The performance of ICDAS-II using low-powered magnification with light-emitting diode headlight and alternating current impedance spectroscopy device for detection of occlusal caries on primary molars

Research Article

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It is well established that caries levels in industrialized nations have decreased over the last few decades with the greatest reductions occurring on the smooth and approximal surfaces. Because of the complex occlusal anatomy, more sensitive and reproducible diagnostic tools for precise caries detection in children are needed. Visual examination still is the most commonly used method for detecting dental caries, but various studies showed problems for sensitivity and reproducibility problems. A standardized scoring system, International Caries Detection and Assessment System (ICDAS-II), has been developed for clinical practice and research to overcome these problems. A complimentary approach to visual examination is to use visual aids such as low-powered magnification (dental loupes) and special headlights mounted on them. These visual aids became popular among dentists to improve precision of visual examination and for ergonomic reasons. Advances in caries research led novel technologies to help dentists in the diagnosis of early lesions. ACIS device (CarieScan PRO, Dundee, Scotland) is one of the recent examples of the novel technologies. This device relies on the application of a small alternating electrical signal (undetectable by the patient) through the tooth while monitoring the response at the sensor. By changing frequency of the applied signal, a spectrum is captured which provides valuable insights into the physical and chemical properties of the tooth. The result is displayed on the LCD screen and the color LED display that enables dental professionals to evaluate the depth of the carious lesion. Pediatric dentistry, with its small operating field and its demands for emergent skills and precision, is particularly suited to the use of novel technologies and visual aids.

Therefore the aim of this study was to compare in vitro the diagnostic performance of low-powered magnification (5×) with mounted LED headlight illumination using ICDAS-II criteria and AC Impedance Spectroscopy device, on occlusal surfaces of primary molars.

Materials and Methods

Prior to undertaking the study, ethical approval was granted by Western University Research Ethics Board for Health Sciences Research (File no. 15-10974; 17/3). Eighty recently extracted second primary molars (n = 80) were selected for this in vitro study. Extracted teeth were kept in 0.5% neutral buffered formalin immediately following extraction. Only teeth with sound to incipient lesions were selected, teeth with occlusal restorations, occlusal fissure sealants, and hypoplastic pits were excluded from this study. Prior to examinations, each tooth surface was cleaned with pumice and water slurry to remove any debris and rinsed thoroughly in sterile water. The teeth were mounted to impression putty (VP Mix Putty; Henry Schein Inc., USA) in order to mimic intraoral anatomical position for mixed dentition.

The details of each score for ICDAS-II examination and ACIS device instructions were discussed. Examiners were calibrated by a training exercise on both techniques followed by discussion to consensus of any uncertainties. In order to assess intra- and interexaminer reproducibility, 15 primary molars (7 primary 1st molars and 8 primary 2nd molars) that were not included in the present study were examined on two separate occasions with two weeks interval by both examiners. All examinations were conducted under standard conditions in dental surgery, with conventional dental light (a-dec300, USA) and a syringe. The teeth were positioned 40 cm from examiners’ eyes and kept dry throughout examinations unless when dried for ICDAS-II examination. One site on each tooth was selected on the occlusal surface, and examiners were guided by black and white photographs printed on draft quality paper containing a dot on the test site to allow the precise assessment of the same area. The examinations were first carried out with custom made dental loupe (2.5X magnification) with mounted LED headlight (Univet Optical Technologies, Italy) and then AC Impedance Spectroscopy device (CarieScan PRO, Dundee, Scotland) on separate occasions. After all examinations were completed, the roots of the teeth were sectioned just apical to the cementum-enamel junction prior to histological examination. A marker was placed on the mesial cervical area of each tooth, and nail varnish was applied to this mesial groove in order to identify tooth surfaces and therefore orientation after sectioning. To obtain the histological sections, each tooth was immersed in orthodontic resin (Caulk Orthodontic Resin, Dentsply, USA) and allowed to set into blocks (18 individual blocks), with approximately 1 cm to one side. Each mounted block was then serially sectioned in a longitudinal buccolingual direction with a water-cooled diamond disc on a thin sectioning machine (Corry Podent, NY, USA). Each section was approximately 120 microm thick, and based on visible caries location the cuts were done approximately every 200 microns. The sections were separated from the block and numbered for examination. After sectioning the grooves and artifacts left by the diamond disc were peeled away with a F (Al2O3) In spray.

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria used in the Downer histological examination [12]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No demineralisation at a narrow surface zone of opacity (edge phenomenon)</td>
</tr>
<tr>
<td>1</td>
<td>Enamel demineralisation limited to the outer 50% of the enamel layer</td>
</tr>
<tr>
<td>2</td>
<td>Demineralisation involving the inner 50% of the enamel, up to the enamel-dentine junction</td>
</tr>
<tr>
<td>3</td>
<td>Demineralisation involving the outer 50% of the dentine</td>
</tr>
<tr>
<td>4</td>
<td>Demineralisation involving the inner 50% of the dentine</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method</th>
<th>AC Impedance Spectroscopy</th>
<th>Low powered magnification + LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examiner 1</td>
<td>0.6286</td>
<td>0.9057</td>
</tr>
<tr>
<td>Examiner 2</td>
<td>0.6372</td>
<td>0.955 SE</td>
</tr>
<tr>
<td>Examiner 1 versus Examiner 2</td>
<td>0.6473</td>
<td>0.8199 SE – 0.106</td>
</tr>
</tbody>
</table>

Table 1: Criteria used in the histological examination

Table 2: Intra- and interexaminer reproducibility (weighted kappa)
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- Universal shade in a convenient Automix syringe for efficient placement

For each examiner, the relationships between both intra- and interexaminer histological scoring system (Downer) were assessed using the Spearman rank correlation. Data derived from these measurements were used to calculate sensitivity and specificity at the Downer diagnostic threshold of a gold standard. The use of a gold standard is a prerequisite in assessing the receiver operating characteristic (ROC) curve.** This analysis involves a plot of pairs of sensitivity and “specificity” for a given cut-off value of a diagnostic test.** Since this study is focusing on early detection of carious lesions, we select DT level as diagnostic threshold. Using these sensitivity and specificity values under ROC curve (AUC) was carried out for each investigator and method. The performance of each method for AUC was interpreted by using the following classification: 0.10–0.24 low, 0.25–0.50 poor, 0.51–0.70 fair, 0.71–0.90 good, and 0.91–1.00 excellent.** The McNemar test was used to compare the sensitivity, specificity, and AUC between examiners and extractions.

**Results**

A total of 18 teeth were examined with both methods by two examiners and by histology. Table 2 shows intra- and interexaminer reproducibility analysis. The degree of intrapatient interexaminer reproducibility for ACIS device was good. The weightedin standard kappa values for intra- and interexaminer reproducibility for ACIS-LED using LPMLED was good to excellent (Kappa Table 2). Table 3 shows the statistical analysis performed using MedCalc v.9.3.11 statistical package (MedCalc Software, Mariakerke, Belgium). For the ICDAS-II scores, intra- and interexaminer reproducibility was measured using kappa-squared statistical test. Kappa values above 0.75 denoted excellent agreement, while values between 0.40 and 0.75 indicated good agreement.** For each examiner, the relationships between both intra- and interexaminer histological scoring system (Downer) were assessed using the Spearman rank correlation. Data derived from these measurements were used to calculate sensitivity and specificity at the DT diagnostic threshold of a gold standard. The use of a gold standard is a prerequisite in assessing the receiver operating characteristic (ROC) curve.** This analysis involves a plot of pairs of sensitivity and “specificity” for a given cut-off value of a diagnostic test.** Since this study is focusing on early detection of carious lesions, we select DT level as diagnostic threshold. Using these sensitivity and specificity values under ROC curve (AUC) was carried out for each investigator and method. The performance of each method for AUC was interpreted by using the following classification: 0.10–0.24 low, 0.25–0.50 poor, 0.51–0.70 fair, 0.71–0.90 good, and 0.91–1.00 excellent.** The McNemar test was used to compare the sensitivity, specificity, and AUC between examiners and extractions.

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**Discussion**

Ocular surfaces account for the majority of new carious lesions, affecting both primary and permanent dentitions in children. Although occlusal surfaces are the most visited sites during clinical examination, complex occlusal anatomy and histopathology of the disease makes it why we are early caries lesion detection difficult.** If dentistry is to move from restorative to a preventive and therapeutic based approach, early caries detection and quantification of lesions to track lesion arrest or progression over the time is essential. One of the purposes of the ICDAS-II system is to detect and to overcome this short fall and describe the earliest visible changes on all tooth surfaces. Clinical results of the ICDAS-II system provide an acceptable reproducibility of diagnostic and scientific data for reproducibility of ICDAS-II caries detection are promising. According to Long et al.,** the ICDAS-II presents good to excellent reproducibility (kappa coefficients range from 0.80 to 0.93). In a study where ICDAS-II codes were used in both primary and permanent teeth,** intra- and interexaminer reproducibility values were found to be excellent (weighted kappa values > 0.82). Even when using a detailed system (ICDAS-II), there might be a degree of subjective interpretation due to perhaps visual limitations.**

When ACIS device was used lower values of sensitivity (0.68–0.70) and specificity (0.60–0.68) were achieved. In a previous study where permanent caries detection in children was performed using a magnified tomography technique for histology was used, better sensitivity (0.92) and specificity (0.95) values were recorded.** This difference can be accounted for by the subjective variations on the occlusal surfaces of permanent and primary teeth and perhaps different settings was recorded for the histology technique.

When ICDAS-II examination using LPMLED was used, excellent AUC performance and strong correlation with histology were found by both examiners. Despite its potential, the AUC performance of device readings on primary teeth was low. Since the previous studies showed promising results for ACIS device, the possibility that the sensitivity for this low performance would be the variation in the conductance of electrical current due to enamel thickness of primary teeth.

To our best knowledge, this is the first study carried out using both systems on extracted primary teeth. According to our results visual aids had a remarkable positive impact on early caries detection precision on primary teeth was low. Since the previous studies showed promising results for ACIS device, the possibility that the sensitivity for this low performance would be the variation in the conductance of electrical current due to enamel thickness of primary teeth.

Conclusio

Within the limitations of this in vitro study it can be concluded that the use of low-powered magnification (2x) and LED headlight illumination complements ICDAS-II system in caries detection. Clinicians should keep in mind that visual aids may hold the potential to improve the performance of caries detection and clinical diagnosis in children.

**Note:** The references list is available from the publisher.