Overcoming the Challenges of Caries Detection using The Canary System

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Dental caries is one of the major diseases that we treat in dentistry on a daily basis. The treatment of dental caries is a very common procedure in every dental practice. We have a vast array of techniques for treatment including: direct-placed restorations using materials such as composite resins, glass ionomers and amalgam, indirect-placed restorations including crowns, veneers, onlays and inlays and techniques for replacement of teeth destroyed by caries including implants, fixed or removable prosthesis. All these techniques are based upon the detection of cavitation and then placement of a restoration to restore the tooth to shape and form.

Techniques for caries detection have not changed radically over the last 60 years. These techniques were designed for detection of cavitation not for detecting caries across the continuum of the disease process. Detection of caries depended upon locating mineral loss on bite wing radiographs, examining stain and discoloured areas on the tooth surface or probing lesions with a sharp explorer. These techniques were and still are considered the gold standard even as the treatment of the disease has evolved.

What is dental caries? In 2001, the National Institute of Health's (NIH) Consensus Conference on the Diagnosis and Management of Dental Caries throughout Life defined it as:

"Dental caries is an infectious, communicable disease resulting in destruction of tooth structure by acid-forming bacteria found in dental plaque, an intraoral biofilm, in the presence of sugar. The infection results in the loss of tooth minerals that begins with the outer surface of the tooth and can progress through the dentin to the pulp, ultimately compromising the vitality of the tooth."[1]

In the early stages of the disease, lesions (such as the lesion in Fig. 1) can be remineralized or their progression halted by using a variety of remineralization products such as fluorides.[2] But the question remains, how do we detect and monitor lesion changes across the entire continuum of the disease process? Once detected, can we then treat the disease in its various stages? One can place a number of restorations in a mouth, without treating the underlying disease. The bacteria remain in the plaque biofilm on the remainder of the teeth capable of creating new areas of decalcification and cavitation.

THE CANARY SYSTEM

The Canary System, developed by Quantum Dental Technologies in Toronto, Canada has, an innovative approach to caries detection. The Canary System directly examines the status of the enamel and root crystal structure by using PTR-LUM technology. Pulses of laser light are shone on the tooth and the laser light is converted to heat (Photothermal Radiometry or PTR) and light (luminescence or LUM) which are emitted from the tooth surface when the laser is off

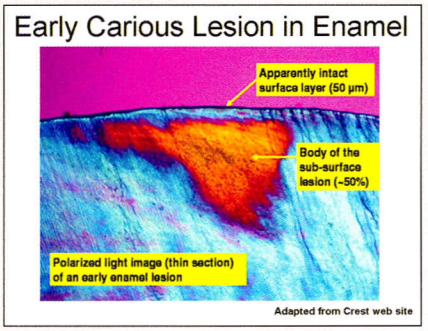

FIGURE 1

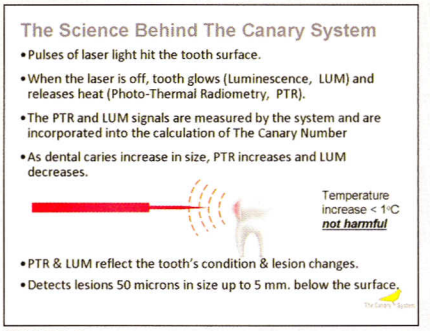

FIGURE 2

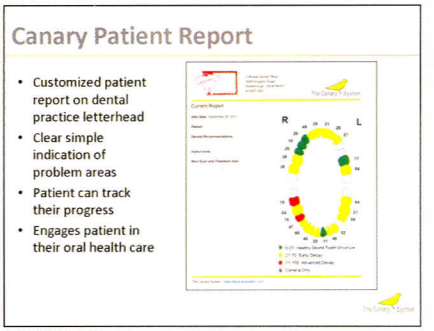

FIGURE 3

(Fig. 2). The Canary System measures four signals:

1. The strength or amplitude of the converted heat or PTR signal;
2. The time delay or phase of the converted heat or PTR;
3. The strength or amplitude of the emitted luminescence (LUM);
4. The time delay or phase of the emitted luminescence (LUM).

As a lesion grows, there is a corresponding change in the signal as the heat (PTR) is confined to the region with crystalline disintegration (dental caries) and the glow or LUM decreases. As remineralization progresses and enamel prisms begin to reform their structure, the thermal and luminescence properties begin to revert back in the direction of healthy tooth structure. The system is so sensitive it detects very small changes in temperature (less than 1–2 degrees Celsius), much less than that generated by a conventional dental curing light and imperceptible to the patient.

The Canary Number is created from an algorithm combining these four signals and is directly linked to the status of the enamel or root surface crystal structure, not from measuring the level of fluorescence from bacteria or bacterial by-products. The Canary Number ranges from 0–100 with lower numbers (under 20) indicating healthy tooth surface. Shifts in The Canary Number indicate changes within the crystal structure of the tooth. Using a simple numbering system allows the clinician to communicate with their patients and easily explain the evolution or changes in caries lesions (Fig. 3). It also allows patients and clinicians to track progress of remineralizing early lesions and the outcomes of various preventive measures.

Research has shown that PTR-LUM technology used in The Canary System can detect:

- occlusal pit and fissure caries[3-5]
- smooth surface caries[6,7]
- acid erosion lesions[8,9]
- root caries[10,11]
- interproximal carious lesions[12,13]
- demineralization and remineralization of early carious lesions[14-17]

PTR-LUM technology enables clinicians to detect small early lesions as small as 50 microns and at a depth up to 5mm. below the tooth surface, even in the interproximal regions of teeth.[18] It provides a repeatable measurement that is linked to the status of the enamel or root surface under examination.

The Canary System has been studied in two Health Canada approved investigational trials. The first trial[19,20] involved 50 patients and confirmed the safety of the system along with the ability to detect carious lesions and white or brown spots on both wet or dry tooth surfaces and the ability to detect lesions on tooth surfaces with moderate stain. Patients in this first clinical trial, which was completed in early 2010, have continued to be seen in clinical practice with no adverse events associated with this trial or the use of The Canary System.

The second clinical trial finished enrolment in May 2011. The trial involved 98 patients seen at four trial sites over a nine month period. The primary objective of this study was to establish how The Canary System detects and monitors tooth decay *in vivo* in dental practice situations. The secondary objectives of this study were to develop a treatment scale that correlates to lesion size, explore the ability of the investigational device to detect caries and erosion lesions, and monitor changes in lesion size in response to various therapies.

Our preliminary findings were that The Canary System could detect erosion and carious lesions and track the progress of remineralization therapies during the course of the trial.

DETECTING SECONDARY CARIES AROUND RESTORATIONS: A CHALLENGING PROBLEM

This is one of the most challenging clinical situations for the new detection technologies in the market. Restorative ma-

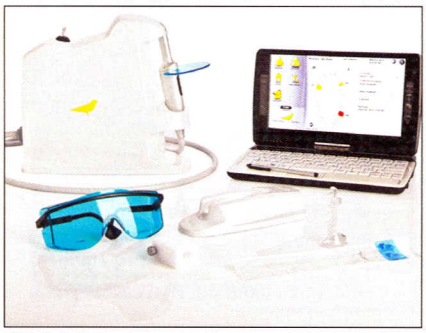

FIGURE 4

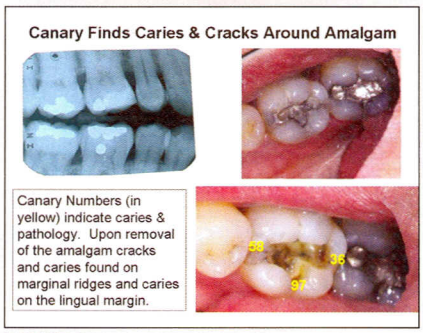

FIGURE 5

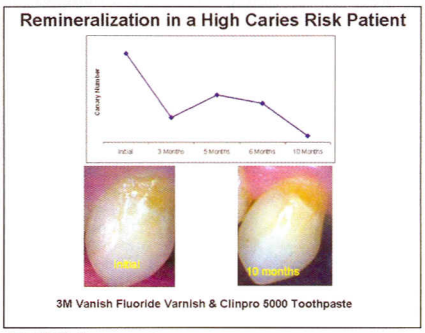

FIGURE 6

terials, including amalgam and composite resin, at times, mask the ability of laser light or other forms of energy to penetrate the material. Radiographs can show defects along the gingival seats of Class II restorations but they can not examine the walls of the restorations nor the occlusal surfaces. DIAGNOdent,[21] Spectra and QLF have limitations with caries detection although QLF and Spectra claim to be able to monitor the margins of composites and sealants on the occlusal, buccal and lingual surfaces. The Canary System using PTR-LUM has shown in preliminary studies the ability to detect lesions around the visible margins of composites.[22]

In my clinical practice, a patient was seen on an emergency basis complaining of pain in the right posterior area of the mandible. A bitewing radiograph did not reveal any pathology. Visual exam showed amalgam restorations on the occlusal surfaces of the mandibular right first and second molar. There was some tenderness on percussion on the first molar (see Fig. 5). A Canary Scan of the mandibular first molar had readings above the healthy area on both the mesial and distal marginal ridge. There was a Canary Number of 97, a very high reading at the lingual margin of the amalgam restoration. The amalgam was removed and caries was found on the lingual aspect of the occlusal surface. Cracks were found on both the mesial and distal marginal ridges that had just progressed through the enamel shell and into the dentin. The caries along the lingual marginal ridge was much more extensive, resulting in a very high Canary Number. The Canary was able to detect caries and cracks in this tooth which were not seen with the traditional detection techniques.

DETECTING AND MONITORING PREVENTIVE/REMINERALIZATION THERAPY RESULTS

Detection and tracking of carious lesions is an essential part of implementing any remineralization or early lesion treatment program. Tracking smooth surface lesions negates the use of radiographs but one can use various visual ranking systems to monitor caries.[23] Using parameters such as the appearance of a lesions when wet or dry does not indicate what is happening beneath the enamel surface. Subtle changes in the carious lesion can not be capture by visual examination.

In our second clinical trial, a subset of 38 patients were involved in a remineralization program to see if The Canary could track lesion changes over a 3–8 month time period. Preliminary results from the second clinical trial confirm laboratory findings, that The Canary System can detect and monitor changes to teeth undergoing remineralization therapy with a number of different therapeutic regimes.[24,25]

Fig. 6 illustrates the Canary readings scanned from a patient participating in this trial. A 41-year-old male at high risk for developing caries had DMFT of 54% (13 restored teeth) and a DMFS of 27% (35 restored surfaces). In the year prior to the trial, he had had 2 teeth restored and one endodontic procedure. He did consume three between-meal snacks per day.

During the trial, fluoride varnish (Vanish™ 5% Sodium Fluoride White Varnish, 3M™ ESPE™) was applied to his teeth at three month intervals. The patient was instructed to use Clinpro™ 5000 ((1.1% Sodium Fluoride Anti-Cavity Dentifrice (3M™ ESPE™) toothpaste twice daily at home. The Canary readings over an eight-month period decreased and the lesion surface appeared more regular and smooth.

This was one example from our clinical trial and preliminary results indicated that The Canary System could track lesion changes when patients were undergoing remineralization therapy. As expected, our preliminary results indicated that not all lesions decreased in size or stabilized and some did develop into large lesions. Since caries is a multi-factorial disease, applying remineralization therapy without dealing with issues such as diet, timing of carbohydrates or plaque control may not

yield a positive outcome.

CARIES DETECTION AND CLINICAL PRACTICE

Dental caries is a disease that involves the breakdown of tooth structure by exposure to acids produced by bacteria. Caries detection and monitoring involves looking for changes in structure of the tooth surface — changes in the crystal structure of the enamel and root surface, which would indicate disease progression. Finding the right tool for caries detection means understanding what the system is detecting. Are the systems detecting porphyrins of some oral bacteria strains, detecting small or large changes in enamel crystal structure or detecting stain and calculus on the tooth surface? Can the system detect changes in a variety of clinical situations? Can it detect subtle changes and provide reproducible measurements? Does one need clean, dry tooth surface for detection which adds more complexity and time to the procedure? These are questions we need to assess when looking at caries detection systems.

The Canary System is linked to changes in crystal structure and can be used to assist in the diagnosis of caries in clinical practice. As with all detection systems, the final step in the process is how we, as trained professionals, interpret the results. Diagnosis of caries involves using the results obtained from these systems and integrating this with our knowledge of the dental history of our patients. **OH**

DISCLOSURE

Dr. Stephen Abrams is the CEO and Co-Founder of Quantum Dental Technologies which has developed The Canary System mentioned in this article. He has not received any compensation for the preparation of this article.

Stephen Abrams is a general dental practitioner with over 30 years of clinical experience. Dr. Abrams founded Quantum Dental Technologies, a company developing laser based technology for the early detection and ongoing monitoring of dental caries. He has developed the "Triple Laminate Technique for utilizing soft tissue undercuts when fabricating complete and partial dentures. He can be contacted at (416)-265-1400 or email: dr.abrams4cell@sympatico.ca

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