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Bleaching of discolored teeth

A Project Submitted to
The College of Dentistry, University of Baghdad, Department of Restoration and aesthetic dentistry
in Partial Fulfillment for the Bachelor of Dental Surgery

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{بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ}

"يَرْفَعِ ٱللَّهُ ٱلَّذِينَ ءَامَنُواْ مِنكُمْ وَٱلَّذِينَ أُوتُواْ ٱلْعِلْمَ دَرَجَٰتٍ وَٱللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ"

صدَقَ اللهُ العَظِيم.

سورة المجادلة: الآية ١١

Certification of the supervisor

I certify this project entitled " Bleaching of discolored teeth" was prepared by the fifth-year student "Hiba Khalid Hameed" under my supervision at the College of Dentistry/University of Baghdad in partial fulfillment of the graduation requirements for the Bachelor Degree in Dentistry.

Dr.Mirvet M. Al-Bakri

Date: 1/5/2023

Dedication

I hope I did this research to be usefull for readers and used in beneficial way, although my only proceed from it is deeds from Almighty God.

I dedicate this work to myself, for trying to do my best…

To my father who supports me all the years of my life…

To my mother who stands next to me and prays for me…

To my brothers and sisters for their encouragement and kindness …

To my supervisor for her patience and guidance.

Acknowledgment

This work would not have been possible without bless and facilitations from Allah, So first of all I thank Almighty God for inspiring and giving me strength and patience to complete this work.

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Introduction

Tooth whitening continues to grow in popularity as an effective, non-invasive method for alteration the shade of discolored teeth **(Sulieman et al., 2005).** This discoloration varies in its etiology, localization, appearance, severity, and its adherence to tooth structure **(Dahl et al., 2003).** It may be classified as intrinsic, extrinsic, and a combination of both **(Hattab et al., 1999).** The esthetic appearance of anterior teeth has a major concern for patient nowadays.

Ingle has defined teeth discoloration as :"any change in the hue, color or translucency of a tooth due to any cause"

Bleaching is an initial step in analysis and production of smile aesthetics , for that reason it is so very important for the dentist to diagnose the cause of color change before the whitening procedure for appropriate dental treatment **(junior et al., 2018).**

The most common side effect in vital teeth whitening is the tooth sensitivity. This hypersensitivity post bleaching procedure is 10% to 90%. It can be mild to moderate; it may become intense or severe that results in discontinuation of treatment. This is caused by the passage of oxygen ions through the enamel and dentin, therefore it reaches the pulpal tissue, which has the innervations of blood vessels and nerves of the tooth , so this will result in sensitivity **(florez et al., 2007).**

The most current in-office bleaching systems are based on hydrogen peroxide in concentrations up to 35%, it applied as a gel or paste to the tooth surface. Both in office and take home techniques have proven its effectiveness in the process of teeth whitening, but the first one have an immediate result **(Hafez et al 2010).**

1. Tooth discoloration

1.1 Natural tooth color

Natural teeth color is actually not one color, teeth are made up of many colors, a natural gradation from dark to light colors from the gingival third toward the incisal edge. This depend on the light transmission in the tooth, reflection and absorption. Thickness of tooth layers and its translucency affect that color.

Tooth discoloration defines as any change in the light transmission properties that lead to change in the normal color of tooth due to change in tooth structure (enamel, dentine and pulp) during formation or throughout development and even post-eruption **(AM Sulieman, 2008)**

1.2 Classification of tooth discoloration

Tooth discoloration can be classified according its etiology to intrinsic and extrinsic causes, which the first one is sub classified to pre-eruptive and post-eruptive causes:

1. Intrinsic causes:
    a. Pre-eruptive causes:
        - Fluorosis
        - Tetracycline stain
        - Developmental defects
        - Hereditary
        - Childhood infection
        - Maternal infection
        - Teeth infection
        - Trauma

b. Post-eruptive causes:
    - Caries
    - Dental materials
    - Tooth material loss
    - Internal resorption
    - Trauma

2. Extrinsic causes:
    - Aging
    - Plaque
    - Calculus
    - Tobacco
    - Betel nut chewing
    - Chlorhexidine
    - Food and drinks
    - Chromogenic bacteria
    - Tooth material loss

Table(1): classification of etiology of tooth discoloration

Extrinsic Discoloration	
Metallic	**Non Metallic**
Occupational exposure to metallic salts 1. Iron supplements (black) 2. Copper salts (green) 3. Potassium permanganate (violet-black) 4. Stannous fluoride (golden brown) 5. Silver nitrate (grey)	Adsorbed on the tooth surface (plaque, acquired pellicle) 1. Beverages 2. Tobacco 3. Mouth rinses 4. Chromogenic bacteria

Intrinsic Discoloration	
Systemic Causes	**Local Causes**
1. Medicine related discolouration (tetracycline stain) 2. Flourosis, calcification 3. Genetic causes like hyperbilirubinemia, 4. Congenital erythropoetic porphyria, amelogenesis imperfecta, Cystic fibrosis of Pancreas, Dentin dysplaisa	1. Pulp Necrosis, 2. Age of the patient 3. Remnant of pulp tissues in the canal 4. Hemorrhage of the pulp 5. Restorative material in the coronal third of the canal.

1.2.1 Intrinsic discoloration

Intrinsic discoloration is that type if discoloration that occurs due to a change in the structural composition or due to the thickness of the dental hard tissues (enamel and dentin).

The chromogenic material will become incorporated within the dental hard tissue: it may be either during tooth development (pre-eruption), such as the dental fluorosis, tetracycline stain, hereditary development defects of enamel and dentin without any systemic features and hematologic disorders, or during the post-eruptive phase of tooth development, such as the pulpal necrosis. These stains can be localized on one or several teeth, through trauma, improper endodontic treatment, and restorations such as amalgam staining **(Alazmah et al., 2021).**

We will discuss the following:

- Metabolic causes
- Inherited causes
- Iatrogenic causes
- Traumatic causes
- Idiopathic causes
- Aging causes

1.2.1.1 Metabolic cause of discoloration

several metabolic diseases can cause intrinsic teeth discoloration such as congenital hyperbilirubinemia, congenital erthropietic porphyria and alkaptonuria.

- Alkaptonuria is an inherited metabolic disease results in brown discoloration of the permanent dentition **(link, 1973).**
- Congenital erythropoietic porphyria, which is autosomal recessive rare disorder reddish-brown teeth discoloration **(fayle and pollard, 1994)**

- Congenital hyperbilirubinemia characterized by yellow-green discoloration. The deposition of bile pigments in the hard calcifying dental tissues, especially in neonatal period.
- Thalassaemia and sickle cell anemia effect appear as blue, breen or brown discoloration.

1.2.1.2 Inherited cause of discoloration

Inherited discoloration is caused by gene mutation or altereion in expression. It is a group of hereditary conditions affects the tooth enamel appearance and structure, it associated with changes in other intra and/or extraoral tissues.

- Amelogenesis imperfacta (AI) is an inherited condition in which the mineralization or the formation of enamel matrix is disturbed. It has 14 different subtypes based on clinical appearance which are varying in degree of expressivity **(sundell and Koch, 1985).**

Figure(1): Amelogenesis imperfac

- Depending on the appearance, the types of Amelogenesis imperfacta vary from the relatively mild hypomaturation type “snow-capped” enamel to the more severe hereditary hypoplasia with thin, hard enamel, which has a yellow to yellow–brown appearance **(Huda, 2019).** Phenotypes are: hypoplastic,

hypocalcified, hypomaturation, hypomaturation-hypoplastic with taurodontism **(Gadhia et al., 2012).**

1. **.Characterisitcs of hypoplastic AI**
    - Enamel of reduced thickness due to a defect in the formation of normal matrix
    - Pitting and grooves
    - Hard and translucent enamel
    - Radiographically, the enamel contrasts normally from dentine.
2. **Characteristics of hypocalcified AI**
    - Defect in enamel calcification
    - Enamel of normal thickness
    - Weak in structure
    - Appears opaque or chalky
    - Teeth become stained and rapidly wear down
3. **Characteristics of hypomaturation AI**
    - Enamel of normal thickness but mottled in appearance
    - Slightly softer than normal and vulnerable to tooth wear, but not as severe as the hypocalcified type
    - Radiographically, similar radiodensity as dentine.
4. **Characteristics of hypomaturation-hypoplasia with taurodontism**
    - Mixed hypomaturation and hypoplasia appearance
    - Taurodontism: body and pulp chamber enlarged, and the floor of pulp chamber and furcation is moved apically down the root.

If the child affected by AI, the clinical appearance and structure of all or the most of primary and permanent dentitions will be affected. The prevalence differs

depending on region or country of origin; however, the average global prevalence is less than 1 in 200.

- Dentinogenesis imperfacta can cause brownish violet or gray discoloration. Unfortunately this condition cannot treated by bleaching and should be corrected by restoration.

1.2.1.3 Iatrogenic cause discoloration

Dental fluorosis is the most common cause of intrinsic tooth pigmentation. Fluorosis occurs when concentrations of fluoride exceeds 1ppm in drinking water. The severity of pigmentation is age and dose dependent. Both primary and permanent dentitions can be affected

Tetracycline can cause brown or brown –grey tooth pigmentation. Tetracycline staining was first described in the mid-1950s. After that there was a warning about the use of this antibiotic for pregnant women and young children. mynocycline cause blue-grey discoloration of the incisal three-fourths of crowns in fully erupted teeth. Iron supplements cause Black discoloration **(Mortazavi et al., 2014).**

Figure(2): tetracyclic discoloration

1.2.1.4 Traumatic cause of tooth discoloration

Pulpal hemorrhage follow trauma is one of the most common cause that seen in every day practice. That happen due to accumulation of hemoglobin

molecules in the traumatized tooth gives us the color of black-pink. If left un treated pulpal necrosis will occur, breakdown the blood product, so dark grey color appear **(Dubal and Porter,2018).**

Root resorption has a color of pink spot at the CEJ **(Rotstein, 1998).** Other traumatic cause is Enamel hypoplasia in permanent teeth due to trauma to the tooth germ or infection of primary tooth, it has color of yellow-brown.

Dentine hypercalcification, is an excessive irregular dentine deposiyion in the pulp chamber and canal walls, may result following trauma ehich affect the odontoblast **(rotstein, 1998).**

1.2.1.5 Idiopathic causes of discoloration

Molar incisor hypomieralization is unknown cause condition, severe hypomieralized enamel in molars and incisors. Some suggestions that environmental changes during limited time period such as infection or dioxin in breast milk and genetic factor. It is asymmetrical one molar affect and contralateral may not affect.

1.2.1.6 Aging causes of discoloration

Aging have its effect on the color of teeth, thinning of enamel, excessive dentin deposition, textural changes and pulp stones all together lead to darkening of teeth with age.

1.2.2 Extrinsic discoloration

Extrinsic discoloration is outside the tooth substance and lies on the tooth surface or in the acquired pellicle. Its etiology may be metallic and non-metallic **(Alali et al., 2020).**

1.2.2.1 Metallic discoloration

Extrinsic staining of teeth that may be associated with occupational exposure to the metallic salts also a number of medicines contains metal salts can be a factor in extrinsic staining **(Addy et al., 1981).**

Iron supplements intake or people who works in iron factory has a characteristic *black* staining **(Nordbo et al., 1982).**

Figure(3): Iron supplements discoloration

Copper in mouth rinses causes *green* staining **(Waerhaug et al., 1984).** Silver nitrate salt causes a *grey* color. Potassium permanganate causes *a violet to black* color, and stannous fluoride causes a *golden brown* color **(Je.E, 1982).**

1.2.2.2 Non-metallic discoloration

Tobacco smoking is a common cause for teeth discoloration which ranges from brown to black stain **(Ness et al., 1977).** Other possible etiological agents of this type include dietary components, beverages, tobacco, mouth rinses, and some drugs. *Green and orange* stain in children with poor oral hygiene and *black/brown* stains in children with good oral hygiene caused by chromogenic bacteria **(Theilade et al., 1973).**

Extrinsic discoloration can be subdivided to direct and indirect staining, direct staining are stains by compounds incorporated into the pellicle layer and produce stains such as tobacco, while the indirect staining there is chemical interaction at tooth surface with another compound, which the latter one produces the stain such as chlorhexidine **(zyla et al., 2015)**

1.2.3 Dentist related cause of discoloration

Sometimes teeth discoloration occur due to several dental materials or inappropriate operating techniques.

1.2.3.1 Endodontically related causes

1.2.3.1.1 Pulp tissue remnants

Remnants of the pulp tissue in the pulp chamber disintegrates gradually and may cause discoloration. Pulp horns must always be included in the access cavity to ensure removal all pulpal tissue, and to prevent retention of the sealer on later stages.

1.2.3.1.2 intracanal medicament

Many intracanal medicaments cause tooth discoloration, especially when these material remains in the crown of the tooth for a long period of time **(Thomson et al., 2012)** . Tooth discoloration primarily occurs due to penetration of materials into the dentinal tubules. Moreover, it was shown that materials placed in the pulp chamber for long periods of time darkened the teeth over time **(Kim et al., 2000)**. Tooth discoloration due to use of endodontic materials compromises esthetics. Therefore, the endodontic treatment should not only focus on the biological and practical aspects, but also pay attention to the esthetics **(Lenherr et al., 2012).**

Calcium hydroxide (CH) is extensively used intracanal material. I is the most effective intracanal medicament. This material has several favorable biological properties, such as its antimicrobial activity, tissue-dissolving ability, prevention tooth resorption, and the induction of hard tissue barrier formation. Some additional materials are incorporated into the formulation of CH to confer antibacterial properties or radiopacity; tooth discoloration is attributed to those materials.

Chlorhexidine (CHX) is a broad-spectrum antimicrobial material, it uses as an intracanal medicament. Previous studies have found that the mixture of CH and CHX had greater antibacterial efficacy than CH alone. Enamel discoloration is reported following the use of CHX mouthwash alone; but, no study has reported tooth discoloration following the application of CHX combined with CH as an intracanal medicament **(Afkhami et al., 2020)**

Triple antibiotic paste (3Mix) (metronidazole, minocycline, and ciprofloxacin) has recently been used as an intracanal medicament for the disinfection of root canals during endodontic treatment. Studies on tooth discoloration following the use of this paste has been reported.

Figure(4): tooth discoloration associated with triple antibiotic paste

1.2.3.1.3 Obturating materials

Incomplete removal of the obturation materials and remnant of sealer in pulp chamber, especially those containing metallic components, cause frequent and severe single tooth dark discoloration. To prevent that all obturation materials should remove from coronal potion.

1.2.3.2 Coronal restoration related causes

1.2.3.2.1 Amalgam

Dentin affect by silver alloys in severe form, because of its dark colored metallic components that give the dentin appearance of *dark-grey*. Amalgam restoration discolor the crown when used to restore lingual preparation, or developmental groove in anterior and premolar teeth.

1.2.3.2.2 Pins and posts

Metal pins and posts are sometimes used to reinforce a composite restoration in the anterior dentition. Inappropriately placed pins and posts caused discoloration by the metal seen through the composite or tooth structure. In such cases, coverage of pins with a white cement or the removal of the metal material and replacement of the composite restoration is indicated.

1.2.3.2.3 composites

Microleakage around composite restoration causes staining. Open margins may allow the chemicals to enter between restoration and tooth structure and discolor the underlying dentin. In addition to this, composites may become discolored with time, affecting the shade of the crown.

2. A good diagnosis for a good outcome

A good diagnosis need criteria to follow, the most appropriate treatment is then made. Diagnostic criteria can include **(Waish et al., 2004)**:

1. Number and distribution of the affected teeth
2. Duration of staining
3. Progression of the darkness/intensity of stain
4. Habits such as smoking and some types of food
5. Color of stain
6. History of trauma and Previous treatment
7. Familial consideration
8. Syndromes and diseases associated.

3. History of bleaching

Reports on bleaching of discolored non vital teeth were first described during middle of the 19th century, advocate different chemical agents. Initially chlorinated lime was the recommended material, later followed by oxalic acid and agents such as chlorine compounds and solutions, sodium peroxide, sodium hypochlorite, or mixture consists of 25% hydrogen peroxide in 75% ether (pyrozone).

The walking bleach technique was introduced in 1961 it involves placement of mixture of sodium perborate and water into pulp chamber, which sealed in place between dental visits **(Spasser 1961; Joiner,2006).** That method modified later by replacing water with 30-35% hydrogen peroxide to improve whitening effect **(Nutting 1963).**

4. Bleaching agents

Most commonly used bleaching agents are hydrogen peroxide, sodium perborate, and carbamide peroxide. Sodium perborate is mainly indicated for intracoronal bleaching, while hydrogen peroxide and carbamide peroxide for extracoronal bleaching.

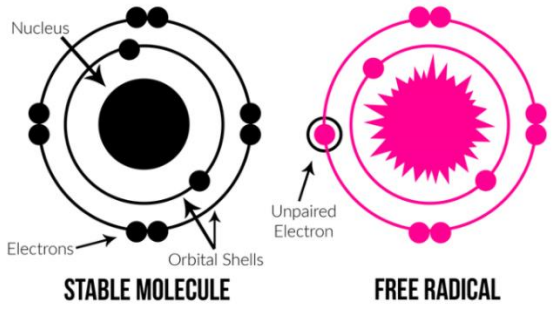
4.1 Hydrogen peroxide

Hydrogen peroxide is an oxidizing agent, used in wide number of industrial applications for example bleaching or deodorizing textiles, wood pulp, hair, fur and food). It is a bitter taste colorless liquid highly soluble in water to give an acidic solution. Most commonly form of hydrogen peroxide used in dental bleaching is gel **(kwon et al., 2013)**

30%-35% concentration is the most common concentration used in dental bleaching, but recent studies shows that even 6% concentration with nitrogen-doped titanium dioxide light activated agent is also effective for tooth bleaching.

Main disadvantage is tissue burns and releasing toxic free radicals. High concentrations are thermodynamically unstable and may explode, so it should store in cold and dark containers **(Llan et al., 2015).**

Peroxides have different forms, such as hydrogen peroxide, carbmide peroxide and sodium per carbonate. Method of application are gel in tray, painting, strips and films.



Figure(5): free radical formation

4.2 Sodium perborate

An oxidizing agent available as powder or commercial preparations. It is stable when it dry. But, in the presence of humidity, acids or warm air, it decomposes to form sodium metaborate, hydrogen peroxide, and nascent oxygen.

The available types of sodium perborate are three: monohydrate, trihydrate, and tetrahydrate. They differ in their oxygen content which affect in their bleaching efficacy. Sodium perborate is safer and more easy to control than hydrogen peroxide, for that reason, it used in most intracoronal bleaching procedures **(Llan et al., 2015).**

4.3 Carbamide peroxide

It is also known as urea hydrogen peroxide, it is available in the concentrations range 3-45%. The 10% aqueous solution is most used in home bleaching kits **(Myssa, 2007).** Bleaching preparations containing carbamide peroxide usually include glycerine or propylene glycol, sodium stannate, phosphoric or citric acids, and flavor additives.

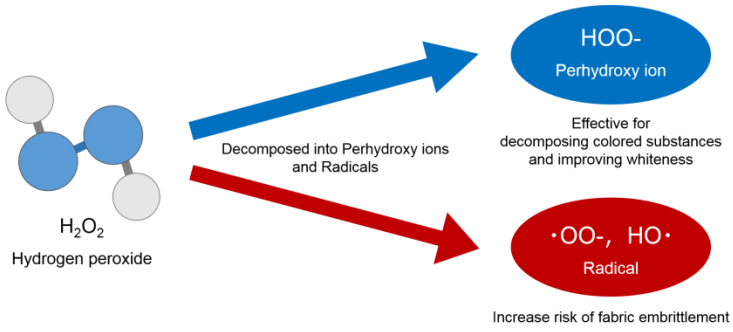
Carbamide peroxide based preparations associated with various degree of damage to teeth and mucosa, they also may advertly affect bonding strength of

composite resin and their marginal seal. Long term studies are not yet available, so this material should use with caution.

5. Mechanism of bleaching

The mechanism of tooth bleaching is unclear, however, Bleaching agents are mainly oxidizers, act on the tooth organic hard tissues that slowly degrading them into chemical by-products, such as carbon dioxides, which are lighter in color. Inorganic molecules are not usually breakdown as well. The oxidation-reduction reactions occurs during bleaching known as a Redox reaction. Generally, unstable peroxide convert to unstable free radicals. Those free radicals may oxidize (remove electron from) or reduce (add electron to) other molecules.

The mechanism of bleaching by hydrogen peroxide is not well understood. In-office and home bleaching gels contain hydrogen peroxide or its precursor, carbamide peroxide, as the active ingredient in concentrations ranging from 3% to 40% of hydrogen peroxide equivalent. Hydrogen peroxide bleaching generally proceeds via the perhydroxyl anion (HO2 _). Other conditions can give rise to free radical formation, for example, by homolytic cleavage of either an O–H bond or the O–O bond in hydrogen peroxide to give H_ + _OOH and 2_OH (hydroxyl radical), respectively.



Figure(6): bleaching mechanisim

Under photochemical reactions initiated by light or lasers, the formation of hydroxyl radicals from hydrogen peroxide has been shown to increase.

Hydrogen peroxide is an oxidizing agent that, as it diffuses into the tooth, dissociates to produce unstable free radicals which are hydroxyl radicals (HO_), perhydroxyl radicals (HOO_), perhydroxyl anions (HOO–), and superoxide anions (OO_–) **(Kashima-Tanaka et al., 2003; Hannig et al ., 2003**) which will attack organic pigmented molecules in the spaces between the inorganic salts in tooth enamel by attacking double bonds of chromophore molecules within tooth tissues. The change in double-bond conjugation results in smaller, less heavily pigmented constituents, and there will be a shift in the absorption spectrum of chromophore molecules; thus, bleaching of tooth tissues occurs_–) **(Kashima-Tanaka et al., 2003; Hannig et al ., 2003).**

Bleaching mechanism differs according to type of tooth discoloration and the chemical and physical conditions at time of reaction.

The mechanism of tooth whitening with the use of peroxide-based materials is a complex phenomenon encompassing diffusion, interaction, and surfaces changes within the tooth **(SR Kwon et al., 2015)**

6.Composition of commercial bleaching agents

Both active and inactive ingredients are contained in current bleaching agent. The active ingredient include hydrogen peroxide and carbamide peroxide compounds. Inactive ingredients include thickening agents, flavoring, preservative, carrier and the surfactant and pigment dispersant **(HD Al-baker, 2019).**

6.1 thickening agents

Carbopol (carboxypolymethylene) is most commonly used thickening agent in bleaching materials. Its concentration between 0.5% and 1.5%. This high-

molecular-weight polyacrylic acid polymer offers two main advantages. First, it increases the viscosity of the bleaching materials, which allows better retention of the bleaching gel in the tray. Second, it increases the active oxygen-releasing time of the bleaching material up to 4 times**. (Rodrigues et al., 2007).**

6.2 Carrier

Glycerin and propylene glycol are most commonly used carriers in commercial bleaching agents **(Greenwall et al., 2001).** The carrier maintain moisture and help to dissolve other ingredients **(Nathoo et al., 2003).**

6.3 Surfactant and pigment dispersant

The addition of the surfactant or pigment dispersant **(Feinman, R.A., 1991)**. increases the effectiveness of the bleaching **(Gerlach, et al., 2002).** Surfactant allows the diffusion of HP across the gel and tooth boundary by increasing the surface wetness. The pigment dispersant holds the pigments within the gel in suspension.

6.4 Preservative

propylparaben, Methyl, and sodium benzoate are commonly used as preservative substances **(Joiner and Thakker., 2004).** They have the ability to prevent bacterial growth in the bleaching materials. In addition, these agents can accelerate the breakdown of hydrogen peroxide by releasing transitional metals such as copper, iron, and magnesium. **(Feinman, R.A., 1991).**

6.5 Flavoring

Flavorings are substances used to improve the taste and the consumer acceptance of bleaching products. Examples include peppermint, spearmint,

wintergreen, sassafras, anise, and a sweetener such as saccharin. **(Feinman, R.A., 1991).**

More recently, amorphous calcium phosphate (ACP) has been added to some of the tooth whitening products, to reduce sensitivity, reduce the demineralization of enamel through a remineralization process after whitening treatments, and add a lustrous shine to teeth **(Ciavoi et al., 2017).**

7. Factors influencing tooth whitening

7.1 Types of bleach

The majority of contemporary tooth whitening studies involve the use of either hydrogen peroxide or carbamide peroxide **(Abouassi et al, 2011**). The latter one is an adduct of urea and hydrogen peroxide which on contact with water breaks down to urea and hydrogen peroxide.

In general, the efficacy of hydrogen peroxide containing products are approximately the same with carbamide peroxide containing products with equivalent or similar hydrogen peroxide content and delivered using similar format and formulations, either tested in vitro **(Joiner et al, 2004)** or in vivo **(Kihn et al, 2000; Nathoo et al, 2003).** For example, Nathoo et al. demonstrated in a clinical study that a once a day application of either a 8.7% hydrogen peroxide gel or a 25% carbamide peroxide gel both gave a statistically significant tooth shade lightening after 2 weeks use compared to baseline, but found no statistically significant differences between products.

An alternative source of hydrogen peroxide is sodium percarbonate which has been used in a silicone polymer containing product that is painted onto the teeth forming a durable film for overnight bleaching procedures **(Date et al, 2003).** The

peroxide is slowly released for up to 4 h **(Mahony et al, 2003**) and gave significant tooth Colour improvement after 2 weeks versus baseline.

However, the relative clinical or in vitro efficacy of sodium percarbonate versus hydrogen peroxide tested in the same product formats and conditions has not been reported. A tooth bleaching system based on sodium chlorite applied to the tooth surface and activated under the acidic conditions has been described in the literature **(Attin et al, 2004; Joiner, 2006)**, however, no efficacy data has been reported to date. Similarly, other potential vital tooth bleaching systems have been outlined in the literature with limited supporting evidence for their efficacy. These include sodium perborate, peroxymonosulphate, peroxide plus metal catalysts **(Sulieman, 2005; Kakar et al, 2004; Gerlach et al, 2004)** and oxireductase **enzymes (Viscio et al, 2000).**

7.2 Concentration and time

Two of the key factors in determining overall tooth whitening efficacy from peroxide containing products are concentration of the peroxide and duration of application **(Malpani et al., 2019)**. For example, Sulieman et al. compared the in vitro tooth bleaching efficacy of gels containing 5–35% hydrogen peroxide and found that the higher the concentration, the lower the number of gel applications required to produce uniform bleaching **(Suliemanet al., 2004)** .

Similar results were found by Leonard et al. who compared the in vitro tooth bleaching efficacy of 5%, 10% and 16% carbamide peroxide gels and found the whitening was initially faster for the 16% and 10% than the 5% concentration. However, the efficacy of the 5% approached the higher concentrations when the treatment time was extended.

In a clinical study using custom made bleaching trays, Kihn et al. showed that a 15% carbamide peroxide gel gave significantly more tooth whitening than a 10% carbamide gel after 2 weeks use. In addition, clinical studies with hydrogen peroxide strip based products have shown similar concentration and time effects for tooth whitening efficacy. **(Sulieman et al., 2004; Alqahtani, 2014; Dahl, 2003)**

7.3 Heat and light

The use of highintensity light, for raising temperature of hydrogen peroxide and accelerating the rate of chemical bleaching of teeth was reported in 1918 by Abbot. The rate of chemical reactions can be increased by increasing the temperature, where a $10^{o}C$ rise can double the rate of reaction. Contemporary approaches and literature focus on accelerating peroxide bleaching with simultaneous illumination of the anterior teeth with various sources having a range of wavelengths and spectral power, for examples, halogen curing lights, plasma arc lamps, lasers and the light-emitting diodes. For some light sources, significant increases in pulpal temperatures have been measured using in vitro models during tooth bleaching.(**Toh et al., 1993).**

The light source can activate peroxide to accelerate the chemical redox reactions of the bleaching process. In addition, it has been speculated that the light source can energise the tooth stain to aid the overall acceleration of the bleaching process. Some products that are used in light activated bleaching procedures contain ingredients that claim to aid the energy transfer from the light to the peroxide gel and are often coloured materials, for examples, carotene and manganese sulphate.**(Alqahtani et al., 2014).**

7.4 Other factors

There are other factors that may affect the rate of tooth whitening such as the type of intrinsic stain **(Irusa et al., 2022).** With regards to the type of staining, severe tetracycline staining responds slower to chemical bleaching **(Haywood, V.B., 2000).**

Other factor is the baseline color of tooth, the darker the teeth are at baseline, the longer the tooth whitening process becomes **(Mahony et al., 2003).** Gray or blue staining is less amenable to bleaching than yellow staining **(Haywood, V.B., 2000; Gerlach et al., 2001).**

8.Types of dental bleaching procedure

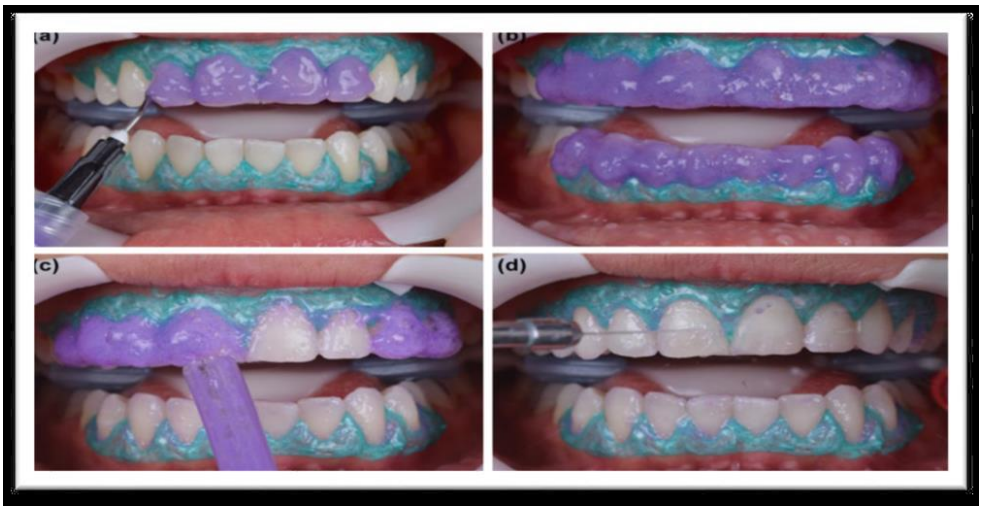
8.1 vital tooth bleaching

Nowdays dentists have an array of treatment options to harmonize a smile with discolored vital teeth. The spectrum of treatment ranges from invasive options such as the crowns, veneers, and placement of direct restorations to minimally invasive therapies such as macroabrasion, microabrasion, and bleaching to merely prophylaxis **(fearon J, 2007).** Vital teeth were bleached in the 1860s, by the use of oxalic acid **(Haywood, VB., 1992).** Later, hydrogen peroxide (HP**) (Al-Nomay et al., 2015) ,** or pyrozone was used instead of oxalic acid **(Joshi, S.B., 2016).**

8.1.1Thermo/photo bleaching (in-office bleaching)

The first product introduced for the professional use was Crest Whitestrips (Procter and Gamble) for in-office dispensing. After a year a lower hydrogen peroxide concentration was introduced. Nowdays, the most popular systems for in-office bleaching use is high concentration hydrogen peroxides and are often referred to as *"one-hour bleaching."* These high concentration hydrogen peroxides

range from 25% to 35%. The use of the light enhanced bleaching techniques, a laser-activated bleach or a paint-on bleaching gels or solutions. For the in-office, light-enhanced systems, usually the light only can be used for bleaching **(Strassler, H.E., 2006).**



Figure(7): in-office bleaching technique

8.1.2 Mouthguard bleaching (Home bleaching)

At-home tray bleaching requires a number of steps, include accurate study casts then vacuum-down, thin, flexible mouthguard to fabricate. The patient should be instructed on the how to place the bleaching *gel* in the trays and remove any excess gel after insertion.

Concern over the effectiveness of bleaching potential with overnight wearing of tray has been addressed; wearing a tray overnight with a bleaching gel has demonstrated a degradation in peroxide concentration over time, but the bleaching agent is still effective. Hydrogen peroxide has a greater than 50% degradation within 30 minutes, whereas carbamide peroxide bleaching gels can be used overnight **(Matis et al.,1999).** Research has shown that a bleaching endpoint will

be reached at 6 weeks independent of the concentration and type of peroxide used **(Strassler, H.E., 2006).**

8.2 Non-vital tooth bleaching

Discoloured, non-vital anterior teeth are common aesthetic concern for many patients. It have an effect on self-esteem, interaction with others and employability. Discoloured non-vital teeth are frequently due to previous trauma, caries, endodontic therapy and failed restorations.**(Poyser et al., 2004**).

Internal tooth bleaching is a minimally invasive, conservative, relatively simple, effective, and low-cost method in treatment of discolored endodontically treated teeth **(Coelho et al., 2020).**

8.2.1 Walking-bleach technique (Conventional technique)

It is the most common being the walking-bleach technique, first described by Spasser **(Spasser 1996).** The walking-bleach, or conventional, technique consists of inserting bleaching agent or agent into the pulp chamber, closing the access cavity with temporary filling, and the dentist refreshing the bleaching agent on a weekly basis until a satisfactory color is achieved **(Attin et al.,2003) (Amato et al.,2018).**

8.2.2 Thermocatalytic technique

The thermocatalytic technique is similar to conventional technique The thermocatalytic technique involves placement of a bleaching agent in the pulp chamber followed by heat application.. However, the thermocatalytic method uses various heat forms in order to accelerate the release of the reactive oxygen species. Currently this technique is not advisable since heat can damage the periodontal tissue and lead to root resorption **(Zimmerli et al., 2010) (Plotino et al., 2008)**

Table(2) walking-in and thermo-catalytic bleaching technique

	Basic procedure	Time taken to complete treatment
Walking bleach technique	- The bleaching agent is placed in the tooth. - A temporary filling is placed into the tooth, which allows the bleach to be sealed. - Regular appointments are arranged to assess success, and to re-apply bleach.	- Depending on each clinician, the time required is minimal. - Approximately 30-40 mins is required per treatment.
Thermo-catalytic technique	- The bleaching agent is placed in the tooth. - A temporary filling is placed into the tooth, which allows the bleach to be sealed. Heat is then applied to the tooth. - Regular appointments are arranged to assess success, and to re-apply bleach.	- Depending on each clinician the time required is minimal. - Approximately 30-40 mins is required per treatment.

8.2.3 inside and outside technique

The inside–outside, or combined, technique was proposed by Settembrini in 1997 **(Settembrini et al., 1997).** it consists of simultaneous internal and external bleaching, with the use of custom-fitted trays. In this technique, the access cavity remains open and the patient is responsible for replacing the bleaching agent each day. Therefore, the whitening effect relies on the patient compliance **(Zimmerli et al., 2010) (Poyser et al., 2004).**

8.3 Light activated tooth bleaching

Minimally invasive, immediate visible results and no need of patient cooperation technique **(ferreira et al., 2011).** the use of curing lights (including halogen curing lights, plasma arches, LED, LED plus lasers, lasers) has been recommended to accelerate the action of the bleaching gel **(Marson et al., 2008).**

8.3.1 laser activated tooth bleaching

the process of bleaching with lasers is concerned by the absorption of laser light in the bleaching gel. The absorption of photons will influence the temperature rise which occurs within the bleaching product, the dental hard tissues, and/or pulp

tissues. There must be a careful alignment between the laser and the characteristics of the gel, that is, the presence of additives which affect the absorption spectrum and colour. The thickness of the gel and its pH also have to be taken into account; the latter because the pH influences the patterns of radicals which are generated **(DeMoor et al., 2015).**

9. Adverse effect of teeth bleaching

9.1 Tooth sensitivity

Teeth sensitivity occurs in two-third of the patients treated with home bleaching products. The majority (55%) may experience mild sensitivity whereas 10% experience moderate and only about 4% may experience severe sensitivity **(Jorgensen et al., 2002).** The aetiology of tooth sensitivity following bleaching is multifactorial and is poorly understood **(Perdigão et al., 2004**), Sensitivity is thought to be caused by the diffusion of by-products produced during HP and CP breakdown through dentinal tubules **(Gökay et al., 2000).** The use of bleaching products with high peroxide concentration also increases the risk of tooth sensitivity **(Jacobsen and Bruce., 2001).** Glycerine, used as a carrier in most of bleaching agents, is hydrophilic and lead to dehydration of tooth structure during bleaching treatment. This can also result in the sensitivity of tooth **(Leonard et al., 1997).**

9.2. External cervical root resorption

External root resorption occasionally develops after intracoronal bleaching with hydrogen peroxide **(Rotstein et al., 1991).** Cervical root resorption is an inflammatory mediated external resorption of the root, which can be seen after trauma and following intracoronal bleaching, A high concentration of hydrogen peroxide in combination with heating seemed to promote cervical root resorption

(Friedman et al., 1988), It has also been speculated that the peroxide, by diffusing through the dentinal tubules, denatures the dentin, which then becomes an immunologically different tissue and is attackedas a foreign body **(Lado et al., 1983).**

Intracoronal bleaching with 30% hydrogen peroxide reduces micro-hardness of dentine and enamel **(Lewinstein et al., 1994**), and mechanically weakens the dentine structure **(Chng et al., 2002).**

9.3.Gingival irritation

Some patients may experience mucosal or gingival irritation during home bleaching procedures. Soft tissue irritation may be caused by an ill-fitting trays impinging on the gingiva and/or the use of excess material **(Sulieman., 2005).**

it managed simply adjusting and polishing the tray and or instructing the patient to use less materials **(Majeed et al., 2015).**

9.4. Chemical burns

During in-office bleaching procedure, a higher hydrogen peroxide HP concentration is usually used. HP is a caustic substance and can cause burns of gingival or mucosal tissue **(Pretty et al., 2006).** Therefore, a rubber dam or a light-cured resin, provided by the manufacturer, should always be used to protect the soft tissues during in-office bleaching procedures **(Majeed et al., 2015).**

9.5.Effect on tooth structure

Teeth are important biological structures in the field of bio-mineralization. The mineral tissue of a tooth consists of hydroxyapatite (HAP) crystals, $Ca10(PO4)6(OH)2$. The inorganic content of dental hard tissues has been shown to consist of not only calcium (Ca), phosphorus (P), and oxygen (O), but also carbon

(C), magnesium (Mg), sodium (Na), and fluoride (F), as well as large trace elements **(Cakir et al.,2011).**

Investigations have shown that at-home tooth bleaching with low concentrations of hydrogen or carbamide peroxide have no significant damaging effects on enamel and dentin surface properties **(Demarco et al.,2011).**

9.5.1 Effect on enamel structure

Tooth enamel, is a hard calcified tissue that completely surrounds the crown of a human tooth. It possesses a shiny surface. Its color varies from pearl white to dark yellow. Enamel consists of an inorganic matrix 96% , and organic constituents (i.e. proteins and lipids) and water 4% **(de Dios Teruel et al., 2015).**

Some studies of scanning electron microscope reported changes in surface morphology of enamel following bleaching with carbamide peroxide **(Pinto et al., 2004) (Smidt, 1998).**and/or HP products **(Ernst et al.,1996).** while other studies reported no alterations in enamel morphology **(Haywood et al., 1990).**

9.5.1.1 Surface texture

Significant surface alterations occurs in enamel following vital bleaching using carbamide or H2O2 **(Shannon et al., 1993).** High concentrations of carbamide peroxide damage enamel surface integrity, but less than phosphoric acid etch **(Ernst et al.,1996).** As a result of this increased the surface roughness it is possible that teeth may be more susceptible to extrinsic discolouration after bleaching **(Tredwin et al., 2006).**

In the enamel, a significant reduction in Ca and K levels was found following treatment with CP. Bleaching systems did not create any change in the levels of P, Mg, and Na in the enamel. On the other hand, F and O levels increased significantly following CP treatment **(Cakir et al.,2011).**

9.5.1.2. Mechanical and Chemical properties

studies have reported negative effects on enamel and dentin microhardness, while other studies reported no change in the microhardness of enamel and dentin. Lewinstein et al. reported that in-office bleaching products, 35% HP and 35% CP, reduced hardness of enamel significantly more than the home bleaching products **(Majeed et al., 2005).**

The decrease in the microhardness values is attributed to peroxide action on the enamel organic matrix, since the organic matrix is degraded, resulting in a more fragile enamel **(Potočnik et al .,2000)(Sa et al., 2012).**

9.5.2.Effect on dentine structure

Dentin, is a hard-calcified tooth tissue that is coated with enamel in coronal and cementum. It surrounds a central cavity the pulp, which houses the dental innervations. It is a yellowish-white, less hard than enamel but harder than bone**.** Mature dentine composed of 70% mineral, 20% organic matrix, and 10% water **(de Dios Teruel et al., 2015).**

9.5.2.1 Surface texture

Bleaching process has been reported to soften dental surfaces, An on vitro studies show that "Bleaching increased surface loss on noneroded dentin and decreased loss on eroded dentin" **(Engle et al.,2010).**

In the dentin, the use of bleaching systems did not cause any difference in Mg levels ,whereas Na, F, and O levels increased. A significant reduction in Ca, P, and K levels occurred in the dentin following treatment with CP **(Cakir et al.,2011).**

9.5.2.2 Mechanical and Chemical properties

Bleaching agents causes a significant reduction in dentin surface microhardness, An increase in peroxide concentration and gel acidity negatively affected microhardness and concentrations of calcium and phosphorus in enamel and dentin.

Reduction of microhardness or changes in the chemical structure are primarily the result of the oxidation process in the enamel and dentin organic and inorganic substances **(Rodrigues et al., 2001).** However, it is highly probable that the low pH of the bleaching agents can also lead to chemical and structural changes in dentin, which was demonstrated for internal dental bleaching **(Carrasco-Guerisoli et al., 2009).**

9.6. Effect on composite resin restoration

9.6.1 Effect of bleaching agent on sealing ability of composite restoration

Pre-restorative effect

Crim reported that pre-restorative bleaching with 10% CP did not affect the marginal sealing of subsequently placed restorations **(Crim, G.A., 1992).** Ulukapi et al. reported that pre-operative bleaching with CP increased marginal leakage of resin composite restorations at enamel and dentine margins but amalgam restorations showed no alterations **(Ulakapi et al., 2003).** In contrast, other studies did not report the increase of microleakage rate at enamel margins **(Owens et al., 1998).**

Post-restorative effect

Controversy exists about the influence of pre- and post-operative external bleaching on microleakage of composite restorations. Ulukapi et al. reported that post-operative bleaching with CP increases the marginal leakage of resin composite restorations at the enamel and dentine margins **(Ulakapi et al., 2003).** The oxidizing effect on polymer-matrix of resin-based materials also increases surface porosities **(Splading et al., 2003).** However, polishing of resin composite fillings following bleaching procedures is advisable to decrease the adherence of certain cariogenic micro-organisms.

9.6.2 Effect on bond strength of composite resin restoration to tooth structure

Pre-restorative effect

The majority of the studies reported that the bond strengths of composite restorative materials to enamel and dentine was significantly reduced when applied immediately after bleaching with HP or CP **(Shinohara et al., 2005) (Sryrides et al., 2000).** However, Josey et al. reported no negative effects of 10% CP bleaching on composite-enamel bond strength **(Josey et al.,1996).**

Several factors are responsible for the reduction in composite bond strengths to enamel and dentine. Polymerization inhibition of the resin adhesive systems, due to the presence of oxygen released by the bleaching process on the enamel surface and within the dentinal tubules, is the likely mechanism for the reduction in bond strength **(Barbosa et al., 2008).** Significant loss of enamel calcium and phosphorus content and morphological alterations of the majority of the crystals of the surface layer caused by the peroxide-based bleaching agents also adversely affects the bond

strength **(AMBROSE, W.W., 1998).** That it is necessary to wait seven days before performing adhesive restorative procedures **(Bittencourt et al., 2010).**

Post-restorative effect

Three studies dealing with the postoperative effect of bleaching gels on bond strength provide controversial results.

Cavalli and others used a microtensile bond strength method to study the resistance of enamel-composite and dentin-composite bonds created with the two-step etch-and-rinse Single Bond and the two-step self-etch Clearfil SE Bond. After bleaching with a 10% carbamide peroxide gel for six hours daily over two weeks, a decrease in the enamel-composite bond strength for Clearfil SE Bond was found. No significant influence of the bleaching gel on the dentin-composite bond strength was reported **(Cavalli et al., 2005).**

On the other hand, Barcellos and others, using a two-step etch-and-rinse Adper Single Bond 2, observed a decrease in the microtensile bond strength to bovine enamel and dentin after treatment with bleaching gel containing 15% and 20% carbamide peroxide for six hours daily for two weeks **(Barcellos et al., 2010).**

Degradation of the dentin-composite bond created with the two-step etch-and-rinse Single Bond was reported by Far and Ruse **(Far and Ruse , 2003).**

10. Tooth whitening for under 18 year old patient

Following the 2012 Cosmetic Products Safety Amendment Regulations, it became legal for tooth whitening to be in concentations less than 6% hydrogen peroxide **(Greenwall-Cohen et al., 2018).**

However, restriction on under-18 bleaching remained, limiting the use of it to less than 0.1% hydrogen peroxide. This placed dentists in a precarious situation,

with regards to clinical situations whereby bleaching was indicated, however, legally could not be provided. Ethically, the available clinical treatment was more invasive, direct and indirect restorations were permitted. However no restoration is 100% successful **(Saunders, W.P. and Saunders, E.M., 1998).**

Thankfully, after lobbying from the British Dental Bleaching Society (BDBS) and the British Society of Pediatric Dentistry (BSPD), a revised position statement on the General Dental Council's (GDC) website was released stating: 'Products containing or releasing between 0.1% and 6% hydrogen peroxide cannot be used on any person under 18 years of age except where such use is intended wholly for the purpose of treating or preventing disease **(Council, G.D., 2016).**

10.1 Indications for bleaching in children and the adolescent patients

The indications for bleaching in children and the adolescent patients according to Green-wall et al:

- Severe and moderate discolouration
- Enamel conditions
- White lesions, white markings and white flecks
- Brown, orange and yellow staining
- Coronal defects

10.2 Effectiveness of under-18 bleaching

Significant bleaching effects have been repeatedly demonstrated when compared to baselines in clinical trials. There have been some suggestions that bleaching success and rate of bleaching may increased in adolescent patient, when compared to the adult patient. This may be due to the increased permeability of the dentine and enamel and the diffusion flux experienced due to the anatomy of the younger enamel structure, which is more porous and permeable **(Camps et al., 2007).**

11. Contra-indication of dental bleaching

Contraindications according to Sulieman, M.A., 2008:

- Higher patient expectation
- Caries and periapical lesion
- Pregnancy
- Cracks and exposed dentine, sensitivity
- Existing crowns or large restorations
- Elderly patients with visible recession

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