ACTA SCIENTIFIC DENTAL SCIENCES (ISSN: 2581-4893)

Volume 3 Issue 9 September 2019

Research Article

Three-dimensional Analysis of the Distance between Pulp Tissue and Caries or Obturation in Different Projections using CBCT

Federico Valenti Obino, Dario Di Nardo, Linda Quero*, Gabriele Miccoli, Gianluca Gambarini, Luca Testarelli and Massimo Galli

Department of Oral and Maxillo Facial Sciences, "Sapienza" University of Rome, Italy

***Corresponding Author:** Linda Quero, Department of Oral and Maxillo Facial Sciences, "Sapienza" University of Rome, Italy.

Received: July 24, 2019; **Published:** August 26, 2019

Abstract

Aim: The aim of this research was to analyze the distance between radiographic pulp chamber and caries or obturations *in vivo* using cone-beam computed tomography (CBCT) imaging in different projections.

Materials and Methods: A total of 50 premolar and molar teeth from 50 patients were examined using CBCT imaging, previously taken for diagnosis and treatment. Slices in different projections were scanned and the distance between radiographic pulp chamber and caries or obturations was measured using a software's tool.

Results: The distance in two-dimensional projection was significantly lower than in three-dimensional projection in all the examined teeth, showing a less distance from the pulp chamber and the caries or obturation.

Conclusions: The distance between the caries and the pulp tissue of a tooth in a three-dimensional projection is less than in a two-dimensional projection; for this reason, it would be better to pay attention to the proximity to the pulp chamber and it is recommended to consider a smaller distance than the one the two-dimensional radiograph showed.

Keywords: Pulp Tissue; CBCT; Distance

Introduction

An accurate diagnosis of caries is essential for clinicians, to have an exact knowledge of the depth of the cavity in order to determine the right type of restoration and treatment required [1].

Various studies have examined different methods, both intraoral and extraoral, to determine the extension of a caries, such as microcomputed tomography [2], swept-source optical coherence tomography [3], near-infrared transillumination [4], histological analysis [5], high-frequency ultrasound [6], bitewing radiography [7], periapical radiography [8], panoramic [9], cone-beam computed tomography [10].

Extraoral radiography such as the panoramic had an inferior performance compared with intraoral imaging due to the superimposition of additional structures, increased image blurriness and inconsistent opening of posterior proximal contacts [11].

The intraoral radiography is widely used for diagnosis of proximal caries that cannot be readily identified by clinical examination [12].

CBCT imaging produces three dimensional images with high resolution and its radiation dose is lower than computed tomography [13]; the main disadvantage of the CBCT is the

possibility of metal artefacts due to the presence of these materials within the oral cavity [14].

Our understanding of the caries disease process has identified lesion depth, activity and cavitation status as significant indicators for caries progression [15,16].

Assessment of cavitation is also important because cavitated lesions demonstrate a much higher chances of progression [17,18].

The aim of this research was to analyze the distance between the pulp chamber and the caries or obturations in premolars and molars using and comparing 3D radiographs: more precisely CBCT visualized with a sagittal projection (PS images) in a buccal-lingual sense (similar to the two-dimensional periapical endoral radiography) and CBCT visualized with a coronal projection (images in PC) in a mesio-distal sense (hidden anatomy).

Materials and Methods

Sample selection: A total of 50 premolar and molar teeth were examined. Teeth were selected from the CBCT examinations of 50 patients (27 males and 23 females) with an age ranging between 18 and 79 years. Images were obtained from CBCT examinations as part of diagnosis and treatment planning of patients who required large field of view for other reasons. The research was approved by the Ethical Committee of Policlinico Umberto I, Rome, Italy (ref. 582/17).

The samples were selected according to the following criteria

- Class II Black's Classification of caries;
- Deep caries that does not reach the pulp chamber.

All devitalized teeth were excluded.

The teeth were divided into two groups

- Distance between obturation and pulp chamber (figure 1);
- Distance between caries and pulp chamber (figure 2).

Image acquisition

CBCT images had been taken using the GXDP-500 system (Gendex Dental, Biberach, Germany), operating at 90 kVp and 7 mA, with an exposure time of 23 s and a voxel size of 0.2 mm^3, with a field of view of 13x9x13 cm, with an estimated dose of about 5 mSv, allowing measurements to an accuracy of 0.2 mm.

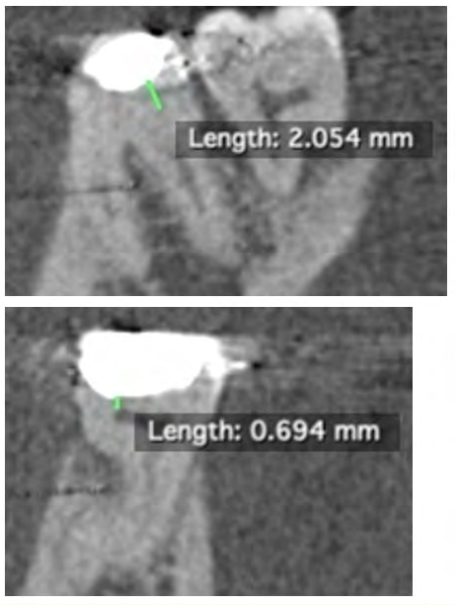

Figure 1: 2D vs 3D slice in obturations.

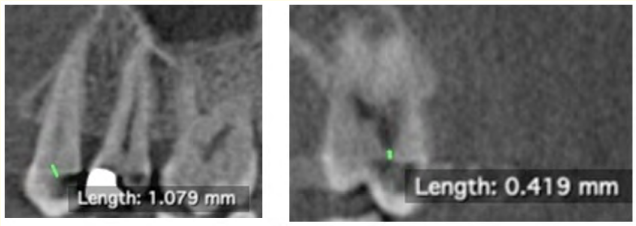

Figure 2: 2D vs 3D slice in caries.

Image evaluation

Through the use of Horos™ software (The Horos Project, 64-bit medical image viewer, GNU Lesser General Public Licence, version 3.0) three-dimensional reconstructions were analyzed to evaluate the parameters of interest. Images were reworked according to the axial, sagittal and coronal planes. CBCT images were viewed on reconstructions according to the axial plane, scrolling the cursor in the coronal-apical direction before, and then in the apical-coronal direction, to get a detailed view of caries and obturations in 2D and 3D slice. This action was repeated 3 times, and when the images in the axial plane were not clear, the tooth was also inspected in the three-dimensional reconstruction. The software had a specific tool which allowed precise measurements (~0,01 mm).

Statistical analysis

The results were analysed statistically using SPSS 20.0 (SPSS, Inc., Chicago, IL, USA) with the significance set at $p<0.05$. One-way ANOVA was used for the association between the variables along with the post hoc tests, Tukey's HSD and Games–Howell. The t-test was used to compare the mean distances from confluence to radiographic root end.

Results

In the present study measurements made on PC images were significantly different from those performed on PS images.

In group A the average distance between the obturation and the pulp chamber is 2,157 mm in PS images and 1,403 mm in PC images. The difference measured about between the two projections was 0,754 mm.

In group B the average distance between the caries and the pulp chamber is 1,532 mm in PS images and 0,798 mm in PC images. The difference measured between the two projections was 0,734 mm.

Overall, there was at least 0,7 mm of discrepance between PS and PC images, showing a more accurate capacity of PC projections in detecting the proximity of the pulp tissue both in caries and obturations.

Discussion

Defining the real extent of a caries has always been a challenge for the clinician, who must adopt different therapies based on the different severity of the process.

Standard bitewing radiographs detect only about 60% of proximal lesions [19-21].

Extraoral imaging had a significantly inferior performance compared with intraoral imaging due to superimposition of additional structures [22,23].

Many researches showed that CBCT caries detection results are approximately equivalent to intraoral modalities for non-restored teeth [24-30].

Other studies demonstrated that CBCT is equivalent to intraoral techniques at detecting clinically relevant caries lesions in minimally restored teeth; artefacts from metal objects and dense tooth structure (enamel) are limiting factors [3,32].

So, there was a minimal difference in detecting interproximal caries between 2D and 3D methods [33].

Previous researches that were performed on extracted teeth to define the accuracy of measurements of the caries using CBCT [34-36] showed there was not statistical difference between 3D and 2D imaging in detecting interproximal caries.

Other studies [37-42] that compared the accuracy of detecting caries between 3D and 2D imaging demonstrated that the accuracy of CBCT may be similar to that of intraoral digital radiographic images for occlusal and proximal caries detection.

On the contrary, some researches [43-45] showed a significant superior ability of the CBCT to precisely define the extent of the carious process.

In particular, the use of CBCT overcomes the limitations of conventional radiography because it is a minimally invasive tool that can provide images displayed in coronal, sagittal and axial planes, a large number of teeth that can be examined with the same exposure to the X-rays, it can provide a precise location of the examined lesion with the possibility of its millimetrical measurement, it gives the possibility of making right and left symmetrical evaluations, it allows the study of the three-dimensionality of the tooth in its entirety. Moreover the most important feature of CBCT is that it reduce the superimposition of the surrounding structures [46].

The research performed by Takahashi., *et al*. [47] to assess the diagnostic property of intraoral bitewing radiographs (BTW) compared with periapical radiographs (PA) showed that there was no significant difference in the specificity of BTW and PAs; moreover, they founded that BTWs offer a significant advantage over PAs in the diagnoses of early stages of interproximal carious lesions.

Our study demonstrated that the distance between obturation and pulp chamber in group A in PC images was less than in PS images. The main distance in PS images was 2,157mm (+/-0,2) and 1,403mm (+/-0,2) in PC images.

The distance between caries and pulp chamber in group B (table 2) also was less in PC images than in PS images. The main distance in PS images was 1,53mm (+/-0,2) and 0,79mm (+/-0,2) in PC images.

Overall, the distance concerning with caries and obturations (table 3) in PC images was significantly lower than PS mages. The main distance in PS images was 1,95mm (+/-0,2) and 1,20mm (+/-0,2) in PC images.

Surely having a double vision from two different points of view means that in the PC images the distance between the lesion and the pulp chamber is shorter and therefore the caries is deeper.

Our results are totally new in literature, because in other studies it was showen that the diagnosis of caries depth was the same in both PS images and PC images [20-26].

A probable explanation for these results is the superposition of healthy structures: the distance in a mesio-vestibular direction between the caries and the pulp is smaller or the total thickness of dentin visible in PC images is smaller.

Our results underline the advantage of using CBCT; however, there is to understand if this advantage can be ensured with a compatible X-ray dose; it can be used a low dose protocol [48] or new machines [49].

In our study there was only one observer, unlike other researches; this can lead to a faster scan of the results, but on the other hand to a less precise evaluation of them [43].

Only in one study was measured the depth of the lesion [43], but only our study examined the millimetric distance between the lesion or the obturation and the pulp.

The clinical relevance is that this research can open up to various approaches of treatment of deep caries: selective caries removal [50], photodynamic therapy [51], antimicrobial composites [52], ozone application [53].

Conclusions

The average distance examined in PC images was lower in all cases compared to PS images both in the caries extension and in the obturations assessments.

This result demonstrates the lack of reliability of a two-dimensional radiograph or of a single three-dimensional projection to examine the extent of a carious process and its presumable distance from the pulp tissue; this argument is superimposable also to evaluate the proximity of a previous obturation to the pulp tissue.

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