

Polymerization of Dual Cure and Phorocuring Bulk-Fill Composites

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Objective

In recent years, bulk fill composites have been introduced to the market claiming that they could be placed in bulk up to 4 or 5 mm thick layers, avoiding the layering techniques, while allowing adequate polymerization. The aim of this in vitro study was to investigate the degree of conversion (DC%), depth of cure (DPC) and microhardness (MH) of a dual-curing bulk-fill composite compared to light-curing ones in deep simulated cavities.

Materials and Methods

Materials tested were Fill-Up! (Coltene), a dual-curing bulk-fill material, and three photocuring bulk-fill composites: SDR (Dentsply), SonicFill (Kerr) and Tetric EvoCeram BF (Ivoclar). Flat dentin surfaces were obtained from extracted non-carious human molars. A cylindrical mold (height: 8 mm; diameter: 5 mm) obtained from a putty polyvinylsiloxane impression material was positioned on the dentin surface. After application of the adhesive system (ParaBond, Coltene), composites were placed into the mold in bulk and polymerized for 20 s with a LED curing light (Coltolux SPEC3, Coltene) from the top of the cylinder. After 24 h molds were removed and composite cylinders were sectioned perpendicularly to the top surface to expose the composite depth. Micro-Raman spectra of the specimens were collected using a Raman equipment (Renishaw InVia) at 1 mm intervals from the bottom to the composite surface. Spectra were acquired over the spectral region of 400 to 1900 cm⁻¹. Micro-Raman spectra of the uncured and cured composites were collected to identify reference and reaction peaks [605cm⁻¹ (C-O-O); 1610cm⁻¹ (aromatic ring); 1640cm⁻¹ (C=C) group]. DC % was calculated using the ratio between reactive and internal reference peak intensities. MH assessment was measured on the same specimens analyzed with micro-Raman at 1 mm intervals from the bottom to the composite surface with a Vickers microhardness tester (Leica Microsystem) at a 200 g load for 10 s. Data were statistically analyzed with Kruskal-Wallis and Mann-Whitney tests.



Raman equipment

Microhardness indenter

Results

Results are summarized in Table 1. Fill-Up!, Tetric EvoCeram BF and SDR showed an adequate DC% at all depths, but MH significantly decreased at higher depths for all materials except for Fill-Up!, which was the only composite with a comparable MH at all depths. SonicFill could not be polymerized beyond 6 mm.

| DC% | Fill-Up! | | SDR | | SonicFill | | Tetric EvoCeram BF | | Micro hardness | Fill-Up! | | SDR | | SonicFill | | Tetric EvoCeram BF | |
|--------------------------------------|--|----------|-------------------|----------|-------------------|----------|--------------------------|----------|--|-----------------------------------|--------------------------|---------------------------|----------------------------|---------------------|-------------------------|---------------------------|-------------------------|
| depth (mm) | mean | st. dev. | mean | st. dev. | mean | st. dev. | mean | st. dev. | depth (mm) | mean | st. dev. | mean | st. dev. | mean | st. dev. | mean | st. dev. |
| 1 | 59.7 ^a | 5.4 | 53.1 ^a | 6.8 | 71.9 ^a | 8.1 | 69.6 ^a | 4.1 | 1 | 71.4 ^A | 18.5 | 52.6 ^A | 12.0 | 78.4 ^A | 6.9 | 64.3 ^A | 4.3 |
| 2 | 63.7ª | 5.1 | 58.8ª | 4.5 | 67.3 ^a | 5.2 | 71.6 ^a | 3.0 | 2 | 67.4 ^A | 19.1 | 47.7 ^A | 6.0 | 76.5 ^A | 8.8 | 61.1 ^A | 5.6 |
| 3 | 62.5 ^a | 5.0 | 56.8 ^a | 5.5 | 61.8 ^b | 8.3 | 69.4 ^a | 4.1 | 3 | 64.9 ^A | 9.4 | 49.7 ^A | 7.4 | 78.1 ^A | 11.2 | 63.3 ^A | 4.1 |
| 4 | 60.3 ^a | 5.6 | 55.7 ^a | 5.5 | 54.8 ^c | 11.7 | 69.0 ^a | 3.9 | 4 | 61.5 ^B | 8.8 | 46.0 ^{AB} | 5.3 | 69.7 ^B | 6.9 | 58.5 ^{AB} | 1.9 |
| 5 | 61.7 ^a | 6.1 | 53.8 ^a | 4.9 | 49.2 ^c | 13.8 | 68.2ª | 3.6 | 5 | 62.7 ^{AB} | 10.7 | 51.7 ^A | 9.6 | 66.0 ^B | 6.3 | 55.5 ^B | 3.2 |
| 6 | 66.4 ^a | 9.1 | 50.3 ^a | 10.3 | 40.6 ^d | 15.6 | 67.8 ^a | 4.2 | 6 | 65.4 ^A | 16.6 | 48.0 ^A | 7.9 | 56.8 ^C | 10.1 | 53.1 ^B | 3.3 |
| 7 | 59.5 ^a | 7.6 | 51.7 ^a | 4.0 | 28.0 ^e | 12.9 | 63.7 ^b | 4.5 | 7 | 66.7 ^A | 14.4 | 43.9 ^B | 6.7 | n.a. | n.a. | 49.7 ^C | 2.7 |
| 8 | 61.5 ^a | 6.5 | 50.0 ^a | 4.6 | n.a. | n.a./ | 61.0 ^b | 5.1 | 8 | 66.6 ^A | 14.0 | 42.6 ^B | 8.0 | n.a. | n.a. | 44.2 ^D | 4.4 |
| Table 1: DCsuperscript Ifor each mat | able 1: DC% means and standard deviations of the tested materials at all depths. Same uperscript letters indicate no statistical difference between the different depths (p>0.05) or each material. | | | | | | | | Table 2: <i>M</i> superscript for each ma | H means letters ind terial. | and stand dicate no s | lard devia statistical | ations of th difference | e tested between | materials the differ | at all dept ent depth: | ths. Same s (p>0.05) |

| — | 0.10 | 0.0 | 0010 | | | | 00 | 0 |
|---------------|------------|------------|--------------|-------------|----------|-------------|-------------|------------|
| Table 1: DC | % means | and stand | dard devia | tions of th | e tested | materials | at all dept | hs. Same |
| superscript l | etters ind | icate no s | tatistical d | lifference | between | the differe | ent depths | ; (p>0.05) |
| for each mat | erial. | | | | | | | |

Conclusions

Within the limits of this experimental design, DC%, DPC and MH of bulk-fill composites were material-dependent. All materials could be polymerized for more than 5 mm. Fill-Up!, thanks to its dual-curing formulation, was the only material showing a uniform DC%, DPC and MH at all depths. SonicFill was the only tested composite that could not be polymerized up to 8 mm, with a mean maximum depth of cure of 6 mm.

References

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