cin for preoperative prophylaxis. Prophylaxis should be started immediately before the operative procedure and continued for no more than 2 days after surgery to minimize emergence of resistant microorganisms. The effects of cardiopulmonary bypass and compromised postoperative renal function on serum antibiotic levels should be considered, and doses timed appropriately before and during the procedure.

Careful preoperative dental evaluation is recommended so that required dental treatment can be completed at least several weeks before cardiac surgery whenever possible. Such measures may decrease the incidence of late postoperative endocarditis.

Status after cardiac surgery

The same precautions should be observed in the years after open heart surgery that have been outlined for the unoperated patient undergoing dental procedures. The risk of endocarditis appears to continue indefinitely and is particularly significant in patients with prosthetic heart valves, in whom the mortality from endocarditis is considerable. Patients with an isolated secundum atrial septal defect repaired without a prosthetic patch and those who have had ligation and division of a patent ductus arteriosus are not at increased risk of developing endocarditis after a 6-month healing period after surgery. There is no evidence that patients who have undergone coronary artery bypass graft surgery are at risk to develop endocarditis unless another cardiac defect is present. Therefore, antibiotics to protect against endocarditis are not needed for these individuals.

Other indications for antibiotic prophylaxis to prevent endocarditis

In susceptible patients, prophylaxis to prevent endocarditis is also indicated for surgical procedures on any infected or contaminated tissues, including incision and drainage of abscesses. In these circumstances, regimens should be individualized but in most instances should include antibiotics effective against *Staph aureus*.

Antibiotic prophylaxis for the foregoing surgical and dental procedures should also be given to patients with a documented previous episode of bacterial endocarditis, even in the absence of clinically detectable heart disease.

Patients with indwelling transvenous cardiac pacemakers appear to present a low risk of endocarditis: when such cases occur they are predominantly caused by staphylococci. However, dentists and physicians may choose to use prophylactic antibiotics when dental and surgical procedures are performed in these patients. The same recommendations apply to renal dialysis patients with arteriovenous shunt appliances. Endocarditis prophylaxis also deserves consideration in patients with ventriculo-atrial shunts for hydrocephalus, because there are documented cases of bacterial endocarditis in these patients.

Prophylactic antibiotics are not required in diagnostic cardiac catheterization and angiography because with adequate aseptic techniques the occurrence of endocarditis after these procedures is extremely low.

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This report was prepared by the Committee on Rheumatic Fever and Infective Endocarditis, American Heart Association, in consultation with the Council on Dental Therapeutics, American Dental Association. Committee members include Stanford T. Schulman, MD, chairman; Don P. Amren, MD; Alan L. Bisno, MD; Adnan S. Dajani, MD; David T. Durack, MD, D Phil; Michael A. Gerber, MD; Edward L. Kaplan, MD; H. Dean Millard, DDS, MS; W. Eugene Sanders, MD; Richard H. Schwartz, MD; and Chatrchai Watanakunakorn, MD. The foreword was prepared by Dr. H. Dean Millard, dental member to the committee. Address requests for reprints to the Council on Dental Therapeutics, American Dental Association, 211 E Chicago Ave, Chicago, 60611. The American Heart Association is located at 7320 Greenville Ave, Dallas, 75211. For a copy of the full report, address requests to the American Heart Association, report no. 71-005-c.

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Visible light-cured composites and activating units

Council on Dental Materials, Instruments, and Equipment

Photoactivated composite restorative resins are polymerized by ultraviolet or visible light. A recent council report[1] stated: "The main clinical advantage or indication for using a photoactivated system is the regulation that the clinician has over working time. In cases of extensive and intricate cavity preparations or with patient behavioral problems, this control can prove most valuable. The incremental addition of resin to build restoration contours and to minimize the amount of excess material removed during finishing are also noteworthy advantages for a photoactivated system." The number of visible light-activated systems has increased substantially in the past 2 years. Several ultraviolet light-activated systems are also available. There are also composites that can be activated by either visible or ultraviolet light. The visible light systems are gaining popularity and replacing the ultraviolet systems for many reasons, which include the possible hazards of ultraviolet radiation and the more extensive visible light penetration of tooth structure for deeper depths of cure. This council report summarizes the current information on photoactivating composites and photoactivating light units.

Composites

The compositions of photoactivated composite resins differ from the chemically activated resins only in the activators and initiators. The ultraviolet light-activated composites contain benzoin alkyl ethers as initiators.[2,3] The visible light-activated composites usually contain diketone initiators such as camphoroquinone and a reducing agent such as a tertiary amine to produce ion radicals after the controlled irradiation by visible light to initiate polymerization.[3,4] The camphoroquinone initiator is activated by wavelengths in the range of 400-500 nm (blue region of the visible spectrum).[5] As a comparison, chemically activated composites depend on the mixing of the initiator (for example, benzoyl peroxide), and the activator (for example, dihydroxyethyl-p-toluidine) for polymerization.[2-4] For all currently available composites, the basic resin matrices are based on Bis-GMA, modified Bis-GMA, or urethane dimethacrylate type systems with diluents such as ethyleneglycol dimethacrylates or methyl methacrylate. The inorganic fillers may be quartz, lithium aluminum silicate, barium glass, strontium glass, collodial silica, or mixtures of these fillers. The filler particle sizes may range from as small as 0.04 μm in microfilled composites to 1-20 μm in conventional composites as well as the "polishable" composites (up to 5 μm) or mixtures of these particle sizes.[6]

The physical and mechanical properties of photoactivated composites, when adequately polymerized, are similar to those of chemically activated composites.[7-9] Both types are evaluated under specification no. 27 for direct filling resins.[10] A recent listing of certified products includes both visible light-activated, ultraviolet light-activated, and chemically activated resins.[11]

Photoactivated composites appear to be comparable to chemically activated composites at this time, and may have some advantages. Only a limited amount of clinical data, however, is available for photoactivated composites versus chemically activated composites. In a 2-year study involving Class IV restorations, an ultraviolet light-activated system (Nuva-Fil) was reported to be significantly better than two chemically activated systems (Exact, Restodent) in color match, cavosurface margin discoloration, margin adaptation, and anatomic form.[12] In a study of composites in posterior restorations, three ultraviolet light-activated resins (Nuva-Fil PA, Uvio-Fil, Estilux) showed little loss of anatomic form after 3 years, and color matching was reported to be excellent.[13] These results were considered better when compared with two chemically activated composites (Adaptic, Concise) used in another study of posterior restorations.[14] An extension of the study of ultraviolet light-activated resins reported that surface comparisons of the photocured resin systems are significantly superior to the autocured systems when subjected to occlusal loading.[15] A 3-year study of a "polishable" visible light-cured composite (Prisma-Fil) in Class III, IV, and V restorations reported significantly better performance when compared with a conventional, chemically activated composite resin (Concise).[16]

It has been postulated that the reported differences that favor photoactivated composites may be related to the method of activation. Photoactivated composites do not require spatulation and, therefore, have less porosity as the spatulation of the two components of chemically activated composites would incorporate minute air bubbles.[17,18] Furthermore, the action of mixing and manipulating chemically activated composites after the initiation of the polymerization, but before setting, could compromise the microstructures and the resin matrices of the systems, resulting in less desirable properties.

Adequate polymerization (curing) of composites is of paramount importance to ensure clinical performance. Underpolymerization is usually associated with inferior physical and mechanical properties, higher solubility, and less than optimal performance for the composites. The internal degree of polymerization of a photoactivated composite decreases with increasing distance from the surface. In fact, the presence of a hard top surface of a photoactivated composite restoration is not an indication of adequate polymerization throughout the restoration. The depth of cure of photoactivated composites is of great importance and is the subject of numerous investigations. Methods of depth of cure evaluations include scraping,[19-21] dye[22] and optical distinction,[23,24] and surface hardness measurements, which are predominantly used in the majority of the studies because hardness is an indicator of the degree of polymerization.[25] A comparison of these evaluation methods for determining depths of cure indicated that the former two methods showed deeper (3 mm) values where the hardness values were less than 30% of the top surface values.[26] A spectroscopic study reported high percentages of unreacted methacrylate groups at 2 to 3 mm below the surface.[27]

Most depth of cure evaluations were done in vitro. Some studies also incorporated simulated in vivo conditions with consideration of the presence of enamel[28-31] or dentin[32] (or both). Results of all these studies indicate that several factors influence in vitro depth of cure evaluations. These factors include mold material,[33-35] mold size,[36] exposure time,[29,35,37-43] photoactivating light source intensity,[29,34,37-47] time of measurement after controlled light applications,[29,34,37-41] and other variables. Two inherent factors in the composite, composition[21-48] and transmission coefficient,[20,21,28,43,49,50] also influence depth of cure. Most of these factors affect the intensity of photoactivating light reaching the bottom surface of samples tested. In general, reported depth of cure values are higher for translucent molds such as Teflon as compared with opaque metal molds.[33] Mold sizes larger than photoactivating beam sizes also give higher values as the surrounding composite acts as a translucent mold.[36] Exposure times longer than recommended by manufacturers usually result in somewhat higher hardness values for both the bottom and top surfaces.[37] Although there are reports suggesting that sequential exposure (more than one light application to achieve total exposure time) and slow scanning over large samples may result in lower hardness values,[25,51] no difference in hardness values was observed by Stanford and others[52] when several composites were adequately polymerized by sequential exposure or continuous exposure. Polymerization continues after the initial light application and hardness values increase up to 1 day.[41] Also, lower activating light intensity is associated with lower hardness values and corresponding shallower depth of cure.[44]

The transmission coefficient or attenuation factor of a composite is an indication of the reduction of photoactivating light intensity passing through the composites. Microfilled composites, because of larger light scattering by the smaller filler particles, have lower transmission coefficients and normally shallower depth of cure.[1,49] This, however may be compensated by the composition used in formulating the composites. The ultraviolet light-activated composites also have shallower depth of cure because of the increased amount of scattering at lower wavelengths.[27,46,49]

Currently, there is no consensus on the method of depth of cure evaluations. There is also no consensus on either an absolute hardness value or relative ratio of hardness[40] of the bottom and the top surfaces for a depth of cure criterion. At the present time, the subcommittee on ANSI/ADA specification no. 27 for direct filling resins is revising the specification to include depth of cure considerations. The profession should be cautious in the interpretation of claims of extensive depth of cure and should follow manufacturers' instructions explicitly. Care should be taken to recognize that a hard, adequately polymerized top surface does not necessarily indicate that the deeper areas are adequately polymerized. There is inadequate evidence to show that prolonged exposure will eventually cause adequate polymerization in deep restorations. It is suggested that for visible light-activated composites, thickness beyond 2 to 3 mm should be placed in increments and polymerized after each increment. For some darker shades, even thicknesses less than 2 mm may require increment placements. It is also suggested that if there is doubt on the amount of exposure time required, a longer exposure time should be used.

Visible light-activated composites may also be significantly affected by exposure to extraneous light sources in the dental operatory. The intensities of dental operatory lights cause some degree of polymerization if the composites are exposed or manipulated in these light beams.[53] Even strong ambient lighting may be sufficient to cause some polymerization. These conditions may result in premature polymerization of the composites to the extent that desirable restorative procedures with the affected composites may be hindered and the materials would have limited working time and adversely affect the properties. It is suggested that visible light-activated composites be subjected to minimize exposure to dental operatory lights and other room lighting systems until photoactivation by the use of a light-curing unit is desired.

Light activating units

A photoactivating light unit or dental curing light unit generally consists of a light source, a filter to select the range of wavelength transmitted, and a light tube for delivering the light beam to the area of application. There are at least two types of designs. A gun type unit has the light source and filter in a casing to be held by the operator, and the light tube is rigid and short. The other type of design has the light source and filter in a unit designed to rest on a flat surface in the operatory or as a part of a dental unit, with a long, flexible light tube, which may be a fiber-optic bundle or other light transmission design. Most units have timers for automatic switching off at the end of the selected exposure time.

Visible light-photoactivating units usually emit wavelength spectra from around 400 nm to about 550 nm.[5,54-56] Some units may also have small to moderate amounts of light below and above this range. There are differences in the spectral distribution, luminous intensity, and radiation intensity among the visible light units.[5,34,54-56] Differences in total light intensity among models have been reported to be 4 times,[5] 16 times,[35-36] and 59 times[18] between the lowest intensity unit and the highest intensity unit tested. The results are influenced by the differences in measuring methods and instrumentation used. Thus, the intensities and rankings of visible light-curing units based on measured intensity varied among the reports (Table). In addition, there is inadequate information on the intensity of the different units in the range of 400-500 nm, which is more effective in the photoactivating process.[5] The brightness or illumination ability is not a measure of effective photoactivation.

At the present time, there is insufficient information on the quantum efficiencies at various wavelengths and the spectral distribution correlation to use the total light intensity as the only criterion in the selection of a light unit. In addition, there is little information currently available on the luminous intensity and spectral distribution of the light units as affected by variations in line voltage, age of the light bulb, age of the filter, condition of the light tube, and several other factors. A standard for visible light activator devices is being developed. At the present time, these devices may be evaluated under the Guidelines for the Acceptance Program for Visible Light-Activating Devices of the Council.

The use of different combinations of composites and activating light units has been studied by several investigators.[24,34,38,57] The results indicated that curing patterns and depth of cure varied among the combinations. The results were also influenced by the experiment conditions used, methods of measure-

Table ▪ Reported intensity values of visible light curing units.

	Cook[5] (Lumen/cm²)	Cook[5] (mW/cm²)	O'Brien[55] (mW/cm²)	Blankenau[54] (mW/cm²)
Command	...	...	...	7.0
Elipor	20.6	528	53	16.0
Fotofil Activator	...	...	46	...
Heliomat	32.0	348	141	14.0
Kulzer Translux	86.7	746	20	20.5
Prisma-Lite	51.8	638	36	7.4
Visar	...	...	...	10.5
Visar II	...	...	...	6.6

ment, and interpretations of the measurements by the investigators. Until more information and more uniform interpretation becomes available, manufacturers' instructions should be taken as the basis for the use of different light/composite combinations.

As there are differences in the features associated with different photoactivating light units,[58] individual considerations of need and preference should be taken into consideration by the practitioner in the selection of a photoactivating unit.

Precautions

Precautions should be taken when photoactivating light units[59,60] are used. The Center for Devices and Radiological Health/Food and Drug Administration recommends that the use of appropriate protective eyewear be considered when operating these devices (O. Ellingson; R. Landry; and R. Bostrom, unpublished report). Although there is little information on the effects of high intensity visible light radiation on the eyes of dental personnel associated with the use of these photoactivating light units, there is a growing concern about the potential for retinal photochemical injury from chronic exposure to the emitted blue light (400-500 nm). These concerns are based on animal studies and limited human observations.[61-64] The American Conference of Governmental Industrial Hygienists (ACGIH) has proposed threshold limit values for ultraviolet, visible, and infrared light in the workroom environment.[65] Because of the many variables and use conditions, including workload, it is not possible to say whether, under certain conditions, the ACGIH values for visible light would be exceeded in the dental operatory. Thus, to reduce any long-term risk to the eyes of photoactivating light unit users, it is prudent that appropriate protective eyewear be used when operating these devices.

Properly filtered glasses would reduce the near ultraviolet and blue radiation reaching the eye to levels far below the ACGIH limits, while transmitting much of the remaining visible light (O. Ellingson; R. Landry; and R. Bostrom, unpublished report). Use of such eyewear may also improve the viewing comfort and task performance while working with a device where the direct or reflected light may be uncomfortably high. Other precautions include: avoid staring at the light, warn patients against staring at the light, and follow the manufacturer's instructions for use of the unit. Until more extensive information becomes available on exposure levels and their long-term effect, it would be prudent to be cautious in the use of dental visible light-curing devices.

A number of companies are marketing protective glasses for dental personnel or patients (or both), to be worn when light-curing devices are used. Product claims include filtering out high percentages of light below 450-525 nm. As emitted blue light with wavelength 400-500 nm is of concern, protective lenses that filter out light in this region would be effective in reducing the intensity of blue light reaching the eye. Preliminary measurements on the filtering efficiencies of these and some other commercially available lenses were obtained by the council laboratory (unpublished report) and the Center for Devices and Radiological Health (O. Ellingson, R. Landry, and R. Bostrom, unpublished report). The wavelengths below which transmissions are reduced to 1% or less for some of these protective lenses are: Liteshield, 500 nm; Guardian Perception Orange Lenses, 500 nm; Noviol, 470 nm; Wox, 470 nm; and Guardian Perception Yellow Lenses, 440 nm. Corning CPF 550 transmits less than 1% below 550 nm but it transmits up to 10% between the wavelength range of 350 to 450 nm. Protective glasses intended to filter out ultraviolet light, such as no. G-40, which allows less than 1% transmission below 400 nm, do not filter out visible light in the blue region. The long-term effectiveness of protective glasses for visible light has not been clinically evaluated. The council will publish a report on this topic when additional information becomes available. Meanwhile, until the absence of a hazard has been proved, the prudent approach would be to take proper precautions to minimize the potential hazard by the use of special filter glasses to diminish the light intensity reaching the eyes. It is important to recognize that the use of these special filter glasses should not imply that it is safe to stare at the lights.

Heat generation by the visible light-curing units or by the exothermic reaction of the photoactivated composites (or both) has been reported.[66-69] The results of these in vitro studies indicated differences among units and composites. Conclusions were postulated that, in some systems, the amount of heat generated may have the potential to affect the pulp; however, no in vivo study on this heat effect has been reported.

Summary

In summary, visible light-activated composites offer better regulation of working time. Their composition differs from chemically activated composites only in the initiators and activators. The physical and mechanical properties of adequately polymerized photoactivated composites are similar to chemically activated composites. Depth of cure evaluations of the photoactivated composites are dependent on many factors, both experimental and inherent. There is currently no consensus on depth of cure values and evaluation methods. It is suggested that, if necessary, visible light-activated composites should be placed and polymerized in about 2-mm increments. It is prudent to use a longer exposure time. Exposure of visible light composites to dental operatory lights or strong ambient lighting (or both) during restorative procedures should be minimized to avoid premature polymerization. There are differences in design, spectral distribution, and radiation intensity of photoactivating light units. No definitive information is currently available on the effectiveness and optimal conditions for use of different light/composite combinations. Little information is currently available on the bioeffect of visible light radiation on human optical systems and oral tissue. At the present time there are reports of afterimages but no long-lasting bioeffects. It is strongly recommended that precautions should be taken in the care, use, and operation of photoactivating light units. Protective filter glasses should be used.

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Cost-effectiveness of sealants in private practice and standards for use in prepaid dental care

Council on Dental Research

The concept of pit and fissure sealants is usually attributed to Hyatt[1] and his suggested technique of prophylactic odontotomy. Although Hyatt's ideas were not fully accepted by the dental profession even before modern methods of prevention,[2] they probably led to the "preventive filling" approach to caries control. At a time when the development of caries was more generalized and severe than it is today and preventive options were few, this approach was probably rational enough.

Various chemicals, painted directly onto the tooth, were tested as caries preventives in the prefluoride era without success.[3,4] Even after the evolution of fluoride as the primary caries-preventive agent, interest in some material specifically to benefit occlusal surfaces persisted because pit-and-fissure surfaces are those that benefit least from fluoride.[5] Early