Knowledge, Attitude and Practice about Cone Beam Computed Tomography for periodontal diagnosis among Orthodontists and Periodontists

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ABSTRACT

Introduction: The aim of this study is to analyze about the knowledge about cone-beam computed tomography (CBCT) on periodontal diagnosis among orthodontists and periodontists. Materials and Methods: A questionnaire was prepared with a set of 10 questions about CBCT to 50 orthodontists and 50 periodontists in Chennai population through an online survey. Results: The responses varied among both the groups in each question. Discussion: Both imaging modalities had the same over- and under-estimation rates for periodontal bone defects. Periodontal bone level measurements are reproducible on film-based conventional radiography, while examiners’ agreement is not enhanced using intraoral digital imaging systems. Nevertheless, the latter reduce radiation exposure and offer potentials for image analysis, optimization, and quantification, such as contrast enhancement, periodontal filtering, and digital subtraction. Conclusion: Though the knowledge among the orthodontists and periodontists with the use of CBCT for diagnosis is equally distributed, the necessity of using advanced technology for better management and smooth handling of the patients is to be incorporated among all dentists for accurate diagnosis.

KEY WORDS: Cone-beam computed tomography, Knowledge; attitude; and practice study, Orthodontists, Periodontists, Survey

INTRODUCTION

Periodontal disease is a chronic bacterial infection that affects the gingiva and bone supporting the teeth. Recent epidemiologic studies show that destructive periodontitis is found in about 30% of the American population. Only careful clinical examination of the patient can detect periodontal disease at an early stage. Radiographs are necessary for showing hidden anatomical structures such as the alveolar bone. They expose the degree of interdental and intraradicular bone loss, root length, crown-root ratio, periodontal ligament space, and any apical pathology in the tooth.

Early precise evaluation of the periradicular status is necessary in diagnosis, treatment, and follow-up. Although radiographs are a useful diagnostic aid, the interpretation of these images may not provide accurate information for many reasons. Bender described the basic principles involved in the detection of bone loss in local resorptive lesions; the results indicated that, due to the low mineral content of medullary bone, large resorptive lesions in this region could go undetected; furthermore, the cortices (particularly in the mandible) have a masking effect on lesions occurring within the cancellous bone.

Several other studies have reported difficulties in accurately assessing periradicular tissues, especially for radiolucent lesions (45% ± 28), including interobserver abnormality: 50%–100%, normal features: 10–80%) and intraobserver variability.[2,3] Benn suggested that the current measurement techniques are insufficiently sensitive to measure 1 mm of bone loss until at least 1.9 mm of bone resorption has occurred.[4]

Besides the detection ability problem, Eickholz and Hausmann showed that radiographic assessment using periapical (PA) radiographs tends to underestimate the amount of bone loss by 1.41 ± 2.58 mm.[5]

The standard technique for the initial examination of a periodontitis patient was for many years a full-mouth
periodontal probing complemented by a set of full-mouth intraoral radiographs or a panoramic radiograph with a limited number of selective PA radiographs, depending on the severity and distribution of increased probing pocket depths, furcation involvements, or various non-periodontal findings.\(^6\)

Nevertheless, the problem is that the transmission radiographs are limited because they are two-dimensional (2D) representations of the three-dimensional (3D) alveolar bone, tooth, and soft tissue. This 2D representation is strongly affected by vertical and horizontal angulation errors during film exposure.\(^7\)

The collapse of the 3D anatomy into 2D space results in the superimposition of structures that can potentially obscure the features of interest and decrease diagnostic sensitivity. Consequently, a radiographic tool with a 3D presentation is preferred in pre- and post-treatment assessment of periodontal defects.\(^8\)

Computed tomography (CT) scanners employing cone-beam geometry are becoming popular tools in modern dental practice. Some machines cover the entire maxillofacial area while others are used for imaging a much smaller region of interest, although usually with finer resolution. Unlike conventional CT scanners, which must provide contrast resolution sufficient to visualize differences in soft tissues, scanners used in dentistry are mostly used to distinguish bone from soft tissue. As a result, noise is not as important in dental CT scanners and it is possible to get by with much fewer X-ray photons. This means that much lower-powered X-ray generators can be used (dental X-ray machines similar to those used in panoramic radiography are not uncommon) and that the radiation dose to the patient required for such scanners is much lower than that used in medical CT.\(^9\)

As cone-beam reconstruction algorithms make it possible to reconstruct an entire volumetric region, this region can be reformatted to show anatomical detail in any imaginable plane. Views not usually seen with traditional modes of dental radiography can be achieved, and accurate measurements can be performed free from the usual problems of magnification and distortion.

Current approaches to diagnose periodontal disease include probing of gingival tissues and radiographs to evaluate osseous support.\(^10\) Imaging includes bitewings and PA radiographs,\(^11\) with the main radiographic technique used for periodontal diagnosis being the paralleling extension cone method.\(^12,13\)

Unfortunately, radiographic methods are severely limited by the inherent overlay of anatomic structures and the difficulty to reproduce angles over time. There is ample research, demonstrating that funnel-shaped or lingually located defects cannot be detected\(^14\) and that destruction of the buccal plate can be undiagnosed or distinguished from lingual defects.\(^15\)

Further studies comparing radiographs to presurgical measurements concluded that bone loss can be underestimated by 1.5 mm, with large variations between examiners.\(^5\) Consequently, traditional radiography remains a limited diagnostic tool.\(^16\) To address these issues, CT has been explored because it enables cross-sectional and 3D analysis without distortion. CT has been used for imaging of the temporomandibular joint,\(^17\) evaluating oral osseous lesions,\(^18,19\) assessing maxillofacial deformities,\(^20\) and pre-operative planning of dental implants.\(^21,22\)

Unfortunately, CT is impractical because of machine cost, complexity, high radiation, and relatively low resolution. More recently, cone-beam CT (CBCT) was introduced for head and neck applications.\(^23-27\)

Contrary to CT, it consists of a conical radiographic source and a high-performance digital panel detector. In most CBCT machines, the apparatus is similar in size to a conventional panoramic machine, the examination takes 30 s, and radiation is within the range of an intraoral full-mouth series.\(^28,29\)

In addition, CBCT resolution can be as small as 0.2 mm, compared to 0.5–1 mm for CT. There is some preliminary evidence that it is reliable for evaluation measurements of large structures associated with dental and maxillofacial imaging,\(^30,31\) and it may be adequate to visualize periodontal alveolar bone changes.

Although 2D radiography is of use for interproximal lesions, six its limitation were anticipated during early investigations determining its diagnostic value for PA and periodontal disease.\(^10,11\) On the other hand, geometric accuracy was expected for CBCT: Using an in vitro geometric model to test head and neck CBCT, Marmulla et al.\(^32\) found that variation was 0.13 mm (−0.09 standard deviation) with a maximum deviation of 0.3 mm; using large measurements of skulls in vitro with the same machine, Lascola et al.\(^29\) found errors varying from 0.07 to 0.2 mm. The present results are not as accurate because of human intervention in detecting bone level. Furthermore, Gutta-percha was placed on roots adjacent to measure the sites to standardize measurement localizations. Visualization of Gutta-percha on radiographic images also facilitated identification of Cemento enamel junctions (CEJs), which would be more difficult in a clinical setting, resulting in a potential error increase. In contrast, using a dry skull with artificial defects may have influenced results because radiographic and CT representation of cortical outline was missing, thus affecting bone-level detection negatively. Despite these encouraging results, CT has been scrupulously limited to advanced dental applications such as maxillofacial trauma or complex implant treatments because of higher radiation doses.\(^33\) Yet there is evidence that CBCT radiation is highly reduced compared to traditional CT. Comparing skin exposure of traditional CT versus a small-view CBCT, Honda et al.\(^34\) reported a total radiation reduction from 160 to 1.19 mSv. Investigating organ exposure, Scaf et al.\(^35\) reported...
a radiation exposure of 1.031 mSv for a maxilla and 2.426 mSv for a mandible using CT. This is compared to a reported CBCT organ radiation of 0.037 mSv versus a panoramic film that was 0.022 mSv in one study or to 0.15 mSv for a full-mouth series.\cite{36,37}

Finally, it is likely that radiation exposure will further decrease as technology evolves.

Intraoral radiography is the most common imaging modality used for diagnosing periodontal bone defects. However, intraoral radiography is 2D and the amount of bone loss can be underestimated due to projection errors or observer errors in identifying the reliable anatomical reference points. Assessing pre-surgical bone levels and changes in post-periodontal treatment often requires 3D information. The introduction of digital intraoral imaging and CBCT may bring new potentials for periodontal diagnosis and treatment planning. Intraoral digital imaging not only reduces radiation exposure but also optimizes assessment of oral structures, improving the accuracy of periodontal diagnosis. Conventional CT provides 3D information, but the dose remains quite high. The recent development of CBCT reduces this radiation exposure significantly.

Over the past 15 years, there have been many publications concerning the applications of digital intraoral radiography, but few of these have dealt with its validity to monitor periodontal bone lesions. The same scenario applies to the use of CBCT for periodontal indications. Many questions regarding both digital intraoral imaging and CBCT need to be addressed: Are periodontal bone levels, lamina dura, and bone craters well visualized on both imaging modalities? How accurate are these imaging techniques in assessment of the bone levels and defects? Can the availability of 3D images assist the diagnosis of the bone loss and defects? Therefore, the overall aim of this study was to validate applications of digital intraoral imaging and CBCT in the determination of the periodontal bone loss and defects. We hypothesized that both digital intraoral radiography and CBCT would allow the accurate assessment of periodontal bone levels.

**MATERIALS AND METHODS**

A survey questionnaire consisting of 10 questions was distributed among 50 orthodontists and 50 periodontists who are in and around Tamil Nadu through online using Survey Monkey link. Moreover, the questions which were asked are listed below in Diagram 1.

**RESULTS**

The best adjunct for planning on regenerative periodontal therapy and bone graft among both the groups are depicted in Figures 1-10.
One of the very first things to note during a periodontal examination is the presence or absence of disease. This often can be determined in seconds by looking for signs of gingival inflammation. The four most common signs of gingival inflammation that are routinely observed during a periodontal examination are redness, swelling, bleeding on probing, and purulent exudate (pus). Gingival redness and swelling usually are seen together and occur first at the gingival margin. Without treatment, the inflammation can eventually involve the entire interproximal area and, in some cases, extend into portions of the attached gingival. Sometimes, the redness associated with gingival inflammation can be quite subtle. If one is uncertain about the presence of inflammation-associated gingival redness, it is useful to compare the color of the site in question with that of a confirmed healthy site (e.g., such a site is often the adjacent attached gingival). Recognition of gingival swelling or edema requires that the clinician has a very clear mental picture of the shape and texture of healthy gingiva.
Healthy gingiva is firm and resilient, whereas edematous tissue is often enlarged and puffy. If there is some uncertainty about the presence or absence of gingival edema, it is sometimes useful to gently press the side of a periodontal probe against the tissue for a few seconds and then remove it. At edematous sites, the imprint of the periodontal probe can often be seen, whereas at sites without marked edema, no imprint will be observed. Recognition of the presence or absence of gingival edema helps the clinician to determine if the tissues are healthy or diseased. In addition, it also serves another very important purpose ± anticipating the response to treatment. Gingival edema and the accompanying redness often disappear shortly after scaling and root planing. Therefore, by noting that the tissues are edematous during the examination, the clinician can predict the likely response to therapy. It should be remembered that not all areas of gingival redness and swelling are due to periodontal diseases. Endodontic infections, sometimes, drain through the orifice of a periodontal pocket, thereby mimicking a periodontal abscess. Elsewhere, this volume discusses in detail the diagnosis of endodontic-periodontal lesions. Bleeding on probing is a somewhat the objective sign of gingival inflammation; it is either present or absent. Inflamed gingival tissues bleed when gently probed because of minute ulcerations in the pocket epithelium and the fragility of the underlying vasculature. At the initial examination, the percentage of sites that exhibit bleeding on probing prior to treatment is a clinically useful piece of information since it provides a full-mouth pretreatment assessment of the extent of gingival inflammation. For example, if 70% of the sites exhibit bleeding on probing before treatment, a decrease to 20% of the sites after initial scaling and root planing and oral hygiene instructions is encouraging to both the patient and periodontist by indicating that progress has been made. In other words, knowledge of this improvement reassures the patient and periodontist that their joint efforts to control the periodontal infection are working.

Both imaging modalities had the same over- and under-estimation rates for periodontal bone defects. Bone craters and furcation involvements were better depicted on CBCT than on intraoral images. This could be because the CBCT provides multiplaner slices and 3D information. However, because of the lower resolution, CBCT scored less than the intraoral images, in contrast, bone quality, and delineation of lamina dura. This indicated that the current CBCT system could not replace intraoral radiography for periodontal assessment. In fact, a combination of both imaging modalities could benefit periodontal bone assessment and assist presurgical treatment planning. Radiation dose is always a concern for using conventional CT. However, radiation dose of CBCT was reported up to 15 times less than conventional CT. Nineteen recent studies reported that CBCT systems only require 4–15 times the dose of a standard panoramic image 18 or only the dose of a film-based full-mouth radiographic examination (FMX). An FMX in the United States varies from 18 to 22 intraoral radiographs with a dose range of 13–100 Sv. The effective dose of CBCT, starting at 36.9 Sv, was in the range of the FMX. Furthermore, Scarfe et al. reported about dose reduction when using smaller field of view (FOV) examinations. The 9-inch FOV of the I-CAT images (69 Sv) should be capable of visualizing both jaws and providing all necessary information for periodontal treatment planning of implants. The images require 8 times the dose of a standard panoramic image (1.9–11 Sv). If more information is required in a broader area, the
12-inch FOV (135 Sv) should be used, but in that case, the radiation dose would rise until 15 times a standard panoramic image dose. As the radiation dose of CBCT is lower than conventional CT, there is growing concern over its overconsumption and radiation safety. In our opinion, the use of CBCT should still be carefully justified (diagnostic benefit and risk to be balanced). The imaging system must be performed by experienced and trained practitioners. As low as reasonably achievable radiation, safety principle must be followed. In the current study, a low exposure setting of CBCT (only 23.87 mAs and 0.4-mm voxel size) was used. More studies with a large sample size in the future will determine ideal exposure settings, which optimize the image quality and lower the radiation exposure further. The present study found that CBCT had a higher quality rating on bone crater and furcation involvement assessment, whereas contrast, bone quality, and delineation of lamina dura were rated lower than for digital intraoral radiography.

Previous studies show that periodontal bone level measurements are reproducible on film-based conventional radiography, while examiners’ agreement is not enhanced using intraoral digital imaging systems. Nevertheless, the latter reduce radiation exposure and offer potentials for image analysis, optimization, and quantification, such as contrast enhancement, periodontal filtering, and digital subtraction. These dynamic functions can aid periodontal diagnosis as well; however, 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. In the present study, we actually attempted to reduce the radiation dose as much as possible while keeping full diagnostic capabilities to offer a clinically applicable comparison to CBCT. The lowest settings applied (0.28 mAs at 60 kV) were still able to visualize the periodontium with the same accuracy, and thus, these can be further recommended for the present tube specifications. CBCT allowed similar periodontal bone level measurements as digital intraoral radiography. Bone craters and furcation involvements were better depicted on CBCT, while contrast, bone quality, and details of lamina dura scored better on digital intraoral radiography. A selective use of both imaging modalities might, thus, aid periodontal diagnosis and treatment planning. However, selection criteria are needed to define the conditions and specific indications for the use of 2D and/or 3D imaging modalities in periodontology.

CONCLUSION

Though the knowledge among the orthodontists and periodontists with the use of CBCT for diagnosis is equally distributed, the necessity of using advanced technology for better management and smooth handling of the patients is to be incorporated among all dentists for accurate diagnosis.

REFERENCES


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