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Comparative Evaluation of Periodontal Osseous Defects Using Direct Digital Radiography and Cone-Beam Computed Tomography

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Abstract

Objectives:

To evaluate and compare the accuracy of Direct Digital Radiography (DDR) and cone-beam computed tomography (CBCT) in determination and diagnosis of periodontal osseous defects.

Methods:

A nonrandomized *in vivo* study was conducted to compare the two imaging modalities, DDR and CBCT, for the diagnosis of periodontal osseous defects. Comparison was made between the linear measurements of DDR and CBCT images with the actual measurements of various osseous defects during surgical exposure (Gold standard).

Results:

The results of the present study demonstrated the difference in the mean values of the DDR and surgical exposure measurements of periodontal osseous defects, whereas comparable mean values were found between the CBCT and surgical exposure measurements, with no statistically significant difference ($P > 0.05$) being found between each modality.

Conclusion:

CBCT proved to be an indispensable imaging tool in detecting and quantifying periodontal defects and furcation involvement more precisely and could provide additional benefits over the traditional radiography for clinical and postsurgical evaluation.

Keywords: *Cone-beam computed tomography*, *direct digital radiography*, *periodontal osseous defects*, *surgical exposure*

Introduction

Periodontitis is one of the most prevalent oral diseases and if left untreated, it leads to severe bone loss.[1] Early detection can prevent the loss of teeth. The periodontal diseases are broadly classified into two clinical forms of periodontitis. Aggressive Periodontitis and Chronic Periodontitis (CP).[2] Diagnosis is crucial for its treatment planning and prognosis. The present diagnostic approach by periodontal probing, bone sounding, and intraoral radiography have several limitations.[3] The shortcoming of probing is the size and shape of probe tip, probing force, resistance of the tissue, and direction of penetration which can be misleading.[4] Bone sounding is the most accurate method to figure out the extent of the infrabony component of the pocket and of the furcation defect,[5] but it is still an invasive method, while intraoral radiographs may violate the degree of loss of bone due to projection errors and overlapping of anatomical structures, making it difficult to distinguish between the lingual and buccal cortical plate for the detection of infrabony defects, osseous craters, 1, 2, 3, and 4 walled defects, and furcation involvements.[6]

Interproximal radiography has come up with the best results to evaluate crestal bone height with high-quality images but missed the crucial features of alveolar bone due to overlying structure and improper placement of X-ray beam.[7] Furthermore, the traditional radiographs are not able to produce an accurate clinical assessment of the furcation involvement due to similar drawbacks.[8]

Various attempts have been made over the past few years to overcome the drawbacks of the routine diagnostic methods such as electronic probes, direct digital radiography (DDR), and digital subtraction radiography (DSR). However, electronic probes proved to be disappointing over manual probing.[9,10] Digitalization of intraoral radiography is a sensitive technique and miscalculates alveolar bone crest height,[11] whereas in DSR, there is a need of identical projection alignment during exposure of sequential radiographs which is very technique sensitive and requires highly specialized computer imaging processing equipments.[12]

Visualization of the defect by surgical exposure gives the accurate analysis of the defect, but still it is an invasive method, although the minimal invasive surgical techniques have been described but not for generalized periodontal defects.[13] Hence, the noninvasive imaging modality of three-dimensional (3D) nature for the detection of the periodontal osseous defects and for its clinical application in periodontal practice was essential.

Conventional computed tomography (CT) produces axial images but has disadvantages such as high cost, low resolution, and high radiation dose. To overcome the conventional CT drawbacks, the recent introduction of cone-beam CT (CBCT), also called dental CT, has become an indispensable tool in periodontal diagnosis and further evaluation of periodontal therapy.[14] CBCT proved to have less radiation exposure to patients[15] as compared to conventional CT, it consists of a conical radiographic source and a digital panel detector and the apparatus is similar the size of the panoramic machine. It takes only 30 s, and its radiation is within the limit of an intraoral full-mouth radiographs,[16] Also it can be adjusted up to 0.1 as compared to 0.5–1 mm for CT. The previous evidence about CBCT confirms that it is reliable and may be adequate to detect periodontal alveolar osseous defects. American Academy of Periodontology recently releases series of papers on best evidence consensus for the application and use of CBCT in periodontology.[17]

Materials and Methods

A nonrandomized *in vivo* study was conducted to evaluate and compare the efficiency and accuracy of DDR and CBCT to measure and quantify the periodontal osseous defects.

Based on history, clinical findings, and radiographic analysis, patients were diagnosed as Generalized CP. One hundred forty-five defects were selected from 10 patients. They were all evaluated using DDR and CBCT. Phase I therapy was performed and full-mouth quadrant-wise flap surgery was planned for the selected patients. During surgical exposure, the defects were completely debrided and measured with the help of the periodontal probe (UNC 15 and Nabers probe) from the cementoenamel Junction to the base of the defects. The clinical measurements of the osseous defects during surgery were recorded by the blinded trained periodontist who was unaware of the digital radiographs and CBCT measurements data. The clinical data then compared with measurements of the osseous defects on the DDR and CBCT images.

Inclusion criteria

Patients with Moderate to Severe Generalized CP were included in the study.

Exclusion criteria

Medically compromised patients, drug allergy, pregnant patients, smokers, and failure to complete the informed consent were excluded from the study.

Purpose and the design of study was explained and written consent was obtained from all participating patients prior to the initiation of the study. The approval was given by the institutional ethical committee.

Intraoral full-mouth digital radiographs were obtained by long cone paralleling technique with 60 kVp and 8–10 mAs with sensor of CCD (Planmeca Pro X) using a film-holding device placing gutta purcha points in the periodontal pockets as a marker. They were stored in digital viewing software for further interpretation. CBCT scans were carried out with Kodak CS 9300 scanner at voxel resolution (0.18 mm × 0.18 mm × 0.18 mm). The beam height was set at low-dose protocol 80 kVp and 4 mAs. All the MPR images and panoramic and volumetric rendered images were then stored in CS 3D imaging DICOM software [Figure 1].

Osseous craters on DDR and CBCT images were given an ordinal scale from 0 to 4 (no defect and 1, 2, 3, and 4 walled)[18] and for furcation involvement 0–3 (Class I, Class II, and Class III).[19] Measurements of the walled defects and craters on DDR images were also done by linear measuring tool of the software (KODAK RVG 5100) by measuring mesial and distal sites of the buccal aspect of the defects and for the measurement on lingual aspect, gutta percha point was placed into the periodontal pocket as a marker before taking radiographs with the help of SLOB technique[20] [Figure 2].

The defects on CBCT images were measured with the help of the linear measuring tool and a digital magnification lens of the CS 3D imaging software to the nearest 0.01 mm. Measurements of the defects were recorded by taking cementoenamel junction (CEJ) as the reference point till the base of the defects. On the buccal aspect, they were measured on the panoramic reconstruction view with a slice thickness of 5.2 mm [Figure 3] and on lingual aspect, they were done on sagittal slice thickness 0.2 [Figure 4], midbuccal and midlingual measurements of alveolar bone loss and furcation involvement (vertical) were made on cross-sectional slice thickness 0.2, whereas horizontal bone loss measurement of furcation area was done on the axial slice [Figure 5]. Recordings of defect on three different modalities DDR, CBCT, and surgical exposure, are shown in Figure 6.

Actual clinical measurements of the surgically exposed and thoroughly debrided osseous defects were recorded and rounded up to the nearest 0.5 mm using a UNC 15 probe and a Nabers probe. Distance between the CEJ and alveolar crest was measured by placing the probe parallel to the long axis on the mesiobuccal, midbuccal, and distobuccal and mesiolingual, midlingual, and distolingual line angles of teeth for measuring the bone hight, crater depth, and vertical measurements of furcation involvement (buccal and ligual for mandibular and buccal, mesiopalatal, and distopalatal for maxillary). They were taken for comparison with the DDR and CBCT images measurement, as shown in Figure 6. Patients were informed about the postoperative instructions, Amoxicillin (500 mg) every 8 h for 5 days was prescribed. A periodic checkup was planned for every 3 months for evaluation.

The recorded data was subjected to SPSS 19 IBM Corp.,(N.Y., USA). Descriptive statistics included computation of mean and standard deviation. The statistical test applied for the analysis was the independent sample *t*-test. The confidence interval and *P* value were set at 95% and less than or equal to 0.05.

Results

By comparing the walled defects and osseous craters measurement using two different imaging modalities, CBCT and DDR, with direct surgical exposure, the mean values of walled defects were 4.28, 5.00, and 4.38, and of osseous craters, they were 6.09, 5.74, and 6.06, $P > 0.05$, which was not statistically significant, but the difference in the mean of surgical exposure and CBCT measurements of walled defects and osseous craters was found to be ±0.07 and ±0.03 which was less and comparable, while that of DDR and surgical exposure of both walled defects and craters, it was ±0.72 and ±0.32 which was more and noncomparable.

On surgical exposure of defects, measurements of both horizontal furcation involvement and vertical furcation involvement when compared with those on the cross-sectional images (vertical measurements) and axial images (horizontal measurements) of CBCT data with 0.2-mm thickness slice show the difference in the mean value of vertical furcation involvement on DDR images and surgical measurements which is ±0.12 which was more as compared to surgical data and CBCT ±0.03, whereas the horizontal furcation involvement was not recordable on DDR images due to two-dimensional (2D) nature. Only the CBCT measurements of horizontal furcation involvements were compared with the surgical exposure measurements showing the mean value of 3.89 and 4.15, respectively, with a difference in mean of ±0.26, with $P > 0.05$ which is not statistically significant, whereas there was a difference in the mean rank between surgical and DDR furcation involvement measurements which were not comparable.

On CBCT, osseous craters and furcation involvements were detectable and diagnosed 100%, while 71% of the osseous crater and 56% of the furcation involvements were diagnosed on DDR [Figure 7].

Discussion

From the past few years, CBCT is considered to be an important diagnostic modality among various investigations.[21,22,23,24] Generalized CP is a commonly occurring condition causing bone loss due to chronic inflammation. Diagnosis is made on the basis of history, clinical and radiological examination. Radiological examination generally includes 2D radiographs in routine practice. An accurate diagnosis is required for successful management of a case. Being noninvasive, 3D CBCT demonstrated the precise measurements of all the osseous defects examined.

The technique for CBCT used in the present study was standardized as recommended by Vandenberghe *et al*.[1] and Misch *et al*.[25] All the affected sites were measured on DDR images using the measuring tool. The selected sites with osseous defects were measured again on the CBCT with 0.2-mm thickness of the slice.

The measurements of various osseous defects had provided an adequate amount of information on the 3D images, which is important for the diagnosis and treatment planning of the periodontal patient. The quality of CBCT images was found to be excellent. The present study further elaborated the classification of osseous defects using both the modalities. After measuring/quantifying the defects on surgical exposure which is considered as a gold slandered, they were compared with those obtained from DDR and CBCT, demonstrating better description of furcation involvements and walled defects on CBCT than DDR. Measurements of horizontal furcation involvement were not possible on DDR images because of its 2D nature which was the main drawback as compared to 3D CBCT images. It was possible to take horizontal furcation involvement measurements on axial images of CBCT; buccal and lingual osseous defects and trifurcations of maxillary molars were precisely detected by CBCT as compared to DDR images. Fuhrmann *et al*.[26] demonstrated 21% of the artificial furcation involvements on radiographs and 100% on CBCT images.

The present study confirmed that accurate evaluation could be achieved on CBCT images for the infrabony defects and other osseous defects than DDR images. Radiation dose of CBCT is 15 times less than conventional CT and 4–15 times the dose of a standard panoramic image and full-mouth radiographs.[27]

Misch *et al*.[25] conducted a study showing 100% detection of the artificially created infrabony defects with CBCT and only 67% on 2D imaging.

Vandenberghe *et al*.[1] stated that the use of CBCT optimized exposure protocols (following the As Low As Reasonably Achievable principle). The present study was conducted to evaluate and compare the accuracy of DDR and CBCT in detecting various periodontal osseous defects, justifying the utilization of CBCT in the periodontal field.

Usually, postsurgical evaluation of periodontal regenerative procedures requires surgical reentry to verify outcomes, which is not only invasive and inconvenient for the patient but also time consuming. With the introduction of CBCT in periodontal practice, this step could be eliminated relying completely on noninvasive 3D technique.

Conclusion

Traditionally, periodontal diagnosis is based on clinical and radiographic examination. 2D imaging is routinely practiced for the diagnosis of intrabony defects and furcation involvement with limitations. When compared DDR with CBCT imaging for determining periodontal osseous defects, it was proved that CBCT is not only beneficial for the assessment of bone levels effectively via circumferential quantification but also could assist in evaluation following regenerative surgical treatment avoiding the unnecessary surgical reentry to verify the outcomes.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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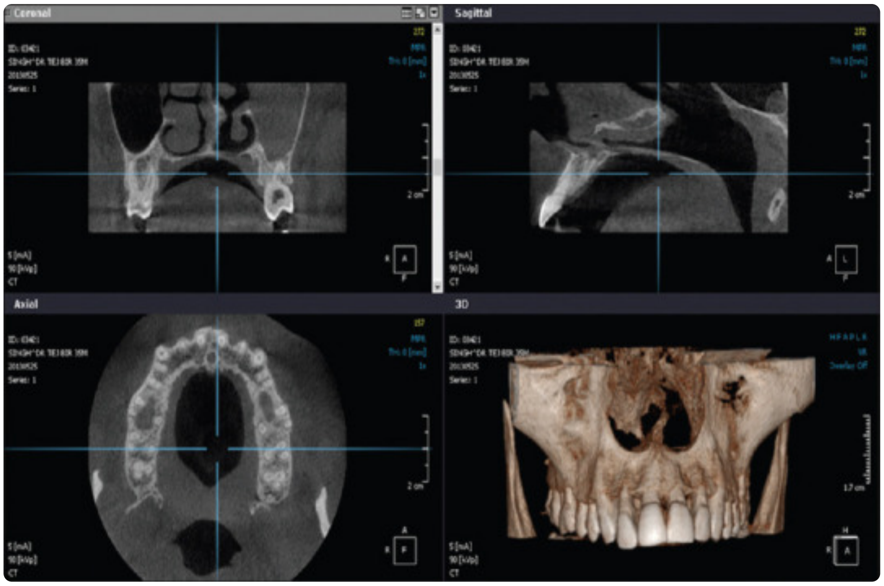
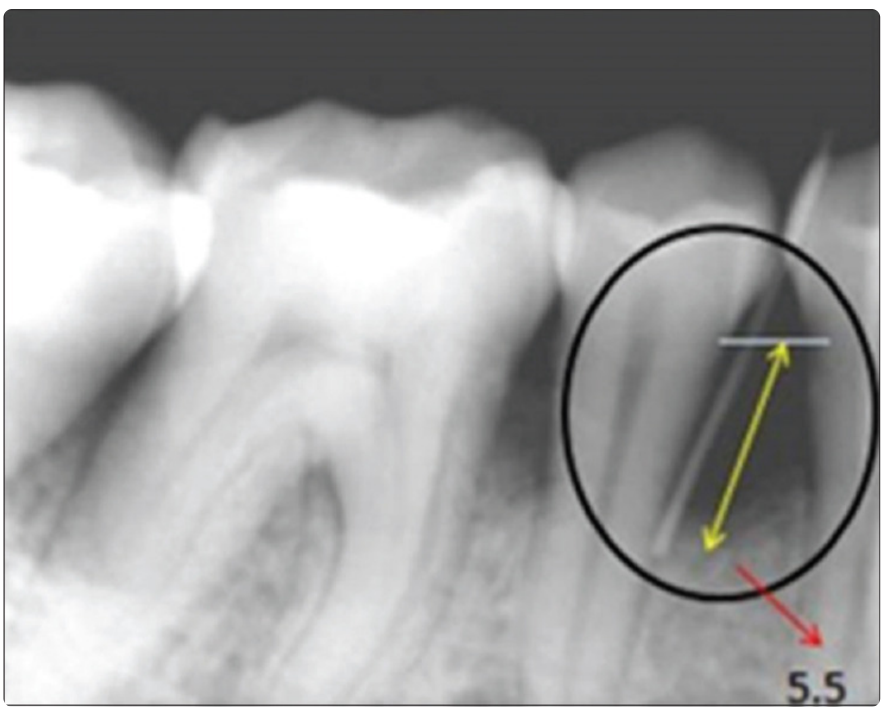
Figures and Tables

Figure 1



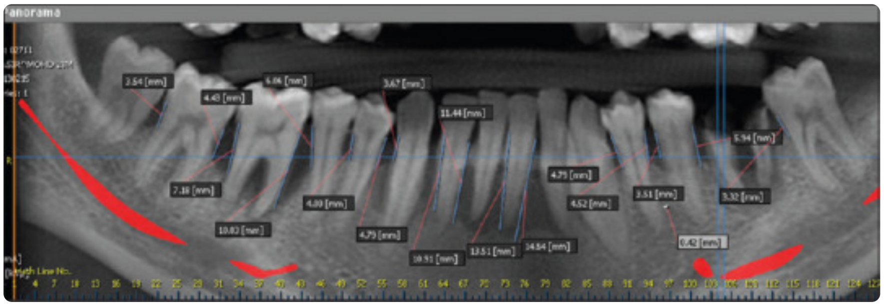
Multiplaner reconstruction images of cone-beam computed tomography

Figure 2



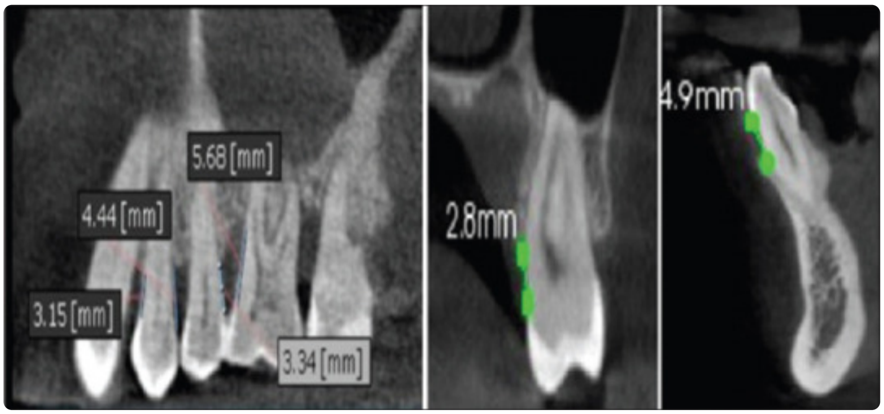
Mesial and distal measurements of lingual side of the defect with placed gutta purcha point on DDR image

Figure 3



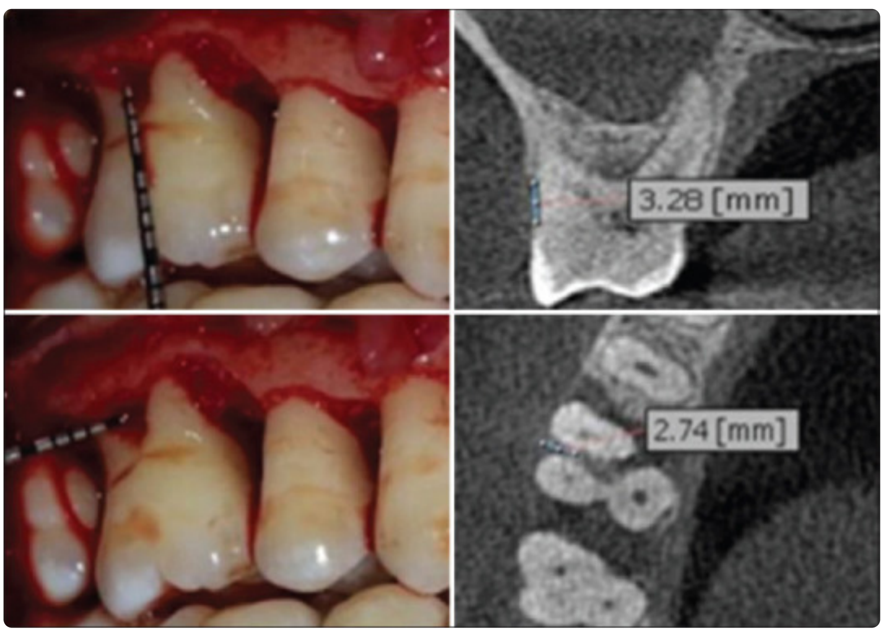
Mesial and distal measurements of the defects of buccal aspect on the panaromic slice of cone-beam computed tomography

Figure 4



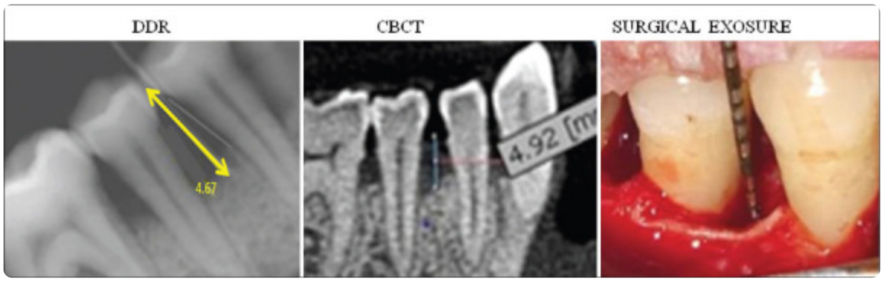
Midbuccal and midlingual measurement of the bone loss on the cross-section slices of cone-beam computed tomography images

Figure 5



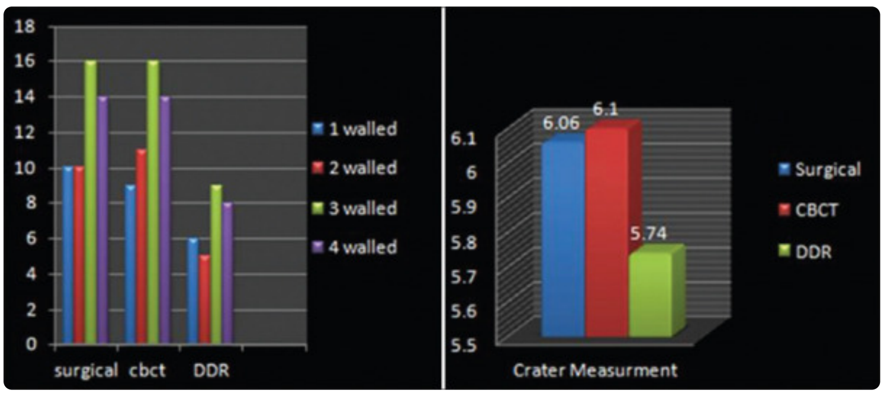
Comparision of verticle and the horizontal bone loss measurement of the furcation involvement on both cone-beam computed tomography image and surgical exposure

Figure 6



Data recordings of defect on three different modalities DDR, cone-beam computed tomography, and surgical exposure

Figure 7



Bar diagram showing comparison of walled defects and osseous craters ratings by three different modalities