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Original article

Comparative Study Between 0.125mm, 0.35mm and 0.75mmVoxel Sizes of Cone Beam Computed Tomography in Diagnosis of Secondary Caries Lesions Under Composite Restorations (An In vitro Study)

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ABSTRACT

The aim of this study was to assess the diagnostic accuracy of Cone Beam Computed Tomography (CBCT) with different voxel sizes in detection of simulated recurrent caries beneath composite restoration. In this study, a total of 40 proximal slots of class II cavities were prepared on 40 extracted human premolars and molars. Then, 20 teeth were randomly selected out of these sample and artificial carious lesions were created on these teeth by a round diamond bur no .2(study group). All cavities were restored by using composites resin and radiographed with CBCT unit (Cranex 3D) using 5x5mm field of view at three voxel sizes 0.35mm, 0.125mm, 0.75mm. Intra- and inter-observer agreements were calculated with Kappa statistics (κ). The area under the receiver operating characteristic (ROC) curve was used to evaluate the diagnostic ac curacy. The AUCs value for CBCT with voxel sizes 0.35mm, 0.125mm, 0.75mm was 0.983 ,0.900,0.817, respectively. The kappa value for inter-observer agreement was 0.993,0.989,0.938; respectively. Diagnostic Accuracy of CBCT was high in detecting the simulated small secondary proximal caries under composite restoration, voxel size 0.125mm can be used to detect caries lesions with adequate accuracy and the least patient exposure dose.

Keywords: Cone-Beam Computed Tomography, Secondary Caries, Digital Dental X-rays.

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كان الهدف من هذه الدراسة هو تقييم الدقة التشخيصية للتصوير المقطعي المخروطي بأحجام فوكسل مختلفة في الكشف عن التسوس تحت الحشوات. في هذه الدراسة، تم تحضير ما مجموعه 40 فتحة قريبة من تجاويف الدرجة الثانية على 40 من الضواحك والأضراس البشرية المستخرجة. بعد ذلك، تم اختيار 20 سناً عشوائياً من هذه العينة وتم إنشاء آفات نخرية اصطناعية على هذه الأسنان بواسطة السن الماسي الدائري رقم 2 (مجموعة الدراسة). تم ترميم جميع التجاويف باستخدام الراتنجات المركبة وتصويرها شعاعياً بوحدة CBCT (Cranex 3D) باستخدام مجال رؤية 5 × 5 مم بثلاثة أحجام فوكسل 0.35 مم، 0.125 مم، 0.75 مم. تم حساب الاتفاقيات داخل وبين المراقبين باستخدام إحصائيات كابا .(κ) تم استخدام المنطقة الواقعة أسفل منحنى خاصية تشغيل المستقبِل (ROC) لتقييم دقة التشخيص. قيمة AUCs لـــ CBCT بأحجام فوكسل 0.35 مم، 0.125 مم، 0.75 مم كانت 0.817،0.900،0.983 على التوالي. كانت قيمة كابا لاتفاق بين المراقبين 0.938،0.989،0.993 على التوالي. دقة تشخيص CBCT كانت عالية في الكشف عن التسوس الثانوي تحت الترميم المركب، ويمكن استخدام حجم فوكسل 0.125 ملم للكشف عن آفات التسوس بدقة كافية وبأقل جرعة تعرض للمريض.

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INTRODUCTION

Dental caries is the most common dental disease that, if left uncontrolled, can have serious consequences [1]. Secondary caries lesion is a type of caries frequently found in restored teeth and is defined as a type of caries occurring at the margin of an existing restoration, running along the cavity walls, especially in areas of plaque stagnation [2].

Composites are now the most frequently used materials in dental restorations because of their desirable esthetics and adhesion to dental tissue, enabling minimally invasive preparation [3,4]. Despite the advances in composite restorative materials and dentin bonding systems, recurrent caries is still a main cause for failure of resin restorations [5,6]. Accurate, early detection of recurrent caries is the key for success and longevity of dental restorations [7].

Various methods are available for diagnosing dental caries. Sometimes, the extension of caries is so small that they cannot be visualised or diagnosed without the assistance of radiographic images. X-rays are one of the best methods for diagnosing dental caries and damage to the tooth root [8]. In order to enable better detection of caries, it may be recommended to combine using traditional methods like visual examination and probing [9] with other diagnostic aids such as radiography, laser or light fluorescence-based methods [10].

Conventional intraoral film, solid-state detectors and photostimulable phosphor plates are the most commonly preferred and available modalities for diagnosing caries in conjunction with visual and clinical examination in routine dental practice [11]. Compared with traditional film technology, digital imaging systems have a number of advantages, such as adjustable images, avoidance of chemical processing, lower dose, less working time and convenient communication, etc [12]. Regardless the type, a major limitation of intraoral radiographies is that it is a 2-dimensional (2D) imaging method that is used to record 3-dimensional (3D) anatomic structures [13]. Because of that, their ability to detect caries may be affected by beam angulation, imaging settings, and patient-related factors [14].

Some studies have concerned about the dental application of 3D imaging modalities to avoid the overlap of 3D anatomic structures in 2D images.[15] CBCT is a high-quality radiography for diagnosis and treatment planning. This imaging modality provides three-dimensional (3D) images of axial, coronal and sagittal planes with excellent submillimeter resolution.[16] CBCT has been suggested as a suitable tool for detection of small carious lesions. Intraoral radiography provides 2D images of the teeth and thus, caries on the buccal and lingual walls cannot be detected using this technique [17]. The aim of this study was to assess the diagnostic accuracy of cone beam computed tomography (CBCT) with different voxel sizes in detection of simulated recurrent caries beneath composite restoration.

METHODS

In this study, 40 non-carious non-restored extracted human permanent premolars and molars were used due to orthodontic or periodontal reasons. All the teeth were randomly divided to two equal groups (n = 15); one group as the study and the other as the control group. Standard proximal slots of class II cavities were prepared on all teeth using Komet fissure bur1.2 to 1.4 mm. In the study group, round bur (1.0 mm in diameter) was used for preparing a hole at the proximal of the cavity to simulate an artificial secondary caries. Then, filling the holes of each tooth with rose wax, the proximal cavities were filled with composite (Z250 XT, 3M ESPE Dental Products, St, Paul, MN, USA). The same procedure was done for the control group without artificial secondary caries preparation. All the teeth were randomly embedded in the wax blocks. Each block held four teeth consisting of two premolars and two molars and the block mounted in plaster simulating the normal anatomical position. The radiographies were taken from the teeth using CBCT.

For taking the CBCT images, each model was placed on the chin rest to be radiographed using, CRANEX 3Dx machine (SOREDEX, PaloDEx Group Oy Nahkelantie 160 Tuusula,04300 Finland) CBCT system The CBCT

system operated at 89 kVP, 6 mA with 5 cm× 5 cm field of view (FOV) andscanning time, at three different voxel sizes (0.35,0.125,0.75mm) and the acquired data were reconstructed with 1 mm thickness All 3D sections (axial, coronal and sagittal) were evaluated.

Three observers, Oral and Maxillofacial Radiologists, experienced Operative dentist and a postgraduate student evaluated all radiographs on two separate occasions with at least 1week interval.

The images were arranged in random, but it was the same for all three observers. Regarding the presence of recurrent carious lesion, a 5-point confidence level was used: 1 = definitely no caries, 2 = probably no caries, 3 = questionable, 4 = probably caries, 5 =definitely caries. SPSS (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp) adopted for statistical analysis. The area under (AUC) the receiver operating characteristic (ROC) curve was used to evaluate the diagnostic accuracy. Kappa analysis was used to evaluate the inter- and intra-operator agreement. Differences were considered to be statistically significant when $P < 0.05$.

RESULTS

The AUC value for CBCT with different voxel sizes. 0.35mm, 0.125mm, 0.75mm was 0.983, 0.900 and 0.817 respectively. although AUC of CBCT with voxel size 0.125mm was inferior to that of 0.35mm voxel sixe, no significant difference in discrimination ability between both voxel sizes (p=0.150). While AUC of 0.75mm voxel size was significantly lower than 0.35mm voxel size(p=0.005).

Decrease the voxel size was associated with increased discrimination ability between caries and non caries. The sensitivity, specificity, and accuracy were highest at CBCT with voxel size 0.85mm, followed by 0.125mm voxel size, then 0,75mm voxel size. The kappa value for inter-observer agreement was high to perfect, ranged from (0.938 to 1) The highest agreement was found at CBCT with voxel size 0.35mm, while the lowest was found at CBCT with voxel size 0.75mm.

DISCUSSION

Diagnosis of secondary caries may cause problems for the clinician. In order to enable better detection, it is advised that visual examination and probing be combined with other diagnostic aids such as X-ray imaging, laser or light fluorescence-based method [18].

Advancement of secondary caries, which happens beneath distinctive filling of helpful materials, is considered a major cause of remedial disappointment and substitution. It is in this manner pivotal to analyze early secondary caries, in arrange to avoid extreme devastation of difficult tissue and to upgrade the forecast for a successful treatment outcome [19].

The diagnostic accuracy of CBCT was tested in different types of cavities with composite restorations for secondary caries detection in the present study. The komet burr with one-mm-diameter was used to simulate secondary caries under restorations in accordance with previous studies The use of small burs has been recommended since larger burs were found to be ineffective for simulation of caries lesions [20].

With the widely usage of the Cone-Beam Computed Tomography in the dental field, this current in vitro study was designed to evaluate its role in assessment of artificially secondary caries of proximal surface to aid clinicians decide the most valid and accurate technique in detecting this type of caries lesions without exposing the patient to unnecessary radiation.

In the present study, three observers evaluated 40 teeth and found that the diagnostic accuracy of the CBCT system with different voxel sizes was 0.983, 0.900 and 0.817 respectively. although AUC of CBCT with voxel size 0.125mm was inferior to that of 0.35mm voxel sixe, no significant difference in discrimination ability between both voxel sizes (p=0.150). While AUC of 0.200mm voxel size was significantly lower than 0.35mm voxel size(p=0.005)

In this study, the small voxel size and FOV were selected for CBCT scanning because reducing field size has been reported to increase spatial resolution and image quality [21].

Table 1. Diagnostic performance of CBCT with different voxel sizes and Inter observer agreement of CBCT with different voxel sizes for diagnosis of secondary caries lesions

Caries in proximal wall	AUCs of CBCT with different voxel sizes in diagnosis of caries	Sensitivity	Specificity	Accuracy	ICC between First and second observer	ICC between First and third observers	ICC between Second and third observers	ICC between all observers
0.35mm	0.983	96.7(%)	100 (%)	98.3 (%)	1	0.984	0.997	0.993
Voxel size 0.125 mm	0.900	86.7	93.3	90	0.994	0.991	0.984	0.989
Voxel size 0.75mm	0.817	76.7	86.7	81.7	0.943	0.961	0.930	0.938
Voxel sizes The mean of all voxel sizes	0.933	90.0	96.7	93.3	0.979	0.984	0.970	0.973

In the present study the Inter-operator kappa agreement value in CBCT images was and that reveals the potential of new radiological technologies like CBCT in detecting a common dental problem like the secondary caries. Finally, we performed this study not aiming to use or to support CBCT images in detection of secondary caries. However, a provisional guideline for CBCT application (produced by the SEDENTEXCT project in Europe in2009) [22], states that "CBCT images must undergo a thorough clinical evaluation ('radiological report') of the entire image dataset," It is, therefore, possible to find suspected secondary caries on CBCT images prescribed for other dental purposes such as implants, root fractures, complex maxillofacial fractures, and so on. Our study might, at least, indicate that CBCT images had some efficiency but still had some limitations in detection of secondary caries.

CONCLUSION

This in vitro study, with a limited number of samples, showed the CBCT system was significantly more accurate in detecting the simulated secondary proximal caries under composites restoration. 0.125mm voxel size is ideal voxel of CBCT in detection of secondary caries lesions

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