Evaluation of Cone Beam Computed Tomography in the Detection of Horizontal Periodontal Bone Defects: An In Vivo Study

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The purpose of this in vivo study was to verify the accuracy of cone beam computed tomography (CBCT) in the measurement of horizontal periodontal bone defects. Six patients with periodontitis were selected, and eight maxillary molars were assessed. A total of 72 measurements were performed. The images were obtained using CBCT, and measurements were performed using the appropriate software. Periodontal bone defects were measured during the surgical intervention using the cementoenamel junction as the reference point. There were no statistically significant differences between clinical and CBCT measurements (P > .05). CBCT accurately reproduced the clinical measurement of horizontal periodontal bone defects. (Int J Periodontics Restorative Dent 2012;32:e162–e168.)

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Periodontal disease is characterized by periods of disease activity in which dental support structures are destroyed by the action of chemical mediators of inflammation followed by periods of latency.[1] This condition is currently considered one of the most prevalent oral diseases affecting the adult population.[2] Progression of periodontal disease causes attachment loss, bone crest resorption, alveolar bone loss, and consequent tooth mobility. These characteristics, associated with the complexity of the disease, grant importance to the use of imaging methods in the detection of such alterations. Further, it is important to use side-by-side clinical and radiographic examinations to obtain a more accurate diagnosis, thus leading to a correct therapeutic choice in the treatment of both the disease and periodontal bone injury.[1]

Radiography plays an important role in periodontal diagnosis, mainly because radiographs can reveal the amount and type of damage caused to the alveolar bone. A more accurate evaluation of alveolar bone height in relation to the cementoenamel junction (CEJ) is the primary benefit of radiologic examination in periodontal diagnosis.[3]

One of the main disadvantages of intraoral radiography is the presence of overlying anatomical structures and the lack of three-dimensional (3D) information. In many cases, radiographs hinder the actual distinction between the cortical vestibular and lingual aspects, making it difficult to obtain an effective evaluation of periodontal bone injury, especially crater defects and furcation involvements.[1] This is most commonly observed when interproximal, periapical, and panoramic radiographs are used to evaluate alveolar bone height. Interproximal radiography has yielded the best results in the evaluation of bone crest height; however, important features of the alveolar bone may go undetected as a result of overlying structures or an unfavorable orientation of the x-ray beam. Only interproximal bone levels can be more accurately detected, even when high-quality images are generated.[3]

Computed tomography (CT) has been explored because of its capacity to perform precise 3D registrations, but this technique has some limitations, such as the amount of radiation exposure and equipment size and cost.[4] Recently, cone beam CT (CBCT) has emerged as a feasible tool in dentistry, providing a lower-cost alternative to conventional CT with high-quality images and lower radiation exposure to patients. However, few studies have analyzed the use of this technique,[4,5] although this imaging method has been largely used in the detection of pathologic conditions and trauma in the maxillofacial area and in the planning of dental implants and surgeries, in addition to the evaluation of the temporomandibular joint in orthodontics.[6]

CBCT generates conic-shaped beams instead of a fan-shaped x-ray beam as with conventional CT, offering several advantages in the evaluation of the maxillofacial area,[7] such as the capacity to obtain a complete skull image in a single 360-degree rotation. In addition, reducing the irradiated area by collimation of the primary x-ray beam to a smaller area of interest provides an approximate 15-fold reduction in the absorbed radiation dose.[8,9]

Recent in vitro studies have shown better precision in the evaluation of bone changes associated with periodontal disease using CBCT when compared to conventional and digital radiography, mainly in the visualization of the vestibular aspects—as well as aspects within furcations—of the alveolar bone.[3,10] Unfortunately, in vivo studies are still scarce. Therefore, the objective of this study was to assess the effectiveness of CBCT in the detection of horizontal periodontal bone defects, determining its quantitative precision in the measurement of alveolar bone height.

Method and materials

This study was approved by the Research Ethics Committee of the University of Fortaleza, Ceará, Brazil (protocol no. 164/09). A total of six patients were selected from the database at the University of Fortaleza School of Dentistry. Although without any systemic alterations, all study patients had advanced periodontal disease requiring surgical periodontal treatment. For standardization purposes, only maxillary molars were assessed, totaling 8 teeth with 12 measurement sites each: 3 on the vestibular aspect, 3 on the palatal aspect, 3 on the mesial aspect, and 3 on the distal aspect (Fig 1). Since 24 sites could not be measured clinically, they were excluded from the study, resulting in 72 measurements. Test or adjacent teeth with restorations or crowns were not included.

CT images were obtained using a cone beam scanner (i-CAT Cone Beam 3D Dental Imaging System, Imaging Science International) with a voxel size of 0.2 mm, which provides a more detailed image. Images were acquired in a single 360-degree rotation around the head of the patient. The standard image-acquisition time was 40 seconds. All images were then stored in DICOM (Digital Imaging Communications in Medicine) file format. Following image acquisition, measurements were made using the measurement tools available in the software within the i-CAT scanner (Xoran CAT v 3.0.1, Xoran

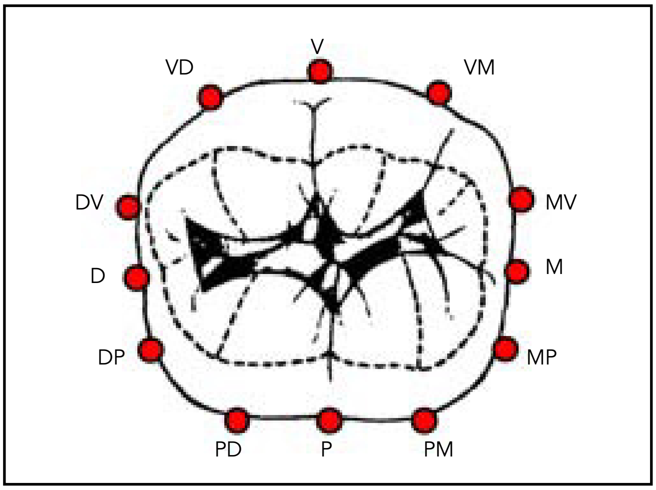


Fig 1 *Measurement sites around the tooth. V = vestibular; VD = vestibular/distal; VM = vestibular/mesial; D = distal; DV = distal/vestibular; DP = distal/palatal; M = mesial; MV = mesial/vestibular; MP = mesial/palatal; P = palatal; PD = palatal/distal; PM = palatal/mesial.*

Fig 2a *CBCT measurements on the mesial and distal aspects.*

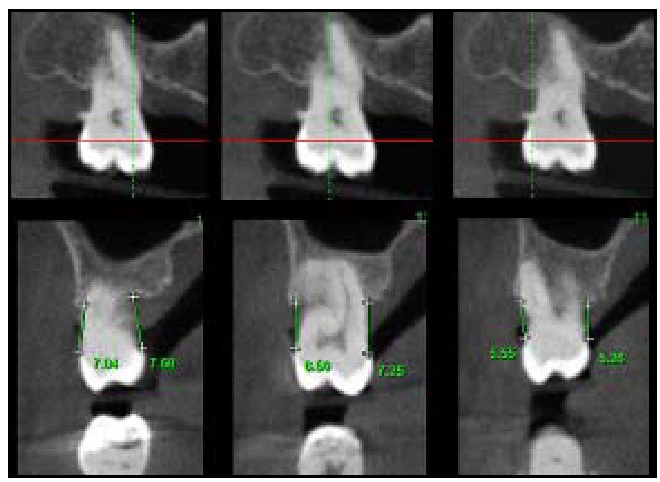
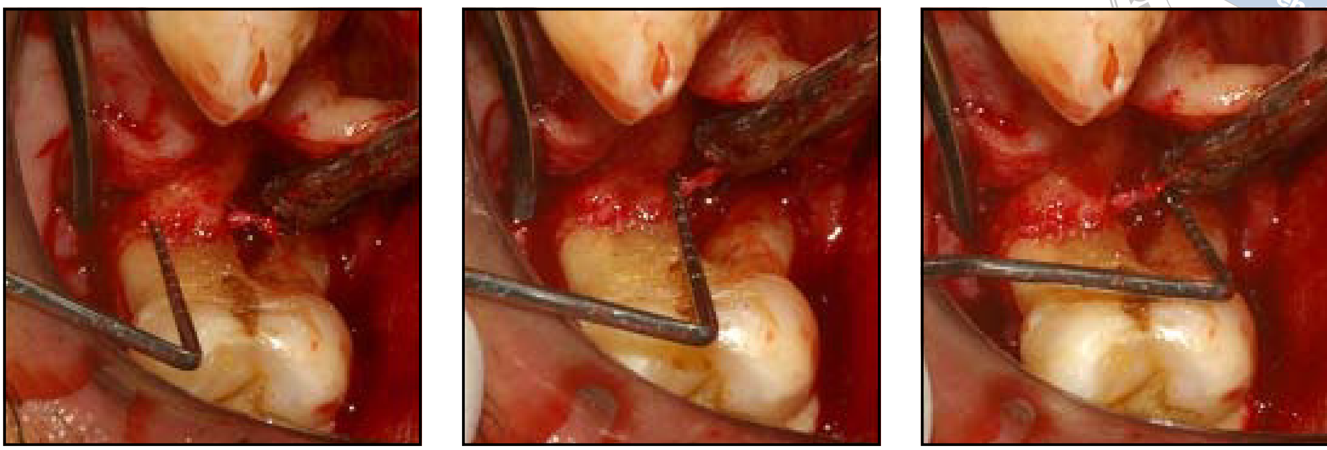


Fig 2b *CBCT measurements on the vestibular and palatal aspects.*

Technologies) (Figs 2a and 2b). The CEJ was used as the reference point. CBCT images were displayed on a computer screen (FlexScan S2000 LCD Monitor, EIZO) with a resolution of 1,024 × 1,200 pixels (32 bits) and read by a single experienced radiologist.

During surgical intervention, the distances between the CEJ and alveolar crest were measured by a single experienced professional using a graduated periodontal probe placed in a line parallel to the long axis of the tooth (Figs 3a to 3c). Measurements falling between two marks of the periodontal probe were rounded up to the nearest millimeter. Similar to the study by Grimard et al,[11] these measurements were considered as the number of sites with defects (n = 72) for statistical analysis.



Figs 3a to 3c *Clinical measurements obtained on the mesial aspect.*

The Wilcoxon test was used to compare clinical and CBCT measurements, and the Mann-Whitney test was used to compare standard errors in the measurement of vestibular/palatal and mesial/distal aspects, both at a level of 5%. Taking into consideration the study design and variability of results, a clinically relevant difference of 0.5 mm, an α error of .05, and a β error of .24 were expected. Thus, the statistical power of this study was 76%.

Results

There was no statistically significant difference between clinical and CBCT measurements (*P* = .639) (Table 1). When mesial and distal aspects were compared, no statistically significant difference was observed between measurements (*P* = .063) (Table 2). However, there was a statistically significant difference in the results concerning the palatal and vestibular aspects (*P* = .008) (Table 3).

Discussion

Many studies have validated the use of CBCT in the planning of implant treatment, in orthodontics, in the study of temporomandibular joint diseases, in the diagnosis of embedded teeth, and in pathologies, but few have analyzed the use of CBCT in periodontal diagnosis. In a recent systematic review of the literature, only 3% of studies reported CBCT imaging in periodontics,[12] and most of these were in vitro.[1,4,6,13,14]

The main advantages of CBCT imaging include good accessibility and easy handling in addition to a real-size data set with multiplanar cross-sectional and 3D reconstructions based on a single scan at low-dose radiation exposure.[12] In a study comparing two measurements of effective dose, dental CBCT was recommended as a dose-sparing technique compared to alternative medical CT scans for oral and maxillofacial radiographic imaging tasks.[15]

Regarding radiation dose, although CBCT appears to be a promising option for periodontal imaging, the image quality achievable with this method depends on the actual dose applied.[16] In this study, a voxel size of 0.2 mm was used, as opposed to 0.4 mm used in the in vitro study by Vandenberghe et al,[10] because a higher dose would provide higher-resolution images in an in vivo study. Although the radiation dose used is well below the conservative limits recommended by the National Council on Radiation Protection and Measurements even at the highest CBCT exposure settings,[17] further studies with a larger sample size should be conducted to determine ideal exposure settings that can optimize the image quality of periodontal defects and further decrease radiation exposure.[10]

Recently, a few in vivo studies have been published concerning periodontal bone height measurements using CBCT, two of which were case reports[18,19] and two of

Table 1 Means ± SDs and medians of clinical and CBCT measurements*

	Mean ± SD	Median (min – max)
Clinical	5.86 ± 1.98	5.50 (3.00–10.00)
CBCT	6.11 ± 2.32	5.50 (2.14–12.58)

SD = standard deviation; min = minimum; max = maximum.
*$P > .05$.

Table 2 Comparison of standard errors between mesial and distal measurements*

	Mean ± SD
Mesial	0.75 ± 0.59
Distal	1.14 ± 0.88

SD = standard deviation.
*$P > .05$.

Table 3 Comparison of standard errors between vestibular and palatal measurements*

	Mean ± SD
Vestibular	0.58 ± 0.39
Palatal	1.29 ± 1.04

SD = standard deviation.
*$P < .05$.

which compared different methods of measuring guided tissue regeneration–treated bone defects and furcation lesions.[11,20] This leaves only a few reports on CBCT accuracy in measuring periodontal defects, and none concerning horizontal bone defects.

Detecting periodontal changes, mainly bone defects surrounding the vestibular aspects of the tooth, remains a challenge for the examiner.[16] This study aimed to evaluate the accuracy of this method in the diagnosis of horizontal periodontal defects, especially in the vestibular and palatal regions where two-dimensional (2D) radiographs may be inappropriate.[16] Although Vandenberghe et al[10] suggested that CBCT should only be used for relatively complex periodontal treatment planning and potential use of dental implants, this system may provide a new tool for periodontal diagnosis, such as in endodontic and periodontal involvement and in the detection of dehiscence and fenestration defects before orthodontic treatment.[16,21]

According to the results obtained, bone defects did not show statistical differences between clinical and CBCT measurements, which is in agreement with other studies.[3,4] Similarly, Misch et al[4] showed that CBCT measurements were as accurate as direct measurements using a periodontal probe in buccal and lingual defects. When compared with CBCT, digital intraoral radiography is still a 2D technique with the limitation of presenting 3D periodontal defects, particularly the buccal and lingual aspects of bone loss.[10]

Although the study by Vandenberghe et al[10] showed that CBCT image measurements of periodontal bone levels were comparable to those by digital intraoral radiography, both techniques under- and overestimated actual linear measurements in a similar way. Conversely, in this study, CBCT measurements overestimated clinical measurements by 0.4 mm. Since a 0.5-mm discrepancy between clinically and radiographically estimated bone levels is considered clinically acceptable,[22,23] CBCT and clinical measurements were similar in this study.

It is worth noting that Vandenberghe et al[10] conducted an in vitro study using human skulls that did not reproduce the ideal clinical situation, such as patient and operator position and visualization problems, in addition to the absence of motion that may cause image degradation.[7] Therefore, comparison between the present results and those obtained in that study must be done carefully. Moreover, gutta-percha fragments were used as indirect reference points for measurements in the case of a faded CEJ, and only one measurement on each side of the tooth was performed. These differences in methodology may explain, at least in part, the conflicting results between studies.

CBCT shows better precision in the detection of periodontal bone loss when compared to conventional periapical and interproximal radiographs of posterior teeth[3]; digital radiography provides better outcomes regarding contrast, bone quality, and details of lamina dura.[10] The difference concerning CBCT diagnostic accuracy between anterior and posterior teeth may be because of the morphologic differences in periodontal bone in these areas, and is also probably a result of difficult visualization during the clinical examination, mainly in the distal aspects.[4,24] Furthermore, clinical measurements were obtained using probes with an accuracy of 1 mm, whereas CBCT measurements allowed an accuracy of up to three decimal places.

CBCT may be a useful and more practical clinical tool for the assessment of periodontal bone changes over time. However, further clinical studies are necessary to establish selection criteria that define the conditions and specific indications for the use of 3D imaging methods in periodontology, thereby aiding in periodontal diagnosis and treatment planning.

Conclusion

CBCT can effectively reproduce the clinical measurement of horizontal periodontal bone defects.

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