Comparative evaluation of the precision of cone-beam computed tomography and surgical intervention in the determination of periodontal bone defects: A clinicoradiographic study

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Abstract:
Context: Major limitations of conventional radiography are overlapping and lack of 3D information. Surgical exposure, though being able to provide accurate information, provides very little time to plan-out the type of periodontal regeneration required during surgery. Cone Beam Computed Tomography (CBCT) has emerged as a feasible tool and found to be accurate. Unfortunately, in-vivo studies are still scarce. Aim: Aim of the present study was to assess the efficacy of CBCT in the detection of periodontal bony defects while determining its quantitative precision in the measurement of alveolar bone height as against the open flap debridement (OFD) procedure which is set as the gold standard. Setting and Design: Present study is a cross-sectional study. Materials and Methods: The present study includes patients with Chronic Periodontitis indicated for periodontal surgeries. Bone defects were measured with the help of CBCT and with William's periodontal probe during surgical intervention and compared. Statistical Analysis: Measurements were compared with Student’s t-test; unpaired t-test & correlation were tested with Pearson’s correlation coefficient test. P < 0.05 was considered statistically significant. Results: The mean CBCT & surgical value of palatal/lingual & distal sites of anterior teeth showed statistically significant difference (P = 0.001). All the values for posterior teeth were statistically non-significant. Conclusion: Statistically CBCT & clinical measurement with OFD have similar potential of accuracy to access the bony topography but CBCT provides good accessibility to visualize the sites which are difficult to access during surgical interventions like palatal sites & the distal sites of the posterior teeth.

Key words: Alveolar bone height, chronic periodontitis, cone-beam computed tomography, periodontal bone defects, UNC 15 periodontal probe

INTRODUCTION

Periodontal disease causes attachment loss, alveolar bone loss, and consequent tooth mobility.[1,2] Radiographs play an important role in diagnosis because they can reveal the amount and type of damage. One major limitation of conventional radiography is the presence of considerable overlapping of the anatomical structures and lack of three-dimensional information.[3,4] In a plethora of situations, this becomes an actual hindrance in distinction between the buccal and palatal/lingual cortical aspects, making it difficult to obtain an effective evaluation, especially the crater defects and furcation involvements.[5,6] This is most commonly observed when periapical, interproximal, and panoramic radiographs are used to evaluate the alveolar bone architecture.

Thus, precision of the defect or hidden pathology cannot be ascertained, for which surgical exposure has been the only means to...
accurately detect the extent of the bone loss, as well as to evaluate the gain in bone height after a definitive periodontal treatment.\cite{10} Surgical exposure, though provides accurate information of the area, gives very little time to plan out for periodontal regeneration required. Recently, cone-beam computed tomography (CBCT) has emerged as a feasible tool in dentistry, providing a lower cost alternative to the conventional computed tomography (CT) with high-quality images and lower radiation exposure to the patients.\cite{11,12} For the detection of smallest periodontal osseous defects, CBCT can display the image in all its three dimensions by removing the interfering anatomical structures and making it possible to evaluate each root and surrounding bone.\cite{13-18} CBCT is found to be as accurate as direct measurements using a periodontal probe and as reliable as intraoral periapical radiograph for the detection of interproximal areas, which are considered to be the highest of the resolution till date. Recent in vitro studies have shown better precision in the evaluation of bony changes associated with periodontal disease using CBCT when compared to the conventional and digital radiography,\cite{19,20} but there are scarcity of in vivo studies. Therefore, the aim of the present study was to assess the efficacy of CBCT in detection of periodontal bony defects in chronic periodontitis patients and compare it with the open flap debridement procedure which is the gold standard for the evaluation of bone topography.

**MATERIALS AND METHODS**

This study was designed as a cross-sectional study and patients were selected from the outpatient department. In inclusion criteria, the individuals between 25 and 55 years of age with moderate-to-severe chronic periodontitis which were indicated for surgery and with no history of systemic disease and tobacco use were included. All the individuals were clinically and radiographically evaluated as a routine diagnostic procedure with the exclusion criteria of pregnant and lactating females. In the present study, 12 patients with 12 teeth (6 anterior and 6 posterior) each were selected, and thus, a total of 144 teeth with chronic periodontitis were selected. For anterior teeth, 12 patients were considered with six teeth and eight sites as shown in Figure 1. The number of sites calculated was 12 patients × 6 teeth × 8 sites = 576. For posterior teeth, 12 patients were considered with six teeth and 12 sites as shown in Figure 2. The number of sites calculated was 12 patients × 6 teeth × 12 sites = 864. Hence, the total sites calculated as: anterior sites (576) + posterior sites (864) = 1440, which are shown in Tables 1 and 2. Presurgically, each patient received an initial full-mouth scaling and root planing, oral hygiene, and plaque control instructions. Once the patients showed plaque proficiency up to the mark, then surgeries were initiated. CBCT images were acquired for the same area of interest in a single 360° rotation around the head of the patient. The standard image-acquisition time was 36 s in which the patient received pulsed radiation. All images were then stored in Digital Imaging Communications in Medicine file format. Following image acquisition, measurements were made using the proprietary NNT software (Version 5.4, cefla dental group, newton GiANO, Italy) integrated with Newton-Giano CBCT equipment which has multiple adjustable field of views. The data were acquired with an image size of 400 × 400 × 400, voltage of 90 kV, voxel size of 400 µm, and current of 10 mA. The examiner underwent training for performing the measurements. The CBCT measurements were performed with the same pattern as clinical measurements of sites. In case of horizontal defects, distance between cementoenamel junction (CEJ) and alveolar crest was measured, and in case of vertical defects, the distance between CEJ and the base of the defect was measured. The viewer software accuracy was 0.2 mm. Informed consent was signed by every subject who fulfilled the inclusion criteria and agreed to participate voluntarily, after thorough explanation of the nature, risk, and benefit of the clinical investigations and associated procedure. The University Ethical Committee approved the consent form and experimental protocol (IEC No: IEC/MDCRC/2013–14/0106).

**Surgical procedure**

During the surgical intervention, periodontal osseous defects were measured with the help of UNC 15 periodontal probe to the nearest millimeter from the CEJ to the deepest level of the bony defect, which is considered as the “gold standard” in literature.\cite{21,22} Assessment of depth of the bony defect was measured during the surgical procedure in the same region where CBCT measurements were evaluated (Figures 3a, b and 4a-d).

**Postoperative care**

All the patients were instructed to rinse with 10 ml 0.2% chlorhexidine twice daily till 2 weeks postoperatively. Periodontal dressing and sutures were removed postoperatively after 7 days.

**Table 1**: Eight sites selected in anterior teeth for evaluation

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| B | BD | BM | D | M | P | PD | PM |
| Buccal | Buccal/Distal | Buccal/Mesial | Distal | Mesial | Palatal | Palatal/Distal | Palatal/Mesial |
| Buccal: Mean of B, BD, BM | Distal | Mesial | Palatal: Mean of P, PD, PM |

In anterior teeth, 4 mean values were considered for statistical analysis from measurement of 8 sites

**Table 2**: Twelve sites selected in posterior teeth for evaluation

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B | BD | BM | D | DB | DP | M | MB | MP | L | LD | LM |
| Buccal | Buccal/Distal | Buccal/Mesial | Distal | Distal/Buccal | Distal/Palatal | Mesial | Mesial/Buccal | Mesial/Palatal | Lingual | Lingual/Distal | Lingual/Mesial |
| Buccal: Mean of B, BD, BM | Distal: Mean of D, DB, DP | Mesial: Mean of M, MB, MP | Lingual: Mean of L, LD, LM |

In posterior teeth, 4 mean values were considered for statistical analysis from measurement of 12 sites
Statistical analysis
Clinical and CBCT measurements were compared in each anterior and posterior tooth with the help of Student’s paired t-test. If $P \geq 0.05$, the difference observed was considered statistically insignificant, and if $P \leq 0.05$, it was considered significant. Pearson’s correlation coefficient ($\rho$) test was used to test correlation. Unpaired $t$-test was used to compare the data in the same measurement method.

RESULTS

All 144 teeth sites were measured and the mean of each site was calculated which comes as four sites (mean of 8 sites) in anterior and four sites (mean of 12 sites) in posterior as shown in Tables 1 and 2 which is according to Figures 1 and 2.

Descriptive values for anterior tooth
1. Buccal sites – The mean CBCT value was 4.156 mm and mean surgical value was 4.195 mm. The mean difference was statistically nonsignificant ($P = 0.171$) [Tables 3-5 and Graph 1]
2. Palatal/lingual sites – The mean CBCT value was 4.044 mm and mean surgical value was 4.182 mm. The mean difference was statistically significant ($P = 0.001$) [Tables 3, 4 and Graph 2]
3. Mesial sites – The mean CBCT value was 4.1547 mm and mean surgical value was 4.1982 mm. The mean difference was statistically nonsignificant ($P = 0.775$) [Tables 3, 4 and Graph 3]
4. Distal sites – The mean CBCT value was 3.3667 mm and mean surgical value was 3.5217 mm. The mean difference was statistically significant ($P = 0.001$) [Tables 3, 4 and Graph 4].

All the measurements were found to be in correlation with each other.

Descriptive values for posterior teeth
1. Buccal sites – The mean CBCT value was 6.0565 mm and mean surgical value was 5.9833 mm. The mean difference was statistically nonsignificant ($P = 0.150$) [Tables 6-8 and Graph 5]

Table 3: Mean and standard deviation values of anterior teeth measured through cone-beam computed tomography and surgical intervention

| Site (anterior) | Method  | Mean   | SD     | SE    |
|----------------|---------|--------|--------|-------|
| Buccal         | Surgical| 4.1950 | 1.84685| 0.13766|
| Palatal/lingual| Surgical| 4.1822 | 1.93478| 0.14421|
| Mesial         | Surgical| 4.1982 | 2.10894| 0.14820|
| Distal         | Surgical| 3.5217 | 1.31717| 0.17005|

SD – Standard deviation; SE – Standard error, CBCT – Cone-beam computed tomography; Surgical – Surgical intervention

Table 4: Mean and standard deviation values of posterior teeth measured through cone-beam computed tomography and surgical intervention

| Site (anterior) | Method  | Mean   | SD     | SE    |
|----------------|---------|--------|--------|-------|
| Buccal         | Surgical| 6.0565 | 1.92259| 0.14330|
| Palatal/lingual| Surgical| 5.9833 | 2.12341| 0.27413|
| Mesial         | Surgical| 5.9833 | 1.35255| 0.17461|
| Distal         | Surgical| 3.3667 | 1.31717| 0.17005|

SD – Standard deviation; SE – Standard error, CBCT – Cone-beam computed tomography; Surgical – Surgical intervention
2. Palatal/lingual sites – The mean CBCT value was 6.1111 mm and mean surgical value was 6.1556 mm. The mean difference was statistically nonsignificant ($P = 0.405$) [Tables 6, 7 and Graph 6]

3. Mesial sites – The mean CBCT value was 5.6956 mm and mean surgical value was 5.6444 mm. The mean difference was statistically nonsignificant ($P = 0.192$) [Tables 6, 7 and Graph 7]

4. Distal sites – The mean CBCT value was 6.0867 mm and mean surgical value was 6.0389 mm. The mean difference was statistically nonsignificant ($P = 0.731$) [Tables 6, 7 and Graph 8].

**Anterior teeth**

1. CBCT measurements – The mean difference for buccal and palatal/lingual sites was 0.446 mm which was nonsignificant. The mean difference for mesial and distal sites was 0.829 mm which was nonsignificant ($P > 0.05$) [Table 9]

2. Surgical measurement – The mean difference for buccal and palatal/lingual sites was 0.444 mm which was nonsignificant. The mean difference for mesial and distal sites was 0.723 mm which was nonsignificant ($P > 0.05$).

**Posterior teeth**

1. CBCT measurement – The mean difference for buccal and palatal/lingual sites was 0.806 mm which was nonsignificant. The mean difference for mesial and distal sites was 0.446 mm which was nonsignificant ($P > 0.05$) [Table 9]

2. Surgical measurement – The mean difference for buccal and palatal/lingual teeth was 0.360 mm which was nonsignificant. The mean difference for mesial and distal sites was 0.043 mm which was significant ($P \leq 0.05$).

**DISCUSSION**

CBCT has opened a new vista in maxillofacial imaging facilitating transition of diagnostics from two-dimensional
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...to three-dimensional imaging and having the potential to expand the role of dental imaging from mere diagnosis to image guidance of surgical procedures. Numerous studies have validated the use of CBCT for planning of implants, in diagnosis of embedded teeth, in orthodontics and numerous pathologies,\(^{[16,21-39]}\) however, very few have analyzed the need of CBCT in periodontal diagnosis, regeneration, and treatment planning. Recently, \emph{in vivo} studies have been published concerning periodontal bone height measurements using CBCT. This leaves only a few reports on the accuracy of CBCT in measuring periodontal defects while almost none of them concerning horizontal bone defects.\(^{[7,8,15,36]}\) The main advantages of CBCT include good accessibility and easy handling in addition to a real-size data set.\(^{[40,41]}\) Although Vandenberghe \emph{et al.}\(^{[19]}\) suggested CBCT to be used only for relatively complex periodontal treatment planning and potential use of dental implants, this imaging modality may provide a new tool for diagnosis of various bony defects, interdisciplinary approach to treatment planning such as in case of periodontal–endodontic lesions and in the detection of dehiscence and fenestration defects before initializing the orthodontic treatments.

This present study had given us the clear idea about the precision of CBCT measurement and its status. The analysis of anterior teeth concluded that the mean difference for both the methods made for mesial and buccal surfaces was more precise in surgical intervention than CBCT analysis [Table 3], but it was statistically nonsignificant with \(P = 0.171\) and \(0.775\), respectively. For palatal/lingual surface \((P = 0.001)\) and distal surface \((P = 0.001)\), the mean difference for both the methods was found statistically significant [Table 4]. The said results were found to be correlated with the results obtained in the study conducted by Mol and Balasundaram,\(^{[40]}\) who found less accuracy in the measurement of buccal bone defects in the anterior region of mandible in comparison with the posterior region on images with the New Tom 9000 Scanner. Furthermore, using helical CT, Fuhrmann \emph{et al.}\(^{[8]}\) found that

### Table 5: Pearson’s correlation test for all sites of anterior teeth and the significance status of sites

| Site (anterior) | Method      | Correlation (Z) | \(P\)   |
|----------------|-------------|-----------------|---------|
| Buccal         | Surgical    | 0.980           | <0.001**|
|                | CBCT        |                 |         |
| Palatal/lingual| Surgical    | 0.964           | <0.001**|
|                | CBCT        |                 |         |
| Mesial         | Surgical    | 0.956           | <0.001**|
|                | CBCT        |                 |         |
| Distal         | Surgical    | 0.968           | <0.001**|
|                | CBCT        |                 |         |

\(^{**}\text{Highly statistically significant; } P \leq 0.05 – \text{Considered statistically significant,}\)\(^{*}\text{P} \leq 0.01 – \text{Highly statistically significant. CBCT – Cone-beam computed tomography; } P – \text{Probability value, } Z – \text{Pearson’s correlation coefficient, Surgical – Surgical intervention}\)
For posterior teeth, the mean difference of the buccal surface (P = 0.150) and palatal/lingual surface (P = 0.405) was statistically nonsignificant. Mesial and distal surface (P = 0.192 and P = 0.731) was also found statistically nonsignificant. The results obtained were in concordance with the results of the previous studies conducted by de Faria et al.,[7] Grimard et al.,[10] and Feijo et al.[18] The difference in the diagnostic accuracy of CBCT in the anterior and posterior teeth is likely the result of the difference in the morphology of the periodontal bone in each region. The lingual plates are considerably thinner in the anterior region and tapers toward the alveolar crest than in the posterior teeth. A thinner bone plate has low image resolution decreasing the precision of linear measurements in case of anterior teeth. Similar to the present study, Misch et al.[16] showed that CBCT analysis was as accurate as direct measurement using a periodontal probe during surgical intervention. However, within same analytical parameters, when unpaired t-test was applied, it was found that there was a significant difference between the mesial and distal sites in posterior teeth in the measurements made during surgical intervention. This difference can be explained by the fact that the distal site accessibility is difficult while performing periodontal surgeries, especially in case of molars while instrumentation as well as for measurements attempted with the help of standard periodontal probing. On the contrary, CBCT provides good accessibility to visualize the sites which are difficult to access during surgical interventions, clinically including the distal sites of posterior teeth. Similarly, Feijo et al.[18] showed that a clinical measurement gives accuracy up to 1 mm whereas CBCT measurements allowed an accuracy of up to three decimal places. Ideally, 0.5 mm discrepancy between clinical and radiographical estimated bone levels is accepted. Smaller or larger errors in locating the CEJ and crestal levels can, respectively, lead to over- and under-estimation of disease. Because of the limitations of surgical re-entry to evaluate regenerative outcomes, different radiographic techniques such as intraoral radiographs, digital subtraction radiography, and computer-assisted densitometric image analysis have been used as surrogate methods.[40] However, these techniques are difficult to standardize from two different time points and having limitation to assess three-dimensional morphologic changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes. Hence, this present study gave us a view that the results of surgical intervention and CBCT give similar value changes.
CONCLUSION

This present study compares CBCT analysis and surgical intervention method and concluded having similar potential of accuracy to access the bony topography in both the measurement methods. However, the diagnostic accuracy of CBCT is lesser for anterior teeth as compared to the posterior teeth due to thinner buccal/lingual cortical plates. The quality of the CBCT image slices is insufficient to resolve the alveolar crest reliably in the anterior region. However, CBCT having better accessibility and precision to visualize any area of interest, which is difficult to access during surgical intervention like distal surface of posterior teeth. The bone density/volume can be detected with supremacy by CBCT. It gives benefit to plan the treatment for better prognosis and its outcome, by avoiding surgical re-entry to evaluate postoperative regeneration precisely and help to improve futuristic approach.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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