Clinical applications of preheated hybrid resin composite

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IN BRIEF

- Explains how hybrid resin composite can be preheated to improve its handling characteristics.
- Describes the use of preheated hybrid resin composite for luting porcelain laminate veneers.
- Discusses practical points to consider when using a composite heating device in the surgery.
- Reviews the effect of preheating on the properties of resin composite.

PRACTICE

This clinical article describes and discusses the use of preheated nanohybrid resin composite for the placement of direct restorations and luting of porcelain laminate veneers. Two clinical cases are presented. Preheating hybrid composite decreases its viscosity and film thickness offering the clinician improved handling. Preheating also facilitates the use of nanohybrid composite as a veneer luting material with relatively low polymerisation shrinkage and coefficient of thermal expansion compared to currently available resin luting cements.

INTRODUCTION

Since Buonocore[1] first described bonding acrylic resin to enamel, materials and techniques have developed to allow adhesive dentistry to become commonplace for the restoration of teeth affected by caries, tooth surface loss (TSL) and traumatic fractures. Modern resin composite has evolved since Bowen's development of Bis-GMA resin[2] and enables clinicians to provide restorations that are both aesthetic and biologically conservative. The development of systems with multiple shades for dentine and enamel enables clinicians to apply the 'natural layering concept', producing direct restorations that closely emulate the optical properties of the original tooth structure.[3] Conventional resin composite has no intrinsic adhesion to enamel and dentine but relies on intermediary agents with a mechanism that is essentially micromechanical. The 'total etch' technique with phosphoric acid followed by the application of a separate primer and adhesive resin (3-step etch-and-rinse approach) remains the gold standard, despite the increasing interest in simplified bonding protocols.[4]

Resin composites are presented in compules or syringes and consist of a viscous organic resin matrix filled with glass particles bonded to the resin via a silane coupling agent. The resin is converted to a rigid polymer by an addition reaction, typically brought about by visible blue light activation, although chemical and dual-cure resin composites are available. The glass filler takes no part in the polymerisation reaction, but its quantity and type influence the mechanical and physical properties of the composite. Flowable resin composites adapt well to cavity preparations but their low filler content severely compromises their mechanical properties. Their application is limited due to poor wear and stress resistance and high polymerisation shrinkage,[5] which can lead to debonding, marginal failure and increased microleakage.[6]

Highly filled micro- and nanohybrid resin composites can be used with long-term success for load bearing restorations.[7,8] However, during placement these materials can be difficult to extrude from the compule or syringe. Furthermore, poor adaptation to cavity preparation walls[9] and voids within the bulk of the material have been reported.[10] In an attempt to improve adaptation and reduce microleakage associated with posterior resin composite restorations some authors have suggested placing a layer of flowable composite, before the placement of the more highly filled material.[11] However, their use is not without controversy due to the materials aforementioned short-comings.

Fig. 1 Composite warmers with interchangeable compule and dispenser gun trays

Over recent years there has been growing interest in making highly filled resin composite less viscous by preheating without detriment to the properties of the polymerised material.[12-15] The authors use the Calset Composite Warmer (AdDent Inc, Danbury, Connecticut, USA) which takes ten minutes to reach the temperatures that have been investigated in the literature for preheating composite (54°C and 68°C), and then about three minutes to warm the material. The device has interchangeable trays (for example, a standard compule tray and a dispenser gun tray) to suit the clinician's preference for a particular case (Fig. 1). Potential benefits to preheating

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highly filled resin composites are: (a) easier extrusion from compules or syringes; (b) enhanced adaptation of the material to cavity walls; (c) decreased potential to trap air and therefore less risk of voids at the margins or within the bulk of the material; (d) increased monomer conversion and therefore improved physical and mechanical properties of the final restoration.[16] The clinician is still able to control the morphology of composite increments, since preheated highly filled resin composite does not become as fluid as room temperature flowable composite and will not sink under its own weight.

The use of preheated restorative hybrid resin composite has been recommended by some authors for the adhesive luting of porcelain laminate veneers.[17,18] Veneers can be a useful treatment option in the management of TSL and fractured teeth and are more conservative than full coverage crowns. Bonding etched porcelain restorations with resin composite has a bifunctional role: the porcelain-resin-tooth complex both retains the veneer in the absence of retention and resistance form, and reinforces the otherwise brittle restoration.[19] Tooth preparation design,[20] functional load, and the strength of the bond of the veneer to the tooth, all play important roles in the longevity of a veneer. As such resin cements developed for bonding veneers (for example, Rely X Veneer, 3M ESPE, Seefield, Germany) utilise etch-and-rinse bonding systems as these provide the most predictable clinical performance.[4] It follows that self-adhesive resin composite cements (for example, Rely X Unicem, 3M ESPE) are not currently appropriate for bonding veneers. Similarly, dual-cure resin cements are not advisable for veneers because their amine activator results in long-term colour instability[21] and they do not offer 'unlimited' working time. A further parameter in the longevity of porcelain veneers is the stress distribution brought about by polymerisation shrinkage of the luting resin and thermal changes which occur at the anterior teeth (where the temperature can range from 0 to 67°C[22]). Resin composites with low filler content, such as luting cements, not only exhibit relatively high polymerisation shrinkage but also thermal expansion coefficients much greater than those of enamel and dentine.[23] The resultant stresses can contribute to microleakage and crack formation within a veneer.[24] Using a hybrid resin composite in place of a resin luting cement could reduce these stresses because their polymerisation shrinkage and coefficient of thermal expansion are significantly lower.

It is the purpose of this clinical technique paper to describe and discuss the use of preheated hybrid resin composite for the placement of direct resin composite restorations (Case 1), and also to describe how preheated hybrid resin composite may be used to bond porcelain laminate veneers (Case 2).

CASE STUDY ONE AND CLINICAL TECHNIQUE

A 28-year-old female presented complaining that one of her fillings had begun to feel rough to touch with her tongue. Examination revealed that the mesio-occlusal amalgam present in 16 exhibited marginal degradation (Fig. 2). Bitewing radiography revealed secondary caries and it was decided to replace the failed amalgam restoration. Resin composite was considered the material of choice due to the aesthetic demands of the patient and the moderate size of the existing restoration which was bound by an uninterrupted enamel margin. A nanohybrid resin composite (Miris 2, Coltene-Whaledent, Altstatten, Switzerland) was chosen, and the manufacturer's proprietary shade guide was used to achieve a good colour match. One compule of the enamel shade and one of the dentine shade were placed in separate composite guns and then into the dispenser gun tray of two individual composite warmers (AdDent Inc), both preheated to the 54°C setting. Following the provision of a local anaesthetic the failed amalgam restoration and caries were removed. After mechanical preparation 16 and both immediately adjacent teeth were meticulously isolated using rubber dam and a sectional matrix system applied (V3 Ring, Triodent, Katikati, New Zealand) to facilitate contact point formation. A 3-step etch-and-rinse bonding system (Optibond FL, Kerr, Orange, CA, USA) was then applied, carefully following the manufacturer's instructions. One increment of approximately 1 mm thickness of the preheated enamel shade of the resin composite was then placed 'vertically' from the base

Fig. 2 Defective amalgam restoration

Fig. 3 Second increment of 'dentine' composite with staining effects

Fig. 4 Final composite restoration marked with articulating paper

of the proximal box against the matrix band to the occlusal surface forming the proximal wall and marginal ridge, and light polymerised. This was done to restore the anatomy of the marginal ridge which the authors use as a reference point when restoring the remaining occlusal anatomy. The disadvantage of this approach is that the configuration factor (ratio of bonded to unbonded surfaces) and shrinkage stress during polymerisation is greater for subsequent increments.[25,26] Since it had been preheated, the hybrid resin composite was easily extruded from the compule and readily adapted to the cavity walls and sectional matrix. Subsequently, a 2 mm increment of the preheated dentine shade of the hybrid resin composite was placed 'horizontally' into the base of the cavity

Fig. 5 Anterior non-carious tooth tissue loss

Fig. 6 Rubber dam isolation before bonding

Fig. 7 Removal of excess nanohybrid composite

and light polymerised. A second 2 mm increment of the same material was placed 'horizontally' to approximately the level of the amelodentinal junction. Both guns, containing their compules, were replaced in the dispenser gun tray of their respective composite warmers while not in use: when using the other shade or during light polymerisation. After light polymerisation of the second 'dentine' layer staining effects were added using Kolor Plus (Kerr) (Fig. 3). The preheated enamel-like hybrid resin composite was then placed obliquely and cured in increments to emulate cuspal inclines and a life-like occlusal morphology. Placing increments obliquely can also reduce their configuration factor and hence shrinkage stress produced during polymerisation. Glycerin jelly was placed over the surface of the restoration which was light polymerised a final time to remove the oxygen inhibited layer. Following removal of the rubber dam the occlusion was checked in both intercuspal and excursive positions and adjusted minimally with fine diamond burs. The restoration was finished with polishing discs (Sof-Lex Discs, 3M ESPE, Seefield, Germany) and low viscosity resin varnish (Biscover LV, Bisco, Illinois, USA) (Fig. 4).

CASE STUDY TWO AND CLINICAL TECHNIQUE

A 43-year-old female presented requesting cosmetic dental treatment to improve the appearance of her upper anterior teeth. On examination, the appearance of her upper anterior teeth was compromised due to tooth surface loss (TSL) and a large midline diastema was present (Fig. 5). Her oral hygiene was good, the gingival tissues were healthy and no caries was present. Following investigation into the history of her TSL it was determined that significant risk factors were now controlled. Cosmetic treatment options and their associated risks and benefits were discussed at length over two consultation appointments giving the patient time to reflect on the possibilities away from the surgery environment. The options included direct resin composite additions or veneers to change the shape of the teeth and orthodontic therapy to close her diastema. The patient objected to wearing an orthodontic appliance, no matter how discreet it could be made. She requested porcelain veneers to increase the incisal length and prominence of her anterior teeth (11, 12, 13, 21, 22 and 23) and to partially close her diastema. She understood that moderate sacrifice of sound tooth tissue would be necessary. The authors considered this to be acceptable for a middle aged patient with moderate to severe TSL: indirect restorations facilitate good control of tooth form and porcelain veneers would be expected to provide a more durable result than direct composite additions.[27,28]

On study models, a diagnostic wax-up was made by adding to the contours of the anterior teeth. An impression of the wax up was taken in laboratory putty (Platinum 85, Zhermack SpA, Rovigo, Italy) and used as an index to transfer the proposed changes to the patient's teeth with a provisional acrylic resin material (New Outline, Anaxdent, Germany). This technique is described in depth elsewhere[29] and enables the patient and clinician to visualise increases in the prominence and length of teeth before committing to tooth preparations. At a subsequent appointment, the shade was recorded, tooth preparations were carried out and impressions and provisional restorations made. Silicone indices from the additive wax-up were used to facilitate precise tooth reduction, providing space for ideal porcelain thickness while preventing over preparation.[30]

At the fit appointment, the veneers were tried in to verify their appearance. The patient's anterior teeth were then isolated with rubber dam. A clamp (number D6) was placed sequentially on each tooth, clearly exposing the preparation margins, as its corresponding veneer was cemented. In turn, wedges and clear matrix strips were placed on either side of the tooth isolated with the clamp (Fig. 6). Before cementation, each veneer was etched chairside with hydrofluoric acid, cleaned in an ultrasonic bath to remove crystalline precipitate[31] and silanated. A layer of adhesive resin (Optibond FL adhesive) was placed on the fit surface followed by a thin layer of a translucent enamel shade of nanohybrid composite (Miris 2, Coltene-Whaledent) which had been preheated for at least 15 minutes at 54°C using a Calset Composite Warmer (AdDent Inc). The prepared veneer was then placed into the central well of the compule tray of the composite warmer for storage and the lid placed to exclude light while the tooth surface was prepared. The abutment tooth was etched and bonding agent (Optibond FL adhesive) applied. The veneer was taken from the central well of the compule tray of the composite warmer and seated on the underlying tooth preparation, until its advancement was halted by the presence of the matrix bands and wedges, and excess composite removed with a straight probe. The wooden wedges were removed and the veneer seated further, again removing any excess with a probe (Fig. 7). The matrix strips were then removed allowing complete seating of the veneer which was confirmed when no further excess composite extruded under seating pressure. The nanohybrid luting composite was then light-polymerised (this was repeated through a layer of glycerin jelly placed over the restoration margins to remove the oxygen inhibited layer), excess removed with a number 12 scalpel and serrated diamond finishing strips (NiTi-Kahla GmbH, Kahla, Germany), and the sequence repeated in turn for each remaining veneer (Fig. 8). The author of this case prefers to prepare and fit each veneer in turn. However, an alternative approach would be to place preheated composite on the fit surface of all of the veneers and store them together in the veneer tray (with the lid in place) of a composite warmer, which could save clinical time.

DISCUSSION

In the above cases the use of preheated hybrid resin composite vastly improved the handling characteristics of the material and its decreased viscosity aided the attainment of excellent restoration margins. Used as a lute in Case 2, hybrid composite did not prevent proper seating of the veneers, although dynamic seating was essential. Dynamic seating overcomes hydrodynamic forces within the luting material which occur as a restoration approximates the underlying tooth and is typically performed by intermittent manual pressure, although sonic energy can also be used. Use of a specially designed soft sonic tip (Sonic Flex Cem, Kavo Dental GmbH, Biberach, Germany) has been described for the purpose of seating bonded inlays using preheated hybrid composite,[32] however, we have not found this to be necessary for veneers. Preheating the composite significantly decreases its film thickness[16] and its use provides a lute with a smaller coefficient of thermal expansion, less polymerisation shrinkage and greater wear resistance at veneer margins than a conventional resin luting cement. Incomplete seating of a veneer would increase the thickness of resin in the lute space, which could exacerbate the effects of polymerisation shrinkage and thermal expansion. This would appear to be of greatest concern when the thickness of the lute space becomes greater than 0.1 mm and if a veneer is particularly thin ie when the ratio of veneer to luting composite thickness is less than 3:1.[33] In Case 2, the veneers provided were to restore the patient's teeth to full contour following advanced TSL. As such the veneers were relatively thick and since there were no complications with the colour of the underlying tooth tissue, a translucent resin composite was chosen. If a veneer is particularly thin (perhaps if a single tooth in a dentition with moderately worn enamel is being restored), or the underlying tooth tissue is slightly discoloured, use of a soluble try-in paste might be desirable. The need for a try-in paste can be ascertained by first trying in the veneer with water or glycerin jelly. If it is determined that achieving the correct colour for the final restoration will require the use of a shaded lute then one of the light-polymerising resin luting cements with corresponding try-in pastes are to be recommended.

The efficacy of Calset Composite Warmers identical to the one used for the above cases was investigated by Daronch and co-workers.[15] The device has two temperature presets for heating resin composite: 54°C and 60°C. However, the maximum compule temperature they attained for hybrid composites was 48.3°C when the unit was preset to 54°C, and 54.7°C when preset to 60°C. Presumably, the inorganic filler particles and organic resins function as thermal insulators as does the storage compule. It is possible to store compules in the warming device at the chosen preset temperature for the entire working day. However, there may be some practical limitations to the extended storage of resin composite at elevated temperatures. In the short-term, resin composite does not undergo spontaneous thermal polymerisation until temperatures of 140°C to 200°C,[34] and reactant evaporation and photoinitiator degradation does not occur until nearly 90°C.[35,36] However, concern exists that, under prolonged heating, certain low molecular weight components of the photoinitiator system could be volatilised, potentially compromising subsequent light polymerisation. Trujillo[34] reported that after eight hours storage, at 54.5°C, hybrid composite exhibited reduced immediate conversion when light polymerised when compared with control samples that had been stored at room temperature, whereas storage at the same temperature for four hours had no adverse effect. In view of these findings, it is prudent to limit storage times to four hours and to replace compule caps (if compules are to be reused) to avoid the potential for reactive components to volatalise.

Fig. 8 Definitive veneers at 13, 12, 11, 21, 22 and 23

At room temperature, conventional light polymerisation of resin composite yields 50% to 75% conversion of the dimethacrylate monomers. The degree of conversion is influenced by: (a) the light source; (b) the photo initiator; (c) the amount of comonomer; (d) filler particle size and shape; (e) the interactions between the monomer and filler particles.[37] Ideally, all of the monomer would be converted to polymer to impart optimal physical and mechanical properties to the material, including improved wear resistance, increased dimensional and colour stability, and decreased solubility. The decreased viscosity brought about by preheating resin composite causes free radicals and propagating polymer chains to become more mobile and react to a greater extent resulting in a more complete polymerisation reaction and greater crosslinking.[38]

A large loss in temperature from preheated resin composite is observed in just a short period after a compule is removed from the heat source and the material extruded. Daronch and co-workers[39] observed that for microhybrid composite, it could be expected that 50% of the temperature gain would be lost after two minutes and 90% after five minutes. However, an increase in the degree of conversion could be expected even when a degree of cooling is taken into account.[12] Clinically, composite is placed in small increments to ensure full depth of cure which facilitates quick placement and therefore limited cooling of the material. Unfortunately, a high rate of conversion is also generally associated with increased polymerisation shrinkage. A further potentially negative effect of preheating composite is that a prolonged delay between its initial placement and subsequent polymerisation could increase microleakage, due to shrinkage as the composite cools.[13] Practically, however, these potential drawbacks do not appear to be clinically relevant. It has been suggested that light polymerisation times could be reduced by up to 75% for preheated composite due to increased conversion of the resin[38] (Calset Composite Warmer promotional material, AdDent Inc, Danbury, Connecticut, USA). Clinically, however, this cannot be recommended since it assumes that the elevated temperature is maintained throughout the extrusion of the resin composite from the compule (or syringe), placement in the cavity and subsequent light polymerisation.

It is generally accepted that pulp vitality could be compromised by temperature rises of greater than around 5°C from the baseline level of approximately 32°C to 34°C.[40] However, Daronch and co-workers[41] reported a less than 1.0°C rise in intrapulpal temperature *in vitro* corresponding to the placement of composite preheated at a device setting of 60°C, when compared to room temperature composite placed in identical cavities. The amount of heat transferred to the pulp during composite placement and light-polymerisation is dependent upon the thickness of the remaining tooth tissue; the thermal diffusivity of both the tooth tissue and the restorative material;[42,43] and the geometry of the tooth preparation.[44] Although any mechanical preparation of a tooth carries an inherent risk of pulpal damage, in the clinical cases described above, there were no additional concerns regarding pulp vitality as a direct consequence of using preheated resin composite.

As this paper is a case report we cannot verify the claimed beneficial effects of preheating highly filled composite upon the physical and mechanical properties of the final restoration. However, the enhanced handling characteristics and improved adaptability of these materials, along with the option of using hybrid composite as a lute for porcelain veneers, makes composite heating devices a useful addition to the surgery armamentarium.

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