ORIGINAL RESEARCH

Comparative Evaluation of Cone Beam Computed Tomography and Surgical Measurements of Periodontal Bone Defects in Periodontitis Patients: An *In Vivo* Study

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Abstract

Aim: The present study aimed to evaluate the accuracy of noninvasive cone beam computed tomography (CBCT) in the estimation of periodontal bone defects and compare it with that of measurements obtained by invasive surgical exploration using open flap debridement procedure for the evaluation of bony topography.

Materials and methods: Bone defects in 384 sites with moderate-to-severe periodontitis from eight patients were considered. Probing depth was measured in the following six sites in the selected teeth: mesiobuccal (MB), mesiopalatal (MP)/mesiolingual (ML), buccal (B), palatal (P)/lingual (L), distobuccal (DB) and distopalatal (DP)/distolingual (DL). The bone defects were measured from CBCT images followed by surgical intervention at all six sites. Data were recorded and statistically analyzed.

Results: There was no significant difference observed between CBCT and surgical intervention. However, surgical intervention was found to have higher mean values than the CBCT measurements. The Pearson correlation showed a significantly positive correlation ($p < 0.05$) between CBCT and surgical intervention in all sites except L/P site. Additionally, there were negative correlations observed for all sites except B and L/P sites; however, these were not statistically significant. Moreover, there were significant differences ($p < 0.05$) observed between anterior and posterior sites measured via CBCT except for the MB site. On the other hand, a comparison between anterior and posterior teeth measured via surgical interventions showed significant differences ($p = 0.0001$) in all measured sites.

Conclusion: A significant correlation has been observed between measurements acquired from CBCT and surgical intervention for the anterior teeth. On the contrary, no significant correlation was observed for the posterior teeth.

Clinical significance: Overlapping and the absence of 3D information are two of traditional radiography's main drawbacks. Surgerical exposure can yield precise information, but it gives less time to plan the kind of periodontal regeneration that will be needed. The accuracy and feasibility of CBCT have been established.

Keywords: Cone beam computed tomography, Periodontal pocket, Periodontitis, Surgical intervention.

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Introduction

The periodontium is a group of specialized tissue that is situated around the teeth and supports the teeth. Oftentimes, periodontal diseases cause tooth loss by affecting the gingiva and the supporting bony structures. People above 30 years of age are more likely to suffer from periodontal diseases which include loss of alveolar bone, mobility of the tooth, and decrease of the clinical attachment level (CAL).[1]

An accurate periodontal examination is crucial for the periodontal treatment planning and prognosis of periodontal diseases. Thus, clinical probing and intraoral radiography were considered the gold standards for diagnosing periodontal disorders in two-dimensional imaging era.[2] Periodontal probing is important as it allows the dentist to locate areas that are previously affected by periodontal disease or at risk for periodontal rupture. Clinical attachment level or the distance from the probe tip to the cemento-enamel junction (CEJ), provides a more accurate picture of periodontal damage than probing depth alone.[3]

The radiographic investigation could give information about the extent of periodontal bone loss and patterns of bone loss that are crucial to the diagnostic process. Periapical, bitewing, and panoramic radiographs are the most often utilized radiographic procedures to supplement periodontal evaluation and diagnosis. Bitewing and periapical radiographs are ideal for two-dimensional (2D) radiographic diagnosis as they are simple to acquire, inexpensive, and provide high-resolution images in digital radiography.[4] Intraoral radiographs on the other hand are

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not accurate in periodontal defect analysis due to the absence of three-dimensional (3D) information on the underlying anatomical structures. The traditional 2D radiographs lack spatial depth and anatomical features and often overlap. Due to this, it is challenging to acquire an accurate periodontal defect assessment, particularly about crater defects and furcation involvements.[5–10]

The only reliable way to estimate the degree of bone loss evaluation is surgical exposure. A surgical re-entry enables measuring the rise in bone height after definitive periodontal therapy.[11] Once the surgery is performed, the region may be accurately assessed by surgical exposure, and the necessary periodontal regeneration could be planned with minimum delay. However, this is an invasive procedure and cannot be routinely carried out unless the benefit outweighs the risk of surgical exploration.[12] In order to resolve this concern and to avoid invasive procedures for the accurate diagnosis of periodontal bone defects, there was a need for a 3D noninvasive tool that could be utilized for accurate bone defect detection and analysis. Cone beam computed tomography (CBCT) is an advanced 3D imaging modality in dentistry that reshaped the periodontal defect diagnosis to a new dimension. Cone beam computed tomography was explored in cases when traditional radiographic evaluation does not provide sufficient data for periodontal treatment.[13–22]

While several studies compared the accuracy of CBCT with 2D radiographs,[23–26] there was a need to compare the findings of CBCT with the accuracy of detection of periodontal bone defects via surgical exploration. This requirement was based on the fact that despite the surgical exploration of periodontal defects being considered accurate, it is an invasive procedure.[18] Moreover, surgical re-entry for measurements of periodontal bone defects is not ethically acceptable if it has no benefit for the patient.[27] Therefore, the present study aimed to evaluate the accuracy of noninvasive CBCT in the estimation of periodontal bone defects and compare it with that of measurements obtained by invasive surgical exploration using open flap debridement (OFD) procedure for the evaluation of bony topography. The null hypothesis of this study is periodontal bone defects analyzed through CBCT and intraoperative surgical measurements have no correlation.

Materials and Methods

This *in vivo* study was conducted in the periodontics clinics of Riyadh Elm University, Riyadh, Kingdom of Saudi Arabia during the year 2021. The ethical clearance was obtained from the ethical community of Riyadh Elm University (FPGRP/2021/575/519/503) and followed the guidelines of the Declaration of Helsinki.

The sample size of the study was calculated using the Raosoft@ software where the margin of error was 5%, the confidence level was 95%, the population size was 15,000, and the response distribution was 50%. The total sample size was estimated at 384 sites of anterior and posterior teeth. Patients with ages ranging from 25 to 55 years and who were suffering from moderate-to-severe chronic periodontitis that indicated surgery and were willing to participate in the study were included in the current study. On the other hand, pregnant and lactating patients, with a history of systemic disease, uses of tobacco, de-generative bone disease, and CBCT images of patients with artifacts were excluded from the study. Written informed consent was obtained from all the patients who were included in this study.

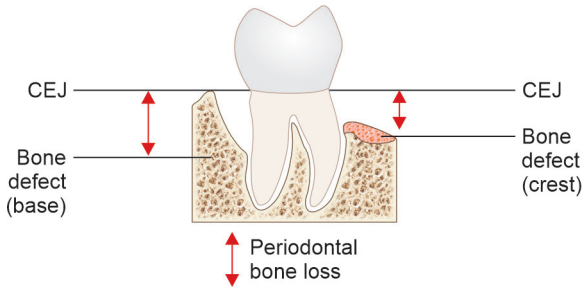

Fig. 1: Reference points for estimation of periodontal bone loss evaluation using CBCT

Clinical examination was performed for all the selected patients. Probing of the patients was carried out using UNC 15 periodontal probe. Probing depth (PD) was calculated by measuring the distance from the CEJ to the base of the pocket along the groove using a UNC-15 periodontal probe. Periodontal charting was done to record the probing measurements in the following six sites in the selected teeth: mesiobuccal (MB), mesiopalatal (MP)/mesiolingual (ML), buccal (B), palatal (P)/lingual (L), distobuccal (DB) and distopalatal (DP)/distolingual (DL).[28]

Cone beam computed tomography imaging was constructed prior to the commencement of direct surgical exploration and measurement of the bone defects. All images were taken from the CBCT imaging system (Sirona Galileos, Germany), with an exposure of 85 kVp, 5–7 mA for 14 seconds. The measurement of the radiographic defect was done using Galileos 3D imaging software (On Demand 1.1 Version).

The bone defects were analyzed from all six sites using CBCT images with the following reference points; distance between the CEJ and the deepest point of the defect bone. The horizontal bone loss was the deepest point of periodontal bone defect in the crest of the alveolar bone from the CEJ and vertical bone loss was considered at the base of the bone defect from the CEJ (Fig. 1).

Prior to surgery, every patient got instructions on maintaining good oral hygiene, controlling plaque, and received full-mouth scaling and root planing. Surgical intraoperative measurements were carried out for six sites. The measurements were recorded using reference points; CEJ to the deepest point of the periodontal bone defect. Each reading was recorded once. After the surgery, it was instructed that the area should not be cleaned with a toothbrush, brush, or toothpick until the stitches are removed. Patients were advised to rinse with chlorhexidine mouthwash twice daily to inhibit bacterial growth until the stitches were removed. The other areas of the mouth must be kept clean in the usual way. The sutures were removed in 10–14 days.

Statistical Analysis

All data were transferred to a Google sheet and statistical analysis was carried out using SPSS software, version 22.0 (IBM Corp, Armonk, New York). The normality of the data were checked with the Kolmogorov–Smirnov test. The independent *t*-test was used to compare the CBCT measurement with surgical intraoperative measurement. The paired *t*-test was performed to compare the anterior and posterior sites in both CBCT and surgical procedures. The Pearson correlation test was used to determine any correlation between CBCT and surgical procedures on six sites. The statistical significance was fixed at 0.05.

Table 1: The comparison of CBCT and surgical intervention for the anterior teeth

Site (anterior teeth)	*Methods*	*Mean*	*SD*	*p*
MB	CBCT	4.39	1.99	1.000
	Surgical	4.39	2.02	
B	CBCT	3.35	1.84	0.323
	Surgical	3.37	1.89	
DB	CBCT	3.35	1.84	0.160
	Surgical	3.37	1.89	
DP/DL	CBCT	4.30	2.09	0.570
	Surgical	4.32	2.11	
L/P	CBCT	3.88	2.42	1.000
	Surgical	3.88	2.42	
MP/ML	CBCT	4.44	1.91	0.421
	Surgical	4.49	1.91	

B, buccal; CBCT, cone beam computed tomography; DB, distobuccal; DL, distolingual; DP, distopalatal; L, lingual; MB, mesiobuccal; ML, mesiolingual; MP, mesiopalatal; P, palatal; *p*, *p*-value; SD, standard deviation

Table 2: Pearson's correlation test for all sites of anterior teeth

Site (anterior teeth)	*Methods*	*Correlation (r)*	*p*
MB	CBCT	0.994	0.0001*
	Surgical		
B	CBCT	0.997	0.0001*
	Surgical		
DB	CBCT	0.996	0.0001*
	Surgical		
DP/DL	CBCT	0.992	0.0001*
	Surgical		
L/P	CBCT	1.000	1.000
	Surgical		
MP/ML	CBCT	0.981	0.0001*
	Surgical		

*Statistically significant. B, buccal; CBCT, cone beam computed tomography; DB, distobuccal; DL, distolingual; DP, distopalatal; L, lingual; MB, mesiobuccal; ML, mesiolingual; MP, mesiopalatal; P, palatal; *p*, *p*-value; SD, standard deviation

Results

This study examined 384 sites for the evaluation of 112 teeth from a total of eight patients, of which a total of 38.3% were anterior teeth ($n = 43$) and 61.70% were posterior teeth ($n = 69$). A total of 34% ($n = 15$) and 66% ($n = 28$) of the anterior teeth were examined from male and female patients, respectively. Whereas a total of 56.9% ($n = 39$) of the posterior teeth were examined from male patients and 43.1% ($n = 30$) from females. Kolmogorov–Smirnov test showed that the data were normally distributed; therefore, the parametric tests were applied.

Comparison of CBCT Readings and Surgical Intervention in Anterior Teeth Sites

While the periodontal bone loss was compared between CBCT and surgical intervention, the independent *t*-test showed no significant difference ($p > 0.05$) between the two interventions in the anterior teeth (Table 1). However, surgical intervention was found to have higher mean values than the CBCT (Table 1).

The Pearson correlation showed a significantly strong correlation ($p < 0.05$) between CBCT and surgical intervention in all sites except L/P site ($p = 1.000$) (Table 2).

Comparison of CBCT and Surgical Intervention in the Posterior Site

While the periodontal bone loss was compared between CBCT and surgical intervention, the independent *t*-test showed no significant difference ($p > 0.05$) between the two interventions in the posterior teeth (Table 3). However, surgical intervention was found to have higher mean values than the CBCT in all sites except the buccal site (Table 3).

There were negative correlations observed for all sites except B and L/P sites; however, these were not statistically significant ($p > 0.05$) (Table 4).

Moreover, the paired *t*-test of anterior and posterior sites showed there were significant differences ($p < 0.05$) observed in all sites which were measured via CBCT except the MB site ($p = 0.078$). On the other hand, a comparison between anterior and posterior teeth measured via surgical interventions showed significant differences ($p = 0.0001$) in all measured sites (Table 5).

Table 3: The comparison of CBCT and surgical intervention for the posterior teeth

Site (posterior teeth)	*Methods*	*Mean*	*SD*	*p*
MB	CBCT	4.79	1.99	0.109
	Surgical	4.88	1.96	
B	CBCT	4.07	1.95	0.125
	Surgical	4.06	1.97	
DB	CBCT	5.46	2.01	0.092
	Surgical	5.49	1.83	
DP/DL	CBCT	5.90	2.20	0.703
	Surgical	5.97	2.16	
L/P	CBCT	5.10	2.62	0.754
	Surgical	5.16	2.62	
MP/ML	CBCT	5.33	2.27	0.441
	Surgical	4.49	1.91	

*Statistically significant. B, buccal; CBCT, cone beam computed tomography; DB, distobuccal; DL, distolingual; DP, distopalatal; L, lingual; MB, mesiobuccal; ML, mesiolingual; MP, mesiopalatal; P, palatal; *p*, *p*-value; SD, standard deviation

The inference of the present study includes that when comparing the accuracy of assessing periodontal bone abnormalities, CBCT and surgical intervention did not significantly differ in this study's findings. But there was a strong positive correlation for the anterior teeth between measurements obtained from CBCT and surgical intervention.

Discussion

In general, periodontal defects are evaluated by clinical probing and 2D radiographic analysis. However, both methods have limitations due to the lack of 3D details of the periodontal bone defects.[10,13] With the introduction of CBCT in dental practice, the periodontal bone defects analysis gained a new dimension of evaluation leading to improved diagnostic and therapeutic planning of

Table 4: Pearson's correlation test for all sites of posterior teeth

Site (posterior teeth)	*Methods*	*Correlation (r)*	*p*
MB	CBCT	−0.069	0.672
	Surgical		
B	CBCT	0.266	0.098
	Surgical		
DB	CBCT	−0.148	0.362
	Surgical		
DP/DL	CBCT	−0.306	0.055
	Surgical		
L/P	CBCT	0.076	0.642
	Surgical		
MP/ML	CBCT	−0.164	0.313
	Surgical		

B, buccal; CBCT, cone beam computed tomography; DB, distobuccal; DL, distolingual; DP, distopalatal; L, lingual; MB, mesiobuccal; ML, mesiolingual; MP, mesiopalatal; P, palatal; *p*, *p*-value; SD, standard deviation

Table 5: Comparison between anterior and posterior teeth with CBCT and surgical interventions

	CBCT			*Surgical intervention*		
Sites	*Anterior*	*Posterior*	*p*	*Anterior*	*Posterior*	*p*
MB	4.39	4.78	0.078	4.39	4.88	0.0001*
B	3.35	4.07	0.008*	3.37	4.06	0.0001*
DB	4.35	5.46	0.0001*	4.39	5.49	0.0001*
DP/DL	4.30	5.90	0.0001*	4.32	5.97	0.0001*
L/P	3.88	5.10	0.003*	3.88	5.16	0.0001*
MP/ML	4.44	5.31	0.004*	4.49	5.33	0.0001*

*Statistically significant. B, buccal; CBCT, cone beam computed tomography; DB, distobuccal; DL, distolingual; DP, distopalatal; L, lingual; MB, mesiobuccal; ML, mesiolingual; MP, mesiopalatal; P, palatal; *p*, *p*-value; SD, standard deviation

periodontal disorders.[29] The 3D accessibility and accuracy of CBCT make it possible to examine even the most inaccessible anatomical structures, such as the distal surfaces of posterior teeth, before any invasive surgical procedure.[30,31] CBCT has thus appeared as a new standard method for detecting bone density and bone volume of periodontal bone defects. However, the most accurate periodontal bone defect evaluation was studied to be intraoperative surgical measurements.[28,32] Despite its accuracy in periodontal bone defect detection, surgical evaluation of periodontal defects before diagnosis or post-treatment evaluation of periodontal bone defects is an invasive process. Hence, it is important to evaluate whether the CBCT analysis of these periodontal bone defects is comparable to the intraoperative surgical measurements. The current study was conducted to determine the accuracy of radiographic periodontal bone defects measured by CBCT in comparison to OFD surgical measurements.

The present study revealed a significant correlation in MB, B, DB, DP/DL, and MP/ML ($p < 0.005$) sites in the anterior teeth. The results for the P/L and DB sites were similar to the findings of the study by Pitale et al.[27] The morphologic changes in the periodontal bone between L and MP/ML sites of anterior and posterior teeth, especially in the distal portions, contribute to the significant difference in CBCT diagnostic accuracy between the two regions. In addition, 1 mm accurate probe was used in clinical settings, whereas CBCT readings might be accurate to three decimal places.[19] No statistically significant differences were observed among the values of CBCT and surgery in the anterior area, which was similar to the previous studies.[8,14]

The current study also revealed a statistically significant positive correlation between CBCT and surgical method when measuring all anterior sites except L/P, which is similar to the findings of the study by Pitale et al.[27] However, no significant correlation was observed in the posterior sites between CBCT and the surgical method of measurement, which was contrary to what was reported by Walter C et al.[31] This might be due to the morphologic changes that occur in the periodontal bone.[19]

According to the results obtained, bone defects did not show statistical differences between clinical and CBCT measurements, which agrees with other studies.[31–37] Similarly, Misch et al.[18] 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.

Moreover, there was a statistically significant positive correlation between CBCT and surgical intervention when measured for the anterior teeth. When these findings were compared with Pitale et al.,[27] similar results were observed for the anterior teeth. However, there was no statistically significant positive correlation for the posterior teeth, in contrast to the findings of the study by Pitale et al.[27] This might be attributed to the difference in the morphological characteristics between anterior and posterior teeth including multiple roots, tooth size, and pattern of bone defects.

In Eskandarlo A et al.[11] study compared the accuracy of CBCT in assessing periodontal abnormalities with the intraoral radiographs and probing techniques which showed that compared with clinical probing and conventional radiographs, CBCT had a smaller mean difference. All three techniques were reliable for spotting periodontal problems. However, in comparison to traditional methods like probing and conventional radiography, the CBCT approach yielded the most accurate measurements of periodontal abnormalities.[11,33–35]

Cone beam computed tomography has shown promising results when performing measurements in periodontal diagnosis. Complicated cases in periodontology could be diagnosed successfully using this 3D technology.[30,36] A high accuracy (80–84%) of CBCT measurements compared with intra-surgical findings of periodontal diagnosis was observed in several studies.[23,37,38] Banodkar et al.[21] supported the use of CBCT and also emphasized that the method should only be used when it provides crucial information that could not be provided by other radiographic methods using a lower radiation dose. It might be employed as a complementary imaging approach when conventional 2D methods fail to provide enough accurate information for periodontal evaluation and therapy due to its submillimeter resolution that permits the non-orthogonal sectioning of the generated data sets. The results of this study rejected the null hypothesis, as there was a statistically significant correlation achieved in the anterior teeth as well as there was no significant difference between the bone defect evaluations using CBCT and direct surgical measurement.

The current study possesses a few limitations, which include access to the patients and finding the exact match of cases.

Moreover, the grading of the severity of the periodontal condition was not included. The morphological difference between the anterior and posterior teeth impersonated difference in evaluations. In addition to this, the study did not segregate the patterns of bone defects. Future studies could be designed with the inclusion of a grading method for periodontal disease severity, which could help overcome the limitations of this study. Moreover, a new classification could be postulated using CBCT for the evaluation of bone defects in the future.

Conclusion

The present study did not find significant differences between CBCT and surgical intervention to assess the accuracy of measuring periodontal bone defects. However, a significant positive correlation between measurements acquired from CBCT and surgical intervention, for the anterior teeth was exhibited. On the contrary, no significant correlation was observed for the posterior teeth. From the results of the study, CBCT could be recommended to be used successfully to perform periodontal bone defect analysis the diagnosis and treatment planning purposes as compared with direct surgical evaluation.

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