Evaluation of the effectiveness of clinical and radiographic analysis for the diagnosis of proximal caries for different clinical experience levels: comparing lesion depth through histological analysis

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Abstract
Proximal cavity lesions are difficult to diagnose and are also hard to examine due to their location. Radiographic examination and teeth separation are resources used to help in caries diagnosis. The aim of this study was to evaluate, in different professional experience levels, the effectiveness of clinical and radiographic examinations in diagnosing proximal cavities, comparing lesion depth considered in these examinations to histological examinations. Thirty nine human teeth were used, 20 premolars and 19 molars, with clinical alterations on one proximal surface, such as lesions with either white or brownish stains and small cavitations which showed no clinical signs on the occlusal face, causing the professional insecurity in performing an accurate diagnosis as well as appropriate treatment. Samples were made using x-ray interproximal technique. Forty professionals of different experience levels performed clinical and radiographic examinations of the samples by filling out a form after classifying lesions depth. The samples were later sectioned for a histological analysis. Results showed that there was great variability on answers to examinations, with a low agreement percentage among examiners. After concluding all evaluated examinations, the examiners were not able to come up with an accurate diagnosis of lesions conditions on proximal cavities. The rate of cavitation was greater in lesions found on the external half of dentine, surpassing the amelodentinal limit, and an agreement percentage to conventional and digital x-ray examinations were equivalent.

Key Words:
diagnosis, oral, dental caries, radiography, bitewing
Introduction

In Dentistry, a lot of studies have been carried in areas of early prevention and diagnosis of caries lesions. The diagnosis of proximal cavity lesions was, for a long time, regarded by the dentist as difficult to identify. The two reasons that contributed to this difficulty were: first, difficult clinical visualization in the early stage of caries development because it is usually located below the “contact point”, and second, it is believed that caries progression on proximal surfaces was faster than lesions on other dental surfaces. Those factors contributed to an immediate invasive treatment as soon as a lesion was detected. There are many difficulties when performing an examination to detect early caries lesions on proximal faces. During the last decades, a more strict criterion was used for decisions made on whether or not to repair lesion, based on the extension observed in x-ray. Criteria considered issues such as risk of caries in patients and if lesions are sensitive to remineralization and control. That might be due to a decrease in caries predominance in several countries and an increase in the use of preventive procedures, making the untreated disease less severe.

Caries lesions diagnoses is controversial among professionals and requires constant updating and information, not only because of the variability of existing diagnostic methods and procedures but also because of pattern changes, predominance and behaviors of the disease that modify with fluoride use. Aspects such as differences in color hues, lesion depth, uncertainty about the progression and stage of caries, make it critical that a decision about what treatment to perform for the lesions. Challenges appear not only due to the changes in morphology and speed in caries progression, but also for the lack of an effective method enabling the accurate diagnosis both the disease – sensitivity, and health of tooth – specificity.

Radiographic examination became an essential aid in diagnosing proximal lesions and the quality of the examination should be fundamental. However, the radiolucence presence reflects a two dimensional image of a three dimensional lesion, without an accurate distinction between healthy and carious surfaces. The x-ray images do not provide either the depth or extension of lesions in their current format. The difficulty of caries diagnosis generated a clear need of visualization and local conditions evaluations of these surfaces. Auxiliary methods such as use of elastic bands for setting apart the contact points, help the professional visualize these areas; however, these methods do not provide any certainty whether a cavity exists. Currently, it is known that there is a slower advancement of caries and it is inconceivable to not take preventive care in order to stop caries progression whenever possible. It is advisable to say that the ideal situation is that the dentist should know beforehand about the caries depth and extension, patients’ diet and hygienic habits, while also including the patient in an educational health program where they could receive some treatment to control plaque and diet, together with the use of fluoride.

The most precise knowledge about caries extension is necessary to suggest the correct treatment since invasive treatments are just recommended in cases of active lesions that have reached, considerably, dentine.

The objective of this study was to evaluate, for different professional experience levels the effectiveness of clinical and radiographic diagnosis on proximal caries; comparing lesion depth considered in these examinations to histological examination.

Material and Methods

Thirty nine human teeth from a Human Teeth Supplier from the Dentistry Department of Taubaté University were used. There were 20 premolars and 19 molars with clinical alterations such as white or brownish lesion stains and small cavitations not treated on one of the proximal surfaces. The samples were cleaned and submitted to sterilization methods. All samples were kept in distilled water inside a refrigerator until x-ray examination and presentation to be analyzed by professionals.

Clinical Examination

Teeth were horizontally displayed on a wax lamina with the proximal face showing caries lesions facing the lens. On a lamina were the premolars, on the other the molars. All teeth were numbered.

Radiographic Examination

For bitewing radiographs, teeth were positioned in pairs on an articulate dummy, one molar and one premolar, with proximal contact, radiographed using the bitewing technique with radiographic film holders (Jon – São Paulo – Brazil). It was carefully observed that film and holder were kept in the same position during every radiographic taken, with a heavy silicon base for molding fixed to a support, focusing on the occlusal face the dummy’s upper tooth.

Histological Examination (golden-standard)

Each tooth was individually placed in fast curing, colorless environment temperature polyester resin (REDELEASE – UCEFLEX VC 2120) Teeth were placed in the cutting device, Labcut 1010 (EXTEC) using a 0.30 mm thick disc. Each caries lesion was sectioned lengthways along the tooth axis in a distal-mesial direction 500 um thick slices in a number equivalent to the superficial lesion extension area. The cut that showed the greatest lesion depth was selected.
for histological analysis. Each selected section was fixed on a glass plate, which was identified with the corresponding number of the tooth slice came from. All plates were placed in a plate case, separated in premolar and molar groups.

All examiners were highly and equally instructed through oral orientation. Each received a form, which was to be filled out after each tooth and each radiography evaluation. Visual examination was performed prior to the radiographic examination so as to not permit the examiner prior knowledge about the teeth conditions. Professionals were selected according to their professional experience: 10 specialists in operative dentistry, 10 recently graduated dentists, 10 dentists with more than 5 years of clinical experience and 10 specialists in oral and maxillofacial radiology.

**Diagnosis Examination**

Three classifications establishing a correlation between lesion evolution degrees in clinical, radiographic and histological examinations were compared (Table 1).

**Clinical Examination**

Professionals, except for radiologists, performed a visual, not tactile, examination7, and classified caries lesions observed on the proximal faces of teeth, according to criteria used by Kidd et al.8 with small stage alterations. Criteria for clinical lesion classification through visual examination can be seen in Table 1.

**Radiographic Examination**

Radiographs were placed in transparent plastic molds with proper identification and examined under the light of a viewbox with the help of a gradual magnifying glass at 2 and 4 X magnifications. Radiologists did not perform, visual clinical examinations of the samples, they just assessed radiographs. First, the conventional radiographs were viewed in a viewbox with gradual magnifying glass at 2 and 4 X magnifications. Second, the same radiographs that were indirectly digitized were examined. When classifying the lesions as described below, the practitioners filled out a form that contained radiography identification and the proximal face to be evaluated.

Radiographic examinations were analyzed by classifying the lesion: images specified in the form, following a slightly modified classification system by Sanden et al.9 (Table 1). Histologic Examination (golden-standard)

Three histologists, with the help of a stereoscope magnifying glass (CARL ZEISS – JENA), at 2.5 X magnification, classified lesions according to following the classification system of proximal lesions used by Kidd et al.5, with slight alterations (Table 1).

For lesion classification, irreversible histological dental tissue alteration, which had to be removed through clinical intervention, was considered. Tissues modified by reversible demineralization, providing the ability to be repaired, were not considered.

**Results**

Student’s t-Test was applied to verify the agreement percentage during clinical and conventional radiographic examinations in relation to histological examination of the total samples (premolars and molars), with 5% significance, demonstrating that there was not a statistic difference (p >0.05).

Tables 2 and 3 show the percentage of answers given and

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**Table 1 – Criteria to classify the lesions in the diagnosis procedure.**

<table>
<thead>
<tr>
<th>Evolutions</th>
<th>Clinical Examination</th>
<th>Radiographic Examination</th>
<th>Histologic Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>White or brownish stain on enamel</td>
<td>Absence Rl*</td>
<td>DEM** involving external half of enamel</td>
</tr>
<tr>
<td>I</td>
<td>Lesion on enamel up to ADL***</td>
<td>RI* limited to enamel up to ADL***</td>
<td>DEM** involving internal half of enamel ADL***</td>
</tr>
<tr>
<td>II</td>
<td>Lesion affecting half of dentine</td>
<td>RI* limited to external half of dentin</td>
<td>DEM** involving external half of dentin</td>
</tr>
<tr>
<td>IV</td>
<td>Lesion affecting internal of dentine</td>
<td>RI* limited to internal half of dentin</td>
<td>DEM** involving internal half dentine</td>
</tr>
<tr>
<td>V</td>
<td>Lesion affecting pulp cavity</td>
<td>RI* affecting pulp cavity</td>
<td>DEM** involving pulp cavity</td>
</tr>
</tbody>
</table>

* - Radiolucent image  
** - Demineralization  
*** - Amelodentinal Limit

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**Table 2 - Percentage of answers for premolars in clinical examination**

<table>
<thead>
<tr>
<th>Golden-Standard</th>
<th>Classification Given</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>I</td>
<td>41%</td>
</tr>
<tr>
<td>II</td>
<td>23%</td>
</tr>
<tr>
<td>III</td>
<td>5%</td>
</tr>
</tbody>
</table>
percentage of correct answers that agreed with the gold standard (histological - colored) in premolar and molar lesion classification through clinical examination.

**Table 3 - Percentage of answers for molars in clinical examination**

<table>
<thead>
<tr>
<th>Molars</th>
<th>Clinical Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden-Standard Classification Given</td>
<td>I</td>
</tr>
<tr>
<td>I</td>
<td>30%</td>
</tr>
<tr>
<td>II</td>
<td>13%</td>
</tr>
<tr>
<td>III</td>
<td>3%</td>
</tr>
</tbody>
</table>

Figures 1 and 2 illustrate graphical form the percentage of agreement and disagreement in premolar and molar lesion classification through clinical examination with the gold standard.

**Fig. 1 – Premolar clinical examination.**

<table>
<thead>
<tr>
<th>Molars</th>
<th>Clinical Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden-Standard Classification Given</td>
<td>I</td>
</tr>
<tr>
<td>I</td>
<td>40%</td>
</tr>
<tr>
<td>II</td>
<td>25%</td>
</tr>
<tr>
<td>III</td>
<td>14%</td>
</tr>
</tbody>
</table>

In Tables 4 and 5, the percentage of answers given and percentage of correct answers that agreed with the gold standard (histological - colored) can be observed in premolar and molar lesion classification for radiographic examination.

**Table 4 - Percentage of answers for premolars in the radiographic examination**

<table>
<thead>
<tr>
<th>Premolars</th>
<th>Radiographic Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden-Standard Classification Given</td>
<td>I</td>
</tr>
<tr>
<td>I</td>
<td>55%</td>
</tr>
<tr>
<td>II</td>
<td>15%</td>
</tr>
<tr>
<td>III</td>
<td>1%</td>
</tr>
</tbody>
</table>

**Fig. 3 – Premolar radiographic examination.**

Figures 3 and 4 illustrate graphical form the percentage of agreement and disagreement in premolar and molar lesion classification through radiographic examination with the gold standard.

**Fig. 4 – Molar radiographic examination.**
Discussion
Radiographic images of lesions that were found on the dentine external half were generally underestimated rather than overestimated (Tables 3 and 4) according to the current work and other studies. Lesions were mostly overestimated when interpreted by professionals with considerable experience, with over 5 years in clinics, suggesting a necessity for professional retraining, updating their knowledge of new concepts in Restorative Dentistry and of new means to control and stop caries lesions from advancing.

In this study, during clinical analysis, the teeth were positioned with their proximal face that showed the lesion to be studied turned to the eyepiece, so that a direct visualization was possible, simulating a temporary separation of contact points. This method may be justified because a probe, which professionals use to determine lesions, was not used. As a result, dental professionals have not developed enough visual accuracy to examine the enamel superficial texture (formation) without touching it. These results can confirm the necessity of associated methods in diagnosing lesions on proximal caries so that information closer to reality can be obtained. Although this study has not related the results of clinical to radiographic examinations, based on statements in literature, the radiographic examinations associated with visual assessment offer greater understanding of caries depth, raising the examiner sensitivity to visual examination, qualifying the professional to perform a diagnosis that gets closer to actual condition presented by the patient. Association of methods may contribute to information closer to the clinical lesion reality.

The agreement percentage was lower in the clinical examination of superficial lesions on the enamel external half for both premolars and molars. These data indicate that there was an overestimation of the superficial lesion depth and questions the sensitivity of visual examination, which is a preferable method in diagnosing caries lesions according to Meneghim et al. For radiographic examinations, results showed that radiographic image interpretation of lesion depth was also overestimated; lesions found only on the enamel external half were mostly interpreted as if they were deeper. This fact makes one reflect about the statement that radiographic examination does not allow an early examination of superficial lesions and the inability of radiographs to detect lesions restricted to enamel.

Based on the low agreement in both visual and radiographic examinations related to histological examinations, we can state that no treatment decision should be grounded only on one diagnosis method. The results of this study point to an inefficiency in both the clinical and radiographic examinations in respect to the determination of the lesion depth on proximal caries. This is due to the low percentage of agreement reached by the clinical and radiographic examinations in relation to histological examinations. Lacking a precise method for a true knowledge of caries extension, the safest thing to do is to never make a decision to repair a tooth before trying lesion control and retention by including the patient in an education and health programs while also controlling caries disease through plaque and diet control proceedings and also adding the use of fluoride. The difficult of diagnosing proximal caries in the initial stages, and the x-ray images do not provide either the depth or extension of lesions in current format, many times could lead to unnecessary tooth preparation or restoration failure. The studied examination methods were not capable of conveying a precise diagnosis of lesion extension on proximal caries. Despite the low percentage agreement rates in relation to histological examination (gold standard), clinical and radiographic examinations are still mostly used as the most accessible methods with no other method that could be considered better.

In this study, reinforces the necessity of improvement of the diagnostic methods that could lead to coherent decisions of treatment with minimum intervention. In this direction, the efforts currently are for becoming the more effective diagnostic methods, such as: clinical examination, bite-wing radiograph exam, digital imaging systems and laser-based instrument (DIAGNODent).

References


