Advances In Dental Bleaching Techniques

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ABSTRACT

Tooth bleaching is a widely accepted esthetic procedure in dentistry aimed at addressing both intrinsic and extrinsic discoloration. Various bleaching agents, including hydrogen peroxide, carbamide peroxide, and sodium perborate, function through oxidation to break down chromogenic compounds. Techniques such as the walking bleach method, in-office power bleaching, and at-home tray bleaching have been developed to enhance whitening efficacy. Despite its benefits, bleaching may lead to complications such as enamel demineralization, tooth sensitivity, and external cervical resorption. Recent advancements, including laser-assisted bleaching, cold atmospheric plasma, and nano-filled bleaching gels, offer improved outcomes with reduced side effects. This review explores the mechanisms, techniques, complications, and innovations in bleaching, providing a comprehensive understanding of its role in endodontics.

Keywords: *Bleaching agents, carbamide peroxide, hydrogen peroxide, sodium perborate, walking bleach.*

1. INTRODUCTION

Tooth whitening has become one of the most sought-after cosmetic treatments in dental practices in recent years. This growing demand is largely driven by patients' increasing interest in not only maintaining oral health but also enhancing their smile aesthetics. Bright, white teeth are often associated with youthfulness, higher social standing, and a health-conscious lifestyle. The most commonly used bleaching agent is hydrogen peroxide (HP), typically applied at concentrations of around 35%. The whitening process involves a chemical oxidation reaction, where pigmented compounds are broken down into colorless forms.[1]

Addressing tooth discoloration requires various clinical protocols to achieve an optimal aesthetic outcome. It is important to assess the cause of the discoloration and consider any underlying infections, as treatment approaches differ between vital teeth and those that have undergone endodontic therapy. These methods may involve either external or internal bleaching techniques, depending on the condition of the tooth. Additionally, patient expectations may extend beyond just improving tooth color, sometimes necessitating prosthodontic interventions for comprehensive dental rehabilitation. [2]

2. HISTORICAL BACKGROUND [3]

The bleaching of discolored, non-vital teeth was first documented in 1864 (Truman, 1864). Over the years, various bleaching agents, including chloride, sodium hypochlorite, sodium perborate, and hydrogen peroxide, have been utilized—either individually, in combination, or with and without heat activation (Howell, 1980). In 1961, the "walking bleach" technique was introduced, in which a mixture of sodium perborate and water was placed inside the pulp chamber and sealed between patient visits (Spasser, 1961). This technique was later refined by substituting water with 30-35% hydrogen peroxide to enhance the whitening effect (Nutting and Poe, 1963).

The discovery that carbamide peroxide could lighten tooth color occurred in the late 1960s when an orthodontist prescribed an antiseptic containing 10% carbamide peroxide in a tray to manage gingivitis. This unexpected whitening effect was shared among colleagues and is now considered the origin of night guard bleaching. Over two decades later, a technique involving the overnight use of 10% carbamide peroxide in a mouth guard to whiten teeth was formally introduced.

3. ETIOLOGY OF TOOTH DISCOLORATION

Tooth discoloration can differ based on its cause, appearance, location, severity, and how strongly it adheres to the tooth structure. It is generally categorized as extrinsic, intrinsic, or a combination of both, depending on its origin and location.

Extrinsic:
This type of staining primarily results from chromogenic substances found in commonly consumed foods and beverages such as coffee, tea, wine, carrots, oranges, licorice, and chocolate. Additional contributors include tobacco use, certain mouth rinses, and plaque accumulation on the tooth surface.

Intrinsic:
Intrinsic staining can stem from systemic or local factors.

- **Systemic Factors:** These include drug-induced discoloration (e.g., tetracycline), metabolic conditions such as fluorosis and dystrophic calcification, and genetic disorders like congenital erythropoietic porphyria, cystic fibrosis, hyperbilirubinemia, amelogenesis imperfecta, and dentinogenesis imperfecta.
- **Local Factors:** These include pulp necrosis, intrapulpal hemorrhage, residual pulp tissue following endodontic treatment, staining from endodontic and restorative materials, root resorption, and age-related changes. [4]

Central and lateral incisors are the most commonly impacted teeth due to trauma, with occurrences of 69% and 20%, respectively. Discoloration occurs due to residual endodontic materials in the pulp chamber or hemolytic byproducts accumulating in dentin tubules. Discoloration in the anterior region is a cosmetic concern, as non-vital teeth are visibly distinct. Typically affecting a single tooth, trauma-related discoloration can occasionally involve multiple teeth. The primary causes include necrotic byproducts and endodontic materials, particularly silver-containing pastes, with inadequate irrigation being a common iatrogenic factor. While the exact mechanism is unclear, hemolytic byproducts like hemosiderin, hemin, and hematoporphyrin release iron, leading to yellow-brown staining. Treatment options include restorative procedures or bleaching, which can effectively restore esthetics. [5]

Tooth discoloration has also been linked to regenerative endodontic procedures (REPs) that use triple antibiotic pastes (TAPs) containing minocycline, along with MTA as an intracanal barrier placed over an induced blood clot up to the cemento-enamel junction (CEJ). [6]

4. COMPOSITION OF BLEACHING AGENTS

The most commonly used bleaching agents for tooth whitening include hydrogen peroxide, carbamide peroxide, and sodium perborate. Over the years, various external and internal bleaching agents have been introduced in dental practice, with these three being the most widely utilized. Their whitening effect is achieved through hydrogen peroxide, which is either directly applied or released as a byproduct of the chemical breakdown of carbamide peroxide or sodium perborate. [3,4] Hydrogen peroxide (H_2O_2) is a powerful bleaching agent; however, high concentrations (30%) should be used cautiously to minimize the risk of root resorption. [7]

Sodium perborate is another widely used bleaching agent. It remains stable in its dry form but breaks down into hydrogen peroxide and free oxygen when exposed to acid, heat, or moisture. [8] Sodium perborate is produced through the reaction of disodium tetraborate pentahydrate, hydrogen peroxide, and sodium hydroxide. It exists in monohydrate, trihydrate, and tetrahydrate forms, with the oxygen release varying depending on the specific form. [9] The monohydrate form decomposes more efficiently than the tetrahydrate and exhibits greater temperature stability. [10]

Carbamide peroxide is a white, odorless, water-soluble crystalline solid that breaks down into urea and hydrogen peroxide when dissolved in water, ultimately releasing oxygen and free radicals. [11] It is an organic compound composed of hydrogen peroxide and urea. In vitro studies have shown that its bleaching effectiveness is comparable to that of hydrogen peroxide.[12] Products containing 10% carbamide peroxide release approximately 3.5% hydrogen peroxide.[13] A recent systematic review and meta-analysis confirmed that carbamide peroxide, hydrogen peroxide, and sodium perborate are all effective in bleaching discolored root-filled teeth. However, the bleaching efficacy of carbamide peroxide, hydrogen peroxide, and their combination with sodium perborate was found to be superior to using sodium perborate alone. [14]

Discoloration occurs due to the presence of chemically stable, chromogenic compounds. These pigments are composed of long-chain organic molecules. During the bleaching process, oxidation breaks these compounds into smaller, lighter-colored molecules. [15]

The chemical theory of hydrogen peroxide bleaching suggests that peroxides break down into unstable free radicals. These free radicals penetrate the interprismatic region of the enamel, breaking down large organic chromophores into smaller molecules. With the help of its foaming action, these smaller molecules are then transported to the tooth surface. [16, 4] These free radicals interact with chromophores responsible for enamel discoloration, breaking them down into simpler molecules that reflect less light, resulting in a whitening effect. [17, 18, 19] During the bleaching process, only hydrophilic, colorless structures remain at what is known as the saturation point, causing the whitening effect to slow down. If bleaching continues beyond this stage, the carbon-containing compounds and protein bonds break down, leading to the fragmentation of hydroxyl groups. This further breakdown accelerates the conversion of the remaining material into carbon dioxide and water, increasing enamel loss. [20]

The use of a diode laser showed no significant improvement in bleaching results compared to a halogen lamp. [21]

5. BLEACHING TECHNIQUES

Non-vital Tooth Bleaching [figure 1]

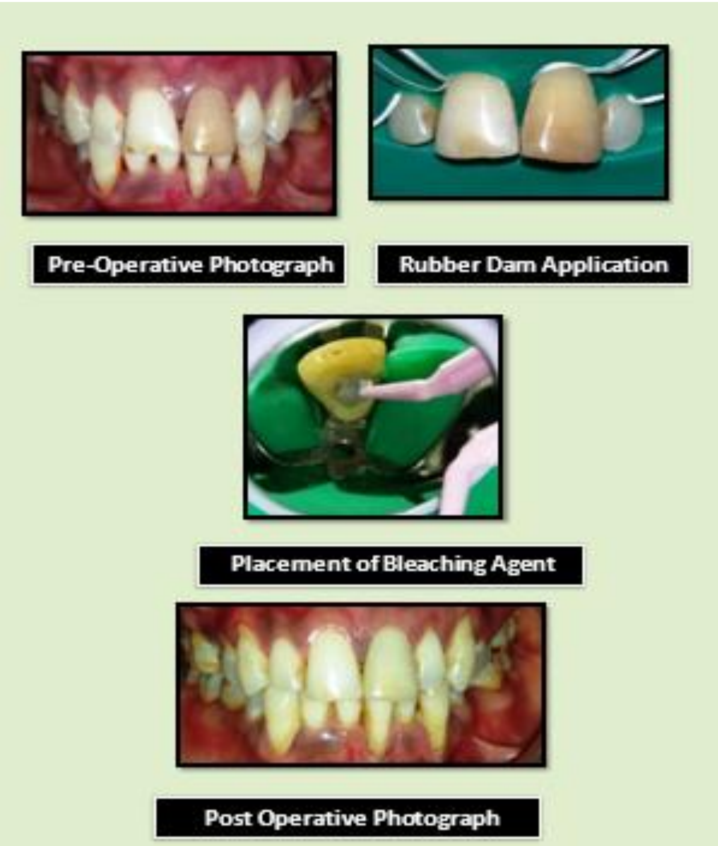

Figure 1: Non-vital tooth bleaching

Nonvital bleaching techniques include the walking bleach method, modified walking bleach, nonvital power bleaching (also called heat- or light-activated bleaching), and inside/outside bleaching.

The walking bleach technique was initially introduced by Spasser, involving the placement of sodium perborate mixed with water into the access cavity of an endodontically treated tooth.[22] Nutting and Poe later modified the technique by using hydrogen peroxide instead of water to improve effectiveness. Additionally, the combination of carbamide peroxide with sodium perborate was proposed to further enhance bleaching efficiency.[23,24]

In nonvital power bleaching, a 30-35% hydrogen peroxide gel is applied to the pulp chamber and activated using light or heat. The temperature typically ranges between 50-60°C, with heat activation paused every 5 minutes for a 5-minute cooling period. [25]

Settembrini et al. (1997) introduced the inside/outside bleaching technique, which combines intracoronal and extracoronal bleaching using carbamide peroxide. This method requires patients to apply the bleaching agent at home daily, making the results dependent on their adherence. The technique utilizes carbamide peroxide in concentrations of 5%, 16%, 22%, or 35%. [26]

Vital tooth bleaching [figure 2]

Figure 2: Vital tooth bleaching

Vital tooth bleaching can be done either at home or in a dental office.

Barghi (1998) identified and reviewed four distinct approaches to tooth whitening. [27]

Dentist-administered bleaching – This involves the application of a highly concentrated hydrogen peroxide (35–50%) or carbamide peroxide (35–40%), often activated with a heat source.

Dentist-supervised bleaching – A bleaching tray filled with a high concentration of carbamide peroxide (35–40%) is placed in the patient's mouth for 30 minutes to 2 hours under professional supervision in the dental office.

Dentist-provided bleaching – Commonly referred to as "at-home" or "night-guard" bleaching, this method requires the patient to apply a carbamide peroxide solution (5–22%) using a custom-made tray.

Over-the-counter whitening products – These products contain varying concentrations of carbamide peroxide or hydrogen peroxide and are available in pre-fabricated trays or whitening strips, which the user applies independently. [29]

6. COMPLICATIONS

Tooth bleaching can have adverse effects on both hard and soft dental tissues, including external cervical resorption, compromised adhesive bonding, and increased solubility of dental materials.[29] The primary active ingredient in bleaching gels is hydrogen peroxide (HP) or its precursor, carbamide peroxide (CP). The whitening process relies on an oxidation-reduction reaction driven by reactive oxygen species (ROS) of low molecular weight. These ROS, released from peroxide-based gels, penetrate hard tissues but may also alter enamel properties by increasing surface roughness and reducing flexural strength and hardness. Additionally, HP diffusion can reach the pulp, potentially causing cell membrane damage, apoptosis, enzymatic dysfunction, and an upregulation of pro-inflammatory markers such as substance P (SP), tumor necrosis factor (TNF)-α, interleukin (IL)-6, and IL-17. Cervical root resorption, a form of inflammatory-mediated external resorption, can occur following trauma or intracoronal bleaching procedures.[3]

7. ADVANCES: [6]

Inside–outside closed bleaching

This method integrates the walking bleach technique with single-tooth external tray bleaching to accelerate the whitening process and potentially minimize the number of required dental visits.

Inside–outside open bleaching

This technique enables the bleaching agent to act both externally and within the pulp chamber simultaneously. The access cavity remains open, with a protective base covering the root filling. The patient applies a 10% carbamide peroxide bleaching agent using a syringe into the access cavity and externally in a tray every 4–6 hours. A follow-up appointment is scheduled after 2–3 days to evaluate the discoloration improvement.

Lasers

The laser energy accelerates the chemical reactions in the bleaching process by heating the bleaching agent, thereby improving its effectiveness. [1]

Cold atmospheric plasma

Cold atmospheric plasma is generated through dielectric barrier discharge, where the glass electrode serves as the primary electrode and the tooth acts as the secondary electrode.

Nano-filled bleaching gels [31]

Bleaching protocols utilizing visible light radiation and nano-filled bleaching gels may offer favorable esthetic results with minimal dentin hypersensitivity while also exhibiting biomimetic properties.

8. CONCLUSION

Tooth bleaching has evolved significantly, offering effective solutions for intrinsic and extrinsic discoloration. Advances in bleaching agents and techniques, including laser-assisted and nano-filled gels, have improved outcomes while minimizing risks. However, complications like enamel alterations and external cervical resorption highlight the need for careful case selection. With continued research and innovation, bleaching remains a safe and valuable esthetic procedure in modern dentistry.

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