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Performance of 5 different displays in the detection of artificial incipient and recurrent caries-like lesions

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Objectives. The aim of this study was to assess whether auto-calibrating medical-grade monitors perform better than off-the-shelf monitors and tablet computers in detecting artificial incipient and recurrent caries-like lesions.

Study Design. Sixty extracted teeth (30 premolars and 30 molars) were selected. All molars received class II amalgam and composite restorations. A 7-mm^2 area on the crowns of half of the teeth was demineralized. Phantoms consisting of 4 teeth were created. Three observers using a 5-point scale evaluated digital periapical radiographs for the presence of caries on 5 displays: 2 autocalibrating medical-grade monitors, 2 tablets, and 1 off-the-shelf monitor. Sensitivity, specificity, accuracy, and receiver operating curve data were calculated and verified through analysis of variance and Tukey tests. Observer agreements were assessed using Cohen's κ test.

Results. Intraobserver agreement ranged from 0.347 to 0.612 (molars) and 0.617 to 0.811 (premolars). Interobserver agreement ranged from 0.239 to 0.559 (molars) and 0.657 to 0.858 (premolars). The performances of tablets and the off-the-shelf monitor were similar to medical monitors when the same tooth groups were compared. Medical-grade monitors presented fewer statistically significant differences when different lesions where compared within the same display and restorative material.

Conclusions. Evaluations of similar lesions were not significantly different among the 3 types of displays. However, the autocalibrating medical-grade monitors performed better when incipient and recurrent lesions were compared. (Oral Surg Oral Med Oral Pathol Oral Radiol 2017;■■:■■–■■)

Digital radiography has become a mainstay in dentistry over the last couple of decades. Based on the acquisition receptor type, digital radiography is broadly classified into computed radiography, which uses the photostimulable phosphor plate for image capture, and direct digital radiography, in which charge-coupled device or complementary metal-oxide semiconductor image sensors are used. The imaging monitor is also a very important component in digital radiology. The monitor should be able to accurately display the true clinical status, given that failure can result in missed opportunities for intervention. Although most monitors are liquid crystal displays, newer monitor options include light-emitting diode backlight displays. Image displays may also be monochrome or color. Recent advances in hand-held devices, including portable computers and tablets, offer similar viewing functionality and resolution as an off-the-shelf display, but with portability. Regardless of the technology used to acquire images, off-the-shelf displays are commonly used for viewing digital radiographs in dentistry, whereas medical radiology relies on autocalibrating medical-grade displays with robust criteria for both display selection and calibration standards.[1]

A primary advantage of medical-grade imaging displays is that they are capable of adjusting the brightness levels depending on ambient light (autocalibrating) to Digital Imaging and Communications in Medicine (DICOM) standards, which saves time and money.[1] However, they are much more expensive than off-the-shelf displays or tablets, which, to our knowledge, do not offer this level of functionality at this time. If off-the-shelf displays or tablets are used, it is recommended that periodic manual calibration be performed on a regular basis. At a minimum, it is recommended that all displays be manually calibrated at initial setup, if a discrepancy is observed, and on a regular basis; medical-grade monitors require less frequent manual calibration, saving personnel time and resources.[1] Poor display quality may lead to a missed diagnosis and/or misinterpretation of overall disease state or progression,[2] which may result in inappropriate or no treatment for a particular condition.

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Statement of Clinical Relevance

The diagnostic outcomes of observers' evaluations of similar artificial caries-like lesions were not significantly different between displays. However, medical-grade monitors performed better when incipient and recurrent caries-like lesions were compared within the same display and restorative material.

A systematic review on the use of tablet computers for the radiologic interpretation of medical images has shown that the accuracy of tablets is comparable with that of autocalibrated displays.[3] Some studies have compared the effects of using medical displays, off-the-shelf consumer monitors, and/or computer tablets on the diagnosis of dental-related diseases.[2,4-8] However, we did not find any studies that included recurrent caries as a diagnostic variable.

Recurrent caries is the most common reason for restoration replacement, even though a scientific basis for the diagnosis has not been consistent.[9] The combination of a clinical tactile examination and radiographic evaluation has been shown to be both effective and economical for caries diagnosis.[10] However, the interpretation of images may be impacted by the quality of the display device.[11] Given the rapid and continuing evolution of image displays, and the increasing use of mobile tablet computers, the impact of these new technologies on the interpretation of recurrent caries has yet to be tested.

The aim of this study was to assess whether the autocalibrating medical-grade monitors perform better in comparison with off-the-shelf monitors and tablet computers in detecting artificial incipient and recurrent caries-like lesions. The null hypothesis was that there were no differences among the display devices.

MATERIALS AND METHODS

The protocol of this in vitro study was reviewed and approved by the Institutional Review Board of the University of Campinas (São Paulo, Brazil), where specimen preparation and image acquisition were accomplished. The following is based on the methodology described by Belem[12] and also reported by Sousa Melo et al.[13]

Tooth selection

Sixty extracted human teeth (30 molars and 30 premolars) were chosen for the investigation. Only unrestored, noncavitated teeth with a fully formed crown and morphology within the range of normal anatomic variations were chosen. All teeth were extracted as part of orthodontic therapy or because of impaction. Following disinfection with 2% glutaraldehyde, all teeth were stored in a pH-neutral saline solution. One premolar and 1 molar were placed in a phantom to be treated and examined, as described below. An additional molar and premolar were chosen and set aside to be used as the second molar and the first premolar in every phantom quadrant created; no alteration was made to these teeth. One half of the molars and premolars were randomly divided into either an experimental group or a control group. As further described, the experimental group underwent the demineralization protocol to create an artificial caries-like lesion.

Amalgam restorations

The selected premolars were kept in saline solution. No preparation or restoration was performed.

All 30 molars had a class II restoration prepared with a high-speed water-cooled handpiece adapted to the mobile platform of an optical microscope. By utilizing this preparation machine, the movement of the tooth in relation to the fixed handpiece could be controlled with precision. The preparation was performed at the center of the mesial surface of the molar, 3 mm away from the cementoenamel junction, and had 3-mm box-shaped preparation dimensions. All margins were placed only in enamel. After preparation of all molars, the teeth were restored with amalgam (Permite C – regular setting speed; SDI, San Francisco, CA). The amalgam restorations were condensed in small increments and carved and the margins burnished. After 24 hours of saline storage, the restorations were polished. Half (n = 15) of the amalgam-restored molars were selected for the experimental demineralization protocol.

Demineralization of the experimental group

All of the teeth in the experimental group (15 restored molars and 15 unrestored premolars) underwent the demineralization protocol, as described below.

Standardized 7-mm^2 round vinyl tapes were placed below the proximal height of contour on the premolars and centered on the cervical margin of the amalgam restorations on the molars. The entire coronal surface of each tooth was then painted with a fast-drying acid-resistant nail varnish. After allowing the varnish to dry, the tapes were removed, thereby creating 7-mm^2 windows of exposed enamel (or enamel/amalgam in the case of the molars).

In the demineralization protocol, we used a buffer solution that was at 50% saturation compared with the dental enamel. The demineralizing solution had a pH of 4.8 and was composed of 0.05 M acetate buffer, 1.12 mM calcium, 0.77 mM phosphate, and 0.03 ppm fluoride.[14] This solution has been proven to induce subsurface demineralization in other in vitro studies.[13-16] The recommended ratio is 2 mL of demineralizing solution to 1 mm^2 surface area of exposed enamel. The area to be exposed to the demineralization solution was 7 mm^2. Therefore, the teeth in the experimental group were each submerged in 14 mL of solution and incubated at 37°C for 120 days. At 60 days of immersion, the demineralizing solution was replaced to avoid supersaturation and stagnation of the demineralization rate.[15]

The demineralized areas were quantified and validated by Knoop cross-sectional microhardness profiling (described in detail below), which has been proven to be as effective as microradiography in determining mineral profiles of areas of demineralization.[17]