

Gold Standard Device in Early Dental Caries Detection; Canary System™
-Frequency-Domain Infrared Photothermal Radiometry and Modulated
Luminescence (PTR/LUM)

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Abstract

Dental caries is the commonest disease of oral cavity for every age group of patients. The prognosis of the caries is very much relevant to the time of detection as preventive measures minimize the tooth morbidity. There are different diagnostic tools available at now a days for the early detection of caries. Canary System (CS) is regarded as one of the most reliable and authentic tool for the accurate diagnosis of dental caries. We have discussed the principle, assessment system and advantages of the system in brief through the article.

Keywords : Photothermal radiometry (PTR), Canary Numbers (CN), Canary System™ (CS), ICDAS II, luminescence (LUM).

Introduction

Caries remains a significant health problem for both children and adults. To date, one of the most straightforward definitions of dental caries, also referred to as tooth decay, is a localized breakdown of dental hard tissues as a result of acid byproducts produced from the metabolism of fermentable carbohydrates by bacteria in the plaque biofilm (Selwitz et al., 2007). Accurate detection as well as quantification of the size of the developing lesions at a very early stage will provide the practitioner with the opportunity to initiate early preventive therapy (Rodrigues et al., 2017). The International Caries Detection and Assessment System (ICDAS II) visual criteria were introduced to assist in caries detection. When evaluating diagnostic tests for dental caries, it is important to consider the sensitivity and specificity of the test as well as the predictive values. Sensitivity is defined as the proportion of true positives that are correctly identified by the test while specificity is defined as the proportion of true negatives that are correctly identified by the test. Positive predictive value is the proportion of subjects with positive test results who are correctly diagnosed, and negative predictive value is the proportion of subjects with negative test results who are correctly diagnosed.

There are several systems today to detect early dental caries like Fiber-optic transillumination (FOTI), Digital imaging fiber-optic transillumination (DIFOTI), Near-infrared light

transillumination (NILT-DIAGNOcam), Quantitative light-induced fluorescence digital Biluminator™ (QLF-D), Laser fluorescence (DIAGNOdent), Alternating current impedance spectroscopy (CarieScan PRO). (Rodrigues et al., 2017; Teo et al., 2014).

One of the most recent and innovative developments in caries detection is the Canary System which is regarded as 'Gold Standard' in caries diagnosis. It is developed by Quantum Dental Technologies in Toronto, Canada, the Canary System incorporates the combined technologies of photothermal radiometry (PTR) and luminescence (LUM). With this system, pulses of laser light are shone on the tooth where it is converted to heat and light (Jeon et al., 2005). Where there is a lesion developing, there is a corresponding change in the signal as the heat (PTR) is confined to the area of demineralization and the glow (LUM) decreases. According to the company website "The Canary System is a precise, low-powered, laser-based instrument with an integrated intraoral camera that detects the presence of cracks and caries (tooth decay) before they are large enough to appear on dental X-rays. Intraoral camera images can be displayed for immediate chair side review with the patient. A patient report is generated containing an odontogram with Canary Numbers, which are color-coded for the examined teeth, along with the dentist's treatment recommendation. This

report can also be examined by the patient on The Canary Cloud.”(Jeon et al., 2005; Jeon et al., 2007).

The Canary System™ 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.

The Canary System™ measures four signals:

- The strength of the converted heat (PTR Amplitude)
- The time delay of the converted heat to reach the surface (PTR Phase)
- The strength of the converted luminescent light (LUM Amplitude)
- The time delay of the converted luminescent light (LUM phase)

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. Changes in the tooth microstructure, due to caries, causes corresponding changes in the optical and thermal properties of the tooth and the resultant PTR-LUM response. (FIG 1).

The Canary System uses a low-power, pulsating laser light to scan teeth for the presence of dental caries. The laser light is absorbed by the tooth and converted into luminescence and a tiny amount of heat. Simultaneous measurement of the reflected heat and light using fifty-two different algorithms evaluates the crystalline structure and can help determine the presence and extent of tooth decay. (Matvienko et al., 2011).

Extensive research shows it to be highly accurate and more sensitive to early changes than traditional methods of diagnosis. (Matvienko et al., 2011).

CS detects decay on all tooth surfaces including:

1. Around and beneath the intact margins of restorations including amalgam, composites and crowns
2. Smooth surfaces,
3. Occlusal pits and fissures, including beneath stained areas
4. Around orthodontic brackets
5. Interproximal regions
6. Beneath opaque and transparent dental sealants

There are three benefits of the system:

1. It “sees” under an amalgam. The Canary is the only caries detection system I am aware of that allows you to detect decay under and around an existing amalgam restoration. There is no more watching and guessing only to find that there is extensive decay lurking under a filling that seems OK on the surface and has no radiographic evidence of disease.
2. It gives a number. The readings, called the Canary Number, range from zero to one hundred. Twenty or less is

considered healthy. Between twenty and seventy is decay. More than seventy is advanced decay. You can observe a suspicious area over time and determine if there are changes that require treatment rather than watch an area until the decay is obvious.

3. Early detection. The Canary finds decay and enamel breakdown at such an early stage that you can treat it with non-invasive remineralization options such as Clinpro 5000. Then you can evaluate the treatment using the Canary and actually document remineralization. This means less drilling and less lost tooth structure. (Silvertown et al., 2017).

The Canary System Assessment

The CS was used in accordance with the manufacturer’s operating instructions to obtain readings from the tooth surface. The device was calibrated in accordance with the manufacturer’s calibration instructions. Each tooth was air-dried for five seconds, the cone of the disposable plastic tip on the hand piece was positioned over the examination site, and a scan was taken. Five measurements were taken with the operator removing the tip and then placing back on the surface between each scan. The CS is able to capture and store both PTR and LUM values which are used to calculate the Canary numbers (CN). An explanation of the Canary scale is also offered:

“A Canary Number is the output generated by The Canary System to inform the oral health care professional about the probable health status of a given tooth. Using a complex algorithm, The Canary System converts the unique PTR/LUM signatures into a Canary Number on a scale from 0 to 100 which appears on a monitor screen and is also audible. Lower numbers suggest healthy enamel and higher numbers suggest the presence of cracks and caries.” (Matvienko et al., 2009; Jablonski-Momeni et al., 2012).

Fig. (2) shows the Canary Number scale. The PTR-LUM technology used in the Canary System has been shown to detect early lesions as small as 50 microns and at a depth up to 5 mm below the tooth surface.

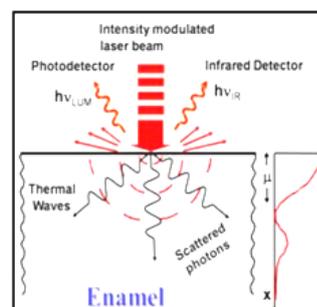


Figure 1: Principle of Canary System



Figure 2: Canary Scale

Conclusion

With limited studies conducted to date, the Canary System shows promising potential for use in early caries detection. When compared to conventional methods of visual examination and bitewing radiology for detecting proximal caries, the Canary System had the highest sensitivity, and a specificity that was only slightly lower than bitewings. Overall the Canary System had the highest positive and negative predictive values with histological examination used a reference standard for the presence or absence of carious lesions. Different studies conducted using the Canary System to detect proximal caries on primary molars showed it was well tolerated by the patients and overall had a high sensitivity but low specificity compared to bitewing radiographs. Some studies also demonstrated the high sensitivity and correlation of CS with caries compare to DIAGNOdent and CARIES PRO systems. Keeping in mind of the exclusive features of system it can be concluded that CS may serve as a gold standard diagnostic probe for early detection of caries.

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