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

By Prof Timucin Ari and Prof Nilgun Ari, UK

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 loupe) 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 (Cariscan 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 evocative 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 (LP) with mounted LED headlight illumination using ICDAS-II criteria and AC Impedance Spectroscopy device. The results will be presented in this presentation. The sections are separated from the block and numbered for examination. One site on each tooth was selected on the occlusal surface, and examiners were guided by black and white photographs printed on drafted, and the teeth were resected just apical to the cementum-enamel junction prior to histological examination. One site on each tooth was selected on the occlusal surface, and examiners were guided by black and white photographs printed on drafted and numbered for examination. The teeth were immersed in orthodontic grade aluminum oxide (320 grade) for 5 minutes and then in 6% buffered formol 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 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-dec90, USA) and a syringe. The teeth were positioned 40 cm from examiners’ eyes and kept dry for examination unless when dried for ICDAS-II examination. Prior to examinations, ethical approval was granted for the study. Materials and Methods

Preliminary Examination of Patients

Examiner: Intra- and interexaminer reproducibility (weighted kappa).

Table 1: Criteria used in the histological examination[12]

| Score | Criteria used in the histological examination [12] |
|-------|---------------------------------------------------|
| 0     | No demineralization or a narrow surface zone of opacity (edge phenomenon) |
| 1     | Enamel demineralization limited to the outer 50% of the enamel layer |
| 2     | Demineralisation involving the inner 50% of the enamel, up to the enamel-dentine junction |
| 3     | Demineralisation involving the outer 50% of the dentine |
| 4     | Demineralisation involving the inner 50% of the dentine |

Table 2: Intra- and interexaminer reproducibility (weighted kappa)

| Examiner | AC Impedance Spectroscopy | Low powered magnification + LED |
|----------|---------------------------|-------------------------------|
| Examiner 1 | 0.6286 | 0.9057 |
| Examiner 2 | 0.6072 | 0.955 SE |
| Examiner 1 vs Examiner 2 | 0.6473 | 0.8089 SE = 0.0062 |

*Table 1: Criteria used in the histological examination*

*Table 2: Intra- and interexaminer reproducibility (weighted kappa)
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total ≥10 sections were produced per crown and ≤4 sections were available to view for each investigation site. Histological sections were examined under a Nikon 80i-1000 stereomicroscope (Nikon Instruments, Inc., Melville, NY) and digital images were captured with incident light at ≥16 magnification.

All histological sections for each tooth were assessed by both examiners who were blind to each other according to five-point scale Downer histological classification system (Table 1). Caries extent was based upon colour and structural changes in enamel and dentin, with emphasis being placed on differentiating carious changes from protective changes of the pulp-dentine complex such as tubular sclerosis and reactionary dentine formation. A histological score was given to each section and the deepest score section was taken as the definitive for further analysis. Where there was disagreement, two examiners reviewed the sections again and new examinations were performed until a consensus decision was reached.

### Table 1: Area under the ROC curve (standard error), sensitivity, and specificity at DT diagnostic threshold

| Examiner 1 | Examiner 2 | AUC (SE) | Sensitivity | Specificity |
|------------|------------|---------|-------------|-------------|
| 0.60 (0.14) | 0.62 | 0.60 (0.15) | 0.57 | 0.67 |

*Correlation significant at the 0.01 level.*

### Table 2: Spearman’s correlation coefficients using Downer classification system

| Examiner 1 | Examiner 2 | AUC Impedance Spectroscopy | Low-powered magnification + LED |
|------------|------------|----------------------------|---------------------------------|
| 0.37 | 0.36 | 0.78 | 0.73 |

*Correlation significant at P < 0.05.*

For each examiner, the relationships between both methods and the histological scoring system (Downer) were assessed using the Spearman rank correlation. Data from these measurements were used to calculate sensitivity and specificity at the DT diagnostic threshold using a gold standard. The use of a gold standard is a prerequisite in such investigations to monitor the progression of lesions to frank carious lesions and histopathology of the disease makes detection of early lesions difficult. If dentistry is to move from restorative to a preventive and therapeutic based approach, early caries detection and quantification of lesions to assess the efficacy of any treatment over progression or over time is essential. One of the purposes of the ICDAS-II system is to overcome this short fall and describe the earliest visible changes on all tooth surfaces. Clinical results of the ACIS system provide an acceptable performance of early caries detection and scientific data for reproducibility of ICDAS-II can be promising. According to Landy et al., the ICDAS-II presents good to excellent reproducibility (kappa coefficients ranging from 0.63 to 0.65 and 0.91). 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 subjectivity in interpretation due to perhaps visual perception and lighting problems. This is why we early caries -impact of low-powered magnification (2x) and LED headlight illumination using ICDAS-II criteria. Surprisingly, very little scientific research with diverging results about the influence of visual aids on caries detection has been published so far. One study showed that the use of low-powered magnification significantly improved the accuracy of examination, and a more recent article found that the use of magnification caused a drop in reproducibility of the ICDAS-II scores.4 Although both examiners started to use these visual aids for the first time with this study, our results showed excellent interexaminer (0.92–0.92) and intraexaminer reproducibility (0.90) of ICDAS-II using LPMLED. Our results indicate that the use of a standard criterion for visual inspection with the help of visual aids tends to increase the intra- and interexaminer reproducibility and makes ICDAS-II system a highly reproducible diagnostic modality for occlusal caries diagnosis.

Unfortunately there are not many published materials for the performance of ACS device. One in vivo study prediction of caries -deep caries and ICDAS-II scores. Both examiners started to use these visual aids for the first time with this study, our results showed excellent interexaminer (0.92–0.92) and intraexaminer reproducibility (0.90) of ICDAS-II using LPMLED. Our results indicate that the use of a standard criterion for visual inspection with the help of visual aids tends to increase the intra- and interexaminer reproducibility and makes ICDAS-II system a highly reproducible diagnostic modality for occlusal caries diagnosis.

**Conclusion**

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