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Influence of Different Bioactive Tooth Colored Restorative Materials in Caries Detection Using Cone Beam Computed Tomography

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Abstract **Aim:** To ensure the diagnostic ability of CBCT for caries detection under different types of tooth colored restorative materials. **Material and Methods:** In the present study a total of 80 extracted carious permanent molar teeth were selected. Caries was classified as grade 3 according to International Caries Detection and Assessment System (ICDAS) criteria. Half of carious lesions were removed from 40 molars as Control specimens. Carious teeth were randomly assigned into two groups and each group was divided into four subgroups including: two carious and two non-carious as controlled group and all the teeth were filled with different bioactive restorative materials, then all the specimens were scanned with cone beam computed tomography (CBCT) using a Promax® 3DMid CBCT device (Planmeca, Oy, Helsinki, Finland). **Results:** Caries was detected in all the carious specimens of all the groups except that group A2 was much less remarkable than other groups. In the control specimens (non-carious) of all the groups: No caries was detected .**Conclusion:** Although CBCT is an excellent tool for secondary caries detection under different types of restorative materials but it should not be used as a primary diagnostic tool on regular basis. If its use is a must, so, optimized low dose low resolution protocol is recommended.

Keywords: *caries detection, CBCT, bioactive restorative materials, recurrent caries*

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1. Introduction

Recurrent or secondary caries is a carious sore happening at the interproximal edge of a current restoration, particularly in territories of biofilm gathering, for example, the cervical edges. Recurrent caries is once in a while observed on occlusal surfaces of the teeth that those edges are effortlessly cleaned. Strikingly, around 50 to 60% of restorations are supplanted on account of a determination of recurrent caries [1-6].

A visual clinical examination ought to be joined with an exploring and radiographic examination, laser or light fluorescence-based techniques, electrical impedance estimations, ultrasound, MRI and so forth to enhance the identification of recurrent caries. It is generally acknowledged that radiography is the most widely recognized and valuable assistant for the finding of caries. The quick improvement of innovation has brought forth different advanced dental imaging modalities, including digital intraoral radiography and cone beam computerized tomography (CBCT) scanners. CBCT has made storming in maxillofacial imaging, encouraging the progress of dental determination from 2D to 3D pictures and extending the part of imaging from finding to imaging guidance of operative and surgical systems by utilization of outsider programming [2-11].

2. Materials and Methods

2.1. Specimens Selection and Classification

In the present study a total of 80 extracted carious permanent molar teeth were selected. Individual tooth surfaces were hand scaled to remove any remaining soft and hard tissues. All the teeth were stored in distilled water at room temperature. Caries was classified as grade 3 according to International Caries Detection and Assessment System (ICDAS) criteria. Half of carious lesions were removed from 40 molars as Control Samples. Carious teeth were randomly assigned into two groups

Group A: 40 teeth divided into 4 subgroups

- Sub group A1: 10 carious teeth, carious cavities filled with Filtek Z350 nanofilled composite
- Sub group A1 control: 10 caries free teeth, prepared cavities filled with Filtek Z350 nanofilled composite
- Sub group A2: 10 carious teeth, carious cavities filled with glass ionomer base and Filtek Z350 nanofilled composite as final restoration

Sub group A2 control: 10 caries free teeth, prepared cavities filled with Vitrebond light cure glass ionomer base and Filtek Z350 nanofilled composite as final restoration

Group B: 40 teeth divided into 4 subgroups

Sub group B1: 10 carious lesion teeth, carious cavities filled with ACTIVIA Bioactive Restoratives

Sub group B1 Control: 10 caries free teeth, prepared cavities filled with ACTIVIA Bioactive Restoratives

Sub group B2: 10 carious teeth, carious cavities filled with ACTIVIA Bioactive base and ACTIVIA Bioactive Restoratives as final restoration

Sub group B2 Control: 10 caries free teeth, prepared cavities filled with ACTIVIA Bioactive base and ACTIVIA Bioactive Restoratives as final restoration. (Table 1).

2.2. Preparation of the Specimens

2.2.1. Group A Specimens Preparation

For subgroup A1 Cavities were etched for 10 seconds with 37% phosphoric acid, and rinsed with water spray for 10 seconds . Excess water was removed with cotton pellet or mini sponge. Bond (Adper Single bond 2) was applied with a disposable brush, 2 to 3 consecutive coats for 10 seconds with gentle agitation using a fully saturated applicator. Gently air thin for five seconds in evaporative solvents. Light cured for 10s using a halogen light source (Visulux curing unit, Vivadent; Schaan, Liechtenstein). The output of the light curing unit was regularly checked (500 mW/mm^2).

A nanofilled restorative composite (Filtek Z350 Shade A2, 3M, USA) was carefully applied into cavities and irradiated for 40 seconds according to the manufacturer's instructions. The specimens were then stored in artificial saliva at 37°C for 24 hrs.

For subgroup A2 cavities, firstly, were filled by Vitrebond light cure Glass ionomer base. One level scoop of loosely packed powder and one drop of liquid provide the recommended powder to liquid ratio. A small cement spatula used to rapidly mix (10-15 seconds) all the powder into the liquid. The mixed cement should have a smooth consistency and glossy appearance. The mixed liner/base applied to the dentin surfaces of the (carious or prepared) cavity in a thin layer (1/2mm or less) using a ball applicator. Vitrebond liner/base light cured for 30 seconds. Then, finally, Filtek Z350 Shade A2 was applied. With same steps mentioned in group A1

2.2.2. Group B Specimens Preparation

For subgroup B1, cavities were etched using 37% phosphoric acid for 10 seconds, rinsed and dried, removing all excess moisture with a cotton pellet, A mix tip was placed on the ACTIVA syringe. Syringe was inserted into ACTIVA-SPENSER and snapped into place using firm pressure. Material was dispensed using gentle pressure. To ensure an even mix of base and catalyst, 1-2mm of material was dispensed onto a mixing pad and discards this material.

ACTIVA was applied in increments up to 4mm / increment , light curing for 20 seconds between each layer. Initial self-cure setting time is 2½-3 minutes. If allowing self-curing, exposed ACTIVA surfaces were covered with an oxygen barrier, e.g. glycerin. Self-curing capability is ideal for the bulk fill technique.

For subgroup B2 cavities were dried and removing excess moisture with cotton pellet. A mix tip was placed on the ACTIVA syringe. Syringe was inserted into ACTIVA-SPENSER and snapped into place using firm pressure. Material was dispensed using gentle pressure. To ensure an even mix of base and catalyst, 1-2mm of material was dispensed onto a mixing pad and discards this material. ACTIVA Bioactive-BASE/LINER was applied to cavity dentin surfaces under final restoration then Light cured for 20 seconds. The restoration was completed along enamel surface with ACTIVA BioACTIVE-RESTORATIVE.

2.3. Caries Detection of the Specimens

All the specimens were embedded in mold of pink wax (Cavex Holland BV, Netherland) in the form of dental arch then scanned with CBCT using a Promax® 3DMid CBCT device (Planmeca,Oy, Helsinki, Finland) with following parameters (KvP 90, MA 8,exposure time 12.057s, voxel size 0.2µ).

Table 1. Composition, lot number, and manufacture of the tested materials

Material	composition	Lot number	Manufacture
Scotchbond etchant gel	35 % phosphoric acid	N 1201152	3M ESPE
Adper Single bond 2	(10% colloidal nanofiller) BisGMA, HEMA, dimethacrylates, ethanol, water, a novel photoinitiator system and a methacrylate functional copolymer of polyacrylic and polyitaconic acids	N43666	3M ESPE
Filtek Z350 XT	(20 nm silica filler 4-11 nm zirconia filler) as 72.5% by w filler bis-GMA, UDMA, TEGDMA, PEGDMA and bis-EMA resins	N664814	3M ESPE
Vitrebond™ Light Cure Glass Ionomer Liner/Base	The powder component is a light sensitive fluoro-aluminosilicate glass. The liquid component is a light sensitive polyalkenoic acid.	7510	3M ESPE
Bio active restoratives	56% by weight reactive ionomer glass particles that mimic physical and chemical properties of natural teeth., shock absorbing ionic resin component containing acidic monomer with antimicrobial properties .no Bisphenol A, No BisGMA, no BPA derivatives'	150318	PULPDENT Corporation
Bio active base	45% by weight bioactive fillers that mimic the physical and chemical properties of natural teeth. It releases and recharges with calcium, phosphate and fluoride ions, Strong, resilient ionic resin matrix. It chemically bonds to teeth, releases fluoride and Contains no Bisphenol A, No Bis-GMA and no BPA derivatives.	160408	PULPDENT Corporation

2.3.1. Visual Detection for Caries under Different Restorative Materials

The CBCT caries detection was done using "*Planmeca Romexis viewer 4.4.0.R"*. The adjustment of the image contrast and brightness by the operator to reach a subjective, personal optimum was done using built-in manipulative tools supplied by the machine software. (Figure 1). One independent well-trained radiologist with experience more than 10 years made all the CBCT caries detection after appropriate training and working on the software used in the current study *(Planmeca Romexis viewer 3.5.1.R).*

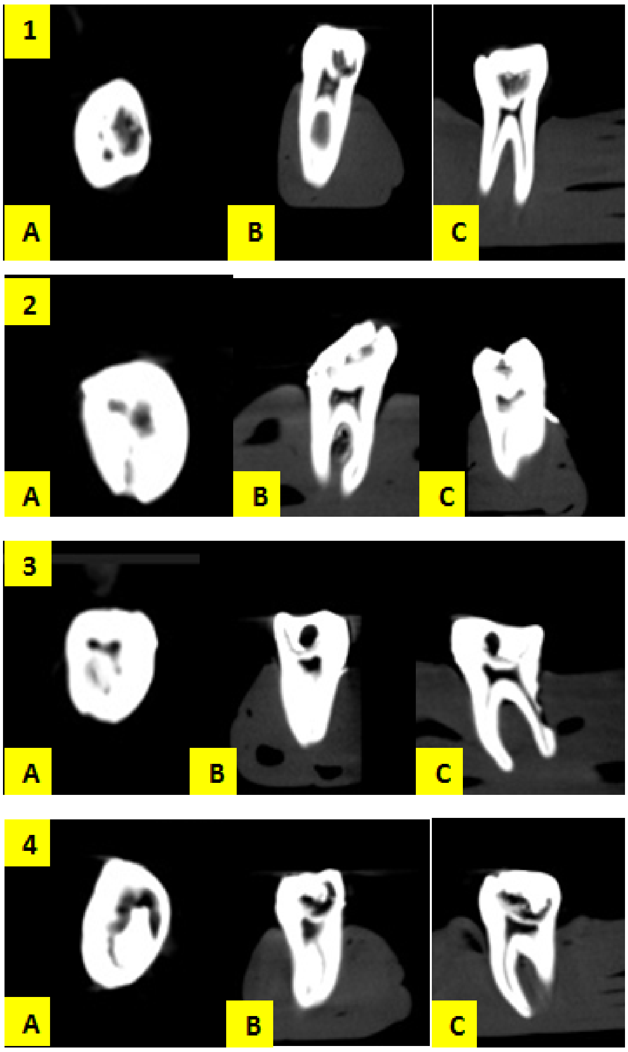

Figure 1. Showing four CBCT pictures represent the four groups conducted in the current study as follow: picture 1 represents group A1, picture 2 represents group A2, picture 3 represents group B1 and picture 4 represents group B2. In all pictures, A represents axial cut, B represents coronal cut and C represents sagittal cut. Caries was detected in all CBCT cuts

3. Results

Caries was detected in all the carious samples of all the groups except that group A2 was much less remarkable than other groups.

In the control samples (non-carious) of all the groups: No caries was detected.

4. Discussion

The present study verified the hypothesis stands for the superior diagnostic ability of CBCT for detection of secondary caries.

In spite of the advances in composite restorative materials and dentin bonding frameworks, secondary caries is yet a primary driver for failure of resin restorations. Precise, early detection of recurrent caries is the key for progress and life span of dental restorations. Radiography is among the most essential techniques for detection of caries, especially in the posterior teeth. The primary diagnosis of recurrent caries around composite restorations is especially vital in light of the fact that these restorations lack self-sealing and antibacterial properties. Resin restorations of the posterior teeth must be radiopaque because detection of marginal defects overhangs and secondary caries around these restorations exceptionally relies upon the radiopacity of these restorations [12].

The high diagnostic accuracy of CBCT frameworks is because of the way that they empower simple perception of all tooth surfaces in sagittal, coronal and axial planes and any gap or caries around the restorations are viewed as lucent zones at the tooth- restoration interface. In any case, in metal restorations, metal artifacts on the cavity walls compromise precise appraisal of the walls for caries which can dramatically reduce image quality and effectively produce caries-like 'lesions' in teeth. Therefore, the evidence indicates that CBCT should not be used for the purpose of caries diagnosis. Titanium and zirconia restorations as well as composite resins containing a minimum of 20% $AlSiO2$ cause clear artifacts on CBCT scans. The intensity of artifacts increases by an increase in the radiopacity of composite resins. In the present study, the cavity walls were effortlessly evaluated because of the nonappearance of artifacts [4,6,12,13,14].

The utilization of CBCT in routine clinical practice is impractical. However, CBCT examinations performed for different purposes it might be utilized as a subordinate for caries identification. Regardless of the conceivable favorable circumstances in analytic result of CBCT, it ought to be borne as a main priority that despite everything it brings about higher radiation dosages than conventional imaging options and intraoral examinations. Based on a systemic literature review, guidelines for the application of the CBCT have been detailed in the SEDENTEXCT project in Europe. These guidelines don't suggest CBCT for caries identification and analysis principally in light of the higher radiation dosage included contrasted with different types of intraoral radiography [2,3,15,16,17,18].

Since the radiation dose is increased when taking a CBCT image with a high spatial resolution, so, low resolution low radiation dose protocol is recommended for evaluating dentinal caries when necessary as the spatial resolution did not have any impact on the detection accuracy of proximal caries. The CBCT images should not be used for evaluating carious lesions confined in enamel [8,19,20].

In the current study, A2 carious group, caries detection was less remarkable than the other groups owing to type of the filling material as the use of glass ionomer base under Filtek Z350 nanofilled composite as final restoration has dissolved in the underlying dentine makes the caries detection less recognizable as the glass ionomer has chemical bond with dentine. This justification regarding the glass ionomer was in line with previous studies reports [23,24,25,26,27].

As almost the greater part of the investigations was done in vitro, So, their impediments were in accordance with our fundamental restrictions of the present investigation which is the in vitro think about recreated a perfect condition that avoids object movement, other teeth and tissue around the teeth, and other parameters that could create artifacts and convolute the diagnosis of caries. These might be viewed as the confinements of the present investigation.

Owing to 3d capability of CBCT, it has shown promising results in terms of the detection of caries lesions. CBCT system was evident superior to conventional and digital radiography for in vitro assessment of proximal caries lesion depth. Other factors that also compromise image quality of these systems include the voxel size, detector and FOV (field of view). As caries depth is also crucial for the diagnostic accuracy of radiographic systems. In respect to voxel size, Surprisingly, insignificant differences among machines with different voxel sizes (0.076mm to 0.322mm) was found on proximal caries diagnosis in previous study comparing five different CBCT machines regarding caries detection [1,10,20,28,29].

5. Conclusion

Although CBCT is an excellent tool for secondary caries detection under different types of restorative materials but it should not be used as a primary diagnostic tool on regular basis. If its use is a must, so, optimized low dose low resolution protocol is recommended.

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