The effect of image enhancements and dual observers on proximal caries detection

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Objectives. The aim of this study was to determine if the use of certain image enhancements and dual observers had an effect on the detection of caries, dentin extension, and cavitation.

Study Design. Seven observers viewed unenhanced and enhanced images taken on photostimulable phosphor plates (PSP) and Schick 33 sensors and were asked to determine whether proximal caries lesions, dentin extension, and cavitation were present. Pairs of observers also evaluated the unenhanced PSP images and recorded their confidence. Micro-computed tomography was used as the gold standard.

Results. For caries lesion detection, PSP outperformed Schick sensors, although the differences are most likely not clinically significant. Observers (single and dual) and filters had no effect on any of the diagnostic tasks. Schick sensors and unfiltered images were more specific for dentin extension.

Conclusions. Caries detection was statistically greater with the PSP plate, but both detectors allowed for high accuracy. Expensive software or time-consuming consultations did not improve outcomes. (Oral Surg Oral Med Oral Pathol Oral Radiol 2017;123:e133-e139)

Dental caries is one of the most common diseases affecting humans. It is a progressive and cumulative condition that, when left untreated, destroys the hard tissues of the mouth and leads to increased patient morbidity and treatment costs.[1,2] A disproportionate amount of the caries burden in the United States rests on those who do not have the necessary resources to correct dental-related conditions.[2] In 2012, total national dental expenditures in the United States reached $111 billion dollars.[3] Because loss of tooth structure resulting from caries often requires invasive, surgical restoration methods that lead to a cascade of treatments for the lifetime of the patient, prevention and early detection of disease that can be treated noninvasively will reduce overall health care costs for the individual and for society as a whole.[1] Knowing this and the fact that previous caries history is the best predictor of future disease, dentists can help reduce the burden of disease by using any means of early detection at their disposal.[4]

To maximize patient benefit from a radiologic examination in terms of detection of decay caused by oral bacteria, a radiographic detection system should be able to record the entire spectrum of the demineralization process.[5] The detection system should be both sensitive to the subtle contrast changes taking place in enamel and dentin and specific for demineralization caused by cariogenic bacteria.[5-8] By far the most common and widely accepted radiographic modality for detection of this process is the use of intraoral bitewing receptors evaluated by trained clinicians.[9] However, observer performance, far from being ideal, has remained relatively constant throughout the years despite advancements in imaging, including digital technology.[10,11]

Many companies have introduced task-specific image enhancement filters designed to improve detection of early caries lesions. Some studies have shown promise in the use of these filters, but some others have reported little to no improvement in early detection.[12-17] Because of the numerous dental, digital imaging software and systems products available on the market, many of these filters remain untested. To address the

Statement of Clinical Relevance

The loss of tooth structure as a result of caries often requires invasive methods that lead to a cascade of treatments for the lifetime of the patient. Early detection of small lesions can reduce overall health care costs and improve patient outcomes.

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contrast-limited identification of early demineralization, Sirona (Sirona Dental, Salzburg, Austria) has introduced a task-specific “General Dentistry” sharpening enhancement designed to aid the clinician in the detection of dental caries lesions. Similarly, MiPACS (Medicore Imaging, Charlotte, NC) has a “dentin−enamel” filter, which also aims to increase contrast differences in dentin and enamel. No research testing the effect these filters have on the diagnosis of demineralization caused by caries has been published to date.

Observer performance in the detection of carious demineralization has remained fairly constant in the past few decades.[10,11] Until now, no studies have focused on the use of dual observers. Because the number of dental practices with more than 1 dentist has increased drastically in the past decade, this low-tech detection aid may be an alternative to software enhancements.[18]

MATERIALS AND METHODS

Institutional review board approval was obtained to collect deidentified extracted human teeth and to perform observer sessions at the University of North Carolina at Chapel Hill (UNC) School of Dentistry (Study #13-2843). Human premolar and molar teeth, obtained after extraction for necessary, indicated dental conditions in the Department of Oral and Maxillofacial Surgery at The UNC School of Dentistry, were assessed visually, tactilely, and radiographically to determine the presence or absence of proximal dental caries lesions. For the purposes of this article, we defined “demineralization” as the radiographic sign of the dental caries process whether seen in enamel or dentin. Demineralization status was classified as “sound” (no demineralization), “initial” (demineralization in the enamel or at/including the dentoenamel junction [DEJ]), or “dentinal” (demineralization past the DEJ). Teeth with proximal surfaces that were frankly cavitated, filled, or had defects were excluded. “Frank cavitation” was defined as teeth that had large visible lesions with substantial loss of tooth structure. These teeth were excluded because caries diagnosis would have been too easy for the observers. Twenty-nine teeth were selected for use in the study. Three of the teeth were used twice because they demonstrated the “ideal” proximal lesion with the classic triangular shape, in which the base was at the outer surface of the enamel and the point extended to the DEJ. This allowed for a total of 64 surfaces to be viewed (Table I).

A dry human mandible with edentulous posterior segments and residual extraction sockets was used as an ex vivo phantom for the study. The selected teeth were placed in the “19,” “20,” “29,” and “30” positions and held in place by wax. Unrestored second molars and first premolars were mounted distally and mesially, respectively, to the teeth to be viewed. The teeth were arranged so that contacts were anatomically correct and closed to simulate ideal dental alignment. Approximately 1 cm of boxing wax was placed around the mandible to simulate the attenuating characteristics of soft tissue.

Table I. Proximal surface ground truth status by micro-computed tomography (micro-CT)

Sound	30
Total demineralized (enamel or dentin)	34
Enamel	15
Dentin (past dentoenamel junction [DEJ])	19
Cavitated	11

Size 2 photostimulable phosphor plates (PSP) (Gendex, Hatfield, PA) were exposed with a Focus intraoral source (Instrumentarium Dental, Tuusula, Finland) at 70 kVp, 7 mA, 0.2 seconds, at 40 cm SID with 30 cm rectangular collimation. According to the manufacturer, the resolution is 14.3 lp/mm for these receptors. These settings were slightly lower than that in the standard UNC radiographic protocol to adjust for the differences between the attenuating characteristics of the wax used in our phantom and the soft tissue of a human face. The beam was placed at a perpendicular plane to the teeth to achieve images with non-overlapping contacts. Exposed plates were scanned by a ScanX IO ILE scanner (Air Techniques, Melville, NY) through MiPACS Dental Enterprise Viewer 3.1.1401 operating ScanX Plugin, version 1.2.8 (Meicore Imaging, Charlotte, NC). Settings on the scanner were Intraoral High (#2), 16-bit, invert images, and Image Enhancement: Enable histogram stretch, Upper histogram cut 0.2, Lower histogram cut 3.4, and Gamma correction 0.7. According to the manufacturer, the ScanX resolution is 18 lp/mm with a theoretical resolution of 40 lp/mm. The images were saved first without any additional processing or enhancement and then saved after the “dentin−enamel” enhancement was applied resulting in 2 sets of images: 1 unenhanced and 1 “dentin−enamel” enhanced.

The teeth were also exposed on Schick 33 digital sensors with the same intraoral source at 70 kVp, 7 mA, 0.05 seconds, at 40 cm SID with 30 cm rectangular collimation interfaced with CDR DICOM for Windows Version 5.4.1658.5883 (Sirona Dental, Salzburg, Austria). These settings were used to achieve proper exposure, based on the exposure indicator in the CDR DICOM software. Acquisition settings were Schick 33 High Resolution Acquisition, subtract dark image, and acquire 12-bit image. According to the manufacturer, theoretical resolution is 33 lp/mm. The same geometry was used in this sensor as was used for the PSP. Images were first saved unenhanced in the CDR DICOM