Curing Techniques of Composite Resin: Continuous or Intermittent?

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Abstract

While composites have continued to be refined, significant differences between the available systems in physical and mechanical properties, and clinical performance have minimized. Nevertheless, with all the changes, there is one constant: it is necessary to light-cure direct composites. Clinicians need to understand the importance of light curing principles because unbound monomers are cytotoxic and poorly cured composites are less biocompatible. Four techniques are currently available for light-curing composites. The clinician will consider multiple factors once the light source is chosen to ensure that the composite is satisfactorily cured. This article analyses the various current technologies, their strengths and weaknesses, and the importance to ensuring proper polymerization by following such protocols.

Keywords: *Composite, light-curing, continuous, intermittent, polymerization.*

Introduction

When composite materials were first introduced, their field of application was very limited compared to that of amalgam. Early composite materials were suitable only for restoring anterior teeth because of their weak mechanical properties. However, in the past few decades, dental composites have developed from an inferior resin material into the material of choice. They are capable for use in the fabrication of highly esthetic, durable posterior and anterior restorations in direct restorative dentistry.[1]Apart from being used in the field of restorative dentistry, composites slowly gained entry into the field of orthodontics to bond brackets on the teeth. Chemically activated resin composites were widely used in Orthodontics which required mixing of two pastes, which could induce incorporation of air bubbles into the material. Other disadvantages included longer working time, slower polymerization reaction and lower mechanical properties because of the incorporation of oxygen in the mass which inhibits the polymerization.[2,3] For these reasons, light-activated orthodontic composite materials have been ever more frequently used for bracket bonding to dental enamel. Composite photoactivation time is particularly important because underpolymerization may result in early bracket debonding.Working with resin-based materials requires a detailed understanding of the curing properties and the factors that affect this process. Most modern composite materials are either based on a light-curing technology or offer a dual mechanism of light- and self-curing technology. In the case of light-curing materials the clinician needs to assure that enough photons reach the bottom of the composite, or the composite will not achieve the properties necessary for its long term survival.This article focusses on the various light-curing technologies and its potential drawbacks.

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CONTINUOUS CURING TECHNIQUE

Polymerization shrinkage is a problem inherent to light-cured resin composites. This process creates contraction stress in the composite restoration, which causes disruption of the marginal seal between the composite and the tooth structure.[1]Previous reports indicate that the magnitude of stress varies according to the C-factor and elasticity of the structures involved in the bonding process, such as cavity substrate, hybrid layer and bonding resins.[2,3]

Reduction of polymerization shrinkage stress can be attained in several ways. Attempts have been made using incremental layering of the composite resinduring packing and through use of a low elastic modulus liner between the tooth and the restorative composite resin.[4]A second alternative is the slow-curing technique. The most recent approach aims at an initially reduced conversion of the resin materials to allow the restoration some freedom of movement between the cavity walls and the centre of contraction.[5]

It had been previously claimed that light curing composites shrink toward the light, because the energy at the surface nearest the light would be higher than that in the deeper parts of the composite.[6,7]Thus, an energy gradient would be created within the composite, which would result in quicker polymerization closer to the light source.[8]

Uniform Continuous Cure

In uniform continuous curing, a light of constant intensity is applied to the composite resin for a specific period of time. This type of continuous curing technique is currently used. It is carried out using QTH and LED curing units[9].(Figure1)

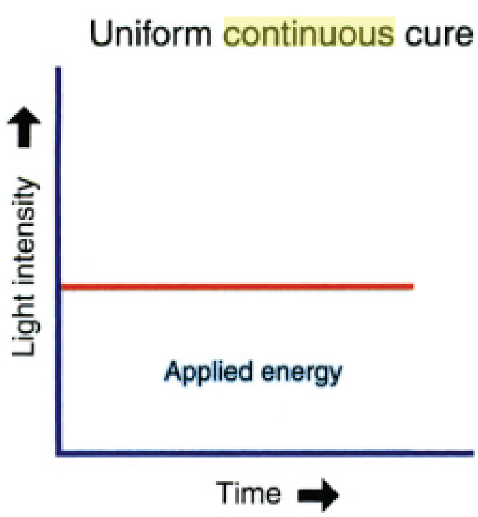


Figure 1

Step Cure

In the step cure technique, the composite is first cured at low energy, then stepped up to higher intensity, each for a set period of time. This is done to reduce the polymerization stress by inducing the composite to flow in a gel state. This technique reduces the overall polymerization shrinkage at the margin of the final restoration. [10,11]

The first commercially available light cure unit based on this technique was Elipar Highlight (ESPE). It uses a 10-second exposure of light at 150 mW/cm followed by 30-50 seconds at 700mW/ cm. However, this technique results in an uneven cure, as the top most layer is more saturated with light and thus more highly cured. [12]Step curing is possible only with halogen lamps. Arc lamps and lasers cannot be used because they work by applying large amounts of energy over a short period of time[13]. (Figure2)

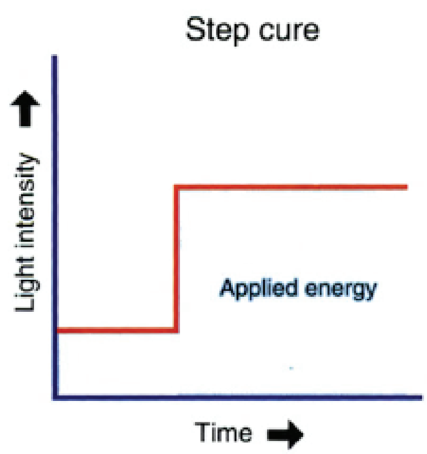


Figure2

Ramp Cure

In the ramp cure, light is initially applied at low intensity and gradually increased over time to high intensity levels. This allows the composite to cure slowly, thereby reducing the initial stress, as the composite can flow during polymerization.[14] Also, this function is designed to reduce polymerisation shrinkage. Ramp curing is done as an attempt to pass through all of the different intensities with the hope of optimizing a composite's polymerization. Studies indicate that ramp curing causes polymerization with longer chains, resulting in a more stable composite.[15]

Theoretically, very high energy applied over a short period tends to cause dimethacrylate monomers to attach to themselves, resulting in short polymer chains and a more brittle material with higher polymerization shrinkage and presence of more marginal gaps.[16]Ramp curing is possible only with halogen lamps. Arc and laser lamps can generate only large and non-variable amounts of energy.It is possible to ramp cure composites manually by holding a conventional curing lamp at a distance from the tooth and then slowly bringing it closer to the tooth to increase the intensity[17]. (Figure3)

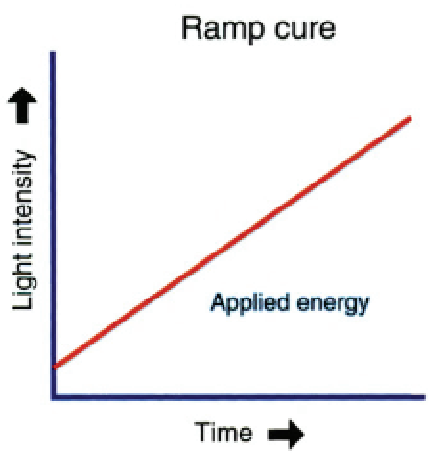


Figure3

High Frequency Pulse Cure

The high-energy pulse cure technique uses a brief (10 seconds) pulse of extremely high energy (1000-2800 mW/cm^2), which is three to six times the normal power density.[18]This type of polymerization has not yet been adequately examined and there are a few areas of potential concern.

1.The rapid application of energy might result in a weaker resin restoration due to the formation of short polymer chains. [19]

2.It is possible that rapid application of very high energy could reduce the diametral tensile strength.

3. Higher energies would result in more brittle resins.

This type of curing is carried out by argon laser, plasma arc and third generation of LED. (Figure4)

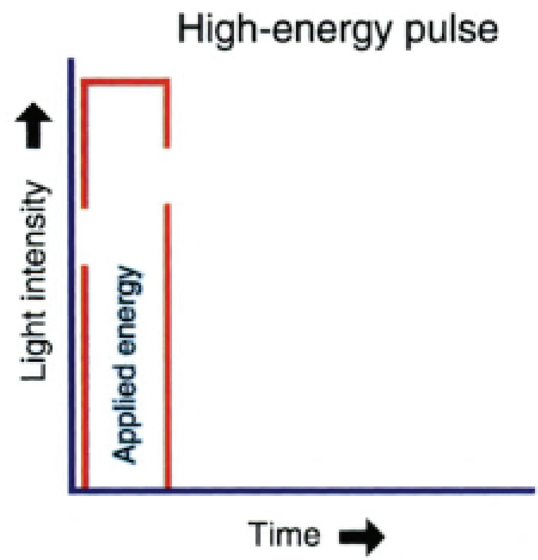


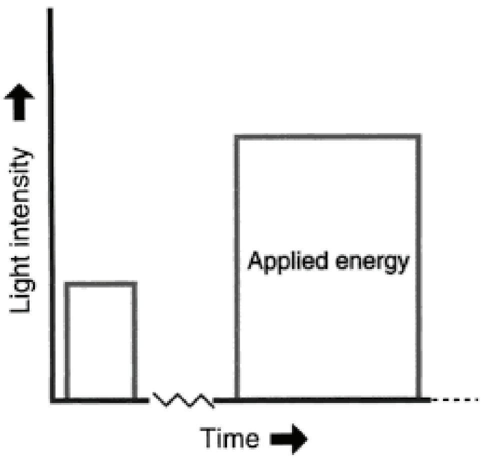
Figure 4

INTERMITTENT CURING TECHNIQUE

Intermittent or Discontinuous Curing Technique is also known as soft-cure technique. A low intensity or soft light is used to initiate slow polymerisation that allows the composite to flow from the unbound restoration surface to the bound tooth structure. This helps in reducing polymerisation stress at the margins and can reduce marginal gaps and defects. To complete the polymerisation cycle, the intensity of the next curing cycle is drastically increased to produce the needed energy for optimal polymerisation.[18]

Pulse Delay Cure

In this technique, a single pulse of light is applied to a restoration, followed by a short pause, and then by a second pulse of light which has greater intensity and duration of exposure than the first one. This technique is believed to be an interrupted step increase. The lower intensity light slows the rate of polymerisation, thus allowing shrinkage to occur until the composite becomes rigid. Thus the margins do not show much discrepancy. [20] The second pulse of greater intensity brings the composite to the final stage of polymerisation. Halogen lamps are used for this technique.The VIP light from BISCO used the pule delay cure technique, a very short exposure time of 3 seconds at 200 mW/cm^2 is first used to harden the composite resin. After a waiting period of three minutes, a 30-second exposure time at 600 mW/cm^2 is used. The waiting period allows stress relaxation and the restoration can be finished and polished at this time. (Figure5)



Pulse Delay Cure

Figure 5

Conclusion

Dental composite polymerization is a very complex process. The dentist must be aware of the limitations and factors that affect this operation. Over the past few years, the LED curing lights have been dramatically improved, but they face a new challenge: they need to provide the broadband spectrum required for modern esthetic composites that use other than initiators than camphorquinone, such as Lucirin TPO. Some manufacturers have already started producing the third generation of LEDs, such as polywave LEDs, and these curing lights showed promising results. In addition, a light guide, preferable 10mm wide and parallel, is essential for LED lights. If the curing light contains enough energy turbo light guides should be stopped when the composite is healed at a distance from the light emission window to prevent unnecessary energy loss. It has slowly emerged over the course of several years of study that advanced curing methods are unable to remove shrinkage stress. Nevertheless, intermittent techniques provide clear advantages.The soft-start technique presents the best compromise between curing time, mechanical properties, bond strength and reduction of shrinkage stress.

Ethical Clearance – Not required since it is a review article

Source of Funding – Nil

Conflict of Interest – Nil

References

1. Mahn E. Clinical criteria for the successful curing of composite materials. Revista clínica de periodoncia, implantología y rehabilitación oral. 2013 Dec 1;6(3):148-53.
2. Aguiar FHB, Ajudart KF & Lovadino JR Effect of light curing modes and filling techniques on microleakage of posterior resin composite restoration Operative Dentistry (2002) 27(6) 557-562.
3. Bouillaguet S, Ciucchi B, Jacoby T, Wataha JC & Pashley D Bonding characteristics to dentin walls of Class II cavi- ties, in vitro Dental Materials (2001) 17 316-321.
4. Feilzer AJ, de Gee AJ & Davidson CL Setting stress in composite resin in relation to configuration of restoration Journal of Dental Research (1987) 66 1636-1639.
5. Rajagopal, Rangaswamy, Sridevi Padmanabhan, and Janakirama Gnanamani. “A comparison of shear bond strength and debonding characteristics of conventional, moisture-insensitive, and self-etching primers in vitro.” The Angle orthodontist 74.2 (2004): 264-268.
6. Choi KK, Condon JR & Ferracane JL The effect of adhe- sive thickness on polymerization contraction stress of compos- ite Journal of Dental Research (2000) 79 812-817.
7. Hansen EK Visible light cured composite resin: Polymerization contraction, contraction pattern and hygroscop- ic expansion Scandinavian Journal of Dental Research (1982) 90 329- 335.
8. Davidson CL & Feilzer AJ Polymerization shrinkage and polymerization shrinkage stress in polymer-based restoratives Journal of Dentistry (1997) 25(6) 435-440.
9. Nasim, Iffat, et al. “Color stability of microfilled, microhybrid and nanocomposite resins—an in vitro study.” Journal of Dentistry 38 (2010): e137-e142.
10. Kempt-Scholte CM & Davidson CL Marginal integrity related to bond strength and strain capacity of composite resin restorative systems Journal of Prosthetic Dentistry (1990) 64 658-664.
11. Dennison JB, Yaman P, Seir R & Hamilton JC Effect of variable light intensity on composite shrinkage Journal Prosthetic Dentistry (2000) 84

499-505.

12. Labella R, Lambrechts P, Van Meerbeek B & Vanherle G Polymerization shrinkage and elasticity of flowable composites and filled adhesives Dental Materials (1999) 15 128-137.
13. Prasanna, N., et al. "Degree of conversion and residual stress of preheated and room-temperature composites." Indian Journal of Dental Research 18.4 (2007): 173.
14. Sakaguchi RL & Ferracane JL Stress transfer from poly- merization shrinkage of a chemical-cured composite bonded to a pre-cast composite substrate Dental Materials (1998) 14 106-11.
15. Uno S & Asmussen E Marginal adaptation of a restorative resin polymerized at reduced rate Scandinavian Journal of Dental Research (1991) 99(5) 440-444.
16. Versluis A, Tantbirojn D & Douglas WH Do incremental filling technique reduced polymerization shrinkage stresses? Journal of Dental Research (1996) 75 871-878.
17. Unterbrink GL & Muessner R Influence of light intensity on two restorative systems Journal of Dentistry (1995) 23 183-189.
18. Neelakantan, Prasanna, et al. "The shear bond strength of resin-based composite to white mineral trioxide aggregate." The Journal of the American Dental Association 143.8 (2012): e40-e45.
19. Hussain, Sharmila. Textbook of dental materials. Jaypee Brothers Publishers, 2008.
20. Yoshikawa T, Burrow MF & Tagami J A light curing method for improving marginal sealing and cavity wall adaptation of resin composite restorations Dental Materials (2001) 17 359- 366.
21. Dunne, Davis, Millar, Effect of different light curing units on tensile strength and microhardness of composite, J Appl OralSc, v 15(6), Dec2007 470-474