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DeltaFil Glass Ionomer Restorative Remineralization and Acid Erosion In-Vitro Evaluation

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Introduction:

DeltaFil (DMG America) is a new fluoride releasing glass ionomer restorative with micelle technology which gives it increased strength, fracture toughness and improved wear characteristics. This study measured the remineralization characteristics and ISO 9917-1 Acid Erosion values compared to another glass ionomer restorative in ***Ketac Universal*** (3M).

Acid erosion is a test that measures the potential in which glass ionomer cement materials dissolve due to low pH environments, in this case by Lactic Acid which is produced by cariogenic bacteria. It is one of the benefits of glass ionomer materials that they dissolve during cariogenic challenges to release ion that buffers the acid and releases fluoride to the surrounding tissues. Previous generations of glass ionomer cements were prone to dissolve to the point that they reduced the physical properties in low pH environments.

Remineralization of tooth tissues and caries arrest potential is the main selling point for choosing to use a glass ionomer restorative. This material can be used in the ART (atraumatic restorative treatment) to promote remineralization, hardening carious lesions and halting decay while requiring less tooth structure to be removed. Newer glass ionomer restorative materials like this one have increased strength and esthetics to be useful in an increasing number of cases. This study used a combination of µCT scanning to measure the mineral density of extracted teeth in an in-vitro model combined with measuring the surface hardness.

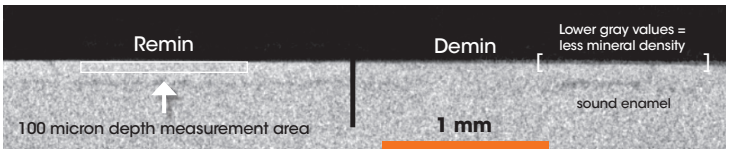
Conclusion:

DeltaFil has more acid erosion resistance than ***Ketac Universal***, and both were better than required by ISO 9917. Both materials exhibit similar and effective remineralization

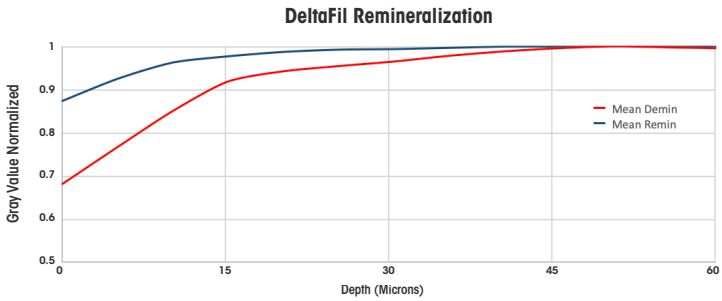
Methods and Results:

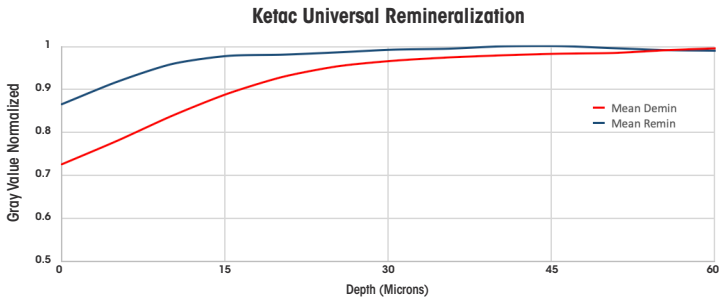
Remineralization: Enamel specimens (n=5) were mounted and screened to have a Vickers microhardness (Shimadzu HMV-G21, 200 g, load 15s dwell time) over 340 HV. Specimens were then submitted to a pH-cycling protocol based on Featherstone et al., 2011 in which blocks were kept at 37°C in a demineralizing solution (2.0 mM calcium, 2.0 mM phosphate, 0.03 ppm F, 75 mM Acetic Acid, pH 4.3) for 3 hours and in a remineralizing solution (1.5 mM calcium, 0.9 mM phosphate, 150 mM KCL, 0.05 ppm F, in 20 mM cacodylic buffer, 7.4 pH) for 21 h and rinsed between cycles. This was repeated for 5 days and then placed in the remineralized solution for a further 2 days. Surface hardness measurements were taken and were largely above the desired 200 HV. A 2 x 2 mm window was painted on the specimens using a chemical resistant varnish (Revlon Black), and glass ionomer restorative was placed on the enamel surfaces according to manufacturer instructions (mixed with ProMix (Dentsply) at 4200 RPM), which for ***DeltaFil*** included the cavity ***DeltaFil Conditioner***. Specimens were stored in distilled water at 37°C for 3 weeks with daily immersion in 1100 ppm fluoride solution to simulate toothpaste use. After this period, the varnish and material were scrapped off. Surface hardness measurements were conducted before specimens were scanned with a ZEISS Xradia 520 Versa X-ray microscope with a 5-micron voxel resolution. Scans were processed with Dragonfly Pro (ORS) and transverse images analyzed with ImageJ (U.S. NIH Bethesda, Maryland, USA) to determine change in radiographic density levels vs depth every 5 microns. Radiographic density which is correlated to mineral density was measured and averaged in a 1 mm x 0.1 mm depth along the surface by the ImageJ Plot Profile function. The gray values were normalized for each image, with the maximum intensity set to 1. The area under the curve for the area that was remineralized and demineralized was calculated to measure the change in overall mineral density. The relative remineralization was calculated with the formula RelΔA = (A(remin)-A(demin))/A(demin) *100, or the difference in the area under the remineralization curve and demineralization curve.

ZEISS Xradia 520 Versa X-ray microscope

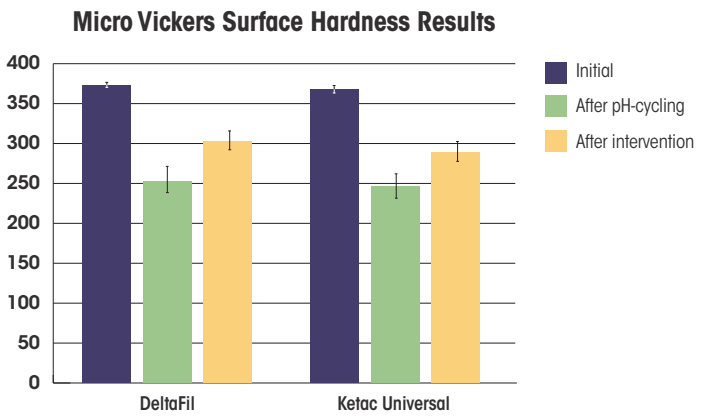


Transverse cross-section of a demineralized enamel specimen, the left had glass ionomer applied, the right was covered by a varnish as a control

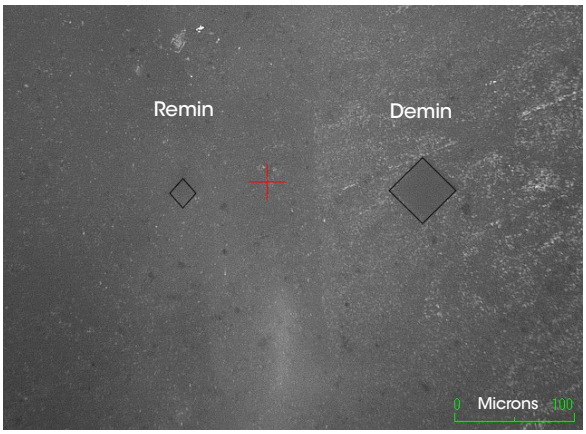




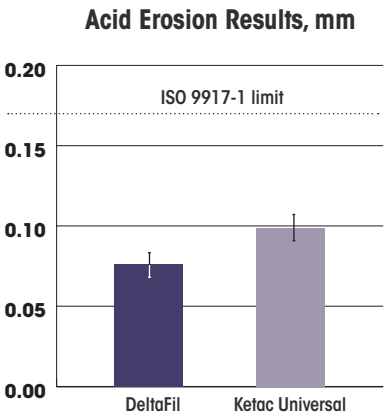
Lesion depth created by the pH cycle was approximately 50 microns averaged over 5 replications. The relative change in remineralization was 6.3 ± 2.9 % for DeltaFil and 6.5 ± 2.9 % for Ketac Universal. For context, the pH cycling removed approximately 8% of the mineral density of the 50 microns closest to the surface, and the intervention of the glass ionomers restored approximately 6.5% of that mineral density.



The surface hardness of the enamel specimens improved with both products to similar degrees.



(Left) Surface hardness indent after demineralization and intervention by ***DeltaFil.*** (Right) Surface hardness indent after demineralization and covered by a chemical resistant varnish.



The ISO 9917-1 limit for glass ionomer restorative erosion depth is 0.17 mm, which both materials easily passed. DeltaFil has less acid erosion than Ketac Universal, which was similar to DMG's listed internal testing of 0.067 mm.

Acid Erosion was tested using the ISO 9917-1 method which uses 5 specimens with the products cured in a 5 x 2 mm cavity, mounted in acid resistant PMMA, cured for 24 hours at 37°C before being finished with 1200 grit paper to produce a smooth surface. Specimens were immersed in a lactic acid solution at pH 2.74 for 24 hours and then rinsed. Measurements of the height of the specimen to 0.001 mm with a micrometer (Mitutoyo 293-831-30) are compared before and after the acid challenge to determine the eroded depth.

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