Current Oral Health Reports (2020) 7:376–380
https://doi.org/10.1007/s40496-020-00283-1

CLINICAL PERIODONTICS (P STATHOPOULOU, SECTION EDITOR)

Cone-Beam Computed Tomography (CBCT) Imaging for the Assessment of Periodontal Disease

Saulo L. Sousa Melo[1] · Karla Rovaris[2] · Aria Mirzazadeh Javaheri[3] · Gabriella L. de Rezende Barbosa[4]

Accepted: 24 October 2020 / Published online: 3 November 2020

Abstract

Purpose of Review Cone-beam computed tomography (CBCT) imaging has become a significant imaging modality in periodontology, and its applications to dentoalveolar disease and conditions are frequently updated. This review highlighted some of the current evidence of the use of CBCT scans for imaging the most common conditions related to periodontal diseases.

Recent Findings CBCT imaging should not be the first choice for the routine assessment of vertical or horizontal bone loss, and its use should be preferable for cases where clinical information and conventional 2D images are insufficient or unclear for diagnosis and treatment decision. On the other hand, the use of CBCT appears to be prudent for an accurate diagnosis of furcation defects in patients with advanced periodontal disease, and in cases where dehiscence and fenestration are suspected. Should volumetric evaluation of those periodontal bone defects be required, it is important to use small voxel sizes for a more accurate measurement.

Summary CBCT exams provide little additional benefit in the decision-making and disease managing in most cases of periodontal disease, being advocated only on patient-specific situations involving more complex conditions such as alveolar defects with intricate morphology, dehiscence, and fenestration.

Keywords Cone-beam computed tomography · Periodontal disease · Periodontal bone loss · Furcation defects · Dehiscence · Fenestration

Introduction

Periodontitis is a primary cause of tooth loss and a potential risk factor for several systemic conditions [1]. It is characterized by an inflammatory response in the periodontal tissues to bacterial toxins from the biofilm. These inflammatory mediators are then responsible for the injury of supporting tissues (i.e., alveolar process and soft tissue) that, once damaged, cannot provide proper support, causing loosening of teeth to the point of exfoliation.

The amount of periodontal bone support is an important factor for determination of periodontal diagnosis, prognosis, and treatment [2]. A thorough clinical examination is essential but in the absence of radiographic data, it may not allow an accurate assessment of the supporting bone. For that reason, imaging exams are considered the standard of care whenever a clinical diagnosis of periodontitis is considered. Given the variety of imaging methods available (such as film-based intraoral radiographs, digital intraoral radiographs, panoramic radiograph, and 3D imaging), one should be aware that limitations of the chosen diagnostic tool may lead to inaccurate prognosis and potential execution of inappropriate treatment or even overtreatment [3••].

Intraoral radiographs, specifically periapical and bitewing images, are frequently used for periodontal assessment of those patients with clinical evidence of periodontal destruction. However, two-dimensional (2D) imaging is known for

This article is part of the Topical Collection on *Clinical Periodontics*

✉ Saulo L. Sousa Melo
sousamel@ohsu.edu

1 Department of Integrative Biomedical and Diagnostic Sciences, Oregon Health and Science University School of Dentistry, 2730 S Moody Ave SD-RAD, Portland, OR 97201-5042, USA

2 Department of Pathology and Clinical Dentistry, Federal University of Piaui School of Dentistry, Teresina, Brazil

3 Oregon Health and Science University School of Dentistry, Portland, OR, USA

4 Area of Oral Diagnosis, Federal University of Uberlandia School of Dentistry, Uberlandia, Brazil

its inherent overlapping of structures and inaccuracy on facial-lingual visualization of the structures. In this sense, for periodontal assessments, intraoral radiographs provide limited information, especially regarding the severity of periodontitis as only the height and the mesio-distal width of bone defects can be measured [3••, 4].

Nowadays, it is possible to overcome these limitations by assessing the maxillofacial complex three-dimensionally (3D) by cone-beam computed tomography (CBCT) images. Its application for imaging evaluation of regional anatomy in the management of a diverse range of oral conditions is well known and broadly accepted. That includes the potential to gather accurate diagnostic and qualitative information regarding the alveolar bone loss, intrabony lesions, cortical plate perforations, and furcation defects.

Since CBCT imaging has become a significant imaging modality in periodontology, and its applications to dentoalveolar disease and conditions are frequently updated, the goal of this review was to highlight some of the current evidence on the use of CBCT scans for imaging the most common conditions related to periodontal diseases.

Periodontal Bone Loss

The presence, severity, extent, and rate of progression of periodontal bone loss are important factors to be considered when assessing periodontitis. Although the gold standard for periodontal evaluation is the measurement of clinical attachment levels (CAL), the challenges associated with accurate assessment of CAL often lead to the utilization of probing depth measurements in combination with a set of intraoral radiographs [5]. Even though 2D imaging always presents with some level of superimposition that may mask bone defects, little evidence currently supports CBCT as a replacement or adjunct to intraoral imaging in the routine diagnosis and management of periodontitis.

A systematic review published in 2018 concluded that there was moderate level of evidence that CBCT can be accurately used for the measurement of periodontal bone defects [6••]. Several other studies also reported that the accuracy of CBCT images in detecting either vertical or horizontal bone loss around posterior teeth was comparable to surgical exploration [7–9]. However, the accuracy of CBCT images does not appear to be significantly different from that of 2D intraoral digital images in the assessment of periodontal bone level [10–13]. In fact, intraoral radiography performed significantly better for contrast resolution, bone quality assessment, and delineation of the lamina dura [10]. For that reason, CBCT imaging should not be the first choice for those tasks, and its use should be reserved for cases where clinical information and conventional 2D images are insufficient or unclear for diagnosis and treatment planning [6••].

CBCT images may improve the understanding of the morphology of alveolar defects [2, 10, 11]. A study comparing CBCT scans, intraoral radiographs, and direct surgical measurements of intrabony defects from patients exhibiting moderate-to-severe chronic periodontitis and undergoing periodontal regeneration procedures concluded that measurements done on CBCT images were more accurate than those obtained from intraoral radiographs [14]. CBCT images also increase the odds of accurate evaluation of intrabony defect more than 2-fold compared with intraoral radiography [13] and might be beneficial for treatment decision that involved periodontal regeneration and tooth extraction [2].

Conversely, it has also been shown that CBCT images may under- or overestimate alveolar bone loss measurements, depending on the voxel size used [6••]. A recent study compared the accuracy of linear and volumetric measurement of three-wall intrabony defect by using clinical measurements and CBCT images. Volume measurements increased as voxel size decreased. The authors concluded that should volumetric evaluation of periodontal bone defects be required, it is important to use of small voxel sizes for a more accurate measurement [15].

Even though some authors may recommend CBCT imaging for treatment planning of those few generalized advanced periodontitis cases [4], its use may not be warranted from a radiation exposure and cost standpoint [3••]. There is still limited evidence also demonstrating improvements in therapy execution and clinical outcomes for intrabony defects when CBCT imaging is used [3••]. However, if used for these purposes, it is recommended for the field of view to be limited to the area of interest to avoid unnecessary exposure of the patient to radiation [6••, 16].

Furcation Involvement

A comprehensive decision-making in periodontal therapeutics is frequently challenging when that involves the accurate assessment and treatment of furcation areas affected by periodontal disease [17, 18]. The diagnosis of furcation-involved teeth is mainly achieved by the assessment of probing pocket depth, clinical attachment level, furcation entrance probing, and intraoral radiographs. 3D imaging such as CBCT has the potential to provide additional information in the assessment of those bone morphologies [18].

Several studies have highlighted the applicability of CBCT images in furcation involvement assessment. In a recent study, the correlation rates between clinical examination and CBCT when detecting and measuring bone loss in the furcation region of maxillary and mandibular first molars were higher than when intraoral radiographs were used [19]. CBCT scans may even provide more details than clinical examination. In a sample of 39 maxillary molars, only 17.9% of the furcation involvement cases that were otherwise classified by probing as degree II (horizontal bone loss but no through-and-through defects) were confirmed by CBCT as being degree II. Most of those cases were actually diagnosed in the CBCT images as fused roots (15.4%), degree I (a small amount of vertical bone loss and no horizontal bone loss in the furcation area; 20.5%), and degree III (through and through defects; 46.2%) [20].

The assessment of furcation involvement on CBCT images is comparable to that of direct intra-surgical measurements. A study involving patients with moderate-to-severe chronic periodontitis and at least one mandibular molar with grade ii or grade III furcation involvement indicated for periodontal surgery reported no differences between surgical and CBCT measured parameters [18]. CBCT images were more accurate than the clinical measurements in a study that included intra-surgical measurements of 200 grade II furcation defects in 40 patients diagnosed with chronic periodontitis. The use of CBCT appears to be prudent for an accurate diagnosis of furcation defects in patients with advanced periodontal disease [17].

Some authors have raised the question if the information available in CBCT images is really being fully identified. It appears that some bone patterns possibly affected by periodontal disease may still not be identified on CBCT images since these changes are characterized by minor structural variations that cannot be visually recognized [21]. A study suggested that texture analysis (TA) applied to CBCT images to evaluate regions close to lesions affected by grade C periodontitis can show and quantify alterations when those occur. Their positive results demonstrate the potential of this tool as a diagnostic aid for regions with similar tomographic aspects [21].

Dehiscence and Fenestration

Dehiscence and fenestration are bone defects that compromises the osseous coverage of the roots. Dehiscence is characterized by a loss of alveolar bone, lowering the crestal bone margin, and creating a root-exposed defect that is originated from the cementoenamel junction in direction to the apex. The dehiscence can present a millimetric extend or involve the full length of the root. The dehiscence defects involve complications such as gingival recession, alveolar bone loss, and root exposure. On the other hand, fenestration is a bordered defect that does not involve the alveolar crest and exposes locally the root surface. This opening caused by the bone loss can occur on the facial or lingual cortical plate and it is located more apically. Both defects cause a direct contact of the root with the overlying mucosa [22].

In a tomographic study, a greater number of dehiscences were found in the mandible of the observed individuals, with greater frequency in the mandibular incisors, while fenestrations had greater prevalence in the maxilla, especially in first premolars and first molars [23]. Fenestrations are more frequently observed in subjects with class II malocclusion when compared to subjects with classes I and III [23]. However, in relation to dehiscences, no significant difference was found among the different types of malocclusion, even though class III patients present a thinner mandibular symphysis [24].

Given that dehiscence and fenestration are defects that compromise the integrity of the buccal and lingual cortical plates, a proper visualization of these bone lesions in conventional intraoral radiographs is not possible due to image superimposition of the anatomical structures. In order to overcome this limitation, CBCT presents high accuracy in the detection of periodontal structures and allows the 3D identification of the defect, its location and extension, and eventually associated contributing factors [22, 25, 26]. In this sense, dehiscence and fenestration could be more precisely represented in 3D images, including CBCT, when different imaging modalities were compared to evaluate such bony defects [27, 28••].

Even though the detection of bone loss on buccal and lingual sites is significantly better with CBCT than with conventional intraoral radiographs, one should be aware that its diagnostic accuracy is lower for anterior teeth [29]. It is also worth mentioning that the accuracy of 3D images in depicting dehiscences and fenestrations relies on the image spatial resolution, which is directly related to the voxel size. Differences in voxel size affect the precision of measurements of the bony coverage [30]. Areas with bone thickness smaller than the size of the voxel may be seen on the image as areas without bone, which can lead to misdiagnosis—false positive diagnosis of a defect [31, 32]. Yet most studies support the use of CBCT for detection of these buccal bony defects.

Conclusion

Even though CBCT can be considered an adjunct diagnostic method in periodontal assessment, its routine use for the evaluation and management of patients with periodontitis is not indicated and it should only be requested after a comprehensive periodontal examination. CBCT exams provide little additional benefit in the decision-making and disease managing in most cases of periodontal disease, being advocated only on patient-specific situations.

CBCT appears to be an accurate imaging method for the assessment of more complex conditions such as alveolar defects with intricate morphology, dehiscences, and fenestrations. However, it is imperative that acquisition protocols are not only choosing according to the need but also observing the levels of radiation exposure—most scenarios may demand limited field-of-view high-resolution protocols.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

References

Papers of particular interest, published recently, have been highlighted as:
•• Of major importance

1. Al-Zahrani MS, ElFirt EY, Al-Ahmari MM, Yamany IA, Alabdulkarim MA, Zawawi KH. Comparison of cone beam computed tomography-derived alveolar bone density between subjects with and without aggressive periodontitis. J Clin Diagn Res. 2017;11(1):118–21.
2. Suphanantachat S, Tantikul K, Tamsailom S, Kosalagood P, Nisapakultorn K, Tavedhiku K. Comparison of clinical values between cone beam computed tomography and conventional intraoral radiography in periodontal and infrabony defect assessment. Dentomaxillofac Radiol. 2017;46:20160461.
3. •• Kim DM, Bassir SH. When is cone-beam computed tomography imaging appropriate for diagnostic inquiry in the management of inflammatory periodontitis? An American Academy of Periodontology best evidence review. J Periodontol. 2017;88(10): 978–98 **Review endorsed by the American Academy of Periodontology that recommended limited field of view CBCT only in selective cases for periodontal disease diagnoses.**
4. Mandelaris GA, Scheye ET, Evans M, Kim D, McAllister B, Nevins ML, et al. American Academy of Periodontology best evidence consensus statement on selected oral applications for cone-beam computed tomography. J Periodontol. 2017;88(10):939–45.
5. Papapanou PN, Sanz M, Buduneli N, Dietrich T, Feres M, Fine DH, et al. Periodontitis: consensus report of workgroup 2 of the 2017 world workshop on the classification of periodontal and peri-implant diseases and conditions. J Periodontol. 2018;89(Suppl 1): S173–82.
6. •• Haas LF, Zimmermann GS, Canto DL, Flores-Mir C, Correa M. Precision of cone beam CT to assess periodontal bone defects: a systematic review and meta-analysis. Dentomaxillofac Radiol. 2018;47:20170084 **Systematic review that evaluated the diagnostic validity of 3D CBCT generated measurements in the evaluation of periodontal bone defects.**
7. Guo YJ, Ge ZP, Ma RH, Hou JX, Li G. A six-site method for the evaluation of periodontal bone loss in cone-beam CT images. Dentomaxillofac Radiol. 2016;45:20150265.
8. Pour DG, Romoozi E, Shayesteh YS. Accuracy of cone beam computed tomography for detection of bone loss. J Dent (Tehran). 2015;12:513–23.
9. Feijo CV, Lucena JGF, Kurita LM, Pereira SLS. Evaluation of cone beam computed tomography in the detection of horizontal periodontal bone defects: an in vivo study. Int J Periodontics Restor Dent. 2012;32:162–8.
10. 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;37:252–60.
11. de Faria VK, 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: 64–9.
12. Li F, Jia PY, Ouyang XY. Comparison of measurements on cone beam computed tomography for periodontal intrabony defect with intra-surgical measurements. Chin J Dent Res. 2015;18(3):171–6.
13. Green PT, Mol A, Moretti AJ, Tyndall DA, Kohltfarber HB. Comparing the diagnostic efficacy of intraoral radiography and cone beam computed tomography volume registration in the detection of mandibular alveolar bone defects. Oral Surg Oral Med Oral Pathol Oral Radiol. 2019;128(2):176–85.
14. 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;80:48–55.
15. Tayman MA, Kamburoğlu K, Küçük O, Ateş FSO, Günhan M. Comparison of linear and volumetric measurements obtained from periodontal defects by using cone beam-CT and micro-CT: an in vitro study. Clin Oral Invest. 2019;23:2235–44.
16. Bois AH, Kardachi B, Bartold PM. Is there a role for the use of volumetric cone beam computed tomography in periodontics? Aust Dent J. 2012;57(1 Suppl):103–8.
17. Pajnigara N, Kolte A, Kolte R, Pajnigara N, Lathiya V. Diagnostic accuracy of cone beam computed tomography in identification and postoperative evaluation of furcation defects. J Indian Soc Periodontol. 2016;20:386.
18. Padmanabhan S, Dommy A, Guru SR, Joseph A. Comparative evaluation of cone-beam computed tomography versus direct surgical measurements in the diagnosis of mandibular molar furcation involvement. Contemp Clin Dent. 2017;8(3):439–45.
19. Zhang W, Foss K, Wang BY. A retrospective study on molar furcation assessment via clinical detection, intraoral radiography and cone beam computed tomography. BMC Oral Health. 2018;18:75.
20. Zhu J, Ouyang XY. Assessing maxillary molar furcation involvement by cone beam computed tomography. Chin J Dent Res. 2016;19(3):145–51.
21. Gonçalves BC, de Araújo EC, Nussi AD, Bechara N, Sarmento D, Oliveira MS, et al. Texture analysis of cone-beam computed tomography images assists the detection of furcal lesion. J Periodontol. 2020;91:1159–66.
22. Lindhe J, Lang NP. Clinical periodontology and implant dentistry. 6th ed. Wiley-Blackwell: City; 2015.
23. Yagci A, Veli I, Uysal T, Ucar FI, Ozer T, Enhos S. Dehiscence and fenestration in skeletal Class I, II, and III malocclusions assessed with cone-beam computed tomography. Angle Orthod. 2012;82(1): 67–74.
24. Kim Y, Park JU, Kook YA. Alveolar bone loss around incisors in surgical skeletal Class III patients. Angle Orthod. 2009;79:676–82.
25. Scarfe WC, Farman AG. What is Cone-beam CT and how does it work? Dent Clin N Am. 2008;52(4):707–30.
26. Woelber JP, Fleiner J, Rau J, Ratka-Kruger P, Hannig C. Accuracy and usefulness of CBCT in Periodontology: a systematic review of the literature. Int J Periodontics Restorative Dent. 2018;38(2):289–97.
27. Mengel R, Candir M, Shiratori K, Flores-de-Jacoby L. Digital volume tomography in the diagnosis of periodontal defects: an in vitro study on native pig and human mandibles. J Periodontol. 2005;76(5):665–73.
28. •• Choi IGG, Cortes ARG, Arita ES, Georgetti MAP. Comparison of conventional imaging techniques and CBCT for periodontal evaluation: a systematic review. Imaging Sci Dent. 2018;48(2):79–86 **Updated systematic review that evaluated conventional and 3D imaging techniques for the assessment of infrabony defects, furcation involvement, height of the alveolar bone crest, and the periodontal ligament space.**
29. Mol A, Balasundaram A. In vitro cone beam computed tomography imaging of periodontal bone. Dentomaxillofac Radiol. 2008;37(6): 319–24.

30. Patcas R, Muller L, Ullrich O, Peltomaki T. Accuracy of cone-beam computed tomography at different resolutions assessed on the bony covering of the mandibular anterior teeth. Am J Orthod Dentofac Orthop. 2012;141(1):41–50.
31. Leung CC, Palomo L, Griffith R, Hans MG. Accuracy and reliability of cone-beam computed tomography for measuring alveolar bone height and detecting bony dehiscences and fenestrations. Am J Orthod Dentofacial Orthop. 2010;137(4Suppl):S109–S19.
32. Sun L, Zhang L, Shen G, Wang B, Fang B. Accuracy of cone-beam computed tomography in detecting alveolar bone dehiscences and fenestrations. Am J Orthod Dentofac Orthop. 2015;147(3):313–23.