

# In vitro detection of caries beneath dental sealant with The Canary System™



S.H. Abrams

S. H. Abrams<sup>a,c</sup>, B. Wong<sup>a</sup>, K. Sivagurunathan<sup>a</sup>, R. J. Jeon<sup>a</sup>, J. D. Silvertown<sup>a</sup>, A. Hellen<sup>a</sup>, A. Mandelis<sup>a,b</sup>, W. M. P. Hellen<sup>c</sup>, G. I. Elman<sup>c</sup>, K. Ramalingam<sup>d</sup>, R.A. Ccahuana-Vasquez<sup>d</sup>, B. T. Amaechi<sup>d</sup>

<sup>a</sup>Quantum Dental Technologies Inc, Toronto, Ontario, Canada; <sup>b</sup>Center for Advanced Diffusion Wave Technologies (CADIFT), University of Toronto, Ontario, Canada; <sup>c</sup>Cliffcrest Dental Office, Scarborough, Ontario, Canada; <sup>d</sup>University of Texas Health Science Center, San Antonio, Texas, USA.

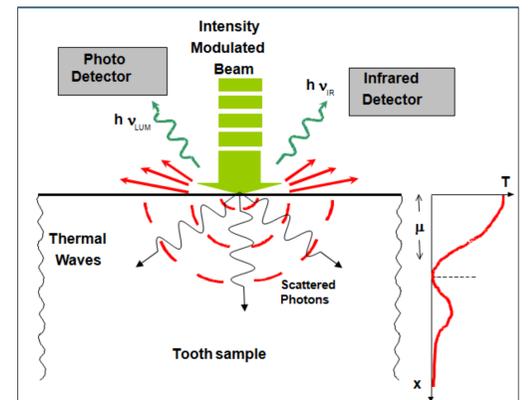
## The Canary System™ Technology

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 or amplitude of the converted heat or PTR signal
- The time delay or phase of the converted heat or PTR to reach the surface
- The strength or amplitude of the emitted luminescence (LUM)
- The time delay or phase of the emitted luminescence (LUM)

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.



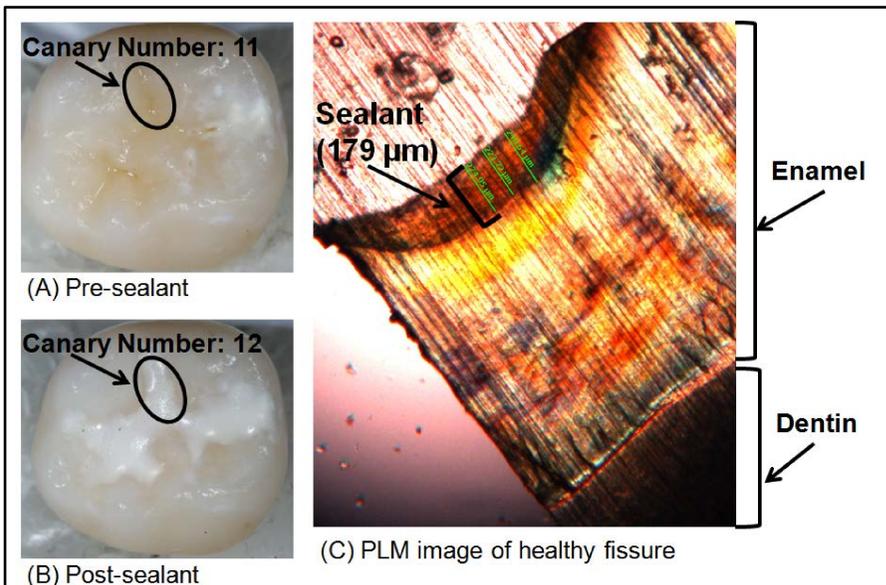
## Objectives

Quantum Dental Technologies' The Canary System™, a caries detection method based on PTR-LUM, aids dentists in the detection and monitoring of dental caries. The aims of this study were to: 1. Evaluate the ability of The Canary System to detect decay beneath dental sealant compared to DIAGNOdent, a fluorescence-based caries detection method; 2. Correlate the Canary Number (CN), an algorithm calculation based upon the PTR-LUM readings from the tooth surface, to carious lesion depth.

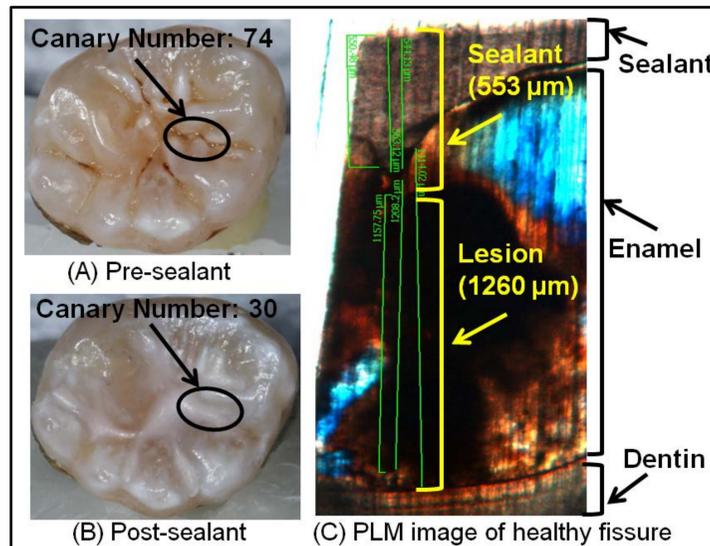
## Materials & Methods

- 28 extracted human teeth composed of 103 potential healthy and carious pits/fissures on their occlusal surfaces were used.
- Pits and fissures were scanned with The Canary System™ and DIAGNOdent before and after sealant placement with 3M™ ESPE™ Clinpro™ Sealant™.
- Polarized Light Microscopy (PLM) was performed at the University of Texas as the 'gold standard' to score examined sites as 'cariou' or 'non-cariou' in a blinded fashion
- Statistical analysis: The specificity, sensitivity and correlation with lesion depth were calculated using PLM as the gold standard. Wilcoxon's matched-pairs signed-ranks test was used to analyze differences in DIAGNOdent and Canary Number readings before and after sealing.

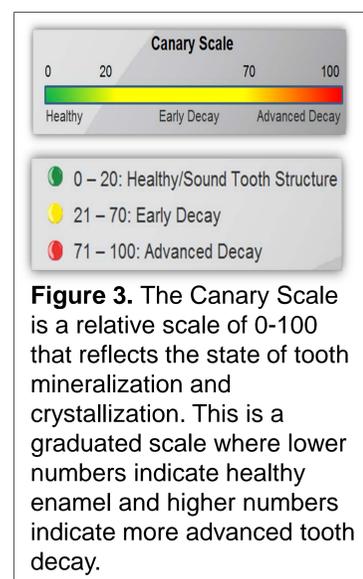
## Results



**Figure 1.** Photographic images of a representative healthy tooth sample (A) before and (B) after application of 3M™ ESPE™ Clinpro™ Sealant™. A site of interest on the occlusal surface (marked by a circle on the images) was scanned with The Canary System before and after sealant placement. Mean±sd Canary Number readings of the scanned site before and after sealant placement were 11±4 and 12±2, respectively. (C) Polarized light microscopy image of the scanned fissure shows healthy enamel and dentin beneath the sealant.



**Figure 2.** Photographic images of a representative carious tooth sample (A) before and (B) after application of 3M™ ESPE™ Clinpro™ Sealant™. A site of interest on the occlusal surface (marked by a circle on the images) was scanned with The Canary System before and after sealant placement. Mean±sd Canary Number readings of the scanned site before and after sealant placement were 74±4 and 30±1, respectively. (C) Polarized light microscopy image of the scanned fissure shows carious lesion extending into dentin beneath the dental sealant.



**Figure 3.** The Canary Scale is a relative scale of 0-100 that reflects the state of tooth mineralization and crystallization. This is a graduated scale where lower numbers indicate healthy enamel and higher numbers indicate more advanced tooth decay.

## Discussions

- The Canary System is able to detect caries beneath sealant with higher sensitivity and specificity than DIAGNOdent.
- DIAGNOdent readings significantly increased by an average of 346% following 3M™ ESPE™ Clinpro™ Sealant™ placement, resulting in potential overestimation of caries beneath sealant. DIAGNOdent is a fluorescence device so the significant increase in readings after sealing may be attributed to the intrinsic fluorescence properties of the sealant materials used in this study. Intrinsic fluorescence properties of the 3M™ ESPE™ Clinpro™ Sealant™ were not examined in this study.
- The low specificity of DIAGNOdent following sealant application indicates that DIAGNOdent registered a relatively high rate of post-sealant false positives.
- Canary Number readings were significantly dampened by an average of 53% following 3M™ ESPE™ Clinpro™ Sealant™ placement.
- When scanning the 3M™ ESPE™ Clinpro™ Sealant™ placed over pit and fissure caries, Canary Numbers > 20 were consistently obtained for 93% of caries of greater than 1000 microns (1 millimeter) in size.
- Canary Numbers ≤ 20 were consistently obtained for 95% of sealed healthy pits and fissures.
- Therefore, results in this study suggest that when scanning pit and fissure caries sealed with 3M™ ESPE™ Clinpro™ Sealant™, Canary Numbers > 20 indicate presence of caries >1000 microns in depth.

## Conclusions

- The ability of The Canary System to detect caries beneath dental sealant more accurately than DIAGNOdent has been demonstrated in the present study.
- This study suggests The Canary System has the potential to aid dental professionals to detect and monitor caries beneath sealants.

**Table 1.** Comparison of The Canary System and DIAGNOdent after dental sealant application.

Caries Detection Method	The Canary System	DIAGNOdent
Sensitivity	0.83	0.64
Specificity	0.79	0.46
Mean readings before sealing	51±30	7±13
Mean readings after sealing	24±13*	31±15*
Correlation with lesion depth	0.61	0.33

\* p < 0.05 for difference between pre-sealing compared with post-sealing (related-samples Wilcoxon signed-rank test).