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Strengths of additions to composite or resin-modified glass-ionomer

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ABSTRACT

Objectives: Adding a new layer of material to cured resin-based composite (RBC) or resin-modified glass ionomer (RMGI) restorations is necessary in dental practice. This study investigated strengths of additions to the two materials.

Material and methods: Beam-shaped specimens were made from monolithic RBC or RMGI, or additions of RBC and RMGI onto RBC or RMGI half-bar substrates. For the additions, the substrates were left undisturbed or were ground with silicon carbide paper followed by the application of a self-etch adhesive. Sample size was 10. Flexural strengths were determined by a 4-point bending test in a universal testing machine. Results were statistically analyzed with one-way ANOVA followed by Student–Newman–Keuls post-hoc test ($\alpha = 0.05$).

Results: Flexural strength of the monolithic RBC (86.7 ± 21.8 MPa) was significantly higher than RMGI (52.6 ± 13.1 MPa). Addition of RBC to cured RBC significantly reduced flexural strength regardless of the substrate surface conditions (34.1 ± 11.5–45.7 ± 21.1 MPa). Addition of RMGI to cured RMGI did not significantly reduce flexural strength (36.2 ± 8.4–52.7 ± 25.2 MPa). Flexural strength of RBC added onto cured RMGI that was ground and bonded was the lowest (21.5 ± 10.0 MPa). Most specimens from this group exhibited adhesive failure.

Conclusions: RBC/RBC additions reduced flexural strength whereas flexural strength of RMGI/RMGI additions was not significantly lower than its cohesive strength. RBC added onto RMGI in the sandwich restorative configuration had lowest failure strength.

1. Introduction

Adding fresh restorative material to previously set material is often necessary in dental restorative (filling) procedures. An incremental filling technique where the resin-based composite (RBC) material is built up in layers of 2 mm to accommodate curing light penetration for optimal polymerization is a standard dental practice [1]. Even after a restoration is polished a new layer of RBC is often added to the cured material to correct restoration contour or improve esthetic appearance.

Monomers of current dental RBC are based on methacrylate chemistry. Their free radical addition polymerization has limited degree of conversion [2]. The unreacted methacrylate carbon double bonds in polymer chains act as sites for bonding when a new increment of uncured RBC is added [3]. However, the free radical polymerization is inhibited by oxygen, evidenced as a tacky layer on the surface that has direct contact with air. Different school-of-thoughts exist about the effect of this oxygen-inhibition layer, where it was shown to interfere with polymerization, improved the bonding, or made no difference in bond strength between RBC increments [4–7]. Regardless of the oxygen-inhibited layer, strengths of fresh RBC additions ranged from 24% to 91% of the material cohesive strength [3,8–10]. Recently a commercial RBC has been introduced using a proprietary monomer (DX-511) based on urethane dimethacrylate chemistry [11]. DX-511 has twice the molecular weight of traditional RBC monomers in order to decrease polymerization shrinkage by reducing the number of carbon double bonds. Since the bonding between layers of RBC was reduced when the number of unreacted methacrylate groups decreased [8], it would be interesting to know how the new RBC performs.

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Resin-modified glass-ionomers (RMGI), another type of tooth-color filling materials, have been the restorative material of choice in individuals with high risk of dental caries due to its caries inhibition effect through fluoride release [12,13], and for cases with lesions close to gingival margins where potential for moisture contamination precludes hydrophobic RBCs [14]. RMGIs have a resin component based on methacrylate monomers such as 2-hydroyethylmethacrylate or pendent methacryloxy groups on polycarboxylate chains of the conventional glass-ionomer cement [15,16]. The resin components of RMGI undergo a polymerization process that may also have available unreacted methacrylate double bonds similar to cured RBC. RMGI restorations are traditionally not built up in increments. However it would be practical if clinicians have an option to add fresh RMGI to the cured material, for example, to correct insufficient contour. To our knowledge, there is no definitive study regarding the addition of RMGI to RMGI.

RMGIs have low mechanical properties and cannot to be used in load-bearing areas such as the occlusal surface of the teeth [15]. In addition, RMGIs lack the surface polish and esthetic quality of RBC. A restorative procedure called a 'sandwich technique' was introduced in the 1990s, where the set glass-ionomer in the deeper part of the restoration was laminated with RBC to use the beneficial properties of both materials [17]. It has been suggested that RMGIs bond chemically to RBC through their methacrylate components [15]. Their bond strengths were higher than RBC bonds to conventional glass-ionomers [18,19]. Comparison between the sandwich configuration and RMGI added to RMGI has not been investigated previously.

To address the noted gaps in understanding the viability of adding fresh material to previously cured substrates, the objective of this study was to investigate the strengths of additions of 1) RBC to cured RBC, 2) RMGI to cured RMGI, and 3) RBC to cured RMGI.

2. Material and methods

2.1. Specimen fabrication

Beam-shaped specimens ($2 \times 2.5 \times 25$ mm) were made from RBC (GC Kalore, GC Corp, Tokyo, Japan) and/or RMGI (Fuji II LC, GC America, Alsip, IL). Material information is shown in Table 1.

Monolithic RBC specimens were made by placing GC Kalore in a stainless steel mold between two glass slides and light-curing them for 40 s, 4 times on each side. The light curing process was carried out using L.E. Demetron I (Kerr Corp, Danbury, CT) or Rembrandt Allegro (Den-Mat, Santa Maria, CA) light sources with light intensity of 525 mW/cm^2 and 560 mW/cm^2, respectively, measured with a radiometer (Demetron Model 100, Demetron Research Corp, Danbury, CT). For the monolithic RMGI specimens, 2 capsules of Fuji II LC were triturated for 10 s using a Rotomix (3M ESPE, Seefeld, Germany) before placing the material in a mold made from vinyl polysiloxane (Express Light Body Impression Material, 3M ESPE, St Paul, MN). The mold was placed between two glass slides and light-cured in the same manner as the composite specimens.

Add-on specimens were made by addition of fresh (uncured) material to a cured half-length beam ($2 \times 2.5 \times 12.5$ mm) of RBC or RMGI substrate. Fig. 1 shows a diagram of the tested groups. Three surface conditions were evaluated for the RBC substrate: 1) "undisturbed" to represent a surface with oxygen-inhibited layer

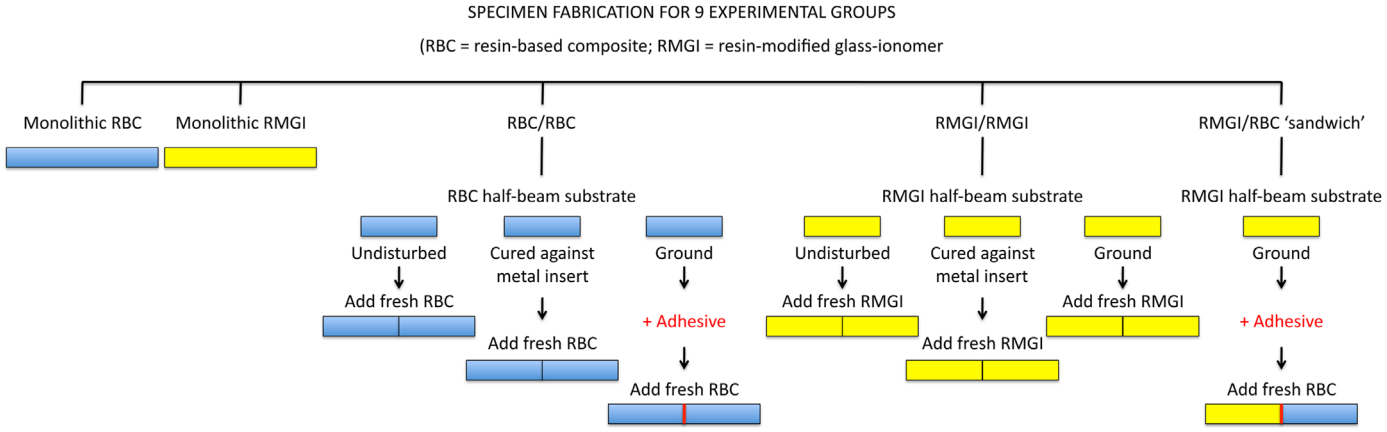

Fig. 1. Flow diagram showing specimen fabrication of the tested groups.

Table 1
Material information.

Material	Product name and lot number	Composition
Light cured universal composite	GC Kalore Shade A2 Lot 1310042	Matrix (18 wt%): urethane dimethacrylate, dimethacrylate comonomers, proprietary DX-511 monomer Fillers (82 wt%): fluoroaluminosilicate glass, strontium glass, pre-polymerized fillers (modified strontium glass, and lanthanoid fluoride), silicon dioxide Others: photoinitiator < 1%, pigment < 1%
Light cured reinforced glass ionomer restorative	GC Fuji II LC capsule Shade A2 Lot 1312188	Powder: fluoroaluminosilicate glass 100% Liquid: distilled water 20–30%, polyacrylic acid 20–30%, 2-hydroxyethylmethacrylate 30–35%, urethanedimethacrylate < 10%, camphorquinone < 1% Capsule: 0.33 g powder/0.085 ml liquid
One component self-etching light cured adhesive	G-aniel Bond Lot 1401231	4-methacryloxyethyltrimellitate anhydride 5–10%, phosphoric acid ester monomer 5–10%, dimethacrylate15–20%, distilled water 15–20%, acetone 35–40%, silicon dioxide 1–5%, trace of photoinitiator