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Clinical Time Required and Internal Adaptation in Cavities restored with Bulk-fill Composites

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ABSTRACT

Aim: The aim of this study was to compare the restorative time required and the internal adaptation after thermomechanical aging of class I restorations using either the conventional incremental technique or bulk-fill technique.

Materials and methods: Cavities (Class I) were prepared on the occlusal surface of human third molars. 40 teeth were divided into four experimental groups according to the restorative technique (n = 10): G1 = 3 mm increment of Surefill SDR Flow + 1 mm Filtek P60; G2 = 3 mm increment of Filtek Bulk-Fill + 1 mm Filtek P60; G3 = Filtek P60 inserted with incremental technique; G4 = 3 mm increment of Filtek Z350 Flow XT + 1 mm increment of Filtek P60. The required restorative clinical time for each technique was marked. Specimens were submitted to thermomechanical loading (20,000 mechanical cycles—80 N/thermal cycling—5/55°C for 30 seconds). After, samples were sectioned, ratio of internal gaps to interface length (%) was recorded using dye-staining-gap technique. Data were submitted to analysis of variance (ANOVA) and Tukey's test (95% significance).

Results: There was no significant difference in gap formation and none of the groups was completely gap-free. However, a significant reduction on required restorative clinical time was observed for G1 (167 ± 7 seconds), G2 (169 ± 4 seconds), and G4 (169 ± 8 seconds) when compared with G3 (204 ± 8 seconds).

Conclusion: No significant difference in gap formation was found among bulk-fill and conventional incremental restorative technique tested; however, the use of a bulk-fill composite reduced 20% of the required restorative clinical time.

Clinical significance: None of the restorative techniques applied were able to prevent internal gap formation. The use of bulk-fill composite reduced the required clinical time to perform class I restorations.

Keywords: Bulk-fill composites, Clinical time, Flowable composites, Incremental technique, Laboratory research, Thermomechanical aging.

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INTRODUCTION

Recent modifications have been made by manufacturers in the composition of the organic and inorganic phases intended to improve properties of dental composites to produce materials with better resistance to degradation.[1,2] Composites of low viscosity, the so-called flowable composites, are obtained from modifications in the content of inorganic and organic components.[3] The first generation of flowable composites was not suitable for complete filling of deep restorations due to their inferior mechanical properties and increased volumetric shrinkage due to lower filler content. In this context, a new group of materials was introduced in restorative dentistry as "bulk-fill composites". Aiming to simplify application and reduce labor time, this generation of flowable composite still requires the placement of a conventional composite resin above it.[4] However, the great advantage of this new category of material is that it can be applied in one increment of 4-mm thick, which can reduce clinical time without negatively affecting the polymerization shrinkage, marginal adaptation, and degree of conversion.[5-7] According to Roggendorf et al,[8] a single increment of this generation of flowable composite could reduce the cuspid deflection during polymerization when compared with the conventional technique with composite applied in oblique increments. Thus, polymerization contraction and its related problems could be minimized.[9]

The ability to withstand masticatory forces is another critical factor in the durability of a restoration. The marginal integrity of a restoration may be affected after a period of time.[10] Thus, the application of laboratory tests that simulate the degradation of the bonded interface is important to predict the clinical behavior of restorative composites.[11,12] Methods that simulate aging of composite restoration as thermal and mechanical loading in multiple cycles are extremely valuable to evaluate the longevity of new materials and techniques as flowable composites used in a single increment. Such laboratory tests have been described in the literature, reflecting higher fidelity in the dynamics of mastication.[12,13] This fact makes possible to evaluate the materials resistance against the masticatory process simulation. This is particularly important in this case, since the restoration technique using first-generation flowable composite as a liner showed increase of internal gap formation after thermomechanical loading.[14]

Considering the aforementioned information, the use of flowable bulk-fill composites might be advantageous in reducing the clinical time to perform class I restoration and also to achieve proper adaptation, even after submission to occlusal forces. However, development of proper data is important to consider such theoretical advantages and, therefore, the aims of this *in vitro* study were:

- To determine and compare the clinical time used for restoration of class I cavities with conventional incremental technique and bulk-filling technique with optimized flowable composites, and
- To determine the internal adaptation after thermomechanical aging of these restorations.

The research hypothesis is that the restorations performed with bulk-filling technique will be made in a shorter time and without differences in internal gap formation.

MATERIALS AND METHODS

Sample Preparation

The research was approved by the ethical committee (CAEE 48831215.8.0000.5289). A total of 40 human third molars recently extracted and caries-free were selected. The teeth were debrided and stored in a 1% thymol solution for 1 week at 4°C. In each specimen, class I cavity was prepared at the occlusal surface with a #145 carbide bur (KG Sorensen Ind. Com. Ltda, Barueri, SP, Brazil) running at a high-speed water-cooled hand piece (Kavo do Brasil AS, Joinville, SC, Brazil). The burs were replaced after 10 preparations to maintain uniformity. The cavities had the following dimensions: 4 mm of axial depth; 3 mm of buccolingual and mesiodistal width.

Specimens were randomly distributed into four groups (n = 10). In all groups, enamel and dentin were etched with 35% phosphoric acid (3M ESPE, St. Paul, MN, USA) for 15 seconds, rinsed off for 15 seconds, and blot dried. After this, adhesive system (Adper Single Bond 2, 3M ESPE, St Paul, MN, USA) was applied in two coats with a brush tip, lightly dried, and photocured (Demi Plus LED Curing Light, Demetron SDS Kerr, Middleton, WI, USA), with power density of 800 mW/cm^2, monitored with radiometer (L.E.D. Radiometer, Demetron SDS Kerr, Middleton, WI, USA), for 10 seconds following the manufacturer's directions. The restorative composites used in this study are described in Table 1. All materials were inserted according to the following groups:

- G1 (Bulk-filling technique): 3 mm increment of SDR Flow + 1 mm Filtek P60.
- G2 (Bulk-filling technique): 3 mm increment of Filtek Bulk-Fill + 1 mm Filtek P60.
- G3 (Conventional incremental technique – Control): Filtek P60 inserted in 2-mm increments with the incremental technique.
- G4 (Bulk-filling technique): 3-mm increment of Filtek Z350 Flow XT + 1-mm increment of Filtek P60.

The curing time of the composites was standardized at 30 seconds with the curing unit tip perpendicular to the long axis of the teeth.

Then, the teeth were stored in water at 37°C for 48 hours. Afterward, finishing and polishing procedures were performed in only one direction with an abrasive rubber (Enhance, Dentsply/Caulk-Milford, DE), in low-speed hand piece without water spray.

Restorative Time

To quantify and compare the required clinical time for each technique, the procedure from etching to the last polymerization was recorded in seconds with a timer (Incoterm, 7651.02.0.00, Porto Alegre, RS, Brazil).

Table 1: Composition and percentage of load volume of each material

Composite	*Color*	*Organic matrix*	*Filler*	*% inorganic filler by weight/volume*
Filtek P60 (3M ESPE)	A3	BisGMA, UDMA, BisEMA, and camphorquinone	Particles of zirconia/silica: 0.01–3.5 µm on average	83% by weight, 61% by volume
Filtek Bulk-Fill (3M ESPE)	A2	BisGMA, UDMA, BisEMA, and procrylat	Ytterbium trifluoride: 0.1–5.0 µm; zirconia particles/silica: 0.01–3.5 µm	64.5% by weight 45.5% by volume
Surefil SDR flow (Dentsply)	A2	Polymerization modulator, dimethacrylate resins (< 10% weight), UDMA (<25% weight)	Ba–B–F–Al silicate glass, SiO_2, Sr–Al silicate glass, TiO_2	68% by weight 44% by volume
Filtek Z350 XT flow (3M ESPE)	A2	BisGMA, TEGDMA, and procrylat K	Yttrium fluoride: 0.1–5.0 µm, silica: 20 nm, zirconia: 4–11 nm, and zirconia/silica clusters of 0.6–10 µm)	65% by weight 46% by volume

BisGMA: Bisphenylglycidyl dimethacrylate; UDMA: Urethane dimethacrylate; BisEMA: Ethoxylated bisphenol-A dimethacrylate; TEGDMA: Triethylene glycol dimethacrylate

Thermomechanical Aging

In order to place the teeth at the right position into the thermomechanical loading machine (ER 37000, ERIOS Equipamentos Ltda, São Paulo, Brazil), the root of each teeth was embedded in acrylic resin into polyvinyl chloride (PVC) pipes (2 cm diameter and 2 cm height). After polymerization of the acrylic resin, the sets (teeth + acrylic resin) were removed from the PVC pipe and fixed into the thermomechanical loading machine. The tip of the mechanical cycling machine was positioned at the center of the restoration surface. The restorations received 20,000 cycles of a vertical load of 80 N (8.0 kgf) simultaneously with alternating 30-second water baths at 5 and 55°C.[15]

Analysis of the Internal Adaptation

After thermomechanical cycling, specimens were transversely sectioned. After each restoration, they were buccolingually sectioned to exposure the internal margins using a water-cooled rotating diamond blade (Isomet Low-Speed Saw, Buehler Ltd., Evanston, Illinois, USA). After 24 hours, each specimen was wet-polished with 600-, 1,200-, and 2,000-grit SiC papers and submitted to internal gap evaluation. Both resulting surfaces were examined, but results of the two sections were taken as a single data. Internal gap formation was assessed using the dye-staining technique.[16,17] After polishing procedures, each half of the restoration was air dried and a drop of 1% acid red and propylene glycol solution (Caries Detector, Kuraray, Osaka, Japan) was placed on the bonded interface for 10 seconds.[16,17] After that, samples were rinsed with water and dried with paper towels, and positioned in stereoscopic microscope (Stereomicroscope SZ61TR, Olympus, Tokyo, Japan) under 16× magnification in which the images of the internal area of the restoration were taken and digital images were obtained. The length of staining along the interface was measured using Image Tool 2.0 software (UTHSC, San Antonio, TX, USA). Internal gap (%) was calculated by the following formula:

GAP% = (Gap length measured slit × 100)/(total length of the margin)

Statistical Analysis

Restorative time (in seconds) and internal gap formation (in %) data were tabulated and submitted to ANOVA and Tukey's test (preset $\alpha = 0.05$), using MINITAB version 14.1 software.

RESULTS

Restorative Time

Restorative time data are shown in Table 2. According to the ANOVA, there was statistically significant difference between groups ($p \leq 0.001$). Tukey's test pointed that G1, G2, and G4 (bulk-filling technique) required shorter restorative time than G3 (conventional incremental technique).

Internal Adaptation

Internal gap formation data are shown in Table 2. According to the ANOVA, there was no statistically significant difference between the tested groups ($p = 0.27$). None of the groups showed complete gap-free interface.

DISCUSSION

The bulk-filling restorative technique is more desired in routine clinical practice than conventional incremental

Table 2: Results of internal gap formation expressed in gap% at the tooth–restoration interface and restorative time expressed in seconds

Group	*Internal gap (%)*	*Restorative time (s)*
G1	22.6 ± 11.5 A	167 ± 7.6 B
G2	27.7 ± 13.0 A	169 ± 4.1 B
G3	19.6 ± 10.2 A	204 ± 8.2 A
G4	29.7 ± 15.2 A	169 ± 8.4 B

Different letters indicate statistically significant difference among groups ($p \leq 0.001$)

technique, mainly because it simplifies the restorative technique, reducing the clinical time. However, there are concerns that the effect of shrinkage stress may be more pronounced in bulk-fill composites. As a result, an ideal bulk-fill composite would be one that could be placed into a cavity having a high C-factor design and still exhibit very little polymerization stress while maintaining good marginal and internal adaptation and high degree of cure throughout.[18]

According to manufacturers, bulk-fill composites are materials with a slow polymerization rate[8] and with a satisfactory depth of cure in 4 mm.[5] Moreover, manufacturers stated that the polymerization shrinkage of those materials is even lower than flowable composite (first generation) and conventional chemically cured resin-based composites.[19,20] This could be attributed, in materials, such as Surefil® SDR™, to a polymerization modulator, which has a high molecular weight, chemically embedded in the center of the polymerizable resin backbone of the SDR™ monomer. Due to the conformational flexibility around the centered modulator impart, the modulator is supposed to optimize flexibility and network structure of the SDR™ resin.[19] As a result, problems related to polymerization could be minimized.[21,22]

The formation of gaps along the gingival margins of composite restorations might be related to composite–tooth bond strength.[8] In this study, none of the groups' bulk-filling technique, with bulk-fill composites (SDR and Filtek Bulk-Fill), caused less gap-free margins compared with the control groups using incrementally layered restorative technique. No differences among the groups were detected, and these findings are consistent with the results of previous studies.[8,21] This finding suggests no deleterious effect in employing the bulk-fill flowable composite on the tooth/restoration interface compared with conventional composites.

Even though no differences were ascertained among the experimental groups, the results of this investigation pointed a percentage that varies from 20 to 30% of open margins in the restorations. This infers that the critical issue regarding internal gap formation is still a matter of concern. Therefore, although composite may be cured to enhanced depths,[5] the potential for developing any postinsertion sensitivity, i.e., related to gap formation at the pulpal floor, and the resulting hydraulic movement of fluids that will occupy this space upon occlusal loading is still present.[23]

One of the main advantages behind the use of bulk-fill composites might be the reduction on the operator time.[21] This gain of time beyond the technique accessibility is due to packaging that has a syringe to deposit the product and should be proportional to the size of the cavity. With this procedure, a reduction of 20% of the operation time was detected when the bulk-filling technique (G1, G2, and G4) was compared with the incremental layering technique (G3). In this investigation, the research hypothesis that restorations produced with bulk-filling technique will be made in a shorter time and without differences in internal adaptation when compared with incremental technique was confirmed.

It is important to consider that G4, restored with a conventional flowable composite covered by similar material as the others, demonstrated similar internal adaptation and time for clinical execution as those groups restored with the bulk-fill flowable materials (G1 and G2). Therefore, questions could arise about the possibility of using conventional flowable composites instead of the bulk-fill, but a proper analysis of the depth of cure might demonstrate that degree of conversion might be lower at deeper parts of conventional flowable composites than bulk-fill ones.[5]

All bulk-filling techniques performed in this study were covered with the conventional composite according to the manufacturer's instructions. More recently, bulk-fill composites of regular consistency were launched into the market and have also been studied.[24] However, further studies are necessary to determine other variables as assessing depth of cure, larger cavities, or class II restorations restored with bulk-fill composites.

CONCLUSION

Under the conditions of this *in vitro* study, it was possible to conclude as follows for that:

- For bulk-filling and conventional incremental techniques, similar internal gap formation is observed.
- None of the restorative techniques could eliminate internal gap formation.
- Bulk-filling technique can reduce 20% of the restorative time when compared with incremental technique.

Clinical Significances

Bulk-fill composites aim to simplify application and reduce clinical time. Development of proper data is important to consider such theoretical advantages. In this work, none of the restorative methods could eliminate internal gap formation, but bulk-filling technique significantly reduced the clinical time required to restore class I cavities.

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