Application of Two-Dimensional Radiography and CBCT in Periodontology

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Abstract: ***The use of radiographic examinations has long been part of dental diagnostics and treatment planning because of their ability to provide information about rigid structures in the maxillofacial area. The most commonly used X-ray methods for determining the level of alveolar bone in dental medicine are intraoral periapical radiographs and orthopantomography (OPG). Cone Beam Computed Tomography (CBCT) is the imaging technology required for the correct three-dimensional diagnosis of the anatomical features of the alveolar bone. It presents in detail the anatomical features and the absorptive changes in the alveolar bone compared to intraoral X-rays and orthopantomography.***

Keywords: CBCT, two-dimensional and three-dimensional radiographs, intraoral X-rays, segment radiographs, radiographic evaluation, periodontal examination, periapical X-ray

1. Introduction

The use of radiographic examinations has long been part of dental diagnostics and treatment planning because of their ability to provide information about rigid structures in the maxillofacial area. The most commonly used X-ray methods for determining the level of the alveolar bone in dental medicine are intraoral periapical radiographs and orthopantomography (OPG) [1]. Cone Beam Computed Tomography (CBCT) is the imaging technology required for correct three-dimensional diagnosis of the anatomical features of the alveolar bone. It presents in detail the anatomical features and the absorptive changes in the alveolar bone compared to intraoral X-rays and orthopantomography [2].

2. Aim

The purpose of this study is to describe, review and compare two-dimensional and three-dimensional radiographs in periodontics.

3. Materials and Methods

Articles related to the subject were searched in PubMed and Google Scholar databases. Articles only in English language, published from 1985 to 2019, were included. The search was performed using a combination of different keywords such as: CBCT, two-dimensional and three-dimensional radiographs, intraoral X-rays, segment radiographs.

4. Results

Intraoral segment radiographs and OPG are still used to diagnose and evaluate the severity, prognosis, and outcomes of periodontal disease treatment [3-7]. Two-dimensional X-ray studies are unable to provide sufficient three-dimensional information regarding the alveolar bone and dental structures. Determination of bone craters, vertical bone defects, initial furcation defects, and marginal bone level are limited by 2D radiographs due to overlaping of surrounding anatomical structures, as well as lack of bucco-lingual visibility [5, 6, 8-10].

Digital subtraction radiography is a useful method for detecting changes in the alveolar bone mineralization up to 5% [11, 12]. It was first used in 1935 by Ziedses des Plantes [13]. This technique requires two intraoral X-rays, assigned at different times with almost identical geometry of projection and density. Both images are overlaid and processed to show areas of bone resorption or areas of deposition of new bone [14, 15]. In addition to detecting changes in the alveolar bone height, digital radiography can also detect quantitative changes in bone density [16, 17]. When the brightness and contrast of an image are adequately standartized, the measurements taken with digital subtraction radiography can be very accurate. However, as with all two-dimensional radiographs, there are the same disadvantages in digital radiography - bone changes can not be evaluated in all three dimensions [18].

Because of these shortcomings, it is necessary to find another approach with another type of image. In 1967, the first tomograph was developed by Hounsfield [19]. All researchers have gradually turned their attention to the use of computed tomography (CT) in the diagnosis of periodontal defects and yielded relatively good results. Other disadvantages, such as high cost, difficult accessibility and high radiation dose, are outweighed by the use of this study.

CBCT is mainly used for planning and placement of dental implants, in maxillofacial surgery and endodontics [20]. The advantages of CBCT over other imaging studies are not insignificant. One of the main advantages of CBCT over other imaging techniques is the lower radiation dose compared to conventional CT. Anatomical structures were not observed to overlap in the CBCT images and were found to be statistically more accurate when measuring the dimensions of vertical alveolar bone defects compared to 2D radiographs [8, 21, 22].

A solution to all the drawbacks of two-dimensional radiographic examination can be found in a CBCT. The CBCT makes it possible to evaluate the maxillofacial region in all three dimensions and to provide three-dimensional volume reconstructions that can be seen from every angle. The use of serial CBCT scans to evaluate progression or regression of the disease eliminates the requirements for standardization of parameters in two-dimensional studies, since three-dimensional volumes can be reoriented without losing their spatial integrity [23].

In the period around 2000, the CBCT was introduced for active use in the head and neck area [24-28]. The CBCT is used to visualize the temporomandibular joint [29], to assess vertical defects of the alveolar bone [30, 31], to evaluate maxillofacial deformities [32], for preoperative planning for placement of dental implants [33-36].

In 2011 Mohan R et al. [19] examines the principles and evolution of the CBCT, its differences with CT, its advantages and limitations, and its application as a diagnostic tool in periodontics and implantology. In the field of medicine, 3D imaging using computed tomography (CT) has been available for many years, but in dental medicine, its use is limited in cases of maxillofacial trauma and head and neck diagnostics. The routine use of CT in dentistry is not accepted because of its cost and excessive radiation. In recent years CBCT has been available in dental clinics and hospitals for obtaining 3D images of oral structures. It is cheaper than CT, less bulky and generates low doses of X-radiation (5 times lower radiation dose than the normal CT). Today, CBCT is a valuable imaging mechanism in periodontics as well as in implantology. To detect the smallest bone defects, CBCT can display the image in all three dimensions, eliminating disturbing anatomical structures and making it possible to evaluate each root and surrounding bone. With implant treatment, the appropriate location or size can be selected before insertion, and osteointegration can be examined after a specified period of time.

For the first time, CBCT has been applied in periodontology for the diagnosis and evaluation of the results of the treatment of periodontitis [37, 38].

The advantages of CBCT include faster scanning time, less radiation than conventional CT, image precision with a resolution of 0.4 mm to 0.076 mm, lower cost than conventional CT. It allows planning for bone defects regeneration and the most important advantage of CBCT is that it provides unique 3D images demonstrating features that intraoral, panoramic and cephalometric images cannot provide [39]. Regarding implant therapy, it is possible to decide the most appropriate implant site, the appropriate implant size and the process of osteointegration can be monitored on time. CBCT can avoid many complications during surgery, but it can also minimize the need for additional procedures in some situations. [40]

CBCT has 80-100% sensitivity when examining and determining alveolar bone loss, while conventional radiographic methods show about 60-70% sensitivity. [41]

Radiation dose, image quality, method sensitivity, patient tolerance, and duration of radiographic examination are all important factors in selecting the appropriate technique for examining periodontal tissues [42, 43].

CBCT has been proven to be superior to intraoral X-rays for the detection of class1 furcation defects, 3-wall intrabony defects, dehiscences and fenestrations. Fenestrations and dehiscences would be difficult to evaluate as the thin cortical bone is superimposed on the dense root structure [44]. Statistically more accurate measurements of the size of bone defects in patients with periodontitis have been established with a CBCT, in comparison with 2D radiographic techniques [45, 46].

CBCT images are dependent on many variables and technical factors such as field of view (FOV), kVp, mA, voxel size and the detector itself. The voxel size is determined by its height, width and depth and affects the properties of the final image [47]. The smaller the voxel size, the higher the resolution [48]. Therefore, it is clinically important to select the optimal voxel size to obtain optimal image quality. It is important to choose the optimum FOV for each patient, depending on the area to be scanned, since less FOV provides lower doses of radiation [49].

Several in vitro studies have been performed to evaluate the accuracy of CBCT measurements of vertical bone defects in patients with periodontitis. The results indicate that CBCT can provide accurate 3D morphology of periodontal defects and is a significantly better diagnostic method compared to convectional 2D X-ray studies.

Using human jaws, Fuhrmann et al.[50] also compared radiographs with CBCT and found that only 60% of intraosseous defects were identified on X-ray, while 100% of defects were identified on CBCT.

In 2012 de Faria Vasconcelos et al. made a comparative evaluation of segmental periapical radiographs and CBCT images. During the study, they concluded that CBCT offers improved visualization of defect morphology compared to segmental periapical radiography. In the same year Vasconcelos et al. compared the images of a periapical X-ray and CBCT to detect and locate intraosseous defects by comparing the height, depth and width of the defects. The results show that there are no statistically significant differences between the two methods with regard to the identification of the type of bone resorption, but there are differences in the dimensioning of the intraosseous defects [51].

In 2014. Aljehani YA [52] published an article aimed at reviewing the diagnostic application of CBCT in the field of periodontics. The conclusion reached is that "CBCT does not offer a significant advantage over conventional radiography in the assessment of alveolar bone loss."

Braun et al. [53] report that CBCT is superior to intraoral radiographs in the detection of vertical bone and furcation defects. Overall, correct identification of intraosseous defects was observed 82.7% using intraoral radiographs and 99.7% with CBCT. They also found that CBCT was the better technique for identifying furcation defects

(94.8%). Their conclusion is that the addition of the third dimension significantly improves the accuracy of diagnosing periodontal diseases.

Bagis et al. [54] obtained similar results with regard to the detection of dehiscence (46.8% vs 78.2%) and fenestrations (25.7% vs 89.1%) when comparing intraoral radiographs versus CBCT.

In 2015, Akshaya Banodkar et al. are conducting a study aimed at assessing the accuracy of CBCT measurements of vertical bone defects, compared with actual measurements during surgery (which is the gold standard). The study included 100 vertical bone defects in 15 patients suffering from periodontitis and planned for surgery. On the day of the surgery, a CBCT-examination was performed. Clinical measurements of the periodontal defect were made after a mucoperiosteal flap was reflected. The team found a very high correlation of 0.988 between surgical and CBCT measurements, which led to the conclusion that CBCT is a very accurate method for measuring periodontal defects [55].

Walter et al. concluded that CBCT can improve diagnostic accuracy and optimize treatment planning for periodontal defects, and that due to higher radiation doses, a benefit-negative ratio needs to be carefully analyzed before using CBCT for periodontal diagnosis and treatment planning [56].

Nikolic-Jakoba et al. concluded that there was insufficient scientific evidence to justify the use of a CBCT to diagnose and / or plan treatment for intraosseous and furcation defects. However, they have found that CBCT has a higher diagnostic accuracy than intraoral periapical radiographs for the presence of intraosseous and furcation defects. [57].

In 2016 Enas Anter et al. [58] made a systematic review of the literature to evaluate the degree of accuracy of a CBCT as a means of measuring alveolar bone loss in periodontal defects. The initial selection found 47 potentially relevant articles, of which only 14 met the selection criteria of the team. The conclusion is that CBCT presents bone loss in the periodontal defect with a minimum mean measurement error of 0.19 ± 0.11 mm. and a maximum reported mean measurement error of 1.27 ± 1.43 mm.

5. Conclusion

In conclusion, many studies have been done over the years comparing the use of three-dimensional (3D) and two-dimensional imaging (2D) in intraosseous defects, which show that CBCT has a sensitivity of 80 to 100% in detecting and determining the type of bone defect, while radiographic images lag 63 to 67%. [59-61].

Although many in vivo studies have been made to evaluate the role of CBCT in periodontology, CBCT currently seems to be an additional imaging technique in this field. It is mainly used when obtaining unreliable information from intraoral or panoramic radiographs. CBCT may be particularly preferred when treatment planning is done, depending on the morphology and the size of the defect, and provides additional information compared to other intraoral conventional radiographs [62].

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