Thermally Assisted Flow and Polymerization of Composite Resins

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The increasing demand among patients for esthetics has led to the widespread use of tooth-colored composite resins for the restoration of both anterior and posterior teeth. The ideal composite resin for posterior teeth would exhibit high strength and wear resistance, low shrinkage to prevent untoward stress on the adhesive bond, and low viscosity to ensure adaptation to tooth structure.[1] Unfortunately, these desirable characteristics are often at odds with one another.

Currently available composites demonstrate excellent clinical durability.[2] To achieve this characteristic, manufacturers have increased the filler concentration in these composites—to greater than 80% in some cases. This has led to better physical properties, and because the filler increase has been made at the expense of the resin component, there is less of the "shrinking component." The result has been lower volumetric shrinkage and presumably less stress on the interfacial bond.[3]

Unfortunately, dentists have discovered that the high viscosity of these heavily filled materials may create difficulty in achieving good marginal adaptation—sometimes leading to void formation at the critical gingival margin. This has been particularly prevalent with the use of packable composites.[4] Flowable composites provide excellent adaptation to tooth structure and allow the dentist to restore minimally invasive tooth preparations with confidence. Many dentists first place an increment of flowable in the proximal box to achieve marginal adaptation, followed by the highly filled packable. While successful, this technique requires a compromise in physical properties. The increase in flowability is achieved by decreasing the filler concentration, which makes a runnier composite. With this increase in resin content comes a decrease in physical properties and an increase in polymerization shrinkage.[5] It would appear that it is impossible to satisfy all the requirements of the ideal material.

Temperature Increase, Viscosity Decrease

One way around the problem is to take advantage of a basic property of viscoelastic materials: as the temperature of the material increases, the viscosity decreases and the material becomes more flowable. If heated sufficiently to achieve better flow, a viscous hybrid could be used for the entire restoration. The Calset™ unit (AdDent, Inc) was developed to heat composite compules to a preset temperature of 130˚F, which significantly decreases the viscosity of the composite. When measured as a function of film thickness, the viscosity of Herculite® XRV (Kerr Corporation) has been decreased by 27% using this method (FA Rueggeberg, Medical College of Georgia, School of Dentistry, oral communication, April 24, 2001).

In clinical use, composite compules (or syringed composite) is placed on the tray of the unit (Figure 1). The cover should be placed on the unit and the control switch pressed once, resulting in illumination of the amber light-emitting diode (LED). This indicates that the unit is on and functioning properly. The green LED will also light and flash until the compule is brought to the proper temperature (about 10 minutes). The heated compule is then removed from the unit and placed in the syringe gun. The effect of heat on the viscosity of Z100™ composite (3M ESPE) is demonstrated in Figures 2 and 3. Figure 2 is Z100™ at room temperature. When heated to 130˚F, the material takes on a honeylike consistency and is easily adapted to the cavity preparation (Figure 3).

Heating Benefit

One added benefit of heating is that the polymerization process is accelerated and the reaction is driven farther toward completion. Depending on the composite used, an 8% to 17% increase in the degree of cure can be achieved and curing time is reduced by 50% to 80%.[6] This being the case, one concern might be that polymerization may occur if the compules are left in the heater for an extended time. Compules can be left in the unit for up to 8 hours without causing premature polymerization of the composite (JW Stansbury, University of Colorado, oral communication, August 27, 2002). Another concern is the preheated composite might cause a damaging increase in intrapulpal temperature. Data obtained at the Medical College of Georgia School of Dentistry indicate that the injection of composite resin heated to 130˚F into a cavity preparation results in a pulpal temperature rise of only 1.6˚ C (2.9˚ F) when 1 mm of dentin remains (FA Rueggeberg, Medical College of Georgia School of Dentistry, oral communication, April 24, 2001). This is well below the critical temperature rise thought to be the threshold for pulpal effects.[7]

Conclusion

Current generation posterior composites exhibit excellent physical properties and clinical durability, but have less than optimal flow characteristics. The Calset™ composite heating unit provides a simple method of improving flow and increasing the degree and speed of polymerization.

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Figure 1—Calset™ heating unit with compules in place.

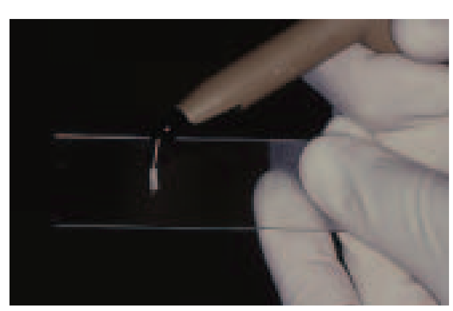

Figure 2—Z100™ at room temperature.

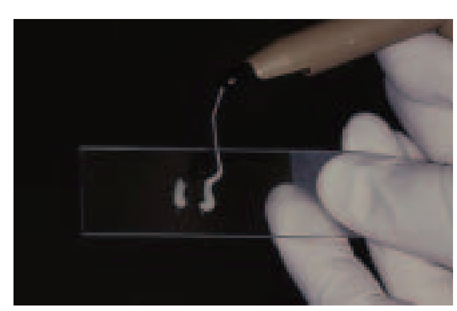

Figure 3—When heated to 130˚F, the material takes on a honeylike consistency.


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