Bleaching the Single Dark Tooth

Changing the color of just one anterior tooth presents unique challenges.

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ABSTRACT

Single dark teeth represent a major challenge to obtain best esthetic outcome in a patient's smile. Treatment options may include single crowns, veneers, bonding, or bleaching. Bleaching is the most conservative option to consider, but the potential for a successful outcome varies based on the cause and extent of the discoloration.

Learning Objectives

- identify the causes of tooth discoloration in the initial examination.
- discuss how tooth trauma impacts the approach to tooth bleaching.
- discuss how endodontic treatment impacts the approach to tooth bleaching.
- describe each possible bleaching approach, the indications for each, and its benefits.

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When a patient presents with either intrinsic or extrinsic staining or discoloration and seems to be a candidate for tooth bleaching, there is a variety of factors and options for the clinician to consider. What is the cause for the discoloration? Is there tooth trauma involved, or has the affected tooth been endodontically treated? What is the best delivery method for the patient's lifestyle, financial situation, and commitment level to home care? Single dark teeth present a unique challenge for color change and the clinician must be aware of the basic principles of changing the color of one or more teeth in order to implement a successful treatment plan.

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The Initial Examination

The first and most important consideration is to determine the cause of the tooth discoloration. A clinical examination is conducted, which includes evaluation of the color of the teeth and the adjacent gingiva (Figure 1). Additionally, transillumination, radiographs, and pulp testing may be appropriate. Radiographs should always be taken of a single dark tooth, as teeth can undergo pulpal necrosis without any other symptom than becoming dark (Figure 2). From this examination, the determination is made of whether the tooth is vital or not. A vital tooth may be darker due to trauma and resultant bleeding into the dental tubules without loss of vitality. Vital teeth may also discolor from internal or external resorption, calcific metamorphosis, as well as decay or leaking restorations on the proximal or lingual surfaces. A non-vital tooth may have become darker from the same reasons as a vital tooth, but also have experienced pulpal death. A tooth that has received endodontic treatment may also later darken, especially if there is a poor seal of the endodontic access opening (Figure 3).

Even if a tooth tests as non-vital, it may not require endodontic therapy. If there is no radiographic evidence of pathology and no clinical symptoms, then there is no reason to initiate endodontic therapy based on vitality testing alone. Often single dark teeth are the result of trauma, which should be determined in the dental history. It can take anywhere from 1 to 20 years after the trauma before any pulpal problems develop.

Additional considerations for the single dark tooth are the color of the gingival tissues around the tooth, as well as whether there is any root structure visible due to recession. A smile analysis is used to determine these conditions as well as the movement of the lip during smiling and whether a "gummy smile" exists. The dentin in the root is different from the dentin in the anatomic crown, and does not bleach well if at all, regardless of whether internal or external bleaching is attempted. Also, discolorations of the gingiva may cause a tooth that may be a perfect color match to not be harmonious. Either of these conditions is magnified if the lip exposes much of the root or gingiva because of a hyperactive lip or gummy smile.

Trauma and Calcific Metamorphosis

Many studies suggest that the prevalence of traumatic dental injuries (TDI) is high, although significant variation occurs between countries, populations, age, and gender.[1-4] Epidemiological studies, while not always comparable, support the growing body of evidence that TDIs represent a significant challenge for clinicians.[5] A study by Koste and colleagues reported that 25% of 6- to 50-year-olds in the United States had experienced a TDI.[6] Approximately 30% of children have sustained a TDI to their primary dentition, and 25% of all school-aged children have experienced a TDI.[7-9] Other reports document that luxations represent the majority of primary teeth injuries, whereas crown fractures constitute the most commonly occurring injury in permanent teeth.[10,11] Also, studies have reported that 71% to 92% of TDIs occur by age 19.[12]

The etiology of dental injuries varies by age. In the 0 to 6 age group, falls predominate.[13] As children enter school, falls, collisions with other children and objects, as well as participation in organized physical activities and sports contribute to dental injuries.[9,14-16] TDIs in the teen and young-adult age group are more the result of sports and motor vehicle accidents.[14] Several studies have documented that approximately one third of dental injuries are sports-related.[15-23] Other causes of TDIs include physical abuse, fights, and assaults—often involving alcohol as an aggravating factor.[24-26]

The pulp can respond to trauma in a limited number of ways. Primarily it can survive, die, or undergo pulp canal obliteration (PCO), often referred to as calcific metamorphosis.[27] The latter represents a common finding subsequent to luxation injuries, 3.8% to 24%, and root fractures, 69% to 73%.[2,28-30] The precise mechanism of PCO is not known but disruption of the neurovascular bundle appears to stimulate the rapid formation of hard tissue (dentin or osseous) beginning within the pulp chamber and progressing along the pulp canal walls.[31] It may present as partial or total obliteration of the pulp canal space. Although radiographs may reveal what appears to be total obliteration of the pulp canal, generally there remains clinical evidence of a pulp canal and pulpal tissue.[32,33] Clinically, the tooth will appear dark yellow due

to the increased deposition of underlying dentin. Additionally, there may be a gradual diminution in response to electrical and thermal pulp testing. PCO occurs more frequently in teeth with open apices and in more severe luxation injuries involving displacement.[2,34] Extrusive and lateral luxation injuries in immature permanent teeth have demonstrated high rates of PCO.[35] A recent study by Netto and colleagues reported the chances of PCO in intruded permanent teeth to be six times greater than in mature teeth, open vs closed apex, and that PCO occurred in 26.7% of such injuries.[36] PCO can occur in subluxated and crown-fractured teeth, although with less frequency.[37]

As mentioned previously, PCO is a common occurrence after root fractures. The location of PCO is thought to be indicative of the type of healing. PCO in the apical segment only is suggestive of hard-tissue callus formation, whereas PCO in the coronal segment or in both coronal and apical fracture segments is indicative of connective tissue repair of the fracture.[2,38]

Pulp necrosis as evidenced by periapical radiolucency is an infrequent sequela to PCO occurring in approximately 7% to 16% of cases; consequently, prophylactic endodontic therapy is not recommended by most authors.[28,39-41] Teeth with PCO likely have diminished healing capacity, and it is not well established whether a secondary trauma or additional dental treatment causes necrosis. In some instances, such as preparing a tooth with PCO for an abutment, it may be prudent to perform prophylactic endodontic therapy before the definitive restorative procedure. A recent article by daCunha and colleagues suggests implementing endodontic therapy prior to development of a periapical radiolucency in a tooth with PCO, based on two major considerations: (1) the technical difficulty and complications that may occur in treating these teeth; and (2) their review of a study that demonstrated a 97.9% success rate for teeth treated without periapical radiolucencies vs a 62.5% success rate for teeth treated with periapical radiolucencies.[42] Specific clinical situations will dictate clinical decisions; however, given the relatively low incidence of pulp necrosis in teeth with PCO, endodontic treatment usually is not recommended in the absence of a periapical radiolucency or symptoms. Nonetheless, if a periapical lesion develops, endodontic therapy can be both challenging and fraught with complications (Figure 4). The use of operatory microscopes in the hands of a skilled clinician is warranted and improves the chances of a successful outcome.

Most traumas to primary teeth are luxation injuries that frequently result in radiographic evidence of PCO. Although this may or may not result in crown discoloration, it ceases to be a concern for the patient, parent, or clinician as the tooth is eventually exfoliated. The only indication for bleaching primary teeth, which are generally very light, is trauma that caused the tooth to become dark and the patient is being affected psychologically by the darker teeth. There is no indication for endodontic therapy.

In contrast, younger patients who sustain TDIs where development of the permanent tooth is incomplete, PCO in the form of a discolored incisor presents a long-term esthetic challenge. The most conservative approach to managing PCO-induced discoloration is bleaching without endodontic therapy.

Tray Bleaching

There are a number of types of bleaching techniques to consider for both vital and non-vital teeth, but these types may be divided mainly into those performed in-office or those continued at home. With the advent of nightguard vital bleaching involving tray application of 10% carbamide peroxide, a method for bleaching single dark teeth became more readily available, and did not involve the use of highly caustic chemicals.[43] The original recommendation for a single dark tooth was to make a non-scalloped, no-reservoir tray, and bleach all the teeth. The tooth that was darker generally took longer, so an "X" was made on that tooth mold of the tray so the patient could continue to bleach that tooth longer than the other teeth. The use of the "X" on the teeth to be bleached was also helpful when the patient already had crowns on some teeth, and placing bleaching material on them was a waste of material. While this tray system was simple and effective, it did not always result in a perfect match of the teeth. All the teeth would lighten, but often the darker tooth was not able to lighten as much as the normal teeth, and the resultant outcome was lighter teeth, but still with one tooth slightly darker than the others. Some authors have recommended using a reservoir on the darker tooth, but the use of reservoirs has not been shown to increase bleaching efficacy.[44] It is not possible to "spot bleach" a tooth either, because the bleaching material goes through the enamel and dentin to the pulp in 5 to 15 minutes, and bleaches under restorations and from one surface to the other (facial to lingual). It has also been shown to bleach beyond the borders of the tray, generally to the cementoenamel junction (CEJ), even if the tooth is only partially erupted.

The ideal bleaching tray is fabricated on a horseshoe-shaped cast with no vestibule to provide good adaptation of the bleaching tray material. Also, the cast should be trimmed such that the central incisors are vertical to avoid folds on the facial. One challenge in fabrication of the single-tooth or regular bleaching tray is trimming the cast without abrading either the teeth or the gingiva. This outcome is accomplished by trimming the cast from the base rather than the sides (Figure 5).

Single-Tooth Bleaching Tray

An improvement on this concept is the use of the "single-tooth" bleaching tray when one tooth is darker, but the other teeth are reasonably acceptable (Figure 6). In this tray design, a conventional non-scalloped, no-reservoir tray is fabricated. Then the teeth molds on either side of the dark tooth are removed (Figure 7 and Figure 8). The patient is given one syringe of bleaching material and applies it only to the single dark tooth mold and sleeps in the appliance. Teeth will bleach at different rates and to different color levels. The goal is to determine how light the single dark tooth will bleach first. If the color of the single


FIG. 1


FIG. 2

CLINICAL EXAMPLES (1.) A clinical examination demonstrates a single, very dark lateral incisor and a moderately dark central incisor with a crown on the adjacent central incisor and several dark gingival areas. **(2.)** A radiograph finds no pulp chamber in the slightly dark central incisor and a silver point on the darkest lateral incisor. A titrated approach to bleaching was needed using individual tooth treatments.


FIG. 3


FIG. 4

CLINICAL EXAMPLES (3.) A radiograph will indicate whether the dark color is related to materials remaining in the pulp chamber, leaking restorations, caries, internal resorption, or failed endodontic therapy. **(4.)** Endodontic therapy was attempted on a tooth with calcific metamorphosis, with subsequent perforation and file fracture in the PDL.

dark tooth does not get as light as the surrounding teeth, then the other teeth are not bleached (Figure 9) and the closest match has been achieved. If the single dark tooth matches the other teeth then, again, the other teeth are not bleached. Only if the single dark tooth gets lighter than the adjacent teeth should they be bleached, and in that case, daytime bleaching in short intervals should be used to avoid getting the adjacent teeth lighter than the single dark bleached tooth. Generally, the patient should be informed that the bleaching time for the single dark tooth is about 8 weeks, although it is highly variable.

"One challenge in fabrication of the single-tooth or regular bleaching tray is trimming the cast without abrading either the teeth or the gingiva. This outcome is accomplished by trimming the cast from the base rather than the sides."

Endodontically Treated Anterior Teeth

If the dark tooth has already received endodontic therapy, then additional considerations for the discoloration include remaining pulp materials in the pulp chamber, endodontic sealer or filler in the pulp chamber, and dark or leaking restorations in the endodontic access opening, as well as endodontic failure. The type of filler is also important, as silver points require different considerations from gutta-percha fillers. Treatment considerations also may depend on when in the endodontic treatment and subsequent follow-up the tooth was noticed to be dark.

Endodontically treated teeth may be treated from the inside, the outside, or both. The decision for inside or outside depends on a knowledge of what has occurred inside the tooth during the endodontic therapy, as well as the type of restoration used to seal the access opening. The tooth may have received a satisfactory endodontic treatment and been subsequently restored with an acceptable lingual composite that matched the tooth color. However, in subsequent years, the tooth may have discolored (Figure 10). In this situation, the decision for bleaching favors external bleaching, because going inside the tooth to remove the composite will weaken the tooth (Figure 11). However, the choice not to go inside the endodontic tooth depends on whether the treating dentist is aware of the extent to which the pulp chamber was debrided during endodontic therapy, as well as the height in the chamber of the cement and filler.

In-Office Bleaching

In-office bleaching is the oldest form of bleaching. Attempts to bleach single dark teeth date back to the 1800s, and bleaching a single dark tooth was one of the first bleaching research areas.[45] A number of materials have been used, but hydrogen peroxide has been the historic favorite. The high concentration of hydrogen peroxide could be applied externally or internally, and often involved heat and light. The classic non-vital in-office bleaching technique involved the placement of 35% hydrogen peroxide into the pulp chamber, and increasing the chemical reaction by the use of heat or light. However, this technique lacks precise control as to the amount of lightening. More critically, when cases of external or internal resorption were evaluated, there were four common concerns listed: 1) teeth had received trauma; 2) high concentrations of peroxide were used; 3) high heat was used to enhance the bleaching, and 4) there was no seal over the gutta-percha. Although the dentist cannot control the trauma, elimination of the other three areas under dental control should be done to lessen the chances of resorption and loss of the tooth. Other possibilities for resorption include the fact that 10% of teeth do not have a connection between the enamel and cementum, with possible percolation of hydrogen peroxide into the surrounding areas, lowering the pH. Using a bleaching product with a higher pH or a salivary catalase are attempts to reduce resorption issues.

Walking Bleach Technique

The change in in-office bleaching led to the next step of "walking bleaching." In this technique, the gutta-percha was removed 2 mm below the CEJ and a


FIG. 5


FIG. 6


FIG. 7


FIG. 8


FIG. 9


FIG. 10


FIG. 11

CASE EXAMPLE ONE (5.) Trimming the cast only from the base (with the central incisors horizontal) until the vestibule is removed and a hole occurs in the palate will avoid the danger of damaging teeth from traditional trimming as well as create the best cast for use in a vacuum-former. **(6.)** A single dark tooth from trauma needs to be examined carefully and evaluated with a radiograph. The safest approach is to bleach this tooth alone until the tooth's response and maximum lightening can be determined. **(7.)** The "single-tooth" bleaching tray has no reservoir or spacers and extends onto the gingiva 1 mm to 2-mm, but avoids frenum movements. The teeth not to be bleached have the tooth molds removed from the tray while maintaining the intact tray. **(8.)** The single-tooth bleaching tray extended further onto the palate than the traditional tray to preserve the tray integrity when the adjacent teeth molds were removed from the tray. The tray edges are hidden behind rugae and go onto the tissue in all areas. **(9.)** A reasonable match was obtained from about 8 weeks of single-tooth bleaching. Often patients discontinue treatment when the single tooth is no longer a mismatch, even if the outcome is not ideal. **CASE EXAMPLE TWO (10.)** This root canal has been successful for 30 years, but the tooth has become slightly discolored. There is no reason from the radiograph to re-enter the pulp chamber, as this will further weaken the tooth. External bleaching by a single-tooth bleaching tray is indicated **(11.)** The 10% carbamide peroxide bleaching material was applied externally with the single-tooth bleaching tray nightly until the shade of the endodontically treated tooth returned to match the adjacent teeth. Should the tooth re-darken again, the process can be repeated without danger to the tooth. Figure 10 and Figure 11 courtesy of Meigan Johnson.


FIG. 12


FIG. 13


FIG. 14


FIG. 15


FIG. 16


FIG. 17


FIG. 18

CASE EXAMPLE THREE (12.) The initial examination and radiograph determined that the dark lateral incisor was abscessed. After endodontic therapy, the tooth was then ready for bleaching. Had bleaching been performed without the radiograph, the abscess would have remained untreated and further damaged the tooth. **(13.)** The endodontic access opening should be enlarged until it can be certain that all the remaining brown pulp tissue has been removed from the lateral walls of the pulp chamber as well as the incisal extent. Pulps that became necrotic when the tooth was young often have pulp chambers much larger than the endodontic access opening. **(14.)** Even before bleaching the tooth, the removal of the brown necrotic pulp remnants and dental materials makes the tooth much lighter. This occurrence demonstrates how the materials inside the tooth affect the color of the outside. **(15.)** For internal bleaching, the gutta-percha should be removed 2 mm below the CEJ. **(16.)** Once the gutta-percha has been removed to the appropriate depth and from the walls of the pulp chamber, the endodontic filler is sealed from the pulp chamber with a resin-modified glass ionomer. Etching is not required for bleaching. **(17.)**The patient may bleach externally (as well as internally) with a full tray rather than a "single-tooth tray" to lighten all the teeth or because there are crowns that will not change color. To identify the dark tooth for additional treatment, an "X" is placed on the tooth mold for the placement of the bleaching material. If the tray is to be worn during the day rather than at night, the "X" should be placed on the lingual. **(18.)** After the tooth being bleached has reached its maximum lightening, the bleaching process should be stopped for 2 weeks to allow the shade to stabilize and the bond strengths to return to normal. Then an opaque whiter composite can be placed in the chamber if needed to further harmonize the tooth color.

base was applied to seal the endodontic filling material from the pulp chamber. Then, initially, a high concentration of hydrogen peroxide was applied, sealed, and the patient "walked out of the office" while the hydrogen peroxide oxidized the discoloration. This treatment took anywhere from 1 to 6 weekly applications. The challenge was that the high concentration of hydrogen peroxide could be caustic to either the dentist or the patient. Later, this technique evolved into mixing the hydrogen peroxide with sodium perborate to form a mixture that was easier to handle. Sodium perborate breaks down into about a 3% solution of hydrogen peroxide. Finally, the high concentration of hydrogen peroxide was eliminated and sodium perborate alone was used. Internal bleaching treatment was followed by the use of a catalase to neutralize the hydrogen peroxide and elevate the pH around the tooth. With any bleaching treatment, time should be allowed for the shade to stabilize and the oxygen to dissipate from the tooth. If bonding is initiated immediately after bleaching, there is a 25% reduction in bond strengths due to the inhibition of the composite set from the oxygen in the tooth, resulting in shorter enamel tags. It generally takes about 2 weeks or longer for the shade to stabilize and the bond strength to return to normal.

Later, 10% carbamide peroxide was found to be equally as effective as sodium perborate for internal bleaching, at the same concentration, with the additional benefit of causing a rise in pH, which may be beneficial to avoid resorption. A 10% solution of carbamide peroxide is equivalent to 3.5% hydrogen peroxide and 6.5% urea. It is the urea that causes the increase in pH within 5 minutes after application to a level above 8, which cannot be accomplished with hydrogen peroxide alone. Also, the carbamide peroxide has a slower peroxide release and is active longer than hydrogen peroxide. This slower application of peroxide seems to favor the rate of color change. Because trauma is one of the initiators of resorption, that event cannot be totally eliminated. Even teeth that have not been bleached can begin to have resorption, so there is always that possibility. Traumatized teeth should have recall radiographs taken every 1 to 2 years, whether they have been bleached or not.

Inside Bleaching

When performing internal bleaching on a non-vital tooth that has received endodontic therapy, it is important to clean out the inside of the pulp chamber (Figure 12). Often, when endodontic therapy is performed because of trauma, the pulp chamber is large, with high pulp horns. The access opening to the apex may not include debridement of the chamber (Figure 13). The restorative dentist should open the access opening enough to access both the incisal extent as well as the lateral extent of the pulp chamber. Often, removal of the remaining pulp chamber will significantly alter the color of the tooth, even before the bleaching has begun (Figure 14).

Inside-Outside Closed Bleaching

One of the best options for an endodontically treated tooth is to use both the inside and outside techniques in combination. Entering the inside of the tooth will allow removal of any pulp tissue, filler, or cement sealer, as well as discolored restorations in the chamber. The classic walking-bleaching treatment is performed as described above (Figure 15 and Figure 16), then the tooth is temporarily sealed while a single-tooth bleaching tray is fabricated. Bleaching continues at home externally using the single-tooth tray approach until the single dark tooth has reached its maximum lightness (Figure 17). Then the patient waits 2 weeks for the shade to stabilize and the bond strengths to return to normal. Upon return to the dentist, a comparison of the single tooth is made to the adjacent teeth. If the endodontically treated tooth remains slightly darker than the remaining teeth, an opaque stark-white composite is used internally to fill the pulp chamber and provide an additional slight lightening of the tooth (Figure 18). The final orifice is closed with the appropriate color-matched composite to the external portion of the tooth. Some clinicians prefer to use a resin-modified glass ionomer internally to improve the bond to dentin, followed by the traditional composite restoration to close the opening. This approach of both inside and outside bleaching with a closed pulp chamber gives the benefits of both techniques. The inside bleaching segment allows the tooth to be cleaned as well as tempers the final color with a composite

restoration, while the outside bleaching segment allows the patient to bleach as long as necessary to obtain the maximum whitening of the tooth without returning to the office (Figure 19 and Figure 20). Because a cast already exists for the single-tooth tray, should the single tooth get lighter than adjacent teeth, a new bleaching tray can be fabricated and the patient can use it for day wear to titrate the color to a final match. The average treatment time for single dark teeth seems to be 8 weeks, although there is a wide range of treatment times. While 10% carbamide peroxide is generally used for traditional overnight treatment, higher concentrations may be used once it is determined that sensitivity is not a problem.

Inside-Outside Open Bleaching

In special patients and situations, the dentist may chose to perform inside and outside bleaching while leaving the access opening unrestored. In this situation, the patient injects carbamide peroxide into the pulp chamber and the tray, then seats the tray in the mouth to protect the opening. While this may shorten treatment time due to the continued application of fresh bleaching material, it is essential that the patient be able to perform their part, and also return to the office to have the opening closed. While the tooth will not get any tooth decay during the bleaching process due to the increase in pH afforded by the carbamide peroxide,[46] there is the danger that the patient may cease bleaching but not return in a timely fashion to have the orifice sealed. If the office is not equipped to fabricate the additional single-tooth tray, then the standard replacement of the internal carbamide peroxide is performed weekly, taking 1 to 6 office visits for completion. A provisional restoration maintains the seal, and the patient is instructed to call the office immediately if occlusion or food disrupts the provisional seal.

Bleaching or Crown Decisions

The question is often asked why the anterior endodontically treated tooth is not crowned today as it once was in the past. One reason for the resurgence of bleaching single anterior teeth is that the research has shown that while posterior teeth that have received a root canal should be crowned, anterior teeth should only be crowned if they needed a crown regardless of the endodontic therapy. The reason is because the single greatest predictor of survival of an endodontically treated tooth is the amount of remaining dentin. If an intact anterior tooth has a root canal, the external enamel and dentin is still intact. Preparing the tooth for a crown after the endodontic treatment removes the remaining dentin and results in a premature loss of the tooth. Research has also shown that the post does not strengthen the tooth, and cannot compensate for the loss of dentin. Hence, the tooth has a better prognosis to be bleached and restored with composite than to receive a post, core, and crown.

Conclusion

The single dark tooth is an esthetic challenge regardless of the treatment approach. Bleaching the single tooth alone is the safest, most conservative approach to determining the response of the single tooth before changing the adjacent tooth colors. A "single-tooth" bleaching tray is the tray of choice for external bleaching. Single dark teeth with calcific metamorphosis should not be treated endodontically unless there are clinical symptoms of pain or radiographic evidence of an abscess.

For internal bleaching of an endodontically treated tooth, a "walking bleach" approach using 10% carbamide peroxide internally seems to afford the safest approach over previous traditional methods. The combination of one internal bleaching appointment to debride the pulp chamber, followed by tray bleaching with a single-tooth tray or full non-scalloped, no reservoir tray provides the flexibility of unlimited time of treatment without incurring significant in-office charges. Additionally, waiting 2 weeks after bleaching for the shade to stabilize and the bond strengths to return to normal and then using internal composite bonding can harmonize final shade discrepancies. Regardless of the technique used for bleaching, a relapse is possible in 1 to 3 years, and is generally best addressed by outside bleaching in a single-tooth tray with 10% carbamide peroxide to re-bleach the tooth until it matches the surrounding teeth.


FIG. 19


FIG. 20

CASE EXAMPLE FOUR ((19.) The endodontically treated canine is much darker than the adjacent teeth, but in this less-esthetic area, a full tray was used to lighten all the teeth. The canine was bleached internally with one treatment and externally to completion. **(20.)** After 3 weeks of external bleaching with 10% carbamide peroxide at night, the adjacent teeth reached their maximum lightness. While the other teeth are slightly lighter than the canine, the color match was much closer and pleasing to the patient.

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Orthodontic Caries Control and Bleaching

Custom tray application of 10% carbamide peroxide to orthodontic patients for removal of plaque and avoidance of white-spot lesions is outlined.

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ABSTRACT

Oral hygiene during orthodontic treatment can be facilitated by applying bleaching materials to elevate the pH of the mouth during the course of treatment. Fabrication of thermoplastic bleaching trays directly in the mouth over the braces without impressions affords a reasonable technique for the multiple trays required during the orthodontic changes.

Orthodontic treatment is one of the most conservative, long-lasting treatments to improve the esthetics and function of a patient. Bleaching is also one of the most conservative treatments to change the color of the patient's teeth. Together, orthodontics and bleaching afford some of the most conservative, long-lasting treatment to offer a patient. Often, bleaching may follow orthodontic treatment, and occasionally use the orthodontic positioner as the tray with which to deliver the bleaching material. The most popular form for tray bleaching of the teeth involves the use of 10% carbamide peroxide in a custom-fitted tray.[1]

One of the most disappointing sequelae of orthodontic treatment may occur after the appliances are removed. Sometimes, white-spot lesions are present due to inadequate cleaning of the appliances during the 1- to 3-year treatment period (Figure 1). Some home care of orthodontic patients, especially teenagers, has been so obviously poor that the orthodontist has found it necessary to remove the braces before the completion of treatment to save the teeth from decay. The challenge of orthodontic treatment is to maintain the cleanliness of the braces throughout the treatment phase.

While bleaching will whiten teeth, tray bleaching with 10% carbamide peroxide has the side effect of removing plaque from teeth, improving gingival scores, and elevating the pH of the mouth and tray.[2-8] Carbamide peroxide has been shown to kill many of the bacteria that cause tooth decay, as well as remove surface staining. This beneficial side effect affords a practical option to deal with the problems of oral hygiene during orthodontic treatment.

There have been many attempts to combine the properties of bleaching with the challenge of cleaning orthodontic patients. In the early 1960s, carbamide peroxide that was available over-the-counter (OTC) was used as a mouthwash in orthodontic patients for this reason, but with limited success, possibly due to the low contact time. When traditional nightguard vital bleaching was introduced in the late 1980s, fabrication of a custom-fitted tray over the brackets in the traditional method using an alginate impression and vacuum-formed matrix was determined to work better. However, over the course of the 1 to 3 years of orthodontic treatment, this approach would involve multiple impressions and trays as the teeth move every few months such that the previous tray would no longer fit the arch. Also, the main OTC ingredient with the best physical properties (Proxigel, GlaxoSmithKline Consumer Health Care, www.gsk.com) was removed from the market, leaving less desirable products available for this situation.

More recently, disposable trays with hydrogen peroxide to be worn for 30 to 60 minutes have been introduced as a cost-effective proposal for in-office debridement of the braces before the orthodontic visit. However, these trays do not fit well, and the nature of hydrogen peroxide does not retain its activity long enough to be beneficial in the caries control process, nor does the pH become elevated above that point at which tooth decay can occur. What is needed is a cost-effective method to create custom-fitted trays that can be worn overnight and contain a cost-effective carbamide peroxide and can be used for the duration of the orthodontic treatment to clean the braces of plaque and avoid white-spot lesions post-treatment. The purpose of this article is to present a technique that addresses those concerns by combining information from several sources in the bleaching literature with clinical applications.

Tray Fabrication

The traditional method for tray fabrication in the tray bleaching process involves a well-made alginate impression

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Learning Objectives

- understand how the pH effects of carbamide peroxide bleaching materials affects the caries process and oral hygiene.
- learn a technique for fabrication of thermoplastic bleaching trays over orthodontic brackets directly in the mouth.
- develop a reasonable treatment option for caries-risk orthodontic patients to avoid white-spot lesions and caries.

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CLINICAL EXAMPLE (1.) Poor oral hygiene during orthodontic treatment can result in decalcified and carious enamel at the end of treatment. (Photograph courtesy of Dr. Andrew Kious.)

of the arch to be bleached. A stone cast is generated from this impression, and trimmed in such a manner as to work well in the vacuum former. The custom-fitted tray is formed from thin soft material.

When considering how to clean orthodontic braces using bleaching tray materials, the main missing portion of the oral hygiene puzzle has been a cost-effective tray fabrication technique that could be used multiple times during treatment. While the traditional alginate impression over the brackets was initially used, it was very difficult to obtain a good impression especially of the area of the teeth between the brackets and the gingiva. This area is the most difficult to clean, and yet the tray fits the poorest in this area. Additionally, the time and labor costs to remove the wires, make the alginate impression, pour the impression in cast stone, trim the cast, then fabricate a bleaching tray in a vacuum former for the many times this would be needed make that approach weary for the patient and the orthodontist.

An alternate method for bleaching normal teeth to the traditional impression, cast, and laboratory fabrication of trays is to use a thermoplastic tray formed directly in the mouth. A dual technique has been previously reported.[9] A later development to this approach was the introduction of a single clear tray sold directly to dentists (Sure-Fit Ultra-Thin Professional Trays, Oratech, LLC, www.oratech.com; Ultra-Thin Dental Trays, Archtek, Inc, www.archtekinc.com). In this technique, the single clear soft tray is heated and softened in warm water that has been initially brought to a boil, then applied to the arch and directly contoured to the teeth by finger pressure. The patient then occludes into the softened tray and applies suction to form-fit the tray to the teeth. After the tray has cooled, the tray handle is then removed and the tray trimmed to fit. The use of this tray eliminates the impression stage for patients who may not tolerate impressions (those who might gag or choke using an alginate impression technique), and is useful in locations where laboratory equipment like a model trimmer or vacuum-forming machine is not available. Generally, a microwave oven, a coffee cup, and a pair of scissors are all that is needed to fabricate the tray. Occasionally, thermoplastic trays may not be long enough to completely cover the molars. However, it has been shown that 10% carbamide peroxide is effective as a bleaching agent well beyond the borders of the tray,[10] and one might expect that the antimicrobial effects would extend beyond the tray as well.

The recently introduced thermoplastic trays, also called "boil and form" bleaching trays, were subsequently used with orthodontic patients to avoid removal of wires and multiple laboratory procedures. Those trays can be fabricated over the orthodontic braces directly in the mouth without removing wires or bands. Also, even though the trays are thermoplastic, they do not get soft enough to imbed themselves in the brackets, yet they can be readily adapted to the gingival area below the brackets, which is the hardest to clean.

The technique for fabrication over orthodontic brackets is outlined in the accompanying figures. Although the two clear trays mentioned above in the previous non-orthodontic bleaching will work, the 1.5-mm thicker tray (1.5 Full Arch Boil & Form, Archtek, Inc) has the advantage of less shrinkage, which means it will cover more brackets and teeth (Figure 2). One difference in the insertion technique from a normal tray is that the tray should be inserted from a facial direction to avoid the wires and brackets causing the ends to fold (Figure 3). The water is heated until it almost boils, then the tray is waved in the hot water until the front edge begins to curl. If it continues too long in the water, it will shrink too much to fit over the brackets. If it touches itself, it will bond and be useless. Once the tray is softened, it is removed and the curled-in edges quickly spread back open to avoid hanging on the brackets. Any excess hot water is shaken from the tray and the tray is inserted from the facial direction. The patient's lips


FIG. 2

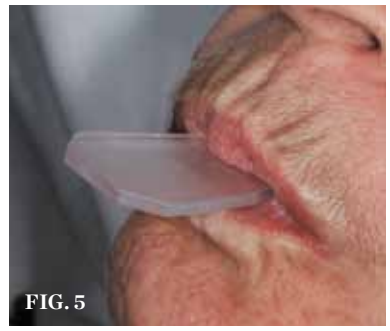
FIG. 5

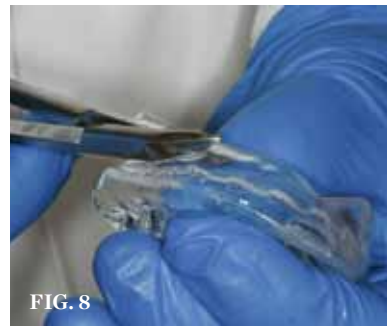
FIG. 8


FIG. 3


FIG. 6


FIG. 9


FIG. 4


FIG. 7


FIG. 10

BLEACHING PROCEDURE (2.) The thicker tray seems to work better over the orthodontic brackets by covering more teeth and shrinking less when heated. **(3.)** The path of insertion of the tray should be from the facial. Try in the tray with the patient before heating to ensure a proper path of insertion and full patient understanding of relaxing their lips. **(4.)** After the softened tray is seated correctly, quickly apply finger pressure on the facial and lingual of the tray to adapt to the gingival areas, starting from the midline and proceeding distally.

BLEACHING PROCEDURE (5.) Instruct the patient to close onto their back teeth, and create suction with their lips. **(6.)** When the tray has completely cooled in the mouth, disengage it from any brackets or wire extensions. **(7.)** Remove the custom-fitted tray that has been made directly in the mouth over the orthodontic brackets.

BLEACHING PROCEDURE (8.) Scissors may be used to both shorten any extended flanges, as well as remove the handle from the anterior portion. **(9.)** Once trimmed, the patient will have a smooth comfortable tray for applying the 10% carbamide peroxide that covers the anterior brackets, which also protects the cheeks and provides a comfortable MI occlusion. **(10.)** A thick 10% carbamide peroxide is applied sparingly in the groove area formed by the brackets.

must be relaxed to allow insertion of the softened tray. Once in the mouth, finger adaptation is used to form the tray over the brackets on the facial and the lingual (Figure 4). When this is completed, the patient closes onto their posterior teeth and applies suction to form the tray with their lips (Figure 5). The tongue can also be used to push the tray against the lingual of the arch. When the tray has completely cooled in the mouth, the edges are disengaged from the brackets (Figure 6). The tray can then be removed, and the result is a custom-fitted tray made directly in the mouth over the braces (Figure 7). A pair of scissors can be used to remove any excess, as well as to remove the tray handle (Figure 8). The tray is reinserted to ensure that the occlusion is comfortable, and the tray handles have been removed smoothly (Figure 9). If needed, an acrylic trimming bur can be used to smooth where the handle was adapted. The mandibular tray can be fabricated in the same manner, although it is more difficult to fit. Only one tray is worn at a time, since the trays are constructed with the patient occluding into MI and are somewhat bulky. The best regime is to alternate nights of wear.

Bleaching Material for Caries Control

In conjunction with a custom-fitted tray made directly in the mouth over the orthodontic bracket is the use of an appropriate-viscosity carbamide peroxide material. Bleaching materials are ideal to use in the tray because their high viscosity maximizes contact time and minimizes leakage from the tray. Tray application is ideal overnight since the carbamide peroxide bleaching materials are effective for overnight application. If this is not reasonable, then the carbamide peroxide can be used for daytime use at a minimum of 2 hours. The one disadvantage of bleaching materials is the relative cost for long-term use. Typical orthodontic wear uses about one syringe for 3 to 4 nights when using a 10% carbamide peroxide product, and the refill kits of four syringes cost about $4 per syringe, so the additional cost for treatment over a 2-year treatment regime would be about $500. However, compared to the cost of restorative treatment and the cycle of replacement restorations that could be avoided, this may be minimal. Other options to be considered are existing OTC products, but none has the appropriate consistency to be as efficacious. Currently available OTC products (Glyoxide, GlaxoSmithKline Consumer Healthcare, www.gsk.com, and CVS Antiseptic Oral Cleanser, CVS Corp, www.cvs.com) are much more affordable but lack extensive amounts of carbopol thickening agent, thus are not maintained in the tray as long as dentist-provided bleaching agents. OTC products can be worn in the tray for a minimum of 1 hour, and still provide some additional cleaning. Whichever material is selected, only the amount that will cover the tooth surface without excessive leakage from the tray should be utilized to conserve materials. It is wise to have the patient demonstrate use prior to dismissal from the office to ensure they understand the location and amount of material to use (Figure 10).


FIG. 11


FIG. 12

CLINICAL RESULTS (11.) This patient has used 10% CP for over 2 years in these trays. The trays were remade every 2 to 4 months, depending on the movement of the teeth. **(12.)** After removal of the brackets, there are no yellow spots or unbleached areas on the teeth, and no white spots from demineralization of the enamel.

Carbamide Peroxide (CP) and its Antibacterial Properties

There are two basic formulations of peroxide materials used in tray bleaching. The initial tray ingredient in the original 1989 article was carbamide peroxide, which is active for 2 to 10 hours. Hydrogen peroxide has also been introduced, but is only active for up to 1 hour, so it is primarily for daytime use in bleaching. Ten percent CP is the commonly used percentage in tooth-bleaching procedures and is the most thoroughly researched CP formulation. It decomposes into 6.5% urea and 3.5% peroxide. The urea further breaks down to ammonia and carbon dioxide. Peroxide breaks down to water and oxygen. Carbopol (carboxy polymethylene polymer) is added to many commercial bleaching preparations because it increases the viscosity of the gel, increases contact time, and slows the release of oxygen from CP.[11] Adding carbopol to CP preparations extends the maximal oxygen release time up to 10 hours, depending on how it is measured.[12,13] The antibacterial properties of CP are well documented, as the original material was marketed as an oral antiseptic. In addition, artificially demineralized fissures (to simulate caries) inoculated with *lactobacillus,* and then treated with 10% CP gel for 2 hours showed no subsequent growth of *lactobacillus* when plated.[14] The authors of this study concluded that 10% CP penetrated the carious fissures and killed the *lactobacillus*. It has also been shown that 10% CP inhibited growth of *Streptococcus mutans* and *lactobacillus* in vitro and reduced levels of salivary *lactobacillus* in vivo. The hydrogen peroxide products used in bleaching are not as effective for caries control since they do not contain urea.

Effect on Saliva, Plaque, Caries, and Gingival Health

Ammonia resulting from carbamide (urea) degradation plays a significant role in modifying salivary and plaque pH. In the 1960s, it was demonstrated that application of urea solutions to plaque resulted in an initial rapid rise in pH followed by a slow fall. The rise in plaque pH was related to urea concentration.[15] More recently, 10% CP applied by wearing a custom tray resulted in a significantly increased salivary pH after 5 minutes of wear even though the CP products tested had an acidic pH (4.8 to 5.2). Salivary pH remained elevated above 8 for the 2 hours of tray wear for the test period.[16] The buffering effect of CP in custom trays extends to plaque pH; measurements of plaque pH during 2 hours of CP application by custom tray showed that mean final plaque pH was significantly higher (8) than baseline (7).[17] These results confirm the buffering effect of urea on saliva, since the normal urea concentration in saliva has a significant role in elevating plaque pH and in negating the rise in plaque pH after sugar challenge.[18] The critical pH at which enamel and dentin begin to dissolve is 5.2 to 5.7 for enamel, and 6 to 6.5 for dentin.[19] These studies demonstrate elevation of plaque and salivary pH significantly above these levels; this presumably results in a lower rate of caries.[20] Elevation of saliva pH by CP also allays fears that acidic bleaching agents may cause enamel erosion. It is important to note that bleaching agents that contain hydrogen peroxide, but not CP, do not have these pH elevating effects, since it is the urea released from CP that causes elevation of plaque and salivary pH. Thus hydrogen peroxide-based agents would not necessarily have the same cariostatic benefits.

A similar study confirmed that salivary urea levels strongly correlated with plaque pH, very possibly causing a lower caries rate than controls or transplanted patients.[21] This confirms the assumption that elevation of salivary and plaque pH by a constant source of salivary urea (for example from CP bleaching agents) may inhibit caries. Such caries inhibition has been demonstrated in


FIG. 13


FIG. 14

CLINICAL RESULTS (13.) Any yellow or discolored areas on the teeth will generally be attributed to the composite bonding material, which penetrates 25 µm into the enamel, and must be removed by abrasion. **(14.)** Because the thermoplastic trays only come in one size, the most posterior teeth are often not included in the tray. However, the increase in pH in the mouth may still protect them from caries.

the rat model, where topical application of 10% CP significantly reduced plaque accumulation and numbers of smooth surface enamel lesions.[22]

Side Effect of Bleaching for Caries Control

The technique for using bleaching materials for caries control has been previously reported in elderly patients.[23] The rise in pH creates an environment in which caries cannot flourish. However, because it creates a basic pH, then calculus is more likely to form.[24] It has been noted in the orthodontic patients that more calculus is present, often getting in the channels for the wires. However, it was determined that cleaning calculus was more reasonable than dealing with caries.

The other possible side effect is that the teeth may get whiter. However, for most patients in orthodontic treatment, this is desirable. For teenagers, this may be the motivating reason to wear the tray with the bleaching material, rather than the hope to avoid tooth decay.

Expressed Concerns

Concern is often expressed of the impact the bleaching material will have on the orthodontic bond strength. However, research has shown that the oxidation process of bleaching will actually strengthen the polymerization of the composite-bonded brackets by further curing the composite.[25] Generally, composite only cures about 70%, so the addition of carbamide peroxide further increases the bond strength of the brackets. The opposite of this is true if bleaching is performed before bonding. In that case, the residual oxygen in the tooth reduces the bond strengths by 25%.[26] Patients should wait at least 2 weeks after bleaching before any bonding procedure is attempted, to allow the complete dissipation of the oxygen from the enamel.[27] However, once the bonding has been polymerized, then bleaching over the bonding will further polymerize the composite.

The second concern expressed of bleaching during orthodontic treatment is that there will be a "yellow spot" remaining after the bleaching. However, this has not been shown to be true either, as the peroxide passes easily through the tooth in 5 to 15 minutes,[28] and will bleach under any composite or veneers[29] already in the mouth (Figure 11 and Figure 12). If there were to be any yellow spots, those are most likely the residual composite from the bonding procedure, which will be embedded into the tooth at least 25 µm (Figure 13). Abrasion techniques must always be used after debonding orthodontic brackets to remove this composite. Even if there were a chance of a yellow spot, the simple solution would be to re-bleach the teeth. However, it has been shown that a tooth cannot be "spot bleached" due to the easy passage of peroxide from facial to lingual, and all clinical examples of bleaching during orthodontics have not shown any hint of an unbleached spot.

Concern has been expressed about the long-term use of the material, and the swallowing of material. However, the safety of 10% carbamide peroxide has been demonstrated pre-bleaching in use in newborn infants, and in previous long-term uses.[30-32] The original product (Proxigel) was approved as Generally Recognized as Safe (GRAS) for use as an oral antiseptic by the US Food and Drug Administration for the life of the patient.[33]

Additionally, the long-term treatment of tetracycline patients has shown no detrimental effects on the teeth,[34,35] and the 20-year history of research on the technique[36,37] has shown the low-concentration, neutral-pH bleaching products from reputable manufacturers to be as safe to the teeth as normally ingested food stuffs and drinks. The more recent review of all the literature on safety by the European market further strengthens the safety of 10% carbamide peroxide.[38]

Additional Benefits of the Tray

In addition to having a custom-fitted tray that provides a carrier for the bleaching material to remove the plaque and elevate the pH, the tray also provides additional benefits. Because it was made with the patient occluding into maximum intercuspation, the patient has a stable MI bite registration in which to rest. Often during orthodontic therapy, there may be times when one tooth hits high, and becomes sore. The tray levels the occlusion so all teeth are in contact and provides a relief to occlusal trauma even when no bleaching material is added.

Additionally, because the tray covers the brackets and wires of the anterior portion of the mouth, it provides protection from the irritations to the lips and cheeks of orthodontic hardware, much in the same manner as wax, but much smoother. The oral antiseptic properties of the bleaching material also help with ulcer healing, because this was the original use of carbamide peroxide. The bleaching material also helps in controlling malodor, since it provides a bubbling action to clean the teeth of food debris, as well as provide a bacteriostatic cleaning of interproximal spaces from its oral antiseptic activity.

As has been noted earlier, the disadvantage of the tray options is that they only come in one size. Hence, the tray fabricated in this manner may not cover all the teeth (Figure 14). Because the tray was made with the patient occluding into MI, this does not create an occlusal problem. The question concerns whether the teeth not covered will be protected. However, because the elevation of the pH is the primary mechanism for reducing caries activity rather than plaque removal, it may not be as critical to cover all teeth, but rather have a tray that will hold the 10% carbamide peroxide in place during the night to elevate the pH above that which tooth decay can occur. When cross elastics are worn during orthodontic treatment, this technique cannot be used. Other options used during orthodontic therapy when elastics are being worn is to squirt the 10% carbamide peroxide material directly into spaces that are hard to clean for the mechanical debridement of those areas.

At this time, it is unknown whether this technique needs to be applied continually, or if it can be done for a week to clean, then do every other or third day. More research is needed in this area as to the elevation of the pH and how long it takes to drop below the critical levels to allow caries to progress, as well as the amount of plaque removed and how long takes it take to rebuild. This may vary from patient to patient. Disclosing tablets may show effectiveness over time. Additional cleaning appointments for the increased amount of calculus may

need to be included in orthodontic plans.

As with any bleaching technique, sensitivity may be a side effect.[39] However, to date, the sensitivity associated with orthodontic therapy exceeds any noted during this process. Additionally, the use of potassium nitrate in the bleaching materials, or the topical application of potassium nitrate, should help any problems.[40,41] The use of orthodontic trays for both bleaching application and sensitivity application is another adjunct to orthodontic therapy.

Conclusion

A technique has been presented to fabricate a thermoplastic tray directly in the mouth over orthodontic brackets without removal of the brackets and without traditional impression techniques. The fabrication of this tray allows the patient to use 10% carbamide peroxide nightly as a means to reduce plaque and elevate the pH in the mouth above that which will cause tooth decay. The goal of this technique is to reduce or eliminate the need for restorations to restore white-spot and caries lesions after orthodontic treatment. No negative sequelae have been noted when this technique is used clinically, other than the additional cost of the trays and material.

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