Radiographic Assessment of Proximal Caries: A Comparison between Film-based and Dexis Digital Imaging Systems

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ABSTRACT

This study compared Kodak Ektaspeed film and Dexis digital imaging systems for their diagnostic accuracy in detection of proximal caries in 210 proximal surfaces from 105 extracted human teeth (20 premolars and 85 molars), 129 of which were carious. Ground teeth were evaluated histologically. The images were assessed by an observer. ANOVA revealed that groups differ in scoring patterns with f-value of 26.72 and p < 0.01. The mean caries score by histologic assessment was significantly (p < 0.01) more when compared with the scores obtained by conventional and Dexis digital radiographic methods. The mean score for conventional radiographic method was slightly more than Dexis digital radiographic method, but the difference was statistically insignificant (p < 0.05). Both the radiographic methods were less accurate in detecting proximal caries confined to enamel, but as the lesion depth was increased to dentin, the rate of caries detection increased dramatically. It was concluded that both conventional and Dexis digital radiographic methods underestimated caries depth when compared with histologic method. Lastly, conventional film radiographs and Dexis digital radiographs did not perform significantly different from each other in the detection of caries.

Keywords: Conventional radiography, Dexis, Digital radiography, Proximal caries, X-ray film.

INTRODUCTION

Radiographic examination often detects 30 to 70% more proximal caries than a clinical examination alone.1 Radiographic film has been the most common X-ray photon detector in dental radiography for more than 80 years. However, a film has many drawbacks like, it is relatively inefficient as a detector of radiation requiring high dose for exposure, requires chemical processing by solutions that are potentially allergic and polluting, film provides a static image and it is sensitive to variations in exposure. Because of the drawbacks, there was a need for better alternatives.2 The rapid advances in semiconductor and computer technology have made a significant impact on dental radiography. In 1987, the first direct digital radiographic systems became commercially available as an alternative to conventional radiography. Since then several systems have been introduced in the market.3 In addition to many other digital systems, a new system called Dexis digital system has been introduced, to the dental professional market. There are only a few articles regarding the diagnostic accuracy of Dexis digital system. Hence, this study was aimed to compare conventional radiography and Dexis digital system for assessment of their diagnostic accuracy in detection of proximal caries, with histologic appearance of hemisected teeth being used as a validation criteria.

MATERIALS AND METHODS

The study material comprised of 210 proximal surfaces from 105 extracted human teeth (20 premolars and 85 molars). They were collected from local sources. The teeth were inspected for the presence or absence of caries on the proximal surface. There were 129 carious surfaces and 81 noncarious surfaces on inspection. All the teeth collected were immersed in 10% formalin for 2 weeks. Teeth were randomly divided into 35 groups for purpose of mounting with three teeth in each group. The teeth in each group were embedded in plaster of paris from apex to CEJ with their approximal surfaces in contact (Fig. 1). These teeth were numbered serially from number 1 to 105. A jig, made up of wood with slots for placement of film or sensor and teeth blocks, was prepared to eliminate any variations in image quality due to changes in angulations or distance between X-ray source and film or sensor. In the jig, the film or sensor lay immediately behind the teeth. A 1.8 cm thick acrylic plate was placed between the cone and the tooth blocks to produce a soft tissue equivalent scattering effect4 (Fig. 2). Reproducible radiographs were obtained for each group of teeth with Kodak Ektaspeed film and Dexis digital sensor separately. The X-ray source was operating at 65 Kvp, 8 mA with the exposure time of 0.6 seconds and TID was 24 cm. All the conventional films were processed in automatic processor (Durr Dental) using fresh processing solutions. The
processed radiographs were coded, randomized and mounted in frames in such a way that the identification of films was completely covered. The conventional and digital images were viewed separately and assessed. The viewing conditions for the film and digital images were made as similar as possible. Assessment of both conventional and digital radiographs was carried out by the same observer. After 10 days, these were reassessed using same viewing conditions. This will help to evaluate any observer-based differences that might have existed between the two sessions. All the scores were entered in a tabular format. The depth of the caries was assessed as follows using criteria of Russell and Pitts.5
- R0: No radiolucency
- R1: Radiolucency extending up to outer half of enamel
- R2: Radiolucency extending up to inner half of enamel but not into dentin
- R3: Radiolucency extending up to outer half of dentin
- R4: Radiolucency extending up to inner half of dentin with or without apparent pulp involvement.

HISTOLOGIC EXAMINATION
 IS teeth were removed from the plaster mounts and were bisected into mesial and distal halves with a rotating carborandum disk. The mesial and distal halves were made in order to facilitate the plane of section through the center of carious lesion. Wherever, no carious lesion could be detected clinically, the plane of that section was planned through the center of the contact point or area. Each mesial and distal halves were embedded separately in self-cure acrylic and labeled with appropriate number and surface. Both the halves were sectioned longitudinally using a hard tissue microtome (Leica SP 1600, Germany) with a diamond cutting blade. Sections of about 100 μ thickness were obtained. These ground sections were placed on glass slides and cover slip was mounted over them using DPX media (Dibutyl ptylate xylene). The slides were marked with appropriate number and surface. These slides were observed under a research microscope (Olympus Bx 51, Japan) in both transmitted and polarized light. The images were captured with a 3-chip CCD camera (Pro-Series, Media Cybernetics, USA), which was attached to a computer. The images thus captured were stored in the computer. The images were assessed by an oral pathologist and scores were given, following the criteria of Russel and Pitts.5
- H0: No caries
- H1: Caries extending up to outer half of enamel
- H2: Caries extending up to inner half of enamel but not into dentin
- H3: Caries extending up to outer half of dentin
- H4: Caries extending up to inner half of dentin with or without apparent pulp involvement.

Histologic scores were used as the validating criteria. They were compared with the conventional and Dexis digital radiographic scores.

RESULTS
The results were subjected to statistical analysis. Comparison of mean scores for all three methods was analyzed by one-way analysis of variance (ANOVA) followed by studentized range test. Agreement in the assessment of proximal caries by various methods was measured with weighted Kappa measure of agreement. On comparison of radiographic methods with the histology, it was found that both conventional and Dexis digital radiographic methods showed significantly less score than the histologic scores (p < 0.01). However, the difference between conventional and Dexis digital radiographic methods was not significant (p > 0.01) (Table 1).

The extent of proximal caries into enamel and dentin, assessed by conventional and Dexis digital radiographic systems, was compared with histological findings as a gold standard. It was found that caries detection is more when the lesions have penetrated into the dentin (Table 2).

The measure of agreement and disagreement for all the methods was calculated. There was a poor agreement of kappa scores, when conventional (0.46) and Dexis digital (0.47) radiographic methods were compared with histologic method. Whereas, when conventional and Dexis digital radiographic methods were compared, the kappa score was 0.74 indicating high agreement (Table 3).

Fig. 1: Teeth mounted in Plaster of Paris with their approximal surfaces in contact

Fig. 2: A jig to keep the X-ray tube, teeth and film in a reproducible relationship
The measure of repeatability for both the radiographic assessments was done. The difference between the two assessments was statistically insignificant and there was a high kappa measure of agreement. For Dexis digital radiographic method, the difference between the mean scores for the two assessments was 0.03, which was statistically insignificant (p-level of 0.84). There was also high kappa measure of agreement (Table 4).

**DISCUSSION**

Intraoral radiography is steadily moving from analog to digital. Digital dental radiography has become an alternative to conventional film-based radiography because of its diverse capabilities. In addition to many other digital systems, a new system called Dexis digital system has been introduced to the dental profession market. Probably as it stands today, few studies have been conducted for the assessment of proximal caries using Dexis digital radiographic system. Usually, the introduction of a new caries diagnostic method is traditionally accompanied by an evaluation of its performance in vitro. It has been shown that we can perform well-designed in vitro studies in the confidence that the results can be transferred to the clinical situation. In evaluating the value of a diagnostic method, a truthful validation method is needed to express the true state of disease.

The mean scores between different methods indicate that both conventional and Dexis digital radiographic methods underestimated the caries depth or failed to detect some carious lesion. This may be due to the fact that the radiolucency on the radiograph is visible only when there is 30 to 60% of demineralization. The results of the present study are similar to the observations made by Downer, Eickholz and Syriopoulos. They have reported that radiological diagnosis produces a net underestimation of the severity of caries at individual sites. Both conventional and Dexis digital radiographs were less accurate in detecting proximal caries confined to enamel, but as the lesion depth was increased to dentin, the rate of caries detection increased dramatically. Similar results were also noted in the studies conducted by Gwinnett, Kang, Wenzel and Jones. They have observed that conventional radiographic methods underestimated the caries depth and were of no value in the detection of small carious lesions.

### Table 1: Comparison between different methods

<table>
<thead>
<tr>
<th>Methods</th>
<th>Mean score ± SD</th>
<th>Difference between methods</th>
<th>Groups compared</th>
<th>Mean difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1.16 ± 1.48</td>
<td></td>
<td>C-H</td>
<td>0.88</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>D</td>
<td>1.11 ± 1.47</td>
<td>26.72</td>
<td>D-H</td>
<td>0.32</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>H</td>
<td>2.03 ± 1.42</td>
<td></td>
<td>C-D</td>
<td>0.05</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS: Not Significant

### Table 2: Comparison of conventional and Dexis digital systems for diagnosis of caries in enamel and dentin with histologic findings as validating criteria

<table>
<thead>
<tr>
<th>Histologic Conventional</th>
<th>Dexis digital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caries in enamel (Score 1 to 2)</td>
<td>73 (17%)</td>
</tr>
<tr>
<td>Caries in dentin (Scores 3 to 4)</td>
<td>94 (76%)</td>
</tr>
</tbody>
</table>

### Table 3: Measure of agreement and disagreement

<table>
<thead>
<tr>
<th>Methods compared</th>
<th>Agreement (correct classification)</th>
<th>Disagreement (miss-class)</th>
<th>Measure of agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>C and H</td>
<td>90 (42.9)</td>
<td>120 (57.5)</td>
<td>0.46</td>
</tr>
<tr>
<td>D and H</td>
<td>88 (41.9)</td>
<td>122 (58.1)</td>
<td>0.47</td>
</tr>
<tr>
<td>C and D</td>
<td>149 (71)</td>
<td>61 (25)</td>
<td>0.74</td>
</tr>
</tbody>
</table>

### Table 4: Measure of repeatability

<table>
<thead>
<tr>
<th>Methods</th>
<th>Mean score ± SD</th>
<th>Agreement</th>
<th>Disagreement</th>
<th>Measure of agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>1st</td>
<td>1.16 ± 1.48</td>
<td>173</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>1.25 ± 1.58</td>
<td>(83.4%)</td>
<td>(17.6%)</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>-0.09</td>
<td>(NS)</td>
<td></td>
</tr>
<tr>
<td>Dexis digital</td>
<td>1st</td>
<td>1.11 ± 0.48</td>
<td>176</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>1.08 ± 1.51</td>
<td>(83.8%)</td>
<td>(16.2%)</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>0.03</td>
<td>(NS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p-level</td>
<td>0.84</td>
<td>(NS)</td>
<td></td>
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</tbody>
</table>

NS: Not Significant
REFERENCES


