Preheating Composites

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Resin composite is the most commonly used material for direct placement restorations. In particular, composite is now used more frequently than amalgam for direct posterior restorations. However, resin composite still suffers from some disadvantages, including the use of an adhesive interfacial bond that degrades with time, moisture, and function in the mouth, and certain key mechanical properties (e.g., modulus of elasticity) that are inferior to those of amalgam. As such, there is a concern that the resin composite should be inserted into a preparation with as few voids as possible to enhance interfacial adaptation, and maximizing the composite degree of conversion so as to maximize mechanical properties. The use of preheated composite has been suggested to aid in both of these goals. This Critical Appraisal looks at evidence in the peer-reviewed scientific literature that examines the value of inserting warm composite into cavity preparations.

Clinically Relevant Issues Related to Preheating Composites

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ABSTRACT

Objectives: The purposes of this study were to evaluate multiple aspects of a composite preheating device (Calset, AdDent Inc., Danbury, CT, USA): (a) consistency in performance among the different units, (b) amount of time necessary for the devices to achieve the preset temperature and temperature stability, (c) possible effects of the compules on temperature rise of resin composite, (d) if preset temperature values are reached in the resin composite itself, (e) rate of decrease in composite temperature upon removal from the heating device, (f) the expressed composite temperature when preheated individually in the heating unit storage well or preloaded into a delivery syringe, and (g) the effect of repeated composite heating and cooling on monomer conversion.

Materials and Methods: For purposes a and b, the performance of devices was evaluated by fixing a K-type thermocouple in three heating units. The preset temperatures (54 and 60°C) were recorded for 30 minutes.

For c to e, the temperature of composites was measured by inserting a thermocouple into the mass of two composites supplied in different compules, Esthet-X (Dentsply Caulk, Milford, DE, USA) and Herculite (Kerr Corporation, Orange, CA, USA). The compules were placed in the heating unit and the temperature was measured during heating (15 minutes) and cooling (30 minutes).

For f, the facial enamel of a bovine incisor was ground flat, and a thermocouple was placed in an access hole

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just above the flat tooth surface. A small brass ring was placed on the facial surface of the tooth, simulating a tooth preparation. Composite compules were either preheated in the heating unit individually or pre-loaded in a delivery syringe. After 15 minutes preheating, each composite was expressed into the ring and the temperature was continously recorded. Five replications for each test condition were made.

For g, three composites were evaluated: Esthet-X, Filtek Supreme (3 M ESPE, St. Paul, MN, USA), and Prodigy Condensable (Kerr). Five compules of each composite were submitted to one of the temperature cycles: *control*—room temperature, *repeated preheating*—10 cycles of heating the composite for 15 minutes at 60°C and cooling it down for 15 minutes, and *extended preheating*—the compules were left in the heating device for 24 hours at 60°C and then cooled to room temperature. The uncured composite submitted to each cycle was placed on an attenuated total reflectance (ATR) of a Fourier transform infrared spectrometer and light activated for 20 seconds. The temperature of the ATR was controlled at 35°C to simulate intraoral temperature. Monomer conversion was calculated from infrared spectra using standard methods.

Results: (a) Two of the three tested units achieved the preset temperatures, but one unit was 4–5°C below the preset temperature. (b) It took the same amount of time, 11 minutes, for the two devices to warm to either of the two preset temperatures. The temperature of the units oscillated with time and the change was greater when set to 54°C (± 7.3) than when set to 60°C (± 4.4). (c) Different compule types did not affect composite temperature. (d) The maximum compule temperature attained was 48.3°C when the unit was set to 54°C and 54.7°C when set to 60°C. (e) Fifty percent of the temperature attained during composite heating was lost 2 minutes after composite removal and almost 90% was lost after 5 minutes. (f) Heating the compule while pre-loaded in the syringe provided a slightly higher expressed composite temperature (36.6°C) immediately after compule removal from the heater than did heating the compule separately (33.3°C). (g) Neither prolonged compule preheating nor repeated heating and cooling affected the degree of conversion of preheated composites compared with composites maintained at room temperature.

Conclusions: There is some inconsistency among the heating devices in terms of reaching the preset temperature, and the temperature oscillates with time. Neither of the two different compule types influenced temperature, and composite temperature inside the heated compule reached temperatures near that of the heating unit. Composite temperature decreased rapidly upon compule removal from the heating device. Preheating the compule while it is seated in the delivery syringe provided higher composite temperatures at delivery compared with heating the compule by itself in the warmer. Neither repeated preheating and cooling nor extended preheating of composite significantly affected monomer conversion.

COMMENTARY

According to the authors, preheating composite has potential benefits but should be used with knowledge of its limitations. They suggested that not all heating device units are capable of reaching their preset temperature and they should be heated for at least 11 minutes in order to achieve the maximum preset temperature. They commented that the slightly lower composite temperature compared with the heating source was expected because composite is filled with inorganic particles and organic resins that function as thermal insulators. The more filled the material, the more it will thermally behave as an insulator. Therefore, composite with different compositions may take different times to reach stable temperatures. Regardless of the composite temperature inside the heated compule, there is a dramatic drop of temperature upon composite placement in the cavity. A noteworthy fact is that the extracted bovine tooth temperature in which composite was expressed was 20°C, differing from intraoral tooth temperature.

The authors also advised the clinician to work with the composite quickly in order to ensure the least temperature drop possible and achieve the best clinical

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performance. They noted that pre-placement of the compule directly into the delivery syringe during compule heating seems advantageous over preheating only the individual compule. Heating the composites several times caused no problems with the materials. No polymerizable components were lost upon heating, nor was there any degradation of monomer during different heating treatments.

Effect of Preheating Resin Composite on Restoration Microleakage

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Operative Dentistry 2010 (33:72–8)

ABSTRACT

Objectives: The purpose of this study was to compare the microleakage of Class II composite restorations when resin composite was applied using different techniques.

Materials and Methods: Class II preparations were made on the mesial and distal surfaces of 20 third molars and the cervical margins were placed on cementum. Five specimens (10 preparations) were randomly assigned to each of four treatment groups: control (resin composite at room temperature), preheated composite at 54°C using a Calset heating device, delayed curing of heated composite for 15 seconds, and flowable liner placed under the room temperature composite. Esthet-X and Esthet-X flow were the composites evaluated.

Within 15 minutes following placement and curing, the restorations were finished and polished. The specimens were stored in water for 24 hours prior to thermocycling between water bath temperatures of 5 and 55°C for 1,000 cycles. The teeth were placed in 0.5% fuschin dye for 24 hours, rinsed, then embedded in self-cure resin. The embedded teeth were sectioned mesiodistally providing multiple sections per restoration. Microleakage was determined by the amount of dye penetration at both occlusal and cervical aspects of the restorations and rated by two evaluators using a 0–4 ordinal scale using a light microscopy at 40× magnification.

Results: There was no difference in microleakage among the treatments at the occlusal margins. There was a significant decrease in microleakage on the cervical margin for the preheated composite treatment compared with the other groups. Both the flowable liner and delayed heating groups had microleakage values similar to the control group.

Conclusions: Injecting heated composite into a cavity preparation and immediate light-curing resulted in reduction of microleakage at the cervical margin of teeth. All other techniques, including use of a flowable composite liner, placing room temperature composite, and delaying the cure of preheated composite by 15 seconds, led to greater microleakage than placing and immediately curing heated composite.

COMMENTARY

The authors noted that all of the techniques evaluated in this study produced comparable microleakage at the occlusal margin, whereas preheating composite prior to placement and immediate curing reduces microleakage at the cervical margin. The increased microleakage at the cervical margin of the preheated group with delayed curing is difficult to explain and runs counter to what might be expected. A concern of using preheated composite is that thermal contraction is additive with polymerization shrinkage to increase the overall shrinkage of the composite during curing. A delay in curing preheated composite should, in theory, allow the thermal contraction to take place in the unset composite and minimize the contribution of thermal contraction to the composite pulling away from cavity walls. The authors suggested that the delay in curing allowed for viscoelastic deformation that caused the unset composite to pull away from the cavity walls.

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In Vivo Temperature Measurement: Tooth Preparation and Restorations with Preheated Resin Composite

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ABSTRACT

Objectives: This study measured in vivo temperature changes within cavity preparations during various stages of tooth restoration, using both warmed and room-temperature composite.

Materials and Methods: One adult male volunteer requiring multiple Class I and Class II restorations was used for all measurements in the study. At each visit, one tooth was prepared using standard operative techniques with a high-speed handpiece with water irrigant. All procedures were accomplished without a rubber dam. Prior to definitive tooth preparation, cavities of approximately the same dimension were cut to ensure about the same volume of composite was used for each measurement throughout the study. Thermocouples that allowed simultaneous temperature measurement of the pulpal floor and top composite surface were used. Esthet-X composite was used at either room temperature (23.6°C) or preheated in a Calset warming device set at 60°C, which previous work had shown actually warmed the composite to 54.7°C.

At each visit, temperature readings were taken of the following procedures: after tooth preparation, after acid-etching and rinsing, after curing the adhesive system, and during placement of either room temperature or warmed composite. The composite itself was not light-cured. Following temperature measurements, the uncured composite was removed, the preparation was minimally refined to remove the adhesive agent, and the procedures and temperature measurements were reaccomplished two more times on the same tooth. After the third set of measurements, the cavity preparation received final refinement and restoration. The three sets of measurements were averaged to provide a single value for each stage of the procedure for a single tooth at a single visit. The data from a total of three teeth at three visits were used for statistical analysis. Monomer conversion was calculated from previous work and was based on the composite temperature at the time light-curing would have occurred.

Results: The following pulpal floor temperature values were obtained: 27.8°C after tooth preparation, 26.3°C after acid-etching and rinsing, and 30.5°C after adhesive light-curing. The pulpal floor temperature after adhesive light-curing was significantly higher than after preparation or after acid etching and water rinsing, which were not different. Pulpal floor temperature after adhesive light-curing was not different from either the top or bottom composite surfaces after placing room temperature composite. However, the composite temperature at the pulpal floor (36.2°C) and at the top surface (38.4°C) was significantly greater following placement of the warmed composite compared with the room temperature composite. The calculated monomer conversion values for the warmed composite were significantly greater than for the room temperature composite.

Conclusions: Although the temperature measured in cavity preparations immediately after inserting heated composite was significantly higher compared with room temperature composite, the temperature rise in the cavity was relatively small. The temperature of the composite in the warmer was approximately 54.7°C, but only recorded at 38.4°C (versus 29.6°C for room temperature composite) at the top surface of the cavity preparation, and 36.2°C (versus 30.4°C for room temperature composite) at the pulpal floor of the preparation. This shows that there is a rapid cooling of composite upon removal from the composite warmer and insertion into the tooth. It also demonstrates that the tooth acts as a heat sink, which aids in rapidly decreasing the warmed composite temperature. Another interesting finding was the measured temperature of the cavity pulpal floor, which was

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recorded at 30.5°C and not 37°C as has been generally assumed.

COMMENTARY

Although the results of this study must be tempered by the fact that it represents data from only three teeth in only one patient, it nonetheless provides unique insight into the thermal behavior of preheated composite when placed into a cavity preparation. The temperature of the composite tends to very rapidly approach the temperature of the cavity preparation pulpal floor, with room temperature composite warming, and warmed composite cooling. This increase in composite temperature provides multiple benefits, allowing for reduced viscosity, improved adaptation to preparation walls, and increased degree of conversion.

Composite Preheating: Effects on Marginal Adaptation, Degree of Conversion, and Mechanical Properties

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ABSTRACT

Objectives: The purpose of this study was to evaluate the effect of composite preheating on multiple properties—monomer conversion, flexural strength, microhardness, polymer cross-linking and marginal adaptation—when the material was light-activated at two energy densities (12 J/cm^2; 24 J/cm^2).

Materials and Methods: Class V preparations were made in 40 bovine incisors with enamel margins and axial walls in dentin. The standard cavity dimensions resulted in a C factor = 3. A 2-step etch & rinse adhesive (Adper Single Bond 2, 3 M ESPE), followed by room temperature or 68°C composite (Filtek Z350, 3 M ESPE) was placed and cured in bulk in the ambient temperature cavity preparations. The composite was cured at 600mW/cm^2 for either 20 or 40 seconds.

Restorations were stored for 7 days in 37°C distilled water, sectioned through the middle of the restorations, polished, impressions taken of the resulting sectioned surfaces with polyvinylsiloxane (Express, 3 M ESPE), and poured in epoxy resin. The epoxy replicas were sputter-coated and interfacial gaps assessed at 200x with a scanning electron microscope. Degree of conversion was measured using FT-Raman spectroscopy, flexural strength was assessed using a three-point bending test, and polymer cross-linking was estimated using Knoop hardness measured after 24 hours dry storage following curing, compared with Knoop hardness measured after the specimens were stored for 24 hours in 100% ethanol.

Results: Preheated composite showed significantly fewer interfacial gaps compared with room temperature composite; axial walls had a higher number of gaps than cavity side walls. There was no difference in flexural strength, degree of conversion or estimated polymer cross-linking for either composite temperature or energy density.

Conclusions: The authors attributed the fact that flexural strength, degree of conversion, and estimated polymer cross-linking were not affected by composite preheating to the rapid decrease in composite temperature upon removal from the warmer, and placement and manipulation into the cavity preparation. It required nearly 2 minutes for this composite handling to take place, and previous research has shown that composite temperature can drop 35–40% or more in that period, reducing the temperature to a level that the authors suggested may have been insufficient to allow for improvement in mechanical properties.

Likewise, an energy density of 12 J/cm^2 was apparently adequate to fully cure the composite, regardless of the composite temperature immediately prior to filling the

preparation. However, there was adequate residual temperature in the preheated composite to allow better adaptation to the cavity walls, resulting in fewer gaps being formed compared with room temperature composite.

COMMENTARY

A positive aspect to this study is that the authors attempted to simulate the clinical situation in their assessment. Many studies that evaluate the impact of warmed composite on marginal adaptation and mechanical properties perform their evaluations at the elevated temperature to which the composite is heated. This obviously does not duplicate the clinical situation, where the time to manipulate the composite, as well as the fact that the composite is being placed into cooler surfaces, is going to result in the composite being much lower in temperature than it is in the composite warmer. It is important to consider the limitations of this study as well: only one composite was used, it is an in vitro study, bovine rather than human teeth were used, no stressing of the adhesive interface with thermomechanical loading or prolonged water storage was done, and the teeth were at ambient temperature rather than intraoral temperature during composite placement and curing.

SUGGESTED READING

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THE BOTTOM LINE

Warming composite prior to placement into a cavity preparation appears to offer several advantages. Warming the composite reduces its viscosity, allowing the material to be injected into the preparation, rather than manipulating it into the preparation with hand instruments. This allows practitioners to duplicate what has become a popular placement technique of injecting flowable composites.

The warm composite technique allows handling characteristics similar to those of flowable composite without sacrificing the benefits of superior mechanical, wear and polymerization shrinkage properties associated with the use of heavily filled restorative composite. The reduced viscosity also allows for improved wetting of cavity walls compared with room temperature, heavily filled restorative composite. This in turn provides for improved adaptation to cavity walls and decreased gap formation. Because the warmed composite is at an elevated temperature relative to room temperature composite following placement, molecular mobility is enhanced, which can lead to improved mechanical properties following cure.

The effect of warming on composite viscosity will vary depending on composite type and brand. Some concern has been voiced that injecting warm composite into a cavity preparation might result in temperature increases incompatible with pulpal health. However, composite cools very rapidly upon removal from the composite warmer, and the tooth acts as a heat sink, resulting in composite temperatures immediately after placement that are only slightly elevated above intraoral tooth temperature, and that are essentially equivalent to body temperature. Although the use of warm composite does require additional equipment and an adaptation of the dentist's placement technique, the cost is low, the learning curve is shallow, the benefits are high, and the propensity for adverse events is low.

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