



Detection of Surface Erosion: A Novel Application for PTR-LUM Technology

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Abstract

Objectives: A caries detection system based on photothermal radiometry-modulated luminescence (PTR-LUM) technology called the Canary System uses a 660 nm visible (red) laser that penetrates 5mm into the tooth. This creates a photo thermal and luminescence response signals related to mineral integrity that is converted into a "Canary Number" (CN) which can be interpreted for early caries detection. Because the surface is the first layer encountered by the laser and the last surface registered by the response signal detectors, it's possible that erosion may exert a measurable effect on the CN. We wanted to determine if PTR-LUM technology is effective for detecting surface erosion.

Methods: Extracted human premolars were protected with nail polish to leave circular windows of uncoated tooth surface. An orthodontic bracket was bonded to each exposed tooth surface using Transbond XT, Fuji Ortho or an experimental fluoride-containing sealant (n=8 per treatment group). CNs were recorded above and below each bracket (incisal and gingival surfaces), the teeth were eroded four hours in 1% citric acid at pH 3.6, and the CNs retaken. The teeth were sectioned into sagittal slices through the brackets. Digitized micrographs of the cross-sections were analyzed for surface loss using Image-J software.

Results: There was significant (p<0.01) linear correlation between change in CN and surface loss (µm) for the two groups of orthodontic treatment that allowed surface loss and very few false positive responses where there was no surface loss.

Treatment Group*	Gingival Loss (µm)	R ² Gingival	Incisal Loss (µm)	R ² Incisal
T-XT (Halo)	19 ± 17	0.73, p<0.01	35 ± 22	0.82, p<0.01
FO (whole surface)	12 ± 9	0.81, p<0.01	14 ± 7	0.91, p<0.01
Exp-F (whole surface)	2 ± 4	0.37, p≥0.05	3 ± 7	0.60, p<0.05

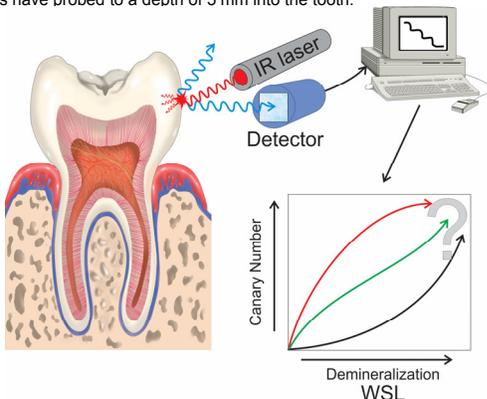
Conclusion: The incisal zones tended to erode more than the gingival zones. There were very few false positives found for the group that did not show surfaces loss. The Canary System may be useful for monitoring early erosion.

Introduction

- Dental erosion is the loss of tooth structure by acid dissolution without the involvement of bacteria.
- At this time there are three methods available to evaluate surface loss of dental hard tissues. They all assess the cross sections to observe surface loss
 - Light microscopy
 - X-ray microradiography
 - Profilometry
- We tested PTR-LUM technology as a possible fourth method to determine early surface loss (erosion) by comparison to light microscopy measurements.

Introduction PTR-LUM

Photothermal Radiometry (PTR) and Modulated Luminescence (LUM) signatures are combined to detect demineralization within the tooth. The PTR signature is the result of a pulsed 660 nm visible (red) laser beam focused on the tooth surface that generates a thermal wave absorbed by the tooth which in turn generates a Planck radiation emission out of the tooth. The LUM signature is the result of the absorbed light causing light emission from the tooth at different wavelengths based on the crystal orientation and demineralization. These two signatures provide complimentary results that when combined can be used to detect very small changes in the mineral and specifically demineralization. The Canary System (Quantum Dental Technologies, Inc.) uses the PTR-LUM methods that have been refined to pulse the laser light such that the resulting signatures have probed to a depth of 5 mm into the tooth.



The resulting signatures are combined in a mathematical formula developed from repeated scans of teeth to generate a single number called the Canary Number which is diagnostic of mineral quality where the larger the number the more likely there is demineralization. What is not known is how the Canary Number relates to white spot lesion depth, or what features may alter the resulting Canary Number.

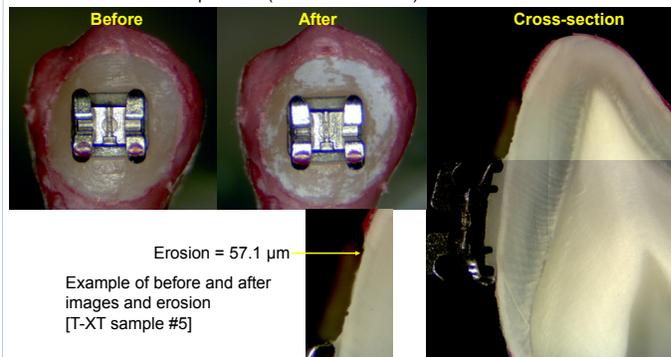
*Information about the Canary System can be found at Quantum Dental Technologies, Toronto CN, www.thecanarysystem.com. The authors have no financial or research relationship with Quantum Dental Technologies.

Purpose

To establish the reliability of PTR-LUM based technology to quantitatively evaluate surface loss from human enamel after exposure to erosion standard of 1.0 % citric acid at pH 3.60. This was established by use of light microscopy, an established reference method, and correlation analysis between the quantities determined from both analyses.

Methods

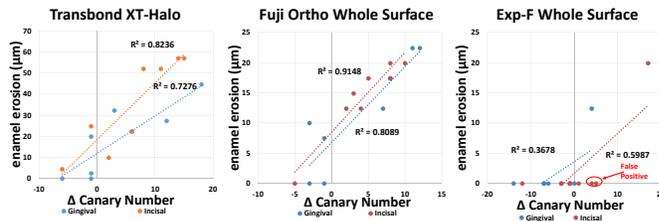
- We used an orthodontic model for the erosion,
 - Circular areas of human premolars extracted for orthodontic purposes were protected with nail polish, leaving 6mm circular windows of uncoated tooth surface to define experimental zones,
 - orthodontic brackets were bonded to the buccal surface of each tooth by use of one of three adhesives, n=8 for each treatment group:
 - Transbond XT (T-XT) leaving an unprotected halo around the bracket,
 - Fuji Ortho (FO) covering the whole exposed surface around the bracket,
 - Experimental fluoride-containing bonding resin (exp-F) covering the whole exposed surface around the bracket.
- Note that there was an exposed (unprotected) portion of the surface for the T-XT samples (control) verses completely covered surfaces for the exp-F and FO samples.
- Digital images were taken and PTR-LUM (Canary Numbers) were determined at the incisal and gingival regions (above and below) the bracket before the erosion,
- The teeth were exposed to 1 % citric acid (pH 3.60) erosion standard for 4 hours stirred @ 250 rpm.
- Digital images were taken and PTR-LUM (Canary Numbers) were determined at the incisal and gingival regions (above and below) the bracket after the erosion,
- The teeth were sagittally sectioned to create two 1 mm thick cross-sections through the bracket and thus through the incisal and gingival zones.
- Digitized light microscopy images were taken of the cross-section samples, see figures below,
- The digital images were analyzed with Image-J software to determine the maximum amount of surface loss (µm) in each zone (incisal or gingival).
- The change in Canary Number (ΔCN) was calculated by subtraction,
- The incisal and gingival surface loss was plotted against the ΔCN and the linear correlation was calculated.
- The statistical significance of the correlation coefficient (r) was determined by Pearson's r statistic.
- The incidence of false positives (from the PTR-LUM) was counted for all data.



Results

Treatment Group*	Gingival Loss (µm)	R ² Gingival	Incisal Loss (µm)	R ² Incisal
T-XT (Halo)	19 ± 17	0.73, p<0.01	35 ± 22	0.82, p<0.01
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*n=8 for each gingival and incisal group, significance determined by Pearson's r.



Discussion

- The correlation between the change in the Canary Number (ΔCN) and the surface lost (µm) was linear for the treatments that resulted in surface loss.
- Two false positive responses were observed where there was no surface loss
- The incisal zones tended to erode more than the gingival zones. There were no false positives found for the group that did not show surfaces loss.

Conclusions

- There was significant linear correlation between ΔCN and the two groups of orthodontic treatment that allowed surface loss and very few false positive responses where there was no surface loss.
- The Canary System may be useful for monitoring early erosion.

Funding

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