TOOTH WHITENING

Indications and Outcomes of Nightguard Vital Bleaching

Van B. Haywood, DMD

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TABLE OF CONTENTS

PREFACE

This book is intended to provide clinicians and patients with valuable information about the benefits and safety of using nightguard vital bleaching, a dentist-prescribed home whitening treatment using a 10% carbamide peroxide solution applied in a custom-fitted tray. The following topics are addressed to help clinicians educate their patients and treat their esthetic needs using nightguard vital bleaching:

- Overview of the nightguard vital bleaching technique
- Importance of a proper examination
- Diagnosis of the discoloration
- Treatment of naturally yellow teeth
- Treatment of brown or white partial discolorations
- Extended treatment of nicotine and tetracycline stains
- Treatment options for single dark teeth
- Combined bleaching and restorative treatments
- Design and fabrication of a custom-fitted tray
- Treatment of sensitivity
- Caries control

The book serves as a resource the clinician can use to demonstrate case studies of patients who presented with one or more of these esthetic problems. In this way, posttreatment photographs provide concrete examples of both the efficacy and limitations of bleaching treatment for patients in similar clinical situations.

The technique of nightguard vital bleaching can be traced back to the late 1960s and an orthodontist in Fort Smith, Arkansas, named Dr Bill Klusmier. He was treating a patient with sustained trauma to the mouth who was in the retention phase of orthodontic treatment and periodically wore an orthodontic positioner (similar to a custom-fitted nightguard). In an effort to facilitate tissue healing, Dr Klusmier instructed his patient to place an over-the-counter oral antiseptic containing 10% carbamide peroxide into the orthodontic positioner at night. After treatment, not only did Dr Klusmier note a significant improvement in tissue health, he discovered that his patient's teeth were lighter in color. Thereafter he used this technique for bleaching discolored teeth, and from 1970 to 1975 he presented his findings at several dental meetings.

Although the technique was never published, it spread by word of mouth to many practitioners, including Dr David Freshwater, who presented the technique to the Coastal Dental Study Club in Jacksonville, North Carolina. In April 1988, while on the faculty of the Uni-

versity of North Carolina School of Dentistry, I was invited to present a continuing education course on esthetic dentistry and porcelain veneers to the Coastal Dental Study Club. Following the presentation, the participants were very appreciative of the information I had shared; however, one of the dentists surprised me with his comment: "We don't do things that complicated here. We just make a mouthguard and bleach the patient's teeth whiter at night." Several other participants also indicated that they had been using this mouthguard bleaching technique for a number of years with great success. Knowing that I was a researcher and faculty member at the UNC School of Dentistry, they encouraged me to do research into this area of esthetic dentistry and publish the results.

I shared my interest in this bleaching technique with Dr Harald Heymann, my colleague on the faculty at UNC School of Dentistry and a very well-respected dentist and lecturer in the area of esthetic dentistry. Together we concluded that this option offered some validity and resolved to research it further. Our first case involved a woman who had requested porcelain veneer treatment for the discoloration of her teeth. After the initial examination and consultation, we offered nightguard bleaching as our first choice of treatment. The patient agreed and was fitted with a custom mouthguard. When the patient returned weeks later for a follow-up visit, we were amazed at the results of whiter, natural-looking teeth. Dr Heymann and I then wrote the first article describing this new technique, which we termed *nightguard vital bleaching*. The article was published in the dental journal *Quintessence International* in March of 1989. Since then, we have continued to research the variations and applications of this treatment and publish the results of our findings.

Nightguard vital bleaching has proven to be a cost-effective, dramatic, simple, and safe treatment option for improving the smiles of patients, whether they are young children teased about the discoloration of their teeth, former smokers seeking to erase years of tobacco stains, or older patients embarrassed by the discoloration of their aging teeth. It is my hope that this book will help clinicians provide a whiter, brighter smile to even more patients, giving them new confidence and vitality for life.

ACKNOWLEDGMENTS

I would like to acknowledge and extend my heartfelt gratitude to the many persons who made this book possible:

My friend and colleague, Dr Harald Heymann, for his support and sharing of his expertise in this area of esthetic dentistry and in the writing of articles.

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Dr Ralph Leonard, for his collaboration in research projects, and for continuing our work at the University of North Carolina after I moved to the Medical College of Georgia.

My fellow dentists and researchers at the University of North Carolina School of Dentistry and the Medical College of Georgia School of Dentistry, who have given much professional advice and personal research to advance the study of tooth whitening.

Colleagues around the world who have befriended and supported me in my efforts to educate dentists about bleaching: Dr Dan Fischer, Dr Bruce Matis, Dr Yiming Li, Dr David Alexander, Dr Linda Greenwall, Dr Martin Kelleher, and Dan Perkins, as well as the Coastal Dental Study Club and others too numerous to name.

The leaders in the academies who invited me to participate in their quality programs: the American Academy of Esthetic Dentistry, the American Academy of Restorative Dentistry, the Academy of Operative Dentistry, Hinman Dental Society, and the American Academy of Cosmetic Dentistry, among many others. Their high standards challenged me to achieve excellence as a lecturer and clinician.

The companies who have supported my research, lectures, and the generation of patient photographic records, including Ultradent, Colgate Oral Pharmaceuticals, GlaxoSmithKline, Discus Dental, ArchTek, and many others.

My wife, Angie, who has been my best friend and partner in life. She has been a constant source of strength with her patient counsel, encouragement, and love throughout my career.

My children, Lisa, David, and Michael, who have been the greatest joy in my life. I am grateful for their willingness to be included in many of my professional lectures and to spend summers vacationing at dental meetings.

Most importantly, I thank God who made all this possible.

May your dental career be blessed as you bring brighter smiles to the faces of your patients.

DIAGNOSIS AND TREATMENT PLANNING FOR BLEACHING | 1

White teeth are commonly associated with health, beauty, success, and happiness. As a method of achieving whiter teeth, bleaching is a relatively low-cost, noninvasive, and highly effective esthetic dental treatment. Generally speaking, 9 out of 10 patients will have successful bleaching results. Treatment longevity usually ranges from 1 to 3 years, and some patients never require touch-ups or re-treatment. A certain percentage of patients will experience sensitivity, primarily of the tooth but also of the gingivae, during bleaching; however, all side effects cease upon termination of treatment. Nevertheless, there are many considerations to be made before bleaching treatment is initiated.

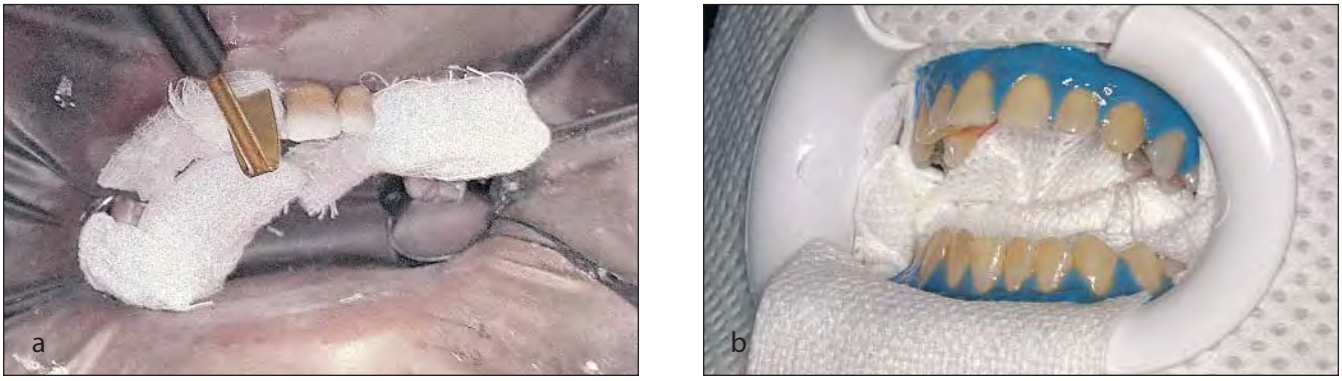
Bleaching Basics

Mechanism of bleaching

It is helpful to understand the way in which bleaching works when determining whether it can be used to treat different clinical scenarios. Initially, it was thought that the color change occurred either through the removal of the discoloration from the surface of the enamel or through a change in the enamel only. However, it has since been established that the tooth is a semipermeable membrane, and the ingredients for bleaching—carbamide peroxide and hydrogen peroxide—penetrate the enamel and dentin, reaching the pulp in 5 to 15 minutes. It is not only the enamel but mainly the dentin that changes color, and it does so as quickly next to the pulp chamber as it does next to the dentinoenamel junction. This explains why bleaching is effective in removing not only extrinsic stains but also intrinsic stains such as those caused by the ingestion of tetracycline, a drug that binds to the dentin.

Several other observations regarding the bleaching process have been made over the last 10 to 15 years. For example, it seems that each tooth has a maximum degree of whitening beyond which it will not progress, regardless of how long material is applied or what type of material is used. Also, each tooth has a maximum rate of change. There is an optimum bleaching formulation beyond which higher concentrations of the material or special activation techniques will not affect

FIG 1-1



In-office bleaching using 35% hydrogen peroxide and isolation with traditional rubber dam *(a)* and paint-on rubber dam *(b)*.

the speed of the color change. Lastly, it has been observed that once the tooth has reached its maximum color change during bleaching and the treatment is terminated, there is a small relapse in shade equivalent to about half of the difference between standard shade tabs. This phenomenon is believed to be related to a change in the optical qualities of the tooth that occurs during treatment as a result of oxygen release from the peroxide, which makes the tooth appear to be whiter. Once treatment is discontinued, this effect is lost and the teeth appear to darken slightly. When using tray bleaching, it is recommended that patients wait 2 weeks to allow the color to stabilize before undergoing restorative treatment to ensure a good match between the teeth and the restorative materials. This also allows the bond strengths between the enamel and composite materials to return to normal. Various explanations for this reduction in bond strength have been offered, but it appears that the oxygen remaining in the tooth from the bleaching process inhibits the setting of the composite material in the etched enamel. When in-office bleaching is used, the enamel is more greatly affected, and it seems that the bond strengths never again reach their pretreatment values.

Bleaching options

There are a number of different techniques for bleaching teeth. These are generally classified into one of three categories: in-office procedures, nightguard vital bleaching, or over-the-counter (OTC) products. Within each of these classes, there are variations in procedure; type and concentration of material; barrier type; and duration of treatment. All of these bleaching techniques can be used for vital or nonvital teeth; however, no bleaching treatment should be initiated without a comprehensive examination, including radiographic imaging. When considering which technique to choose, the clinician must consider the available literature on safety, efficacy, and cost.

In-office bleaching, or power bleaching, has been practiced since the late 1800s. In-office bleaching has been associated with heat or light activation and involves isolation of the teeth with either traditional rubber dam or the newer paint-on rubber dam (Fig 1-1). After proper isolation, a high concentration (originally 35%) of hydrogen peroxide is applied for a specific time period and possibly for a number of applications per visit. Research has indicated that light activation does

FIG 1-2

The most popular OTC whitening product is the bleaching strip, which contains low-concentration hydrogen peroxide on a tape-like matrix.

not affect the efficacy or final outcome of bleaching, but only creates the temporary illusion of additional whitening due to dehydration. In-office bleaching generally requires one to four complete treatments to obtain the maximum whiteness for the patient.

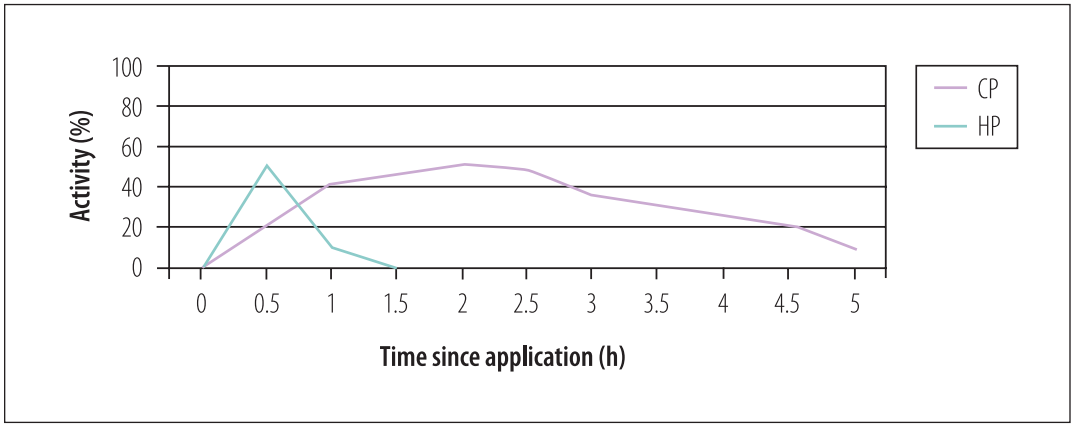
Nightguard vital bleaching, or tray bleaching, was officially introduced to the profession in 1989, but its origins can be traced back to 1968. It involves fabrication of a custom-fitted tray on a cast of the patient's teeth generated from an alginate impression. A low concentration of carbamide peroxide (originally 10%) is applied overnight for 2 to 6 weeks. Results can be obtained in as few as 3 days or as long as 6 weeks, but the average treatment time is 2 weeks. Of all the bleaching techniques, nightguard vital bleaching has been the subject of more research and has the longest history of safety in controlled research. Most importantly, the cost to the patient is very reasonable since the majority of the treatment can be done outside of the dental office.

OTC products offer several methods, from imitations of the clinical techniques involving trays, to strips, wraps, or paint-on products. The most notable product, introduced in 2002, is the whitening strip (Fig 1-2). This tape-like product contains low concentrations of hydrogen peroxide and is applied one or two times per day for 30 minutes to 1 hour. Other OTC products include toothpastes and chewing gums, but these only treat extrinsic stains and do not change the color of the tooth.

Materials used for bleaching

There are two basic materials used to whiten teeth: hydrogen peroxide and carbamide peroxide. The original in-office bleaching technique used a high concentration of hydrogen peroxide, usually 30% to 35%, which is capable of burning the skin or gingivae upon contact. Extreme caution should be used in handling this product, as it is a potent oxidizer and can harm the patient, the clinician, or the assistant. This danger is

FIG 1-3



Activity of hydrogen peroxide (HP) compared with carbamide peroxide (CP). The release of active ingredients from carbamide peroxide is much more gradual, which is why it is best applied in trays overnight.

one reason that in-office bleaching has never been universally accepted by clinicians, even though it has been in clinical practice for 125 years. Newer bleaching methods use hydrogen peroxide in much less caustic concentrations, generally in the 6% to 14% range.

The original nightguard vital bleaching technique used 10% carbamide peroxide in a custom-fitted tray that was worn overnight for 2 to 6 weeks. Carbamide peroxide is a combination of hydrogen peroxide and urea, and is also known as *urea peroxide*. A 10% carbamide peroxide solution is equivalent to 3.5% hydrogen peroxide and 6.5% urea. The hydrogen peroxide degrades to oxygen and water, while the urea becomes ammonia and carbon dioxide. The action of carbamide peroxide is very different from that of hydrogen peroxide, which influences both application time and side effects. Hydrogen peroxide is very unstable and remains active only for 30 to 60 minutes, with most of its activity occurring in the first 30 minutes after application. Consequently, all hydrogen peroxide products have application times of 30 to 60 minutes. When urea is added to hydrogen peroxide to make carbamide peroxide, it is much more stable. Carbamide peroxide releases about 50% of its active ingredients in the first 2 hours of application, then the remainder is released over the next 4 to 6 hours (Fig 1-3). Therefore, carbamide peroxide–containing bleaching materials are ideally applied in trays worn overnight. If the patient decides to use the product during the day, then 2 to 4 hours would be the minimum application time.

In addition to adding stability to the hydrogen peroxide, urea elevates the pH of the material in the tray and the saliva in the mouth to about 8 within 5 minutes of application and for several hours thereafter. This is very important in minimizing the effects of a low pH material such as hydrogen peroxide on the enamel, which affects the caries process. In order for enamel to demineralize in the caries process, the pH must be below 5.5; for dentin, the pH only needs to be below 6.8 for the caries process to begin. Hence, carbamide peroxide avoids the need to treat active caries prior to bleaching; the caries process is either stopped or inhibited during bleaching. The only time restorative procedures should be carried out prior to bleaching on teeth

affected by caries is when the decay is encroaching on the pulp or when the patient has tooth sensitivity.

There are different concentrations of hydrogen peroxide and carbamide peroxide used in tray and strip bleaching. Generally, the higher the concentration, the greater the chance of tooth or gingival sensitivity. Ultimately, the concentration does not affect the outcome, since the final color of the tooth is determined by the genetics of the tooth, not the product used in bleaching. Higher concentrations may work slightly faster, but the difference is not directly proportional (eg, a 20% solution is not twice as fast as a 10% solution). With a more highly concentrated material, there does seem to be a greater illusion of whitening, followed by a more noticeable rebound to the actual color of the tooth after termination of bleaching. This can sometimes cause frustration and disappointment in patients who want extremely white teeth but whose teeth are genetically unable to maintain such a level of whiteness. It is important to note that the majority of research on safety and efficacy has only been done on 10% carbamide peroxide. Although there is some research on 15% products, defense of safety in legal terms is best supported with data for 10% carbamide peroxide. All products that have obtained the American Dental Association's seal of approval use 10% carbamide peroxide.

Safety of carbamide peroxide

Carbamide peroxide originally appeared as an oral antiseptic in the 1960s. The most familiar form that is still on the market is Gly-Oxide (GlaxoSmithKline), which is used for intraoral wound debridement for canker sores or after oral surgery. In addition, the original Proxigel (Reed & Carnrick Pharmaceuticals) is now available in a thicker version (GlaxoSmithKline). Earlier, in the late 1800s, low concentrations of hydrogen peroxide were used as rinses to prevent tooth decay in children with pitted teeth. Since the early 1960s, 10% carbamide peroxide has been used in newborn infants who have candidiasis or throat infections. Ten drops are applied to the throat every 2 hours for 7 to 10 days, considerably reducing the duration of the infection. In the 1970s, research was performed on use of the material in orthodontic patients to reduce the incidence of white spot lesions following debanding. Later carbamide peroxide was studied as an oral hygiene agent for elderly patients in nursing homes. For all of these applications, there were no reported side effects or dangers to the patients, with the exception of a laxative effect in the elderly population due to the glycerine base. More recently, research has determined that the liver produces about 648 mg of peroxide per day, while the amount of bleaching material in two trays is only 3.5 mg. Saliva contains peroxidases that break down naturally occurring hydrogen peroxide at a rate of 29 mg of peroxide in 1 minute. Based on the minimal amount used in a tray, the previous history of oral use, and the body's mechanisms for clearance, little concern exists about the effects of swallowing the material. Long-term follow-up of patients who bleached their teeth using carbamide peroxide shows no subsequent need for root canal therapy, no internal or external resorption, no sensitivity outside normal limits, and no detrimental effects on tooth structure.[1–5]

Concerns are often expressed regarding free radical formation in the breakdown of hydrogen peroxide and its effects on soft tissue. However, the American Dental Association, World Health Organization, and the US Food and Drug Administration have all stated that low concentrations of hydrogen peroxide do not cause cancer.[6–9] After more than 15 years of clinical use of tray bleaching and with millions of patients having performed bleaching treatment on their teeth, there has been no increase in the incidence of tongue cancer or other oral manifestations.[10] Researchers have repeated the studies that initially raised concerns but found no evidence to support the earlier findings.[11] Moreover, in one of the most significant documents

recently released on the subject, the European Commission and the Scientific Committee on Consumer Products[12] reviewed all of the safety literature on bleaching, focusing on data compiled since the introduction of tray bleaching. The report concluded that bleaching with low concentrations of peroxide is safe. However, they did not support the use of OTC products due to the lack of a proper examination by a clinician. At the time of the review, the maximum allowable concentration was 6% hydrogen peroxide, which is equivalent to approximately 17% carbamide peroxide. Thus, as long as the material is provided in a safe delivery mode, such as a tray that can be altered to accommodate individual patient needs, and in a low concentration that the body can handle, it can be considered safe for use.

There have been many articles written evaluating the effects of bleaching with carbamide peroxide on the enamel, and some evaluating its effect on dentin.[13–18] The effects on the enamel are considered within normal limits with a neutral pH solution. The hardness of the enamel is not affected by carbamide peroxide bleaching, nor is the subsurface hardness. Due to the permeability of the tooth and the small size of the urea peroxide molecules, the bleaching will occur under existing restorations and throughout the tooth, even when only placed in one area. Although every procedure has some effect on the enamel, including brushing and oral prophylaxis, the effect of bleaching is minimal. One study indicated that 6 hours of bleaching has the same effect on the enamel as 2.5 minutes of contact with a cola beverage.[19,20] Many studies show the detrimental effects of soda beverages, fruit juices such as apple and orange, white wine, and yogurt on enamel. Most of these foods and beverages have the same pH as stomach acid, which is about 2.6. Patients who are comfortable with the ingestion of these materials should also be comfortable with bleaching using a 10% carbamide peroxide material.

Bleaching Examination

The most essential component of bleaching treatment is proper examination by the clinician to evaluate the prognosis. It is a good idea to clean the teeth prior to examination to remove any superficial extrinsic stains and determine the baseline color of the teeth.

Bleaching is the treatment of choice when teeth have good form and function but are discolored in some manner. Patients may be born with genetic tooth discoloration, they may acquire discoloration from habits such as smoking, or it may occur as a natural result of the aging process. There can also be partial tooth discolorations, such as brown or white spots resulting from high fluoride ingestion. The antibiotic tetracycline can cause mild to severe discolorations, mainly when ingested during tooth formation, but it also may occur in fully formed adult teeth. Some patients present with a single dark tooth resulting from trauma and/or endodontic therapy. Bleaching is an option, whether such traumatized teeth are vital or nonvital (see chapter 5).

During the examination, the clinician should look for moderate to severe tetracycline staining, especially dark blue or gray discolorations located at the cervical area, as well as white spots on the teeth. Such tetracycline stains are resistant to bleaching treatment, and white spots do not change color with bleaching, although they will become less noticeable as the background tooth color lightens.

Overall, the following factors would lead to a guarded prognosis for bleaching:

- History or presence of sensitive teeth
- Extremely dark gingival third of tooth visible during a smile
- Extensive white spots that are very visible
- Temporomandibular joint dysfunction or bruxism
- Translucent teeth or exposed root surfaces

FIG 1-4

(a) A single dark tooth may be the sign of a necrotic pulp. *(b)* Because this pathology can occur in the absence of other clinical signs, such as pain, swelling, and tooth mobility, a radiograph should be taken prior to bleaching to determine if endodontic treatment is required.

The contraindications for at-home whitening are as follows:

- Unrealistic expectations
- Unwilling or unable to comply with at-home treatment
- Excessive existing restorations not requiring replacement
- Inability to tolerate the taste of the product
- Pregnancy or lactation

Following are some special considerations for the bleaching examination.

Discolorations related to pathology

When discolorations are caused by pathology, bleaching will mask but not resolve the problem. Discoloration could be a sign of an abscessed or nonvital tooth. Often teeth abscess over a long period of time after trauma with no pain or fistulae, and the first indication of a problem is the discoloration in the tooth (Fig 1-4). Endodontic therapy may be required; bleaching would remove the discoloration, but the abscess would remain and ultimately may cause loss of the tooth due to root resorption from the long-standing infection.

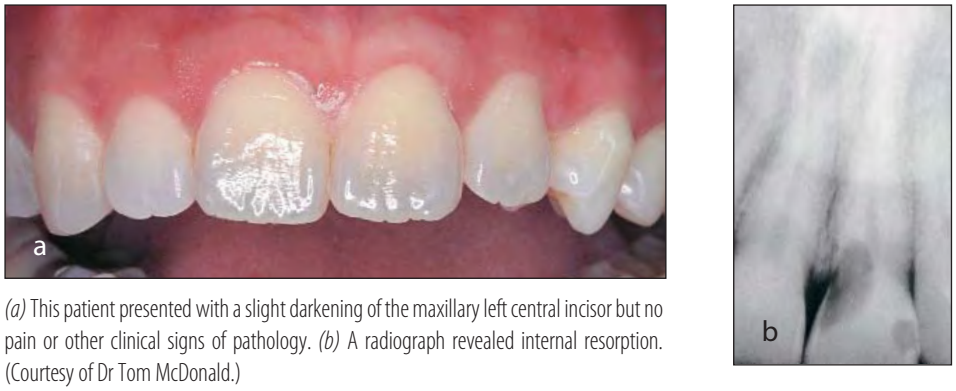
Interproximal decay that remains for a long period of time without restoration will typically turn black from the staining of foodstuffs (Fig 1-5). This problem requires restorative treatment, not bleaching. Occasionally bleaching may be indicated in addition to the proximal restorations, but the primary cause of the discoloration is the long-standing decay. Again, pain may not be present as an indicator of a problem.

The most insidious yet least common cause of discoloration is internal or external resorption. This condi-

FIG 1-5

(a and b) The tooth is dark as a result of decay. *(c and d)* A restoration has been placed to resolve the problem.

FIG 1-6



(a) This patient presented with a slight darkening of the maxillary left central incisor but no pain or other clinical signs of pathology. *(b)* A radiograph revealed internal resorption. (Courtesy of Dr Tom McDonald.)

tion, which is characterized by the loss of tooth substance, may occur after trauma. The first indication of internal or external resorption is often the slight discoloration of the tooth (Fig 1-6).

All of the aforementioned conditions can be identified during an examination that includes radiographic imaging. Prior to planning any treatment for tooth discoloration, a radiograph should be taken of the ante-

FIG 1-7

(a) During the examination, the gray appearance of the lateral incisors is noted. *(b)* After bleaching, the central incisors are whiter, but the lateral incisors still look dark because of their translucency.

rior teeth and any single discolored tooth regardless of location. A radiograph of the anterior teeth can be obtained using bitewing film rotated to a vertical orientation. This size and orientation of film should reveal the apices of the four incisors. A radiograph also affords the dentist the opportunity to discover dissimilar pulp sizes that may cause one tooth to lighten faster than another, supernumerary teeth that may be a contraindication for endodontic therapy, or other anomalies. Such an examination would also reveal calcific metamorphosis, a situation in which, after trauma, the pulp chamber is completely obliterated. This condition is very difficult for endodontic therapy, but an excellent opportunity for bleaching.

Translucency

Some teeth are discolored primarily in the incisal region. In some cases, this discoloration could be a result of the translucency of the teeth. When teeth are bleached, often they become more opaque; however, occasionally they will become more translucent. If the teeth look dark before bleaching as a result of translucency and become more translucent during bleaching, they will look even darker following bleaching due to the contrast with the adjacent teeth (Fig 1-7). A simple way to diagnose this situation is to place a white-gloved finger behind the incisal discoloration prior to bleaching. If the tooth turns white, then it is translucent; if the discoloration remains the same, then it is internal to the tooth, and the patient is a good candidate for bleaching. Patients with translucent teeth should be informed of the possibility of the teeth becoming more translucent with bleaching. Should this occur, additional restorative treatments may be required to obtain a uniform smile. Treatment options in such cases could range from bonding composite material on the lingual surface to block the translucency (if the occlusal situation allows for it) to composite or porcelain veneers. The patient needs to be informed of all possibilities in addition to bleaching prior to initiating bleaching treatment.

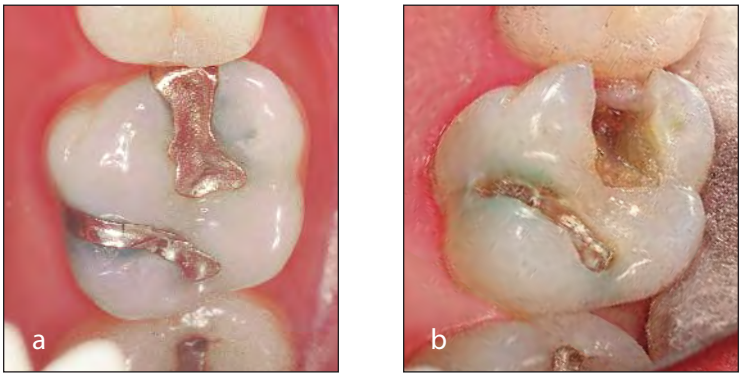
FIG 1-8

(a) This patient appears to be a good candidate for bleaching since yellow and brown stains are generally most responsive to this approach.

(b) However, the gray discoloration caused by the lingual amalgam may become noticeable from the facial aspect if the tooth becomes more translucent during bleaching. *(c)* The amalgam restoration is removed, and a light-colored composite restoration is placed prior to bleaching. *(d)* After bleaching, the composite restoration matches the bleached tooth color.

(e) The facial view reveals the successful bleaching and restorative results.

FIG 1-9



(a) Following extended bleaching, the tooth surface around an amalgam restoration has turned green. *(b)* The green hue remains at the dentinoenamel junction after removal of the amalgam restoration.

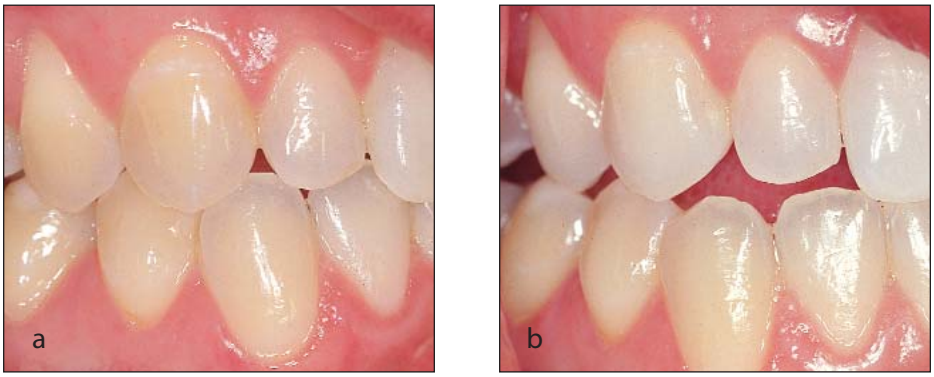
Existing amalgam restorations

Another possible cause for discoloration of the anterior teeth is lingual amalgam restorations. If the tooth becomes more translucent, the lingual amalgam is visible from the facial aspect and requires replacement. Generally, composite restorations in a matching shade are placed after bleaching. However, for lingual restorations, it may be more appropriate to replace the amalgam with a very light composite restoration, then bleach the teeth (Fig 1-8). Some of the very old amalgam materials create a gray hue around the restoration that may actually become green during extended bleaching, much like copper sulfate (Fig 1-9). If this type of amalgam restoration is in place, it is better to replace the amalgam prior to bleaching than risk the green discoloration being visible after bleaching. Unfortunately, however, the gray hue often cannot be completely removed from the tooth.

Tetracycline staining of adult teeth

Typically, dentists and pharmacists think of tetracycline as only staining permanent teeth during the early years of tooth formation. However, there have been several reports in the literature of adult teeth stained by tetracycline. The tetracycline is deposited in the secondary dentin and also secreted in the saliva and absorbed externally. Tetracycline stains both teeth and bone. Minocycline, a type of tetracycline, is the number one prescribed drug for the treatment of acne. However, over time it will also cause a gray discoloration of the teeth. It is important to inquire whether minocycline is being taken, and if so how long, on the health history questionnaire. Because there is not another medication for acne that is as effective or safe as minocycline, discontinuing use of the drug is not usually a viable option. Therefore, the best course of action is simply to advise these patients that periodic

FIG 1-10



(a) This patient's canines are significantly darker than the adjacent teeth. *(b)* Bleaching lightens all the teeth and brings the canines within a half shade of the adjacent teeth, which is the normal color variation.

touch-up bleaching may be required. More on tetracycline staining and treatment can be found in chapter 4.

Need for additional treatment

There are many situations in which it is appropriate to combine bleaching with other esthetic treatments, such as recontouring, microabrasion, composite bonding, veneers, or crowns. In conjunction with the bleaching examination, the dental team can perform a smile analysis and inform patients of other treatment options that may help them reach their objective of a beautiful smile. Additional treatment also could include periodontal surgery to cover a root, lengthen a crown, or expose a tooth affected by passive eruption; or orthodontic treatment to address crowded or crooked teeth.

Dark canines

Sometimes canines can be dramatically darker than the surrounding teeth. In these instances, the canines can be lightened to better blend with the adjacent teeth, either by treating the canines alone, or by bleaching all of the teeth until the others have reached their maximum lightening, then placing the bleaching material in the canine mold alone until it more closely matches the color of the adjacent teeth (Fig 1-10).

Existing restorations

During the examination, the clinician should identify all existing restorations and inform the patient that these will not change color with bleaching (Fig 1-11). This includes composite restorations as well as crowns or veneers. Often one of the deterrents to bleaching is the number of existing restorations and the cost of replacing them. Moreover, there also may be a risk involved in the replacement of a successful restoration when the situation is precarious, such as fracture of an endodontically treated tooth during removal of a post and crown. However, in some cases restorations may not require replacement, as some composite restorations are subject to a metamerism effect and will blend

FIG 1-11

(a) Prior to bleaching treatment, all restorations in the esthetic zone should be identified. The clinician must explain to the patient that these restorations will not change color with bleaching. *(b)* The teeth have responded well to bleaching, but the discolored composite restorations are now more noticeable.

FIG 1-12

(a) The patient was informed that the composite restoration on the mesial surface of the right lateral incisor might require replacement after bleaching. *(b)* However, even after a dramatic color change, the composite restoration blends in with the rest of the teeth because of a metamerism effect.

in with the color after bleaching as well as they do before bleaching (Fig 1-12). In other cases, restorations may be so extensive or numerous as to preclude replacement. However, it is important to identify all restorations prior to initiating bleaching so the patient is mentally and financially prepared for the possibility of replacement should they choose to proceed.

Visible roots

If bleaching is performed on teeth with exposed roots, the roots will not respond to bleaching in the same way as the remaining portions of the tooth (Fig 1-13). It is important to inform the patient of this limitation. This phenomenon is true even when bleaching mate-

FIG 1-13

(a) The dentin in the root responds differently to bleaching compared with the dentin in the anatomic crown. Patients with gingival recession should be informed that the color of the roots will not change significantly with bleaching. *(b)* After bleaching, the anatomic crowns are lighter, but the roots are still discolored.

(c) In a different patient, bleaching treatment has been performed on the maxillary teeth. Note that only the crowns of the teeth with recession have changed color; the roots remain discolored.

rial is placed inside endodontically treated teeth. A compromised outcome also can be expected if the discolored root of the endodontically treated tooth is evident though the gingiva.

Worn teeth

Some patients, particularly elderly patients, have stained mandibular anterior teeth with such extensive wear that dentin normally located deep in the tooth is located at the incisal edges. These incisal edges will not respond well to bleaching. The best approach is to lighten the dentin as much as possible with bleaching, then restore the incisal edges with composite. Adding composite to the incisal edges of worn mandibular anterior teeth requires a careful evaluation of the occlusion; adjustments may be required to avoid altering the functional path of the teeth.

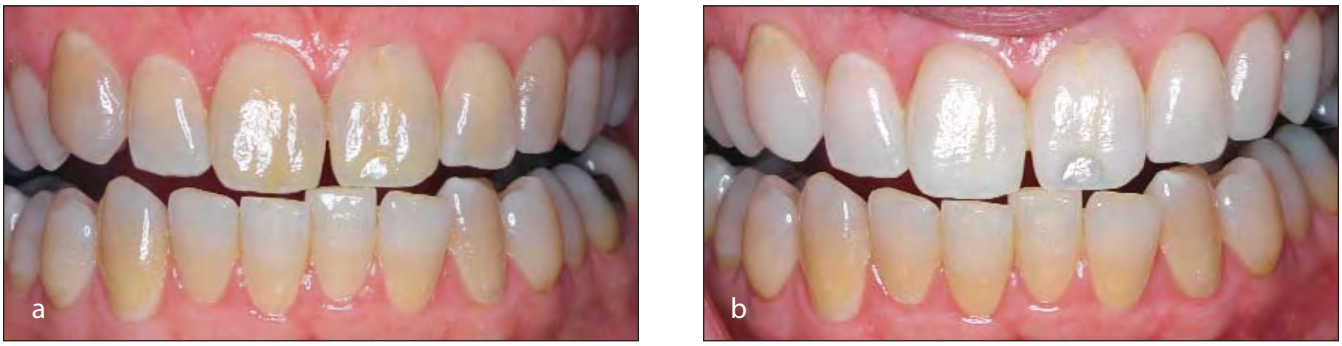
Existing defects

Patients often expect that all problems associated with their teeth will be resolved by bleaching. Therefore, it is important to identify any defects present prior to bleaching and explain to the patient that they will remain afterward (Figs 1-14 and 1-15). These include surface defects, as well as cracks, irregularities, and roughness. Patients should be educated regarding what the bleaching procedure can accomplish and what must be treated by restorative means.

FIG 1-14

(a) The patient was informed that the defects on his teeth would not be altered by bleaching. *(b)* After bleaching, the teeth have been lightened, but the defects remain. Additional treatment is required to cover or remove the defective areas and complete the esthetic treatment.

FIG 1-15



(a) Prior to bleaching, defects are noted on the gingival and incisal regions of the left central incisor. *(b)* After bleaching, the teeth are whiter, but the defects remain. The patient has the option to seek further treatment to address the defects.

Treatment Times and Longevity

Once the examination has been completed, and it has been determined that the patient is a good candidate for bleaching, patients usually want some indication of the expected treatment time. The average treatment time is about 2 weeks, although some patients with lighter teeth may bleach in a few days, and some more challenging cases may take 6 weeks or more. Tetracycline-stained teeth require extended treatment times, sometimes up to several months (see chapter 4). Nicotine stains generally require 1 to 3 months of nightly treatment. The idea is to not adhere to a particular duration of bleaching treatment, since that is dependent on the tooth and the stain, but to bleach the teeth until they have reached their maximum whiteness. Once the teeth have reached their maximum color, or the patient is pleased with the color, a 2-week waiting period should be observed to allow the shade to stabilize and, if restorative procedures are planned, the bond strengths to return to normal. There can be as much as a 25% reduction in bond strengths if the composite is applied immediately after bleaching.

FIG 1-16

Treating one arch at a time makes it easier for the patient to see the progress of bleaching.

After the color has stabilized, there usually is no need for scheduled touch-up treatments. In one study, bleaching patients maintained their post-bleaching color a minimum of 1 to 3 years and as long as 10 years with no further treatment.[21] The best approach is to ask the patient to return for an examination if they feel bleaching re-treatment is necessary. This allows the dental team to evaluate whether or not the discoloration requires treatment other than bleaching. There are also cases in which a patient wants a bleaching touch-up just before an event, such as a reunion or wedding, even though the color achieved immediately after bleaching is not the actual color of the tooth.

Single-Arch Treatment

Bleaching one arch at a time is a good approach to treatment. This allows the patient to see the progress in the treated arch by comparing it with the untreated arch, which encourages compliance (Fig 1-16). Since compliance is the main concern with at-home treatment, this is a significant advantage. Moreover, some patients are not able to discern color changes well, and single-arch treatment allows friends or family to validate that the color change has occurred.

Single-arch treatment also allows patients to experience whitening at a lower fee compared with full-mouth bleaching. If the color change is dramatic, they can then proceed to bleaching the mandibular arch. However, if bleaching treatment is ineffective, at least they have invested less money in the procedure. If their funds allotted for dentistry are not sufficient to proceed immediately to the second arch, they can postpone the bleaching until a better time financially. Interestingly, an observation in a number of the author's studies is that a large number of patients who bleached the maxillary arch elected not to bleach their mandibular arch, even though there was no charge for the procedure. Their stated reasoning was that no one saw their mandibular teeth, only their maxillary teeth, when they smiled. Had these research patients been treated in a private practice, they would not have perceived the value of full-mouth bleaching since they were only interested in treatment of one arch. It therefore may be beneficial to offer a single-arch bleaching fee in private practice.

An additional benefit of a single-arch bleaching approach is that the patient is able to adjust much more easily to bleaching the maxillary teeth than the

FIG 1-17

(a) This patient's teeth have yellowed with age. *(b)* After bleaching, the patient's appearance is rejuvenated.

mandibular teeth. One reason for this is that the fit of the tray is more comfortable on the maxillary teeth. The patient's tongue often contacts the edges of the mandibular tray, which can become an annoyance. The mandibular teeth also do not respond as quickly to bleaching, possibly due to the interference of saliva from the nearby glands and the fact that the tray is upside down, so the material more easily escapes the tray. In addition, tooth sensitivity, the main side effect of bleaching, most often occurs in the smaller teeth. There are fewer small maxillary teeth, so the patient has fewer chances of tooth sensitivity when bleaching maxillary teeth compared with mandibular teeth. If patients have already bleached the maxillary teeth, then experience sensitivity when bleaching the mandibular teeth, they are more likely to continue treatment since they are already familiar with the procedure, have experienced the feel and taste of the material, and have had a successful outcome. Sensitivity is discussed in greater detail later in this chapter.

Finally, it is much more comfortable to wear one tray rather than two trays, and there is less impact on the temporomandibular joint. For patients in whom extended treatment is required, being able to wear the trays comfortably for the duration of treatment is very important.

Special Patient Populations

While bleaching is most often associated with young adults, the range of patient ages in bleaching treatment ranges from 10 to 90 years. Psychological studies have shown that when people are given the option to change their face, height, or weight, then generally choose their face. When given the option to change their eyes, nose, or smile, they generally choose their smile.[22] Hence tooth whitening would clearly be considered desirable by a wide range of people of different ages and circumstances. There are, however, some groups of patients who require special considerations during bleaching treatment.

Elderly patients

Today older patients are healthy, active, living longer, and retaining their natural teeth for their lifetime, but the discoloration of the teeth does not match their otherwise healthy appearance. Bleaching tends to make patients older than 45 years look about 10 years younger (Fig 1-17). Moreover, their teeth are very responsive to bleaching because the technique works well with stains caused by beverages, the secondary dentin formation that occurs with aging, and nicotine

FIG 1-18

(a) This patient has been a pipe smoker for 20 years. Nicotine stains are initially extrinsic in nature, but become more intrinsic over time. For this reason, the bleaching process for nicotine stains generally takes 1 to 3 months of nightly treatment. *(b)* After 3 months of nightly bleaching with 10% carbamide peroxide in a custom-fitted tray, the nicotine discoloration is removed.

from long-time tobacco use (Fig 1-18). However, older patients are also more likely to have exposed root surfaces in areas of gingival recession and worn mandibular incisal edges, neither of which respond well to bleaching. In addition, this age group often has extensive restorative work. The esthetic outcome of bleaching may not justify the risk and cost associated with replacing otherwise clinically successful restorations.

Use of carbamide peroxide for caries control

As the American population ages, there are more people who have received good dental care in their younger years, but are now faced with the difficulty of maintaining their restorations and existing teeth (Fig 1-19). Clinicians have experienced the frustration of treating recurrent root surface caries, particularly around crown margins, as these patients age. This phenomenon seems to be associated with a reduction in salivary flow due to aging, side effects of medications, and general decline in health. There may also be a loss in manual dexterity and the ability to perform oral hygiene measures, often resulting in the development of caries between dental appointments. This situation is further exacerbated by the increased use of sugar-containing breath mints due to the loss of salivary flow.

A chemotherapeutic approach is needed to resolve this problem. Fluoride and chlorhexidine both have been used for this purpose, although the former does not seem to be very effective, and the latter causes unsightly staining. Application of 10% carbamide peroxide may be useful in these situations in one of two ways. It can be used in combination with chlorhexidine to counteract the staining it causes (Fig 1-20), or it simply can be applied in a tray in the same manner it is used for bleaching to inhibit or even stop tooth decay. As noted earlier, the urea in the composition of the material causes the pH of the saliva and the material in the tray to be elevated to about 8 in less than 5 minutes after application and remain at that value for the duration of the application.[23,24] These pH values are crucial for preventing the formation of tooth decay, since root caries can start when the pH of the mouth is between 6.0 and 6.8. A further study has indicated that 10% carbamide peroxide kills one of the two bacteria involved in tooth decay.[25,26] Gingival indices in bleaching studies also have indicated some improvement in gingival scores.[27] The only side effect will be that the patient will also end up with whiter teeth.

FIG 1-19

Elderly patients often are unable to maintain the excellent dental restorations they have received because of reduced salivary flow and other health issues.

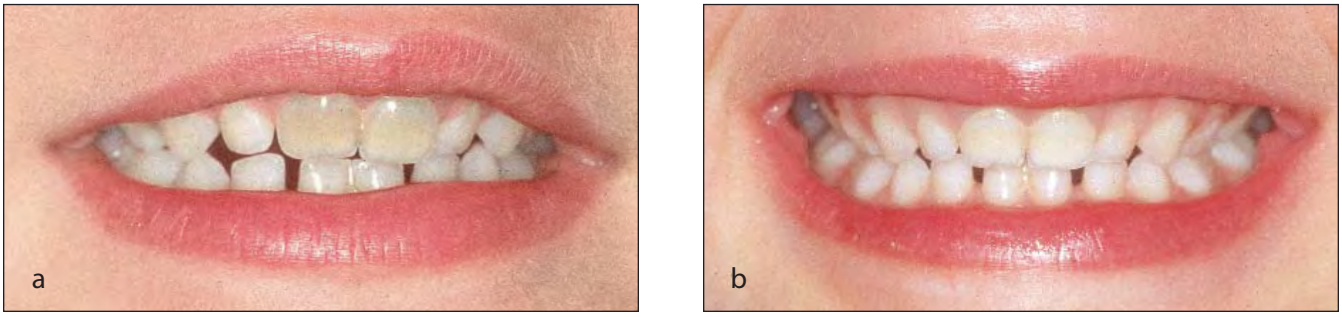
FIG 1-20

Chlorhexidine stains can be resolved by alternating bleaching with chlorhexidine treatment. In this patient, both arches received prophylaxis prior to initiating 3 months of chlorhexidine treatment. The maxillary teeth also received 10% carbamide peroxide in a bleaching tray on alternating nights, while the mandibular teeth did not. Note that there is much less staining on the maxillary teeth.

Children

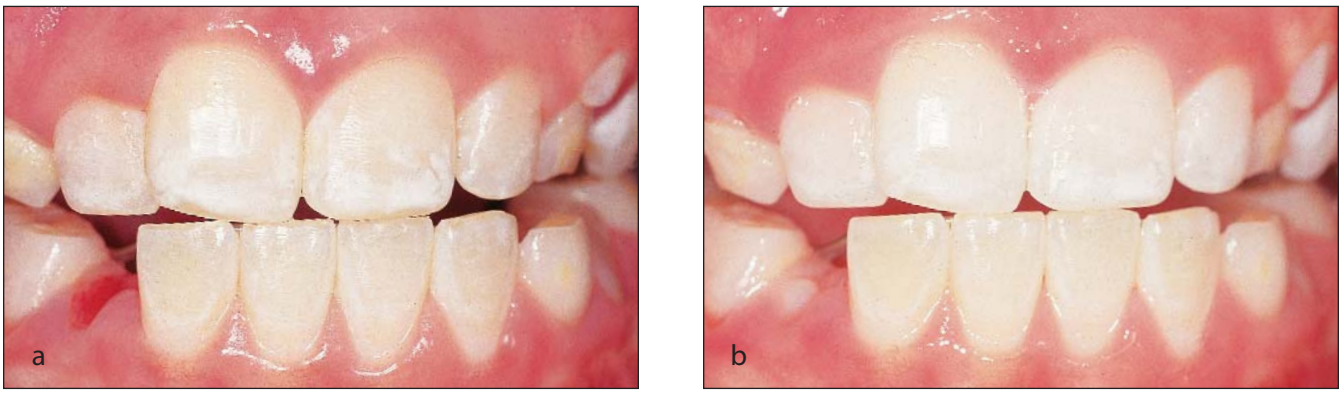
Since the primary teeth are usually very white, there is rarely a need to bleach them. The exception to this would be cases of trauma in which all other causes of discoloration (eg, abscessed teeth or caries) have been ruled out (Fig 1-21). Given the short life of the primary tooth, it is certainly easier, more esthetic, and more cost effective to use bleaching rather than restorative treatment.

FIG 1-21



(a) This child's primary teeth have been darkened by trauma. Pathology has been ruled out. *(b)* Bleaching for a total of 47 hours restores a reasonable color to the primary teeth.

FIG 1-22



(a) Ten-year-old child in the mixed dentition stage is bothered by the white splotchy areas on the newly erupted permanent central incisors. *(b)* After bleaching, the white is not removed, but the background of the tooth is lighter, making the white areas less noticeable.

Not all children in the mixed dentition stage are concerned about the appearance of their teeth. However, if a child is self-conscious about tooth discolorations, he or she may not properly develop social interactions or self-confidence. Bleaching should be administered if the child is having social problems, not just because the parents want their child's teeth to be whiter, particularly since compliance is such an important component in successful bleaching treatment. Nightguard vital bleaching is safe for use in the mixed dentition stage; wearing the tray will not impede eruption during the short time needed for bleaching, but it is best not to have the tray seated on gingival areas where a tooth is on the verge of erupting.

Several types of discoloration may occur in children's teeth. For example, some children are born with yellow teeth. Bleaching can easily remove this yellow coloration in a matter of days or weeks. White or brown discolorations also are often seen in children's teeth as a result of excessive fluoride ingestion (Fig 1-22). These brown discolorations often occur on the central incisors at the time of eruption (usually when the child is around the age of 10 years).

One of the challenges for young orthodontic patients is adequate oral hygiene. It is very discouraging to the patient and the parent when the brackets are removed after 2 to 3 years and there are numerous white lesions or frank decay. Research has previously shown that using carbamide peroxide as an oral rinse improves oral hygiene during orthodontics, and it seems likely that the tray delivery method would provide even better results. There are three types of trays that could be fit over the brackets and used to apply the 10% carbamide peroxide: a conventional bleaching tray, a boil and form tray (made of a thin clear material and formed directly in the mouth), or a disposable tray. Additionally, using 3% hydrogen peroxide in a water irrigation device in a 1:1 solution with water or dispensing the 10% carbamide peroxide directly on the brackets could be helpful. There were early concerns that the tooth under the bracket would not be bleached, but that has been disproved. Also, the concern existed that the orthodontic brackets would debond, but research has shown that the composite bond either stays the same or gets stronger during application of carbamide peroxide.[28,29] Although clinical trials are lacking at this time, when the patient is losing the battle against plaque, there is nothing to lose and plenty to gain by such chemotherapeutic regimens. Bleaching also is often used subsequent to orthodontic treatment and can even be accomplished using the orthodontic positioner as the delivery method.

Pregnant patients

Generally, bleaching is not recommended during pregnancy or during the first few months after delivery if the mother is breast-feeding the baby. Although there is no scientific evidence or reason for concern that the baby or the mother would be harmed by bleaching treatment, there are psychological reasons for delaying treatment. If the mother has problems with delivery and the baby is born with a birth defect, it is important that the mother not suspect that her interest in looking better was in any way connected with the delivery problem.

If a woman initiates bleaching treatment and then determines that she is pregnant, it is prudent to ask that she terminate the bleaching treatment. Any elective procedures are generally not administered in the first trimester. Moreover, some pregnant women have acute episodes of gingivitis and nausea, so the potential irritation of the tray and gagging are other reasons to terminate the bleaching treatment. The tray will still fit after the delivery, and the mother-to-be has a lot of concerns that are more pressing than bleaching. Finally, since so many hormones are passed through the mother's milk, it is best to wait until after she has discontinued breast-feeding to reinstate the bleaching procedure.

Patients with sensitivity

Tooth sensitivity, the most significant deterrent to bleaching, is primarily chemical, but may have a mechanical component. Gingival irritation is primarily mechanical in nature with some chemical components. Gingival irritation generally can be controlled through alterations in tray materials and design. Management of tooth sensitivity, however, may require more in-depth planning both before and during bleaching.

There is no way to predict who will experience tooth or gingival sensitivity. Tooth sensitivity is usually correlated with inherent patient sensitivity, which may be discovered during the preoperative exam and history, and the frequency of application and concentration of the bleaching agent, with applications more than once a day or greater concentrations of bleaching agent increasing the likelihood of sensitivity. All other factors such as pulp size, exposed dentin, cracks, gingival recession, caries, sex or age of the patient, or other physical characteristics are not predictive of sensitivity. Since bleaching tends to produce some tooth sensitiv-

ity under ordinary circumstances, patients with preexisting tooth sensitivity must be cautioned that increased sensitivity, albeit transitory, may occur and that management of the sensitivity may require a longer time span for bleaching.

Research has found that bleaching agents readily penetrate tooth enamel and dentin into the pulp chamber of the tooth and may cause sensitivity in the form of reversible pulpitis. The short-term pulpal response varies from patient to patient and even from tooth to tooth. Although penetration of peroxide through the tooth to the pulp can produce sensitivity, the pulp remains healthy and the sensitivity is completely reversible when treatment is terminated. Tooth sensitivity can also be caused by mechanical pressure exerted by an ill-fitting bleaching tray, possibly due to an inaccurate impression. Research has shown that some patients have tooth sensitivity even when using a nonbleaching agent in a tray or when just wearing a tray alone.[30] Other contributors to sensitivity include rigid tray materials, composition and viscosity of the base vehicle, flavoring agents, or patient habits such as clenching or bruxism.

Patients undergoing at-home bleaching must also be informed that minor sensitivity occurs with as many as two out of three patients, although recent studies have found a significant reduction in that number with better tray materials and bleaching materials.[31–33] Treatment of sensitivity can be either passive or active. Passive treatment involves decreasing the duration or frequency of treatment or interrupting the process for a day or more to allow the teeth to recover, then continuing the procedure. Active treatment involves the application of medicaments using the bleaching tray. Historically, fluoride has been applied for sensitivity. Fluoride acts as a tubular blocker to limit the fluid flow to the pulp; pretreatment with fluoride in the tray may reduce sensitivity. A more direct treatment is the application of 3% to 5% potassium nitrate in the tray for 10 to 30 minutes before or after bleaching.[34,35] Potassium nitrate penetrates the tooth to the pulp and has a numbing or calming effect on nerve transmission and can reduce or eliminate sensitivity in many patients. Some newer bleaching products and many desensitizing toothpastes contain potassium nitrate. Brushing with a potassium nitrate–containing toothpaste for 2 weeks prior to initiating bleaching and continuing this brushing throughout the bleaching treatment has been shown to have an additional benefit in the reduction of sensitivity.[36] This approach places the patient in control of when to treat the sensitivity and for how long, and the potassium nitrate toothpaste is readily available and inexpensive, providing a simple and cost-effective approach to avoiding and treating sensitivity.

If there is significant concern or reason to expect sensitivity, the following measures should be taken:

1. Wait at least 2 weeks after prophylaxis to initiate bleaching.
2. Use a soft tray material (eg, Sof Tray, Ultradent) and carefully consider the tray design. The scalloped, reservoir tray design is the least likely to cause sensitivity, while the nonscalloped, nonreservoir tray is the most comfortable to wear.
3. Have the patient brush with a potassium nitrate–containing toothpaste and a soft toothbrush beginning 2 weeks prior to initiating bleaching and continuing throughout treatment.
4. Instruct the patient to wear the empty tray for 1 or 2 nights to evaluate fit, comfort, and nocturnal habits.
5. The patient should wear the tray with potassium nitrate toothpaste for 1 or 2 nights to experience the sensation of pressure and to reduce excitability of the nerves; should gingival irritation occur in reaction to the ingredients in the toothpaste, substitute it with a professionally supplied potassium nitrate/fluoride desensitizing product.
6. Initiate bleaching using a bleaching material containing potassium nitrate/fluoride in a low concentration (eg, 10% carbamide peroxide), either for a few hours during the day or overnight.

7. Use tray delivery of potassium nitrate material for 10 to 30 minutes as needed for sensitivity.
8. Alternate nighttime use of bleaching materials with potassium nitrate or skip nights if sensitivity continues (eg, bleach for two or three nights, then skip a night or two).
9. Advise the patient to avoid acidic foods and beverages such as soft drinks, fruit juices, white wine, and yogurt.

How to Discuss Bleaching with Patients

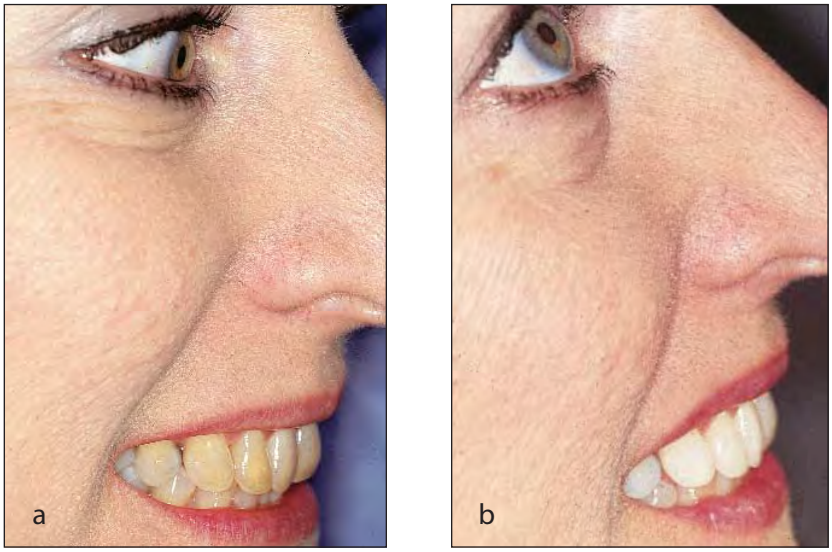
Attempting to tell patients they would look better with a certain procedure can be one of the most awkward situations in esthetic dentistry. This is especially true with bleaching. Since it is such an easy and cost-effective treatment, dental professionals occasionally err in assuming that everyone wants their teeth to be whiter. Telling patients they would look better with whiter teeth implies that they do not look good now, which may be taken as an insult. The challenge is how to inform patients not inquiring about whiter teeth that the office offers the treatment and that they might benefit from it without insulting them. One approach is to have questions on the medical history inquiring whether they are interested in having whiter teeth, or if they have ever tried to whiten their teeth. This nonthreatening approach gives them a chance to think about the color of their teeth without any pressure. Another option is to ask the patient, either during the examination or on the dental history form, if there is anything they would like to change about their smile, or if they are happy with their teeth. Questions of this sort do not directly address the color of the teeth but give the patient the option to express their desires.

However, many established clinicians have been treating their patients since long before bleaching became popular. Since these patients generally do not complete new history forms or go through the standard initial examination, it is a good idea to display posters and/or pamphlets in the hygiene treatment room indicating to patients that the office offers bleaching and encouraging them to ask their clinician about the procedure. The American Dental Association and many manufacturers have brochures that can be distributed in the office or in mailings to patients. It is important that all patients be aware of the treatment options available to them at their dental office. Most people who have their teeth cleaned regularly do so for esthetic reasons. These patients often ask questions about toothpastes, cleaning methods, and other esthetic treatments, which provides a good opportunity to share information about bleaching with them.

During a discussion about bleaching, patients may ask if they would look better if their teeth were whiter. A good indicator is the color of their teeth in comparison with the sclera (whites) of their eyes. Ideally, the whites of the eyes should match the color of the teeth. Teeth that are lighter than the whites of the eyes create too much of a distraction and tend to look unnatural. If, however, the teeth are darker than the whites of the eyes, the patient's appearance is likely to be improved by tooth whitening (Fig 1-23). The color of the whites of the eyes is a much more reliable reference point for bleaching than a shade tab since it is individualized for each patient; moreover, patients are able to see for themselves when they are approaching their ideal tooth color just by looking in the mirror. It also decreases the likelihood of overwhitening in an attempt to match the lightest shade tab.

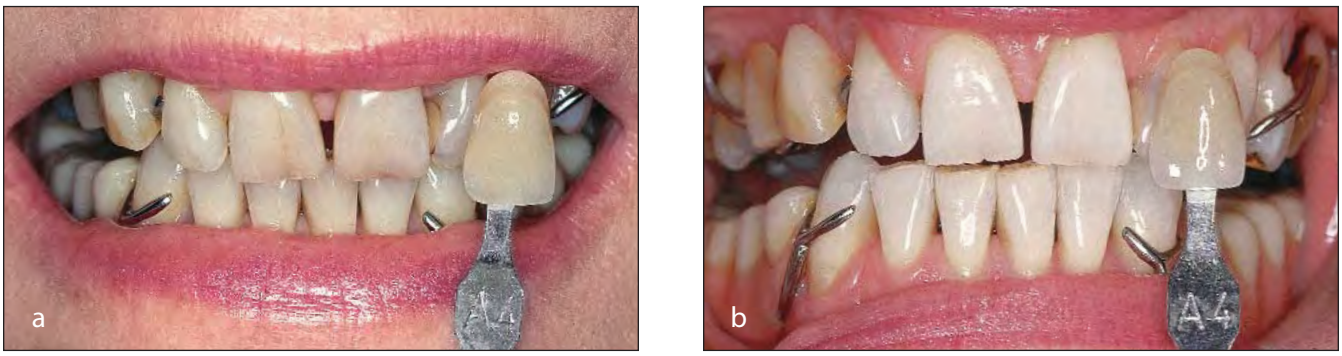
An important time to mention bleaching to patients is when esthetic restorative treatment is indicated. Patients should be informed of the bleaching option prior to choosing the shade for the restorative material (Fig 1-24). Should the patient decline bleaching, this choice should be noted in the chart and initialed by the patient. Occasionally bleaching will be considered

FIG 1-23



(a) Before treatment, this patient's teeth were notably darker than the whites of her eyes. *(b)* After treatment, the teeth and sclera of the eyes more closely match, creating a natural and more esthetic look.

FIG 1-24



(a) The patient is planning to replace her removable partial denture but decides to bleach the natural teeth first to address the brown discolorations. *(b)* Both arches have been bleached. As demonstrated by the shade tab, the teeth are now considerably whiter, which allows the placement of a denture with lighter and more esthetic crowns.

after completion of restorative treatment to more closely harmonize a restoration with the natural teeth; however, there is a risk of creating a larger contrast between the natural teeth and the restoration with this approach (see chapter 6).

As mentioned earlier, when discussing bleaching treatment, it is of utmost importance that the clinician educate the patient about which problems can and cannot be resolved by bleaching, as well as the potential need for replacement of currently well-matched restorations following bleaching. Patients often think that bleaching their teeth will resolve all of their esthetic problems, including defects, gingival anomalies, or unesthetic restorations, and in some cases, previous restorative work has been so skillfully performed that many patients may forget they have a bonded restoration that currently matches the color of the teeth. It is often helpful to show the patient a visual representation of the teeth in the esthetic zone with any existing problems and/or restorations marked (see Appendix B). Realistic patient expectations for the outcome are essential to successful bleaching treatment.

Summary

Tooth whitening is best performed under professional supervision following a proper examination and diagnosis and using materials appropriate to the patient and nature of the discoloration, all for a fair fee for service. Bleaching with 10% carbamide peroxide in a custom-fitted tray is generally the safest, most cost-effective whitening treatment available. However, other bleaching treatments may be indicated based on patient preferences, lifestyle, finances, or other limitations. Patients should be presented with the cost- and risk-benefit ratios of all procedures, and their informed consent should be obtained before treatment is initiated.

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TYPICAL TOOTH DISCOLORATIONS 2


Tooth discolorations most commonly are caused by factors such as genetics, aging, diet, and nicotine use and present as fairly uniform yellow or brown stains that cover the entire surface of all natural teeth. Generally teeth with this etiology and color range will lighten satisfactorily after 3 days to 6 weeks of tray bleaching with 10% carbamide peroxide. In most cases, the teeth look very natural after bleaching, with the incisal area normally lighter than the gingival portion. Tooth discolorations that fall outside of this typical range (ie, tetracycline stains, partial tooth discolorations, and single dark teeth), as well as situations that involve restorative treatment, will be addressed in more detail in the following chapters.

Genetics

Natural tooth color varies greatly amongst individuals. In some cases, permanent teeth erupt with a yellow discoloration that is quite noticeable in contrast to the whiteness of the primary teeth. This is most significant for children in the mixed dentition stage. The permeability of the tooth and the ability of the dentin to change the color allow these genetically yellow teeth to be whitened effectively with bleaching.

Another situation that is commonly encountered is canines that are a half shade darker than the lateral incisors and the first premolars. Occasionally, the canines will be significantly darker than the adjacent teeth, negatively affecting the overall esthetics of the smile. These yellow canines can be lightened to more closely match the incisors and premolars with tray bleaching. The fact that bleaching can effectively change the color of a genetically discolored tooth is a good indication that, in addition to removing stains, bleaching can alter the intrinsic color of the tooth.

Aging

As teeth age, they typically become more yellow, primarily from the internal deposition of secondary dentin and also as a result of extrinsic staining. Hence yellow teeth are associated with older age, and yellow teeth make a person appear older. It is estimated that a person over 45

years of age will look 10 years younger with whiter teeth. As people live longer, are more healthy, and appear more healthy, there is a greater need for tooth whitening.

Diet

Food and beverages can stain teeth. Typically staining is associated with coffee and tea, as well as red wine or other beverages that are dark in color. These stains are very responsive to bleaching. If the patient continues to consume the stain-causing food or beverage, the discoloration will return, but "touch-up" removal is also very easy. While some patients elect to cease consumption of the offending substance during bleaching, it is not necessary. Even in the case of coffee, continued consumption would slow down the bleaching process only by a day or so out of a 6-week period.

Nicotine

Nicotine stains begin as a tenacious external or extrinsic discoloration. Over time, the nicotine stain absorbs into the tooth and becomes an intrinsic stain, causing the teeth to appear very dark. Nicotine stains are much more difficult to bleach than typical brown stains, generally requiring 1 to 3 months of nightly tray bleaching treatment for removal. However, the results can be exceptional and often motivate patients to cease smoking to maintain their beautiful smile.

As shown in the following cases, not all teeth obtain the same outcome from bleaching. It is often difficult to predict how teeth will respond to bleaching treatment. However, excellent outcomes can be achieved for patients with vastly different discolorations.

CASES 1 TO 3 Stains of genetic origin

CASE 1

These genetically discolored teeth have an unnatural appearance.

After tray bleaching with 10% carbamide peroxide, the teeth have a more natural color.

CASE 2

This 16-year-old female patient had markedly yellow teeth at eruption. Although orthodontic treatment improved the alignment of the teeth, the color of the teeth detracts from the overall esthetics.

The results of tray bleaching are dramatic, providing a significant improvement in the patient's self-image.

CASE 3

This patient has canines that are significantly darker than the adjacent teeth, a common genetic occurrence.

After bleaching all of the teeth, the canines more closely match the adjacent teeth.

CASES 4 TO 6 Aging-related stains

CASE 4

Teeth tend to discolor with age as a result of extrinsic staining as well as deposition of secondary dentin.

Tray bleaching creates a much more youthful appearance, often making patients appear 10 years younger.

CASE 5

This middle-aged patient has functionally sound teeth, but they have discolored over time.

Tray bleaching lightens and brightens the teeth to create a more youthful smile, without causing the teeth to become unnaturally white.

CASE 6

This patient's teeth have become discolored with age, marring an otherwise attractive smile.

Tray bleaching can yield a much younger-looking smile.

CASES 7 AND 8 Nicotine stains

CASE 7

This patient had been a pipe smoker for approximately 10 years. The resulting brown discoloration of his teeth made him appear older than he really was.

The stains in the maxillary teeth were removed following 2 months of nightly treatment with 10% carbamide peroxide.

CASE 8

There is heavy nicotine staining around the existing discolored restorations.

After 6 weeks of bleaching, the stains have been removed from the teeth, but now the restorations will need to be replaced.

CASES 9 TO 19 Excellent bleaching results

CASE 9

The gingival area of the central incisors has a brownish discoloration.

Tray bleaching removes the brown stains, resulting in a more esthetic and natural smile.

CASE 10

The nonuniform yellow stains make this patient's teeth appear older.

Tray bleaching harmonizes the shade of the teeth to a lighter but natural color.

CASE 11

The teeth are only slightly yellow, but the patient wants them to "sparkle." Note that the canines are darker than the rest of the teeth.

The patient's smile is now much brighter following tray bleaching, and the canines more closely match the other teeth.

CASE 12

This patient's teeth had a dull yellow appearance, with greater discoloration in the incisal areas than in the gingival areas.

Bleaching with 10% carbamide peroxide in a custom-fitted tray improves the patient's appearance and brightens the smile. The color of the teeth is more uniform and natural.

CASE 13

The brownish yellow of the teeth detracts from the appearance of the nicely formed dentition.

A very nice outcome enhances the patient's smile while retaining the normal distribution of color from the incisal to the gingival regions.

CASE 14

The pretreatment color of the teeth is slightly yellow, an excellent indication for tray bleaching.

After tray bleaching, the teeth are lighter but retain a natural look, with the gingival areas slightly darker than the incisal areas.

CASE 15

These teeth have a somewhat dull and flat appearance.

Bleaching the teeth adds depth and luster to their appearance.

CASE 16

The smile is characterized by mildly discolored central incisors and darker lateral incisors and canines, coupled with root recession on the left side.

The color of the teeth is improved, although the areas of recession do not respond to bleaching.

CASE 17

This patient presented with mild overall discoloration with some darkening at the incisal edges of the central incisors.

Tray whitening produces a much more attractive tooth color.

CASE 18

The teeth are well shaped, but are not white enough, as indicated by the matching dark shade tab.

After tray bleaching, the degree of improvement can be seen by comparing the same dark shade tab.

CASE 19

Nonuniform distribution of brown discolorations highlights the white discolorations on the tips of the teeth.

Bleaching both lightens the teeth and blends in the white incisal areas with the rest of the teeth.

CASES 20 TO 28 Improved but not ideal bleaching results

CASE 20

These teeth are slightly gray, which is a difficult color to whiten.

After tray bleaching, the teeth are a lighter shade of gray, but not white.

CASE 21

These teeth are somewhat gray and dull.

After bleaching, the teeth are lighter, but still not very white.

CASE 22

The overall yellowish hue and darker canines do not provide for an attractive smile.

After bleaching, the teeth are a much more attractive color.

CASE 23

These teeth have a grayish yellow appearance.

After 6 weeks of bleaching, the yellow color saturation is reduced, but the gray still remains. Extended treatment times may further change the color.

CASE 24

Teeth with a grayish yellow appearance often do not completely whiten with bleaching.

After bleaching, the teeth are brighter and whiter, but not as white as other teeth may become. It is impossible to predict the maximum tooth lightening that can be achieved.

CASE 25

These teeth are only mildly discolored.

After bleaching, the teeth look whiter and cleaner, but still retain some of the brown discolorations.

CASE 26

The grayish brown discolorations are not expected to fully respond to bleaching.

After bleaching, the teeth are lighter and whiter, but the esthetic results are not ideal.

CASE 27

The maxillary teeth are darker than the mandibular teeth, which looks unnatural.

After bleaching, the shade of the maxillary arch is much improved and, most importantly, lighter than the mandibular arch. Generally when the mandibular arch is bleached, it will reach the same shade as the maxillary arch or be slightly darker.

CASE 28

The central incisors are darker than the lateral incisors, which detracts from the esthetics of the smile.

Bleaching lightens the teeth and affords a more uniform color distribution.

PARTIAL TOOTH DISCOLORATIONS | 3

Teeth can become partially discolored from a number of causes. Excessive fluoride ingestion or a higher-than-recommended level of natural fluoride content in the local water supply can result in brown and/or white fluorosis staining. Partial brown tooth discoloration also can be idiopathic or the result of trauma sustained during tooth formation. Brown discoloration responds to bleaching treatment about 80% of the time, generally requiring 2 to 6 weeks of nighttime treatment. Although partial white stains usually cannot be removed using bleaching, treatment does result in whitening of the unstained portions of the teeth, thereby making the stains less noticeable.

Many clinicians are more familiar with using abrasion techniques, which predate the recent home bleaching era, to treat white or brown partial discolorations. A common technique is called *microabrasion*, which involves the softening and removal of both enamel and the surface defect and is accomplished with rubber dam isolation, hydrochloric acid and pumice, and a special geared-down handpiece. This procedure is a subtractive method of stain removal, with 12 to 26 µm of enamel removed per 5-second application. Another abrasion technique is called *macroabrasion*, which involves the use of rotary instruments such as a carbide bur in a high-speed handpiece for enamel removal. This is followed by polishing with composite finishing disks and polishing points or pastes.

Bleaching, as a more conservative approach, is generally the first choice of treatment for brown and white stains, followed by abrasion techniques. However, if there is an unsightly, rough, and poorly formed white discoloration covering the majority of the tooth surface, using abrasion first to establish a smooth surface may be the best approach. In most cases, the teeth are more yellow after the white surface is removed; therefore, bleaching is often required following abrasion.

Long-term results have been achieved with nightly bleaching of partial brown tooth discolorations without the need for follow-up treatment.

CASES 1 AND 2 Brown and white stains

The advent of nightguard vital bleaching has offered a more conservative option to abrasion for the treatment of partial brown and white stains. If the enamel surface is intact, shiny, and hard, then nightguard vital bleaching should be the first choice for removal of brown discolorations or masking of white areas. This whitening technique avoids the removal of the fluoride-rich enamel layer and does not alter the line angles or shape of the tooth. In the event that bleaching treatment is not successful, the abrasion technique remains an option.

If the white discoloration appears as one or more isolated spots, it is better to bleach first to lighten the background of the tooth rather than attempt abrasion. Although bleaching does not remove the discoloration, it often makes the white areas less noticeable, and no further treatment is needed.

CASE 1

Highly noticeable brown and white discolorations from fluorosis in a young male patient.

Tray bleaching with 10% carbamide peroxide has removed the brown discolorations. In addition, the white discolorations are less noticeable because of the lighter shade of the rest of the teeth and the removal of the brown stains.

CASE 2

Brown and white discolorations on the anterior maxillary teeth of an elderly woman.

Tray bleaching with 10% carbamide peroxide removes a majority of the brown discoloration and whitens the teeth to approximately the same shade as the white-discolored portions of the teeth.

Three-year posttreatment view. After bleaching was completed, the anterior teeth were re-contoured to further enhance their esthetic appearance. No further bleaching treatment has been performed in the period since, yet the effect of the bleaching has been maintained.

CASES 3 AND 4 Long-term results of bleaching of brown discolorations

CASE 3

Brown discolorations were present in the anterior dentition of this adult patient.

The stains were removed following 6 weeks of nightly tray bleaching with 10% carbamide peroxide.

Three years after bleaching and with no further treatment, the brown discolorations have not returned.

CASE 4

Fourteen-year-old boy with brown discoloration of uncertain etiology, possibly the result of trauma to the primary tooth during permanent tooth development.

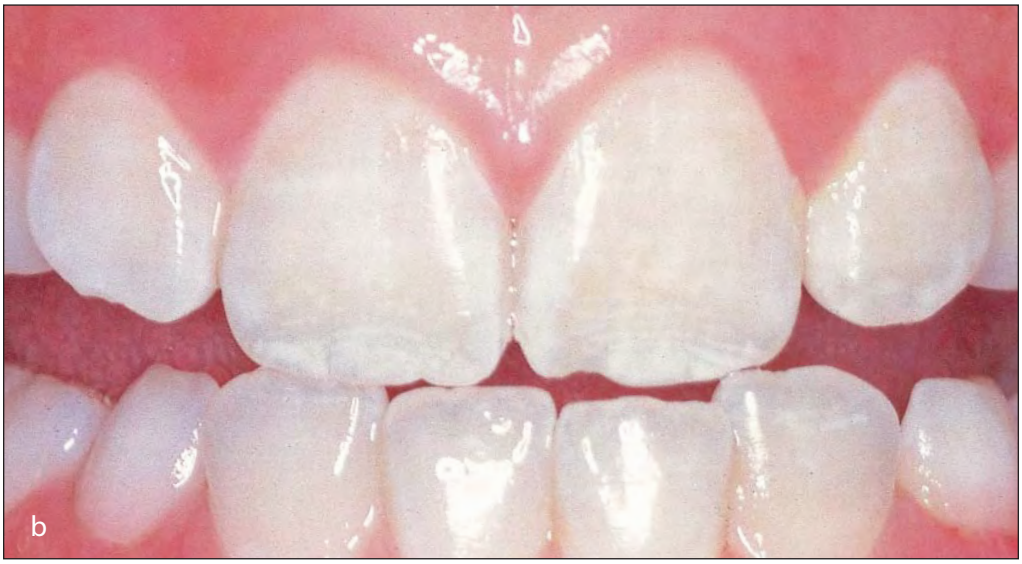
After 6 weeks of bleaching treatment with 10% carbamide peroxide, the brown discoloration is eliminated.

Posttreatment view 3 years after bleaching. The right central incisor shows no evidence of brown discoloration. No further treatment or touch-up bleaching was performed.

Posttreatment view 10 years after bleaching and no additional treatment. Removal of brown discolorations may be permanent in some patients.

CASE 5 Quickly resolved brown discolorations of unknown etiology

This 10-year-old male patient presented with unexplained brown discolorations on both central incisors.



After only 1 week of nightly tray bleaching with 10% carbamide peroxide, the brown discoloration was removed. Should it return, the stain could easily be re-treated in the same manner.

CASE 6 Brown stains on teeth and restorations resulting from high iron content in water

Bleaching has little or no effect on most of the common esthetic restorative materials, such as composite and porcelain; it does not lighten them and generally does not harm them. The most significant effect from bleaching previously restored teeth is that the teeth are lightened enough that the existing restorations may appear comparatively dark and therefore require replacement for esthetic balance.

Although bleaching releases a significant amount of oxygen into the tooth, the bond of existing composite restorations is not weakened; therefore there are no contraindications for bleaching in the presence of existing bonded restorations. However, the oxygen-rich tooth structure does not provide a good surface for bonding new restorations as it hinders the polymerization of the resin. A delay of 2 weeks or more following the bleaching process allows this effect to dissipate so bonding can be performed effectively. This also allows the tooth shade to stabilize prior to selecting the shade of the restorative material.

Brown staining is present on the teeth and composite restorations in the anterior maxillary dentition as a result of the naturally occurring high iron content in the patient's local water supply.

After 6 weeks of 10% carbamide peroxide tray bleaching, the brown discolorations have been removed from the teeth. However, notice that the restorations have remained discolored.

CASES 7 TO 9 White discolorations

CASE 7

This 16-year-old female patient has a slightly yellow color to her teeth with white discolorations on the incisal edges, which are often referred to as *snow caps*.

After nightly tray bleaching, the white discolorations remain but are less noticeable now that the yellow has been removed.

CASE 8

The incisal edges are much whiter than the rest of the teeth.

The teeth now have a much lighter and more uniform shade.

CASE 9

The patient is unhappy with the white spot on the left central incisor, which is more noticeable because of the dark brown shade of the right central incisor.

Three months of bleaching treatment has lightened the brown of the teeth, making the white spot less visible. With the stains removed, the patient noticed that the teeth were not in alignment and requested information about orthodontic treatment. Successful bleaching treatment provided the patient with motivation and encouragement to pursue further esthetic improvement.

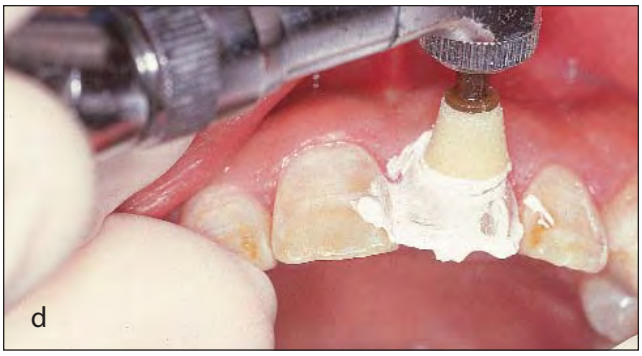
CASE 10 Tetracycline staining with brown and white discolorations treated by macroabrasion and bleaching

Some white discolorations are so stark that it is obvious that the natural teeth either will not bleach to that shade or would not look natural if they did. In these situations, removal of some of the stark white is desirable. The challenge lies in determining whether or not those white areas are deep into the enamel and require a composite restoration, or if they are merely on the surface and can be easily removed. Often a view from the incisal edge will show the depth of the lesion, or a defect may reveal the depth. In this case, a chip on the incisal aspect of the central incisor reveals the shallow depth of the white discoloration. When the discoloration is confined to the surface, it is safe to consider removal prior to bleaching.

Tetracycline staining is present, including both brown and white discolorations.

A fine diamond is used to remove the stark white and superficial brown discolorations without attempting to eliminate all the brown stains.

A series of polishing disks are used to polish the enamel; the process is similar to that used when polishing composite restorations.



The final polish of enamel is accomplished using a diamond-containing polishing paste. The surface texture should match the adjacent teeth.

Several months of nighttime tray bleaching with 10% carbamide peroxide have resulted in the elimination of the remainder of the staining.

CASE 11 White stains treated by bleaching, abrasion, and composite bonding

If white discolorations are still evident after bleaching is completed, abrasion can be performed. However, the patient should be advised that if the defect worsens subsurface, it may have to be removed aggressively and covered with a composite restoration. An advantage of bleaching first is that the composite shade can be selected the day abrasion is performed. Note that abrasion and bonding should be delayed for 2 weeks after bleaching to allow the shade to stabilize and the bond strengths to return to normal. There is a 25% reduction in the bond strength of composite to etched enamel if the bonding is applied immediately after any type of bleaching.

White lesions are present on the incisal edges of the maxillary central incisors of this 16-year-old male patient.

After 4 weeks of tray bleaching with 10% carbamide peroxide, the white stains are less prominent, but still noticeable.

Abrasion was initiated to remove the remaining white discolorations; however, they worsened as the enamel was removed. At this time, a decision was made to remove the white lesions and restore the area with composite.

Final outcome following bleaching, abrasion, and composite bonding. After bleaching, teeth require 2 weeks for color stabilization and return of normal bond strengths. Therefore, it is good practice always to perform bleaching before abrasion in case bonding becomes necessary.

CASE 12 Treatment of partial staining as a gateway to further esthetic treatment

Patients may not have the ability to readily imagine the change in their teeth that is described by the clinician for a complex treatment plan. Often they only see the chief complaint, such as a single discolored area or tooth, and cannot conceive of the impact of further treatment, such as orthodontics or restorative procedures. Bleaching eliminates the immediate concern and allows patients to begin on the path toward the ultimate treatment goal. With the initial bleaching treatment, patients can see an improvement in their smile, which often allows them to visualize the results that could be achieved with additional procedures.

The patient presented with numerous esthetic problems, but requested treatment only for the white and brown stains on the anterior teeth. A small fracture on the incisal edge of the tooth revealed that the white was limited to the surface, indicating that abrasion could be used to remove the white stains prior to bleaching.

The white stains have been removed.

Bleaching is completed to remove the brown stains. Now the patient is interested in correcting the malaligned teeth and occlusion, problems that were not as evident to the patient when the stains were so prominent.

CASE 13 Treatment of brown and white discolorations concurrent with orthodontic therapy

If children in the mixed dentition stage are self-conscious about their teeth and smile, they may suffer from low self-esteem and have difficulty developing good social interactive skills. It is especially important in our culture to have attractive teeth during the teenage years, so this age group is especially interested in bleaching. Bleaching is often used subsequent to orthodontic treatment and even can be accomplished using the orthodontic positioner rather than a bleaching tray.

This 10-year-old girl had brown and white discolorations on her erupting permanent dentition.

The 10% carbamide peroxide was applied in a tray designed to fit inside of the patient's orthodontic appliance. Another option is to alternate wear of the bleaching tray with placement of the orthodontic appliance.

Following 6 weeks of nightly tray bleaching, the majority of the brown discolorations have been removed. Because of the lightening of the tooth, the white discolorations, although still present, are less noticeable.

Three years after bleaching and with no additional treatment, the lateral incisors have erupted without a line of demarcation. The untreated mandibular arch indicates the extent of color change and the stability of bleaching over time.

CASE 14 Attempted in-office bleaching for quick treatment of brown fluorosis staining

Often patients with normal discolorations request that in-office bleaching be used in place of tray bleaching to avoid wearing the tray at night or during the day. They assume that one in-office treatment will yield the same results as tray bleaching. However, it generally takes three in-office visits to achieve the maximum whitening provided by tray bleaching. Only about 25% of patients will have successful results after one in-office visit, and these patients usually have a lighter baseline shade. Contrary to popular belief, the light activation used for in-office bleaching does not enhance the final outcome of bleaching but only gives the appearance of improved whitening due to dehydration. In approximately 2 weeks, this additional illusion of whitening will disappear. The whitening achieved by in-office bleaching is primarily determined by the concentration of peroxide and the time of application, with the ability of the tooth to change color being a limiting factor.

Similarly, patients with brown discolorations may hope that one visit will remove the stains completely without the need for tray applications or extra in-office visits. While this may be possible with some brown discolorations, the patient must be informed that multiple visits may be required or that tray bleaching will be performed in addition to the in-office visit if needed. In-office bleaching incurs a considerable expense when multiple visits are required and an additional expense if combined with tray bleaching. Safety issues associated with repeated applications of the isolation barrier, as well as gingival irritation, also can present a challenge. Moreover, sensitivity is a greater concern with in-office bleaching, often requiring patients to be medicated prior to treatment. However, after being fully informed of all the options, including in-office and tray bleaching and the possible need for composite bonding or porcelain veneers, some patients may still prefer to try the in-office approach.

This patient wanted the brown fluorosis stains removed quickly in preparation for an upcoming social event.

An attempt was made to use in-office bleaching with 35% hydrogen peroxide and light activation. Paint-on dam was used for isolation.

The in-office treatment did not completely remove the brown stains, even after three applications.

After the single-visit in-office treatment was unsuccessful, tray bleaching for 4 weeks removed the majority of the remaining brown discoloration.

CASE 15 Temporary worsening of white stains in intermediate stages of bleaching

Small white spots are evident on the teeth at the initial examination.

The white spots have become more noticeable during bleaching because they respond more quickly than the rest of the tooth, resulting in a so-called splotchy stage.

Bleaching was continued until the background color of the teeth lightened. After completion of bleaching, the white spots returned to their pretreatment color, becoming less noticeable as they blended in with the lightened teeth.

CASE 16 White stains too severe for successful bleaching treatment

Even when stains do not fully respond to bleaching, it represents a good, conservative first step in the management of discolored or malformed teeth. Often bleaching makes the teeth light enough or sufficiently disguises discoloration to satisfy the patient. If subsequent restorative treatment is pursued, a lighter tooth allows placement of a more conservative, less opaque, and more natural-looking restoration.

Some white spots, such as the one on this maxillary left central incisor, are simply too light to be expected to blend in with a bleached tooth.

Bleaching has been used to lighten the tooth color. After the color has stabilized and oxygen has exited the tooth (approximately 2 weeks), the patient can decide if the remaining defect should be abraded and covered with a composite restoration.

CASE 17 Brown discolorations unresponsive to bleaching treatment

In some cases brown discolorations cannot be removed by bleaching; this may be due to the nature of the stain or lack of patient compliance. As a general rule, if the patient has been bleaching for 6 weeks and the stain is still evident, abrasion should be considered. As in the treatment of white discolorations, 2 weeks should be allowed following bleaching treatment before either microabrasion or macroabrasion is used. The drawback to both of these techniques is the loss of enamel. Prior to abrasion treatment, the patient should be prepared mentally and financially to have composite restorations placed.

This patient presented with several areas of brown discoloration.

After 6 weeks of tray bleaching with 10% carbamide peroxide, only partial removal of the brown discoloration has occurred.

Microabrasion, the removal of enamel using a pumice paste containing hydrochloric acid, is used on the right central incisor to remove the staining. The left central incisor was treated with macroabrasion using a high-speed handpiece and a composite finishing bur.

The esthetic appearance following bleaching and abrasion is improved; however, there has been some loss of enamel and contour.

TETRACYCLINE-STAINED TEETH | 4

Nightguard vital bleaching has brightened the smiles of many happy patients since its introduction in 1989. However, it remains difficult to achieve good bleaching results in patients whose teeth have been stained by tetracycline ingestion. Tetracycline can stain teeth if ingested by the mother in the third trimester or by the child during the years of tooth formation. Tetracycline also has been shown to stain teeth in adults who take the drug (eg, minocycline for long-term skin conditions such as acne) both by external absorption into the tooth and by internal deposition into the secondary dentin formed during aging or following trauma.

Tetracycline has several different analogues (eg, doxycycline, oxytetracycline, minocycline, chlortetracycline, demeclocycline) and may cause various types of stains in terms of color (gray, blue, brown, and yellow) and intensity. Recent research has shown that tetracycline-stained teeth may respond to longer bleaching treatments; whereas the bleaching time for other stains is 2 to 6 weeks, some tetracycline stains may require from 1 to 12 months (average of 3 to 4 months) of nightly treatment to achieve a satisfactory result. Brown and yellow discolorations, especially those that are uniform across the surface of the tooth or located in the incisal area of the tooth, are the most responsive; gray and blue stains in the gingival region of the tooth are least responsive. Teeth with banded discolorations have mixed responses, and composite bonding may be required to cover particularly unresponsive mid-tooth gray bands. Some seemingly normal yellow stains that are not responsive to the conventional 2 weeks of treatment may in fact be tetracycline stains. Although bleaching treatment of tetracycline stains involves extended times, research has shown that 6 months of nightly 10% carbamide peroxide bleaching is not detrimental to the tooth or pulp at 7.5-year recalls, and will provide some color improvement in almost every patient.[1–3] Some tetracycline-stained teeth do not become totally unstained, but the tooth color is often much improved. Tetracycline-stained teeth that were gray often retain slight gray overtones (ie, they get lighter rather than whiter).

There are several factors to be considered when using extended time periods for bleaching tetracycline-stained teeth. First of all, the location of the stained area has a great impact on the prognosis for success. A tooth gets progressively thicker from incisal to gingival, which means that with bleaching, teeth generally lighten from

the incisal to the gingival area, and teeth that are heavily stained gingivally have the poorest prognosis for complete lightening. Generally speaking, the further away from the cementoenamel junction the stain resides, the better the prognosis. However, in any situation, there is no way to predict whether the outcome of bleaching treatment will be successful. The patient must be willing to undertake the extended treatment time, recognizing that investing a reasonable amount of time and money is the only way to see if bleaching works for them. Patients should understand that they may not see results in the first few months after an initial slight lightening, although each discoloration responds very differently.

Extended treatment time also offers more opportunity for sensitivity episodes. Patients may have to reduce their exposure time (from overnight to 1 to 2 hours daily) or frequency (from every night to every second or third night or skipping weekends). As with regular bleaching, the presence of sensitive teeth pretreatment or the frequency of application of solution are the only predictors for sensitivity. In the extended treatment situations, the sensitivity may be sporadic and subside with no treatment. Patients may choose to apply fluoride solutions in the custom tray alternately with treatment or prior to application. The most predictable method used to treat sensitivity is the use of desensitizing toothpastes containing potassium nitrate for 2 weeks prior to bleaching, then the use of potassium nitrate in the tray for 10 to 30 minutes as needed during treatment. A reduction in the concentration of carbamide peroxide can also be helpful.

Another practical consideration in extended bleaching situations is the appropriate fee for the service. Practitioners may choose to have an increased total fee or to use the initial fee for their normal bleaching treatment, supplemented with an additional fee for each month of extended treatment. Using the latter "pay-as-you-go" approach, the additional monthly fee will only be for the office visit and the material needed. The patient continues to bleach until their teeth cease to change color, they have reached the desired color, or they are no longer interested in pursuing treatment. This approach is both fair to the dentist and to the patient, since it is highly difficult to predict treatment times for tetracycline staining.

Teeth severely stained in the gingival area generally are better candidates for porcelain veneers than for nightguard vital bleaching. However, it is best to try bleaching first, since it may have a satisfactory effect and eliminate the need for veneers. Even if the lightening effect is only slight and veneers still must be placed, the need for masking will be reduced, allowing the placement of more translucent—and thus more natural-looking—veneers. In cases where bleaching has no effect, the patient is at least confident that the most conservative avenues have been attempted first and that porcelain veneers are now the best option they have for an esthetic smile.

Early research on the longevity of color change indicates that most patients will have some degree of lightening, and 8 out of 10 patients can expect to retain that lightening for at least 1 year and for as long as 7 to 9 years. Even those patients who experienced some regression indicated they were glad they had bleached their teeth and would do it again.[4]

Dentists and physicians are well aware of the detrimental effects of tetracycline ingestion, although the absorption of tetracycline in teenagers taking the drug for treatment of acne has only recently been reported. However, tetracycline-stained teeth may continue to be seen since tetracycline is still the drug of choice for out-patient treatment of Rocky Mountain spotted fever and is the most widely prescribed drug for acne. Bleaching is a conservative, cost-effective consideration for treating tetracycline-stained teeth and a good treatment option if the patient is willing to undergo extended treatment and has reasonable expectations regarding the results.

CASE 1 Efficacy of nightguard vital bleaching to treat tetracycline stains

One of the first studies on extended nightguard vital bleaching treatment of tetracycline-stained teeth enrolled patients for 6 months of nightly treatment using 10% carbamide peroxide. Their total hours of treatment varied, based on lifestyle, sensitivity, and color change, from 568 to 1213 hours, with an average of 952 hours of nightly wear. No long-term problems had occurred at the 7.5-year recall.[5,6]

Moderate tetracycline stains before treatment in otherwise caries-free teeth.

Results after 6 months of nightly bleaching in the maxillary arch with 10% carbamide peroxide for a total treatment time of 720 hours. The results are very good, and the patient reported no problems with sensitivity.

CASE 2 Single-arch bleaching

Single-arch treatment is the preferred approach to bleaching tetracycline-stained teeth. One reason is that in these cases the whitening process is often slow and difficult to notice; having the untreated arch for comparison allows the patient to see the progress that has been made, which encourages continued treatment. Also, some patients are unsure if they will be able to follow the treatment regimen due to either lifestyle issues or sensitivity. Starting with one arch allows the patient to attempt the procedure with the least possible cost and determine if they can continue with the full duration. Additionally, treatment of one arch reduces the potential number of sensitive teeth.

This patient presented with mild tetracycline staining and agreed to treat just the maxillary arch first. Generally, only the maxillary teeth show when the patient is smiling, although the mandibular teeth are often visible when the patient is talking.

Nightly tray bleaching with 10% carbamide peroxide was performed on the maxillary arch for 9 months. The color change, which was very gradual and might otherwise be quite subtle, is easily visible in comparison with the mandibular arch.

Following completion of bleaching of the maxillary arch, the mandibular arch was treated with nighttime bleaching for 6 months with good results.

CASE 3 Gradual color change in the treatment of tetracycline stains

Tetracycline causes stains that can be a number of different colors, depending on the analogue of the drug that was taken. These colors respond to bleaching at different rates, with gray stains being the most resistant to change. Also, teeth lighten from incisal to gingival, so dark discolorations located in the gingival area have the poorest prognosis for bleaching. Patients need to be made aware of the slow process of change and have reasonable expectations for outcomes based on the initial color and location of the stains on their teeth.

Initial clinical presentation of patient with tetracycline staining reveals a banded appearance. The darker gray band in the middle portion of the tooth will be most resistant to bleaching.

After 1 month of nightly tray bleaching with 10% carbamide peroxide, the incisal edges are responding well, but the band is still evident. The untreated mandibular teeth give an indication of the amount of color change achieved thus far.

After 2 months of treatment, the color change is evident, but a subtle banding effect is still noticeable.

After 4 months of nighttime bleaching, the banding is only slightly visible. The patient, having both reasonable expectations for the gradual nature of the color change and the benefit of the untreated mandibular teeth as a point of reference, was motivated to continue treatment long enough to achieve a significant color improvement.

CASE 4 Maximum bleaching results

Teeth have an intrinsic maximum bleaching potential. Once they have reached this point, further treatment, regardless of the agent, concentration, or time, does not cause further lightening. In tetracycline-stained teeth, a minimum of 2 months of treatment should be attempted to determine if the teeth will respond. Once the teeth start responding, then the teeth should be evaluated monthly to determine their progress. When 1 month of treatment has passed with no obvious further color change, it is safe to assume the maximum bleaching result has been achieved.

Tetracycline staining is the suspected cause of discoloration in this patient, who had previously considered veneers the only treatment option.

A dramatic outcome is achieved after 4 months of nightly bleaching using a nonscalloped tray with no reservoir and 10% carbamide peroxide. The patient experienced no problems with increased sensitivity.

The patient wanted to continue treatment to reach maximum lightening of all teeth, so 6 additional months of bleaching were completed. The final result is very good; however, little additional whitening was achieved in the last 6 months of treatment, indicating that the teeth had essentially reached maximum lightness after 4 months of treatment.

Lingual view of mandibular teeth demonstrates the extent of discoloration before bleaching.

Following 5 months of bleaching in the mandibular arch, a good match to the maxillary teeth has been achieved. Mandibular teeth often take slightly longer to bleach than do maxillary teeth. Patients are often not as motivated to bleach the mandibular teeth since the teeth are not as visible as the maxillary teeth and are usually only seen when they are talking.

Bleaching was continued for an additional 5 months to satisfy the patient's desire for maximum whitening. The lingual view shows the dramatic change in color.

Results at 10 months are not significantly different than those achieved at 5 months, indicating the teeth had achieved their maximum lightening much earlier. However, the outcome for both arches is a dramatic improvement from baseline.

CASE 5 Incisal staining

Discolorations located in the gingival third of the tooth are the most difficult to remove for two reasons: *(1)* in this area of the tooth, the enamel is the thinnest and the dentin is the thickest, and *(2)* it is difficult to retain bleaching material in the gingival section of the tray (although nonscalloped trays with no reservoirs can be used for extended treatment since these seal against the tissue better and use less material). As a general rule, patients who have darker staining incisally and lighter gingival discoloration will have a better prognosis since incisal stains are easier to remove.

The tetracycline staining is located primarily in the incisal portion of the tooth.

The unstained premolars had formed after cessation of tetracycline ingestion, providing an excellent point of reference for the patient's ideal tooth shade.

After 6 months of bleaching the anterior maxillary teeth only, the outcome is good. Discolorations in the incisal area respond better to bleaching than do those in the gingival area of the tooth.

Bleaching has resulted in a natural color that closely approximates that of the unstained premolars. However, the bleached tetracycline-stained teeth do not whiten to a shade as light as that of the unstained natural teeth.

CASES 6 TO 13 Mild to moderate staining

Treatment times for tetracycline stains vary widely, even when bleaching discolorations of similar severity. Although the following cases all present mild to moderate tetracycline stains treated with tray bleaching regimens of 10% carbamide peroxide, the duration of treatment varies widely from case to case. Reasons for such variations can include intrinsic differences in the stains, individual characteristics of the teeth, and the degree of whitening desired by the patient. The range for treatment times can be 1 to 12 months of nightly wear, with an average of 3 to 4 months for most discolorations. Also, the patient's ability to continue the treatment and their happiness with the progress will determine whether their teeth reach the maximum whiteness.

CASE 6

Initial discoloration indicates a good prognosis for the incisal two thirds of the tooth, but poor prognosis for the darker stains in the gingival portion.

Outcome after 2 months of nightly bleaching was pleasing to the patient. A low lip line concealed most of the gingival discoloration.

CASE 7

Initial presentation of mild tetracycline stains.

After 2 months of bleaching, this patient's teeth appear more translucent, primarily in the incisal two thirds. Some teeth become more translucent with bleaching, while others become more opaque; it is not possible to predict which outcome will occur.

CASE 8

Initial presentation of moderate discoloration with small areas of staining at the gingivae.

Nightly bleaching with 10% carbamide peroxide for 3 months achieved a satisfactory result for the patient, although the gingival discoloration is still visible.

CASE 9

Mild tetracycline staining at initial presentation *(a)*, and results following 4 months of treatment in the maxillary arch *(b)*.

CASE 10

Moderate tetracycline staining at initial presentation *(a)*, and results following the average treatment time of 4 months *(b)*.

CASE 11

Mild tetracycline staining at initial presentation *(a)*, and results following 7 months of treatment in both arches *(b)*.

CASE 12

Moderate tetracycline staining at initial presentation *(a)*, and following 8 months of treatment *(b)*; the patient occasionally skipped a nightly treatment, but was still able to achieve acceptable results.

CASE 13

Mild tetracycline staining at initial presentation *(a)*, and results following 11 months of treatment in both arches *(b)*.

CASE 14 Moderate to severe staining in a patient with sensitivity

A history of sensitive teeth is an indication that the patient may have sensitivity with bleaching procedures. An extensive protocol using ingredients such as potassium nitrate has been developed for bleaching sensitive teeth, allowing the patient to extend treatment for the maximum time needed to remove the discoloration, particularly in moderate to severe cases. Alternatively, bleaching can be performed at less frequent intervals to reduce sensitivity. Research has shown that any sensitivity experienced during bleaching does not continue after termination of treatment. Recalls of these patients at 7.5 years show no sensitivity outside normal preoperative sensitivity and no apparent damage to enamel, dentin, or pulp.[1,2,5,6]

This patient had moderate to severe gray tetracycline staining and wanted slightly lighter teeth, but was not interested in porcelain veneers.

Because the patient experienced sensitivity with bleaching, treatment was performed only every third night. After 6 months (568 hours) of treatment in the maxillary arch, the gray was not completely removed, but the patient was pleased with the outcome. Bleaching regimens using tray application of potassium nitrate are now available for treating patients with sensitivity. Often gray discolorations only get "lighter" but not "whiter."

CASE 15 Moderate to severe staining in a cracked tooth

At initial presentation, this patient had moderate to severe tetracycline staining, which makes the crack on the maxillary left central incisor more noticeable.

Results following 7 months of nightly treatment with 10% carbamide peroxide in the maxillary arch. The crack is now much less visible.

The mandibular teeth have also been bleached and now are well matched to the maxillary teeth.

CASES 16 AND 17 Severe staining

It can be very difficult to obtain any significant lightening when treating severe discolorations, especially gray stains; unfortunately, however, the outcome cannot be predicted prior to treatment. Patients who have sensitivity in addition to the severe staining have the poorest prognosis and should be managed carefully.

CASE 16

Gray tetracycline staining with darker banding mid-tooth before treatment.

The tooth shade only improved slightly after 6 weeks of bleaching, and the gray banding is still quite evident. The patient discontinued treatment at this point.

CASE 17

Initial presentation of severe tetracycline staining.

Eight months of bleaching in the maxillary arch provides an acceptable outcome for the patient. To avoid sensitivity, the patient followed a regimen of bleaching only 6 nights a week.

Closeup view demonstrates the amount of color change that has been achieved in the maxillary arch.

After 2 months of bleaching in the mandibular arch, the teeth are beginning to match.

CASE 18 Severe staining with erosion and decalcification or caries

Often when people are not happy with the appearance of their teeth, they do not take care of them adequately, resulting in gingival decalcifications or caries. Brushing too aggressively in a desire to obtain whiter teeth also causes the problem of removal of enamel and exposure of the darker discolored dentin. Bleaching the teeth to a lighter shade often is followed by patient improvement in oral hygiene self-care.

The patient presented with severe tetracycline staining in addition to erosion and decalcification at the gingivae due to poor oral hygiene, which made her a poor candidate for veneers.

After 6 months of nightly bleaching treatment in the maxillary arch, the patient is motivated to take better care of her much whiter teeth.

CASE 19 Bleaching as gateway to additional dental treatment

Patients often have difficulty seeing the need for dental treatments described by the clinician, especially if they are focused on the poor esthetics caused by tooth discoloration. Once tooth staining has been addressed, the patient is often interested in correcting other problems that were not as noticeable due to the overriding influence of the discoloration. In this way, bleaching is frequently a gateway to patient acceptance of additional dental care that will improve the patient's oral health, function, and esthetics.

This patient presented with tetracycline staining and poor alignment of the mandibular teeth, but was initially only interested in treating the discoloration.

Following the improvement of the color with bleaching, the patient has decided to undergo orthodontic treatment to improve the alignment of the mandibular teeth.

CASE 20 Bleaching and bonding

One of the main advantages of bleaching is the preservation of the natural enamel of the tooth. Not only does natural enamel look best, the patient does not begin the inevitable cycle of restoration replacement. It is much easier to repeat bleaching treatment should the teeth discolor than it is to remove and replace restorations, which also results in further loss of enamel.

Rather than having restorations placed to address the moderate gray tetracycline staining and diastema between the maxillary left central and lateral incisors, this patient chose the less invasive approach of bleaching and bonding.

Twelve months of nightly bleaching in the maxillary arch has excellent results.

Despite the improvement in tooth color, the diastema still detracts significantly from the esthetics of the patient's smile.

A single composite restoration has been placed on the mesial aspect of the lateral incisor, providing an attractive smile with only bleaching and bonding.

CASE 21 Dark gingival stains with white spots

White spots cannot be bleached away, but they can become less noticeable as the background of the tooth is made lighter. Occasionally during treatment, the white spot actually gets lighter but generally returns to the pretreatment color when bleaching is ceased.

Dark tetracycline staining is present in the gingival third of the teeth, accompanied by a large unesthetic white stain on the maxillary left central incisor. The patient is most concerned about the dark tetracycline stains. Unfortunately, the dark gingival third has a poor prognosis.

Nine months of nightly bleaching treatment have resulted in an improvement of the incisal two thirds, but a poor response on the gingival third; in addition, the white spot is more visible after bleaching since the background of the teeth did not get significantly whiter while the white spot did.

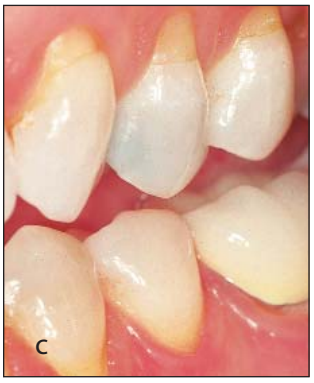
CASE 22 Stains with exposed root surfaces and old amalgam restorations

Research has determined that the properties of dentin differ depending on its location, ie, root versus anatomic crown, near the dentinoenamel junction versus near the pulp. The dentin of exposed root surfaces of both vital and nonvital teeth does not respond well to bleaching. However, veneers placed on dentin rather than on enamel also have poor prognosis, so bleaching is still the best first treatment option to attempt when the roots are exposed. The patient should be informed of the limitations of treatment, and a complete smile analysis should be performed to determine the extent of visibility of the exposed root surface.

Additionally, some of the older (ie, pre-1970s) amalgam restorations cast a gray diffuse discoloration to the tooth that is not amenable to bleaching. In fact, such stains may take on a greenish hue after extended bleaching treatment.

This patient opted first for bleaching rather than immediately using veneers to treat the tetracycline staining on the crowns and the discolored root surfaces.

The anatomic crown has responded well following 7 months of bleaching treatment, but the root surfaces remain discolored. The patient was satisfied with the overall effect from bleaching and elected not to pursue veneers. However, the patient was concerned about the dark maxillary left first premolar.



The dark maxillary left first premolar seen in a lateral view.

The discoloration is the result of an old amalgam restoration, which has turned the color of the tooth gray.

Even after removal of the amalgam, the gray staining remained. Additional bleaching did not change the green-gray color of the tooth. Patients presenting with this situation should consider removal of the amalgam prior to bleaching to determine the prognosis and be made aware of the possible need for additional restorative treatment after bleaching.

CASES 23 AND 24 Bleaching in a dentition with a traumatized tooth

In traumatized teeth the pulp chamber often becomes totally or partially occluded with secondary dentin, resulting in darkening of the tooth. While this is quite noticeable in other teeth, tetracycline-stained teeth are often so discolored that the subtle difference may be overlooked unless given careful examination and evaluated using periapical radiographs. A single dark tooth often will not completely match the rest of the dentition following bleaching; however, the color match will certainly improve.

CASE 23

The traumatized central incisor bleached differently than the other teeth during the 9 months of nightly treatment, resulting in a slightly different shade.

This patient has tetracycline staining, as well as one central incisor that is darker than the other as a result of trauma.

CASE 24

Before treatment for tetracycline staining, the two central incisors do not match. However, the dramatic dark tetracycline staining does not make the mismatch very obvious at first glance.

As bleaching treatment progresses, the maxillary right central incisor becomes much lighter than the rest of the dentition.

A radiograph reveals that the right central incisor does not have a pulp chamber in the anatomic crown, which is the cause of the uneven bleaching. It is hypothesized that the secondary dentin was laid down after trauma and after the ingestion of tetracycline was terminated. As a result, the secondary dentin is unstained and bleached faster than the tetracycline-stained dentin. A radiograph should be taken prior to bleaching treatment to evaluate for this situation, as well as for abcessed teeth or internal resorption. In this case, more uniform whitening should be achieved with extended bleaching of the more severely stained teeth.

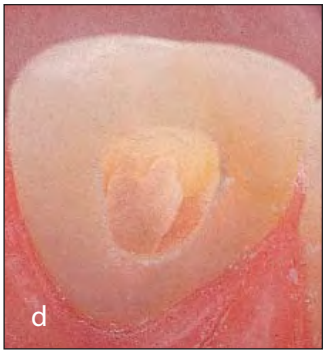
CASE 25 Staining in a dentition with a nonvital tooth

Nonvital teeth respond well to both internal and external bleaching treatment. While the outcome may not be perfect, there is usually an improvement in the color match with other teeth. For more case presentations and information about bleaching nonvital or single dark teeth, see chapter 5.

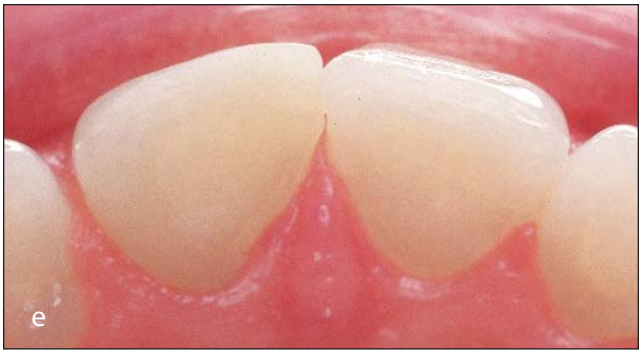
The moderate tetracycline stains detracted from the esthetics of this patient's smile.

The maxillary left central incisor had undergone endodontic therapy and been restored with a Class 4 composite restoration.

Following 11 months of nightly bleaching treatment, the vital teeth have responded reasonably well to the bleaching. However, the endodontically treated tooth is slightly darker than the other bleached teeth.



Internal bleaching with 35% hydrogen peroxide was attempted but had little effect. To help lighten the appearance of the nonvital tooth, the old composite restoration was removed, along with the gutta percha below the cementoenamel junction.



Opaque white composite was placed in the root canal to create an illusion of lightening. This was followed by placement of a Class 4 composite to match the new bleached color.

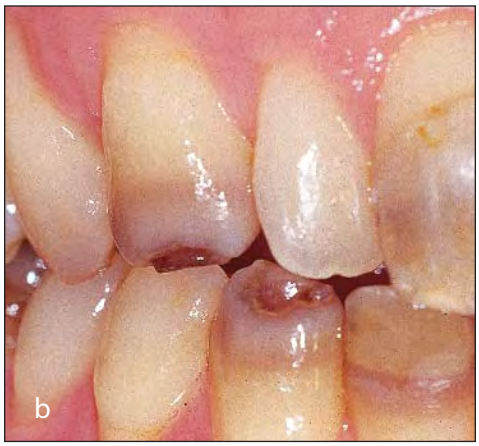
After bleaching and placement of the composite, the left central incisor now blends in with the rest of the teeth.

Minimal intervention of bleaching and composite bonding has resulted in an attractive smile for the patient, with the primary investment being the time required for bleaching.

CASE 26 Stained teeth previously treated with resin composite bonding

Prior to nightguard vital bleaching treatment, composite bonding was the best conservative option for addressing many types of discolorations, with the bonding often placed over unprepared teeth. Today, for cases of teeth previously treated with this approach, the bonding can be removed to reveal the natural enamel, which can be bleached. For more case presentations and information about bleaching teeth restored with composite bonding, see chapter 6.

Pretreatment facial view of composite bonding placed over tetracycline-stained teeth to mask the discolorations. At the time of placement, the composite extended to the gingivae. Now the teeth have further erupted, exposing the edges of the bonding.



The incisal tip of the maxillary right canine, which has no remaining enamel, reveals clear evidence of the severity of the internal tetracycline staining of the dentin.

To avoid making the smile less attractive during the period of bleaching treatment, bleaching is initiated with the restorations in place. The tetracycline discoloration is gradually removed during 2 months of bleaching from the lingual approach under the composite bonding, making the gray less noticeable.

Clinical appearance after 4 months. Composite has been gradually removed as the gray disappeared.

Results after a total bleaching time of 7 months.

After 15 months of bleaching, the only remaining composite lies over the gray band in the middle of the tooth. Treatment has continued for 1 month without any further color change, indicating that the tooth has reached its maximum whiteness.

Abrading the composite with an explorer reveals the extent of the restoration. All other areas are natural bleached enamel.

Final remaining composite has been removed, along with any remaining gray discoloration.

Note the color change in the tetracycline-stained exposed dentin on the incisal edge of the maxillary right canine (compare to Fig b).

Final outcome of bleaching and bonding at 17 months. Composite has been placed on the facial aspect of the maxillary central incisors and the incisal portion of the maxillary canines. All other visible tooth structure is natural enamel.

CASE 27 Staining under veneers

Research has shown that peroxide flows freely through the enamel and dentin to the pulp in 5 to 15 minutes. Hence, it is possible to bleach under existing restoration, even using a lingual approach. Research has also shown that restorative materials such as composite and porcelain do not change color from bleaching. For more case presentations and information about bleaching under veneers, see chapter 6.

Porcelain veneers were placed over unbleached tetracycline-stained teeth 10 years previously. A gray discoloration can be seen through the veneers. The mandibular teeth represent the original color of the teeth prior to veneer placement.

The lingual view shows the tetracycline staining, which the veneers were intended to mask. However, the translucency of the veneers allows the gray discoloration to show through the veneers.

Using a nonscalloped tray with no reservoir, 10% carbamide peroxide was applied to the lingual surfaces of the teeth nightly over the course of 8 months of treatment. The veneers appear lighter following bleaching; however, the color of the porcelain has not been affected. Instead, bleaching has changed the underlying tooth color, which in turn alters the shade of the veneers because of the translucency of the porcelain.

The change in tooth color can be seen from the lingual view. If more translucent (and therefore natural-looking) veneers are desired, it is always wise to bleach the teeth to as light a shade as possible prior to placement. If the veneers are already in place and the patient wants them slightly lighter, bleaching is often a good noninvasive alternative to replacing the veneers

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VITAL OR NONVITAL SINGLE DISCOLORED TOOTH 5

A single dark tooth may be either vital or nonvital, and a nonvital tooth may or may not have previously received root canal therapy. A single tooth may be bleached from the inside out, or from the outside in. A third option that is occasionally used is to bleach from both the inside and the outside, with or without closing the endodontic access opening.

Typically children's primary teeth are not bleached. However, when a tooth has been darkened by trauma, and all other pathology has been eliminated, external bleaching may be the most conservative and cost-effective method to lighten it. Other options include pulpotomy and internal bleaching, or using restorative material to mask the discoloration.

Vital Teeth

Vital teeth may become darkened from trauma that causes blood cells from the pulp to invade and stain the dentinal tubules but is not significant enough to cause pulpal death. Another result of trauma can be the partial occlusion or filling of the pulp chamber with dentin, called *calcific metamorphosis*. Single dark vital teeth in these categories are good candidates for bleaching.

However, there are situations where the teeth are vital, yet are undergoing dramatic pathologic changes such as internal or external resorption. Radiographs and pulp testing are crucial to determining whether bleaching alone is the proper treatment, or more aggressive endodontic therapy or periodontal flap access for treatment is needed. Once clinical and radiographic examinations have ruled out an active pathologic condition as the cause of the discoloration, the patient's esthetic concern of the single dark tooth may be addressed.

As part of the examination, the color of the root and gingiva apical to the anatomic crown should be analyzed. Root dentin does not bleach well, if at all, regardless of the bleaching technique or material employed. Dentin in the anatomic crown of the tooth is different from dentin in the root, and dentin close to the dentinoenamel junction (DEJ) is different from dentin near the pulp; they each respond differently to bleaching.

Patients should be informed of these limitations, which will also affect the esthetic appearance of a veneer or a full-ceramic crown. No reliable method exists for bleaching the roots of teeth internally or externally.

Once the patient is fully informed of the options and associated limitations, the simplest method to lighten dark teeth from the outside is using tray bleaching with 10% carbamide peroxide. The question for the patient is whether they only want to lighten the single tooth, or whether they prefer to lighten all the other teeth as well. Regardless of the bleaching technique employed, the single tooth rarely will be a perfect match after bleaching. However, the single tooth always matches better than before bleaching, whether it alone is bleached, or all the teeth are bleached. Moreover, all other treatment options such as crowns or veneers are still available after bleaching and will have a better appearance when placed on a lighter tooth.

If the patient's desire is to bleach only the single dark tooth to match the other teeth, a nonscalloped, nonreservoir tray is fabricated. The tooth molds for the teeth on either side of the single dark tooth are removed from the tray. The patient then places the bleaching material in the tray nightly until the single dark tooth either matches the remaining teeth or ceases to change color over a number of days.

If the patient would like all the teeth to be lighter, then a conventional nonscalloped, nonreservoir tray is fabricated. To identify the single tooth, a small *x* can be placed on the outside of the tray with an indelible marker. The patient then applies the 10% carbamide peroxide in the single tooth mold for a few nights until its shade approximates that of the other teeth, then proceeds with typical bleaching of all the teeth. An alternative method is to start with traditional night-guard vital bleaching of all teeth, then when the natural teeth no longer change color, the patient can continue placing the bleaching material on the single dark tooth alone until it ceases to alter in shade.

While there are also options for in-office bleaching of single dark teeth, the need for multiple visits make this a more costly alternative. Since the number of visits required to achieve maximum whitening is unknown, the patient must be prepared for an ongoing expense as it is determined whether the procedure will work. Also, since most single dark teeth tend to relapse over time, regardless of the bleaching technique used, the tray approach to bleaching allows the patient future options for re-treatment at a minimal expense.

Nonvital Teeth

If a nonvital tooth has not received endodontic therapy, the patient should be examined clinically for pain or drainage and radiographically for periapical radiolucency. In the absence of clinical signs and symptoms of pathology that would require endodontic therapy, the tooth can be bleached from the outside in the same manner as a vital single dark tooth. There are no reports in the literature of any nonvital tooth requiring endodontic therapy as a result of tray bleaching.

There has been a resurgence of interest in internal bleaching of endodontically treated anterior teeth. There was a time in dentistry when it was thought that all endodontically treated teeth needed a post and crown for maximum survival. However, research has shown that anterior teeth have a better survival rate without full-coverage restorations, unless a crown is needed for other reasons. The primary indicator for the long-term survival of an anterior endodontically treated tooth is the amount of remaining dentin, which is compromised by the removal of tooth structure in preparation for a crown. However, posterior endodontically treated teeth generally should receive full-coverage restorations. This different requirement is due to both the anatomic shape of the posterior teeth (multiple roots compared with the single root of an

anterior tooth) and the occlusal forces placed on the posterior teeth given their location in the arch.

If the anterior discolored tooth has been treated endodontically, then the first question when choosing a bleaching technique is whether or not the endodontic therapy appears satisfactory. If the root fill of gutta percha is well below the cementoenamel junction (CEJ), the access opening is of sufficient dimension to suggest all the pulp horn remnants were removed, and there is no apparent questionable material in the pulp chamber, then the tooth can be treated externally as described above. However, if there is the possibility of inadequate pulpal debridement in the chamber, the gutta percha extends into the pulp chamber, or there is the possibility of the cement extending into the chamber, then internal bleaching would be the best approach.

In these situations, the endodontic access is reopened and the pulp chamber explored for remnants of tissue. This often requires some removal of tooth structure to gain access to the furthest reaches of the chamber. Once the chamber is cleaned, the root filling material is removed 2 mm below the CEJ. A lining is placed to seal off the pulp chamber and keep the gutta percha in the root canal. The liner material could be a glass ionomer, resin ionomer, intermediate restorative material (IRM), polycarboxylate cement, or zinc phosphate cement; the ideal material is one that bonds to dentin. After the material has hardened, a drop of 10% carbamide peroxide is placed into the chamber, followed by a cotton pellet. The orifice is then closed with a provisional sealing material. The bleaching material is left in place for a number of days, then replaced as many times as needed to achieve the maximum lightening of the tooth. The ease of use of 10% carbamide peroxide and a provisional sealing material results in minimal chair time at the additional appointments, which keeps the cost to the patient relatively low. The minimal concentration of the 10% carbamide peroxide makes it safe for oral use, as well as for handling by the dentist or contact by the patient should the seal be broken.

Once the tooth either matches the color of the adjacent teeth or no longer changes color with treatment, it is ready to be restored. It may be best to wait an extra 2 weeks after the last treatment to allow the color to stabilize and the bond strengths to return to normal. Then the internal chamber can be etched, primed, and bonded with composite materials. If the tooth does not match the adjacent teeth, a white opaque composite should be placed internally to further lighten the tooth. The external portion of the tooth can be restored with a shade-matched composite restoration.

Once the tooth has been adequately restored, if there is a need for later bleaching due to relapse, the outside approach is preferable. Any attempt to remove the bonded composite restoration will result in additional removal of dentin, which will weaken the tooth.

Other Bleaching Options

A number of methods have been used to bleach single dark teeth internally. One of the original methods was to place 35% hydrogen peroxide inside the coronal pulp chamber and catalyze it by heat or light to hasten the breakdown of the hydrogen peroxide and potentially accelerate the bleaching process. This process was repeated as many times as necessary until an acceptable result was achieved. A later alternative to this procedure was the walking bleach technique, so called because a mixture of hydrogen peroxide and sodium perborate crystals was sealed in the pulp chamber, and the bleaching occurred while the patient walked out of the office. The advantage of the walking bleach technique was that less chair time was required because the tooth whitening occurred outside of the office over a period of days or weeks. The disadvantages with both of these bleaching techniques are the caustic nature of the 35% hydrogen peroxide and the fact that the results are

difficult to predict or control. There is no way to accurately predict the number of treatments required prior to initiating treatment.

A more serious problem with the use of 35% hydrogen peroxide, especially with heat, is the possibility of internal or external resorption, especially in patients with a history of trauma. A relatively limited number of teeth are affected, but when it does occur, it is a significant problem. Although the causes of this resorption are not fully known, a review of the literature indicates a number of possible causes. The most common relationship was in people who experienced traumatic injury. All the cases reported also used the high (35%) concentration of hydrogen peroxide, and heat used with bleaching seemed to be a causative factor for resorption. None of the cases in the literature employed a protective base or liner between the pulp chamber and the gutta percha. Additional possible causes include a deficiency in the cementum, exposure of the cervical dentin to the oral cavity (occurring in approximately 10% of the population), injury to the periodontal ligament triggering an inflammatory response (trauma), and infection sustaining the inflammation.

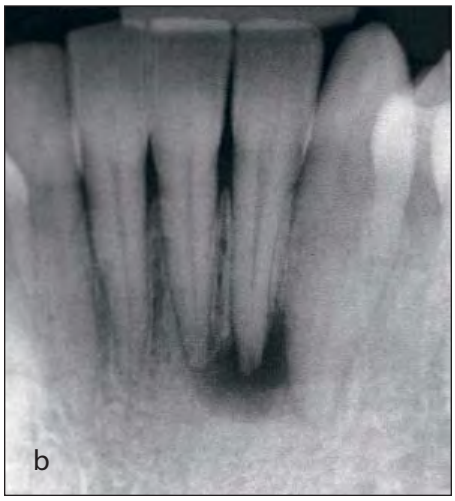
The first alternative to the caustic 35% hydrogen peroxide was the use of sodium perborate alone. No reports of resorption have been cited with sodium perborate when mixed with water or local anesthetic. However, handling of the material is somewhat difficult. It has been shown that 10% carbamide peroxide is equally effective when compared with the higher concentration of hydrogen peroxide or sodium perborate, and it is much easier to inject into the prepared pulp chamber from the dispensing syringe.

Another technique with limited application is the practice of preparing the tooth for the walking bleach technique combined with the at-home tray technique. In one variation of this approach, the pulp chamber is left open, allowing the patient to place 10% carbamide peroxide inside the chamber with the dispensing syringe, and, at the same time, apply 10% carbamide peroxide externally with the tray. This technique is called *inside-outside bleaching*, and can be very effective and safe. However, it is best suited for patients who are conscientious and capable of applying the solution intraorally. With this technique, a barrier should be placed over the gutta percha to prevent contamination of the root canal, and the patient should either wear the tray all the time or place cotton in the chamber when not using the tray. An irrigation syringe for the chamber and a small tool or device for removing the cotton when used should be provided to the patient. There is little cause for concern regarding caries during the limited treatment time because 10% carbamide peroxide inhibits caries formation, but the patient must have the orifice closed after treatment is completed or risk losing the tooth. A variation of the inside-outside technique is to close the orifice after placing the 10% carbamide peroxide inside the tooth while also using a tray externally for additional whitening.

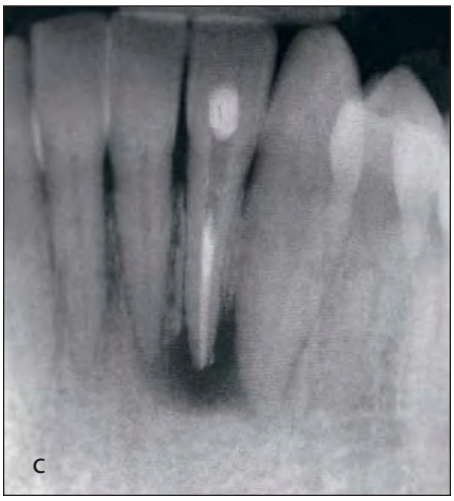
At this time, the safest material for internal bleaching is either sodium perborate mixed with water or 10% carbamide peroxide, but peroxide is preferred because of its ease of use.

CASE 1 Need for radiographic examination

This patient presented with an asymptomatic single dark tooth. In such situations, the first consideration should be whether or not there is a pathologic reason for the discoloration, which can be determined by radiographic examination.



A radiograph reveals a large apical lesion, involving at least one tooth and potentially others and requiring endodontic therapy. The patient had never experienced any pain, discomfort, swelling, or fistula.



Radiograph following endodontic treatment demonstrates resolution of the abscess. If bleaching had been performed without radiographic examination, the discoloration indicating the abscess would have been masked. Failure to treat the abscess could have resulted in loss of the tooth from external resorption and involvement of adjacent teeth.

CASES 2 TO 13 Full-arch external bleaching

The following cases show the treatment of a single discolored tooth using 10% carbamide peroxide in a full-arch nonscalloped, nonreservoir tray with reasonably successful results. When this approach is used, the adjacent teeth will lighten until they reach their maximum whiteness, then stop changing color. The single dark tooth will continue to lighten until its own maximum whitening potential is reached. Often the use of a permanent marker to indicate the single dark tooth mold in the tray helps the patient to localize application of the material when the other teeth have ceased to lighten. Some patients prefer to place the bleaching material in the mold for the dark tooth alone until it approximates the color of the rest of the teeth, then bleach all teeth to their maximum whiteness. In general, the darker tooth is always a better, but not perfect, match to the rest of the dentition.

In every case, clinical and radiographic examination was completed prior to bleaching.

CASE 2

A single dark tooth is very disruptive to the visual balance of the smile. This tooth is vital, but dark from trauma.

Although the color match after bleaching is not ideal, from a conversational distance the smile is more harmonious after bleaching than it was before.

CASE 3

This patient had a vital single dark tooth and slight discoloration in the rest of his teeth. He was self-conscious about the mismatch and was interested in lightening all the teeth if possible.

After 6 weeks of bleaching, all the teeth are lightened, and the single dark tooth more closely matches the surrounding teeth.

CASE 4

The whiteness of the rest of this patient's teeth made the single dark vital tooth very conspicuous.

After bleaching, there is much more harmony in the smile. The color of the other teeth was virtually unchanged, as they were already very close to their maximum whiteness.

CASE 5

This single dark tooth has a history of trauma but has remained vital. The brown discoloration is a result of iron pigments in blood aspirated into the dentinal tubules. The adjacent teeth are mildly discolored.

A single dark tooth often has a slightly yellow appearance after bleaching, but is always a better match to the adjacent teeth than it was before treatment.

CASE 6

The brown staining on this single dark tooth is associated with blood in the dentinal tubules. The tooth tests vital and needs no endodontic therapy. The tooth is a very distracting element in the appearance of the teeth.

After 6 weeks of bleaching there is a slight yellow tinge remaining in the tooth, but the color is much more harmonious when compared to the rest of the teeth.

After 3 years with no touch-up or re-treatment to the single dark tooth, it has become somewhat more yellow. However, the patient remains pleased with the current condition and is not interested in re-lightening the teeth at this time. Regardless of the bleaching technique, a single discolored tooth seems to regress over time.

CASE 7

This single dark tooth did not test vital; however, there are no other signs or symptoms of pathology (no radiographic evidence of pathology, and no pain or fistula). Options for treatment include external bleaching, endodontic therapy with internal bleaching, veneers, or crowns.

A radiograph demonstrated no periapical pathology. However, the presence of a supernumerary tooth make endodontic therapy undesirable unless absolutely necessary.

Bleaching with a nonscalloped, nonreservoir tray using 10% carbamide peroxide is chosen as the method of treatment. After 6 weeks, the anatomic crown of the left central incisor now more closely matches the adjacent tooth. The next step in treatment would be to cover the exposed root using a periodontal procedure. There is no consistently effective way to bleach the root surface of a tooth, either internally or externally.

CASE 8

A slight yellow discoloration in one tooth can be a distraction amongst otherwise white teeth.

After bleaching with 10% carbamide peroxide in a nonscalloped, nonreservoir tray, the appearance is much more desirable.

CASE 9

Although there are other problems with the appearance of the teeth, the single dark tooth is the most noticeable to the patient.

After bleaching lightened the dark tooth, the patient decided to pursue additional dental treatment to further improve the smile.

CASE 10

The tetracycline staining in addition to the single dark vital tooth results in a slower treatment prognosis.

Four months of tray bleaching is required to achieve a reasonable response from the gray tetracycline-stained teeth. During treatment, the shade of the single dark tooth also begins to match more closely to the rest of the teeth.

CASE 11

The maxillary right central incisor is discolored as a result of trauma, but still vital. A removable partial denture has been placed, and the crown replacing the adjacent left central incisor is rough and lacking in surface luster.

After 6 weeks of bleaching, the color match is more appropriate and the denture tooth has been polished. The patient has a more attractive smile and is now interested is options for hiding the clasps of the removable partial denture. (Courtesy of Dr Kevin Frazier.)

CASE 12

The single dark vital tooth and adjacent teeth are to be bleached with a conventional tray. The mandibular arch is not being lightened.

After bleaching, the tooth more closely matches the rest of the dentition.

CASE 13

Some teeth require a longer treatment time to reach an acceptable outcome. In this case, there is only a slight difference between the central incisors at first presentation.

Eight weeks into treatment, the shade of the central incisors matches more closely, and the overall color is better.

Final treatment time was a total of 5 months of nightly tray bleaching, but the outcome produced a good match.

CASE 14 Single-tooth external bleaching

If a patient wants to bleach only a single discolored tooth, a nonscalloped, nonreservoir tray is fabricated, and the molds for the teeth on either side of the single dark tooth are removed from the tray. Nightly tray bleaching continues until the single dark tooth either matches the remaining teeth or reaches its maximum whitening potential.

The patient is concerned about the single dark tooth, but is happy with the color of the remaining teeth. The tooth is vital and has not received endodontic therapy, nor is it indicated. There is no radiographic evidence of pathology nor any symptoms associated with the tooth.

A nonscalloped, nonreservoir tray is constructed, and the tooth molds on either side of the dark tooth are removed. In this photograph, foam has been placed inside the tray to better show the fit.

The patient continues bleaching until the dark tooth more closely matches the adjacent teeth.

CASES 15 TO 18 Less-than-ideal outcomes with external bleaching

Not all single teeth respond well, and some discolorations are difficult to resolve, especially when there is great color variation amongst the anterior teeth. The following cases demonstrate this challenge.

CASE 15

Several variations of shade exist in these anterior teeth. Surprisingly, the darkest tooth, the left central incisor, tested vital, while the right central incisor tested nonvital.

A nonscalloped, nonreservoir tray was fabricated, and the teeth bleached. There is improvement in the color, but a mismatch between the central incisors remains.

CASE 16

The color difference between the central incisors, in addition to the white decalcification, make this a very difficult situation for bleaching alone.

After bleaching all the teeth for 6 weeks, the white is not as noticeable, and all the teeth are lighter. However, there is still a significant mismatch between the central incisors.

CASE 17

The right central incisor is darker than the left central incisor, which has a stark white discoloration. Both conditions have limitations in bleaching therapy.

After bleaching, there is a better match between the central incisors, and the white is less noticeable since the background of the tooth has lightened. However, this result was not acceptable to the patient, so further treatment is required. It is always best to bleach before pursuing other restorative options, so that the teeth are as light as possible, thus imparting the maximum translucency to the restorative material.

CASE 18

In addition to the dark right central incisor, there are poor esthetics in the gingival area surrounding the tooth and a large space between the central incisors. Bleaching was the first treatment option pursued in an attempt to improve the appearance of the smile without restorative treatment.

The outcome was a reasonable match between the central incisors, but further restorative treatment will be required to complete the smile transformation.

CASES 19 AND 20 External bleaching of nonvital teeth

CASE 19

This single dark tooth has had endodontic therapy, with complete removal of the pulp chamber contents, and has been sealed with a clinically acceptable bonded composite restoration. The color distribution on the tooth is unusual.

The dark tooth is very noticeable in the smile because of the patient's high lip line.

After bleaching, most of the brown is removed.

Even though the dark tooth is not an ideal match to the rest of the teeth, the appearance of the smile is much improved, and the patient can decide whether to pursue the next level of treatment, which could be bonding, a veneer, or a crown.

CASE 20

One central incisor is slightly darker than the other after endodontic treatment.

From the lingual view, it is clear that the discoloration is not related to the restoration. The radiograph did not indicate any gutta percha in the pulp chamber, and all contents of the pulp chamber appeared to have been removed.

External tray bleaching with 10% carbamide peroxide is used to harmonize the color of the single dark tooth with the rest of the dentition.

CASE 21 Internal bleaching of nonvital teeth

The porcelain veneer on the left central incisor appears dark because of the endodontically treated and discolored tooth underneath.

The lingual view reveals the darkened central incisor under the porcelain veneer.

Removal of the lingual composite reveals that the discoloration is due in part to gutta percha extending too far into the pulp chamber. Often this is apparent on a radiograph.

Gutta percha is removed 2 mm below the CEJ. Resin-modified glass ionomer is used to seal the gutta percha from the remaining pulp chamber, and a drop of 10% carbamide peroxide is inserted into the pulp chamber. Cotton is placed over the peroxide, and sealant is placed.

The material was changed weekly for 4 weeks, and the access cavity was closed with an acid-etched, bonded composite restoration. The final outcome shows some lightening to the root and anatomic crown. Should there be any further darkening, the tooth can be bleached from the outside.

CASE 22 External and internal closed bleaching of nonvital teeth

Endodontically treated canine is discolored by blood iron pigments. The planned treatment is internal and external bleaching.

After one internal application of bleaching materials and 21 days of tray treatment, a white opaque composite is placed in the pulp chamber to achieve the maximum lightness. (Courtesy of Dr Amber Lawson.)

CASE 23 External and internal open bleaching of nonvital teeth

The left central and lateral incisors are discolored from trauma and have undergone successful endodontic therapy.

A reasonable outcome is achieved with inside-outside bleaching, in which the patient injected bleaching material into the pulp chamber and used a bleaching tray. The treatment time involved is usually shorter using this dual bleaching approach; however, this is only suggested for patients who will be conscientious in the application of the material and who will return and have the orifice sealed after treatment. (Courtesy of Dr Kevin Frazier.)

CASE 24 Bleaching vital teeth to match a lightened single nonvital tooth

After endodontic therapy, the endodontist performed a conventional walking bleach treatment using 35% hydrogen peroxide. This resulted in an overlightening of the endodontically treated tooth.

Tray bleaching with 10% carbamide peroxide is used to lighten the vital teeth to match the endodontically treated and bleached tooth.

CASE 25 Bleaching single dark teeth in children

Children's teeth are generally very white; however, trauma to this 4-year-old child's central incisors resulted in discoloration. After pathology was ruled out, external tray bleaching was selected as the best treatment option.

The patient bleached 1 hour a day for the first week, then for increasing lengths of time per day for a total of 47 hours bleaching over 4 weeks. The color became more acceptable, and the teeth exfoliated normally with no sequelae to the permanent teeth.

BLEACHING WITH RESTORATIVE TREATMENT 6

While bleaching of discolored teeth usually provides significant improvement to a smile, in some cases additional restorative treatments may be indicated to achieve the desired esthetic result. In addition, there are many cases in which a patient presents with existing restorations that need to be replaced for functional reasons or that do not match the natural dentition. It is important to discuss all possible treatment options with the patient during the planning stages and to conduct a thorough smile analysis and bleaching examination. Patients should be aware of the possibilities and limitations associated with bleaching and other proposed procedures, such as esthetic recontouring, microabrasion, macroabrasion, bonded composite restorations, composite or porcelain veneers, and all-ceramic or porcelain-fused-to-metal crowns, used alone or in combination. In nearly every case, it is advantageous to perform bleaching before any other treatments because *(1)* it is the least invasive option and may provide sufficiently pleasing results, precluding the need for further treatment, and *(2)* the lighter shade of the teeth allows for the placement of more esthetic restorations.

When Bleaching Is Not Enough

Sometimes bleaching is successful but the patient is still unhappy with the shape of the teeth. In these cases, it is best to bleach first, then follow with esthetic recontouring or restorative treatment.

Bleaching in conjunction with esthetic recontouring requires knowledge of esthetic principles, which include the appropriate location of the incisal edges of the anterior teeth, the location of the gingival contours of the teeth, and the proper tooth shapes as defined by the line angles. Additionally, understanding of occlusion is essential, since alteration of the anterior teeth can potentially alter anterior guidance. Although recontouring is a subtractive treatment, involving the removal of tooth structure, bleaching combined with recontouring remains the simplest and most long-lasting treatment option.

In some cases, the tooth form requires additive (ie, restorative) treatment if an esthetic smile is to be achieved. Once the teeth have been bleached to the desired color, a matching shade can be chosen for the restoration, whether it may be composite bonding, a veneer, or a crown.

Unsuccessful Bleaching Therapy

When stains are not responsive to bleaching, they have to be either removed by abrasion or masked by a restoration. The patient should be informed up front regarding the treatment options and the different fees for each procedure.

The first option would be to remove the staining using either microabrasion or macroabrasion. Microabrasion involves the softening of the surface of enamel by a mild acid and the subsequent removal of the enamel by abrasion with pumice. Macroabrasion involves the use of a high-speed handpiece and finishing diamonds or carbide burs, followed by disk and paste polishing.

Superficial discolorations can usually be removed from the enamel surface; however, it is impossible to know in advance whether the discoloration is superficial. Should the discoloration extend to the dentin or become more visible following abrasion, a resin composite restoration will need to be placed to seal the defect and restore contour. Unless the tooth enamel is of a chalky texture, it is best to bleach teeth prior to initiating abrasive techniques to establish the tooth shade, should a resin composite restoration be required.

If additions to the tooth shape and form are needed, or if discolorations must be masked, then bonding of composite restorations is an excellent option. The tooth is first bleached to either its maximum whiteness or to the shade with which the patient is most comfortable. Often the bleaching makes the teeth light enough that composite restorations can hide the remaining discoloration and complete the tooth shape successfully. Restorative treatment should be delayed for 2 weeks after cessation of bleaching to allow the tooth to achieve a stable shade and the bond strengths to return to normal. It has been shown that there is a 25% reduction in bond strengths of etched enamel to composite materials if the restoration is placed immediately after bleaching.

Bleaching and bonding offer a very conservative approach to management of discolored and malformed teeth. A combination of conservative treatments is most cost effective and preserves the natural enamel of the tooth. However, should bleaching, abrasion, and bonding not provide the desired esthetic outcome, other restorative options (ie, composite or porcelain veneers and all-ceramic or porcelain-fused-to-metal crowns) are still available.

A composite or ceramic veneer may be placed on discolored teeth to cover the underlying stain. However, the natural appearance of the veneered surface depends strongly upon the transmission and reflection of light from the underlying tooth structure. If the tooth structure is stained too darkly, the discoloration will show through a translucent resin composite or ceramic veneer. The only solution is to make the veneering material thicker and less translucent, and therefore less lifelike. Moreover, it is necessary to remove more of the facial and proximal tooth structure to achieve the esthetic and functional objectives. Bleaching therapy prior to veneer placement decreases the need for a thicker veneer and more tooth reduction.

In some cases, only placement of a crown will adequately restore esthetics and function. In these situations, bleaching prior to restorative treatment is still the best approach, since the surrounding dentition will have a lighter and more esthetic shade to which the crown or crowns can be matched.

Bleaching Restored Teeth

Bleaching will not change the color of existing restorations. Therefore, during the bleaching analysis, the clinician should identify any existing restorations that show in the widest smile and inform patients of the additional fee associated with replacing any restorations that do not match the teeth after bleaching. Occasionally the existing restoration will match well enough after bleaching to be acceptable to the patient, or it may be that the restorations originally matched the teeth, but the teeth darkened with age. In the latter case, bleaching may restore the teeth to the original shade of the restoration, and additional restorative treatment may not be required. In the case of composite bonding and veneers, the shade of the underlying tooth material can be changed from the lingual aspect, which sometimes gives the veneers a lighter appearance. Also, over time, veneers may acquire stains at the margins. Bleaching can also be used to remove these stains prior to resealing the margins with a dentin bonding agent. Occasionally, there are also cases in which conservative restorations can be removed, and bleaching can be performed to achieve an acceptable esthetic result without replacement of the restorations. However, this is only possible if there has been minimal to no reduction of the tooth structure.

CASE 1 Bleaching followed by composite bonding

A smile analysis reveals the need for bleaching and composite bonding.

Two weeks after bleaching the shade has stabilized and bond strengths have returned to normal.

No preparation other than cleaning the enamel, etching, and bonding was required prior to bonding. This noninvasive, conservative approach provides a good esthetic outcome in terms of both shade and shape.

CASES 2 TO 9 Bleaching teeth with existing composite restorations

Although bleaching with existing composite restorations in place is recommended, it is important that the patient understand that the composite will not change color with bleaching. Some surface staining may be removed, but the basic color of the composite remains the same. Patients often expect bleaching to eliminate any discolorations on their teeth or may think that the discolored composite is actually part of the tooth. Therefore, it is important that the restorations be identified in the bleaching analysis, especially since discolored restorations may actually be more noticeable when the teeth are lightened. Patients need to be made aware of their existing restorations, as well as their financial responsibility should the restorations need to be replaced after bleaching. Even when replacement of composite restorations is planned, it is preferable to bleach the teeth with the restorations in place to best maintain esthetics and function during treatment and to determine the optimal shade for the new restorations.

CASE 2

In the preoperative view, the composite restorations are subtle but visible, especially the restoration on the mesial aspect of the maxillary left lateral incisor.

After bleaching, the appearance is improved, but the composite restorations are still discolored. The patient was aware of the possible need for replacement of the composite restorations prior to initiation of bleaching treatment.

CASE 3

During the bleaching analysis, the old chemical-cured type of composite was identified on the mesial aspect of the maxillary right lateral incisor.

After bleaching, the composite restoration is much more noticeable. The patient ultimately decided to have that restoration replaced to better match the lighter teeth.

CASE 4

The patient is unhappy with the appearance of the composite restoration on the mesial aspect of the maxillary right lateral incisor. It is decided to bleach the teeth first to see if an acceptable outcome can be achieved without replacing the restoration.

After bleaching, the composite restoration is less noticeable, but the patient opts to have it replaced.

Two weeks after termination of bleaching, the restoration is replaced, providing an improved esthetic outcome.

CASE 5

The existing composites on the central incisors will need to be replaced after bleaching for esthetic reasons; however, their form and occlusal function are appropriate.

Appearance of teeth following bleaching treatment.

A lingual matrix records the existing form and function. It then can serve as a template during replacement of the composite to maintain functional occlusion.

Final result after replacement of the composite restorations. The esthetic appearance has been much improved and the established form and function maintained.

CASE 6

In addition to tooth discoloration, there are several discolored composite restorations, some defects on the central incisors, and a mismatch in tooth lengths. An occlusal evaluation reveals that the extruded mandibular incisor is the only protrusive guidance for the longer of the two central incisors but has no maximum intercuspation contact, which means it can be shortened without anticipating further eruption.

The mandibular incisor has been shortened.

The teeth respond well to bleaching, but the composite restorations do not change color. However, the areas of the teeth covered by the composite restorations are bleached, since the 10% carbamide peroxide permeates the enamel from the lingual aspect.

New composite restorations have been placed over the defects on the central incisors, and the older discolored composite restorations on the lateral incisors and premolars have been removed, revealing defects similar to those found on the central incisors.

Composite restorations are placed only in the areas of the defects, leaving the natural bleached enamel exposed. Now the patient is ready to begin the bleaching process in the mandibular arch.

Two months later, the mandibular arch is ready for composite replacement.

The composite restorations are replaced on the mandibular teeth in a very conservative fashion, so that the maximum amount of natural enamel remains uncovered.

CASE 7

Tetracycline-stained teeth after only 2 weeks of tray bleaching with 10% carbamide peroxide. A diastema and discolored composites are present.

After 5 months of bleaching, the patient was satisfied with the extent of the color change.

The dental midline is not exactly coincident with the facial midline.

Small amounts of three different shades of composite resin were placed on the teeth to determine the best shade match.

The left central incisor was restored to match the facial midline, then composite was added to the right central incisor to close the diastema and fill the proximal space.

The polished surfaces of the restorations are mirror images of each other, and the contours of the teeth have been restored with proper line angles.

Two years after completion of bleaching and placement of restorations in the maxilla and mandible.

CASE 8

This 16-year-old patient had previously received composite restorations to cover the malformed and discolored teeth caused by amelogenesis imperfecta.

A close-up of the canine demonstrates the pitted enamel and the brown discoloration of the dentin. The treatment objective was to remove the brown to allow the use of a more translucent composite to rebuild the tooth.

After 7 months of nightly bleaching, removal of the previously bonded restorations, and an allowance of 2 weeks for shade stabilization, the brown discolorations were only slightly lightened, not completely removed.

A close-up of the canine reveals the extent of the remaining brown discoloration. A decision is made to restore the teeth in pairs with directly placed composite resin, thereby masking the brown discolorations.

Both the canines and the right lateral incisor have been restored. After etching and priming, a flowable composite resin was used to mask only the dark browns to the same shade as the surrounding tooth structure. The canines were restored with a hybrid composite to provide sufficient opacity for masking of the discolorations.

Over two more appointments, the remaining anterior teeth were restored in a similar manner, using flowable composite restorations to mask the brown and match the surrounding tooth structure.

The final outcome is a much more pleasing smile.

CASE 9

A smile analysis reveals problems in spacing, tooth form, and tooth shade.

Because the facial midline is not coincident with the dental midline, the restorative treatment is planned to involve adding composite to only one of the central incisors.

Bleaching treatment has been completed.

After 2 weeks, composite bonded restorations are placed to close the spaces. Although placing composite on only one side of the space between the central incisors addressed the problem with the midline, it also created an undesirable asymmetry in the gingival architecture. Generally, closing a space at the midline should involve composite additions to both teeth.

In this case, the lips and attractive smile disguised the gingival asymmetry, and the patient was pleased with her new smile.

CASE 10 Bleaching prior to planned crown replacement

Prior to the placement or replacement of a crown, the patient should be informed of the option to bleach the teeth. The new crown can then be matched to the lighter and more esthetic tooth color.

The crown on the maxillary left central incisor will be replaced, but first the patient would like to bleach the natural teeth to a lighter shade.

After bleaching, the mismatch of the crown is more obvious, but the patient is now ready for the new crown, which can be matched to the lighter tooth color.

CASES 11 TO 16 Bleaching teeth to match existing crowns

CASE 11

The single crown on the maxillary left lateral incisor was a reasonable match when first placed. Now the adjacent dentition has become discolored, making the crown stand out.

After the adjacent dentition has been bleached back to its original color, the crown more closely matches. Thus the esthetic life of the restoration has been prolonged. In such cases, care must be taken not to overbleach the teeth.

CASE 12

The natural maxillary central incisors have yellowed since the adjacent porcelain-fused-to-metal fixed partial dentures were placed 17 years ago.

The maxillary teeth were bleached until the central incisors more closely matched the porcelain. The patient was not interested in bleaching the mandibular teeth.

CASE 13

The single crown on the maxillary left central incisor appears lighter than the adjacent teeth because of insufficient reduction in the preparation.

Bleaching of the adjacent teeth makes the discrepancy between the crown and the natural teeth less noticeable.

CASE 14

The all-ceramic crowns on the maxillary central incisors have been in place for many years, and aging has darkened the adjacent teeth.

Bleaching provides a more esthetic smile without the need for costly re-treatment.

CASE 15

The natural maxillary left central incisor has darkened since the adjacent crowns were placed.

Bleaching restores the natural tooth to a shade that more closely matches the crowns.

CASE 16

The color transition from the anterior ceramic restorations to the natural canine is emphasized because of the discoloration of the canine.

Bleaching the natural teeth provides a more harmonious transition from ceramic to enamel.

CASES 17 AND 18 Bleaching a natural arch to match a restored arch

CASE 17

The shade of the maxillary denture teeth requested by the patient is not in harmony with the natural mandibular teeth.

Bleaching of the mandibular teeth provides a better match.

CASE 18

The shade of the veneers placed on the maxillary teeth was chosen to be harmonious with the patient's face but is lighter than that of the natural mandibular teeth.

Bleaching of the mandibular teeth provides a closer match to the restored maxillary teeth without the need for additional veneers. Should bleaching be unsuccessful, mandibular veneers could still be placed and will look more natural and translucent when placed on lighter teeth.

CASE 19 Bleaching followed by a decision to replace crowns

Some patients will begin bleaching treatment with the intention of matching natural teeth to existing restorations—thereby avoiding the need to replace them—then during the course of treatment decide they want their teeth to be lighter. It is important in these cases to be sure patients understand that they will have to bear the cost of replacing the restorations to match the new lighter tooth shade.

Patient's smile at initial clinical visit.

Patient's smile when the crowns were placed more than 20 years ago. At that time the crowns matched the surrounding dentition.

A smile analysis reveals not only a mismatch between the crowns and teeth, but also some tooth form discrepancies. The original intent was to have the patient gradually bleach the teeth back to the color that matched the crowns, taking care not to overbleach to avoid the need to replace the crowns.

However, the patient decided she wanted to continue bleaching until the teeth reached their maximum whiteness. She understood from the pretreatment discussion that if this made the teeth lighter than the crowns and she wanted to replace the crowns, she would be responsible for the full cost.

After the teeth were bleached to their maximum whiteness, esthetic recontouring and composite bonding were performed to improve the tooth shapes.

The crowns were then replaced to achieve a better color match.

Establishing good gingival contours was a challenge, but the lip line covered any remaining disharmony, and the patient was pleased with her new smile.

CASE 20 Bleaching teeth under existing veneers

This patient's porcelain veneers are more than 10 years old. The maxillary central incisors do not match, and the veneer on the left lateral incisor has a fracture.

A lingual view reveals that some of the mismatch in the porcelain veneers on the central incisors is a result of the darkness of the right central incisor tooth showing through the translucent veneer.

After bleaching with 10% carbamide peroxide in a custom tray for 6 weeks, the lingual view shows that the right central incisor has become lighter and more closely matches the left central incisor.

The veneers also match more closely from the frontal view.

The fractured porcelain veneer reveals a slightly stained tooth.

Bleaching was used to clean the fracture and lighten the tooth. The fractured piece was then replaced using composite bonding.

Bleaching was also used to clean the margins of the porcelain veneers, which often become stained over time. Any defects in the resin cement were then sealed with a dentin bonding agent. This conservative treatment regimen yielded good esthetic results.

CASE 21 Bleaching teeth prior to veneer placement

It was unknown whether bleaching could improve this severely tetracycline-stained dentition because gray discolorations, particularly those in the gingival region, are the most difficult to whiten.

After months of bleaching, only the incisal areas of the teeth had responded adequately, so the decision was made to place veneers.

The intense discoloration of the dentin in the gingival region can be clearly seen on the prepared teeth. The gingival portion of the veneers had to be made more opaque to cover the dark staining.

Six veneers have been placed. Although bleaching was not completely successful, it did provide a lighter incisal edge, allowing more translucency in the veneer. More importantly, the patient could feel confident that the expense of the veneers was justified since more conservative treatment was not successful.

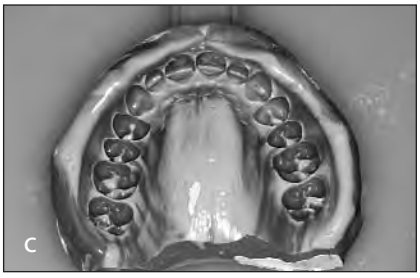
The final placement of all six veneers resulted in a much more attractive smile. The discoloration of the mandibular teeth was masked by the lower lip line, so bleaching alone provided a reasonable improvement to that arch.

APPENDIX A
TECHNIQUES FOR FABRICATING THE BLEACHING TRAYS

STEP 1: IMPRESSION

Tray fabrication begins with a good alginate impression. Wipe alginate on the occlusal surfaces to avoid bubbles.

The alginate impression should be wrapped in a wet paper towel until the cast is poured. It is best to pour the cast soon after taking the impression.



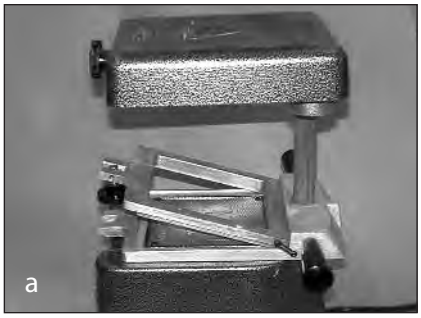
Alternatively, a one-step polyvinyl siloxane putty-wash impression technique can be used; with this approach, the cast does not have to be poured as quickly.

STEP 2: CAST FABRICATION

Once the cast is poured, it should be trimmed from the bottom so that the central incisors are perpendicular to the base of the cast. To facilitate use of the cast in the vacuum former, there should be a hole in the center, and the bottom should be flat. Align the cast in the model trimmer, and trim from the bottom with a firm grasp but light pressure, rinsing periodically to avoid slurry buildup on the stone.

An ideal cast with a flat base, horseshoe shape, and central incisors perpendicular to the base.

STEP 3: VACUUM FORMING

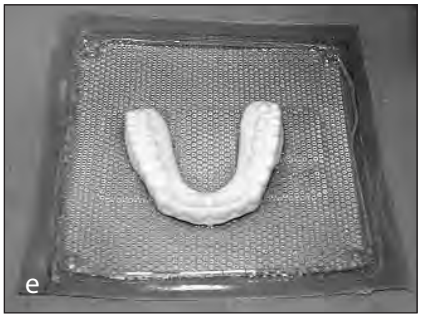


Place the soft, thin tray material in the sandwich holder of the vacuum former.

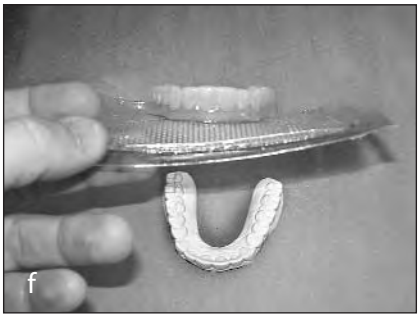
Close the sandwich holder tightly on the tray material, and raise the assembly to the top of the bar where the heater is located. The dry cast should be placed in the center of the vacuum deck. Turn on the heater. After a few minutes, the tray material should become smooth and clear and sag at least 1 inch.

When the material has sagged at least 1 inch below the frame, turn on the machine if it is not automatic. Slowly lower the tray material assembly onto the vacuum deck.

After about 30 seconds of vacuum suction, turn off the machine. Wait for the sheet to cool somewhat, then remove it by grasping it by a corner and peeling it from the machine.

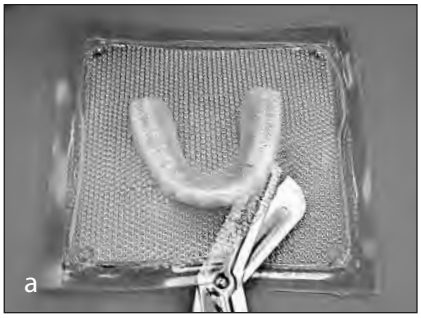


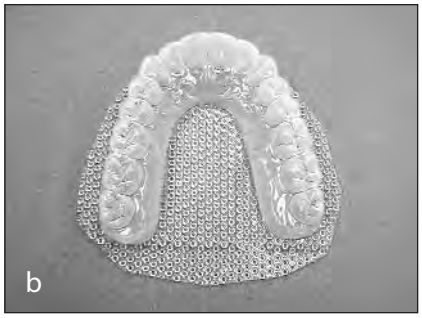
A well-adapted tray should be evident. Let cool prior to removal of cast. If removal is needed immediately, cool the tray under running water to avoid tray distortion.



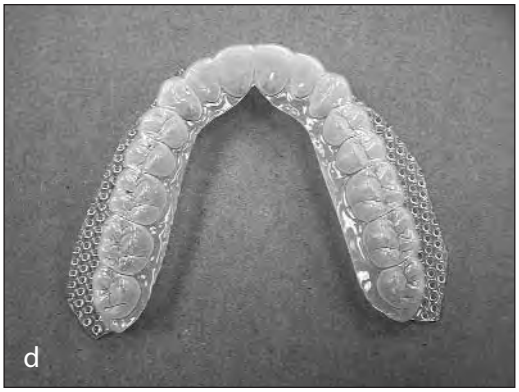
When cooled, the material can be inverted to remove the cast.

STEP 4: TRIMMING THE TRAY





Bulk trimming of the tray material may be accomplished with large, sharp scissors. However, the fine trimming is more easily accomplished with small, sharp scissors with a spring-back mechanism.



Final trimming should be performed using smaller scissors. Trim around the incisive papillae in a *V* shape and about 1 mm beyond the neck of the teeth in a smooth, continuous line. During final trimming, it is helpful to check the fit of the tray on the dentiform cast, making sure there is no contact with the frenum and incisive papilla.

STEP 5: TRY-IN

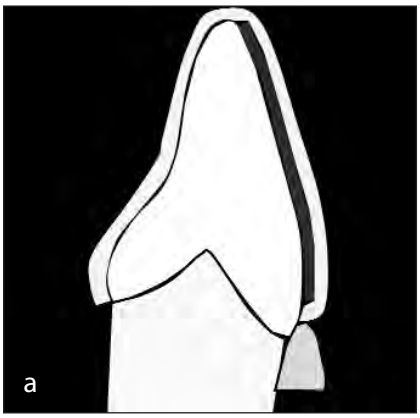
When trying the tray in the patient's mouth, watch for rough edges, blanching of tissue on insertion and closure, and impingement on a torus or frenum.

Remove the tray by grabbing it on one side and peeling it off the teeth.

The tray should be rinsed under cool water, dried, and stored in a carrying case in a cool area away from pets.

The patient needs to practice applying the material in order to know how much to use and where to place it in the tray. This can be done without actually extruding the material into the tray, but the amount to be used should be demonstrated to the patient on a paper towel.

OPTION 1: RESERVOIR TRAYS



A tray may be designed with a reservoir for the bleaching material *(dark blue)* by placing a spacer on the facial aspect of the tooth when fabricating the tray. It extends from the incisal edge to 1 mm away from the gingival margin to allow the tray to seal to the tooth. Reservoirs are not required for bleaching, but they may reduce sensitivity since the tray fits less tightly to the teeth. If using a reservoir tray, it is best to use sticky bleaching materials to help seat the tray.

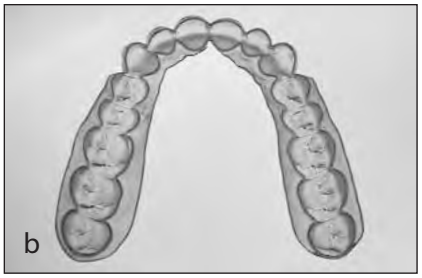
To make a reservoir, place a 0.5-mm-thick layer of light-cure composite material on the facial aspects of the teeth on the cast, leaving a 1-mm space around the gingival margins.

Smooth and light cure the material. Any unset material should be removed by wiping the surface. The cast may then be placed in the vacuum former, and tray fabrication proceeds as usual.

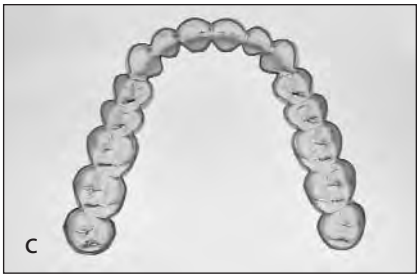
Composite material may also be used during tray fabrication to fill in bubbles and voids in the cast caused by faulty impressions and to fill in undercuts that would interfere with proper seating of the tray.

OPTION 2: SCALLOPED TRAYS

A tray can be trimmed to follow the gingival line; this is called a *scalloped tray*. A scalloped tray can reduce gingival irritation and sensitivity, but the edges may cause tongue irritation, and there is usually poor adaptation in the mandible. When using a scalloped tray, it is best to use sticky bleaching materials to improve retention of the material in the tray and the tray itself.



An alternative is to create a hybrid tray that is scalloped only in the anterior region, since this is where most tissue irritation occurs.



A fully scalloped tray avoids all tissue contact.

OPTION 3: SINGLE-TOOTH BLEACHING TRAYS

A conventional tray design can be used to treat a single dark tooth if all teeth are to be bleached. The dark tooth is identified on the tray with a permanent marker to indicate to the patient where the material should be placed either initially, until the single dark tooth approximates the color of the other teeth, or later, once the rest of the teeth have reached their maximum whiteness but the single dark tooth still requires more bleaching.

If a patient wishes to bleach only a single dark tooth while maintaining the shade of the other teeth, the tooth molds on each side of the dark tooth can be removed and the material placed only in the mold for the single dark tooth.

APPENDIX B
BLEACHING ANALYSIS FORM

Before beginning bleaching treatment, it is important to conduct a thorough patient interview and examination. Using the following form* during this process will help to uncover any possible complications or contraindications, clarify the optimal treatment sequence, and manage patient expectations. This will provide the best chance for good bleaching results and a satisfied patient.

A version of this and other forms, such as information and consent, smile analysis, and patient esthetic self-analysis, as well as bleaching instructions for patients, is also available for download from the author's website, www.vanhaywood.com.

*Adapted from Haywood VB. Bleaching analysis. Contemp Esthet Restorative Pract 1997;1(2):36. Used with permission of Ascend Media.

BLEACHING ANALYSIS FORM

PATIENT NAME: _____ **DENTIST:** _____
CHART NUMBER: _____ **DATE:** _____

INTERVIEW

Medical history:

YES NO Allergic to plastics or peroxides?
YES NO Taking tetracycline antibiotics now?
YES NO Taking hormones that cause bleeding?
YES NO Taking drugs that dry the mouth?
YES NO Tobacco user?
YES NO Pregnant or nursing mother?
YES NO Severe menstrual cycle?

Dental history:

Onset of discoloration? _____
YES NO Previous treatment for discoloration?
YES NO History of trauma?
YES NO History of tetracycline ingestion?
YES NO History of sensitive teeth?
Some: # _____
All
Type of toothpaste used? _____

TMD status:

YES NO Previous treatment? _____
_____
YES NO Current treatment? _____
_____
Current status? _____
YES NO Appliance used? When worn? _____
YES NO Bruxism?
YES NO Other facial pain?

EXAMINATION

Diagnosis of discoloration:

Inherited	Trauma	White fluorosis
Aging	Nonvital	Brown fluorosis
Staining	Tetracycline	Discolored restorations

Tooth visibility in smile:

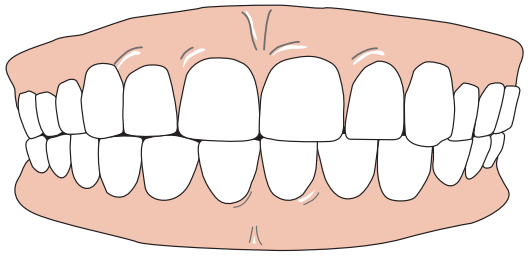
Maxillary vertical: **Tooth #s**
Incisal third _____
Middle third _____
Gingival third _____
Mandibular vertical: **Tooth #s**
None _____
Incisal third _____
Middle third _____
Gingival third _____

Radiographs:

YES NO Periapical concerns? _____
YES NO Pulp size differences? _____
YES NO Internal resorption? _____

Restorations in the esthetic zone:

YES NO Discolored restorations needing replacement:
Crowns: _____
Composites: _____
Other: _____
YES NO Matching restorations that may need to be redone:
Crowns: _____
Composites: _____
Other: _____



Outline the teeth and restorations visible during a full smile to demonstrate to the patient which restorations may need to be replaced after bleaching.

Tooth morphology/characteristics:

			Tooth #s
YES	NO	Surface white spots:	_____
YES	NO	Subsurface white spots:	_____
YES	NO	Brown areas:	_____
YES	NO	Developmental defects:	_____
YES	NO	Single dark tooth:	_____
YES	NO	Translucent teeth:	_____
YES	NO	Exposed dentin:	_____
YES	NO	Caries:	_____
YES	NO	Cracks:	_____
YES	NO	Toothbrush abrasion:	_____
YES	NO	Abfractions:	_____
YES	NO	Wear facets from bruxism:	_____
YES	NO	Other smile deficiencies:	_____
YES	NO	External stains:	_____
YES	NO	Anterior occlusal contacts:	_____
YES	NO	Sensitive to air or touch:	_____

Soft tissue morphology/characteristics:

YES	NO	Soft tissue lesions
YES	NO	Periodontal conditions
YES	NO	Attached gingivae: thick, frail, other
YES	NO	Soft tissue defects: _____

Other prosthesis being worn:

YES	NO	Removable orthodontics
YES	NO	Fixed orthodontics
YES	NO	Removable partial denture
YES	NO	Fixed partial denture
YES	NO	Resin-bonded fixed partial denture

Patient expectations:

YES	NO	Read consent form?
YES	NO	Understands other treatment options?
YES	NO	Reasonable success goals?
YES	NO	Understands fee arrangement?
YES	NO	Understands one-arch treatment?
YES	NO	Understands directions?
YES	NO	Smoking/tobacco discussed?
YES	NO	Understands responsibility for treatment?
YES	NO	Agrees to stop treatment & call office if problems?
YES	NO	Understands possiblitity of relapse and/or need for touch-up in future (1–3 yrs)?
YES	NO	Interested in other treatment? (eg, bonding, veneers, crowns, orthodontics)

Photographs taken: (take "before" and "after" photos at same magnification) YES NO

	Magnification used
Normal smile	_____
Cheeks retracted	_____
Teeth only	_____
Incisal edge end-to-end	_____
Shade tab over lateral	_____

Shade taken: YES NO

Initial shade on value-oriented guide	_____
Special colorants	
Incisal third variation	_____
Middle third variation	_____
Gingival third variation	_____
Mismatched teeth	_____

COMMENTS AND RECOMMENDATIONS

_____

_____

_____

Contraindications for At-Home Whitening

1. Unrealistic expectations
2. Unwilling to comply with at-home treatment
3. Excessive existing restorations not requiring replacement
4. Will not tolerate taste of product

Guarded Prognosis for Whitening

1. History or presence of sensitive teeth
2. Extremely dark gingival third of tooth visible during smile
3. Extensive white spots very visible
4. TMJ dysfunction or bruxism
5. Translucent teeth or exposed root surfaces

APPENDIX C
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