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## Recent Advances in Dental Bleaching with Laser and LEDs

Fatima Zanin, DDS, MS, PhD

**L**IGHT IS ONE OF THE MAIN FACTORS in maintaining life on our planet. Without light, nothing would exist. Our cells depend on light to modulate several functions. We do not survive healthily without being exposed to the sun for a few minutes daily, as its light is transformed into electrochemical energy to keep our metabolic, immune, and endocrine systems working properly. In addition to being essential to our biological balance, it is a marker of the body's natural cycle, because physiological changes are cyclic, and respond to environmental conditions of light/darkness.

Teaching light and its properties should be mandatory in dentistry courses, as in daily practice, professionals are faced with procedures that depend on this knowledge. Performing visual diagnoses of carious lesions, choosing colors for restorations and prostheses, photodynamic therapy, and photo bleachings, all rely on the knowledge of light and its interactions with tissues to optimize results.<sup>1</sup> Nowadays, the innovation that lasers and LEDs have brought to photo-assisted bleaching techniques is unquestioned, and it is considered to be the biggest breakthrough in aesthetic dentistry of the last 10 years.

Dental bleaching techniques evolved to perform the procedure using the most adequate light source, avoiding harmful effects such as morphological and chemical changes on the enamel, pulp, and dental structure. Several kinds of light sources to activate gels, such as incandescent lights, and high- and low-level lasers and LEDs, are described in the literature.<sup>2</sup> In dental bleaching, these lights promote interaction with the gel's photosensitive agent in two ways: through photothermal action by heating or by photochemical action, without heat.<sup>3</sup>

The big challenge is controlling the heat in the process, because temperature increase above 5.5°C can stimulate an inflammatory reaction, causing pain and pulpal degeneration. The advantage of in-office dental bleaching is that it allows the professional to keep all cycles of the procedure under control, customizing its application to the patient's dental needs.

The bleaching agent used in all techniques is a hydrogen peroxide ( $H_2O_2$ ) gel in different concentrations, which throughout the process will cross the dental enamel's intercrystalline spaces and act upon the organic portion of the darkened dentine. Through a photochemical mechanism, the electromagnetic energy of light interacts with the dye molecules present in the gel, electronically exciting the peroxide, which releases radicals that will induce the breakup of

the dental pigment molecules, reducing them to smaller and colorless ones.<sup>4</sup>

Dental bleaching has been associated with aesthetic procedures for the past decades, and many techniques have been developed to improve patient's comfort and decrease product application time. All techniques achieve the same results, because they use the same product, hydrogen peroxide; therefore, what has actually changed?

First, the bleaching gel was activated using a heat source with heated spatulas and high intensity lamps (Fotoflood, Plasma Arc, Halogen lamp). However, the high penetration of hydrogen peroxide, associated with the increase in temperature caused by these sources, resulted in increased dental sensitivity. Since then, techniques have tried to decrease heat generation. The big change in dental bleaching was the use of Argon Laser 488 nm and KTP laser (532 nm because interaction with gel became photochemical, instead of photothermal). Hand in hand with the use of more concentrated bleaching agents, the use of Argon laser as a bleaching activator produced better results by generating a minimum increase in temperature. KTP laser, which is an emission of green light, may cause photooxidation of the red quinone (tetracycline) molecule, making it colorless in addition to being absorbed in the Rhodamine B of the dye present in the bleaching gel. This molecule has its maximum absorption at 539 nm. Therefore, interaction between KTP laser energy and the dyes is a photochemical process that results in the production of radicals free of oxygen and not just of a photothermal nature.<sup>5</sup>

More recently, low-level LEDs came into use. The emission spectrum of blue LEDs is comparable to the emission of Argon laser, which presents light in a narrow band of the electromagnetic spectrum, presents selectivity and does not generate heat. In dental bleaching, blue LEDs are used if the bleaching agent has a specific dye in the orange band that may absorb the blue wavelength (~470 nm); therefore, it is imperative to establish the photochemical interaction between the inciting light and the color of the bleaching agent. The dyes added to bleaching gels should have their absorption peak the closest to the emission of the wavelength of the LEDs or laser, to reach the best possible photochemical interaction. Therefore, each wavelength interacts better with its complementary color of gel. The complementary color of green light is red; therefore, red gel is the one that best absorbs green light. Laser and LEDs interact with the orange gel and the infrared

diode interacts with the blue gel. This means that gels should have a dye that is the correct color to associate with hydrogen peroxide, to absorb the activating light and have a more efficient bleaching process without producing heat.<sup>6</sup> The parameters for laser or LEDs used in this process should not exceed 300 mW, because it activates the product and not the dental structure.

Now, the primary goal is to select a photonic emission able to perform dental bleaching using light, without gel. Is this possible?

Despite being quite efficient, chemical agents used in bleaching procedures generate some degree of roughness on the dental structure, which produces several consequences, including hypersensitivity of the exposed dentine. In general, hypersensitivity is the main reason why patients avoid the bleaching process.

The major breakthrough was a light with a wavelength (violet LEDs  $\lambda$ 405–410 nm) capable of performing dental bleaching without using bleaching gels. This does not mean that bleaching using light alone will substitute for all previously existing techniques, but that by using a wavelength in the violet band, we are able to bleach teeth. The emission band of violet light ( $\lambda$ 405–410 nm) coincides with the absorption peak of pigmented molecules, interacting selectively and breaking them up into smaller and colorless ones. The speed at which this light interacts with these molecules increases thousands of times, thus accelerating the breakup process. If fragments do not rearrange, the molecule stops absorbing and the colored center disappears. This process occurs at higher or lower intensity in almost all objects with pigmented molecules. Dental pigment molecules are photoreceptive, and, therefore, highly reactive to light. Their chains are long and with sequences of chemical bonds that dislocate electrons and are very susceptible to absorption of shorter wavelengths, such as the violet light.<sup>7</sup> The main advantage of the technique using direct violet light is the good aesthetic result obtained after just a few short sessions, preserving the enamel and dental structures.

This violet system can also be used in light-activated bleaching procedures using different concentrations of peroxide in bleaching agents, promoting excellent results. The effect of an experimental light-activated system with LED  $\lambda$ 405 nm was studied, and the results suggested that application of LED  $\lambda$ 405 nm in combination with bleaching gels was the best rated among tested light sources in both colorimetric and spectrophotometric analyses.<sup>8</sup>

As much as people are willing to improve their smiles, they do not want to feel pain or discomfort. Therefore, techniques that generate heat and post-treatment sensitivity

are rejected. For a long time, dental bleaching techniques that did not generate heat and did not make use of bleaching gels were just a dream. However, this dream has come true. Recent publications have shown that the violet LED system has changed the dental bleaching scenario for good. Its results are similar to those obtained with other techniques without the undesired effects of hydrogen peroxide and carbamide on the enamel, dentine, and restorations. It is a new option in dental bleaching, without producing either heat or sensitivity, and with comfort and safety for the patient, and professional.

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