A Supplement to
PPAD
Practical Periodontics & Aesthetic Dentistry

VISUAL DENTISTRY

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A Clinical Comparison of a Plasma-Based Curing Source and Conventional Halogen Lamps

François Duret, DDS, DSO, PhD, MS, PhD, MD*

As composite resin products increasingly become the material of choice for posterior restorations, dental professionals are seeking methods to ease the placement protocols associated with them. Light curing is one aspect of the process that has essentially remained unchanged since the introduction of the halogen lamp. Clinicians now have the opportunity to significantly reduce the polymerization time of direct composite restorations. In less than 5 seconds, a restoration that demonstrates enhanced hardness and less shrinkage can be achieved through the utilization of a recently introduced plasma-based curing and whitening device (Apollo 95E, DMD, Westlake Village, CA).

Over several decades, innovative technologies and restorative materials have improved the field of dentistry. The time required to cure composite resin restorations, however, has remained relatively unchanged. For each increment of material to be cured, clinicians have been required to factor 40 to 60 seconds of operatory time into a direct composite procedure. Dental Medical Diagnostic Systems has introduced a novel system (Apollo 95E, DMD, Westlake Village, CA) to address the clinical concerns associated with curing this material.

The Apollo 95E—a laser-free unit—is based upon state-of-the-art plasma technology. Utilizing the high-energy output of plasma, this system cures a restoration in less than 5 seconds, saving the dentist valuable time that—over a month—can translate into 5 to 8 hours to perform other dental procedures. This decreased time of exposure to the plasma also reduces the polymerization shrinkage of the restoration. Further, the measurements of hardness achieve—and in some cases, exceed—those of restorations cured conventionally with a halogen lamp for approximately 40 seconds. Clinical studies have verified the results achieved when curing a restoration with a plasma-based unit (Apollo 95E) compared to curing with conventional halogen lamps.

Clinical Studies

Seven independent studies were conducted to examine the physical characteristics of eight different composite materials when cured with two halogen lamps and the Apollo 95E. All tests were performed in independent laboratories with no affiliation to the manufacturer. The studies determined that the plasma unit (Apollo 95E) is an acceptable alternative to conventional halogen lamps.

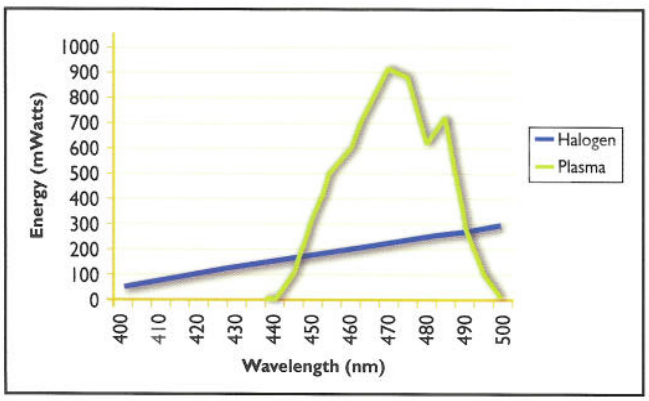

Figure 1. The Apollo 95E produces the greatest energy output in the preferred curing range of 460 nm to 480 nm.

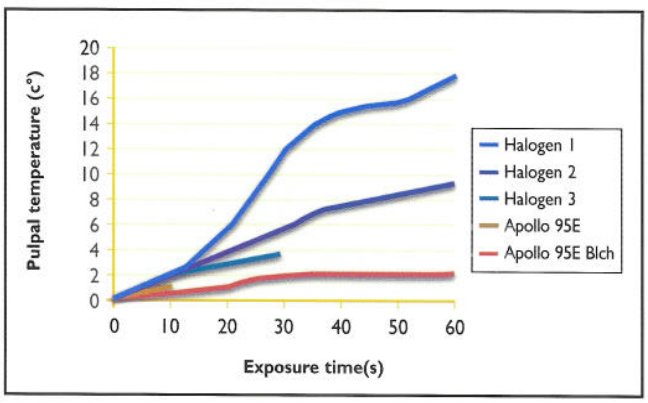

Figure 2. Utilization of the Apollo 95E facilitates a significantly lower pulpal temperature compared to conventional halogen lamps.

Spectral Analysis

Polymerization of a large number of composite resins occurs when the wavelength is at 460 nm to 480 nm. A conventional halogen lamp is more effective in a larger wavelength when a minimal amount of energy is outputted at the desired wavelength. The plasma-powered unit (Apollo 95E), however, demonstrates a peak energy output within this wavelength[1] (Figure 1). Although it exhibits the same level of power as the conventional halogen lamp, the Apollo 95E is 6 to 10 times more effective in the curing of dentition.[2]

Pulpal Temperature

Since curing a tooth with the Apollo 95E requires less exposure time, the increase in pulpal temperature is minimal compared to the increase experienced when a halogen lamp is utilized. When exposed to the lamp for a period of 60 seconds, a rise of 14°C was measured.[2] Utilizing the Apollo 95E for a significantly shorter period of time (4 seconds)—despite the output of twice as much energy—the rise in temperature observed was only 2.2°C (Figure 2). The Apollo 95E, although more efficient in producing energy, outputs less heat than the spectrum generated from a conventional halogen lamp.[3]

Degree of Polymerization

In order to determine the true degree of polymerization, DPC and DSC were utilized to measure the actual number of compounds that had yet to be polymerized following photopolymerization. It was observed that utilization of a halogen lamp for 60 seconds and the Apollo 95E for 5 seconds resulted in the same degree of photopolymerization.[4] In addition, a halogen lamp provided an unsatisfactory degree of polymerization in regular practice when compared to the utilization of the Apollo 95E for 3 seconds, or when set to the step-curing mode.[4]

Knoop Hardness

When evaluating the hardness of composite materials following curing with the Apollo 95E and a halogen lamp, two distinct categories were classified. The first group of composite resins achieved a greater level of hardness when cured for 3 seconds with the Apollo 95E than when cured for 40 seconds with a halogen lamp (Figure 3). Following analysis of the second group, the investigators found that the composite materials that required 5 seconds of curing time with the Apollo 95E demonstrated a level of hardness that was equal or superior to those cured with the halogen lamps for 40 seconds (Figure 4). Reactions within the polymers resulted in the differences in the period required to accomplish light curing. The researchers did not observe any samples in which the halogen lamp facilitated a greater level of hardness than that achieved with the Apollo 95E during a significantly reduced period of time.[5]

Composite Contraction

Contraction of a composite resin material occurs during slow polymerization when incompletely polymerized molecules penetrate other molecules, as demonstrated with the utilization of a halogen lamp. The plasma-based curing unit (Apollo 95E) reduces the incidence of contraction as a result of the rapid cure, which inhibits the restructuring of the composite material. In addition, it is possible that the rapid cure facilitates a decreased level of overall tension in the restoration.[6]

Resin-Tooth Interface

Bonding composite material to restore a tooth may result in the formation of a gap at the interface. It was discovered during the clinical analysis of the resin-tooth interface and

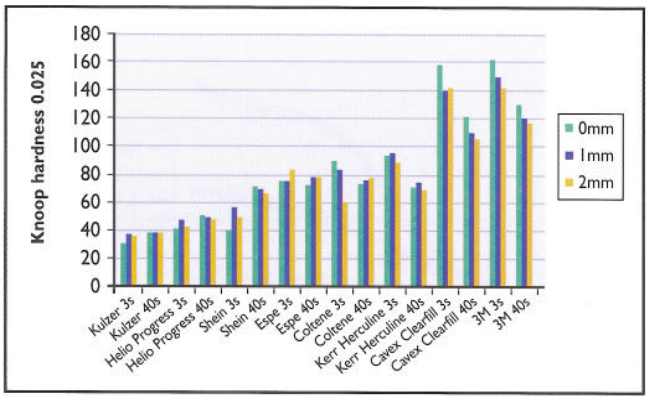

Figure 3. Graph of the comparison of the Knoop hardness following three seconds of curing utilizing the Apollo 95E versus 40 seconds with a halogen lamp.

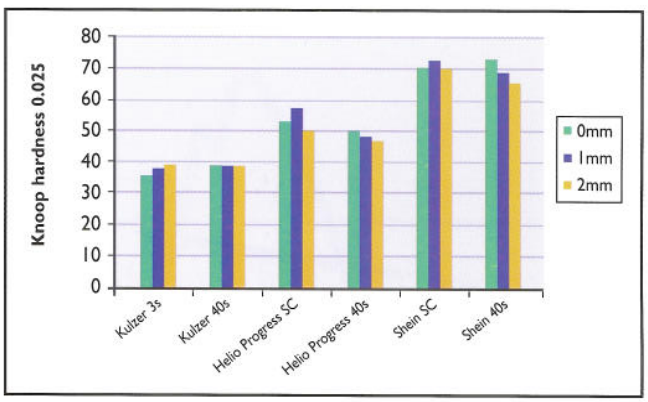

Figure 4. Graph of the comparison of the Knoop hardness following curing at SC (Step Cure) for 5 seconds with the Apollo 95E and for 40 seconds with a halogen lamp.

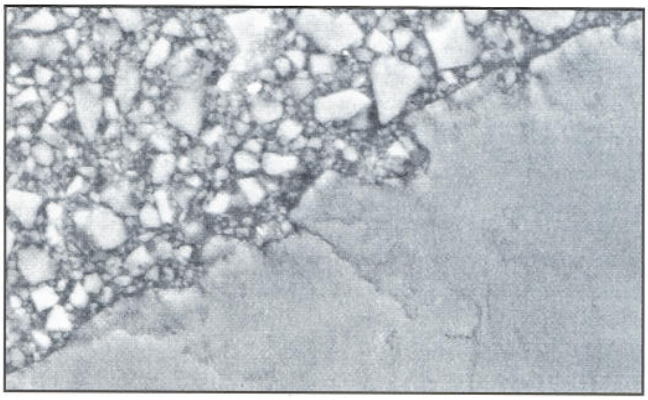

Figure 5. During clinical examination of the bond between the filling and tooth, an SEM is utilized to evaluate the efficiency achieved.

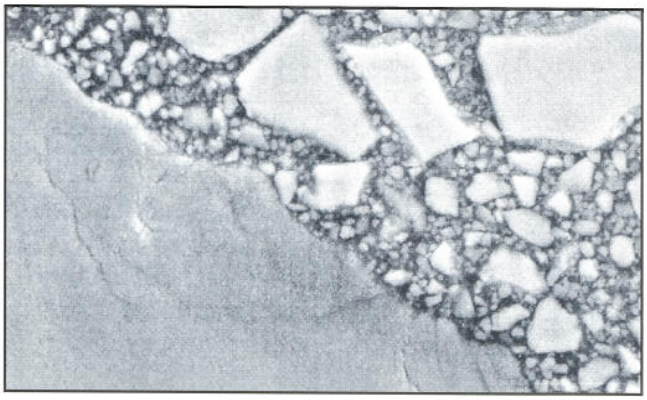

Figure 6. Clinical studies concluded that the interface between the filling and the tooth was smaller when utilizing the plasma-based lamp compared to curing with a halogen lamp.

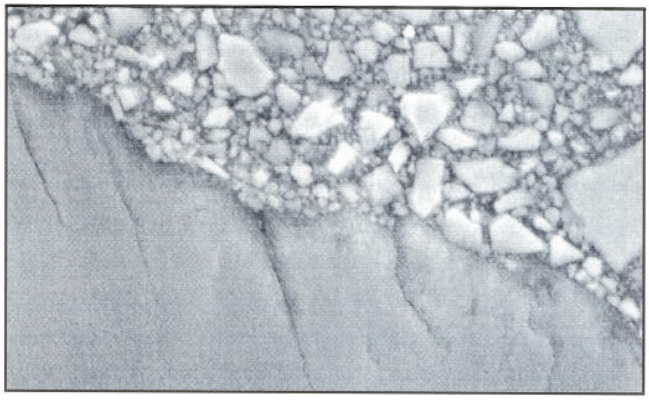

Figure 7. Clinical studies also found less contraction of the composite material when utilizing the plasma-based lamp in place of the halogen lamp.

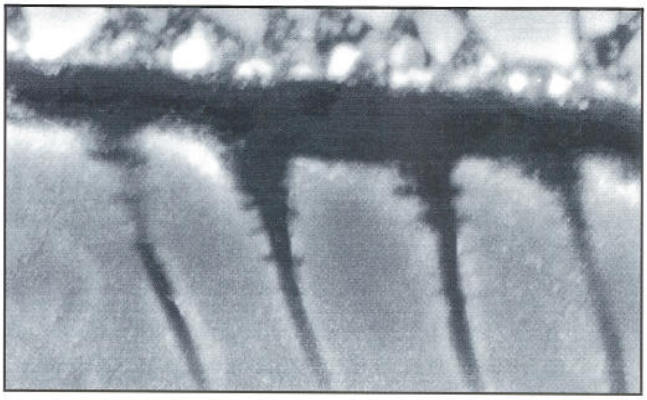

Figure 8. Since the composite material experiences less contraction, there is a measurable reduction of tension and global deformation when the plasma-based lamp is utilized.

the contraction of material between the tooth and composite that utilization of a plasma-based curing unit (Apollo 95E) has reduced this space. The gap between tooth and composite resin appeared nonexistent when bonding to enamel, and the interface surface appeared larger when bonding to dentin and polymerization occurred at a depth that exceeded 1.0 μm to 3.0 μm.[7]

Conclusion

Several independent studies have verified that the utilization of a plasma-based curing device (Apollo 95E) enables restorative materials to demonstrate higher bond strengths, reduced contraction, and increased hardness.[1-7] In addition, decreased pulpal temperatures directly result from light curing with the Apollo 95E when compared to results from a conventional halogen lamp. The Apollo 95E saves clinicians time during restorative procedures. Patients will appreciate the significantly decreased period of curing required to polymerize their restorations, and clinicians will be able to increase their productivity.

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