Accuracy of Cone-beam Computed Tomography and Extraoral Bitewings Compared to Intraoral Bitewings in Detection of Interproximal Caries

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ABSTRACT

Aim and objective: The purpose of this study is to evaluate the diagnostic accuracy of cone-beam computed tomography (CBCT) and extraoral bitewings in the detection of interproximal caries compared to intraoral bitewings.

Materials and methods: Seven preserved cadaver heads with 106 teeth (molars, premolars, and canines) including 183 proximal surfaces were used. Five radiographic modalities were studied: intraoral bitewings, extraoral bitewings, iCAT 3D, ProMax 3D high resolution, and ProMax 3D low resolution. Seven pediatric dental residents were recruited and calibrated as observers and asked to evaluate each proximal surface. Teeth were extracted, mounted, drilled, caries detection dye was applied, and the surfaces were examined under the light microscope. Interexaminer reliability, sensitivity, specificity, and area under the curve values were compared.

Results: No significant differences were found in sensitivity, specificity, and area under the curve values between the five radiographic modalities. Restorations may influence the accuracy of caries diagnosis.

Conclusion: Cone-beam computed tomography radiographs and extraoral bitewings showed similar accuracies in detecting interproximal caries compared to intraoral bitewings. This suggests that with proper training and experience, CBCT and extraoral bitewings could be comparable to intraoral bitewings in detecting interproximal caries.

Clinical significance: Cone-beam computed tomography and extraoral bitewings could potentially serve as alternatives to intraoral bitewings to diagnose proximal caries, especially when the CBCT study is needed for a specific diagnostic purpose.

Keywords: Cone-beam computed tomography diagnostic accuracy, Cone-beam computed tomography, Dental caries, Dental digital radiography, Extraoral Bitewings, Interproximal caries, Intraoral bitewings.

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INTRODUCTION

Since the introduction of the cone-beam computed tomography (CBCT) technology to the world of dentistry in the late 1990s, there has been great interest in CBCT by dentists from multiple specialties such as oral and maxillofacial surgery, orthodontics, implantology, endodontics, periodontics, and forensic dentistry.^{1,2} The promising feature of this new technique is the ability to produce three-dimensional radiographic images that are cheaper and utilize a much lower radiation dose than conventional CT.³ The advantages of CBCT include easy handling, office-size machines, ability to generate three-dimensional and two-dimensional images, accessibility, and user-friendly viewing software.⁴ The applications of CBCT in the clinical dental practice include diagnosis of maxillofacial pathology and skeletal fractures of the head, planning of implant placements, temporomandibular joint (TMJ) assessment, diagnosis and treatment planning in orthodontics, and diagnosis of vertical root fractures.^{5,6} The main drawback of CBCT is its higher dose of radiation compared to conventional dental radiography. However, there is a wide variation in radiation doses among different CBCT machines.⁷ Despite the relatively higher radiation dose imparted to the patient, the use of the CBCT technology has managed to increase dramatically in the field of dentistry by offering new applications that were not previously available. A potential application of CBCT is caries diagnosis. The CBCT imaging is better tolerated by patients, compared to intraoral imaging techniques, as it is associated with less discomfort during imaging.⁸ Although

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Conflict of interest: None

CBCT should not be used for the sole purpose of caries diagnosis, it would be more efficient if the dentist was able to diagnose caries from a CBCT scan that was done for other diagnostic purposes.⁹

Although intraoral bitewing radiographs are considered the standard of care in diagnosing interproximal caries, it is challenging sometimes to obtain bitewings in patients who have increased gag reflex or in uncooperative pediatric patients, which might lead to a dental disease going undetected.^{8,9} In addition, the improper positioning of intraoral films or sensors may require a retake of the image. An alternative diagnostic modality that does not require the placement of a sensor or a film inside the oral cavity might be beneficial in providing appropriate dental care for these patients. The concept of extraoral bitewings has been recently introduced by a few panoramic X-ray machines manufacturers.¹⁰ A special software program utilizes the same projection technique of the panoramic X-ray to produce extraoral bitewings images that show the crown and roots of premolars and molars in addition to parts of the maxillary sinus and the mandibular canal.¹¹ The improved interproximal projection geometry of the extraoral bitewing images shows interproximal contacts without overlap because the rotational movement of the machine ensures that the X-ray beam is perpendicular to each contact area during the imaging.¹² The purpose of this study is to evaluate the diagnostic accuracy of CBCT and extraoral bitewings in the detection of interproximal caries compared to intraoral bitewings.

MATERIALS AND METHODS

This study was designed as an *in vitro* study. The study protocol was exempt by the Health Sciences Campus Institutional Review Board at Tufts University. The sample size was calculated by SAS 9.3, assuming disease prevalence = 60%, sensitivity = 0.17, and specificity = 0.90.^{13,14} It was found that 140 surfaces were required to estimate 95% confidence intervals for the sensitivity and specificity with an 80% power. The Anatomy Department of the School of Medicine at Tufts University provided seven cadaver heads for the study. The seven cadaver heads included 106 teeth (molars, premolars, and canines), which provided 183 surfaces (the mesial and distal surfaces of molars and premolars and the distal surfaces of canines) for radiographic examination. The use of cadaver heads allowed accurate anatomical representation of osseous and soft tissues along with teeth in their natural alignment in the jaws.

Imaging

The cadaver heads were mounted on customized bases for easier handling and positioning in the X-ray machines. The heads were radiographically imaged with intraoral digital bitewings, ProMax

(extraoral bitewings), i-CAT, and ProMax 3D high and low resolution. Table 1 shows the different radiographic modalities that were used in the study and the specifications of each machine. Images were labeled with the anatomy lab's cadaver number. Figure 1 presents an example of positioning a cadaver head in the Promax Planmeca CBCT unit for imaging.

Caries Detection

After the imaging, the teeth were extracted from the cadaver specimens, preserved in saline, and mounted on dental stone bases. The proximal nonrestored surfaces of the teeth were drilled with high-speed fissure bur to create a small narrow cavity. All proximal surfaces were drilled whether caries was visible or not to ensure that caries was detected in surfaces that did not show surface enamel destruction. Caries detection dye was applied into the cavity to determine the depth of the carious lesions. In cases of restored surfaces, the restorations were removed, and the caries detection dye was then applied. Each surface was evaluated under a 10x magnification light microscope and categorized into: 1—sound; 2—caries extends less than half of the enamel depth; 3—caries extends more than half of the enamel depth; 4—caries extends less than a third of the dentin depth; 5—caries extends more than a third but less than two-thirds of the dentin depth; 6—caries extends more than two-thirds of the dentin depth.

Fig. 1: A cadaver head mounted on the ProMax CBCT machines

Table 1: The X-ray machines' specifications and settings used in the study

X-ray modality	kV	mA	Scan time (seconds)	Detector	FOV	Voxel size	Software
Intraoral bitewings Gendex GX-770	70	7	0.08	CDR Elite (Schick)	—	—	MiPACS Dental Enterprise Viewer 3.1.1320, Medicor Imaging, Lead technologies, inc, Charlotte, NC
Extraoral bitewings ProMax	68	8	8.6	CCD sensor	—	—	
i-CAT 3D	120	18.66	20	Amorphous silicon flat panel sensor with CSI scintillator	13 × 13 cm	0.3 mm	Xoran technologies LLC, Ann Arbor, MI
ProMax 3D high resolution	76	6	18	Flat-panel sensor (CMOS FP)	8 × 8 cm	0.16 mm	Planmeca Romexis 4.0 viewer, Planmeca ISA Inc, Roselle, IL
ProMax 3D low resolution	84	6	17.1 (2.8)		8 × 8 cm	0.32 mm	

Calibration and Observation Sessions

Seven residents in the postgraduate pediatric dentistry program were recruited as observers. Residents from the pediatric dentistry department were chosen because pediatric dentistry is one of the specialties that is more frequently involved in diagnosis of proximal caries than other specialties, e.g., orthodontics or prosthodontics. Each participant was given an information sheet describing the study. Participation was voluntary and had no effect on a student's academic standing.

Calibration sessions were held to train and calibrate each observer in diagnosing caries using the different radiographic modalities in the study. Sample images of teeth (teeth that were not included in the study) with sound and carious interproximal surfaces were presented to the observers during these training sessions. In addition, the observers were trained to navigate the software used for viewing the images of each radiographic modality. Each calibration session was approximately 30 minutes long. Following each calibration session, there was an evaluation session where the residents evaluated the study images individually. Calibration and evaluation sessions took place in a dimly lit room and the observers were given Excel spreadsheets to record their evaluations. Each evaluation session lasted approximately 45–60 minutes. There was a 1-week interval between evaluation sessions to minimize learning bias.

The sessions were as follows:

- Session 1a: Software calibration of intraoral bitewings
- Session 1b: Evaluation of intraoral bitewings
- Session 2a: Software calibration of extraoral bitewings
- Session 2b: Evaluation of extraoral bitewings
- Session 3a: Software calibration of i-CAT images
- Session 3b: Evaluation of i-CAT images
- Session 4a: Software calibration of ProMax images
- Session 4b: Evaluation of ProMax high-resolution images
- Session 4c: Evaluation of ProMax low-resolution images

The original software of each radiographic modality was used by the observers to allow adjustment of brightness, contrast, and plane of viewing for the best possible viewing approach that simulated the clinical practice. The images were viewed on similar screens with identical color/brightness and screen resolution settings. The display screens were 17-inch Dell 1703FP TFT LCD (Dell,

TX, USA) screens. The images were presented to the observers in a different and random order in each session to minimize learning bias. The viewers were asked to evaluate and rate with confidence each proximal surface coronal to the cementoenamel junction on a scale adapted from the literature,^{10,11,14–17} as follows:

- Definitely no caries
- Probably no caries
- Questionable
- Probably caries
- Definitely caries

Scores 1 and 2 were treated as sound and scores 3–5 were considered caries for purposes of calculating sensitivity and specificity. An example of the radiographic images of the five radiographic modalities is shown in Figure 2.

Data Analysis

The statistical plan was analogous to the statistical analysis of the previous research concerning CBCT and caries,^{11,15–22} for easier comparison of the results. Interobserver agreement was evaluated by the intraclass correlation coefficient (ICC). Scores above 0.75 were considered excellent, scores between 0.60 and 0.74 were considered good, scores between 0.40 and 0.59 were considered fair, and scores below 0.40 were considered poor.²³ Sensitivity, specificity, and area under the curve (AUC) were calculated for each observer and the values were compared using the ANOVA test to detect any significant differences between the five radiographic modalities. To evaluate the effects of restorations on the accuracy of caries diagnosis, a supplemental analysis was conducted by excluding restored surfaces and analyzing only nonrestored surfaces. The IBM SPSS Statistics 23 software was used for the analyses.

RESULTS

A total 183 proximal surfaces were included in the study. Approximately half of the surfaces were found to be carious, 16.94% of the surfaces were restored with amalgam, and 9.29% were restored with composite. Table 2 shows the frequency of restorations and caries in the extracted teeth according to the depth of lesions, as determined using caries detection dye. Table 3 shows the interexaminer reliability for each radiographic modality measured by ICC for all surface and after excluding

Figs 2A to E: Radiographs of the five radiographic machines showing the proximal surfaces of maxillary and mandibular left premolars: (A) Intraoral bitewings; (B) Extraoral bitewings; (C) i-CAT 3D; (D) ProMax 3D high resolution; (E) ProMax 3D low resolution

restored surfaces. Intraoral bitewings showed excellent agreement (0.884–0.886) between observers while all the other radiographic modalities showed good agreement (0.631–0.773) as demonstrated by the ICC values. Excluding restored surfaces had a slight effect on the values of the ICC. Table 4 shows the sensitivity and specificity for the five radiographic modalities for each observer for all the surfaces. The values of sensitivities, specificities, and AUC of extraoral bitewings and the three CBCT machines were very comparable to intraoral bitewings indicating that they have similar diagnostic accuracy. Table 5 shows the same parameters after excluding the restored surfaces. In general, the AUC values of the observers were slightly higher when all surfaces were analyzed compared to analyzing only nonrestored surfaces. Table 6 shows the mean sensitivities, specificities, and AUC values for each of the radiographic modalities including and excluding restored surfaces. No statistically significant differences were found between the five radiographic modalities in terms of sensitivity, specificity, and AUC values when including or excluding restored surfaces, which indicates that the diagnostic accuracies of interproximal caries of extraoral bitewings and the three CBCT modalities were similar to intraoral bitewings. Including restored surfaces in the analysis negatively impacted the sensitivity of intraoral bitewings, which suggests that restorations in intraoral bitewings may interfere with the detection of caries under restorations. However, including restored surfaces significantly increased the specificity values of intraoral and extraoral bitewings, which implies that the observers were more likely to correctly identify the absence of caries under restorations when these proximal surfaces were truly caries-free. Excluding restored surfaces significantly decreased the AUC values of the three CBCT machines, which may indicate that CBCT could enhance caries detection under restorations.

DISCUSSION

Even though CBCT is a relatively new technology, it has managed to find applications in many fields of dentistry.⁸ The use of CBCT as a tool for caries diagnosis has not gained much interest. Justifiably, the main reason is the higher radiation dose of CBCT imparted to the patient compared to conventional intraoral radiographs.⁹ However, if CBCT radiographs were proven to have comparable and satisfactory caries diagnostic abilities to intraoral modalities, this would allow dentists to retrieve one extra piece of information from a CBCT scan that is obtained for any other diagnostic purpose.

Table 2: Frequency of restorations and carious lesion according to depth as determined by caries detection dye

Caries depth	Amalgam	Composite	No restoration	Total
Sound	11 (6.01%)	8 (4.37%)	70 (38.25%)	89 (48.63%)
Enamel	8 (4.38%)	4 (2.19%)	34 (18.58%)	46 (24.87%)
Dentin	12 (6.56%)	5 (2.74%)	31 (16.94%)	48 (26.23%)
Total	31 (16.94%)	17 (9.29%)	135 (73.77%)	183 (100%)

For example, a CBCT scan that has been ordered for an implant treatment planning could additionally be used to diagnose interproximal caries. In fact, this would exclude the need for bitewings to diagnose caries, which will decrease the radiation dose received by the patient. Additionally, future advances in detector types and software algorithms may lead to a substantial decrease in the radiation exposure of CBCT.

The aim of this study was to assess the efficacy of CBCT and extraoral bitewings in diagnosing interproximal caries, compared to intraoral digital bitewings. The findings show that the difference in accuracy between the five radiographic modalities was not significant, indicating that CBCT and extraoral bitewings are useful alternatives to intraoral bitewings. CBCT has been investigated as a caries diagnostic tool and several advantages have been proposed for that purpose. The results of our study agree with several *in vitro* studies that have explored the area of caries diagnosis using CBCT and indicated that CBCT performed similarly or slightly better than conventional radiography in terms of sensitivity, specificity, accuracy, and area under the curve (AUC) values. Tsuchida et al. found no statistical difference between the AUC values of the 3DX Accuitomo and film (Kodak Insight).²¹ Haiter-Neto et al. also found that the 3DX Accuitomo showed comparable sensitivity and specificity to photo-stimulable phosphor plate (PSP) (DigoraFMX; Gendex DC) and film (Kodak Insight; Gendex DC), but the 3G NewTom showed lower accuracy.¹³ Akdeniz et al. showed that the 3DX Accuitomo was more accurate in determining lesion depth than film (Kodak F-speed; Gendex Oralix DC) or Digora FMX (Soredex; GendexOralix DC).¹⁸ Young et al. concluded that the 3DX Accuitomo improved the detection of proximal caries extending into dentin compared to a charge-coupled device (Gendex 1000).¹⁴ Senel et al. compared Kodak E speed (Trophy Trex), PSP (Diagora Optime; Trophy Trex), and an ILUMA scanner (Kodak) and found similar AUC values between all the radiographic modalities.²⁰ Kayipmaz et al. found that the AUC values obtained from CBCT (Kodak 9500) were not significantly different from the AUC values of film and phosphor plate.¹⁶ These studies showed compelling *in vitro* evidence that the diagnostic efficacy of the studied CBCT systems was as good as film or phosphor plate. Therefore, Qu et al. compared five different CBCT systems (NewTom9000, 3DX Accuitomo, KODAK 9000 3D, Promax3D, a DCT Pro) in proximal detection and found no statistical difference between the AUC values.¹⁹ Few studies demonstrated contradicting results in which the conclusion was that the NewTom 3G did not improve the accuracy of caries diagnosis over the E-speed film. However, the study showed that the NewTom 3G had slightly higher values of sensitivity, specificity, and AUC values than E-speed film.²² Also, Krzyżostaniak et al. found that the accuracy of NewTom 3G in diagnosing proximal noncavitated caries was inferior to that of conventional film and PSP plates.²⁴ The diagnostic power of CBCT for occlusal caries has also been investigated and consistently found to be superior to that of digital and phosphor plate intraoral bitewings.^{13,14,16,24,25} Few studies have compared extraoral to intraoral bitewings but the results were conflicting. Khan et al.

Table 3: The interexaminer reliability for each radiographic modality measured by ICC including and excluding restored surfaces

ICC	Intraoral bitewings	Extraoral bitewings	iCAT	ProMax 3D high	ProMax 3D low
All surfaces	0.884	0.773	0.729	0.675	0.715
<i>p</i> value	>0.001	>0.001	>0.001	>0.001	>0.001
Excluding restored surfaces	0.884	0.737	0.752	0.631	0.696
<i>p</i> value	>0.001	>0.001	>0.001	>0.001	>0.001

Table 4: The sensitivity, specificity, and AUC for intraoral bitewings, extraoral bitewings, iCAT, and ProMax 3D high and low resolution for each observer for all the surfaces

Observers	Intraoral bitewings			Extraoral bitewings			iCAT			ProMax 3D high			ProMax 3D low		
	Sens	Spec	AUC	Sens	Spec	AUC	Sens	Spec	AUC	Sens	Spec	AUC	Sens	Spec	AUC
Obs1	35.42	71.91		56.25	49.44		50	59.55		60.42	43.82		45.83	59.55	
	0.548			0.542			0.545			0.515			0.524		
Obs2	23.96	82.02		33.33	83.15		38.54	66.29		42.71	70.79		59.38	49.44	
	0.546			0.575			0.512			0.571			0.546		
Obs3	28.13	79.78		50	59.55		55.12	56.18		45.83	59.55		36.46	68.54	
	0.590			0.549			0.565			0.521			0.531		
Obs4	59.38	46.07		39.58	64.04		77.08	30.43		32.29	67.42		28.13	74.16	
	0.589			0.525			0.546			0.510			0.507		
Obs5	32.29	64.04		47.92	51.96		45.83	60.76		47.29	66.29		43.75	68.54	
	0.529			0.509			0.510			0.592			0.566		
Obs6	32.29	66.29		57.29	57.3		57.29	49.44		57.29	40.45		61.46	42.7	
	0.499			0.607			0.528			0.508			0.517		
Obs7	35.42	64.04		37.5	60.76		52.08	46.07		88.54	20.22		67.71	43.82	
	0.526			0.496			0.539			0.554			0.553		

Table 5: The sensitivity, specificity, and AUC for intraoral bitewings, extraoral bitewings, iCAT, and ProMax 3D high and low resolution for each observer for the surfaces after excluding restored surfaces

Observers	Intraoral bitewings			Extraoral bitewings			iCAT			ProMax 3D high			ProMax 3D low		
	Sens	Spec	AUC	Sens	Spec	AUC	Sens	Spec	AUC	Sens	Spec	AUC	Sens	Spec	AUC
Obs1	53.80	48.50		51.00	47.10		54.20	50.00		53.10	50.00		51.10	48.30	
	0.489			0.446			0.495			0.401			0.486		
Obs2	54.50	48.20		70.40	54.80		45.50	44.1		57.1	50.00		50.00	46.30	
	0.520			0.575			0.427			0.540			0.449		
Obs3	54.20	48.20		56.50	50.80		55.30	50.80		46.70	46.20		48.40	45.30	
	0.537			0.580			0.487			0.463			0.448		
Obs4	52.40	46.80		46.00	41.70		52.90	49.10		50.00	48.00		41.90	44.60	
	0.524			0.505			0.514			0.534			0.402		
Obs5	47.60	44.60		52.90	50.00		52.30	48.80		49.10	45.30		50.00	48.00	
	0.428			0.518			0.465			0.427			0.495		
Obs6	55.70	52.20		51.40	48.50		50.70	45.50		40.70	44.40		50.00	47.70	
	0.580			0.525			0.478			0.465			0.519		
Obs7	51.20	46.90		51.10	49.10		47.30	44.90		53.80	58.80		57.10	57.50	
	0.500			0.453			0.443			0.524			0.541		

Table 6: The means of AUC in each radiographic modality including and excluding restored surfaces

	Sensitivity			Specificity			AUC values		
	Including restored surfaces	Excluding restored surfaces	p value	Including restored surfaces	Excluding restored surfaces	p value	Including restored surfaces	Excluding restored surfaces	p value
Intraoral bitewings	35.27 ± 11.39	52.77 ± 2.71	0.002	67.73 ± 12.01	47.91 ± 2.31	0.004	0.547 ± 0.033	0.511 ± 0.047	0.18
Extraoral bitewings	45.98 ± 9.36	54.19 ± 7.79	0.10	60.88 ± 11.04	48.85 ± 3.98	0.019	0.543 ± 0.039	0.515 ± 0.053	0.289
iCAT	53.70 ± 12.04	51.17 ± 3.60	0.603	52.67 ± 11.97	47.60 ± 2.70	0.312	0.535 ± 0.02	0.473 ± 0.030	0.001
ProMax 3D high resolution	53.48 ± 18.04	50.07 ± 5.36	0.646	52.86 ± 18.53	48.24 ± 4.32	0.626	0.539 ± 0.034	0.479 ± 0.055	0.001
ProMax 3D low resolution	48.96 ± 14.40	49.79 ± 4.46	0.889	58.10 ± 12.87	48.96 ± 4.86	0.094	0.535 ± 0.021	0.477 ± 0.048	0.013
p value	0.089	0.547		0.222	0.951		0.805	0.30	

found no statistical differences between the two modalities.¹⁰ However, Kamburoglu et al. concluded that extraoral bitewings were inferior to intraoral bitewings in terms of diagnostic accuracy for interproximal caries.¹¹

The effects of restoration on the diagnostic accuracy of the five radiographic modalities were investigated. The sensitivity of intraoral bitewings was significantly higher after the exclusion of restored surfaces. The specificity of intraoral and extraoral bitewings decreased after the exclusion of restored surfaces. The exclusion of restored surfaces did not affect the sensitivity or specificity of the CBCT images. The changes in sensitivity and specificity in two-dimensional images could be related to the superimposition of restoration on adjacent proximal surfaces. As there is no superimposition with three-dimensional modalities, the presence or absence of preexisting restoration did not impact the sensitivity and specificity of these modalities. Regarding the AUC values, no significant difference in intraoral and extraoral bitewing images was evident when including or excluding restored surfaces. However, there was a significant improvement in AUC values for CBCT modalities when including restored surfaces versus excluding them. This could be explained by the corresponding increasing trend in sensitivity and specificity in the three-dimensional modalities when including the restored surfaces.

Several advantages of CBCT over film and phosphor plate have been described in the literature.⁶ An interesting finding in our study and in previous studies was that CBCT had higher sensitivity without a loss of specificity, compared to film and phosphor plate. This suggests that CBCT can better identify carious lesions that might have gone undiagnosed with conventional dental radiographs. Another advantage that has been described in the literature for CBCT over film was the ability to determine the depth of carious lesion more accurately.¹⁸ This could be explained by the fact that carious lesions extending into dentin are pyramidal in shape with the apex of the pyramid toward the pulp. When film and phosphor plates produce two-dimensional images of three-dimensional carious lesions, the sound dentin around the apex of the pyramid blurs the actual extent of the lesion on the radiograph. Cone-beam computed tomography eliminates this deficiency by producing three-dimensional images of three-dimensional objects allowing the viewer to fully control the plane of view.^{14,25} The use of cadaver heads can also be considered as a strength of the study, since it captured the natural alignment of the teeth and exactly represented the soft tissue around the teeth.

One limitation in our study was the low AUC scores obtained for all modalities in this study, which was also found in previous

studies.^{24,26} Of the 183 surfaces included in the study, 48.63% of the surfaces were diagnosed as sound and 24.87% were enamel lesions (Table 2). We think the AUC values obtained across all modalities in this study were influenced by the fact that the majority of the carious surfaces in our study were shallow lesions compared to studies that had higher AUC values with predominantly deep dentin lesions (70.7%).¹² This was an observation that was also made by Kamburoglu et al. in their study,²⁷ recognizing that higher or lower AUC values obtained from different caries methods are highly dependent on the depth of caries. Further research is needed to investigate the applicability of CBCT and extraoral bitewings in clinical situations.

CONCLUSION

The objective of the study was to determine the diagnostic accuracy of CBCT and extraoral bitewings in the detection of interproximal caries in comparison to the current standard of care—intraoral bitewing radiographs. This study presents that CBCT and extraoral bitewings can aid as alternatives to intraoral bitewings to diagnose proximal caries, especially when a specific diagnostic task determines the need for CBCT.

CLINICAL SIGNIFICANCE

Our findings suggest that there is no significant difference in the diagnostic ability of intraoral bitewings, extraoral bitewings, and CBCT for interproximal caries. This implies that CBCT and extraoral bitewings could potentially serve as alternatives to intraoral bitewings to diagnose proximal caries, especially when the CBCT study is needed for a specific diagnostic purpose, making additional radiation burden unnecessary, particularly for uncooperative pediatric patients, because CBCT and extraoral bitewings are more comfortable for patients.

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