ESTHETICS AND THE ARGON ION LASER

by Mark H. Docktor, DDS

The state-of-the-art in polymerization of light-activated restorative materials has advanced significantly with developments in laser technology. Coupled with the increase in patient awareness and interest in appearance, the value of this clinical advance has been enhanced. Innovative developments in materials and techniques, combined with the use of the argon laser, enable both routine and complex procedures to be accomplished with greater facility and with increased strength and hardness of bonding materials, in dramatically reduced time, and with greater patient comfort and confidence.

Evaluating the most basic aspects of laser (Light Amplification by Stimulated Emission of Radiation) physics, one must understand that all forms of light have a characteristic wavelength. Laser light is defined as being coherent, unidirectional, monochromatic, collimated (parallel waves) and potentially high-energy yielding. A laser source, when activated by a power supply, excites the molecules within the medium in a tube to produce photons of energy, which selectively pass out of the tube as a laser beam.

All lasers have an active medium that identifies them, and they usually are named after that medium. Each of these mediums may have different wavelengths and characteristics; the most common systems used in dentistry today are the carbon dioxide laser, the Nd:YAG (neodynium: yttrium-aluminum-garnet) laser, the argon, the holmium:YAG laser, and the erbium:YAG laser. The argon laser addressed in this article has a wavelength in the visible range just below the infrared.

Argon Laser Wavelength Specificity

In dentistry, early ultraviolet curing of resins allowed for rapid conversion of monomer to polymer, but did not allow for the depth of penetration needed for filled resins. The next generation of visible light-curing systems facilitates greater depth polymerization and potential for increased curing through enamel. Visible light-restorative materials typically use a diketone absorber, such as camphoroquinone, to create the ion-free radicals that initiate the polymerization process.

The light-cured resins use the energy from a light source to decompose a photoinitiator, which releases free radicals, forming a chain as they attach to resin molecules, yielding a polymerized composite resin. The wavelength-specific photoinitiator system of these resin materials is very sensitive to light in the blue region of the visible light spectrum, with peak effectiveness in the 480 nm range.

The current visible-light-cured (VLC) units are using a tungsten halogen bulb. These units produce a blue-violet light ranging from 380-600 nm. The argon laser light shows similar capabilities for inducing polymerization, especially at wavelengths of 476.5 nm and 488 nm for the optimum photochemical reaction. Early research indicates enhancement of the physical properties of composite resin following argon polymerization.

This may be related to the fact that lasers emit energy with increased density. It has been demonstrated by Severin that the shear bond strength of composite to dentin depends on the energy density from the curing system. It is, therefore, ideal to polymerize with a radiation wavelength closest to the optimum for camphoroquinone with the greatest intensity possible. Conventional light systems have a typical band width of 120 nm, with an average energy density of 400 mW/cm². In an air-cooled argon laser designed to emit all blue lines, there is a combined band width that encompasses 41.9 nm, with an intensity that could approach 800mW/cm². These emission and energy factors contribute to the enhanced properties of the beam to create the speed of conversion seen with argon lasers.

Severin indicates that this increased energy density produces greater hardness, reduced shrinkage stress at tooth/resin interfaces, an increased degree of polymerization, as well as increased compressive strength and flexural hardness.

Polymerization shrinkage of light-activated composites can result in marginal failure of restorations, staining and ledge-formation at the tooth/resin interface, microleakage and recurrent decay. Clinical techniques to minimize polymerization shrinkage include directional curing with incremental placement of restorative materials. The problem results from the inability of the directional curing-light source to totally polymerize the resin through tooth structure. Preliminary testing performed by Dickerson indicated that the energy density and power of the argon laser allowed direct curing through the tooth, which initiated shrinkage toward the tooth surface. This may effectively prevent gap formation and internal-polymerization stresses. In this situation, it is recommended strongly that additional curing time be used.

Early problems with a small, focused-spot size and the need to polymerize many more small areas, albeit for a shorter time, diminished the potential value of the laser. These problems have been eliminated in the new systems by increasing the spot size to enhance the immediate area of polymerization.

Enhancement of Physical Properties

A number of comprehensive studies were undertaken related to argon laser technology and composite resins. The studies compared the compressive strength, diametral tensile strength (DTS), transverse flexural strength (TFS) and flexural modulus (FM) of a microfilled and small-particle composite resin following argon laser vs. conventional VLC polymerization techniques. Results showed that the physical properties evaluated were enhanced by argon laser polymerization, and that results were obtained using only one-quarter the polymerization time of that used for visible-light curing. As well, the following changes relevant to fractures were shown.

Compressive Strength is a measure of how resistant a material is to fracture or failure when, for example, stressful masticatory loads are applied. This will provide an indication of how the restorative material will perform during function. In the results for compressive strength, both the microfilled and small-particle resins demonstrated greater strength with argon curing.

Diametral Tensile Strength values will provide an indication of a restoration's resistance to the lateral forces that tend to elongate the restoration. Both restorative materials demonstrated enhanced diametral tensile strength when polymerized with the argon laser, indicative of better resistance to lateral forces generated during mastication.

Transverse Flexural Strength provides an indicator of the distortion resistance of the cured resins. Functional stresses can result in the distortion of a restoration. Test results noted that the microfilled resin exhibited a significantly greater flexural strength after argon curing. In one-quarter of the curing time, the small-particle resin's flexural strength was enhanced, but not significantly over VLC polymerization. Hence, the value was predominantly in time savings.

Flexural Modulus indicates the restorative material's stiffness or rigidity as related to restoration deformation. The clinical significance relates to the ability of the resin-to-tooth adhesion site to tolerate and withstand shear forces that build up in masticatory function. Again, the microfilled resin exhibited a significantly greater FM when cured with the argon laser. The small-particle resin exhibited an FM that was greater with argon curing, but not significantly so over the light-cured method. Again, the significance is that, when utilizing argon, 75 percent less curing time was needed.

Efficiency of Polymerization

A study in laser polymerization of dental composites was performed by Puckett and Bennett. The objective was to compare the efficiency levels of the argon laser and the visible-light-cured techniques by testing degree and depth of cure using the Brinell hardness test. There was a significant difference in hardness values of the underside of the laser-cured vs. the VLC samples; this was developed in one-third the curing time. Argon laser 10-second-cured samples showed superior results to the 30-second VLC technique. The study revealed that when testing for hardness on the underside of the laser-cured vs. the VLC samples, values were unattainable because the VLC samples fell apart. This confirms the importance of placing composite in increments of 2 mm or less to ensure complete polymerization when using the conventional light-curing unit, because at depths of 2 mm or more, the deep surface of the composite is not completely polymerized. The argon ion laser also allows a greater thickness of composite polymerized in less time with improved physical properties and decreased chair time for the patient.

Research Data, Current Experimentation

1. The argon laser has been shown to increase the uptake of fluoride by enamel, by altering the surface characteristics of enamel.
2. The potential benefits of dramatically reduced exposure time make the achievement of better clinical results more likely, especially in those cases where moisture control is critical and difficult to secure. Maintaining a dry field should be easier to accomplish for 10 seconds than it is for 40 seconds.
3. A study by Severin and Maquin shows that orthodontic-bracket bonding is 50 percent more effective than classic chemical bonding with resin, and in only six seconds of curing time, rather than two minutes with chemical curing.

   A study by Sedivy et al. concluded that with only a four-second laser-exposure time, and with only 1 watt of power, the argon laser takes 87 percent less time than conventional VLC units to obtain comparable bond strengths.
4. Lased enamel, in one study, showed a positive birefringence suggesting the formation of microspaces in enamel, which would impart an increased acid resistance to the enamel by trapping ions formed during acid decalcification.
5. Another study showed that exposure of enamel to the argon laser results in a significant reduction in acid solubility. When a topical fluoride treatment was performed following argon lasing of enamel, an even more dramatic reduction in enamel demineralization was noted. It appears that the composition of enamel may be altered with reduction in organic, carbonate and water content. The reduction in carbonate content results in increased resistance to acid dissolution. Hicks et al. state, "It has been estimated that the effect of laser irradiation may result in a lowering of the threshold pH at which enamel dissolution occurs from pH 5.5 to 4.78. In other words, a five-fold increase in the concentration of an organic acid would be necessary to solubilize a similar amount of lased enamel compared with untreated enamel."
6. Following argon laser curing, less microleakage was noted when using dental sealants, with the decreased exposure time factor increasing the probability of maintaining a dry field for the procedure.
7. It is surmised that improved diametral strength could result in reduction of pit-and-fissure-sealant failure when stressful occlusion is an additional factor.
8. As a useful modality in endodontic therapy, the argon laser coupled to an optic fiber is a suitable method for polymerizing various resins inside the root canals of teeth. Potts and Petrou believe there are multiple possibilities for developing new techniques for obturating canals utilizing the laser and resin materials. Compared with thermally or chemically hardening materials, light-polymerized resins should allow for an increased flexibility and improved control of the curing process.
9. The argon laser can be used for polymerization of the hybrid glass-ionomer materials with superior diametral tensile strength, with a marked reduction in curing time.
10. A detailed study by Powell, Morton and Whisenant on oral-safety parameters for teeth when using the argon laser showed that, at energy densities needed for proposed uses, no apparent damage to the pulp or enamel of human teeth would be expected.

New argon laser systems are capable of a multiple-operatory delivery system from a distant installation. Installed out of the treatment rooms, a fiber-optic network neatly delivers an easily-accessed handpiece installed in the dental unit alongside dental high-speed handpieces. It is similarly activated by the dental-unit foot control, and operates with a five-second beeper tone for as long as the foot control is depressed, depending on the desired length of cure and the size and number of areas needing polymerization. There is consistent blue, high-energy density, and the collimated optics ensure the proper spot size without the need to manipulate a fiber. There is no loss of energy from divergence down into large preparations.

Conclusion

David Garber states, "The units we have today are but the forerunners of new and exciting technology to follow in the wake of an ever-increasing demand. Clinicians who wish to be in the forefront of change will hasten to add the exciting models to their dental armamentarium–and if they use these units prudently, with judicious care in approved clinical scenarios, they will pave the way for ongoing change."

Slide Legend

Figures 1-3–Replacement of old, failing, amalgam restorations in Teeth 30 and 31. A glass-ionomer base was used (Caulk

Variglass) and Caulk A3.5 TPH.

Figures 4-5–Repair of a fracture on a 16-year-old case: a) diamond-bur roughening of the porcelain; b) gold etching; c) etch with gel for porcelain-metal (Cosmedent); d) then a Silane coupling agent bonding glaze is used; e) mask the gold coping Silux universal opaquer (3M); f) the lingual was built up with A3.5 TPH (Caulk); and g) a combination of Silux UO and YO shades (3M) for the facial bonded-resin veneer. All steps used with the Argon polymerization unit.

Figure 6–Filling in slight voids which developed and created food entrapment on implant bridge with Branemark esthetic copings. Bonded with laser and Silux (Caulk).

Figures 7-8–Porcelain-laminate veneers placed on upper central and lateral incisors and resin polymerized with the argon laser.

Figures 9-10–Bonding with Silux (Caulk) to fill in receded gingival areas on Teeth 3, 4 and 5. Hemisection on Tooth 3 of distobuccal root, and darkened root on endodontically treated tooth, lightened up with Silux universal opaquer (Caulk).

Figures 11-12–Repair of fractured incisal edge of Tooth 9 with 3M Silux YO shade.

Figure 1

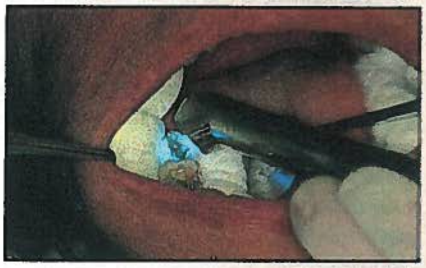

Figure 2

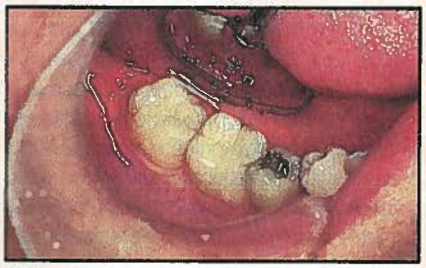

Figure 3

Figure 4

Figure 5

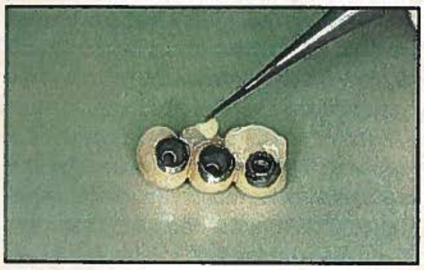

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

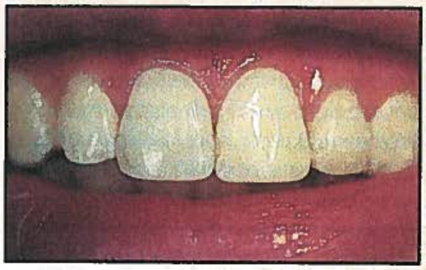

Figure 12

About the Author

Dr. Mark H. Docktor maintains a practice in esthetic and family dentistry in Hoboken, NJ. A 1973 graduate of New York University College of Dentistry, he was an assistant clinical professor from 1973-1976. He is a member of the Pankey Study Group, the American Academy of Dental Practice Administration, the American Society for Dental Aesthetics, the Academy of Laser Dentistry and the New Jersey Academy of Dental Practice Administration where he also served as president. For the past nine years, he was a member of the New Jersey Council on Dental Care Programs. He has given lectures nationwide and has been published in the *Journal of Esthetic Dentistry*. Dr. Docktor can be reached at 726 Washington St., Hoboken, NJ 07030, phone (201) 963-9000.