Report to the Sponsor

Performance of an Improved Dual-cured Bulk fill Composite in Adaptation under High C-factor

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Introduction:

Detection of the interfacial micro-defects is important both from the clinical point of view and in dental materials research. Research has shown that even with the new bulk-filled composites the gaps mainly occur at the line-angles or at the cavity base, and range from less than a micrometer up to several tens of micrometers in size. Clinically, these microgaps are undetectable by the conventional diagnostic methods, such as radiographic films, which suffer from image super imposition and lack of accuracy on the micron-scale. Conventionally, dye-penetration leakage tests and microscopic assessment of the interface have been employed for in vitro detection of such defects. Those destructive methods require sectioning of the teeth to evaluate the interface, and cannot specify the origin and timing of gap formation. In this regard, incorporation of newer diagnostic technologies for research on adaptation of restoration, such as 3D imaging by X-ray micro computed tomography (micro-CT) and optical coherence tomography (OCT) have gained increasing attention in adhesive dentistry research.

Swept-source OCT (SS-OCT) has shown a capability to detect the gap along the cavity floor of composite restorations. It has become a promising imaging modality in dentistry, which does not require cutting and processing of the specimens and allows the visualization of microstructures of tissue and biomaterials in the real time. SS-OCT imaging technology is a unique research theme brought by the PI to the Biomimetics Biomaterials Biophotonics Biomechanics and Technology (B4T) laboratory at the Department of Restorative Dentistry, University of Washington School of Dentistry. This technology demonstrated a remarkable capability with high sensitivity and accuracy in detection and quantification of gaps as small as a few micrometers at the bottom of composite restorations, becoming a modern research tool in this field.

A dual-cure flowable composite product (Bulk EZ, Danville Materials) previously tested at B4T showed promising results in terms of good cavity adaptation and no gap formation, when compared with light-cured composites. ZEST has developed a prototype formulation with improved properties; the original Bulk EZ utilized a microhybrid filler particle system. The new prototype uses 80 nm spherical zirconia fillers. This is expected to have the benefit of increased shade adaptation, polishability, and wear resistance. However, the effect of this filler change on the marginal adaptation of the composite needs to be investigated.

Since OCT is nondestructive, it enables detection of gaps developed during light curing as well as pre-existing defects. In order to create standard cavities to simulate large C-factor conditions clinically, we used simulated composite cavities in the previous study, and plan to continue the same setup in the current experiment.

This project aims to measure and compare gap formation in the pulpal floor of bonded 3mm diameter 4 mm deep simulated preparations using 5 different composites.

Materials and Methods:

Cavity Molds: cavity molds were created using Estelite flow composite to mimic a human tooth. These molds allowed us to create 3D images of the cavity floor because they allow the OCT laser to penetrate through the mold unlike human teeth, which were found to be more difficult to analyze using the OCT

Composite Groups

1. Bulk EZ+Zr fillers Prototype (ZEST); this material does not need a separate occlusal capping
2. Surefil SDR Flow+ flowable light cured (Dentsply); a separate occlusal capping is recommended
3. Surefil One: Self-adhesive capsule type bulk fill (Dentsply): Glass ionomer based restorative
4. Filtek One: Paste-type bulk fill composite (3M), no need for a separate occlusal capping
5. Hyperfil by Parkell (dual-cure automix flowable), can withstand occlusal forces

Light Curing Unit

3M Paradigm Deep Cure LED Unit (1200 mW/cm^2) as specified by Filtek One brochure. Gap formation at pulpal floor was monitored in real time using OCT. A cavity floor adaptation and separation area will be calculated from 3D OCT scans and the results will be reported as average adaptation % for each group. The results were statistically compared using one-way ANOVA with appropriate post-hoc tests at statistical significance level of alpha = 0.05. The 3D raw data obtained by SS-OCT are analyzed by software to calculate the gap areas at the cavity floor in groups.

Gap Analysis

Images from the OCT was collected, along with live videos that show whether there was gap formation or not.

Bright spots on the cavity floor were considered a gap (given light and refraction properties) and percentage of gaps were determined by visual scoring system:

Score 1 = no gap or less than 10% of cavity floor separation

Score 2 = 10 – 50% separation

Score 3 = 50 – 90% separation

Score 4 = >90% separation

Overall Results:

Observations are summarized in Figs. 1-4. Both dual-cured materials showed significantly less gap than other materials, while there was no significant difference between them. Largest gaps were observed with Surefil One. When internal voids (not quantified, excluding interfacial gaps) were considered, Hyperfil created more internal voids than BulkEZ+Zr and SDR. In addition the operator noticed that there were occasional working time issues with Hyperfil, setting too fast. In this, experiment, Filtek One created large areas of voids at the internal line angles and was more difficult to adapt initially.

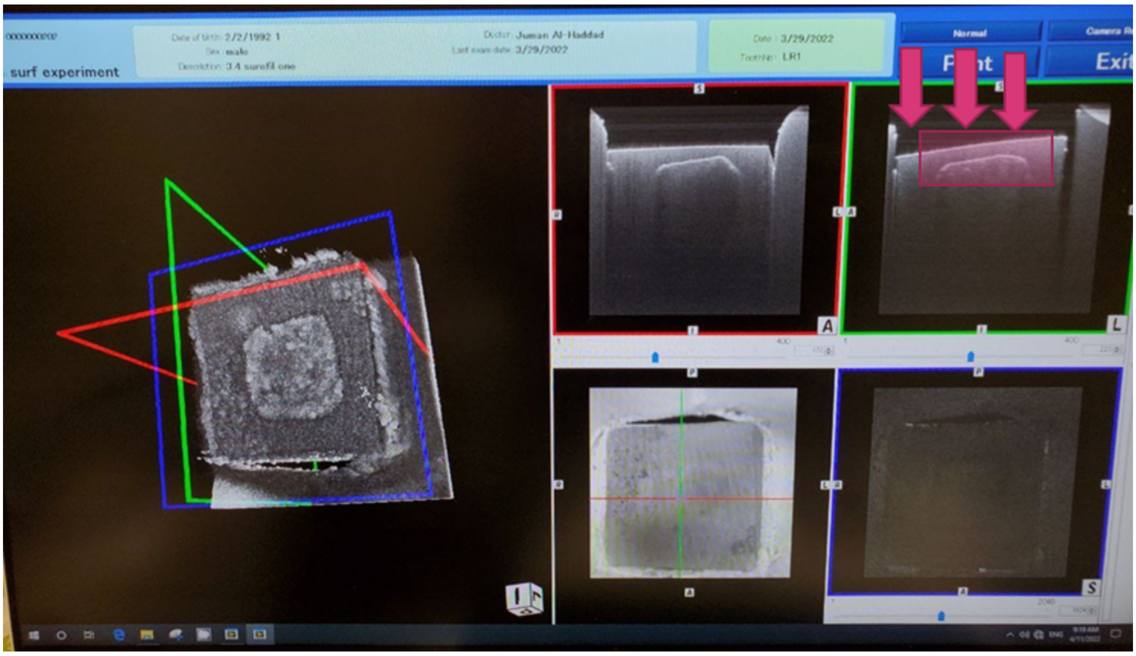

Figure 1 Representative specimen from the Surefil One group. The arrows indicate 100% separation from cavity floor in this sample.

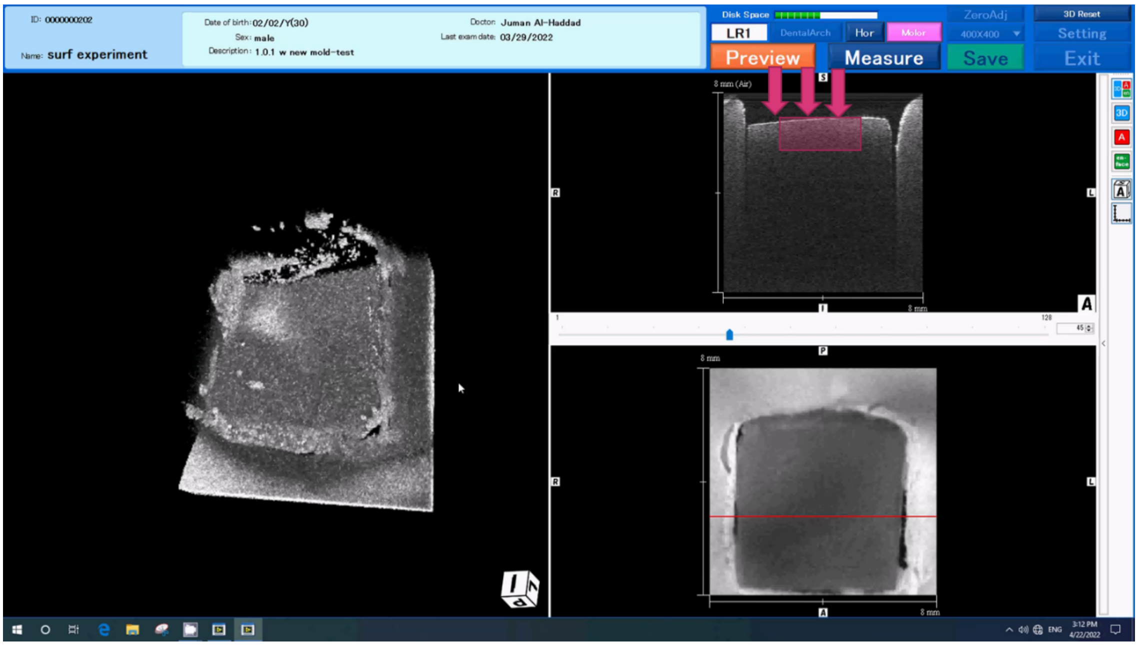

Figure 2 Representative specimen from the prototype BEZ+Zr group. The arrows indicate 100% adaptation to cavity floor in this sample.

3D Gap Images at the Cavity Floors

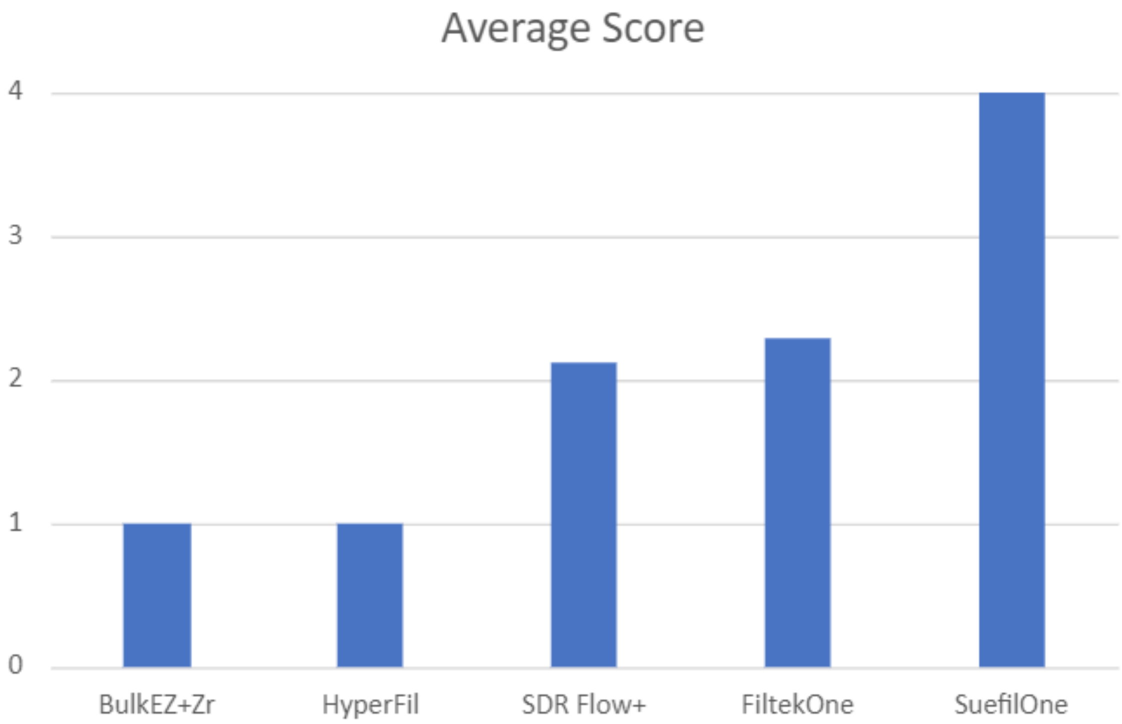

Figure 3 Mean gap scores based on the scoring criteria for each group

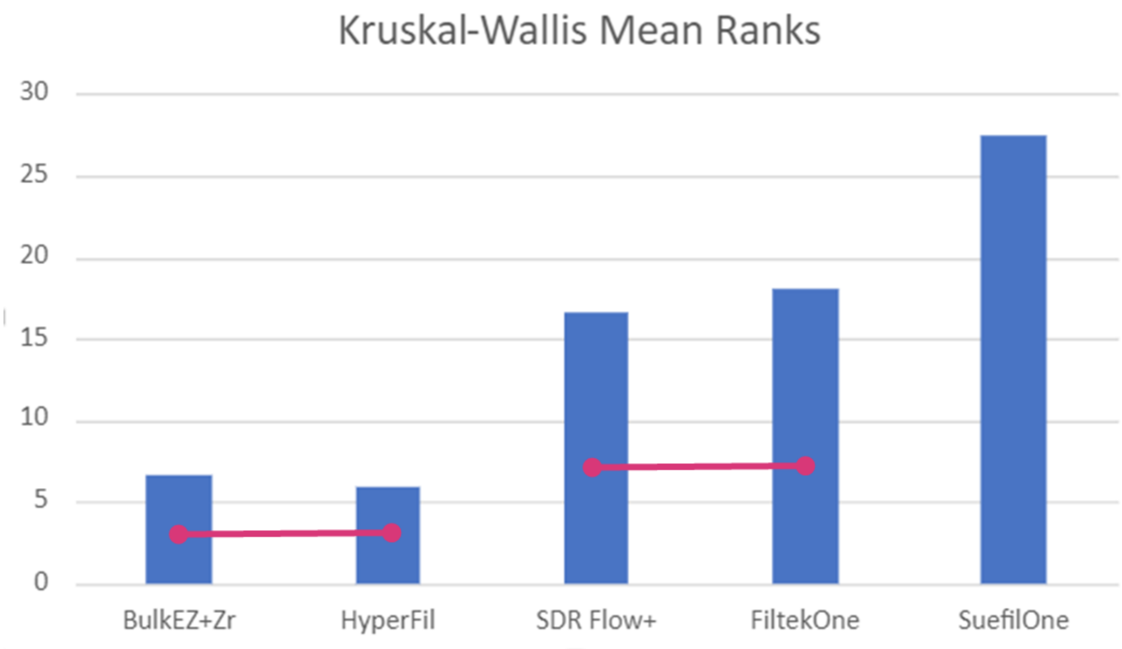

Figure 4 The straight lines indicate no significant difference (p>0.05) Mann-Whitney test; n=8

Conclusions

OCT experiment showed how gaps formed between the cavity floor and different bulkfill composite products upon curing. Dual-cure bulkfill composites tested showed significantly better adaptation than light cured ones.

The so-called self-adhesive capsule restorative material debonded completely, more than all other products tested.

Considerations and Future Steps

Composite mold which provides a C-factor, testing on human dentin is important, given that the composite molds can pose a limitation to this study. We are conducting the MicroTensile Bond Strength test on deep preparations in human teeth to test the bond strength of each composite to the cavity floor dentin.

Appendix

PowerPoint with Real-time videos