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An Effective Method for Spreading Flowable Composites in Resin-based Restorations

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SUMMARY

Cavity lining with flowable composites has been suggested for better marginal adaptation and a reduction in interfacial stress and post-operative sensitivity. The following *in vitro* study compares the spreading of flowable composite that lines the inner wall of a test cavity using an explorer and a specially designed smooth, oscillating, off-center rotating bur spun at 300 to 600 rpm. Two commercial flowable materials were used in this study. Results: With use of the rotating bur, a more consistent, uniform cavity lining was achieved. This was not possible using the dental explorer. Conclusion: The specially designed rotating bur provides an effective way for clinicians to form a uniform cavity lining.

INTRODUCTION

The longevity of resin-based composite restorations is compromised when bonding between the resin and interior cavity walls fails to prevent marginal microleakage. The passage of water and other species into the space between the resin material and cavity wall may give rise to post-operative sensitivity, secondary caries and further physical deterioration of the marginal sealing (Köhler, Rasmusson & Ödman, 2000; Van Nieuwenhuysen & others, 2003; Christensen, 1996). Interfacial debonding between restorative composites and the cavity structure is influenced by polymerization shrinkage, the elastic properties of the cured composite at the interface and marginal adaptation of the composites (Dietschi & Herzfeld, 1998; Lutz, Krejci & Barbakow, 1991).

In dental restorations, composites with increased filler concentrations up to and greater than 80% are the materials of choice, because of superior mechanical properties and minimal shrinkage behavior (Shajii & Santerre, 1999). On the other hand, heavily filled composites have clinically undesirable characteristics at the margins. Increasing the filler concentration will increase composite viscosity and the material, so that the material does not adapt easily to cavity margins. Marginal void formations are a leading cause of failures in resin-based restorations (Van Nieuwenhuysen & others, 2003). Higher-filler concentration reduces the modulus of elasticity of post-cure composites, resulting in higher marginal tensions than would otherwise occur due to shrinkage of the matrix. Marginal tensions can result in debonding if they exceed a critical interfacial bonding stress (Ensaff, O'Doherty & Jacobson, 2001). If bonding is the adhesive work of the resin, for the most part, a decrease in filler concentration will reduce critical marginal bonding stresses.

To improve proximal box bonding, incremental and layered filling techniques have been suggested for con-

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ventional composites (Jordan & Suzuki, 1991). Recent microleakage studies suggest no significant advantage with the layered filling technique method (Gallo, Bates & Burgess, 2000). Dental composites with a reduced filler concentration are known as "flowable" composites, and they are marketed by dental manufacturers to address the marginal adaptation problems associated with conventional restorative materials. These materials are used prior to using the layering techniques to ensure better marginal adaptation in proximal box preparations.

Some studies use the flowable material as a buffer between the conventional composite and inner tooth wall (Estafan, Estafan & Leinfelder, 2000). For Class I and Class II restorations, flowable lining has been shown to greatly reduce the potential for marginal void formation (Estefan & others, 2000; Haak, Wicht & Noack, 2003). However, other studies have shown no major improvement in marginal sealing for restorations lined with flowable composites (Chuang & others, 2003). This inconsistency may exist because of the ineffectiveness of flowable composite application. If the flowable composite is applied using a syringe applicator or explorer, then it cannot be applied uniformly, because it is too tacky. This study compared the movement of flowable material using a dental explorer tip and a specially made bur to uniformly distribute the material.

METHODS AND MATERIALS

The bur and explorer tip used in this study are shown in Figure 1. The tip section of the bur is made by dipping and rotating a composite coated bur (Smartprep, SS White, Lakewood, NJ, USA) into flowable composite (Esthet Xflow, A3, Dentsply, Milford, DE, USA). The tip of the bur is then light cured so that the composite is hardened. It is shaped into a smooth surfaced asymmetric ovoid, roughly 0.5-mm long, with a maximum average diameter of 0.3 mm. The maximum diameter varies between 0.25 and 0.35 mm, with a 90-degree rotation of the bur. Once the bur is set into axial rotation, there is a 0.1-mm variation of the bur at its largest radius. Accordingly, as the rotating bur approaches a mass of composite, it induces displacement oscillations on the composite surface at twice the speed of rotation with a maximum displacement amplitude of 0.1 mm. Such interfacial vibrations can inhibit tacking and help to further manipulate the composite inside a cavity (Li & Abedian, 2001). The spinning rate of the engaged bur was set at a very low speed, 300-500 rpm, in all experiments. A straight electric laboratory handpiece (Bell Hand Engine C-33, Brasseler, Savannah, GA, USA) was used for all testing. A sonic applicator which can vibrate was not used, because the simplicity of the bur system, which also vibrates, presents no learning curve nor any increase in expense. A conventional round bur was not used because the material builds up on the

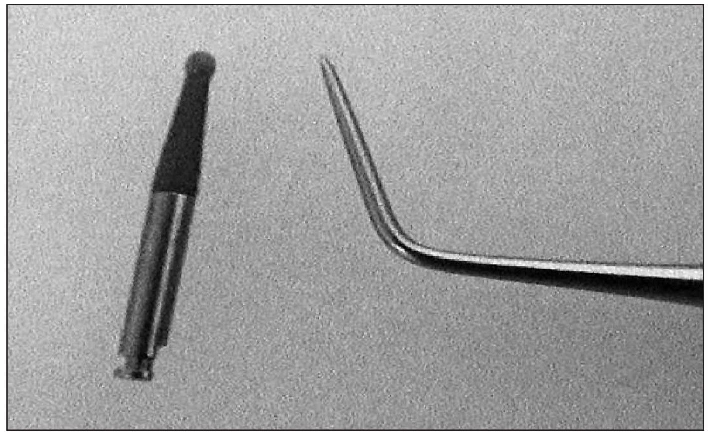

Figure 1. *The experimental bur next to an explorer tip.*

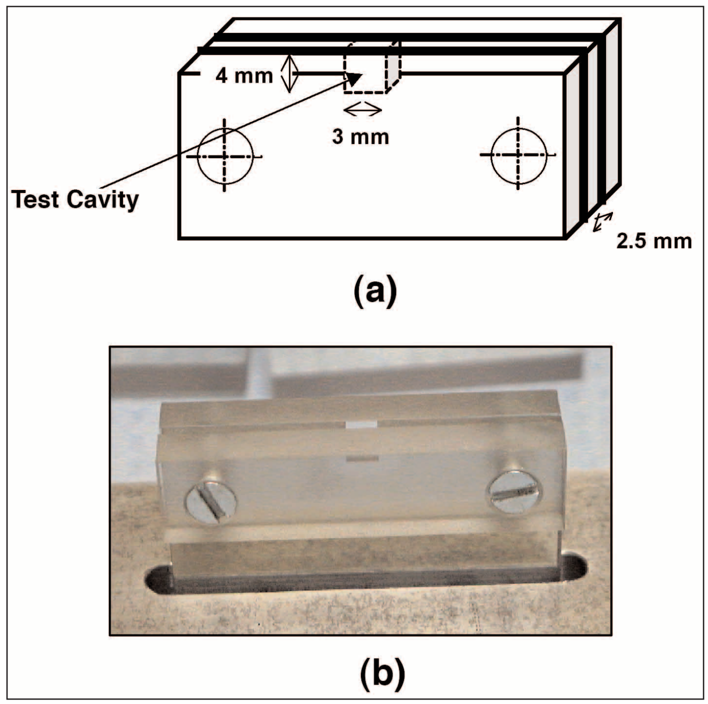

Figure 2. *The rectangular mold in the experiments: (a) schematics with the dimensions; (b) the experimental rig.*

flutes and does not displace the composite. Furthermore, with use of the rotating, non-fluted bur, all surfaces can be brought into intimate physical contact.

Two shade A3 flowable materials—Esthet XFlow (Dentsply International, Milford, DE, USA) and Revolution (Kerr Company, Romulus, MI, USA)— were used in the experiments. All tests were conducted at a room temperature of 20°C. A 3 (depth) x 4 (width) x 2.5 mm rectangular cavity was used for testing (Figure 2). A 2.5-mm thick sheet of plexiglass with a 3 x 4-mm square cut was aligned and tightly sandwiched between two other plexiglass sheets using two side screws. Prior

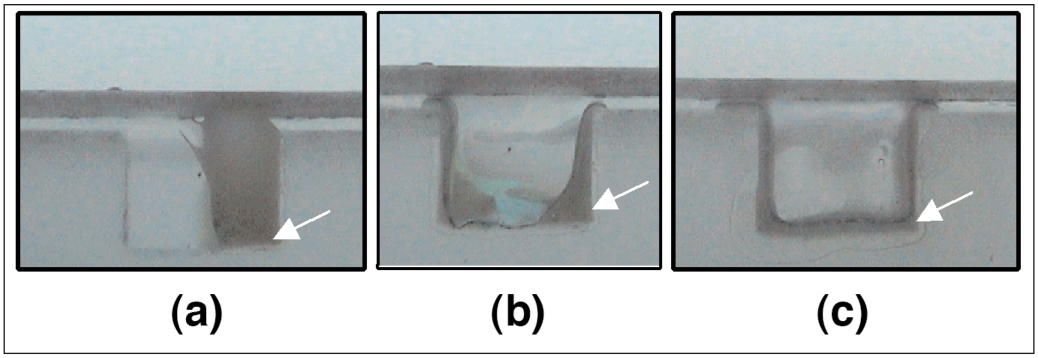

Figure 3. *Esthet-Xflow in the square mold after successive operations: (a) loading with a syringe nozzle; (b) use of a dental explorer; (c) use of the rotating bur. Arrows signify subsequent thinning of composite.*

to each experiment, the mold was disassembled, and the interior of the square cavity was wiped clean with Glass Plus (Reckitt Bendckiser Inc, Wayne, NJ, USA) and a soft cloth. A small volume of composite, approximately 10 mm^3, was injected into the base of the cavity. A straight explorer (Stewart Probe–Premier Company, King of Prussia, PA, USA) was used with a side-to-side and up-and-down motion to spread the material. The clear front side of the mold was then photographed to record the spread of the composite within the cavity. Subsequently, the rotating bur was used with the same material in the same manner for the same amount of time. The clear front side of the mold was then re-photographed. Twelve experiments were conducted for each composite. The same mold was used throughout the study, and a single operator (PM) conducted all the experiments.

Using the lining configuration of the flowable composite as shown in the photographs in Figure 3, two sets of measurements were taken by recording the average thickness of the lining on the sides and base of the test cavity as well as the average thickness of the lining in the corners of the cavity. All measurements were made in millimeters. These measurements were statistically analyzed using analyses of variance (ANOVA) with Bonferroni-adjusted (Stata, Ver 6) results of the ANOVAs.

RESULTS

Using digital imaging, the values for corner height and spatially-averaged based height were obtained from each photograph in the experiments. The measured parameters in each image are shown schematically in Figure 4. The lining thickness was characterized not only by the average height, but also by its maximum and minimum thicknesses at the base and sidewalls. A two-way ANOVA was performed for both sets of measurements, that is, the average of the corner height and the lining thickness (Table 1). This table represents the mean and standard deviation for the four groups (Esthet XFlow using the explorer, Esthet XFlow using the rotating bur, Revolution using the explorer and Revolution using the rotating bur). Note that the mean and standard deviation for both sets of measurements for the bur applications were significantly less than those for the explorer applications. This means that there was a thinner, more uniform application when using the rotating bur.

For lining thickness, there was a statistically significant difference (p=.05) across groups. Using a Bartlett's Test along with a set of t-tests comparing each type with the other type, the two techniques (explorer application and bur application) were significantly different. This, again, indicates a thinner, more uniform application when using the rotating bur. There was no difference between flowable composites.

Results for the corner measurements were basically the same, that is, statistical significant differences between methods of application at a p=.05 level. Again, using a Bartlett's Test for equal variances, there was an overall significant difference. Corner height by type of

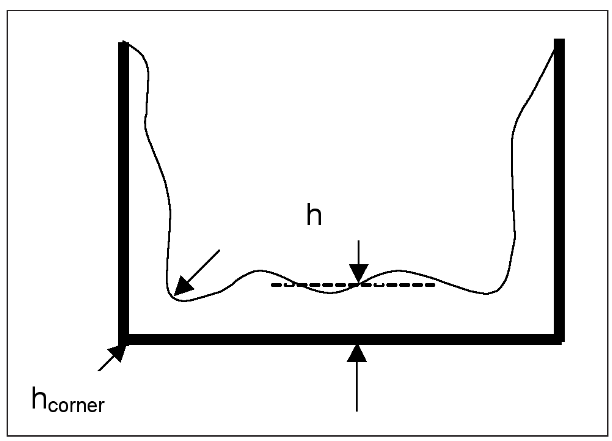

Figure 4. *Schematics of the flowable liner in the mold.*

Table 1: *Averaged-thickness Data on the Marginal Lining in the Square Cavity*

	Corner Height	Lining Thickness
Esthet XFlow with explorer	1.5 (0.3)	.68 (0.2)
Revolution with explorer	1.4 (0.3)	.69 (0.2)
Esthet XFlow with bur	.73 (0.1)	.42 (0.1)
Revolution with bur	.62 (0.1)	.43 (0.1)

The standard deviations are in parentheses. All values in mm.

composite with a Bonferroni correction showed differences between the use of an explorer and a rotating bur but not between composite materials. Again, bur application provided a thinner, more uniform cavity lining.

DISCUSSION

The effectiveness of the rotating bur to forming a marginal lining of a flowable composite in the square cavity is shown in Figure 3. The lining in Figure 3c is more consistent and uniform than the lining obtained by using a dental explorer. The descriptive statistics used in this study confirm that a thin lining can be achieved in both the corners and walls of a square cavity using the rotating bur. The standard deviations for all the data with the bur were approximately 0.1 mm or less, suggesting consistency and repeatability of the data obtained for the bur.

By contrast, repeated attempts to create a uniform lining using the dental explorer were unsuccessful (Figure 3b). A larger standard deviation indicates a non-uniform lining when the explorer was used. This suggests that the flowable linings made by the explorer are not predictable and the configurations from one experiment to the other vary greatly.

When using a flowable material, it is impossible to place the same volume in the cavity each time, because of the bore of the injection syringe and the flow of the material. The rotating bur thins the material and forces excess from the cavity; whereas, with the explorer, the material always remains in the cavity space, and it cannot be forced from the cavity. With the continuous removal of excess material, one can achieve the same end result irrespective of how much material is initially placed in the cavity. Use of the bur may assure physical contact of the composite to dentin; however, this has not been formally tested but has been observed visually in repeated clinical procedures.

Since flow materials are relatively new, there is little information in the literature concerning their application. Marginal adaptation may be beneficial if it were minimal and evenly distributed. It is assumed that polymerization would be complete, because light curing would not be hampered by variations in thickness. It has been shown that application of the light source and thickness of the material are directly proportional to complete and incomplete curing of composite materials. Incompletely cured materials are more conducive to sinking into the cavity and for absorbing and maintaining fluids, which can be precipitants of hypersensitivity.

CONCLUSIONS

Flowable materials vary in relation to heavily filled composites. A heavily filled material can only be moved upon compaction with a plugger. It does not move upon itself. Complete adaptation to cavity walls without the use of a flowable material may be impossible. Manipulating a flowable material with a rotating bur provides the opportunity to discretely fashion a composite restoration to a specific tooth surface.

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