Original Article

Accuracy of Digital Bitewing Radiography versus Different Views of Digital Panoramic Radiography for Detection of Proximal Caries

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Abstract

Objectives: Dental caries are common and have a high incidence among populations. Radiographs are essential for detecting proximal caries. The best technique should be recognized for accurate detection of caries. The aim of this study was to compare the accuracy of detection of proximal caries using intraoral bitewing, extraoral bitewing, improved interproximal panoramic, improved orthogonality panoramic and conventional panoramic radiographs.

Materials and Methods: In this descriptive cross sectional study, 100 extracted human teeth with and without proximal caries were used. Intra and extraoral radiographs were taken. Images were evaluated and scored by two observers. Scores were compared with the histological gold standard. The diagnostic accuracy of radiographs was assessed by means of receiver operating characteristic (ROC) curve analysis ($P<0.05$).

Results: Microscopic evaluation of proximal surfaces revealed that 54.8% of the surfaces were sound and 45.2% were carious (with different depths). The differences in the area under the ROC curve (Az value) among the five techniques were not statistically significant.

Conclusion: Improved interproximal panoramic and extraoral bitewing radiographs were superior to conventional panoramic radiography for detection of proximal caries ex vivo and should be considered for patients with contraindications for intraoral radiographs.

Key words: Dental Caries; Radiography, Panoramic; Radiography, Bitewing

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INTRODUCTION

Dental caries are among the most commonly encountered conditions in clinical dentistry with a very high incidence.

Probing, visual inspection, intraoral film and digital sensors are various types of methods used today for detection of caries; however, 25%-42% of carious lesions remain undetected [1]. Proximal tooth surfaces can hardly be approached or visualized directly and therefore caries in these surfaces are often diagnosed with the aid of radiographs [2]. Bitewing radiography is the most widely used clinical technique for caries detection.

However, it has disadvantages such as patient discomfort. Variable levels of expertise of the operators often result in increased patient radiation dose due to the need for retakes [3].

Intraoral radiography requires greater patient cooperation and tolerance in comparison with extraoral techniques.

Therefore, pediatric and handicapped patients would benefit greatly from an extraoral imaging system. Patients with high gag reflex or other contraindications to intraoral radiography would also benefit from an extraoral approach [4].

The popularity of panoramic radiography as an extraoral method has increased due to its low radiation dose, simplicity of application, less time requirement and greater patient comfort [5].

Panoramic radiography is a method of obtaining images by rotation of the X-ray source and image receptor around the patient. However, extraoral imaging techniques are always associated with magnification and distortion of images [6]. Panoramic radiography alone is inferior to bitewing radiography in the diagnosis of proximal caries [5,7]. However, with technological improvements, panoramic radiography is now comparable to intraoral imaging [8].

Recently, new concepts were developed in panoramic radiography namely extra oral bitewing and improved interproximal panoramic imaging.

Improved interproximal angulation panoramic program

• The X-ray beam and the interproximal contacts of teeth are parallel
• The teeth do not overlap
• Extremely useful for caries detection

Extraoral bitewing program

• Produces bitewing-like images from premolar and molar areas including parts of the maxilla, mandible and ramus.
• Ideal for caries diagnosis
• The bottom of the maxillary sinus as well as the mandibular canal and the mental foramen are visible.
• Uses improved interproximal angulation projection geometry.
• Fifty percent dose reduction compared to the normal panoramic program.

These methods are considered to provide better diagnostic ability for detection of proximal caries. The basic imaging geometry in improved interproximal panoramic imaging is the same as standard panoramic radiography but the X-ray beam is parallel to the interproximal contacts of the teeth.

To the best of our knowledge, no study has compared the efficacy of these techniques in diagnosis of proximal caries. In addition, no study has evaluated the efficacy of these methods in comparison with other panoramic modalities and digital bitewing radiography.

Since some patients cannot tolerate intraoral radiography, an efficient extraoral imaging technique should be found for these patients.

Thus, the aim of the present study was to evaluate the diagnostic accuracy of intraoral bitewing, extraoral bitewing, improved interproximal panoramic, improved orthogonality panoramic and conventional panoramic radiography for detection of proximal caries.

Also, this study aimed to reveal the best extraoral technique for uncooperative children and patients who cannot tolerate intraoral radiographic techniques.

MATERIALS AND METHODS

In this in vitro diagnostic study, 100 human canine, premolar and molar teeth with and without proximal caries extracted for periodontal or orthodontic reasons were collected and used. The teeth were cleaned of calculus and debris and disinfected in 2% sodium hypochlorite solution for 20 minutes and stored in distilled water. Then the teeth were split into crown and root sections using fissure burs. The crown section of teeth was divided into 20 groups of five.

Ten groups included the maxillary teeth and the remaining 10 included the mandibular teeth. Each group contained canines, first and second premolars and first and second molars of the same jaw. Teeth of each group were placed in appropriate alveolar sockets of dry human skull with dry mandible and occluded and fixed by wax. Then the mesial and distal surfaces of the teeth in each group were assessed for caries (a total of 200 surfaces of 100 teeth). Five different radiographic methods were used:

1) Intraoral bitewing radiography
2) Extraoral bitewing radiography
3) Improved interproximal panoramic radiography
4) Conventional panoramic radiography
5) Improved orthogonality panoramic radiography

Intraoral radiographs were taken using photostimulable phosphor plates (Soredex, Helsinki, Finland). All images were exposed for 0.32s using Planmeca dental radiographic unit (Planmeca, Helsinki, Finland) operated at 66 kVp and 8mA with a focus receptor distance of 30mm. Panoramic radiographs were obtained using Planmeca Scara 3 (Planmeca, Helsinki, Finland) with a CCD detector at 54 kVp and 8mA with 16s imaging time. Exposure parameters were determined based on pilot studies to ensure optimal image quality.

With the same exposure parameters, extraoral bitewing, improved interproximal panoramic and improved orthogonality panoramic radiographs were obtained with the respective programs for each image.

These digital radiographs were adjusted by density and contrast enhancement tools.

All images were then evaluated separately by two blind observers (two oral and maxillofacial radiologists with six years of clinical experience) at random order.

Image sets were viewed again one week after the initial viewing. Inter- and intra-observer agreements were assessed using weighted kappa coefficient, and excellent agreement was obtained (kappa coefficient was between 0.885-0.889).

Observers scored the absence/presence of proximal caries using a five-point scale as follows:

1) Caries definitely present
2) Caries probably present
3) Uncertain-unable to tell
4) Caries probably not present
5) Caries definitely not present

Next, each tooth was sectioned mesiodistally parallel to the long axis of the crown and histological status of caries was determined under a stereomicroscope (Carl Zeiss AG, Oberkochen, Germany) at ×10 magnification by a dental pathologist.

Each tooth was recorded as sound or having a carious lesion, which was defined as a demineralized white or yellowish-brown area in the enamel or dentine. Assessment of histological sections was performed using the following scale (Fig.1):

0) No carious lesion in the proximal surface
1) Proximal caries in the enamel
2) Proximal caries extending to the enamel-dentine junction or in the outer half of dentine
3) Proximal caries in the inner half of dentine [6].

We changed pathologic and radiographic scores to become comparable. Surfaces with grades 2, 3, 4 or 5 in radiographic assessment were scored 0 and surfaces with grades 1, 2 or 3 in pathologic assessment were scored 1.

Grade 1 in radiology and grade 0 in pathology assessment were not changed [6].

To evaluate the ability to differentiate teeth with and without proximal caries, the ROC curve analysis was used. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and false positive ratio (FPR) were also calculated for each radiographic technique.

RESULTS

Percentage of carious lesions in each dental region is presented in Table 1.

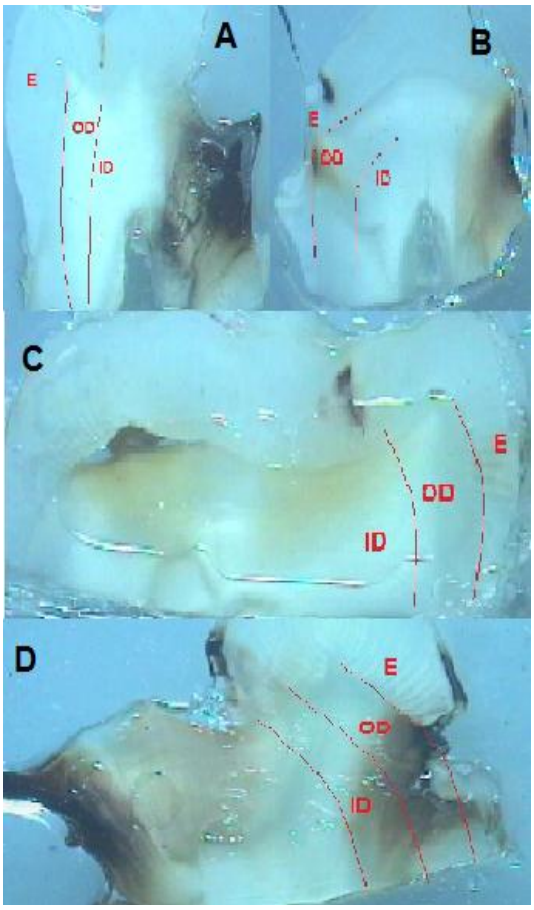

Fig. 1. Samples of sectioned teeth.
E represents enamel. OD represents outer half of dentine and ID represents inner half of dentine.
A) No carious lesion, score 0.
B) Carious lesion extended to outer half of dentine, score 2.
C) Carious lesion in the enamel, score 1.
D) Carious lesion extended to inner half of dentine, score 3.

In total, 54.8% of surfaces had no carious lesion and caries were found in 45.2% of surfaces. When analyzed according to the level of caries, 29.2% of surfaces were found to have enamel caries, 41.5% of surfaces had dentine caries confined to the outer half of dentine and 29.2% of surfaces had deep dentine caries extending to the inner half of dentine.

Sensitivity, specificity, PPV, NPV and FPR of each technique are presented in Table 2.

The Az values were calculated. There was no statistically significant difference in the performance of the five imaging modalities (P >0.05). The Az values and their standard errors are shown in Table 3. Figure 2 shows the ROC curves for the five modalities. T-test with 0.05 level of significance was applied to compare the Az values and revealed no significant difference in the performance of the five techniques.

McNemar's test was applied to compare sensitivity and specificity values of radiographic techniques.

DISCUSSION

The purpose of this study was to compare the efficacy of five imaging modalities namely digital bitewing, extraoral bitewing, improved interproximal panoramic, conventional panoramic and improved orthogonality panoramic radiography for detection of proximal caries. To the best of our knowledge, this study is the first to compare extraoral panoramic and improved interproximal panoramic radiography with other routine radiographic techniques. Analysis of data revealed no significant difference among the five modalities.

The null hypothesis that there would be no statistically significant difference among the five methods in detection of proximal caries was not refuted. The highest sensitivity was obtained by intraoral bitewing images followed by improved interproximal panoramic radiography.

Table 1. Percentage of carious lesions in each dental region

Caries	Caries in the enamel	Outer half of dentine	Inner half of dentine
Percentage (among teeth with carious lesions)	29.2%	41.5%	29.2%

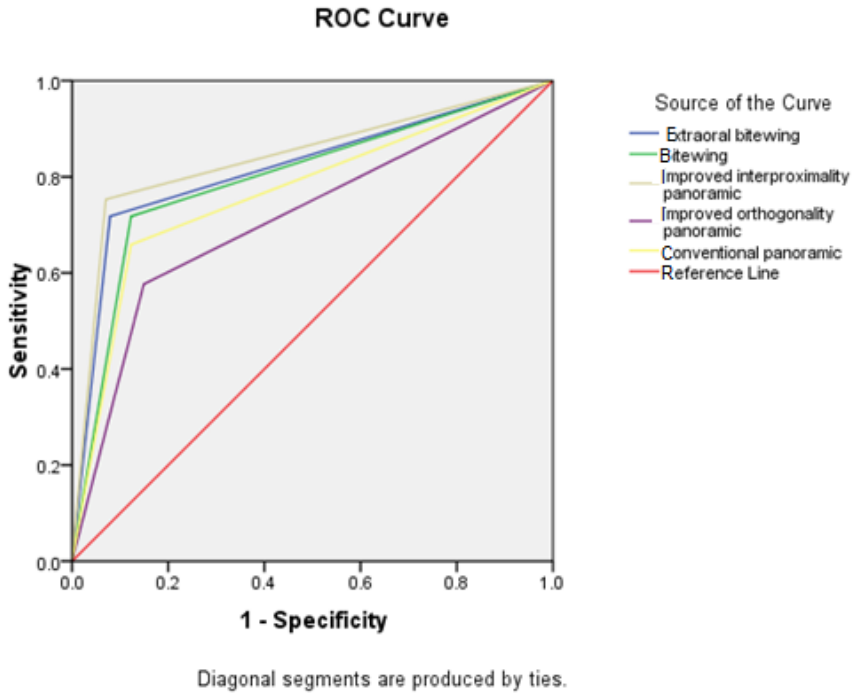

Fig 2. ROC curve indicating the sensitivity and specificity of different radiographic modalities for detection of proximal caries

Table 2. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and false positive ratio (FPR) for each technique.

	Sensitivity	Specificity	PPV	NPV	FPR
Digital bitewing	74.1%	91.6%	88%	81%	8%
Conventional panoramic	61.7%	87.0%	79.7%	73.4%	12.9%
Improved interproximal panoramic	73.0%	94.4%	91.5%	80.9%	5%
Extra oral bitewing	71.9%	95.3%	92.7%	80.4%	6.4%
Improved orthogonality panoramic	56.1%	85.1%	75.7%	70.2%	14.8%

Table 3. The mean areas under the ROC curve (Az) and standard errors (SEs)

Test result variables	Area	Std. errors
Improved orthogonality panoramic	.714	0.038
Improved interproximal panoramic	.841	0.031
Digital bitewing	.797	0.034
Extraoral bitewing	.819	0.033
Conventional panoramic	.768	0.036

The highest specificity was obtained by extraoral bitewing followed by improved interproximal panoramic radiography.

Specificity and sensitivity of improved interproximal panoramic, intraoral bitewing and extraoral bitewing radiography were statistically similar. An objective comparison of diagnostic accuracy of different imaging methods requires a simultaneous evaluation of sensitivity and specificity [9] and ROC curve analysis serves this purpose [10]. The most common index to analyze a ROC curve is the Az value. This value may vary from 0.5 to 1.0; 0.5 represents random decision and 1.0 represents a perfect diagnostic justification [11]. The present study revealed that the diagnostic accuracy (defined by the Az value) of extra oral bitewing, improved interproximal panoramic and intraoral bitewing techniques was almost similar. Also, it was found that sensitivity, specificity, PPV, NPV and FPR were higher for both improved interproximal panoramic and extraoral bitewing radiography than conventional panoramic and improved orthogonality panoramic radiography. Improved interproximal panoramic and extraoral bitewing radiographies are better choices for detection of proximal caries than conventional panoramic and improved orthogonality panoramic radiographies. Therefore, pediatric and handicapped patients or patients with contraindications for intraoral imaging would benefit from these extraoral techniques. An in vitro study by Kamburoglu et al. compared extraoral bitewing, intraoral bitewing and panoramic techniques for detection of proximal caries and revealed that sensitivity and specificity of intraoral bitewing were higher than those of the other two methods [6]. In the current study, we found that sensitivity of intraoral bitewing was higher than that of other techniques.

Results of a clinical study by Scarfe et al. indicated that bitewing radiographs had greater diagnostic value than the orthogonal or standard panoramic techniques and these results were confirmed by the findings of the current study [12].

Akkaya et al. compared the diagnostic accuracy of panoramic and intraoral radiographic techniques for detection of proximal caries in different dental regions in a clinical study. Results of their study demonstrated that panoramic radiography alone was not sufficient for detection of proximal caries in the entire dentition and a combination of panoramic and bitewing plus anterior periapical radiography exhibited a diagnostic accuracy comparable to that of full mouth series for proximal caries [5].

Valachovic et al. examined the sensitivity and specificity of full mouth series, panoramic radiography and panoramic plus bitewing radiography for detection of caries. Their results showed that full mouth series were the most effective for detection of caries [13]. However, in selection of radiographic technique, it is important to provide the most valuable diagnostic information while minimizing the radiation dose of patient. It has been shown that the tissue-absorbed dose in panoramic radiography is less than that in full mouth series [14-16]. Diagnostic ability of visual inspection, film, charge-coupled device, photostimulable phosphor plate, and cone beam computed tomography for detection of proximal caries in posterior teeth was compared by Senel et al. The results demonstrated that these methods had similar efficacy in detection of proximal caries [1].

In a study by Akarsalan et al, the results revealed that the accuracy of unfiltered and filtered digital panoramic images was lower than that of conventional bitewing and periapical radiographs [17]. As mentioned earlier, previous studies demonstrated that conventional panoramic image was inferior to intraoral bitewing for detection of proximal caries. In the current study, we also found that bitewing radiography was more sensitive than the other options of panoramic techniques (which assumed to be more sensitive than conventional

panoramic radiography) for detection of proximal caries. However, for some patients, intraoral images are contraindicated. In these cases, according to the results of the current study, improved interproximal panoramic radiography should be considered, followed by extraoral bitewing radiography.

CONCLUSION

The difference in the diagnostic accuracy of the radiographic techniques compared in the present study was not significant (regarding both sensitivity and specificity). Although intraoral bitewing radiography is more sensitive than conventional panoramic technique for detection of proximal caries, for uncooperative children and patients for whom intraoral radiography is contraindicated, other panoramic techniques may be useful. Improved interproximal panoramic radiography can be the best choice (more sensitive than conventional and other panoramic methods), followed by extraoral bitewing radiography.

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