3D Assessment of Bulk-fill Composites Gap Formation and Polymerization Shrinkage

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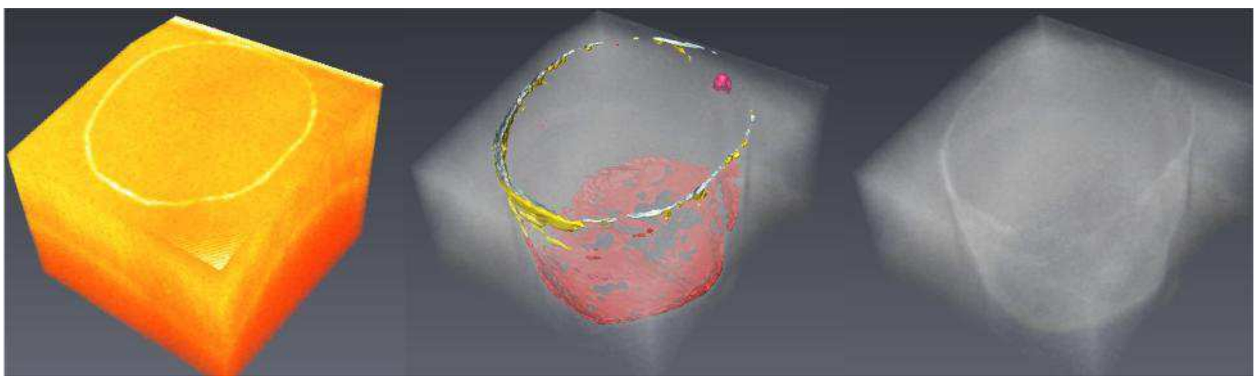


Objectives:

To investigate gap formation and volumetric shrinkage among bulk-fill composites quantitatively by sweptsource optical coherence tomography (SS-OCT).

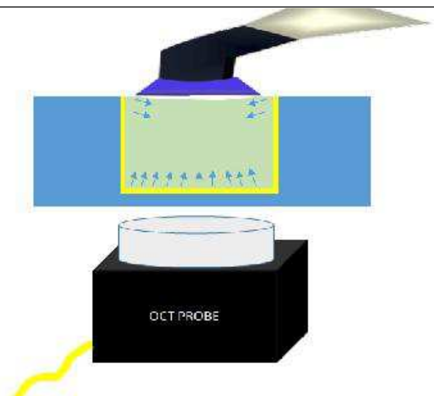
Methods:

Gap formation and shrinkage volume were compared among light-cured bulk-fill composites;

Surefil SDR (SDR, Dentsply),
SonicFill A2 (SNF, Kerr),
Tetric N-ceram
Bulk Fill IVW (TNB, Ivoclar Vivadent), dual-cured bulk-fill composite
Bulk EZ A2 (BEZ, Danville Materials), and
core composite Clearfil Photo Core (CPC, Kuraray Noritake Dental).

Gap formation (n=10) was observed in bonded tapered cylindrical composite cavities (4 mm depth, 3 mm diameter) and free shrinkage volume under un-bonded condition was observed at the top and bottom of tubes with similar dimensions (n=8). The 3D raw data obtained by SS-OCT (IVS-2000 Santec) were analyzed by Amira software to calculate the gap areas at the cavity floor and free shrinkage volumes at the tube. The bottom/top degree of conversion ratio (DC%-R) through 4-mm depth was also measured using micro-Raman spectroscopy (Horiba), with DC calculated as the ratio of peak intensities of the aliphatic 1638 cm^{-1} and aromatic 1607 cm^{-1} peaks in cured composites. Data were analyzed by one-way ANOVA with Bonferroni correction (α=0.05).

Table 1. Diagrams of testing instruments

 OCT: Optical coherence tomography	**Cavity Preparation** Depth: 4 mm Width: 3 mm Material: Estelite Flow Quick A2 shade 

Results:

BEZ group showed no gap formation at the cavity floor in any of the specimens while SNF showed statistically significantly higher gap formation than other groups; the following statistical order was achieved in terms of gap area SNF>SDR=CPC>TNB>BEZ. On the other hand, volumetric free shrinkage was statistically ordered as BEZ>SDR>TNB> SNF= CPC. Meanwhile, TNB showed significantly lower DC%-R than all other groups.

Table 2: Gap Area, Volumetric Shrinkage and DC Ratio Results

Gap Area, Volumetric Shrinkage and DC Ratio Results					
Groups	**TNB**	**SNF**	**SDR**	**CPC**	**BEZ**
Gap Area %	15.0 ± 3.0	74.8 ± 7.2	54.0 ± 9.2[a]	47.9 ± 8.2[a]	0.0 ± 0.0
Free Shrinkage Vol %	1.8 ± 0.11	1.6 ± 0.04[b]	3.2 ± 0.09	1.6 ± 0.04[b]	3.4 ± 0.14
Bottom-Top, DC ratio %	77.4 ± 5.6	92.8 ± 2.6[e]	97.8 ± 1.5[f]	96.8 ± 3.3[e,f]	99.8 ± 2.7[f]
Values marked by similar letters in each row are not statistically different (p>0.05).					

Figure 1. Representative 3D Gap Images at the Cavity Floors

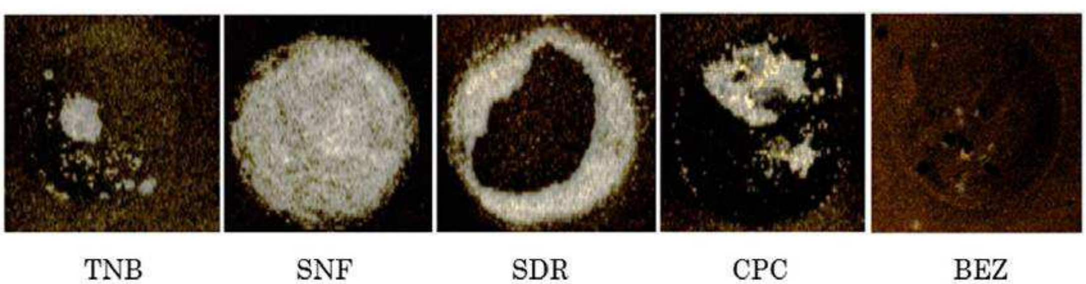
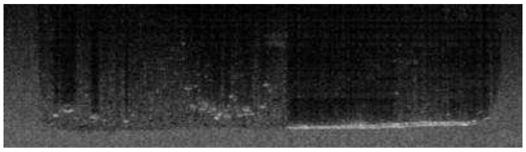
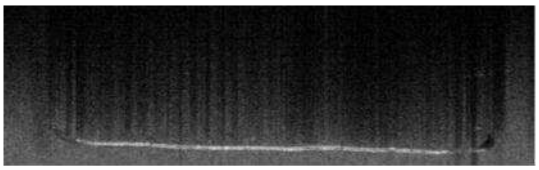
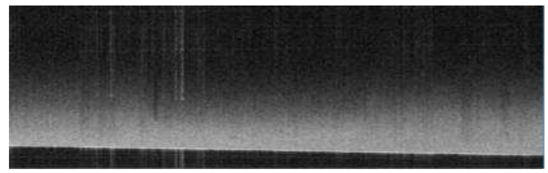


Figure 2. Representative side view Images at the Cavity Floors

 CPC 4 mm	 SDR 4mm
 SNF 4mm	 Bulk EZ 4mm

<u>Conclusions:</u>

Light-cured bulk-fill composites showed various degrees of gap formation and volumetric shrinkage. The dual-cured bulk-filled composite, which mainly underwent chemical polymerization upon placement, showed a stable degree of conversion through the depth and the best sealing performance despite its tendency for higher volumetric shrinkage under non-bonded conditions.