17

Bleaching Discolored Nonvital Teeth

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CHAPTER OUTLINE

LEARNING OBJECTIVES

After reading this chapter, the student should be able to:

1. Identify the causes and nature of tooth discoloration.
2. Describe means of preventing tooth discolorations.
3. Differentiate between dentin and enamel discolorations.
4. Evaluate both the short-term and long-term prognoses of bleaching treatments.
5. Explain the mechanism of tooth bleaching.
6. Select the bleaching agent and technique according to the cause of discoloration.
7. Describe each step of the internal "walking bleach" technique.
8. Select the appropriate method to restore the access cavity after tooth bleaching.
9. Describe how bleaching agents may alter tooth structures.
10. Recognize the potential adverse effects of tooth bleaching and discuss means of prevention.

Bleaching discolored teeth may be internal (within the pulp chamber) or external (on the enamel surface) and involve various approaches. The objectives of treatment are to reduce or eliminate discoloration, improve the degree of coronal translucency, and alleviate present and prevent future clinical signs and symptoms.

To better understand bleaching procedures, you should know the techniques involved, understand the causes of discoloration, recognize the location of the discoloring agent, and apply the correct treatment modality. Also important is the ability to predict the outcome of treatment (i.e., how successfully various discolorations can be treated and how long the esthetic result will last). Therefore before attempting to correct discoloration, there must be a diagnosis (to determine the cause and location of the discoloration), a treatment plan (to select the appropriate bleaching material and technique), and a prognosis (to anticipated short- and long-term success). Patients must be informed of these factors before undergoing the procedure; any discoloration treatment is tempered by the explanation that bleaching bears a certain degree of unpredictability in matching the esthetics of the tooth involved fully and that substantial improvement may or may not occur. However, with proper recognition of the causes of discoloration and careful treatment protocol, no irreversible damage to the crown or root occurs (Video 17.1).

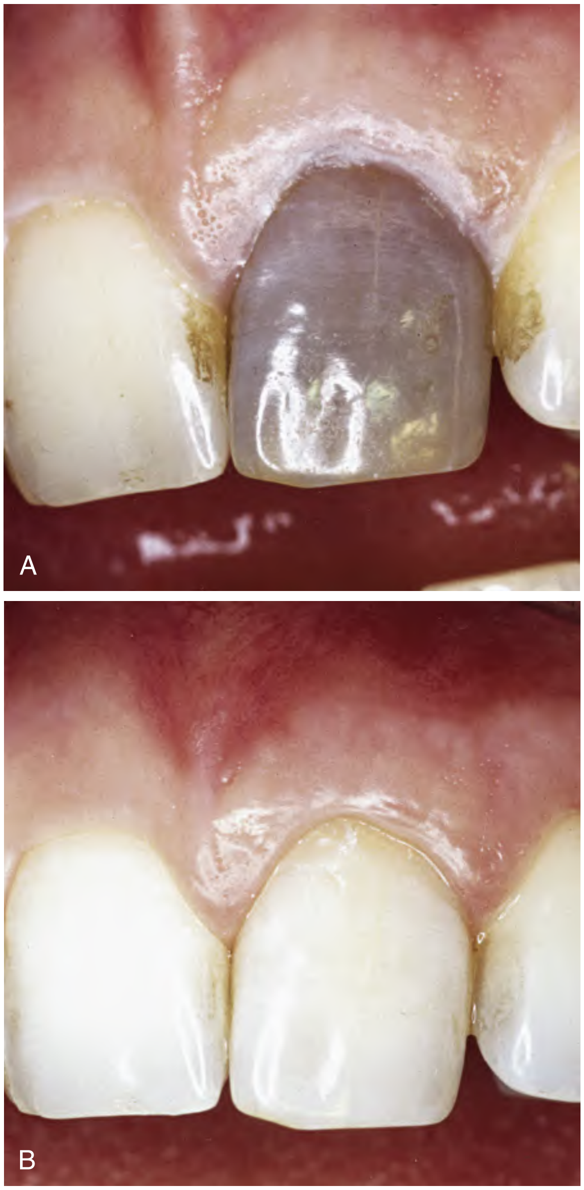
Causes of Discoloration

Tooth discolorations may occur during or after enamel and dentin formation. Some discolorations appear after tooth eruption, and others are the result of dental procedures. *Acquired* (natural) discolorations may be superficial and located on the surface of the tooth or may be embedded and be physically incorporated into tooth hard tissues. Sometimes they result from flaws in enamel formation and structure or a traumatic injury. *Inflicted* (iatrogenic) discolorations, resulting from certain dental procedures, are usually incorporated into tooth structure and are largely preventable.

Acquired (Natural) Discolorations

Pulp Necrosis

Although microorganisms are the main cause of pulpal injury, mechanical or chemical irritation of the pulp may also result in



• **Fig. 17.1** **(A)** Discoloration as a result of a traumatic injury followed by pulp necrosis. **(B)** After root canal treatment, a paste of sodium perborate and water mixed to a consistency of wet sand was sealed in the pulp chamber. After 21 days of walking bleach, the tooth regained its original shade. (Courtesy of Dr. A. Claisse).

tissue necrosis. Pulp necrosis can occur via stagnation of the vasculature and formation of microabscesses. Red blood cells stagnated in the vasculature will lyse and lead to accumulation of hemoglobin and other pulp breakdown byproducts. These tissue disintegration byproducts are colored compounds that may permeate tubules to stain surrounding dentin. The degree of discoloration is likely related to how long the pulp has been necrotic.[1,2] The longer the discoloration compounds are present in the pulp chamber, the greater the discoloration. This type of discoloration can be bleached internally, usually with both short- and long-term success (Fig. 17.1).

Intrapulpal Hemorrhage

Intrapulpal hemorrhage is usually associated with an impact injury to a tooth that results in disrupted coronal blood vessels, hemorrhage into the pulp space, stasis of this extravasated material, and lysis of erythrocytes. Erythrocyte lysis leads to an accumulation of disintegration products, such as iron sulfides. These iron sulfides may permeate dentinal tubules to stain surrounding dentin. Discoloration tends to increase with time.

If the pulp becomes necrotic, the discoloration usually remains. If the pulp survives, the discoloration may resolve and the tooth regains its original shade. Sometimes, mainly in young individuals, a discolored tooth can respond unpredictably to vitality tests. Therefore you should not rely on a single clinical test to establish your diagnosis of the case. If intracoronal discoloration remains despite diagnostic testing indicating presence of a healthy pulp and normal periapex, a porcelain veneer can be considered. Although more invasive, sometimes significantly darker stain may necessitate consideration for elective root canal therapy to remove stain that would not be effectively hidden under a coronal esthetic restoration.

Internal bleaching of discoloration after intrapulpal hemorrhage is usually successful both short term and long term.[1-4]

Calcific Metamorphosis

Calcific metamorphosis, also known as *pulp canal obliteration*, is extensive formation of tertiary dentin in the pulp chamber that causes circumferential narrowing of the pulp chamber and root canal. This phenomenon usually follows an impact injury that did not result in pulp necrosis. There is likely temporary disruption of the blood supply with partial destruction of odontoblasts. Odontoblasts are usually replaced by cells that rapidly form irregular dentin on the walls of the pulp chamber and root canal space. As a result, the crowns take on a "flat" and yellow or yellow-brown discolored appearance as they gradually decrease in translucency (Fig. 17.2). The pulp usually remains vital and does not require root canal treatment. However, routine follow-up is recommended as a result of potential of pulp necrosis after a traumatic injury.[5]

If the patient desires color correction, external bleaching should be attempted first. If this is unsuccessful, root canal treatment can be performed, and internal bleaching done. The esthetic prognosis for such treatment is not always predictable. The unpredictability of this procedure results from the bleaching agent addressing discolored pigmentation in the regular structure of the dentinal tubules but not in the bulk of irregular dentin from the aberrant calcification.

Age

In older patients, color changes in the crown occur physiologically as a result of extensive dentin apposition and thinning of and optical changes in the enamel. Food and beverages also have a cumulative discoloring effect because of the inevitable cracking and other changes on the enamel surface and in the underlying dentin. In addition, previously applied restorations that degrade over time cause further discoloration. Bleaching is usually external because the discoloration is primarily on the enamel surface. Success may vary, depending on the causal factor of discoloration.

Location

The most commonly bleached teeth are the maxillary incisors. Maxillary central incisors comprise 69% of internally bleached teeth, whereas maxillary lateral incisors comprise 20% of bleached teeth.[5]

• **Fig. 17.2** Calcific metamorphosis. Impact trauma resulted in reversible pulp damage in one of the central incisors **(A)** with extensive tertiary dentin formation **(B).** These teeth may present difficulties with root canal treatment and internal bleaching.

Developmental Defects

Discolorations may also result from developmental defects or from substances incorporated into enamel or dentin during tooth formation.

Endemic Fluorosis

Ingestion of excessive amounts of fluoride during tooth formation produces defects in mineralized structures, particularly enamel matrix, with resultant hypoplasia. The severity and degree of subsequent staining generally depend on the degree of hypoplasia, which depends in turn on the patient's age and the amount of fluoride ingested during odontogenesis.[6] The teeth are not discolored on eruption but may appear chalky. Their surface, however, is porous and gradually absorbs stains from chemicals in the oral cavity.

Because the discoloration is in the porous enamel, such teeth are treated externally. Esthetic success depends mainly on the degree and duration of the discoloration. Some regression and recurrence of discoloration tend to happen but can be corrected with future rebleaching.

Systemic Drugs

Administration or ingestion of certain drugs or chemicals (many of which have not yet been identified) during tooth formation may cause discoloration, which is occasionally severe.[7]

The most common and most dramatic discoloration of this type occurs after tetracycline ingestion, usually in children. Discoloration is bilateral, affecting multiple teeth in both arches. It may range from yellow through brownish to dark gray, depending on the amount, frequency, and type of tetracycline, and the patient's age (stage of development) during administration.

Tetracycline discoloration has been classified into three groups according to severity.[8] First-degree discoloration is light yellow, light brown, or light gray and occurs uniformly throughout the crown without banding. Second-degree discoloration is more intense and is also without banding. Third-degree discoloration is very intense, and the clinical crown exhibits horizontal color banding. This type of discoloration usually predominates in the cervical region.[8] The location of the band correlates to the part of the dentin that was undergoing formation at the time of systemic tetracycline ingestion. It is therefore recommended to limit systemic tetracycline use in patients with active permanent tooth development.

Tetracycline binds to calcium, which then is incorporated into the hydroxyapatite crystal in both enamel and dentin. Most of the tetracycline, however, is found in dentin. Chronic sun exposure of teeth with the incorporated drug may cause formation of a reddish purple tetracycline oxidation byproduct, resulting in further discoloration of permanent teeth.

A phenomenon of adult-onset tetracycline discoloration has also been reported.[9] It occurs occasionally in mature teeth in patients receiving long-term minocycline therapy, which is usually given for control of cystic acne. The discoloration is gradual because of incorporation of minocycline in continuously forming dentin.[7] Staining generally is not severe.

Two approaches have been used for bleaching tetracycline discoloration. The first, which involves bleaching the external enamel surface, is limited to lighter, yellowish discoloration and requires multiple appointments to achieve a satisfactory result.[10] The second, root canal treatment followed by internal bleaching, is a predictable procedure, is useful for all degrees of discoloration severity (especially linear-band type discoloration), and has proved successful in both the short term and long term.[11]

Defects in Tooth Formation

Defects in tooth formation are confined to the enamel and are either hypocalcific or hypoplastic. Enamel hypocalcification is common, appearing as a distinct brownish or whitish area, often on the facial aspect of a crown. The enamel is well formed and intact on the surface and feels hard to the explorer. Both the whitish and the brownish spots are amenable to correction externally with good results.

Enamel hypoplasia differs from hypocalcification in that the enamel in the former is defective and porous. This condition may be hereditary (amelogenesis imperfecta) or may result from environmental factors. In the hereditary type, both deciduous and permanent dentitions are involved. Defects caused by environmental factors may involve only one or several teeth. Presumably during tooth formation the matrix is altered and does not mineralize properly. The porous enamel readily acquires stains from the oral cavity. Depending on the severity and extent of hypoplasia and the nature of the stain, these teeth may be bleached externally with some degree of success.

Blood Dyscrasias and Other Factors

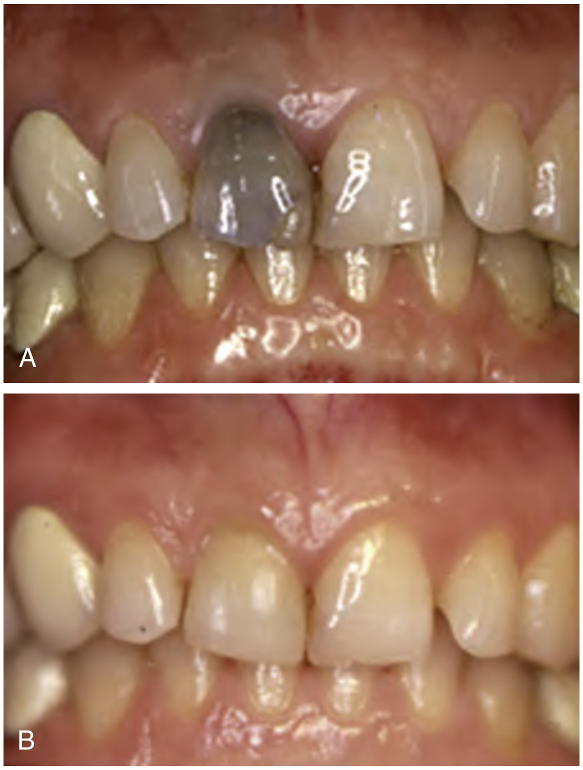
Various systemic conditions may cause massive lysis of erythrocytes.[2] If this occurs in the pulp at an early age, blood disintegration products are incorporated into the forming dentin causing discoloration. An example of this phenomenon is the severe discoloration of primary teeth that usually follows erythroblastosis fetalis. This disease in the fetus, or newborn, results from Rh incompatibility factors that lead to massive systemic lysis of erythrocytes. Large amounts of hemosiderin pigment then stain the forming dentin of the primary teeth. This discoloration is not correctable by bleaching. However, this type of lysis is now uncommon because of new preventive measures.

High fever during tooth formation may result in linear defined hypoplasia. This condition, known as *chronologic hypoplasia,* is a temporary disruption in enamel formation that results in a banding type of surface defect that acquires stain. Hyperbilirubinemia, thalassemia, and sickle cell anemia may cause intrinsic bluish, brown, or green discolorations. Amelogenesis imperfecta may result in yellowish or brownish discolorations. Dentinogenesis imperfecta can cause brownish violet, yellowish, or gray discoloration. Porphyria, a metabolic disease, may cause deciduous and permanent teeth to show a red or brownish discoloration. These conditions are also not amenable to bleaching and should be corrected by minimally invasive restorative means.

Other staining factors related to systemic conditions or ingested drugs are rare and may not be identifiable.[2]

Inflicted (Iatrogenic) Discolorations

Discolorations caused by various chemicals and materials used in dentistry are usually avoidable. Many of these discolorations respond well to bleaching, but some are more difficult to correct by bleaching alone.



• **Fig. 17.3 (A)** Discoloration as a result of trauma and subsequent treatment. The patient was involved in an accident that caused a coronal fracture. Root canal treatment was performed, but gutta-percha and sealer were not completely removed from the pulp chamber. An additional discoloration factor was the defective leaking restoration. **(B)** Two appointments of walking bleach and placement of a new, well-sealed composite restored esthetics. (Courtesy of Dr. M. Israel.)

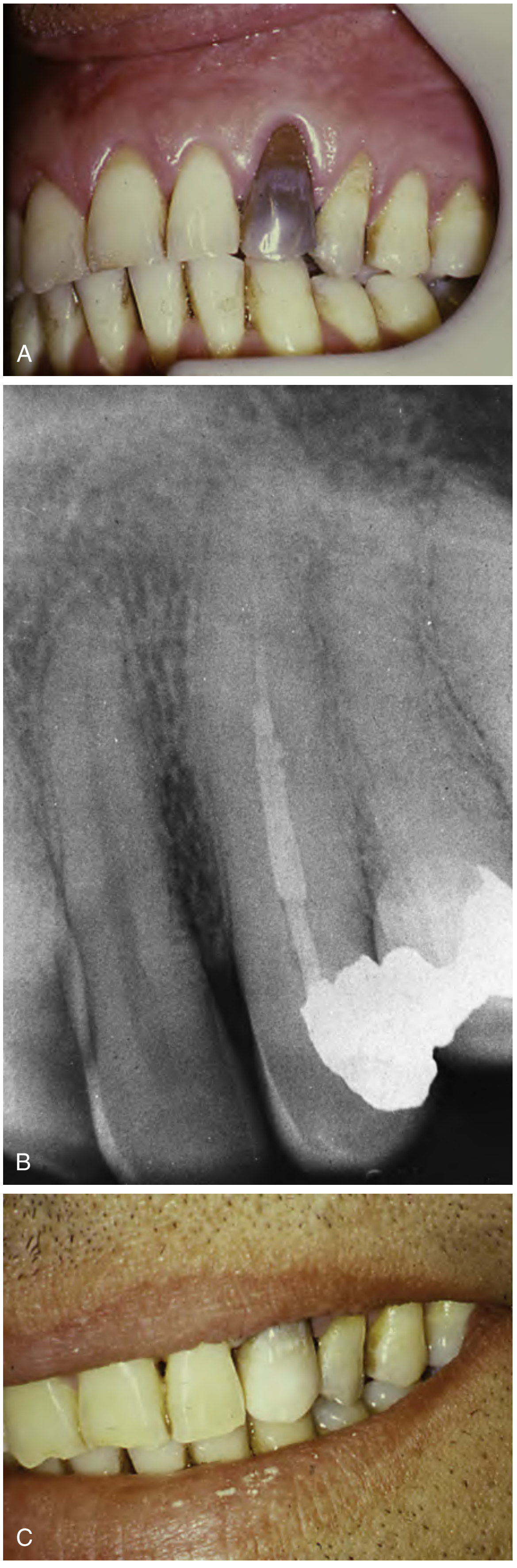
Endodontically Related Discolorations

Obturating Materials

Obturating materials are the most common and severe cause of single tooth discoloration. Incomplete removal of materials from the pulp chamber upon completion of treatment often results in dark discoloration (Figs. 17.3 and 17.4). Removing all obturation materials to a level just cervical to the gingival margin can prevent such discoloration. Sometimes, removal of the obturating material 1 to 2 mm further apically is required. Common obturating materials that can lead to stain are sealer remnants, whether of the zinc oxide–eugenol type or resins. These materials may also darken with time.[12-15] Sealer remnants gradually cause progressive coronal discoloration.[15] The prognosis of bleaching in such cases depends on the components of the sealer. Sealers with metallic components often do not bleach well, and the bleaching effect tends to regress with time.

Remnants of Pulpal Tissue

Pulp fragments remaining in the crown, usually in pulp horns, can cause gradual discoloration. Pulp horns must be exposed



• **Fig. 17.4** **(A)** Severely discolored canine. **(B)** Poor root canal treatment, in which material extended into the pulp chamber, caused some of the discoloration. **(C)** After retreatment and three appointments of walking bleach, esthetics have markedly improved. Although some cervical discoloration remains, it is largely hidden by the upper lip. (Courtesy of Dr. H. Libfeld.)

and cleaned during access preparation to ensure removal of pulpal remnants and to prevent retention of sealer at a later stage. Internal bleaching in such cases is usually successful.

Intracanal Medicaments

Several medicaments have the potential to cause internal discoloration of the dentin.[1,2,16,17] These intracanal medications, sealed in the root canal space, are in direct contact with dentin, sometimes for long periods, allowing penetration to dentin tubules and oxidization. These compounds have a tendency to discolor the dentin gradually. Most such discolorations are not marked and are readily and permanently corrected by bleaching. However, discoloration by intracanal medication containing iodoform tends to be more severe.

Coronal Restorations

Restorations are generally metallic or composite. The reasons for discoloration (and therefore the appropriate correction) are quite different.

Metallic Restorations

Amalgam is the worst offender because its dark metallic elements may turn dentin dark gray. If used to restore an access preparation, amalgam often discolors the crown (Figs. 17.4 and 17.5).

• **Fig. 17.5** **(A)** Discoloration of endodontically treated maxillary central incisor. **(B)** The presence of a silver cone in the canal, failure to remove all remnants of pulpal tissue from the chamber, and amalgam placed in the access cavity appear to be the causes of discoloration. **(C)** Removal of amalgam and refinement of the access cavity. The silver cone was removed, and endodontic retreatment was performed. **(D)** Internal bleaching, followed by placement of a new composite, restored esthetics.)

Such discolorations are difficult to bleach and tend to recur with time. However, bleaching them is worth a try. The result may be an improvement that satisfies the patient. The use of amalgam for tooth restoration is gradually decreasing in many parts of the world.

Discoloration from inappropriately placed metal pins and prefabricated posts in anterior teeth may sometimes occur. This is caused by metal that is visible through the composite or tooth structure. Occasionally, discoloration from amalgam is also caused by visibility of the restoration through translucent tooth structure. In such cases, replacement of old metallic material with an esthetically pleasing restoration will suffice.

Composite Restorations

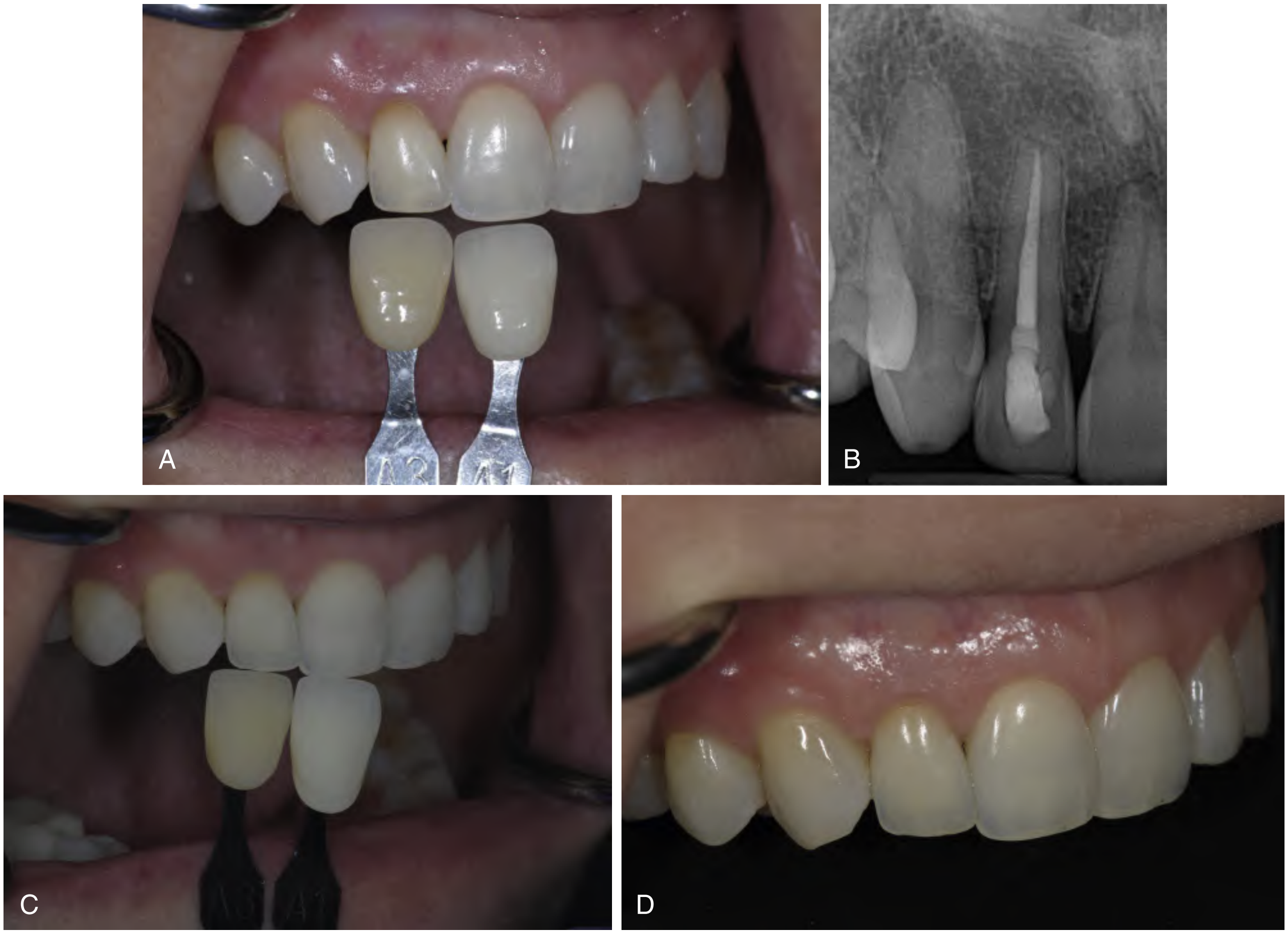
Microleakage of composites causes discoloration. Open margins may permit chemicals to permeate gaps between the restoration and tooth structure to stain the underlying dentin. In addition, composites may become discolored with time and alter the shade of the crown. These conditions can sometimes be corrected by replacing the old composite with a new, well-sealed esthetic restoration. In many cases, internal bleaching is carried out first with good results (Fig. 17.6).

Bleaching Materials

Bleaching chemicals may act as either oxidizing or reducing agents. Most bleaching agents are oxidizers, and many preparations are available. Commonly used agents are solutions of hydrogen peroxide of different strengths, sodium perborate, and carbamide peroxide. Sodium perborate and carbamide peroxide are chemical compounds that are gradually degraded to release low levels of hydrogen peroxide. Hydrogen peroxide and carbamide peroxide are mainly indicated for external bleaching, whereas sodium perborate is mostly used for internal bleaching. All have proved effective.

Hydrogen Peroxide

Hydrogen peroxide is a powerful oxidizer that is available in various strengths, but 30% to 35% stabilized solutions (Superoxyl, Perhydrol) are the most common. These high-concentration solutions must be handled with care because they are unstable, lose oxygen quickly, and may explode unless they are refrigerated and stored in a dark container. Also, these are caustic chemicals and will burn tissue on contact.



• **Fig. 17.6** **(A)** Discoloration of an endodontically treated maxillary lateral incisor in a 61-year-old female. Note the difference in coronal shade between the lateral incisor and the adjacent central incisor. Probable cause of discoloration is coronal microleakage. **(B)** Preoperative radiograph. **(C)** Immediate postoperative results after internal bleaching. The coronal shade of the treated tooth has improved and is now matching the shade of the adjacent central incisor. **(D)** Fifteen-month follow-up appointment. The treated tooth maintains pleasing esthetic results. (Courtesy of Dr. A. Sameni.)

Although highly concentrated hydrogen peroxide bleaches quickly, other chemicals that release much lower levels of peroxide are available; usually they bleach effectively with longer application periods.[18]

Sodium Perborate

Sodium perborate is available in powder form or in various commercial proprietary combinations.[19,20] When fresh, it contains about 95% perborate, corresponding to 9.9% available oxygen. Sodium perborate is stable when dry, but in the presence of acid, warm air, or water, it decomposes to form sodium metaborate, hydrogen peroxide, and nascent oxygen. Various types of sodium perborate preparations are available: monohydrate, trihydrate, and tetrahydrate. They differ in oxygen content, which determines their bleaching efficacy.[20] Commonly used sodium perborate preparations are alkaline; their pH depends on the amount of hydrogen peroxide released and the residual sodium metaborate.[21]

Sodium perborate is more easily controlled and safer than concentrated hydrogen peroxide solutions.[2,3,4,19,22,23] Therefore in most cases, it should be the material of choice for internal bleaching.

Carbamide Peroxide

Carbamide peroxide is usually available in concentrations varying between 3% and 15%. Popular commercial preparations contain about 10% carbamide peroxide and have an average pH of 5 to 6.5. They usually also include glycerin or propylene glycol, sodium stannate, phosphoric or citric acid, and flavor. In some preparations, Carbopol, a water-soluble resin, is added to prolong the release of active peroxide and to improve shelf life. Ten percent carbamide peroxide breaks down into urea, ammonia, carbon dioxide, and approximately 3.5% hydrogen peroxide.

Carbamide peroxide and hydrogen peroxide–based systems are mostly used for external bleaching and have been associated with varying degrees of alterations to dental hard tissues and surrounding mucosa.[24,25] They may adversely affect the bond strength of composite resins and their marginal seal.[24-28] Therefore these materials must be used with caution and usually under strict supervision of the dentist.

Other Agents

In the past, a preparation of sodium peroxyborate monohydrate (Amosan), which releases more oxygen than does sodium perborate, was recommended for internal bleaching. Today, this product is not available in all countries, and its clinical use is less common.

Sodium hypochlorite is a common root canal irrigant that is commonly available commercially as a 3% to 8% household bleach. Although used as a household bleaching agent, it does not release enough oxidizer to be effective and is not commonly used for routine tooth bleaching.

Other nonperoxide bleaching agents have also been suggested for clinical use; however, these have not been significantly more effective than traditional agents.[29,30]

Study Questions

1. Tooth discoloration under existing composites occurs because of:
   a. Open margins of the restoration allowing leakage
   b. Discoloration of the composite itself over time
   c. Excess bonding agent becoming more opaque with time
   d. All of the above
   e. A and B only
2. In order to prevent discoloration from remaining pulpal tissue, the operator should:
   a. Access the entire pulp chamber and pulp horns to completely débride the tissue
   b. Rely primarily on chemical débridement
   c. Ensure that sealer does not contact any tissue remnants, as sealer will only discolor if in contact with pulp tissue remnants
   d. All of the above
   e. A and B only
3. The condition caused by a temporary disruption in enamel formation resulting in a banding type of surface defect acquiring stain is known as:
   a. Progressive dental hypoplasticity
   b. Chromatic chronologic dimorphism
   c. Chronologic hypoplasia
   d. Acute progressive chromatism
   e. All of the above
4. When considering internal bleaching of a tooth with pulp necrosis, which of the following is correct:
   a. Tissue disintegration products leach into dentinal tubules to cause stain
   b. The degree of discoloration is related to the duration of pulp necrosis
   c. Dark discolorations have only short-term success when bleached
   d. All of the above
   e. A and B only
5. What is the current recommended bleaching material used for the "walking bleach" technique?
   a. 5.25% sodium hypochlorite
   b. 30% hydrogen peroxide
   c. Sodium perborate
   d. Iodoform
   e. A and B only

Mechanism of Tooth Bleaching

Tooth bleaching is a dynamic process that involves diffusion of the bleaching material into the dental hard tissues. It is initiated by movement of bleaching agent into the tooth structure, to interact with the stain molecules. Consequently, micromorphologic alterations and changes within the dental structures occur that affect their optical properties and perception.[31]

The mechanism resulting in changed perception of tooth color can be divided into three phases: (1) movement of the bleaching agent into the tooth structures; (2) interaction of the bleaching agent with the stain molecules; and (3) alteration of the tooth structures to reflect light differently. The outcome of this sequence of events results in the final color change of the tooth.[31]

It is theorized that the mechanism of tooth bleaching involves interaction of oxidizing agent with organic chromophores.[32] Chromophores are the parts of molecules responsible for demonstrating color. Bleaching works by an oxidation process removing electrons that allows large pigmented organic molecules to be dissolved into smaller, less pigmented constituents.[32] The altered chromophores are still present, but their size is significantly reduced and not as visible by the human eye.

Internal (Nonvital) Bleaching Techniques

The methods most commonly used to bleach teeth in conjunction with root canal treatment are the *thermocatalytic* technique and the so-called *walking bleach* technique.[1,2,19,33] These techniques are somewhat different but produce similar results.[3,4,19] The walking bleach technique (described later in the chapter) is preferred because it requires the least chair time and is more comfortable and safer for the patient. Whatever technique is used, the active ingredient is the oxidizer, which is available in different chemical forms. The least potent form is preferred.

Indications for internal bleaching technique are: (1) discolorations of pulp chamber origin; (2) dentin discolorations; and (3) discolorations that are not amenable to external bleaching. Contraindications are: (1) superficial enamel discolorations; (2) defective enamel formation; (3) severe dentin loss; (4) presence of caries; and (5) discolored proximal composites (unless they are replaced after bleaching).

Thermocatalytic Technique

The thermocatalytic technique involves placing the oxidizing agent in the pulp chamber and then applying heat. Heat may be supplied by heat lamps, light or laser, flamed instruments, or electrical heating devices, which are manufactured specifically to bleach teeth.[33]

Potential damage from the thermocatalytic approach includes the possibility of external cervical root resorption because of irritation to cementum and the periodontal ligament, possibly from the oxidizing agent in combination with heat.[34,35] Therefore the application of heat during internal bleaching is contraindicated. Also, the thermocatalytic technique has not proved more effective long term than other methods and is not recommended for routine internal bleaching.

A thermocatalytic variation is ultraviolet photo-oxidation. A 30% to 35% hydrogen peroxide solution is placed in the pulp chamber on a cotton pellet, followed by a 2-minute exposure to ultraviolet light applied to the coronal labial surface of the tooth. Supposedly this causes the release of oxygen similar to that seen in other thermocatalytic bleaching techniques.[36,37] It is probably no more effective than the walking bleach technique and requires more chair time. Because of toxicity considerations with concentrated hydrogen peroxide, this technique is not recommended for internal bleaching of nonvital teeth.

Walking Bleach

The walking bleach technique should be used in all situations requiring internal bleaching. Not only is it as effective as the techniques previously described, but it also is the safest and has the shortest chair time requirement.[19,38] The technique is described step-by-step in Fig. 17.7 and Box 17.1.

It is often thought that "overbleaching" is desirable because of future recurrence of discoloration. However, bleaching a tooth to a lighter shade than its neighbors should be performed with caution because the overbleached tooth may not discolor to match the shade of adjacent teeth. A tooth that is too light may be as unesthetic as one that is too dark.

Treatments at subsequent visits are similar. If early bleaching appointments do not provide satisfactory results, the following additional procedures may be attempted: (1) a thin layer of stained facial dentin is removed with a small round bur (see Box 17.1, step 7); and (2) the walking bleach paste is strengthened by mixing the sodium perborate with hydrogen peroxide (start with 3% hydrogen peroxide and increase the concentration gradually, only if necessary) instead of water. Heat is not used. The more potent oxidizer may enhance the bleaching effect but may increase the risk of subsequent root damage.[34,35,39]

Carbamide peroxide has also been suggested for internal bleaching.[40] This agent, however, is probably not superior to sodium perborate.

Although usually the final results are excellent, occasionally only partial lightening is achieved. Surprisingly, the patient often is very pleased and satisfied with a modest improvement and does not expect perfection. Therefore internal bleaching is worth the attempt.

The number of applications varies based on the degree of discoloration and its cause.[5] On average, most discolorations (75%) can be handled in one to two appointments, but sometimes more appointments and reapplications are necessary (Video 17.2).[5,38,41]

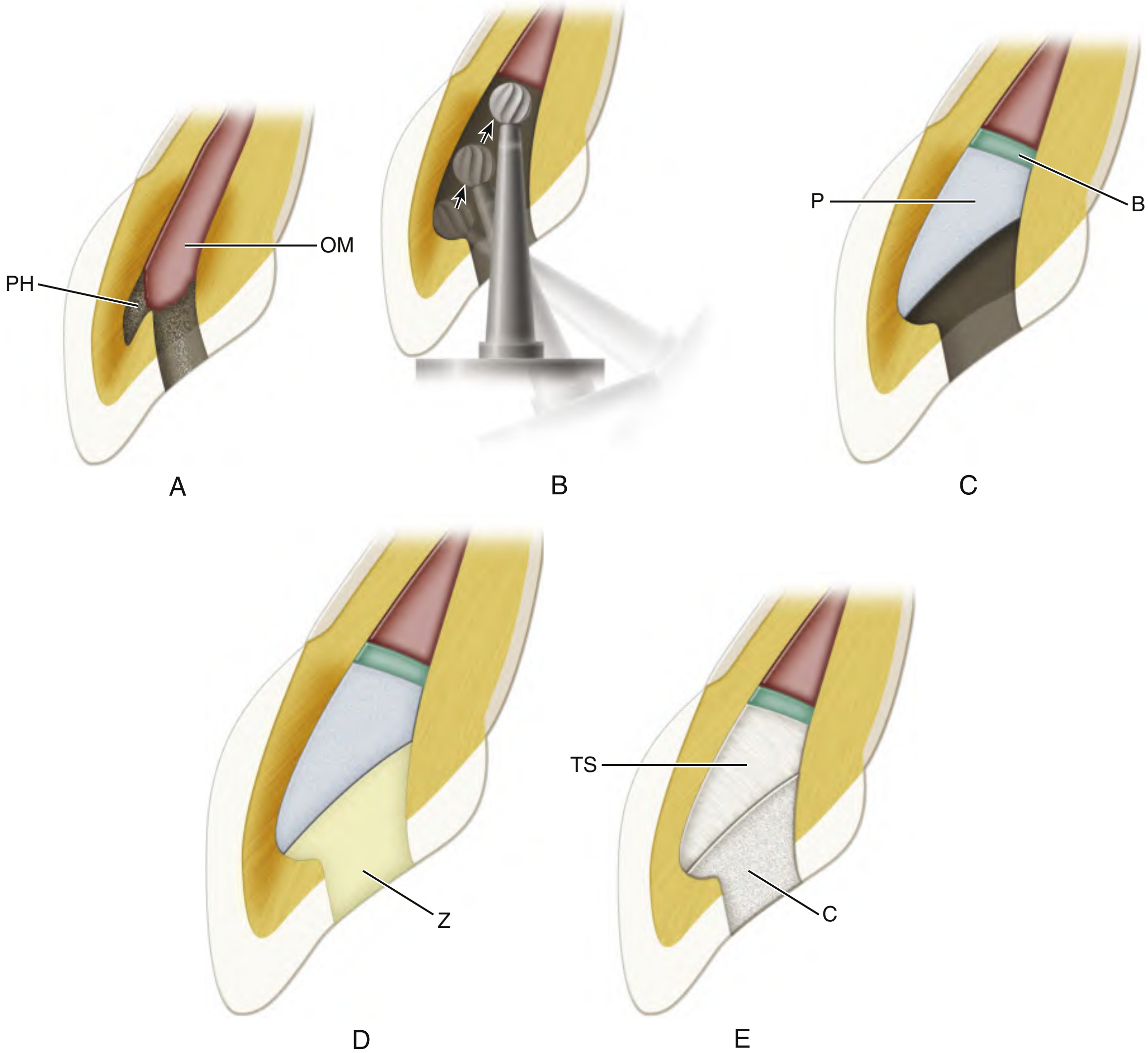
Final Restoration

Proper tooth restoration is essential for long-term successful internal bleaching results.[42-44] The pulp chamber and access cavity are restored at the final visit (see Fig. 17.7, *E*). Although it has been proposed that substances such as acrylic monomer or silicones be placed in the chamber to fill the dentinal tubules, this is not beneficial. Furthermore, these substances may themselves lead to discoloration with time. However, it is important to restore the chamber carefully and to seal the lingual access to enhance the new shade and prevent leakage. The ideal method for filling the chamber after tooth bleaching has not been determined. However, the chamber must not be filled totally with composite; this may cause a loss of translucency of the tooth.[43]

It is easy and effective to fill the chamber with a light-colored gutta-percha temporary stopping, glass ionomer, or a light shade of zinc phosphate cement and then to restore the lingual access with a light-cured, acid-etched composite.[44] Composite resins have different levels of color and contrast ratio.[45] Awareness of such optical properties aids in material selection. An adequate depth of composite should be ensured to seal the cavity and provide some incisal support. Light curing from the labial, rather than the lingual, surface is recommended because this results in shrinkage of the composite resin toward the axial walls, reducing the rate of microleakage.[46] Coronal microleakage of lingual access restorations is a problem.[47] A leaky restoration may lead to recurrence of discoloration.

Residual peroxides of bleaching agents, mainly hydrogen peroxide and carbamide peroxide, may affect the bonding strength of composites to the tooth.[27,48-50] Sodium perborate mixed with water can result in much less loss of bond strength than does concentrated hydrogen peroxide.[50] Therefore it is not recommended that the tooth be restored with composite immediately after bleaching but only after an interval of a few days. The use of catalase and other agents has also been proposed for fast elimination of residual peroxides from the access cavity and for protection against potential hazardous effects[51-54]; this merits further studies.

It has been suggested that packing calcium hydroxide paste in the chamber for a few weeks before the final restoration is placed would reverse the acidity caused by bleaching agents and prevent resorption; however, this procedure is ineffective and unnecessary.[21,38]



• **Fig. 17.7** Walking bleach. **(A)** Internal staining of dentin caused by remnants of obturating materials *(OM)* in the pulp chamber and by materials and tissue debris in the pulp horns *(PH).* **(B)** Coronal restoration is removed completely, access preparation is improved, and gutta-percha is removed apically to just below the cervical margin. Next, the pulp horns are cleaned with a round bur. (Shaving a thin layer of dentin from the facial wall is optional and may be attempted at later appointments if discoloration persists.) **(C)** An optional protective cement base *(B)* is placed over the gutta-percha, not extending above the cervical margin. After the removal of sealer remnants and materials from the chamber with solvents, a paste *(P)* composed of sodium perborate and water (mixed to the consistency of wet sand) is placed. The incisal area is undercut to retain the temporary restoration. **(D)** A thick mixture of a zinc oxide–eugenol–type temporary filling *(Z)* seals the access. **(E)** At a subsequent appointment, when the desired shade has been reached, a permanent restoration is placed. A suggested method is to fill the chamber with white temporary stopping *(TS)* or with light polycarboxylate or zinc phosphate base. Acid-etched composite *(C)* restores lingual access and extends into the pulp horns for retention and to support the incisal edge. (From Walton RE: Bleaching procedures for teeth with vital and nonvital pulps. In Levine N, editor: *Current treatment in dental practice,* Philadelphia, 1986, Saunders.)

Other agents have been proposed to enhance the bleaching effect or to open tubules; none have been shown to be significantly effective.[55,56]

Future Rediscoloration

Although initial bleaching is successful, many of these teeth may rediscolor after several years.[57,58] Patients must be informed of this possible occurrence and that rebleaching usually will be successful.

When to Bleach

Internal bleaching may be performed at various intervals after root canal treatment (see Figs. 17.1 and 17.5). The appearance of the discolored tooth may be improved soon after treatment. However, the walking bleach technique may be initiated at the same appointment as the obturation. In fact, this may motivate the patient to accept bleaching because the appearance of the discolored tooth may be improved soon after treatment. Bleaching may also be attempted successfully many years after

• BOX 17.1 Walking Bleach Technique

The steps of the walking bleach technique are as follows (see Fig. 17.7).

1. The patient is familiarized with the probable causes of discoloration, the procedure to be followed, the expected outcome, and the possibility of future recurrence of discoloration (regression). To avoid disappointment or misunderstanding, effective communication before, during, and after treatment is absolutely necessary.
2. Radiographs are made to assess the status of the periapical tissues and the quality of root canal treatment. Treatment failure or questionable obturation requires retreatment before bleaching.
3. The quality and shade of any restoration present are assessed. If defective, the restoration is replaced. Often tooth discoloration results from leaking or discolored restorations. Also, the patient is informed that the bleaching procedure may temporarily (or permanently) affect the seal and color match of the restoration, requiring its replacement.
4. Tooth color is evaluated with a shade guide, and clinical photographs are taken at the beginning of and throughout the procedure. These provide a point of reference for future comparison by both dentist and patient.
5. The tooth is isolated with a dental dam. Interproximal wedges may also be used for better isolation. If hydrogen peroxide is used, a protective cream (e.g., petroleum jelly, Orabase, or cocoa butter) must be applied to the gingival tissues before dam placement. This protection is not required with sodium perborate use.
6. The restorative material is removed from the access cavity (see Fig. 17.7, *B*). Refinement of access and removal of all old obturating and restorative materials from the pulp chamber comprise the most important stage in the bleaching process. The clinician must check that pulp horns or other "hidden" areas have been opened and are free of pulp tissue remnants.

   A chamber totally filled with composite resin presents a clinical problem. First, this material is resistant to cutting with burs. Second, its shade is often indistinct from that of dentin. However, all composite must be removed to allow the bleaching agent to contact and penetrate the dentin. Care must be taken during restoration removal to avoid inadvertent cutting of sound dentin. The operating microscope or magnifying loupes are beneficial.
7. (Optional). This step may be necessary if the discoloration seems to be of metallic origin or if, on the second or third appointment, bleaching alone does not seem to be sufficient. A thin layer of stained dentin is carefully removed toward the facial aspect of the chamber with a round bur in a slow-speed handpiece. This removes much of the discoloration (which is concentrated in the pulpal surface area). It may also open the dentinal tubules for better penetration by the bleaching agents.
8. All materials should be removed to a level just apical to the gingival margin. Appropriate solvents (e.g., orange solvent, or chloroform, on a cotton pellet) are used to dissolve remnants of the common sealers.
9. If hydrogen peroxide is used, a sufficient layer of protective cement barrier (e.g., polycarboxylate, zinc phosphate, glass ionomer, intermediate restorative material [IRM], or Cavit at least 2 mm thick) is applied as a barrier on the obturating material. This is essential to minimize leakage of bleaching agents.[53] The barrier should protect the dentin tubules and conform to the external epithelial attachment.[54] It should not extend incisal to the gingival margin (see Fig. 17.7, *C*). Acid etching of dentin internally with phosphoric (or other) acid to remove the smear layer and open the tubules is not necessary.[55,56] The use of any caustic chemical in the chamber is unwarranted because periodontal ligament irritation or external root resorption may result.[56] The same reservation applies to solvents such as ether or acetone before application of the bleaching agent. The application of concentrated hydrogen peroxide with heat (thermocatalytic) has been suggested as the next step. This may not be more effective and also may be questionable from a safety standpoint.
10. The walking bleach paste is prepared by mixing sodium perborate and an inert liquid, such as water, saline, or anesthetic solution, to the consistency of wet sand (approximately 2 g/mL). Although sodium perborate mixed with 30% hydrogen peroxide bleaches faster, in most cases the long-term results are similar to those of sodium perborate mixed with water; therefore the former mixture should not be used routinely.[3,4,19,38] Another advantage of sodium perborate and inert liquid is that a protective cement barrier and gingival protection are unnecessary. With a plastic instrument, the pulp chamber is packed with the paste. Excess liquid is removed by tamping with a cotton pellet. This also compresses and pushes the paste into the recesses (see Fig. 17.7, *C*).
11. Excess oxidizing paste is removed from undercuts in the pulp horns and gingival area with an explorer. A cotton pellet is not used, but a thick mix of zinc oxide–eugenol (preferably IRM) or Cavit is packed carefully to a thickness of at least 3 mm to ensure a good seal (see Fig. 17.7, *D*).
12. The dental dam is removed. The patient is informed that the bleaching agent works slowly and that significant lightening may not be evident for 2 or more weeks. It is common to see no change initially, but dramatic results occur in successive days or weeks or after a future reapplication.
13. The patient is scheduled to return approximately 2 to 4 weeks later, and the procedure is repeated. If at any future appointment (third or fourth) progressive lightening is not evident, further walking bleach treatments with sodium perborate and water solution may not prove beneficial.[38]

discoloration has occurred (see Figs. 17.3 and 17.4), even with porcelain veneer restorations (Fig. 17.8). Such teeth show no markedly greater tendency for recurrence of discoloration than teeth stained for shorter discoloration periods.[57] However, it is probable that a shorter discoloration period tends to improve the chances for successful bleaching and reduce the likelihood of recurrence of discoloration.[58]

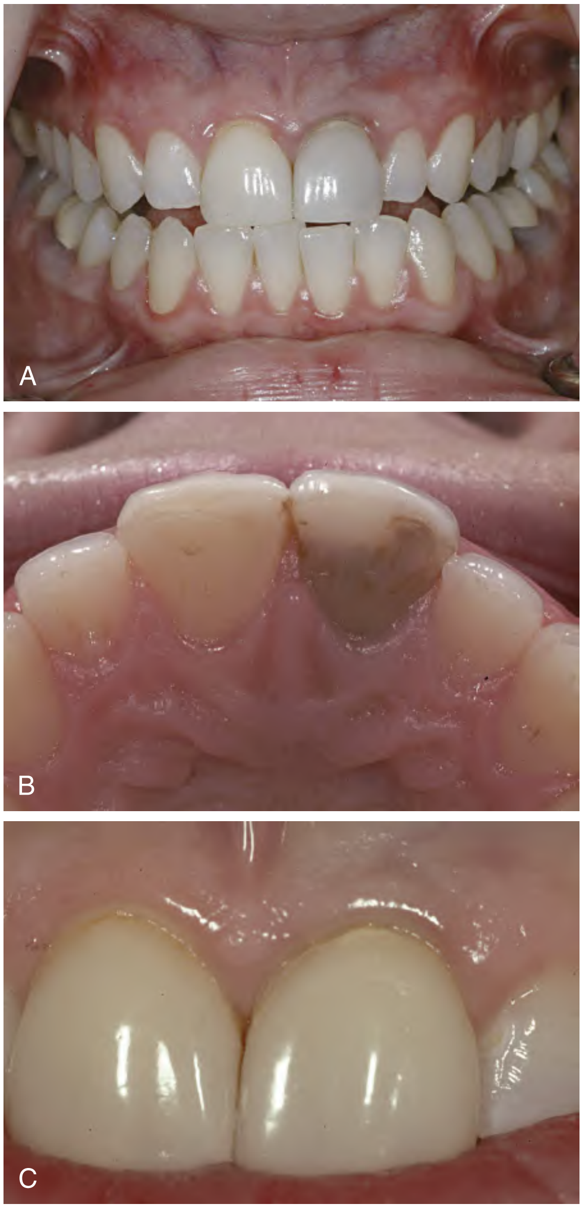
Other factors that may influence long-term success have also been evaluated clinically. The patient's age and the rate of discoloration have no major effect on the long-term stability of bleaching.[57]

Complications and Safety

Patient safety is always the major concern in any procedure. Some possible adverse effects produced by chemicals and bleaching procedures are discussed in the following sections.

External Root Resorption

Clinical reports[35,59] and histologic studies[34,39] have shown that internal bleaching may induce external root resorption. The oxidizing agent, particularly 30% hydrogen peroxide, and heat may be the culprits. However, the exact mechanism by which periodontium or cementum is damaged has not been fully elucidated. Presumably, the irritating chemical diffuses through the dentinal tubules[60] and reaches the periodontium through defects in the cementoenamel junction.[61] Chemicals combined with heat are likely to cause necrosis of the cementum, inflammation of the periodontal ligament, and subsequent root resorption.[34,39] The process is liable to be enhanced in the presence of bacteria.[62] Previous traumatic injury and young age may also act as predisposing factors.[1,2] Therefore injurious chemicals and procedures should be avoided if they are not essential for bleaching. Again, sodium perborate mixed with water should be preferred over 35% hydrogen



• **Fig. 17.8** **(A)** Discoloration of endodontically treated incisor restored with a porcelain veneer. Discoloration is reflected through the veneer and is most evident at the cervical area. **(B)** Lingual view reveals extensive discoloration of the dentin and composite that was used to restore the access cavity. **(C)** Removal of discolored composite, internal bleaching, and placement of a new, well-sealed composite restored tooth esthetics. (Courtesy of Dr. A. Sameni.)

peroxide.[38,63] Also, apical to the cervical margin, oxidizing agents should not be exposed to more of the pulp space and dentin than is absolutely necessary to obtain a satisfactory esthetic clinical result.

Coronal Fracture

Slightly increased brittleness of the coronal tooth structure, particularly when heat is applied, is also thought to result from certain bleaching procedures. This supposedly is a result of either desiccation or alterations to the physicochemical characteristics of the dentin and enamel.[64-67] It appears that bleached teeth are no more susceptible to fracture if properly restored.[68]

Chemical Burns

As mentioned earlier, sodium perborate is safe; however, 30% hydrogen peroxide is caustic and can cause chemical burns and sloughing of the gingiva. When this strong chemical is used, the soft tissues should be coated with an isolation cream such as petroleum jelly, Orabase, or cocoa butter. Animal studies suggest that catalase applied to oral tissues before hydrogen peroxide treatment fully prevents the associated tissue damage.[69]

Intrinsic Discolorations

Intrinsic discolorations are those incorporated into tooth structure during tooth formation.[70] Significantly, most of these discolorations are in dentin and are relatively difficult to treat externally. A good example is staining from tetracycline that is incorporated into the mineral structure of the developing tooth. The incorporated tetracycline imparts its color to the dentin.

Tetracycline

Both external and internal bleaching techniques have been advocated as a means of improving the appearance of tetracycline-discolored teeth. As noted earlier, the internal technique is more effective and has a very good long-term prognosis.[11,70] However, the best resolution for tetracycline discolorations is prevention.

The technique involves root canal treatment followed by an internal walking bleach technique, as outlined earlier in this chapter. If the procedure is explained to patients, they may accept this approach, with gratifying results (Fig. 17.9). However, this procedure is not for every patient. Many will prefer to keep their pulps intact and opt to external bleaching.

Other Intrinsic Discolorations

Other drugs or ingested chemicals are incorporated into teeth that are forming and cause discoloration. There are no reports of attempts to bleach these teeth. Presumably, attempts to lighten teeth with dentinal discolorations by the external application of bleaching agents would be only marginally effective.

Extrinsic Discolorations

Extrinsic discolorations are more superficial and are obviously more amenable to external bleaching. The success of bleaching, however, depends more on the depth of the stain in the enamel rather than on the color of the stain itself. These discolorations are not treated by internal bleaching.

When and What to Refer

The demand for tooth bleaching has been steadily increasing in the last decade.[31,71] It has been proven to be safe and effective when done by a trained dental professional. Most bleaching procedures can be performed by general dentists, particularly if the cause of the discoloration is diagnosed. If the general practitioner cannot make this identification, referral to a specialist should be considered.

The practitioner may also wish to refer patients whose tooth discoloration does not respond to conventional methods of bleaching. Unidentified factors may be preventing the bleaching chemicals from effectively reaching the stain. The specialist may be able to identify and correct these factors.

• **Fig. 17.9** **(A)** Characteristic grayish discoloration and banding of tetracycline discolorations. Cervical regions on maxillary and mandibular teeth show no discoloration; tetracycline was not administered during those periods of tooth development. **(B)** Root canal treatment has been completed on the maxillary anterior teeth, with subsequent walking bleach procedures. **(C)** After the necessary number of bleaching appointments, the teeth are restored permanently. Note the marked contrast with the mandibular incisors, which remain untreated. **(D)** At the 4-year follow-up, no regression and no recurrence of discoloration are seen. (Courtesy of Dr. H. Wayne Mohorn.)

Study Questions

6. Carbamide peroxide:
   a. Is used mainly for external bleaching
   b. Improves composite bond strength
   c. Does not cause any mucosal tissue damage
   d. All of the above
   e. B and C only
7. The mechanism of bleaching is most correctly summarized by the following:
   a. Bleaching proceeds by washing out the pigment of molecules and leaving behind only their unstained external structure.
   b. Reactive oxygen species cause the breakdown of larger pigmented molecules into smaller less visibly pigmented molecules.
   c. Bleaching occurs via alteration of trans bonds to a cis fashion that allows kinked structures to be better aligned and thus creates less visible pigmentation in the visible light spectrum.
   d. Chromophores attack the bonds of other molecules, leading to dissolution of the reactive oxygen species (which otherwise contribute to pigmentation of molecules).
   e. B and C
8. In case internal bleaching procedure requires more than two attempts, it is recommended to:
   a. Remove the coronal aspect of the obturation material and place the orifice barrier more apically.
   b. Place less concentrated hydrogen peroxide containing bleaching material.
   c. Continue replacement of the bleaching agent via the same procedure until the desired shade is reached.
   d. Use a slow speed round bur to hollow out the dentin in the pulp chamber in a deliberate fashion that allows better light transmission.
   e. A and D
9. Which of the following is correct when considering restoration of endodontically treated teeth that have recently undergone internal bleaching?
   a. Acrylic monomer or silicones should be placed as a liner to occlude the dentinal tubules before final restoration of the tooth.
   b. The pulp chamber should not be filled completely with composite resin because it could decrease the natural translucency of the tooth.
   c. Placement of calcium hydroxide for 1 to 2 weeks after bleaching is recommended to increase the pH of the dentin before placement of a restoration.
   d. When curing the access composite, it is recommended to cure from the lingual aspect rather than from the labial.
   e. B and D

Study Questions—cont'd

10. Which of the following statements about internal bleaching is correct?
    a. Long-standing discolorations that are bleached internally are always more prone to rediscoloration than short-term discolorations.
    b. Patient age plays a critical role in the success of internal bleaching procedures.
    c. Although the exact mechanism is not fully clear, it is presumed that the etiology of bleaching related root resorption may be caused by leaching of hydrogen peroxide through dentinal tubules and defects in the CEJ and root surface causing irritation to the periodontium.
    d. Internally bleached teeth are shown to be more brittle and more prone to fracture.
    e. All of the above

ANSWERS

Answer Box 17

1 e. A and B only.
2 a. Access the entire pulp chamber and pulp horns to completely débride the tissue.
3 c. Chronologic hypoplasia.
4 e. A and B only.
5 c. Sodium perborate.
6 a. Is used mainly for external bleaching.
7 b. Reactive oxygen species cause the breakdown of larger pigmented molecules into smaller less visibly pigmented molecules.
8 a. Remove the coronal aspect of the obturation material and place the orifice barrier more apically.
9 b. The pulp chamber should not be filled completely with composite resin because it could decrease the natural translucency of the tooth.
10 c. Although the exact mechanism is not fully clear, it is presumed that the etiology of bleaching related root resorption may be due to leaching of hydrogen peroxide through dentinal tubules and defects in the CEJ and root surface causing irritation to the periodontium.

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Video 17.1 Walking Bleach Introduction
Video 17.2 Walking Bleach