from the monitor). Distance from CEJ to depth of the defect was measured by ruler tool of the software (Figure 2).

3.4. Surgical Treatment

Periodontal flap surgery was performed for the patients. For selection of appropriate technique, we considered

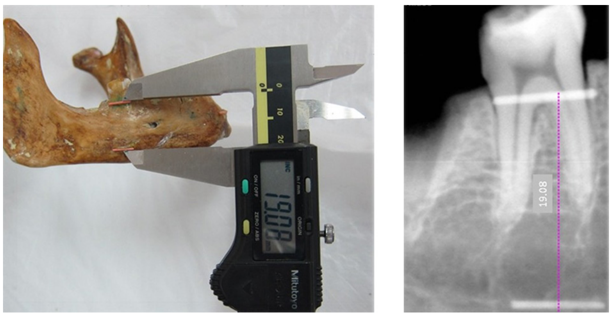
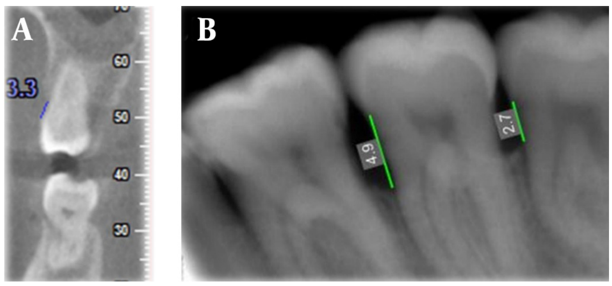


Figure 1. Calibrating Charge-Coupled Device Exposure Machine

Figure 2. Vertical Dimension Measurement of Periodontal Defects



A) CBCT measurement, B) CCD measurement; (CBCT: cone-beam computed tomography; CCD: charge coupled device).

observation and access to the alveolar crest and depth of the defect. After incision, flap was elevated and granulation tissue was removed to increase the access; scaling and root planning was done if necessary. CEJ to defect depth was measured as the gold standard by Williams probe (Hu-Friedy, Chicago, USA). Rubber stop was used in probe measurements. This rubber stop marked dimension was measured by digital caliper (Mitutoyo-Japan). After measurements, bone restorative steps were done if necessary. We considered distal tooth to the defect as a rule in our measurements (both radiographic and surgical gold standard). The line angle was considered as the reference line for measurement.

3.5. Data Analysis

Registered amounts with minimal difference of ± 0.5 mm in comparison with gold standard were recorded. After collecting all the data, paired t-test and ICC (intraclass correlation coefficient) were used to analyze the data. We used SPSS 19 software in our analysis.

4. Results

According to ICC, agreement degree was high between clinicians who evaluated images ($P > 0.05$) (Table 1).

Paired t-test was done in three steps:

Step 1, comparing overall data from two radiography modalities with gold standard,

Step 2, comparing data based on defects location (anterior sextants or posterior),

Step 3, comparing data based on defects type (horizontal or vertical).

According to overall analysis of the data in step 1, discrepancy from the mean of the gold standard was lower in CBCT (0.53 ± 0.59 to 0.56 ± 0.45) ($P = 0.000$). It means that accuracy was higher with CBCT in evaluating vertical dimension of periodontal bony defects.

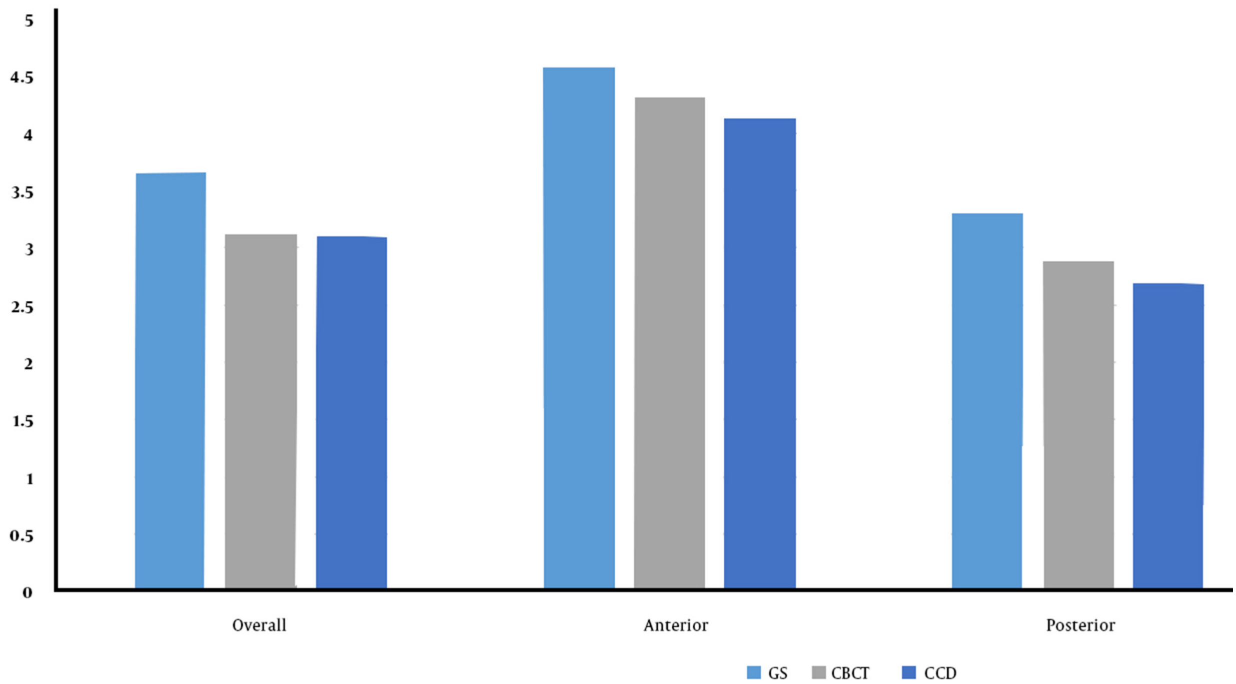
In step 2, samples were divided into two groups (anterior and posterior) according to their location. Twenty-eight percent of the defects were in the anterior region, while 72% were in the posterior region of jaw. The descriptive statistics show a smaller deviation range and the mean error for the CBCT measurements compared with CCD was 0.24 ± 0.31 to 0.43 ± 0.17 ($P = 0.000$) in the anterior region. This reveals that a difference was found comparing the intraoral CBCT bone level measurements with those on the CCD; however, CBCT is slightly better (Table 2, Figure 3).

Table 1. Intraclass Correlation Coefficient in Cone-Beam Computed Tomography and Charge Coupled Device Evaluation[a]

Variables Compared	Intraclass Correlation Coefficient	95% Confidence Interval
CBCT	0.94	0.82 to 0.98
CCD	0.95	0.84 to 0.98

[a] Abbreviations: CBCT, cone-beam computed tomography; CCD, charge coupled device.

Figure 3. Accuracy Comparison of Radiography Modalities Based on Defect Location



GS, gold standard; CBCT, cone-beam computed tomography; CCD, charge coupled device

Also in posterior regions, the descriptive statistics showed a smaller deviation range and mean error for the CBCT measurements compared with CCD (0.41 ± 0.64 to 0.60 ± 0.52). Here, it can be concluded that despite significant differences between the CBCT bone level measurements with those of the CCD, CBCT showed a better accuracy, and it was better in the anterior region of the jaw.

In Step 3, one-third of defects were vertical and the rest were horizontal. Considering deviation from the mean, no significant difference was found in horizontal bone loss patterns ($P > 0.05$). CBCT showed better accuracy than CCD in evaluating vertical defects (Table 3, Figure 4).

Table 2. Accuracy Comparison of Radiography Modalities Based on Defect Location[a]

Pairs of Variables Compared	Mean Differences ± SD	t value	P value
Overall			
CBCT and GS	0.53 ± 0.59	6.27	0.000
CCD and GS	0.56 ± 0.45	8.64	0.000
Anterior			
CBCT and GS	0.25 ± 0.09	9.77	0.000
CCD and GS	0.43 ± 0.17	9.38	0.000
Posterior			
CBCT and GS	0.41 ± 0.64	3.87	0.000
CCD and GS	0.60 ± 0.52	6.97	0.000

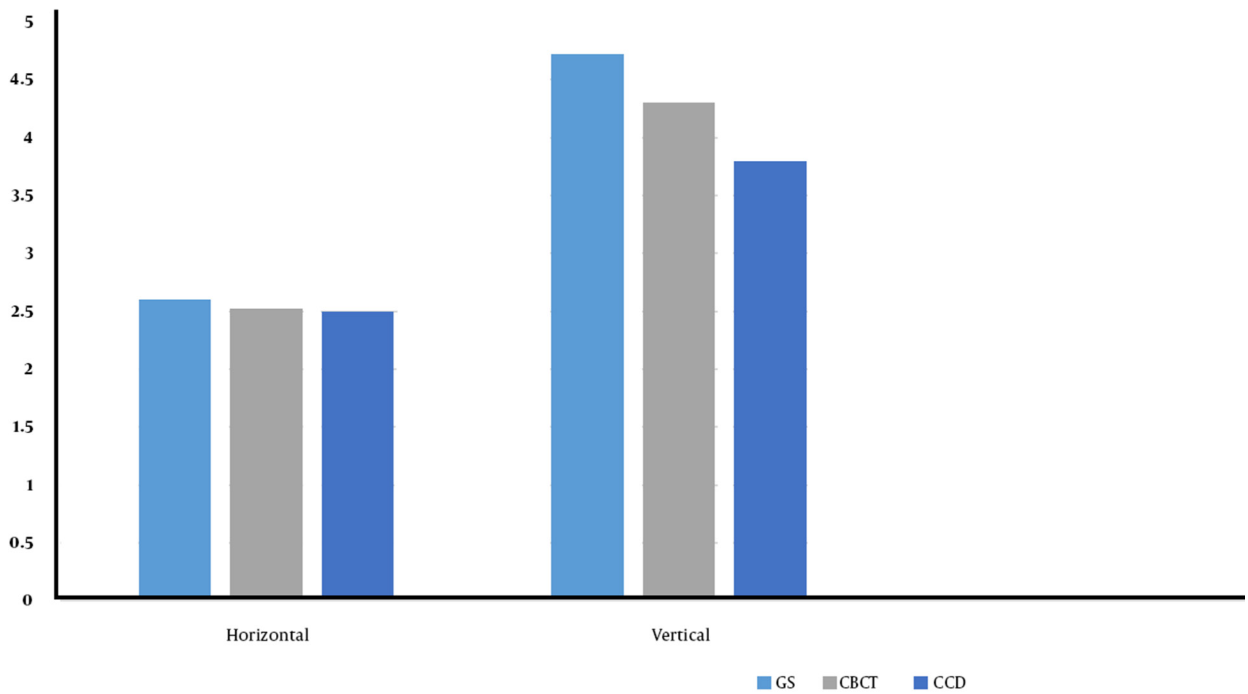
[a] Abbreviations: CBCT, cone-beam computed tomography; GS, gold standard; CCD, charge coupled device.

Table 3. Accuracy Comparison of Radiography Modalities Based on Defect Type[a,b]

Defect Type	GS	CBCT	CCD
Horizontal	2.6 ± 0.6	2.52 ± 0.4	2.5 ± 0.42
Vertical	4.72 ± 1.21	4.3 ± 1.1	3.8 ± 1.18

[a] Abbreviations; GS, gold standard; CBCT, cone beam computed tomography; CCD, charge coupled device.
[b] Data are presented as mean ± SD.

Figure 4. Accuracy Comparison of Radiography Modalities Based on Defect Type



GS, gold standard; CBCT, cone beam computed tomography; CCD, charge coupled device

5. Discussion

Nowadays, nothing has captured the dentist's imagination like CBCT. Its process differs from that of traditional medical CT scanners in that the image is gathered in a voxel format, and the radiation dose absorbed by the patient is substantially lower. CBCT makes clinical decision-making easier and more precise. Dentistry is moving away from "radiographic interpretation" into "disease visualization" (14). Study of radiographs in assessing linear distances between a reference point such as the CEJ and alveolar bone crest or the apical border of a vertical defect is common (15). Linear measurements are usually used in periodontology such as distances between anatomic landmarks or thickness of the bone to facilitate diagnosis and determination of presurgical strategies (9).

The advantages of CBCT in visualizing the alveolus in 3D and making precise measurements before surgery are obvious in the field of implant dentistry. It reduces the likelihood of the need to change the treatment during the operation (14). In our study, ICC was greater than 92% in evaluating CBCT in comparison with the gold standard, and greater than 84% in evaluating CCD images in comparison with the gold standard. Therefore, there was a high agreement between observers in evaluating CBCT and intraoral direct digital images. Our agreement result is similar to what Corpas (16) and Vandenberghe (13) concluded. They stated that the reliability among observer measurements and classifications on CCD and CBCT results in ICC. Confidence intervals (CI) of %95 show high reliability for all observations (13).

Nevertheless, Mol used kappa statistics representing intraobserver agreement for bone loss assessment, and his overall results showed slight agreement, with only two observers showing fair agreement (17). Zybutz assessed observers agreement based on the defect type and stated that the differences in ICC between all defects and the combination of 1 and 2 defects *vs.* probing attachment level measurements indicated better reliability for PAL studies of 3 wall defects than for the combined 1 and 2 wall defects by PAL. The reliability by radiographic changes was good (ICC = 0.61) (15). Nowadays, there is a tendency towards digital images. Khocht compared full mouth digital with parallel film based radiography, and achieved more accuracy with digital images (18). According to our results, accuracy was higher with CBCT in evaluating vertical dimension of periodontal bony defects, but it was not statistically significant ($P > 0.05$). But, both of them were under estimated measurements rather than the surgical gold standard.

This result is similar to Vandenberghe et al. study (13). They found no significant differences ($P = 0.165$) between the two methods. However, on cross-sections of 0.4 mm thickness, the mean error was 0.29 mm, and the Wilcoxon signed-rank test indicated a significant difference when compared with the CCD ($P = 0.006$). Therefore, CBCT is better for the assessment of defect morphology and CCD for detailed information (13). Noujeim et al. found statistically significant differences between CBCT and 2D method. CBCT has perfect diagnostic accuracy in diagnosis of periodontal interradicular bony defects (19). Grimard compared bone level alterations after regenerative treatments used CBCT and periapical radiography, and concluded that CBCT was more accurate; thus, CBCT was suitable for regenerative treatments instead of re-entry surgery (20). Also, Vasconcelos found no significant differences (21). Misch et al. found significant differences between F speed film (mean error = 0.27 mm) and cross sectional CBCT (mean error = 0.41 mm). But they reported no significant linear measurement differences (12). Mol stated better diagnostic and quantity accuracy with CBCT (1 mm cross sections) compared with PSP (17). Despite all of these factors, Donald stated that CBCT is better than 2D radiographies in the assessment of architecture and topography of periodontal defects (22).

All of the mentioned studies were in vitro, except bone regeneration study; however, we conducted an in vivo study. In our study, significant differences were found between CBCT bone level measurements and those of the CCD. CBCT showed better accuracy than CCD and it was better in the anterior region of the jaw. Also, we found significant difference between radiography modalities in horizontal bone loss patterns. Thus, CBCT showed better accuracy than CCD in evaluating vertical defects. The better results in the anterior region of the jaw can be attributed to the defect type (horizontal). Mol found limited accuracy of CBCT in the anterior region; this finding is not in agreement with ours (17). Tyndall et al. study resulted in better accuracy of two-dimensional radiographies in the assessment of vertical dimension of bone (22). Zybutz et al. evaluated vertical bone loss patterns during flap surgery and compared it with radiographic finding. Radiographs were reliable but with expected underestimation (1.4 mm) (15). The result of this study can be useful in different conditions as follows. It can be concluded that CBCT and digital images can be used in periodontal bone assessments; each modality should be chosen based on the defect type, extent, frequency, and patient's specific characteristics (radiation dose, cost, conformance, and so on). We recommend CBCT for generalized or severe periodontitis, complicated implant cases, and extended reconstruction treatment; while digital images are better for smaller and fewer defects or bone regenerations, implants with no anatomic limitations, follow-up periods, and annual implant bone loss evaluation.

Acknowledgements

Authors would like to thank Dr. Parviz Torkzaban.

Authors' Contributions

Janet Moradi Haghgoo: study design, scientific consultation; Abbas Shokri: study design, scientific consul-

tation; Amin Khodadoustan: study design; Masoumeh Khoshhal: consultation; Nazli Rabienejad: clinical studies, literature search, manuscript preparation; Maryam Farhadian: data acquisition and analysis.

Finding/Support

This study was supported by the Dentistry Faculty, Hamadan University of Medical Sciences.

References

1. Oliveira Costa F, Cota LO, Costa JE, Pordeus IA. Periodontal disease progression among young subjects with no preventive dental care: a 52-month follow-up study. *J Periodontol.* 2007;**78**(2):198–203.
2. Research S, Therapy Committee of the American Academy of P. Treatment of plaque-induced gingivitis, chronic periodontitis, and other clinical conditions. *J Periodontol.* 2001;**72**(12):1790–800.
3. Newman MG, Takei H, Klokkevold PR, Carranza FA. *Carranza's clinical periodontology.*St. Louis: Sunders; 2011.
4. Vandenberghe B, Jacobs R, Yang J. Detection of periodontal bone loss using digital intraoral and cone beam computed tomography images: an in vitro assessment of bony and/or infrabony defects. *Dentomaxillofac Radiol.* 2008;**37**(5):252–60.
5. Mol A. Imaging methods in periodontology. *Periodontol 2000.* 2004;**34**:34–48.
6. White SC, Pharaoh MJ. *Oral radiology principles and interpretation.* 5th edNew York: Mosby; 2009.
7. Versteeg CH, Sanderink GC, van der Stelt PF. Efficacy of digital intra-oral radiography in clinical dentistry. *J Dent.* 1997;**25**(3-4):215–24.
8. Ludlow JB, Davies-Ludlow LE, Brooks SL, Howerton WB. Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. *Dentomaxillofac Radiol.* 2006;**35**(4):219–26.
9. Loubele M, Van Assche N, Carpentier K, Maes F, Jacobs R, van Steenberghe D, et al. Comparative localized linear accuracy of small-field cone-beam CT and multislice CT for alveolar bone measurements. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2008;**105**(4):512–8.
10. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. *J Can Dent Assoc.* 2006;**72**(1):75–80.
11. Misch CE. *Contemporary implant dentistry.*New York: Mosby; 2008.
12. Misch KA, Yi ES, Sarment DP. Accuracy of cone beam computed tomography for periodontal defect measurements. *J Periodontol.* 2006;**77**(7):1261–6.
13. Vandenberghe B, Jacobs R, Yang J. Diagnostic validity (or acuity) of 2D CCD versus 3D CBCT-images for assessing periodontal breakdown. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2007;**104**(3):395–401.
14. Blum J, Nicolaievsky E, Zfaz S. *Blum oral-facial surgery associates Implants maxillofacial surgery periodontics.* Miami Beach Office. Available from: www.drblumoralsurg.com.
15. Zybutz M, Rapoport D, Laurell L, Persson GR. Comparisons of clinical and radiographic measurements of inter-proximal vertical defects before and 1 year after surgical treatments. *J Clin Periodontol.* 2000;**27**(3):179–86.
16. Corpas Ldos S, Jacobs R, Quirynen M, Huang Y, Naert I, Duyck J. Peri-implant bone tissue assessment by comparing the outcome of intra-oral radiograph and cone beam computed tomography analyses to the histological standard. *Clin Oral Implants Res.* 2011;**22**(5):492–9.
17. Mol A, Balasundaram A. In vitro cone beam computed tomography imaging of periodontal bone. *Dentomaxillofac Radiol.* 2008;**37**(6):319–24.
18. Khocht A, Janal M, Harasty L, Chang KM. Comparison of direct digital and conventional intraoral radiographs in detecting alveolar bone loss. *J Am Dent Assoc.* 2003;**134**(11):1468–75.
19. Noujeim M, Prihoda T, Langlais R, Nummikoski P. Evaluation of high-resolution cone beam computed tomography in the detection of simulated interradicular bone lesions. *Dentomaxillofac Radiol.* 2009;**38**(3):156–62.
20. Grimard BA, Hoidal MJ, Mills MP, Mellonig JT, Nummikoski PV, Mealey BL. Comparison of clinical, periapical radiograph, and cone-beam volume tomography measurement techniques for assessing bone level changes following regenerative periodontal therapy. *J Periodontol.* 2009;**80**(1):48–55.
21. de Faria Vasconcelos K, Evangelista KM, Rodrigues CD, Estrela C, de Sousa TO, Silva MA. Detection of periodontal bone loss using cone beam CT and intraoral radiography. *Dentomaxillofac Radiol.* 2012;**41**(1):64–9.
22. Tyndall DA, Rathore S. Cone-beam CT diagnostic applications: caries, periodontal bone assessment, and endodontic applications. *Dent Clin North Am.* 2008;**52**(4):825–41.