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Cement composition effects on enamel demineralization adjacent to orthodontic brackets

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Introduction

Incipient caries lesions or white-spot lesions (WSL) continue to be one the most common clinical problems resulting from orthodontic treatment with fixed appliances. It has been reported that enamel demineralization around orthodontic bands and brackets occurs as early as 1 month after starting treatment (O'Reilly, 1987). Several advancements in orthodontic cements have shown promise in reducing the development of these incipient lesions. Recently, a water-based calcium aluminate glass ionomer luting cement (Ceramir) has shown bioactive surface apatite formation which may influence local demineralization and remineralization. This bioactive cement has displayed self-sealing properties (Lööf, 2008), creation of an alkaline environment and has exhibited antibacterial properties (Unosson, 2012). Thus, there are implications of this material as an orthodontic adhesive and its potential to inhibit the development of white-spot lesions.

The Canary System is based on analyses of luminescence and thermal behavior of emitted infrared photons caused by demineralization of enamel. The technology is termed noncontacting frequency-domain photothermal radiometry and frequency-domain luminescence, commonly abbreviated PTR-LUM. PTR-LUM has been shown to be capable of monitoring artificially created carious lesions, their evolution during demineralization, and the reversal of lesions under the growth of a remineralized surface (Jeon, 2008). The software generates a Canary number, indicating the lesion severity.

Fig. 1: (A) Experimental material – Ceramir Crown and Bridge (B) Comparison material – Transbond XT (C) Data collection method – The Canary System

Objectives:

This in-vitro study's objective was to evaluate possible effects of a bioactive cement on enamel demineralization around orthodontic brackets compared to a composite resin cement. A secondary aim was to determine the capability of The Canary System for detecting and quantifying artificial enamel demineralization around orthodontic brackets

Methods

A sample of 32 caries-free extracted human teeth (under an IRB-exempt protocol) was collected. Orthodontic brackets were cemented to each tooth with either Transbond XT (composite resin cement) or Ceramir (bioactive calcium aluminate glass ionomer cement). A 3x3 mm window adjacent to the bracket was created with acid-resistant varnish for an area to measure. The acid-resistant varnish was applied twice to cover the entire tooth, besides the window, and light cured each time for 12 seconds. Each sample was then placed in a 40 mL airtight polypropylene plastic container (Tite-Rite containers, Global Scientific) at 100% humidity and labeled for data collection.

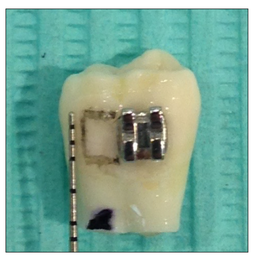

Fig. 2: Example tooth sample

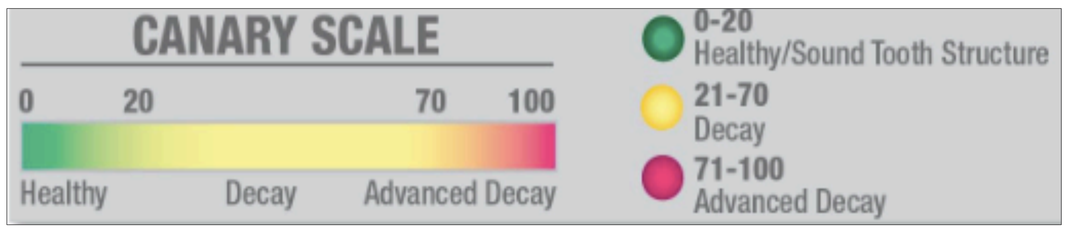

Fig. 3: Canary System scoring scale: 0-20 = Healthy/Sound Tooth Structure; 21-70 = Decay; 71-100 = Advanced Decay

Acetic acid (pH=3) was used as a demineralizing solution and distilled water as a control. The sample was randomized into 4 groups (n=8): composite resin cement in acetic acid, composite resin cement in distilled water, bioactive cement in acetic acid, bioactive cement in distilled water. Five (5) Canary scores (0-100, higher values indicating increased demineralization as seen in **Figure 3**), were obtained at baseline (T=0), 2 days (T=1), 7 days (T=2), and 14 days (T=3). At each measurement time point the tooth samples were removed from their respective solution, dried with air syringe, and let air-dry for 20 minutes prior to obtaining Canary scores. Once ready, the teeth were positioned on their flat side on a table and the Canary laser was used to get 5 independent scores for each sample at each time point. The Canary tip was positioned in the 3x3 mm window as close to the bracket as possible, and flush with the tooth surface to obtain each score. A single investigator obtained the Canary scores for the study and each score was recorded as shown in **Figure 4.** ANOVA and pair-wise post-hoc tests were used to analyze the data.

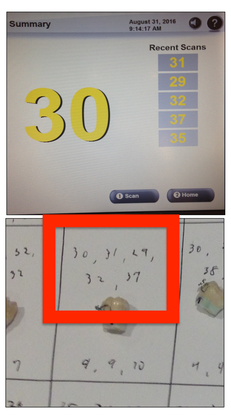

Fig. 4: Data collection and recording

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Results

We studied 32 caries-free extracted human teeth to evaluate the possible effects of a bioactive cement on enamel demineralization around orthodontic brackets compared to a composite resin cement. The Canary System was used for data collection as discussed in the materials and methods. **Table 1** shows a summary of all of the data collected

	T = 0 (Baseline)	T = 1 (2 Days)	T = 2 (7 Days)	T = 3 (14 Days)	Δ (T3-T0)
A = Transbond in Acid					24.45 +/- 10.5
Total Average	27.65	38.35	49.63	52.1	
Total Range	19 (39-20)	35 (60-25)	48 (74-26)	38 (71-33)	
Total SD	4.34	10.4	13.14	9.61	
SD Range	4.89 (5.72-0.83)	7.2 (9.5-2.3)	17.1 (18.2-1.1)	11.5 (13.7-2.2)	
B = Ceramir in Acid					21.175 +/- 12.5
Total Average	23.6	38.25	46.5	44.75	
Total Range	20 (33-13)	42 (62-20)	43 (65-22)	39 (67-28)	
Total SD	4.72	10.36	11.89	11.65	
SD Range	4.2 (4.7-0.5)	11.2 (13.5-2.3)	10.8 (11.5-0.7)	13.1 (13.8-0.7)	
C = Transbond in Water					2.575 +/- 4.8
Total Average	28.2	32.25	31.43	30.78	
Total Range	12 (34-22)	26 (47-21)	23 (43-20)	14 (37-23)	
Total SD	3.24	5.92	5.59	3.52	
SD Range	2.1 (2.9-0.8)	5.0 (6.4-1.4)	5.1 (5.9-0.8)	3.7 (4.5-0.8)	
D = Ceramir in Water					6.375 +/- 4.6
Total Average	20.88	26.28	27.18	27.25	
Total Range	8 (26-18)	11 (31-20)	19 (35-16)	18 (37-19)	
Total SD	2.4	2.58	4.56	3.97	
SD Range	3.4 (3.8-0.4)	2.4 (3.8-1.4)	4.9 (5.7-0.8)	2.5 (4.1-1.6)	

Table 1: Data collection summary

Composite resin cement (p=.0003) and bioactive cement (p = .0001) showed significant demineralization around orthodontic brackets compared to the controls as seen in **Figure 5**. The mean change in Canary score from T0-T3 for Transbond XT was 24.5±10.5, while Ceramir was 21.2±12.5. Although the bioactive cement did have a smaller change in mean Canary score when compared with resin composite, this difference was not significant (p=.438).

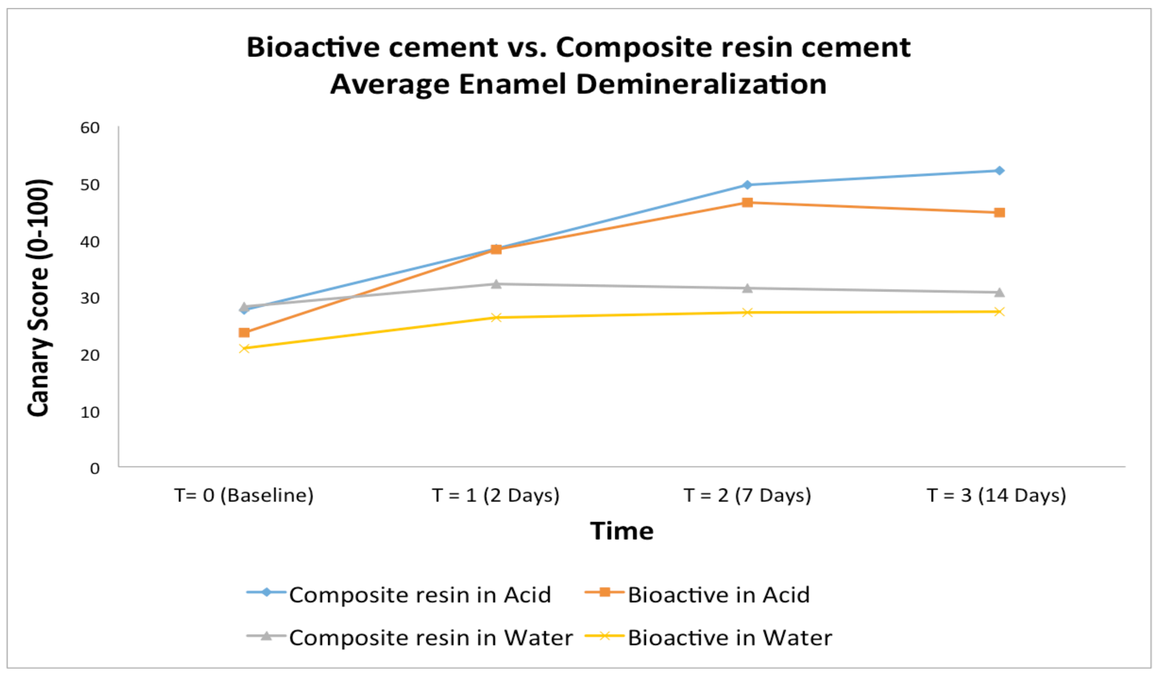

Fig. 5: Graph illustrating the mean Canary score for each of the four study groups over time.

As seen in **Figure 5,** the Canary System displayed capability to detect and quantify artificial enamel demineralization adjacent to orthodontic brackets. In addition, **Figure 6** shows the mean Canary score range for each of the 32 tooth samples. The mean ranges for the experimental samples in acidic solution are greater than the control samples. The total mean Canary score range for each group include: Group A = 12.5, Group B = 14.7, Group C = 7.1, Group D = 6.6.

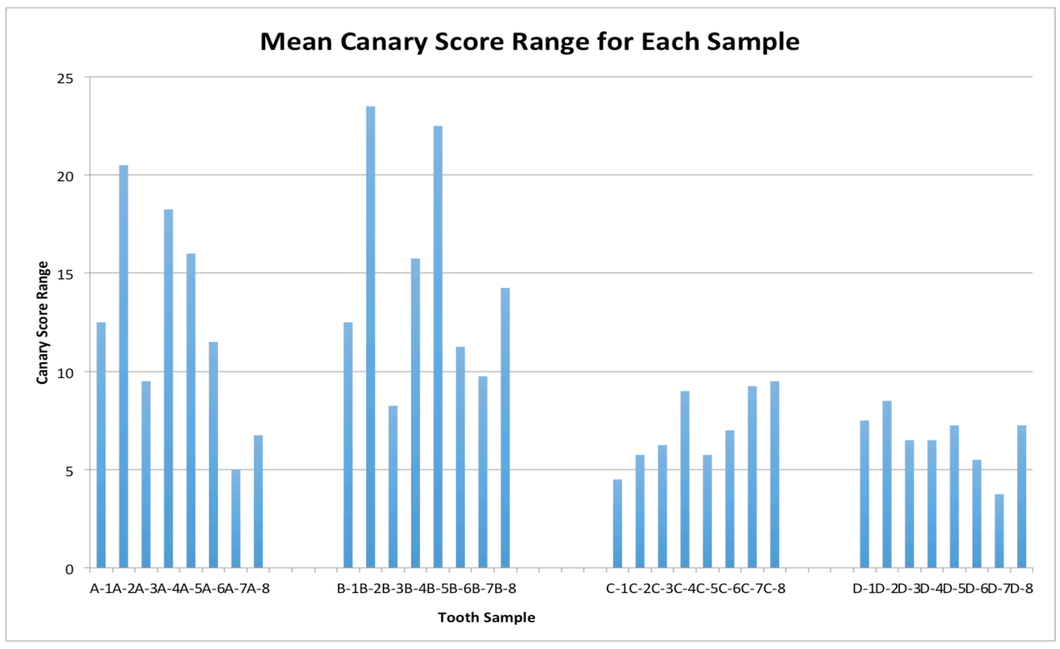

Fig. 6 : This graph represents the mean Canary score range for each tooth sample. Each bar line equals the average of the Canary score range at each of the four (4) measurements: A = Composite resin in Acid; B = Bioactive in Acid; C = Composite resin in Water; D = Bioactive in Water

Conclusions

This in-vitro study:

1. **Displayed no significant difference in demineralization inhibition between the cements tested within the limits of this preliminary study.**

2. **Demonstrated the ability of the Canary System, using PTR-LUM technology, to monitor progressive enamel demineralization, in-vitro, around orthodontic brackets.**

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