Whiter Teeth, Brighter Smiles

Special Supplementa Issue

September-October 1999

Whiter Teeth, Brighter Smiles

One of the questions asked most frequently in the dental office is, "How can I have whiter teeth?" It would seem that nothing could be more desirable than a beautiful, sparkling white smile, and there are many ways to achieve this. In some cases, it may be sufficient to "whiten" teeth by removing surface stains with a thorough prophylaxis. Most of the time, though, it is necessary to actually "bleach" by means of chemical oxidation. This article explores the history, chemistry, diagnosis, and treatment methods of professional tooth whitening.

CONTENTS

Barbara J. Wagner RDH, is a practicing dental hygienist in Atlanta, Georgia, who specializes in cosmetic dental imaging, halitosis therapy, and periodontal therapy. This supplement is based on more than a decade of clinical experience with tooth whitening procedures.

ADHA is the publisher and is solely responsible for the editorial content. Ultradent Products is the exclusive advertiser in this supplement.

Whiter Teeth, Brighter Smiles

ONE OF THE QUESTIONS ASKED MOST FREQUENTLY in the dental office is, "How can I have whiter teeth?" It would seem that nothing could be more desirable than a beautiful, sparkling white smile, and there are many ways to achieve this. In some cases, it may be sufficient to "whiten" teeth by removing surface stains with a thorough prophylaxis. Most of the time, though, it is necessary to actually "bleach" by means of chemical oxidation. This article explores the history, chemistry, diagnosis, and treatment methods of professional tooth whitening.

A thorough prophylaxis is a necessary first step in any tooth lightening process. Professional removal of surface staining reveals discolored fillings and the more resistant, deeply imbedded enamel and dentin stains. At that point, an evaluation and diagnosis can be made to determine appropriate treatment. Bleaching is a relatively noninvasive, inexpensive, low-maintenance way to change a smile dramatically.

Media emphasis on youth in a world population growing increasingly older increases the demand for ways to appear younger. Whitening teeth can be a relatively simple way to have a younger appearing smile. Very often, dental bleaching is the treatment of choice, making it the single most common esthetic dental treatment for adults.[1] Few dental treatments have been so well accepted. In fact, these treatments are so popular that they sparked the disturbing introduction and aggressive marketing of bleaching kits for home use without dental supervision. The obvious lesson here is that the market for these services is huge. Dentistry should be meeting these needs appropriately.

The success of any bleaching treatment is based on the ability of the bleaching agent to permeate tooth structure to the source of the discoloration, and remain there long enough to oxidize, releasing the molecules containing the stain. Only a trained clinician can properly diagnose the type of stain and prescribe the appropriate method and type of bleaching to accomplish the desired objective.

Nevertheless, over the counter (OTC) bleaching kits are now available to the untrained general public, although they may not be appropriate in some cases. The results of OTC bleaching can range from ineffective to harmful. In addition, the low cost of these kits is misleading; often there is an insufficient amount of the bleaching agent to do the job, and the provided appliance is crude and ineffective. It is the obligation of oral health care professionals to educate the public about the true economic value and safety of dentist-prescribed whitening treatments.

A thorough prophylaxis is a necessary first step in any tooth lightening process. Professional removal of surface staining reveals discolored fillings and the more resistant, deeply imbedded enamel and dentin stains.

There are two distinct phases in the bleaching process. The first phase is active bleaching, the second is maintenance. The first phase is the most intense. It involves processes to bring teeth as quickly as possible to their lightest, brightest shade. During the active bleaching phase, teeth will be slightly dehydrated, and consumption of dark-colored foods and drinks should be kept to a minimum, with colored beverages consumed through a straw. The second phase involves periodically applying bleaching materials to return to that bright shade obtained in the initial phase. Once the optimal tooth color has been attained, the teeth may darken slowly over a period of time; touch-up bleaching can be performed every six or

12 months to renew the whiteness. The color will usually return to the optimal shade readily. Bleaching was not originally designed to be performed on a daily basis, and many patients, in their quest for whiter and whiter teeth, will overbleach. This can result in overbleached teeth that appear chalky and translucent.

The success of any bleaching treatment is based on the ability of the bleaching agent to permeate tooth structure to the source of the discoloration, and remain there long enough to oxidize, releasing the molecules containing the stain.

New information, new materials, and new methods of treatment are constantly changing the picture of the diagnosis and implementation of bleaching treatments. Lasers are the most notable of the newest high-tech armamentarium. The use of lasers for bleaching can significantly reduce bleaching time and sensitivity. In addition, new information about tetracycline-stained teeth indicates that stains formerly considered resistant will eventually respond given persistence and an increased number of treatments.

Historical Perspective

Nonvital tooth bleaching using chloride of lime was used as early as 1848, and vital teeth were treated with oxalic acid as early as 1868. People have long been attempting to bleach teeth by applying various bleaching agents to the surfaces of vital teeth and the insides of nonvital teeth using oxalic acid. Other agents used were various forms of chlorine. Hydrogen peroxide was thought to be used for the first time in 1884,[1] and has since been established as the most effective bleaching agent because of its unique ability to penetrate the tooth structure.

The basic mechanism of bleaching, while not fully understood, involves oxidation, with the oxidizing agent coming in contact with the stain. The success of bleaching treatments relates directly to the type of stain, its location, and how deeply the bleach penetrates the enamel and dentin.

Lightening teeth by removing surface stains is relatively simple. The surface of the tooth is polished with pumice and may be etched to remove organic material; however, etching of teeth prior to bleaching is no longer necessary, as indicated by more recent studies. Because of its low molecular weight, hydrogen peroxide passes easily through enamel and dentin.

Since stains often penetrate deep into the enamel and dentin, the challenge has been to find ways to increase absorption and penetration of the peroxide agent. Ultraviolet light and electric current were tried, but in 1918, it was a Dr. Abbot,[1] who first used a high-intensity light to accelerate the bleaching process successfully. This heat-and-light peroxide-catalyst process is still being used today.

In spite of these creative breakthroughs, there was little public interest in lightening teeth till the late 1950s and early 1960s, when the full impact of the new tetracycline antibiotics on tooth color began to become apparent. In 1970, Cohen and Parkins reported promising results using bleaching techniques on tetracycline stains in young adults who had undergone long-term tetracycline treatment for cystic fibrosis.[2]

Quite by accident, in the late 1960s, William Klusmier, an orthodontist in Fort Smith, Arkansas, discovered a process that led to the home bleaching technique. Klusmier instructed one of his patients to use Glyoxide™ (Marion Merell Dow), which contains a 10% carbamide peroxide, in an orthodontic positioner in an effort to facilitate tissue healing. The patient returned with improved tissue health, and, after using the product for an extended time, his teeth were significantly lighter in color. Klusmier began using this technique to lighten teeth. When Proxygel™ (Reed and Carnrick, Jersey City, New Jersey) was introduced, he switched to this OTC 10% peroxide oral antiseptic. Compared to the very liquid consistency of Glyoxide™, the viscosity of Proxygel™ facilitated retention in the appliance. He then began to fabricate custom trays to be used with the gel for the sole purpose of bleaching. From 1970 to 1975, Klusmier presented his findings at several dental meetings, surprising and enlightening the oral health care community with his results.

In 1976, Ronald E. Goldstein, DDS, authored *Esthetics in Dentistry*, the first comprehensive book on dental esthetics. Within this book is a chapter that recommends the procedure as a viable technique for lightening teeth, not only those with tetracycline and fluoride staining, but also those with generalized yellow or gray staining due to age or genetics. Thus, the idea arose that "normal" teeth could be lightened. Goldstein's book *Change Your Smile*, first published in 1984, introduced the public to the possibilities of esthetic dentistry, including bleaching.

Van B. Haywood, DMD, and Harald Heymann, DDS, MEd, have been credited for the resurgence of tooth whitening since 1989, when their article, "Nightguard and Vital Bleaching," was published. In the same month, Omnii International (West Palm Beach, Florida), working with John Munro, a general dentist in Tennessee, developed and marketed White Brite™, the first commercially

available home-bleaching product to be sold through dental offices. This product inspired a rapid, uncontrolled proliferation of bleaching preparations, including some marketed directly to the public and intended for use without professional supervision. Some of these products were potentially harmful because of a high acid content, and others were not strong enough to be effective. There was no product standard being followed at this time.

In 1991, the U.S. Food and Drug Administration (FDA) issued a statement to manufacturers requiring the submission of appropriate documentation on safety prior to the marketing of these products.[3] This action was not meant to restrict the nightguard vital bleaching prescribed by dentists for dental patients, but rather to protect consumers against products that were potentially harmful and obtained easily OTC. The action was later rescinded when challenged by a dental manufacturer. The American Dental Association (ADA) subsequently developed guidelines for granting ADA acceptance.[1]

Nightguard vital bleaching techniques with products containing 10% to 20% carbamide peroxide are generally considered safe and effective. But since the technique is relatively new, there are no documented long-term studies of the effects of the materials on soft tissue and the effects of ingestion of the materials over long periods of time. Also, there are no published studies concerning the possible effects of these materials when used during pregnancy, especially the first trimester. Therefore, these techniques should always be performed with known products from reputable manufacturers, and only under professional supervision.

Van B. Haywood, DMD, and Harald Heymann, DDS, MEd, have been credited for the resurgence of tooth whitening since 1989, when their article, "Nightguard and Vital Bleaching," was published.

The Chemical Process

Oxidation is the chemical process by which organic materials are eventually converted to CO_2 and water. Wood burning in a fireplace is an example of the process of oxidation, and it is that same chemical process that bleaches teeth. The difference between wood burning and teeth bleaching is the rate of the oxidation process. Eventually, both processes will produce CO_2 and water. Since the process of bleaching teeth progresses much more slowly, it can be allowed to progress to the point where the chemical intermediates are lighter in color than the original, and then stopped.

Bleaching is an oxidation—a reduction process or a redox reaction. In a redox reaction, there is an oxidizing agent containing free radicals with unpaired electrons which it gives up readily, thus causing it to be reduced. These electrons are taken up by the reducing agent, the substance being bleached, causing it to become oxidized.

Hydrogen peroxide is an oxidizing agent that produces two free radicals, HO_2 and oxygen. The pH of this solution affects its strength. In its pure aqueous form, hydrogen peroxide is weakly acidic and produces more of the weaker oxygen free radical. This solution is buffered to a pH of 9.5 to 10.8 in order to promote the production of a higher percentage of the stronger HO_2 free radicals.

Organic materials can interfere with the bleaching reaction. The presence of decomposition catalysts and enzymes can change the reaction so that no free radicals are produced. It is therefore very important that teeth be dry and cleaned of debris before any bleaching agent is applied.

The solution must penetrate the surface of the teeth. In dental bleaching, the hydrogen peroxide diffuses through the organic matrix of the enamel and dentin, emitting its free radicals. These radicals react until simpler molecules that reflect less light are formed.

There is a point, called saturation, where the lightening ceases and the destruction of the tooth structure begins. As bleaching proceeds and the process of lightening slows down dramatically, the point of saturation has been reached. At this point, loss of enamel becomes rapid. Bleaching must be stopped at the saturation point to minimize tooth brittleness and increased porosity. Optimal bleaching achieves maximum whitening. Over-bleaching may damage the enamel and will not induce further lightening.

Diagnosis and Treatment Planning

There are many physical and psychological factors to examine when considering a candidate for bleaching. The most important factor is accurate diagnosis of the etiology of tooth discoloration; the next is the physical condition of the teeth. Compromised teeth may be extremely sensitive to the heat and chemicals necessary for the process.

The needs and expectations of the patient may be more difficult to assess, and also are critical to the success of the treatment. Patients must be willing to accept responsibility for their commitment to the treatment. Time must be allocated for the office and home treatments, and personal habits may need to be modified to achieve and maintain the desired goal of whiter teeth.

Types of Stains

There are three categories of stains: extrinsic, intrinsic, and age-related. Extrinsic stains are the most common and easiest to treat. They are superficial and can be caused by coffee, tea, highly colored food, tobacco use, or the patient's own metabolic processes. These stains are usually removed by thorough prophylaxis, with the exception of stains which may have penetrated into the surface of the enamel and dentin.

Intrinsic stains are discolorations permeating the structure of the tooth. They can occur during tooth development due to ingestion of certain drugs or excessive amounts of fluoride. For instance, tetracycline stains go beyond the enamel deep into the dentin of the tooth. Dark dental restorative materials also can cause deep staining. In rare cases, endogenous stains are associated with genetic conditions. These are stains that penetrate the structure of the tooth and are not removed by the prophylaxis. These stains will respond to bleaching depending on the color and intensity of the stain. Very intense stains and "banded" teeth are more resistant to bleaching.

Age-related staining is a combination of extrinsic stains that have remained long enough to penetrate, thinning enamel, and darkening dentin. These stains often respond well to bleaching.

The color or hue of the teeth and the stain are major factors in predicting the result of bleaching. Colors of teeth and stains will be in the yellow-brown range, shades of gray, or a combination of yellow and gray. Generally, bleaching easily removes yellow. Brown, gray, and gray-brown stains are usually more resistant to the process.

Gathering Information for the Diagnosis

It is important to be thorough about the diagnosis and treatment planning for bleaching. The information is necessary for legal purposes and to establish a baseline. The information also will give valuable clues to help predict the success of the proposed treatment. Tools for diagnosis are a visual exam, radiographs, a dental exam, a health history, and a behavioral history. Along with these findings, photographs and video images should be taken to document baseline color.

A current full series of radiographs will reveal defective restorations, periapical lesions, pulp size, nonvital teeth, and bone level. Carious lesions and leaking restorations can be sensitive to the bleaching process, as can teeth with large pulp chambers and areas of recession. Defective restorations should be replaced before bleaching to minimize potential sensitivity. However, if these restorations are on anterior teeth, it may be advisable to wait till bleaching is finished to ensure a good color match. Nonvital teeth may need special treatment, but will be exempt from possible heat damage to the pulp.

A thorough dental exam may include translumination and an intraoral video exam to reveal hidden caries and microcracks. Thickness and integrity of the enamel should be noted. Microcracks may allow the bleaching solution to penetrate deeply into the enamel, causing increased sensitivity or troublesome lighter areas along the cracks.

The visual examination will reveal the location, hue, and intensity of the stain along with clues as to whether it is extrinsic or intrinsic. Banding and lighter decalcified areas should be noted. The patient should be informed that the bands will not be removed by bleaching, and that the decalcified areas may be intensified, making them even lighter at first. With continued bleaching, the lighter areas blend in as surrounding tooth structure gets lighter.

A thorough medical and dental history will reveal diseases, medications, and genetic conditions that may have been factors in the etiology of the staining. The patient's demographic history can give clues to fluoride exposure. Fluoride exposure of more than four parts per million may cause fluorosis. For instance, children who routinely swallow fluoridated toothpaste in areas with fluoridated water may exhibit mottled enamel. The critical time of exposure for anterior teeth to fluorides and other drugs is from the third month of gestation through eight years of age. Sunlight seems to intensify the effects of staining, which is why labial surfaces of anterior teeth are more stained than posterior teeth and lingual surfaces. Most of the tetracycline staining occurs in the dentin; therefore, such stains require more and longer bleaching techniques that penetrate more deeply into the tooth structure. Factors to consider about drugs that stain include intensity and length of exposure, genetic susceptibility, and the point of development at which the excessive uptake occurred.

Minocycline, a member of the tetracycline family of drugs, can cause staining in *adult* teeth. This drug is often used for control of acne and other skin problems, and it also has been used in long-term treatment of rheumatoid arthritis. A new study by William Bowles, DDS, PhD, suggests that vitamin C may block minocycline staining of teeth and other tissues.[4] Patients in minocycline therapy should be strongly encouraged to take vitamin C.

It is important to know if there is a history of thermal sensitivity. This history does not necessarily rule out the possibility of bleaching, but it needs to be noted so that

The difference between wood burning and teeth bleaching is the rate of the oxidation process.

bleaching methods can be customized to reduce sensitivity. Exposed root surface at the cervical area of the tooth can be covered for protection during office bleaching treatments. In-office bleaching may be done with dual-cure, nonheat methods, or with a laser to reduce thermal exposure. Low-concentration home bleaching solutions can be used for shorter periods. Home trays can be modified to cut down on cervical exposure. Fluorides can be prescribed for home use or applied with a laser to reduce sensitivity.

A behavioral history will give information about habits that may undermine the success of the treatments. Habits like chewing ice, pencils, or other foreign objects contribute to microcracks and chips in the enamel. These habits also can undermine and dislodge existing restorations. These injuries may allow the peroxide to penetrate more deeply into the structure of the tooth, with the possibility of increasing sensitivity.

Patient expectations are another important factor in the bleaching process, although a patient's expectations often are overlooked. Communication is critically important. The patient needs to know what the professional expects based on the diagnosis. One of the best ways to communicate this is with computer imaging. Dark-stained areas on teeth, dark crowns, and stains of restorations are easy to see. The oral health care professional can explain that restorative materials will not whiten. Anterior restorations should be postponed till the bleaching process is completed, and the color has had two weeks to "rest" before the new restorations are placed, to ensure a good color match. The computer image can be controlled to give a realistic approximation of the outcome. It is important to be conservative in voicing your expectations, so that the patient gets a better result than expected.

It is important to be thorough about the diagnosis and treatment planning for bleaching. The information is necessary for legal purposes and to establish a baseline. The information also will give valuable clues to help predict the success of the proposed treatment.

Bleaching Pulpless Teeth

Bleaching one discolored tooth to match the rest of the dentition is, esthetically, the most difficult bleaching challenge. When bleaching vital teeth, there is sometimes a single pulpless tooth that is much darker than the rest, or of a completely different hue. This tooth will need special attention before it blends in with the others. However, lightening these teeth can often succeed as far as rendering them less conspicuous. Many conservative patients are pleased with this result even though it is not ideal. Usually, the most successful way to change the color is by restorative means.

There are two categories of pulpless tooth discoloration according to Goldstein and Feinman: incomplete root canal therapy and pulpal degeneration.[5] Examples of incomplete root canal therapy are necrotic debris or filling materials in the pulp chamber or endodontic sealer. For instance, sealers formulated with silver powder may cause stains that are next to impossible to bleach. While the exact mechanism that causes the discoloration of traumatized teeth is not known, it may be caused by the presence of iron sulfide. Grossman hypothesizes that blood in the pulp chamber undergoes hemolysis, thereby releasing hemoglobin. The iron in the hemoglobin then combines with hydrogen sulfide, produced by bacteria to form iron sulfide, which is a very dark pigment.[6]

The most common in-office bleaching agents are 30%–35% hydrogen peroxide and include Superoxyl™ (Sultan Chemists Inc., Englewood, New Jersey). and sodium perborate. This "walking bleach" technique has changed very little over the last 35 years. However, this procedure is not used very much today, because there are safer and more effective methods. One thing to consider with the "walking technique" is root resorption. Root resorption has more to do with too much heat or previous trauma than the agent used. It also has been strongly suggested that it may be caused by the bleach exiting where the enamel and cementum do not meet. Superoxyl™ is stronger and longer-lasting than sodium perborate, especially when used with heat, but may cause root resorption in younger patients. Sodium perborate is slower and denatures more quickly, but is less likely to cause root resorption.

There are two criteria used for case selection for bleaching nonvital teeth. First, the root canal obduration must be complete. To prevent an endodontic failure, the canal must be filled in three dimensions. Second, the remaining tooth structure must be intact.[5] The ideal nonvital tooth for bleaching is an unrestored crown or a crown with very minor restorations.

Vital Bleaching Methods

There are three methods used to bleach vital teeth: the in-office or "power bleach," the home or "matrix"

They may walk out of the office with teeth resembling the color of a man's new white shirt, only to see that color fade dramatically in the next few hours. Teeth are fairly dehydrated after the office treatment, and will darken as the saliva remineralizes the enamel.

method, and a combination of the two consisting of an in-office treatment followed by home bleaching. Currently, the most effective method is the combination.

In-Office "Power Bleach"

The in-office or "power bleach" is the way to achieve a strong color change, but use of this method alone is one of the most costly ways to bleach teeth. Costs range from $225 to $500 per arch, per visit. Patients who choose to have their bleaching done exclusively in the office should understand that while the treatment can give a strong burst of color, it also may fade quickly. They may walk out of the office with teeth resembling the color of a man's new white shirt, only to see that color fade dramatically in the next few hours. Teeth are fairly dehydrated after the office treatment, and will darken as the saliva remineralizes the enamel. It may take two or more additional in-office treatments to achieve a long-lasting change, and darker or banded teeth often require many more treatments.

Prior to Bleaching

As noted above, it is important that the teeth be properly prepared for the bleaching process, and that baseline tooth shade be noted and photos taken. For legal purposes, base shade is to be recorded whether with shade guide, photo, or both. A color check also should be made with the patient observing in the hand mirror. Patients tend to forget how dark their teeth were when the bleaching process was initiated. Also, the oral health care professional must monitor those patients who desire to continue bleaching to excess, even after their teeth have reached maximum whiteness. Those patients are like the people who are thin after dieting, but still see themselves as fat. In these cases, it is best to monitor the home bleaching products dispensed to these patients closely, to protect them from over-bleaching. Photographs may be taken to further document the case.

Prior to bleaching, a thorough prophylaxis should be performed and the teeth should be polished with an air polishing device such as the Prophy-jet 30™ (Dentsply, Milford, Delaware) or a similar device to remove thoroughly as much stain as possible. Normal prophylaxis—rubber cup/pumice polishing is not sufficient for this purpose. In addition, if the patient has recently had orthodontic brackets removed, care should be taken to ensure that all the bracket adhesives and cements are removed. The enamel surface should be free of any composite resin. Retained resin often will restain the teeth.

The Power Bleach

The one-and-one-half to two-hour office bleach appointment incorporates patient education along with the actual bleaching process. This appointment is made after the diagnosis, treatment plan, and prophylaxis have been completed. Photos may be taken at this appointment, and absolutely *must* be done before treatment is started. It is essential that the patient have a good understanding of what to expect at this appointment. The patient should be briefed about the process to reduce anxiety and ensure cooperation. Explanation of each of the steps in the process is important, making sure that the patient understands that all tissues will be protected.

The power bleaching process usually involves bleaching 10 teeth, the incisors, and the bicuspids. Normally, only one arch is bleached at each appointment. This is to provide a color reference point and to minimize sensitivity. The six phases of the power bleach appointment are isolation, application, acceleration, color adjustment, finishing, and follow up. In the author's office, all of these procedures are completed by the dental assistant; however, dental hygienists are just as appropriate to perform them. Dental assistants and dental hygienists use light sources routinely for curing pruposes. Safety and effectiveness of lasers have not been determined, since lasers were grandfathered into bleaching as an alternative light source equal to any other in-office light sources.[7]

Isolation

Much of the appointment time is spent preparing the teeth to be bleached. Isolating the tissue from the teeth is accomplished by means of a rubber dam or a rubber base material such as OpalDam (Ultradent® Products, South Jordan, Utah). Because of the caustic nature of the bleaching agent, it is extremely important to protect the patient with the most reliable means, not forgetting that underlying tissue must still be protected in case leakage occurs. Rubber- and resin-based materials that the practitioner paints onto the tissue can be used in place of the rubber dam when bleaching only one to a few teeth; however,

lip, cheek, and tongue retractors should be used with any isolation method. When using a rubber- or resin-based isolation barrier, the directions included with the product should be used, and all exposed gingiva adjacent to the teeth to be treated should be covered. For example, when using a rubber dam, Oraseal™ by Ultradent® can be applied to the gingiva of all teeth to be bleached. All accessible labial, buccal, lingual, and interproximal surfaces must be covered to protect the soft tissue. The rubber dam should be applied, and all teeth should be ligated with waxed dental floss. Unwaxed floss, acting as a wick, would absorb the hydrogen peroxide, possibly burning the tissue. Any excess Oraseal™ should be wiped away, after which the teeth should be pumiced with a rubber cup to remove any residual sealant or stain, and then rinsed thoroughly for 10 seconds.

No matter what the application, laser technology seems to be perceived as better and more effective than traditional therapies; however, it is necessary to understand lasers and how they work to know the truth.

Application

Severely stained teeth may be etched with 35% phosphoric acid for five to seven seconds to enhance the penetration of the bleaching solution; however, teeth should not be etched if the patient has a history of thermal sensitivity. A drape should be placed over the patient, covering all exposed skin and clothing. The oral health care professional should make sure that the patient understands that clothing and hands must remain covered. Gauze, saturated with cold water, should be placed on upper and lower lips under the rubber dam, on any metal clamps and on top of the dam when bleaching maxillary teeth. These gauze squares should be kept wet during the bleaching process to protect the lips from the heat of the bleaching light. *Anesthesia must not be used during bleaching.* Patient feedback is important should there be leakage, or if the heat gets too intense. The rinsed and dried teeth should be covered with a single layer of gauze that has been saturated with 35% hydrogen peroxide. The gauze should be cut long and wide enough to cover all the teeth to be bleached. When using a gel peroxide product, the gauze may not be needed.

Acceleration with bleaching light

The bleaching light should be positioned about 13" from the teeth. The Illuminator (Union Broach, York, Pennsylvania) is a good choice. The beam should be directed nearly perpendicular to the labial surfaces of the teeth to be bleached. A temperature of 116° to 140° is recommended. Starting with 115°, the temperature can increase gradually as long as there is no sensitivity. The temperature should be fixed about 10° below the temperature at which the patient indicates discomfort. The oral health care practitioner should watch for the patient who tries to "tough it out" because of the strong desire for whiter teeth. The gauze should be continually saturated with the bleaching agent, and the heat/light continued for 20 to 30 minutes. When the procedure is finished, the gauze should be removed and the teeth flushed generously with warm water before careful removal of the floss and the rubber dam.

Alternative acceleration with curing light

The largest light available, ideally 10"–12" in diameter, should be used. The curing light guide should be held close to gel (about 0.25" from surface), and each tooth exposed for 20–30 seconds. Multiple curing lights may be used to expedite the procedure. After four or five minutes, total, of light activation per tooth, the bleaching agent may be reapplied and the process repeated.

Uneven color adjustment

If the color is uneven after the teeth are rinsed and dried, extra bleach may be applied to the isolated darker areas before the rubber dam is removed. A fresh application of the 35% hydrogen peroxide may be put on the stained areas with a cotton swab, and allowed to remain on the teeth for five to 10 minutes. The mixture can then be reapplied, and the enamel disked immediately with a fine cuttle disk or a composite polishing disk. This mixture should be left on the enamel and bleach for five minutes with a bleaching light set 13" from the teeth to be bleached. The temperature should be set at 115° and worked up to a maximum of 160° as long as the patient is comfortable. The sequence of bleach applications may be repeated by disking and light application until the desired shade is reached. The solutions can be neutralized by swabbing with 5.25% sodium hypochlorite and then flushing with copious amounts of room-temperature water before removing the rubber dam and any excess Oraseal™.

Finishing

All bleached teeth may be polished using all three of the Shofu® (Menlo Park, California) aluminum oxide abrasive disks and wheels. These are contained in the Shofu® cosmetic contouring kit. After the last treatment, teeth

may be polished with the yellow wheel; followed by use of the white, impregnated Shofu® rotary polishing wheel to achieve a high enamel luster.

Follow-up

Patients who receive this treatment should be advised that their teeth are chalky white because they are dehydrated and that they will darken over the few days following treatment, but will ultimately be a shade lighter than when the treatment was started. They should also be told that there may be heightened sensitivity to cold for a few days, and that it helps to avoid cold drinks and foods. Two aspirin or other nonsteroidal antiinflammatory pain reliever may be taken every four hours, and daily application of 1.1% neutral sodium fluoride should be used to promote remineralization and reduce sensitivity. Daily application of potassium nitrate can be used in cases of extreme sensitivity.

Bleaching without heat

There also are products available that use a dual activation system of light (not heat) and chemical action. The light is the curing light, and the chemical action is set into motion by mixing a powder and a liquid to form a highly reactive gel or paste. These products are ideal for patients with histories of strong thermal sensitivity, or for younger patients. These products are mixed at the time of use to produce a gel or paste which may change color when the oxidation process is complete. This gel or paste can be applied as many as six times per visit. The curing light should be used for three to four minutes only. If there is tetracycline banding, the gel may be applied on the banded areas only, and cured with the light for three to four minutes. This step may be repeated as many as three times if needed, before the oral health care professional proceeds to bleach the entire tooth through chemical oxidation.

Lasers

The word "laser" is an acronym for light amplification by stimulated emission of radiation. No matter what the application, laser technology seems to be perceived as better and more effective than traditional therapies; however, it is necessary to understand lasers and how they work to know the truth. Someone once said that high technology is simply technology you haven't used yet. Lasers are high technology and most people haven't used them yet.

A laser is a beam of light focused to the point where it can cut almost anything. Lasers have been around since the early 1960s. They are electromagnetic radiation, *not* the ionizing kind like X rays. Lasers are produced by stimulating a specific lasing medium, contained within a tube, selectively letting it pass out of the tube as a collimated, energized beam. The type of medium in the tube determines the type of laser that will be produced. Each type of laser has its own specific wavelength, resulting in its own specific characteristics. When this energized beam is focused on the target tissue, it is transmitted, reflected, or absorbed. It is most effective when it is absorbed.

Three of the lasers currently being marketed for dental use are the carbon dioxide, argon, and Nd:YAG. The carbon dioxide and the Nd:YAG light beams fall in the invisible, infrared area of the electromagnetic spectrum and their wavelength is relatively long. The light beam of the argon laser falls in the visible area of the electromagnetic spectrum and is relatively short. The carbon-dioxide laser has a wavelength of 10.6 microns and is most effective on tissues with a high water content. It is highly absorbed by all biological tissues, regardless of their color, including enamel and dentin. The Nd:YAG has a wavelength of 1.06 microns and is most effective on pigmented tissues. It is transmitted by water as opposed to being absorbed. The argon laser has a wavelength of .51 microns and is more effectively absorbed by dark-pigmented tissues.

Two of these lasers, the carbon dioxide and the argon, have been promoted for bleaching teeth. Currently, only the argon laser is allowed for bleaching by the ADA, although there is no scientific evidence that they are any better than any other light source. Due to safety concerns, the CO_2 lasers are not recommended by the ADA for bleaching. Ronald E. Goldstein, DDS, feels that the argon laser combined with 35% hydrogen peroxide produces the least sensitivity of any office bleaching treatment.[17] Van B. Haywood, DDS, MEd, feels that the increased cost to the patient of laser bleaching is not justified because of the possible dangers to the tissue and results which are similar to the results of bleaching with a conventional heat or light source.[8] The laser is thought to provide ener-

Because of the intensity of the laser, the total tooth exposure time is less than with a bleaching light or a curing light, keeping the tooth cooler during the activation. Cooler teeth are less likely to be sensitive; with less sensitivity, more bleaching can be done at each appointment, and the take-home bleach may be instituted immediately.

gy to the hydrogen peroxide bleaching medium, to catalyze the reaction that provides oxygen free radicals for the oxidization of the stain. Safety and effectiveness have not been determined, since lasers were grandfathered into bleaching as an alternative light source equal to other in-office light sources.[7]

The techniques for utilizing these lasers vary. Some manufacturers use a combined argon and carbon dioxide technique, while others use the carbon dioxide alone, and still others use the argon alone. Those who promote the use of the argon laser believe that the dark stains of the tooth will actually absorb energy, because argon laser energy is more effectively absorbed by dark-pigmented tissues. Manufacturers who are using a combined argon and carbon dioxide technique start with the argon and then, as the tooth gets lighter, progress to the carbon dioxide laser since, as the tooth gets lighter, the pigmented tissues are no longer there to absorb the argon energy. It is important to remember that lasers, on their own, do not bleach teeth. The laser is merely the catalyst to the reaction of the hydrogen peroxide bleaching agent. The carbon dioxide laser is a cutting laser and must be applied by a dentist.

Although allergies are rare, treatment should be discontinued if there are soft-tissue reactions.

Laser Whitening

The laser bleaching process differs from the light-heat bleaching process in price, application, treatment time, and results. Costs for laser bleaching range from $250 to $750 per arch per treatment, making these treatments slightly more costly than the heat/light treatments. There are six phases for laser bleaching, just as there are six phases for heat/light bleaching. The isolation, uneven color adjustment, finishing, and follow-up phases for laser bleaching are the same as for the heat/light power bleach. With the laser, it is even more critical that the tissue be securely isolated because of the possibility of laser burns. The application phase and the activation phase are different for laser bleaching.

The application phase of laser bleaching is different from light-heat bleaching in several ways. One major difference is the peroxide product used. There are currently four companies offering products that may be used with lasers for bleaching teeth, Opalescence Xtra™ from Ultradent®, Quasar Bright™ from Interdent, Inc. (Los Angeles, California), Hyalite™ from Shofu®, and Powergel™ from Kreativ, Inc.® (Albany, New York). These products contain 35% hydrogen peroxide, but additional ingredients give them viscosity and color. One is premixed and the rest require mixing at the time of use. Unlike the liquid Superoxyl™, these gels are viscous enough to be applied directly and thickly on to the enamel where they adhere during the activation phase. Teeth may be etched, but some manufacturers recommend not etching. The laser-activated gels also may be available in higher strengths.

The activation phase is shorter for laser bleaching than heat or light curing procedures. The products made for use with lasers absorb light, allowing them to take advantage of the intensity of the laser's beam. If they are colored, the color changes with the application of the laser. Because of the intensity of the laser, the total tooth exposure time is less than with a bleaching light or a curing light, keeping the tooth cooler during the activation. Cooler teeth are less likely to be sensitive; with less sensitivity, more bleaching can be done at each appointment, and the take-home bleach may be instituted immediately. The gel should be evacuated form the tooth surface before rinsing to avoid splattering the peroxide. It is recommended that the home bleach be done as part of the laser-bleaching process.

The advantages of laser-bleaching techniques are a more uniform color, less sensitivity because of less heat, and less operator time needed for application. The disadvantages of using the laser are that the results are similar to the light-heat method, it is necessary to follow up with home matrix bleaching, and it is a lot more costly.

Matrix (Home) Bleaching

The home treatment is the most cost-effective method of whitening teeth. Prices may range from $150 to $200 per arch for the take-home bleaching matrix and enough carbonamide peroxide to last seven to 14 days. Additional product can be purchased when needed for touch ups at six- or 12-month intervals. Matrix bleaching may be used as the sole method of bleaching when yellow stain is being removed, or may be used in combination with the power bleach for more difficult-to-remove stains.

The initial matrix bleaching appointment is relatively short and may often be combined with another oral health care appointment. Impressions are taken of the arches to be bleached, and the patient is educated about how to use the appliance and the bleaching gel, and told what to expect. The patient may wait for the trays to be fabricated or return to pick them up at another time.

The matrix is fabricated of .020", #31720 coping material by Buffalo Manufacturing (Syosset, New York), or a .035 Opalescence Sof-tray™ by Ultradent® material, on a heat/vacuum tray-forming machine like Sta-Vac™ from

Buffalo Manufacturing. The thinner material causes minimum effects on occlusion, esthetics, and phonetics. Reservoirs are formed on the facial aspect of each tooth by adding light-cured composite spacers to the cast before fabricating the matrix. These reservoirs allow space for the highly viscous bleaching gels. The matrix should be trimmed to remove any tissue undercuts. The incisal papilla should not be covered, if possible. Only the matrix should cover the teeth.

The matrix may be worn all night or for one to two hours during the daytime, not to exceed 12 hours during any 24-hour period. The patient should be informed that the teeth might appear "splotchy" at first, due to the uneven coverage of the bleaching agent or the differences in tooth response, but that the color will even out. The patient should be seen at one- or two-week intervals during treatment to record tooth shade and decide if more bleaching is needed. Although allergies are rare, treatment should be discontinued if there are soft-tissue reactions. The first follow-up appointment should be one week after the initial appointment. The matrix should be brought to the first follow-up appointment so that it may be adjusted, if necessary. Many of the difficulties patients have with this kind of treatment are related to the appliance.

Once it has been determined that optimal lightening of the teeth has been obtained, treatment should be discontinued. A final shade assessment should be made and noted in the patient's record. The patient should be made to understand that matrix bleaching should be done only under the supervision of a dentist. Patients will need to return for more bleaching gel for annual or semiannual "touch ups".

Exposing teeth to bleaching solutions was once thought to cause them to be more susceptible to decay; however, the concern that the lowered pH of the home-bleaching gels would potentiate decay has proved unfounded.

Office/Home Combination Bleaching

Combination bleaching utilizing office and home bleaching techniques together produces the most effective results—the lightest color in the shortest time. Instead of fading, that burst of light color, produced by the office treatment, is preserved and enhanced by follow-up treatment with the home matrix bleaching system. Many times, one office treatment is sufficient for teeth with minimal staining. Manufacturers of laser-bleaching gels utilize home bleaching as part of the laser-bleaching process.

Fluoride

The use of topical fluorides to assist saliva in the remineralization process can be effective over the long term. Most adults will benefit from fluoride even if they do not bleach. The fluoride of choice is 1.1% neutral sodium, and it is easily applied in the home-bleaching matrix. A five-minute treatment after bleaching is recommended. There are three commercially available 5% potassium nitrate products from DenMat (Santa Maria, California), Ultradent, and Discus Dental (Culver City, California) which can be used in the whitening tray.

Safety Concerns

Over the years, there have been many concerns about the safety of bleaching procedures. Much research has been done regarding the effects of 35% hydrogen peroxide solutions in combination with heat and light on pulpal response, since the procedure has been used for many years. The results of these tests show that any damage to the pulp is either nonexistent or reversible after two months.[1] The effects on the pulp of the 10% carbamide peroxide, which is effectively 3% hydrogen peroxide, would be expected to be even less.[1] The FDA classifies 10% and 15% carbamide peroxide as "oral antiseptics"—"category I" materials which are generally recognized as safe. The ingredient carboxmethylenepolymer or Carbopol 940, developed by BF Goodrich (Cleveland, Ohio), is needed to thicken the mixture of peroxide to assure adherence and prolong the release of oxygen. A 10% solution of carbamide peroxide effectively contains 3% hydrogen peroxide and 7% urea. A 15% solution of carbamide peroxide contains 4.5% hydrogen peroxide and a 20% solution contains 7%. The hydrogen peroxide breaks down into water and oxygen. The urea breaks down into carbon dioxide and ammonia. Normal body processes easily handle all four products. Hydrogen peroxide occurs naturally in the body, and is scavenged by enzymes called peroxidases.

Exposing teeth to bleaching solutions was once thought to cause them to be more susceptible to decay; however, the concern that the lowered pH of the home-bleaching gels would potentiate decay has proved unfounded. Urea, which is a normal body component found in saliva, tends to raise salivary pH, keeping it a safe zone. The urea in the carbamide peroxide keeps the pH in the range of 5.3 to 7.2, causing no perceptible etch-

ing of the enamel. The caries process starts when the pH is below 5.5 for enamel, and 6.0 for dentin. Research indicates that carbamide peroxide in the range of 5.3 to 7.2 does not cause any perceptible etching of the teeth.[9, 10]

Hydrogen peroxide, the breakdown product of carbamide peroxide, does have the potential for causing soft-tissue breakdown which, in turn, can promote cancer. However, to date, there are no studies showing where the controlled use of carbamide peroxide in dental bleaching damaged soft tissue, resulting in cancer. Hydrogen peroxide is a known potentiator for the carcinogens such as those in cigarette smoke; therefore, patients are urged to refrain from smoking or using tobacco products during treatment.

Probably the biggest concern should be the possibility of cervical resorption that may be caused by improper bleaching technique of nonvital teeth. The safe technique for bleaching nonvital teeth can be found in the book *Complete Dental Bleaching*.[1]

Over-the-Counter Products

There are countless home care products available commercially that claim to whiten teeth. They range in price from under $10 to over $100. Some of these products are simply toothpaste containing abrasives for the removal of surface stain to "whiten" teeth. Some of these toothpaste products also have a peroxide ingredient that may actually "bleach" the teeth. For added credibility, some products use the words "dental," "dentistry" or "dental experts" in their marketing. Some of the products contain some sort of mouth tray. These mouth trays tend to concentrate the bleaching gel on the tissue more than on the teeth—even those that are custom-fitted by heating to mould them to the mouth. Most of the products do not list the percentage of peroxide they contain. Those products that have 10% or more peroxide usually do not provide enough of the gel to do the job.

Contraindications for Bleaching

The following contraindicate bleaching.

- Large pulps (which may precipitate sensitivity)
- Hypersensitivity
- Severe loss of enamel
- Extensive restorations (restorations are roughened)
- Pregnancy and nursing
- Peroxide allergy
- Latex allergy (use of rubber dam contraindicated)

Conclusion

Bleaching is the treatment of choice for many, but for some the only way to achieve the optimal esthetic result is to veneer or crown the teeth. It is still often advantageous to initiate smile enhancement with bleaching, as it is fairly noninvasive and relatively inexpensive. If a patient is happy with the results of a bleaching treatment, in spite of the fact that restorative work might give a more esthetic result, many times that patient will return for more extensive work later. In the meantime, he or she is pleased with his or her brighter, whiter smile.

Acknowledgments

This paper could never have been written without the help and encouragement of some very special people. For 11 years, Dr. Ronald Goldstein and Dr. David Garber have been my employers, my teachers, my mentors, and my inspiration. Their books and articles have been a rich source of material for this article. With over 15 years of experience, bleaching specialist Regina Baird is one of the world's most talented bleaching specialists. Her help has been invaluable. Special thanks also to Elizabeth Rubbo and Candace Paetzhold for their editing skills.

Notes

1. **Goldstein R, Garber D: *Complete Dental Bleaching*. Chicago, Quintessence, 1991, pp. 2, 12, 75, 94.**
2. **Garber D, Goldstein R, Goldstein C, Schwartz C: Dentist monitored bleaching: A combined approach. *The Bleaching Report* 1991;3(2):22-26.**
3. **Berry J: FDA says whiteners are drugs. *ADA News* 1991; 22(18):1,6,7.**
4. **Bowles WH: Protection against minocycline pigment formation by ascorbic acid (vitamin C). *Journal of Esthetic Dentistry* 1998;10(4):182-186.**
5. **Goldstein RE, Feinman RA: Bleaching of vital and non-vital teeth. In: Cohen S, Burns R (eds.): *Pathways of the Pulp,* 5th ed. St. Louis, Mosby, 1991, pp. 628-629.**
6. **Grossman LI: *Endodontic Practice*, 5th ed. Philadelphia, Lea and Febiger, 1960, p. 385.**
7. ***Journal of the American Dental Association*, October 1998, p. 129.**
8. **Blankenau R, Goldstein R, Haywood VB: The current status of vital tooth whitening techniques. *Compendium* 1999;20(8):781-794.**
9. **Haywood VB, Leach T, Heyman HO, et al.: Nightguard vital bleaching: Effects on enamel surface texture and diffusion. *Quintessence International* 1990;21:801-806.**
10. **Haywood VB, Houck V, Heyman HO: Nightguard vital bleaching: Effects of varying pH solutions on enamel surface texture and color change. *Quintessence International* 1991;22:755-782.**