Detection of Caries Around Ceramic Crown Restorations with The Canary System and DIAGNOdent

S. H. Abrams[a,b], B. Wong[a], K. Sivagurunathan[a], J. D. Silvertown[a], A. Mandelis[a,c], R. Klausz[d], B. T. Amaechi[e]

[a]Quantum Dental Technologies Inc, Toronto, ON, Canada; [b]Cliffcrest Dental Office, Scarborough, ON, Canada; [c]Center for Advanced Diffusion Wave Technologies (CADIFT), University of Toronto, ON, Canada; [d]Klausz Dental Laboratory, Toronto, Ontario, Canada; [e]University of Texas Health Science Center, San Antonio, TX, USA.

S.H. Abrams

The Canary System™ Technology

❑Pulses of laser light (600 nm) are shone on the tooth and the laser light is converted to four signals during a 5 second scan: 1) The strength of the converted heat (**PTR Amplitude**); 2) The time delay of the converted heat to reach the surface (**PTR Phase**); 3)The strength of the converted luminescent light (**LUM Amplitude**); 4) 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.

Objectives

The aim of this proof-of-concept *in vitro* study was to evaluate the ability of The Canary System™ and a laser fluorescence device (DIAGNOdent™) to detect natural decay around the margins of ceramic crown restorations.

Materials & Methods

❑ Sound (n = 1) and carious extracted human molars and premolars with a natural cavitated caries lesions (n = 3) were used.

❑ For carious samples, a dentist used a round bur in a slow speed handpiece to remove visible caries from the walls of the cavity ('sound walls' of carious teeth) while leaving some caries on the wall of one section of the cavity preparation about 1 – 2 mm below the margins ('carious walls' of carious teeth).

❑ Carious and sound teeth were prepared for a ¾ ceramic crown, ensuring that margins remained on enamel.

❑ Crowns were cemented onto the appropriate tooth samples using Cement-It® Universal C&B™ Resin Cement .

❑ Three groups of margins were examined: 'carious walls' in carious teeth; 'sound walls' in carious teeth; and sound walls in sound teeth.

❑ Following restoration, a blinded operator scanned a total of 48 examination sites with The Canary System and DIAGNOdent at the margin of restoration (MOR), and at distances 0.5 mm and 1 mm away from the margins into tooth tissue.

❑ Each examination site was scanned three times with The Canary System and the average Canary Number (CN) reading was recorded; DIAGNOdent measurements were repeated 3 times and average peak value recorded.

Results

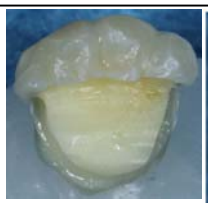
The Canary Scale

Figure 1. 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 sound enamel and higher numbers indicate more advanced tooth decay.

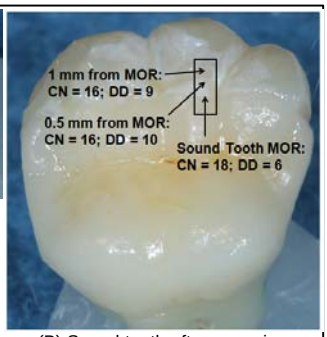
The DIAGNOdent Scale

DIAGNOdent Scale (KaVo DIAGNOdent 2095 Operating Instructions)	
Display value	**Clinical Situation**
0-10	Healthy tooth structure
11-99	Caries

Figure 2. The DIAGNOdent Scale. Reference: KaVo Dental. *KaVo DIAGNOdent Brief Operating Instructions*. Available at http://www.kavousa.com/US/Customer/Document-Library.aspx, Accessed Dec. 20, 2012.



(A) Sound tooth before ceramic crown restoration.



(B) Sound tooth after ceramic crown restoration.

Figure 5. Sound tooth before (A) and after (B) ceramic crown restoration. After restoration, sound tooth margins of restoration (MOR), 0.5 mm and 1 mm distances away from the MOR into tooth were scanned with The Canary System and DIAGNOdent. Corresponding mean Canary Number (CN) and DIAGNOdent (DD) readings are shown.

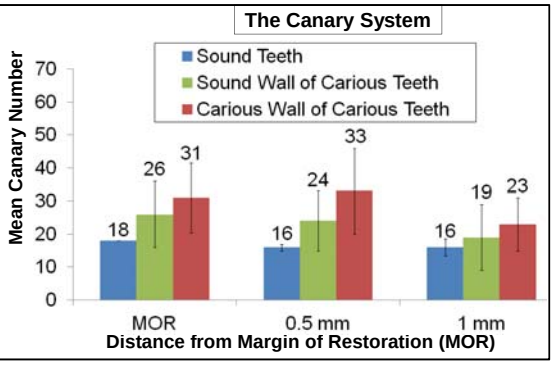


Figure 3. Mean Canary Numbers at margin of restorations (MOR), 0.5 mm and 1 mm from the margin into tooth structure for sound teeth, sound walls and carious walls of carious teeth. Margins of error at 95% CI are shown.

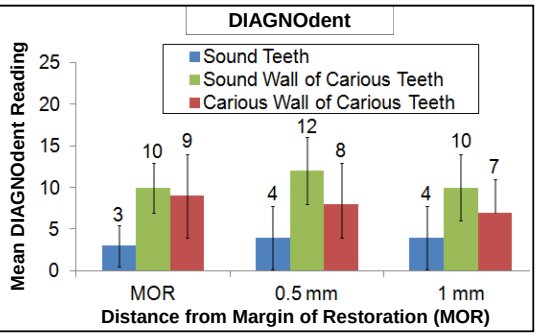
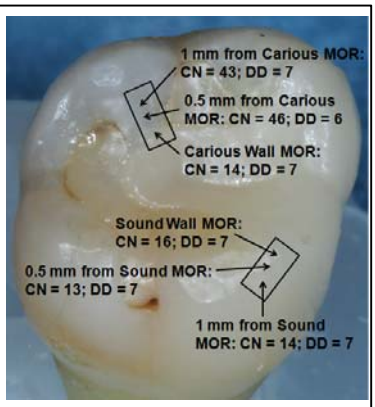


Figure 4. Mean DIAGNOdent readings at margin of restorations (MOR), 0.5 mm and 1 mm from the margin into tooth structure for sound teeth, sound walls and carious walls of carious teeth. Margins of error at 95% CI are shown.

(A) Proximal surface of carious tooth sample before ceramic crown restoration.

(B) Occlusal surface of carious tooth sample before ceramic crown restoration.



(C) Occlusal surface of carious tooth after ceramic crown restoration.

Figure 6. A representative carious tooth sample with natural decay removed from the walls of the cavity ('Sound Walls' of carious teeth) while leaving some caries on the wall of one section of the cavity preparation ('Carious Wall' of carious teeth). The proximal surface (A) and occlusal surface (B) of the carious tooth before ceramic crown restoration. (C) Occlusal surface of carious tooth after ceramic crown restoration. After restoration, margins of restoration (MOR), 0.5 mm and 1 mm distances away from the MOR into tooth were scanned with The Canary System and DIAGNOdent. Corresponding mean Canary Number (CN) and DIAGNOdent (DD) readings are shown for 'Carious Wall' and 'Sound Wall'.

Discussions

❑ Mean Canary Numbers were within decay tissue range (Canary Number 21 to 70) from the margins to 1 mm into tooth in all 'carious walls' and from the margins to 0.5 mm into tooth in all 'sound walls' of carious teeth, indicating presence of caries.

❑ Canary Numbers were within healthy tissue range (Canary Number equal or less than 20) in all walls in sound teeth.

❑ High CN at distances from the restoration margin (1 mm into tooth tissue) demonstrate the ability of The Canary System to detect decay at a distance from the scanned area, a function of the diffuse optical and thermal fields arising within the tooth upon excitation with the incident light.

❑ Thermal wave (heat) diffusion to surrounding areas can detect decay even at a distance from the initial point-scan location; a unique feature of photothermal (PTR) techniques

❑ In contrast, DIAGNOdent readings were all within healthy tissue range (DIAGNOdent reading 0 to 10) for all examination sites, suggesting that secondary caries may potentially be underestimated. The only exception was 0.5 mm away from MOR into tooth for 'sound wall' of carious teeth, where a mean DIAGNOdent reading of 12 indicated presence of caries.

Conclusions

❑ This proof-of-concept *in vitro* study suggests that The Canary System has the potential to detect secondary caries around ceramic crown restorations.

❑ Further studies of greater statistical power are currently in progress.