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Review Article

Dental Bleaching

Overview on Mechanisms and Complications of Dental Bleaching

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Abstract: The practice of bleaching teeth is very common, and various tools and methods have been developed specifically for this purpose. Whiten teeth, various approaches and products are available, each with a distinctive mode of operation. These include products used at home, such as toothpaste, gels, and films, and systems used in dental offices where products with highly concentrated bleaching agents are used under close supervision. Intrinsic and extrinsic staining are the two main types of tooth discolouration causes. Intrinsic staining, also known as internal staining, can be caused by a variety of things, including genetics, ageing, antibiotics, high fluoride levels, and developmental disorders. It can even begin before the tooth has fully emerged. The effectiveness of these various techniques depends on the specific tooth discolouration being treated. Dental bleaching procedures have emerged due to technical advancements to make the procedure easier to use and increase comfort, safety, and efficiency. External dental whitening is typically accomplished with hydrogen peroxide that has been photoactivated or not or carbamate. However, the teeth whitening process in the home and business leads to sensitivity. Certain risks associated with tooth whitenings, such as increased tooth sensitivity and gingival irritation, have been known to the public and professional communities. Recent research has identified other risks, including tooth surface softening and roughening, increased demineralization risk, dental restoration degradation, and unfavourable colour change. This article aims to review and synthesize the most recent research on tooth bleaching methods and side effects.

Keywords: Tooth, Bleaching, Whitening, Hydrogen Peroxide, Tooth Color, Bleaching Light

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1. INTRODUCTION

The media's portrayal of flawless white smiles has influenced the general public. The visual quality of film, television, electronic, and print media has increased people's awareness of tooth discolouration. Currently, it's thought that one of the patients' top aesthetic concerns is their tooth colour. [1] The practice of bleaching teeth is very common, and various tools and methods have been developed specifically for this purpose. For stained teeth treatment, vital tooth bleaching is regarded as a secure, efficient, minimally invasive, non-destructive, and widely accepted procedure. [2] Intrinsic and extrinsic staining are the two main types of tooth discolouration causes. Intrinsic staining, also known as internal staining, can be caused by a variety of things, including genetics, ageing (as the enamel wears down over time, revealing yellower dentin), antibiotics, high fluoride levels, and developmental disorders. It can even begin before the tooth has fully emerged. Some dental restorations can stain teeth after the tooth has emerged [3]. The pigmentations that affect the tooth's thickness and are found in the enamel or dentin are intrinsic. They are made up of deep pigmentation and pose a clinical challenge because they resist treatment options. This is a case of tetracycline-induced pigmentation, which includes various degrees of "enamel hypoplasia," "fluorosis," and "dentinogenesis imperfecta," among other conditions.[3,4] Most environmental factors that cause extrinsic staining, also known as external staining, include smoking, pigments in food and drink, antibiotics, and metals like iron or copper. A stain is produced when coloured substances from these sources are adsorbed into dental pellicule grown or directly onto the tooth's surface. Most extrinsic pigmentations can be removed using mechanical or chemical colouring renewal techniques, and patients can also be counselled on good habits and ways to prevent surface stains .[5] To whiten teeth, there are a variety of approaches and products available, each with a distinctive mode of operation. These include products used at home, such as toothpaste, gels, and films, and systems used in dental offices where products with highly concentrated bleaching agents are used under close supervision. The effectiveness of these techniques depends on the specific tooth discolouration being treated .[6] Since 1861, Noavais and Toledo have recorded the first whitening. [7] The Dental Cosmos Journal published an article emphasizing the significance of this theme in the New Haven convention. When discussing the use of sulphur dioxide and Labarraque liqueur (2.5% sodium hypochlorite) as bleaching agents, he emphasized the significance of understanding the chemical properties of the chemicals in question. Today, the most effective teeth-whitening method is still the one that uses heat and 30% hydrogen peroxide on healthy teeth while using sodium perborate and 30% hydrogen peroxide on pulped teeth.[8] Multiple bleaching processes use various compounds such as carbamide peroxide and hydrogen peroxide in varying amounts. In addition to the various bleaching substances, light sources like an allogeneic, laser, LED, and ultraviolet can enhance the bleaching activity.[9,10] Bleaching is a procedure that makes the dentin more permeable and raises dental sensitivity, especially as the temperature rises. The sensitivity of the whitening mechanism decreases with decreasing heat generation. In addition to reducing the intensity of the light that is supposed to activate the bleaching gel photochemically, new bleaching approaches ought to develop.[11] Certain risks associated with tooth whitenings, such as increased tooth sensitivity and gingival irritation, have been known to the public and professional communities. Recent research has identified other risks, including tooth surface softening and roughening, increased demineralization risk, dental restoration degradation, and unfavourable colour change. [12] This article's goal is to review and synthesize the most recent research on tooth bleaching methods and side effects.

1.1 Enamel And Dentin Substrates

According to Schwartz and Robbins, tooth enamel completely encases the crown of a human tooth and is composed of hard, calcified tissue. It has a shiny surface and is vitreous, as, with the dentin colour supporting it, the enamel colour ranges from pearl white to dark yellow. Mineral salts make up 90% of the enamel's composition, with water and organic materials making up the remaining 10%. The inorganic materials are enamel crystals, which are primarily made of apatite. Additionally, the enamel contains trace amounts of calcium carbonate, sodium, potassium, magnesium, carbon dioxide, phosphorus in variable concentrations, and fluorine.[13] The ideal surface for applying peroxides when important teeth whitening is being done is enamel.[14] After the brief demineralization that happens during the whitening procedure, peroxides can stimulate remineralization and heal the enamel over time. On the other hand, dentin is a hard-calcified tooth tissue with the same outer shape as enamel and cementum in the coronal section. The dentin encircles a central cavity known as the pulp chamber, which houses the tooth pulp. It is a yellowish-white substance that is softer than enamel but firmer than bone. Its composition comprises 20% water, 30% organic matrix, and 50% mineral salts.[13] The essential ingredients, tubules, and fibres are the three primary elements of dentin, according to Schuartz et al. The primary component is a calcified matrix, and the fibrils, which are outgrowths of the odontoblast, are housed in vertebrate tubules canaliculi. Dentin is a substrate that is not directly related to the peroxide used in essential tooth bleaching, but it plays a role in the sensitivity phenomenon.[13]

1.2 Pigmentations And Stains

Extrinsic pigmentations are typically formed on the tooth's surface, according to Moncada, Arangüiz, and Urza. The attraction of various materials to the tooth surface is important in depositing extrinsic pigmentations. Hydrophobic effects, dipole forces, and hydrogen bonds act briefly, together with electrostatic and Van Der Waalas forces that are active for a lengthy period. These interactions enable the chromogenic substance to anticipate reaching the tooth surface and predicting the appearance of pigmentations.[15] These pigmentations can be divided into the following categories: N1 is a chromogenic bind to the tooth surface and a type of direct dental stain. The chromogen's hue is comparable to dental stains caused by things like tea, coffee, alcohol, metals, and bacterial products. N2 is a specific kind of direct dental stain using coloured pigments that alter the colour of teeth after adhering to the surface. The tooth's surface is initially coated with pigmented pigments, which later modify the tooth's colour. Typical examples are coffee or yellow-pigmented plaque on cervical or inter-proximal areas. N3 is a form of indirect dental stain that binds to teeth and contains colourless substances or pre-chromogens that produce a chemical reaction that changes the dye into chromogens and pre-chromogens like fluoride or chlorhexidine.[14] Most extrinsic pigmentations can be treated with mechanical or chemical colouring renewal techniques and educate patients on their habits and avoidance mechanisms to avoid surface stains.[14] The intrinsic pigmentations involve the thickness of the tooth, which can be found in the enamel or dentin. They are made up of deep pigmentation and pose a clinical issue because they resist treatment methods.[15] Santana describes the existence of a "sub-shaped banana"-shaped natural tooth colour space that is situated between light red and light yellow, extended parallel to the direction of light, and whose extreme values (the lighter and darker tooth) correspond to the value of dental colour, which is quantified using various systems, manual or digital.[17]

1.3 Sensitivity

The sensitivity problem is one of the most contentious adverse effects of tooth bleaching. The following theories concerning tooth sensitivity that happens during bleaching: Direct innervation theory: When a mechanical stimulus is received, sensitivity results from direct neural terminals that penetrate the dentin and then the enamel-dentin junction.[18] Theoretically, the odontoblast can operate as a receptor by transmitting a signal to a nerve ending, but numerous investigations have shown that this is not the case. The hydrodynamic theory refers to any stimulus that causes tooth fluid movement (dental lymph). The movement of fluid within tubule recipients increases innervation on the dentin-enamel interface.[18] The hydrodynamic theory, which is the most widely accepted and is thought to be present during the application of the peroxides, was defined by Meglani et al. as dentinal tubules that are open widely and generate fluid movement within them. This fluid is spin-dried and acts on nerve endings or the dentino-pulpar complex.[15,16] Among the compounds used to treat dental sensitivity are fluoride varnishes, adhesives, potassium nitrate, sodium fluoride, calcium phosphate, and calcium phosphate.[18] According to several writers, sensitivity is a completely controllable adverse side effect that may be readily managed by using peroxides that have fluor in their composition or by applying potassium nitrate. This condition can also be avoided.[19,20]

1.4 Light Sources

As Ferrarazi et al. noted, the light sources or laser-based photo-activation most frequently used in dentistry are: CO2 argon laser and diode laser; argon laser requires extreme care due to the length of emitting wavelength and the thermal properties. The most common method of tooth whitening is done in the dental office and uses 35% hydrogen peroxide.[20] In the case of the laser LED, this is better since it provides a blue light with high energy photons that effectively activate the hydrogen peroxide molecule without the heat side effect. However, a major drawback is the expensive cost of this technology.[20] There are other forms of lasers referred to as "the low-level laser or diode laser"; these lasers work by converting electrical energy into laser energy by the action of a solid arsenate semiconductor typically connected to aluminium, gallium, and indium. Because diodes are absorbed by hard tissues and do not produce heat, their wavelength is well absorbed by pigmented tissue.[20] Additionally, the lamp's reasonable size and low price make it an attractive option.[21] When peroxides are chemically activated, they can diffuse more quickly.[20] While Klaric, in a temperature rise study, stated that $Zoom_2$ lamp compared to LED-405 lamp produced higher increments of temperature to the pulp, Ferrarazi et al. concluded that LED lamps are effective, safe, and economical to activate the hydrogen peroxide.[21] According to Dominguez et al., LED lamps are efficient and don't raise the pulp's temperature by more than 5.5 degrees (Celcius).[22] These days, peroxide producers are faced with the task of rethinking the indications and concentrations based on numerous research that provide compelling evidence that light sources are no longer an enhancement for the in-office dental bleaching process.[23]

1.5 Clinical Evaluation Of Teeth Whitening

The colour of teeth and the colour changes during tooth whitening operations can be measured using various techniques. The simultaneous comparison of the teeth with a common shade guide is one of the most used techniques. This has been used extensively in studies on dental whitening that track changes in tooth colour over time. It is a subjective procedure, and various things can affect how it works. As an illustration, consider lighting circumstances, experience, age, eye strain, makeup, room design, and colour blindness. As a result, an effort must be made to regulate and standardize these parameters. Practice and experience can help people better distinguish between different tooth colours. It is frequently noted that when performing tooth whitening studies, investigators perform various colour calibration exercises and training with shade guides.[24] Instruments called colourimeters are used to gauge an object's colour. The Commission Internationale de l'Eclairage (CIE) Lab colour space is frequently used to describe colours. The CIE Lab colour space is an example of a uniform colour space in which perceived equal distances represent colour differences. The three axes in this three-dimensional colour space are labelled L*, a*, and b*. A perfect black has a L* value of zero, and a perfect reflecting diffuser has a L* value of 100. The L* value is a measurement of an object's lightness. The a* value serves as a gauge for how red (positive a*) or green (negative a*) something is. A measurement of yellowness (positive b*) or blueness (negative b*) is the b* value. The amplitude of the a* and b* coordinates increases for more saturated or strong colours while approaching zero for neutral colours (white, grey). A special positioning jig must be made to achieve reliable intra-oral alignment of the instrument's aperture onto the tooth surface while using a colourimeter to measure tooth colour in vivo. This method has been used in several research to measure long-term changes in tooth colour after whitening treatments.[24] Utilizing digital imaging and analysis systems with non-contact cameras is another method for determining tooth colour. The anterior teeth are typically photographed using a digital camera and appropriate calibration tiles or standards under controlled lighting. The individual teeth are then analyzed using computer software to determine their colour, frequently expressed in terms of CIE Lab values. For instance, the mean change from baseline in L* and b* following 14 days of use of a 10% carbamide peroxide tray-based system was 2.07 and 1.67, respectively.[24]

1.6 In Vitro Models For Tooth Whitening

For the initial assessment of prototypes and the optimization of treatment settings, the use of in vitro models is frequently crucial. These models offer mechanical knowledge of the bleaching process and can gather crucial information about the product's safety in terms of its impact on hard tissues. Numerous in vitro models have been published in the literature and used to assess the effectiveness of tooth whitening solutions. Most models use complete or chopped human or bovine teeth samples and preserve their natural colours. Some in vitro models, however, pre-stain the teeth with blood or black tea to boost the levels of intrinsic tooth colour. Instrumental methods are used to measure the changes in tooth colour.[24]

1.7 Some in vitro Models For Tooth Whitening

According to Leonard et al., the used substrate was Human anterior teeth, and the bleaching agent was 5%, 10% and 16% carbamide peroxide, and the colour measurement was Visual assessment with a shade guide, according to Lenhard et al. the substrate was Human anterior teeth, and the bleaching agent was 10% Carbamide Peroxide, and the colour measurement was Colourimeter.[24]

1.8 Factors Influencing Tooth Whitening

1.8.1 Type Of Bleach

Most recent tooth whitening investigations have used either hydrogen peroxide or carbamide peroxide. Compared to carbamide peroxide-containing goods with identical or similar hydrogen peroxide contents and given using comparable formats and formulations, whether studied in vitro or in vivo, the efficacy of hydrogen peroxide-containing products is roughly the same. Sodium percarbonate, a substitute for hydrogen peroxide, has been employed in a silicone polymer-based product painted onto the teeth to generate a long-lasting film for nighttime bleaching procedures. After two weeks compared to baseline, the peroxide significantly improved tooth colour and was released slowly for up to 4 hours73.[24]

1.9 Time And Concentration

The concentration of the peroxide and the amount of time the product is applied are two important aspects in determining the overall effectiveness of peroxide-containing treatments for teeth whitening. Sulieman et al., for instance, examined the effectiveness of in vitro tooth bleaching gels containing 5–35% hydrogen peroxide and discovered that the higher the concentration, the fewer gel treatments were necessary to achieve uniform bleaching.[25] Similar findings were made by Leonard et al.45, who evaluated the effectiveness of 5%, 10%, and 16% carbamide peroxide gels for in vitro teeth bleaching and discovered that the whitening process started more quickly for the higher concentrations. When the treatment period was prolonged, the efficacy of the 5% did, however, approach that of the higher dosages.[24] Additionally, while bleaching tetracycline-stained teeth in vivo over six months, the initial faster rate of bleaching with larger doses of carbamide peroxide has been seen.[26]

1.10 Light And Heat

Raising the temperature can speed up chemical reactions; a 10 C increase can double the rate of a reaction. Abbot first described the use of intense light in 1918 to increase the temperature of hydrogen peroxide and quicken the process of chemically whitening teeth. Other methods, such as heated dental tools, have been suggested to heat the peroxide to quicken teeth whitening. The dental pulp, however, may suffer irreparable harm from overheating. Modern methods and literature have concentrated on quickening the peroxide bleaching process while simultaneously illuminating the anterior teeth with various sources that have a range of wavelengths and spectral power, such as halogen curing lights, plasma arc lamps, lasers, and light-emitting diodes.[24] Using in vitro models, it has been determined that some light sources cause noticeable increases in pulpal temperatures during tooth whitening. Light can activate peroxide to quicken the bleaching process' chemical redox reactions. Additionally, it's been hypothesized that the light source could energize the tooth stain, helping to speed up the whitening procedure overall. Some goods used in light-activated bleaching techniques have additives that say they help the energy transfer from the light to the peroxide gel. These compounds are frequently coloured, such as carotene and manganese sulphate.[24]

1.11 Bleaching With Lasers

The wavelength of the laser's radiant energy, the power density of the beam, and the temporal properties of the beam energy, such as continuous versus pulsed delivery, pulse rate, and pulse duration, are the crucial components of laser light that affect how it reacts with the target. When discussing a pulsed laser, it is more useful to discuss the energy per pulse in Joules than the average output power in watts. Energy density and the amount of energy per unit area are other helpful measurements. Several additional factors, such as contact versus non-contact delivery mode, focussed versus unfocused beams, and beam diameter, are related to variations in how the laser energy is supplied. The power of the radiation delivered and the mode of operation significantly impact the laser's mechanism of action in addition to its wavelength. The mode type affects how quickly the target heats up; for example, accumulated heating in continuous wave mode is more than in pulsed mode. Low irradiances and energy result in interactions between the laser and the tissue that are either entirely optical or a mix of optical, photochemical, and photobiostimulation effects. Photothermal interactions take over as laser or pulse energy levels rise. Photoablation results from the very high power densities that pulsed lasers can produce so quickly. Such results in a bleaching gel are undesirable.[27-29]

1.12 The Interactions Of Laser Targets

Laser light can interact with the target tissue in four ways depending on its optical characteristics. The amount of laser energy absorbed by the intended target varies depending on factors such as pigmentation, the presence of light-absorbing materials (chromophores), the laser wavelength, and the laser emission mode. A variety of photochemical processes, such as photothermal effects (heat emission), fluorescence (light emission), photo-oxidation (photo-bleaching), or photodynamic effects, can be caused by light absorption. The laser energy travels harmlessly through the target instead of being absorbed by it, causing transmission across the target. The wavelength of the laser employed and the target tissue's optical properties have a significant impact on this effect. There are two types of reflection of the beam from the target's surface with no influence on the target. The ideal mirror-like reflection of light from a surface is called a specular reflection. In contrast, diffuse reflection involves various directions in which incoming light is reflected. The difference between gloss and matte paint finishes is a well-known illustration of the difference between specular and diffuse reflection. The reflection pattern is significantly influenced by how smooth or microscopically rough the surface is about the laser wavelength utilized. The laser energy intensity at any one place is reduced by scattering, which disperses the light into the target in many directions.[30]

1.13 Mechanism Of Tooth Bleaching

Decolourization or whitening through bleaching can occur in a solution or surface. [31] Organic compounds with extended conjugated chains of alternate single or double bonds, frequently containing heteroatoms, carbonyl and phenyl rings in the conjugated system, are the most common type of substance that produces colour in solution or on a surface. These substances are known as chromophores. By breaking one or more double bonds in the conjugated chain, cleaving the conjugated chain, or oxidizing other chemical moieties in the conjugated chain, the chromophore can be bleached and decoloured. Numerous organic and inorganic substances are oxidized by hydrogen peroxide. These reactions occur through various processes influenced by the substrate, the surrounding environment, and catalysis.[32] In general, the process of hydrogen peroxide bleaching needs to be better understood. It can produce a variety of active oxygen species depending on the circumstances of the reaction, such as temperature, pH, light, and the presence of transition metals. The perhydroxyl anion (HO2) is typically how hydrogen peroxide bleaching works in alkaline environments. Other circumstances, such as the homolytic breakage of an O-H bond or an O-O bond in hydrogen peroxide to produce H + OOH and 2 OH (hydroxyl radical), respectively, might result in free radicals.[31] It has been demonstrated that the generation of hydroxyl radicals from hydrogen peroxide increases in photo-chemically initiated reactions employing light or lasers.[33] It has yet to fully understand how oxidizing substances like hydrogen and carbamide peroxide whiten teeth. [34] The enamel dentine junction and dentine regions were first reached by the first diffusion of peroxide into and through the enamel, according to the literature that is now available. Indeed, in vitro studies by some writers have shown that following exposure intervals of 15–30 min to a variety of peroxide products and solutions, modest quantities of peroxide can penetrate the pulp chambers of extracted teeth. These investigations measured peroxide levels significantly lower than required to inactivate pulpal enzymes.[35] For at least one scale of colour value on the Vita shade guide to be decreased, three clinical sessions of the vital teeth bleaching method using carbamide peroxide between 10% and 22% are necessary. The patient applies carbamide peroxide to their teeth at home for 8 hours, typically throughout one night and for no more than three weeks, or until a noticeable improvement in colour is seen. To avoid reaching the saturation point where peroxides can damage teeth, it's important to stick to the time recommendations provided by each manufacturer.[36,37]

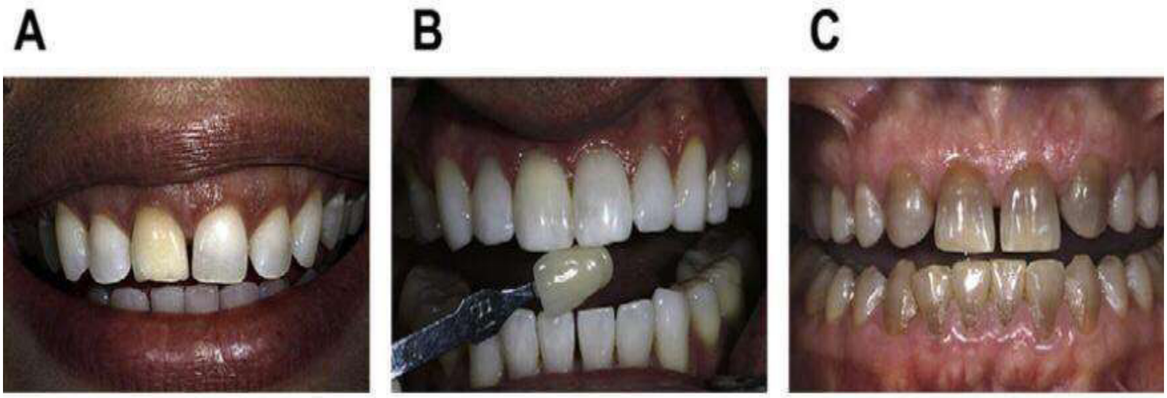
1.14 Enhancing Hydrogen Peroxide Based Bleaching

By photo-oxidizing coloured molecules in the teeth or by interacting with bleaching gel ingredients through photochemical processes, lasers can accelerate the bleaching process. The presence of catalysts, temperature, light, and pH all impact these actions. Six categories can be used to group the many approaches to increasing hydrogen peroxide-based bleaching. Environment With An Alkaline Ph: Always keep hydrogen peroxide at a low, acidic pH. HP becomes substantially more reactive and has a very short shelf life at pH above 7 (alkaline). This is because a hydrogen atom (H+) was lost, resulting in the hydro-peroxyl anion (HO2), which should not be confused with the hydroperoxyl radical (HO2). Since acidic chemicals demineralize and harm enamel in this state, HP becomes a safer tooth-whitening agent and improves bleaching effectiveness due to the enhanced reactivity of hydroperoxyl anions. This increased reactivity can be explained by I the anion's closer connection with positively charged chromophores and (ii) additional reactions where the anion can disrupt chromophores, such as the Dakin reaction and addition to a quinone. For bleaching, HP works best in pH ranges of 9.5 to 10.8. HP is often combined with an alkalinizing agent right before being applied in the mouth due to its inherent instability at high pH to achieve this kind of bleaching enhancement.[38-40] Photochemistry: The photons are absorbed, and the molecule is raised to a higher energy level when a molecule is exposed to photons whose energies match the energy difference between the ground state and some higher or excited state of the molecule. When molecules take in photons with a certain energy, spectra are created. A molecule enters a singlet excited state when it takes in light or photons (an electron in a higher energy state). When a molecule can absorb more light or photons, it is forced into a triplet excited state, where the excited electron's spin is changed by intersystem crossing. Vibration or photon emission—fluorescence for singlet excited molecules and phosphorescence for triplet excited molecules—are used to release the extra energy.[41,42] Photo-thermal Effect and Thermal Enhancement: The bleaching gel can be heated using lasers, specially engineered lamps, and electric heating equipment. Because chemical reactions occur more quickly at higher temperatures, this will increase the effectiveness of bleaching. An increase in temperature of 10 C can accelerate the breakdown of hydrogen peroxide by 2.2 times. Additionally, a temperature rise will improve peroxide's ability to penetrate dental tissues. Due to the inefficient conversion of electric current to heat, lights can generate heat (e.g., tungsten wires in lamps produce heat). This is a more direct method when "cold" lights and lasers cause a temperature increase in the target substrate through the photothermal effect. The molecules in the bleaching gel or the tooth structures will absorb light, causing molecular vibration and subsequent heating.[29,43] Photo-oxidation Effect And Direct Photo-bleaching: Certain compounds are more likely to lose an electron or get oxidized when they reach their triplet excited state. The name of this process is photo-oxidation. When this occurs, chromophores experience direct photo-bleaching, or bleaching, as a result of the disruption of their -conjugated systems. The light must be able to reach the tooth structures when bleaching teeth. Although UV has excellent photo-bleaching qualities, it does not pass through teeth very well and damages soft tissue, burning and scorching the pulp. Since green light is not absorbed by hydroxylapatite or water, it is the best colour for photo-bleaching. As a result, it will effectively pierce the tooth's structure, removing the chromophores that absorb green light. Laser light is more effective at photobleaching than nonlaser light due to its high density.[42,43] Effect of photolysis: When a molecule absorbs light, the molecule undergoes a process called photolysis or photodissociation in which a chemical link is broken, and the molecule disintegrates. HP can absorb UV radiation in this respect, which causes it to split into two hydroxyl radicals (HO). This will increase the bleaching efficiency because HO is a far more potent bleaching agent.[42] Photo-catalysis and the Fenton reaction: By continuously oxidizing and reducing HP, iron ions (Fe2+/3+) can catalyze the generation of hydroxyl radicals (HO) and hydroperoxyl radicals (HO2) from HP. The Fenton reaction is a well-known name for this process. The HO that is generated will accelerate tooth whitening. The drawback is that iron ions also catalyze the breakdown of HO, resulting in producing equimolar HO2 (weaker than HP). This difficulty can be overcome through photo-catalysis. More HO will form out of water when Fe3+ is triggered by UV radiation.[42]

1.15 Case Selection/Reduction Of Risks And Side Effects

A thorough clinical examination should disclose not just situations that are appropriate for in-office bleaching with adjunct light, such as teeth with mild to moderate discolouration (Fig. 1). Still, also cases that are unsuitable, such as the solitary discoloured tooth (Fig. 2A) or the patient who appears with teeth that are darker than the lightest tab on a typical shade chart (Fig. 2B). It may also be beneficial to use long-term at-home bleaching for the patient who exhibits severe intrinsic staining (Fig. 2C). In-office bleaching with adjunct light has been associated with increased tooth sensitivity as compared to bleaching without light.[44] When reviewing the patient's dental history, it is important to look for any potential risk factors for sensitivity, such as current decay, gingival recession, cervical abrasions, or a history of sensitivity. To lessen tooth sensitivity, patients recognized as having it may pre-brush for about two weeks with a toothpaste containing potassium nitrate.[45,46] Ibuprofen can also be given to patients 30 minutes before the office treatment to lessen sensitivity. However, a recent study found that patients who took ibuprofen 30 minutes before their consultation experienced the same level of sensitivity 1 hour after the in-office procedure as patients who took a placebo capsule, and this level of sensitivity persisted for up to 24 hours.[47] This finding suggests that further ibuprofen dosages may be required to prevent postoperative sensitivity after the in-office bleaching treatment. Another method to reduce tooth sensitivity is to apply 4% to 6% potassium nitrate gel to the lingual surface of the teeth during the session. Professional in-office bleaching uses hydrogen peroxide solutions with concentrations ranging from 15% to 40%, which increases the possibility of chemical tissue damage. The bleaching lamp's blue light or ultraviolet (UV) radiation should be kept away from human eyes and oral soft tissue. The health risks posed by optical radiation from seven bleaching lamps sold commercially were recently reported.[48]

Fig1: Patients with mild to moderately yellow extrinsically stained teeth may benefit from in-office whitening with adjunct light. [18]



(A) A patient who has a single stained tooth.
(B) A patient who already exhibits incredibly light teeth.
(C) A patient who exhibits tetracycline-induced intrinsic staining. For in-office whitening with adjunct light, patients with mild to moderately yellow, externally stained teeth may be good candidates.[18]

Fig 2: Three situations where bleaching with additional There may be better options than light.

1.16 Setting Expectations Of Treatment Time

Before discussing treatment alternatives and setting expectations, we must first go over the benefits and drawbacks of in-office versus at-home bleaching methods with patients. Expecting quick results is the main perk people who choose in-office bleaching most frequently look for. Because results can differ between patients and depend on the aetiology of the stains, it can be difficult to determine how much time is saved by using in-office procedures. However, some basic expectations should be stated based on the clinical information that is currently available. It has been demonstrated that seven days of home bleaching with 10% carbamide are equivalent to three 15-minute treatments with 38% hydrogen peroxide11[49] or five days of home bleaching with one hour of treatment with 28% hydrogen peroxide and additional light. [50] It has been demonstrated that combining home and office bleaching is more efficient than only office bleaching.[51] The clinical effectiveness of home bleaching, in-office bleaching (with and without light), and a combination approach of in-office bleaching and home bleaching were all compared by Bernardon and colleagues. [52] Using a special take-home tray and 10% carbamide peroxide, the bleaching procedure was carried out at home over two weeks. The combination procedure involved one 45-minute session with additional light and then home bleaching, as opposed to the two 45-minute in-office bleaching with 35% hydrogen peroxide. After the first week, colour measurements revealed that the combined approach or in-office light bleaching produced superior results over at-home bleaching alone. There was no discernible difference between the three approaches after two weeks. The patient should be advised that the immediate result might be lighter and rebound to some amount during the first week. Realistic expectations should be made regarding the overall whitening impact. The patient might not suffer the rebound effect if the dentist recommends a combination procedure in which the patient starts to augment the in-office therapy with at-home whitening. Following in-office bleaching, it may be advised in postoperative instructions to wait at least 6 hours before consuming any chromogenic beverages.[53]

1.17 Bleaching Light Studies And Potential Sources Of Variability

The use of additional illumination to whiten teeth is contentious in dentistry for several reasons, including safety concerns in non-dental settings and contradictory studies published in the literature. Argon, CO_2, diode, and potassium titanyl phosphate lasers have all been studied in vitro; some report enhanced bleaching outcomes, while others report no appreciable impact. The possible risks connected to elevated pulpal temperature are a common worry with laser bleaching technology.[54]

1.18 Home bleaching

Bleaching at home is regarded as a safe and efficient remedy. Many peroxide compounds have been used as active ingredients in DIY bleaching techniques, including hydrogen peroxide (HP), carbamide peroxide (CP) or urea peroxide, sodium percarbonate (SPC), sodium hexametaphosphate (SHMP), sodium tripolyphosphate (STPP), and calcium peroxide. These medications are provided in various concentrations, applied differently depending on the condition being treated, and are given in different ways .[55,56] Low-concentration hydrogen peroxide (4%–8%) or carbamide peroxide (10%–22%) formulations are used in trays to carry out the technique. Over two to six weeks, these trays are worn in the mouth for two to eight hours each day.[57,58] An OTC product (paint-on gels and whitening strips) and home bleaching systems under the supervision of a dentist are effective when compared to a placebo or no treatment, and the efficacy varies due to different levels of active ingredients, according to a recent systematic review of home-based chemically induced tooth whitening. However, the majority of studies are shorter-term and sponsored or carried out by the manufacturers .[59]

1.19 Over-the-counter bleaching

Recently, a polyethylene strip with a 5.3% hydrogen peroxide coating was made available over the counter. The patient applies each strip for 30 minutes, as directed by the manufacturer [60,] twice daily. You can get a prescription for a comparable strip coated in 6.5% hydrogen peroxide. The hydrogen peroxide-coated polyethylene strips may be a suitable substitute for the night guard method of at-home whitening, according to clinical studies comparing the whitening efficacy of 10% carbamide peroxide (which decomposes into 3.5% hydrogen peroxide) and hydrogen peroxide-coated strips .[61,62]

1.20 In-office bleaching

Because the products deliver higher concentrations of peroxide than OTC, in-office whitening can hasten the process of tooth lightening. Although high concentration hydrogen peroxide (15%–40%) is used during in-office bleaching, it is still popular due to its minimally invasive nature, quick, visible results, and lack of patient cooperation. [63,64] In-office whitening is also the best option for patients who require close monitoring for clinical conditions like pronounced gingival recession or deep, unrestored abfraction lesions, as well as necessary for tooth discolouration by endodontic therapy.[25] The use of curing lights, such as halogen curing lights, plasma arches, LEDs, LED plus lasers, and lasers, has been advised since the advent of in-office bleaching treatments to hasten the action of the bleaching gel. Most light sources are thought to break down peroxide more quickly (by raising the temperature), forming free radicals and whitening teeth.[65] The in-office bleaching of important teeth, according to some studies, was not improved by the use of light sources. Poor clinical results were obtained with these lights, showing increased tooth sensitivity and decreased long-term colour stability, particularly when the treatment was completed in a single appointment.[66] The American Dental Association does not support such whitening systems because a systematic review by Buchalla and Attin [25] did not identify any additional benefits from light-activated systems. After one 30- to 60-minute treatment, results for tooth whitening are visible. Several applications can produce more striking results. Recent advancements in in-office bleaching systems have reduced tooth sensitivity, improved treatment, and improved results. These systems use a chemical catalyst in conjunction with block-out materials and compounds that are light-cured.[67]

1.21 Side effects and complications of bleaching

When present in high concentrations and for extended periods, hydrogen peroxide, a highly reactive substance, can harm oral soft and hard tissues. An increase in tooth sensitivity and mild gingival irritability are risks associated with tooth whitening that are frequently reported. The concentration of the peroxide bleach component, the length of the treatment, and the use of a product that doesn't contain bleach all impact how severe these side effects are. [68] The most frequent side effects of necessary tooth bleaching are tooth sensitivity and gingival or mucosal irritation. Gingival irritation starts within a day of the treatment. It can also last for several days, while tooth sensitivity typically occurs during treatment and can last for several days. Other side effects include a sore throat, minor orthodontic tooth movement, and temporomandibular dysfunction brought on by prolonged use of trays .[19] Depending on the technique used, there is debate over the effects on the oral mucosa. Additionally, one must carefully consider how bleaching agents affect human and animal digestive systems. It is important to apply the findings of in vitro and animal studies to the context of people. Finally, it is crucial to consider general toxicity, genotoxicity, and carcinogenicity when determining safety or tolerability .[69] Dental procedures never expose patients to concentrations capable of causing genotoxicity and cancer. Data from the International Agency for Research on Cancer [70] do not mention any cancer risk or mutations linked to occupational exposure. However, experimental detection of adenoma and duodenum carcinoma following oral administration of H_2O_2 has been made in animal models. Eight weeks after consuming 0.10% or 0.40% (w/v) H_2O_2 solutions, 20–42% of experimental mice exhibit gastric mucosal hyperplasia, and 40–62% exhibit duodenal hyperplasia. In contrast to the stomach, the duodenum experiences stronger reactions. Following force-feeding with 15 mg/kg carbamide peroxide, adenoma and carcinoma were seen in addition to gastric mucosal ulcerations. This pathological change appears to be strain-dependent and specifically related to the catalase activity of the various mouse populations.[71] According to a critical examination of the experimental situation, hydrogen peroxide is not carcinogenic, at least not for the digestive tract.[72] After 22 weeks, repeated applications of 30% (w/w) H_2O_2 in the oral cavity cause weak hyperkeratosis, hyperplasia, and dysplasia. However, using only H_2O_2, no tumours could be found. This is not the case when H_2O_2 and a carcinogenetic agent are administered together. H_2O_2 is known to inhibit gap junctional intercellular communication, but it does not do so in glutathione-deficient cells. An aberrant intercellular junctional communication has been linked to promoting tumours, neuropathy, and teratogenesis. This clarifies possible risks and some genetic aspects of the reaction .[68] If the product is swallowed, some brief adverse effects have been noted on the digestive tract and oral mucosa. Local effects, such as pulp sensitivity, cervical resorption, the release of specific components of dental restorative materials, and alteration of the enamel surface, may happen on the oral mucosa and dental tissues during teeth whitening. Most local effects are technique and product-concentration-dependent, but because bleaching results are unstable, additional treatments increase the negative effects. Dental surgeons should be in charge of making an informed decision about whether to administer bleaching and control its effects, not as it appears to be at the moment, where cosmetics are sold without any restrictions despite the dangers.[73] According to recent studies, aggressive tooth whitening can alter tooth microstructure, increase tooth sensitivity, and affect restorations. Abrasive bleaching can chemically react with ceramic crowns, glass ionomer types of cement, sealants, composite restorations, and other materials, making them less stable .[67] Seven tooth-coloured restoration substrates, including a nanohybrid composite, a microhybrid composite, a flowable composite, and a packable composite resin, along with a compomer, a glass ionomer cement, and a sintered ceramic used for CAD/CAM restorations, were exposed to 40% hydrogen peroxide gel as directed by the manufacturer at either 25 °C or 37 °C and placed in artificial saliva between treatments. All of the materials, with the exception of the sintered ceramic, showed surface softening, with greater softening seen at 37 °C. For any material, there was no substantial loss seen. However, subsequent abrasion (toothbrushing with dentifrice) was not a factor in the experiment's setup, so the loss of restorative material from the softened surfaces is not comparable to what would happen in vivo.[74] The extent to which bleaching impacts enamel is a further crucial issue. This tissue's erosion, which will prevent remineralization, unquestionably creates a temporary surface anomaly that affects the surface's mechanical and chemical properties. This anomaly may also impact the adhesive capabilities of conventional dental restorations. According to some studies, intensive whitening procedures can alter the enamel crystals' microstructure, surface integrity, and susceptibility to demineralization. How long will the treatment last? is one of the frequently asked questions by patients. Because patients may regularly expose their dentition to foods or beverages known to stain teeth, it is difficult to predict how long bleaching regimens will last. Restaining would likely occur within a month. It would be reasonable to assume that teeth whitening could last up to a year if chromogens like coffee, red wine, and cigarette smoke are absent. The colour of bleached tooth samples' enamel, dentin, and combined enamel and dentin samples changed over time, according to an in vitro study that examined this phenomenon. The yellowness, however, did not go back to normal in one year .[75]

2. CONCLUSION

Hydrogen and carbamide peroxide-based tooth whitening products are safe and effective when used under the manufacturer's instructions. However, as with all dental treatments, there are risks, so procedures should be customized to the needs of each patient, taking into account factors like the type and degree of staining, dietary habits, prior restorations, and other intraoral conditions. In addition, patients should be aware of the dangers of tooth whitening and, if using agents at home, given instructions on spotting negative side effects so they can seek medical attention as needed.

Urgent clinical studies are needed on the genotoxic and tumour-promoting effects of hydrogen peroxide bleaching agents. Therefore, it is advised against using tooth-bleaching products that contain concentrated H2O2 without gingival protection until such studies are available to avoid exposure to the gingival tissues or mucosae.

3. AUTHOR CONTRIBUTION STATEMENT

Dr Ashwag Siddik Noorsaeed conceptualized and designed the study. Dr. Eman Ali A Alkhatti and Dr. Hatun Nuwaymi M Aletayani and Dr. Sondus Mansor S Alamer searched data bases for previous literature. Dr. Alhanouf Zaid M Alsamari and Dr. Sarah Mohammed J Alwuhaimed and Dr. Reem Abdullah S Almoshaddak screened and filtered studies. Dr. Faris Eid W Alqarafi and Dr. Amal Abdullah Batarfi and Dr. Nada Khalid Alzahrani wrote the manuscript. Dr. Reem Adnan Alghuneem and Dr. Fahad Saadallah A Alsulami and Dr. Abdulaziz Naif Alanazi revised the manuscript. Dr. Waleed Mufadhi Alanazi and Dr. Sukainah Reda Al-Satrawi emailed journal for publication.

4. CONFLICT OF INTEREST

Conflict of interest declared none.

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