The popularity of tooth whitening has increased with the advent of patient-applied, peroxide-based whitening agents, as well as increased media influence. Peroxides are considered effective and safe when used under professional supervision. Whitening methods include those prescribed by a dental professional for the patient’s at-home use, those applied by the dental professional in the office, a combination of both, or methods available over the counter (OTC). This article reviews the effect of contemporary whitening agents and illustrates the clinical application of three methods prescribed by dental professionals.

LEARNING OBJECTIVES:
This article presents the use of three different types of whitening agents for improved aesthetics. Upon reading this article, the reader should be able to:

• Distinguish the difference between professionally administered in-office and at-home tooth whitening results.

• Identify the effects of whitening agents on dental tissues.
New products and techniques that are less invasive to dental tissues are now being used to fulfill rising patient demands for aesthetics. The use of peroxide is now generally accepted as a safe and effective treatment for discolored teeth. When these discolorations compromise aesthetics, whitening may also be recommended before a clinician can perform an anterior bonded restoration (eg, porcelain veneers and direct bonding).

Carbamide peroxide has been used as a bleaching agent since 1989. Using a concentration of 10% carbamide peroxide, vital bleaching became a standard technique also known as “nightguard vital bleaching” (Figures 1 and 2). This technique (ie, at-home bleaching) allows the patient to use a tray whitening device at home, while the results and concentrations are monitored by a dental professional.

Other materials based on higher concentrations of hydrogen peroxide are also available for in-office power bleaching. More recently, polyethylene strips impregnated with 5.3% or 6.5% hydrogen peroxide (OTC concentration and dentist-prescribed concentration, respectively) were introduced (Crest Whitestrips, Procter & Gamble, Cincinnati, Ohio).

Effects of Whitening Agents on Hard Dental Tissues

Carbamide peroxide has been used for many years as an oral antiseptic before it was applied as a gel for home bleaching. Numerous carbamide peroxide-based home bleaching products have been introduced in the last 13 years for use with the nightguard bleaching technique. Carbamide peroxide is basically urea combined with hydrogen peroxide. Both products are released when carbamide peroxide breaks down in contact with saliva.

Initially, tooth bleaching with peroxides (both hydrogen peroxide and carbamide peroxide) was performed without a comprehensive understanding of the effects of the bleaching procedure on the structure and chemical composition of the enamel surface. More recently, studies on enamel bond strengths and structural effects of peroxide-based materials on enamel have been undertaken. Several studies have shown that hydrogen peroxide- and carbamide peroxide-based bleaching agents adversely affect the immediate bond strength of resins to enamel. Bond strengths to dentin treated with hydrogen peroxide for 60 minutes followed by 37% phosphoric acid for 60 seconds (and vice versa) were reported to be 0.0 MPa. Clinically, this decrease in bond strengths is relevant because whitening is often considered a preliminary treatment to improve the appearance of teeth prior to the application of a bonded restoration. Some authors have implied that the adverse effects of peroxides on bonding are caused by residual oxygen.
Figure 4: The resin spacer was added to the study model over tooth #8 to facilitate development of a reservoir within the whitening tray.

Figure 5: Two windows were cut in the areas corresponding to teeth #7(12) and #9(21) so the teeth would not be affected by the bleaching agent.

Bleaching agents may also cause alterations in the chemistry of hard dental tissues, inverting the ratio between organic and inorganic components and increasing solubility. In a recent energy dispersive spectrometry study, the effects of 30% hydrogen peroxide on enamel were found to differ from the effects induced by two 10% carbamide peroxide-based materials. While 30% hydrogen peroxide resulted in a significant reduction in the Ca:P ratio, neither a commercial 10% carbamide peroxide gel nor an aqueous solution of 10% carbamide peroxide resulted in significant changes in that ratio. Another study has shown that a 6-hour treatment of human enamel with 10% carbamide peroxide results in a significant loss of calcium compared with a water control, as measured with atomic absorption spectrophotometer. These alterations in the chemical composition of enamel may be transitory; their clinical relevance has not been determined.

Effects of Whitening Agents on Soft Tissues

The carcinogenic potential of whitening agents has raised some controversy. A court ruling resulted in a ban of peroxide-containing tooth whiteners in the United Kingdom. Oxidative stress can induce damage in oral epithelial cells, resulting in premalignant changes. The application of hydrogen peroxide and DMBA (9, 10-dimethyl-1,2-benzanthracene), a known carcinogenic analogous to those found in tobacco smoke, resulted in hyperkeratosis or carcinomas in the mucosa of hamsters after 22 weeks, depending on the concentration of hydrogen peroxide. A recent study, however, found that the chronic use of 35% carbamide peroxide did not result in alterations of the cell cycle in the oral mucosa of rats.

Figure 6: The whitening tray was tied in. Note the space allocated for the whitening reservoir on tooth #8.
Figure 7: Postoperative appearance following two weeks of whitening with 10% carbamide peroxide. Note the increased aesthetics and harmony.

Figure 8: Postoperative appearance demonstrates the presence of tetracycline staining.

Figure 9: Right lateral view demonstrates severe staining of the gingival regions in both the maxillary and mandibular dentition.

Figure 10: Left lateral appearance demonstrates discoloration throughout the entire buccal aspect.

Concerning the pulpal tissue, teeth that were scheduled to be extracted for orthodontic reasons were bleached with 10% carbamide peroxide for 4 hours or left untreated. No significant differences were found in the concentration of the enzyme heme oxygenase-1 (HO 1) in the pulp. This enzyme HO 1 is increased in cells subjected to oxidative stress.

Based on current information, it has been concluded that the use of dentist-monitored, at-home tooth whitening gels containing 10% carbamide peroxide carries no carcinogenic risk and does not cause irreversible damage to enamel. The safety of peroxides is corroborated by the inclusion of at-home vital whitening in the curriculum of the majority of dental schools in the United States.

At-Home Whitening

Nightguard vital bleaching using 10% carbamide peroxide gel is the most common whitening method applied by the patient while supervised by a dental professional (Figures 3 through 7). Studies have shown that whitening of vital teeth is very effective, durable, and safe. The literature has further indicated that peroxides diffuse quickly into dentin reaching the pulp chamber. While tooth sensitivity seems to be the most common adverse event with carbamide peroxide whitening, sensitivity subsides with the termination of treatment. Sensitivity is generally associated with previous history of sensitive teeth, increased frequency of application, or the utilization of higher concentrations of carbamide peroxide (eg, 20%) Although sensitivity may be a result of the potential of carbamide peroxide to penetrate the pulp chamber, the rate of penetration depends on the concentration and the commercial brand. Another factor that may affect sensitivity is the pH of the bleaching gel. For whiteners used with the at-home technique, the pH is within a range of 5.66 to 7.35. Sensitivity is also directly
related to the frequency of application of the gel - patients who change the whitening solution more than once a day report significantly more side effects than those who do not change the whitening solution. Potassium nitrate and fluoride have recently been added to the composition of certain whitening gels to prevent sensitivity during treatment. One clinical study demonstrated that potassium nitrate and fluoride added to 10% carbamide peroxide gel reduced sensitivity over a 2-week treatment period when compared to a 10% carbamide peroxide gel without those two components.

The use of reservoirs in the tray to allow for space to retain the bleaching gel is a controversial issue. Despite the recommendation of some manufacturers as a light-cured block-out resin or a self-adhesive strip, the use of spacers to create reservoirs for the bleaching gel does not seem to increase the success of home bleaching. The bleaching gel, however, remains active for longer periods when reservoirs are used.

**Power Bleaching**

In 1918, a high-intensity light was first used to induce a rapid increase in the temperature of hydrogen peroxide and thereby accelerate the whitening process. Lasers and high-intensity lights have been recommended by some authorities for in-office bleaching despite the disappointing results obtained in some studies. Power whitening procedures are currently performed in-office with concentrations of hydrogen peroxide in the range of 15% to 40%. (Figures 8 through 15) The most effective in-office whitening materials are those that include a chemical catalyst: LumaArch (LumaLite Inc., Spring Valley, CA; 35% HP, pH=5.5), Opalescence Xtra Boost (Ultradent Products, South Jordan, UT; 38% HP, pH=7.0); Zoom (Discus Dental, Culver City, CA; 25% HP, pH=7.9). When a chemical catalyst is added to the hydrogen peroxide immediately prior to bleaching, the oxygen is released rapidly, inducing the whitening effect. Both LumaArch and Zoom use light
sources exclusively for the bleaching treatment. For Opalescence Xtra Boost, the use of light is optional. Despite the recommendation, however, the application of light does not significantly affect the rate of decomposition of hydrogen peroxide for any of the three in-office materials, as the whitening results are very similar with and without irradiation with a light source. Heat accelerates the release of oxygen, but these power bleaching gels do not reach temperatures in the mouth high enough to significantly increase the decomposition rate of hydrogen peroxide. The primary advantage of the in-office power whitening technique compared to the at-home technique with a nightguard is that the former is not dependent upon the patient’s compliance and the results can be appreciated by the patient in the same session during which the procedure is completed. On the other hand, in-office procedures require extensive tissue isolation and/or a resin barrier to prevent the gel from irritating the soft tissues.

Hydrogen Peroxide Strips
An OTC, 5.3% hydrogen peroxide-coated polyethylene strip (Crest Whitestrips, Procter & Gamble) was recently introduced to the market. According to the manufacturer’s recommendation, the patient applies two strips per day for 30 minutes each. A similar 6.5% hydrogen peroxide-coated strip is available by prescription. Clinical studies comparing the whitening efficacy of 10% carbamide peroxide (which breaks down in 3.5% hydrogen peroxide) with the efficacy of the hydrogen peroxide-coated strips have demonstrated that the polyethylene strips may be an acceptable alternative to the nightguard method of at-home whitening (Figures 16 through 18).

Other Methods
An 18% carbamide peroxide (equivalent to 6.5% hydrogen peroxide) paint-on liquid is also available as an OTC agent (Colgate Simply White Clear Whitening Gel, Colgate-Palmolive, New York, NY). While clinical
studies have shown that this method can be effective, additional independent clinical studies are needed to confirm its long-term impact on this therapeutic category. Another OTC paint-on liquid is now available (Crest Night Effects, Procter & Gamble) as a 19% sodium percarbonate bleaching film.

**Conclusion**

A variety of whitening options are currently available for patients seeking to enhance the appearance of their smiles. When suggesting a professionally administered whitening option, clinicians must be aware of the variety of options currently available. Based on the patient’s existing condition and desired whitening effects, in-office, at-home, or OTC modalities can be used to safely and effectively address a variety of aesthetic concerns.

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**References**


**Note:** Only the first ten references have been listed to keep the size of this Portable Document Format (PDF) minimal. For a complete list of references, contact the publisher: *Practical Procedures & Aesthetic Dentistry* 2004; 16(3): 185-192