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# Treatment of Discoloration Following Orthodontic Treatment

A project submitted to
The college of Dentistry, University of Baghdad, Department of Orthodontics in partial Fulfillment for the Bachelor of Dental Surgery

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# Certification of the supervisor

I certify that this project entitled **"Treatment of Discoloration Following Orthodontic Treatment"** was prepared by the fifth year student **Sajjad Hamza Kareem** under my supervision at the College of Dentistry/University of Baghdad in partial fulfillment of the graduation requirements for the Bachelor degree of Dentistry.

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**April,2023**

# Dedication

I dedicate this research to my family, who gave me all the support and encouragement despite the difficult year, to all the doctors of the College of Dentistry, University of Baghdad, who had great role in my development and studies.

# Acknowledgements

First and foremost, praises and thanks to **Allah** Almighty for helping me fulfill my dream, for his blessings throughout my work to complete it successfully.

I would like to extend my deepest respect and gratitude to the Dean of College of Dentistry, University of Baghdad, **Prof. Dr. Raghad Abdulrazaq Al- Hashimi.**

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## List of contents

# List of figures:

# Introduction

Aesthetics is an integral part of orthodontics, and color is an important aspect of aesthetics. Discoloration of the tooth is one of the most frequent reasons why a patient seeks dental care. Tooth discoloration is usually esthetically displeasing and psychologically traumatizing. An understanding of the etiology of tooth discoloration is important to a dentist in order to make the correct diagnosis. The knowledge of the cause of discoloration will also help the dental practitioner to explain the exact nature of the condition to the patient. In some instances, the mechanism of staining may have an effect on the outcome of treatment and influence the treatment options offered by the dentist to the patients **(Øgaard and Fjeld, 2010).**

Dental appearance is an important feature in determining the attractiveness of a face, and thus plays a key role in human social interactions. Among the significant factors affecting overall dental appearance are tooth color, shape, and position quality of restoration; and the general arrangement of the dentition, especially of the anterior teeth **(Akarslan *et al* .,2009).**

The factors such as sunlight in the environment, light scattered from adjacent gingival and perioral tissues, and lip and gum color influence the appearance of the teeth Tooth color is altered in the oral environment by intrinsic, extrinsic, and internalized discoloration. **(Watts and Addy ,2001).**

During orthodontic treatment, the color of teeth may darken to gray or brown as a sign of discoloration, necrosis, or devitalization of the pulp. Tooth discoloration is a rare phenomenon, however it may come to patients as a disturbance which may disrupt the doctor-patient relationship **( Huang *et al*., 2013).**

Although enamel color was changed after orthodontic treatment, the light- cured composite was associated with lower discoloration rates than chemically cured resins an orthodontic resin must bond the bracket to the tooth very well, along with protecting its own color during its life span. Even then, discoloration of adhesives is especially problematic when adhesives are subjected to prolonged exposure to staining materials during long-term treatment.**( Karamouzos *et al.*, 2010).**

Orthodontic metal brackets comprise various metals, and their corrosion might release large amounts of nickel and chromium ions, resulting in enamel discoloration **(Amini *et al* .,2015).**

Many manufacturers have produced new orthodontic products meet the esthetic request, these products combined both the acceptable esthetics and the adequate technical performance **(Salehi *et al*., 2013).**

At the beginning esthetic production, there were transparent brackets made of ceramic or composite **(Russell, 2005).**

But the arch-wires are still made of metals such as titanium molybdenum alloy, nickel titanium, or stainless steel. coated metallic and fiber-reinforced wires have been introduced to solve esthetic appearance problem **( Kaphoor *et al.*, 2012).**

# Aims of the study

The objective of this study about discoloration of teeth following orthodontic treatment and the type of stain on teeth extrinsic and intrinsic and the causes and factors of this stain and how we prevent the discoloration and treatment of discoloration following orthodontic treatment by use the most appropriate method.

# Chapter one : Review of literature

The main aim of orthodontic treatment is to correct malocclusion, in order, whenever possible, to achieve functionally appropriate occlusion and optimum dental and facial aesthetics. “Orthodontic treatment need” can be defined as the degree to which a person needs orthodontic treatment because of certain features of his or her malocclusion, the functional, dental health or aesthetic impairment it occasions and the negative psychological and social repercussions to which it gives rise **(Cao and Wang 2011).**

## 1.1Type of orthodontic appliance

The simplest classification is based on the patient's ability to remove the orthodontic appliance. Based on this the appliances can be classified as **(Eslamian and Leilazpour ,2006)**:

### 1.1.1 Removable appliance:

An appliance which can be removed for cleaning by the patient or for adjustment by the orthodontist. These appliances can be taken out of the mouth by patient when required**( Littlewood, 2001).**

According to their mode of action, removable orthodontic appliances are divided into three main groups **(Mitchell, 2007)**.

**A.Active removable appliances:** These appliances are capable of exerting pressure and perform tooth movement.

**B-Passive removable appliances:** These appliances remain passive in the mouth and exert no active pressure.

Example as space maintainer, retainers, habit breaker.

**C-Functional appliances:** These appliances work by transmitting or modifying muscle forces to the teeth and their supporting tissues. Example as: Andersen appliance, Frankel's functional regulators**( Mitchell, 2007).**

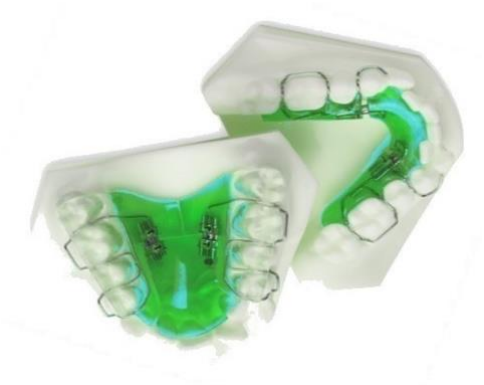

**Figure 1.1 :** Upper and Lower Jaw Functional Expanders **(Mitchell 2007)**

## 1.1.2. Removable-Fixed (combination) appliances:

Here some part of appliances can be removed by the patient and other parts remain fixed on the teeth**( Littlewood, 2001)**.

## 1.1.2 Fixed orthodontic appliance

Fixed appliances can define as the type of appliances that the patient cannot remove it from his / her mouth, because it is fixed to the teeth by cementation or composite **(Mahmood *et al*., 2021).**

Fixed orthodontic appliances include orthodontic devices, which have attachment that are fixed on to the tooth surface, the force exerted by these attachments using archwire and other auxiliaries These appliances should not be adjusted or removed by the patient **(Staderini *et al*.,2020).**

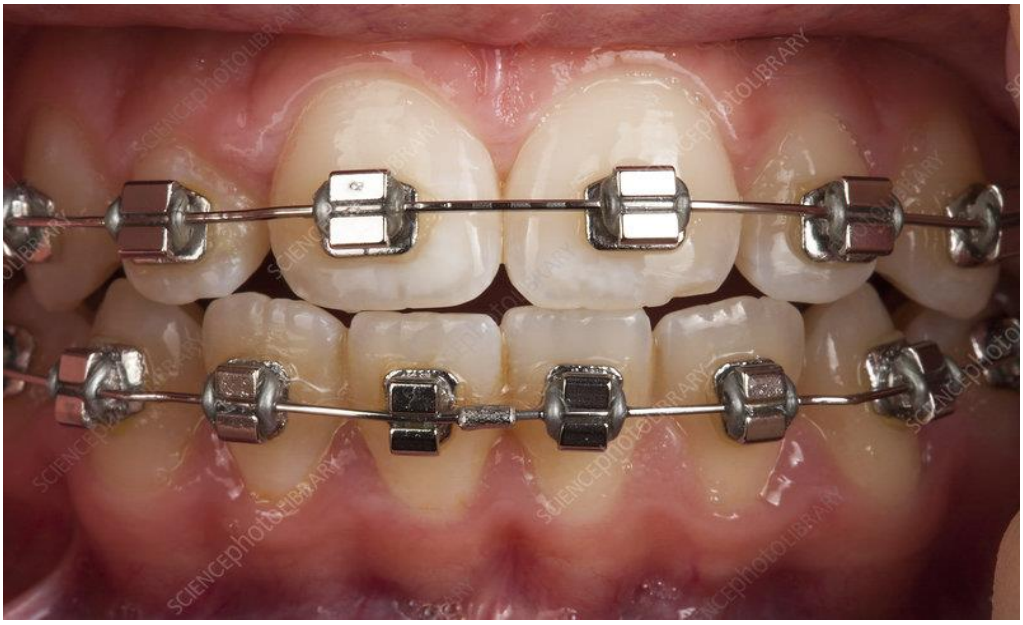

**Figure 1. 2** Fixed orthodontic appliance **(Piel *et al,*. 2011*)***

## 1.1.3.1. Component of fixed orthodontic appliance

The principal component of fixed appliance include (**Mahmood *et al.,* 2021):**

**1) Attachment** (like bracket, band, tube, buttons and cleat).

**2) Arch-wires**.

**3)auxiliaries**

**A) Brackets:**

One of the most important components of fixed appliance, they are merely handling-for attachment of the force producing agents. Brackets can affect the directions of the force vectors when torque, angulations, and in/out are built into the brackets **(Tanimoto *et al .,2015).***

Conventional brackets are made from stainless steel due to superior mechanical properties of stainless steel such as high strength and durability. But esthetic appearance of orthodontic appliances becomes more important nowadays, so tooth colored bracket materials have been introduced **(Ali *et al*.,2012).**

Plastic brackets having better esthetics, composed of unfilled polycarbonate and introduced in early 70s. But they lack strength and stiffness resulting in tie-wing fracture and slot distortion **(Zinelis *et al*., 2005).**

In early 1980s brackets composed of mono-crystalline sapphire and polycrystalline ceramic came into existence as esthetic appliances. They are superior to plastic brackets as these brackets can withstand orthodontic forces and resistant to staining in oral cavity. But still have limitations such as low fracture toughness, more friction between arch wire and bracket slot and unable to form chemical bond with resin adhesives **(Pratten *et al*., 1990).**

**B) Arch-wires:**

Archwire is a major component of fixed orthodontic appliance that is responsible for delivering force to the teeth when activated (arch-wire deflected and tied into the attachment on teeth). Additionally, arch-wire may be considered as a rail for the movement of teeth when it is passive (force delivered from auxiliary springs or elastics) **(Mitchell, 2013).**

## 1.2 Risks and complications associated with orthodontic treatment

A good progress of the orthodontic treatment is related also to the patient's understanding and compliance regarding the physician's indications, which aims mainly the oral hygiene and device maintenance, and rigorously in attending the periodical appointments. Failure to comply with these conditions may result in damaging the components of the orthodontic appliances, damage of the oral structures (risk factor for demineralizations, caries, discolorations, periodontal damage, bad breath), increased duration of the treatment and not achieving the expected result. **(Atai and Atai ,2007)**

The components of the orthodontic devices come into contact with the oral tissues and fluids, being submitted to some complex conditions: immersion in saliva and ingested fluids, temperature fluctuations, mechanical loading during chewing and activation of the devices, physical or chemical interactions. Therefore the orthodontic appliances must not contain compounds that may cause a toxic response, not cause

allergic reaction or have carcinogenic potential, must be resistant to electrochemical corrosion, should not promote the microbial adherence and development, in general - should present an optimal biocompatibility **(Bentahar *et al*., 2005)**.

In this context, it is recommended to use orthodontic devices with lower nickel content, with a good resistance to corrosion and, in order to avoid corrosion of titanium based components, to limit the use of high concentration flour-based products **(Chaturvedi and Upadhayay, 2010).**

For an optimal treatment conduct the materials must be resistant to forces that are applied during their usage period, should not fracture and should be suitable for processing in any configuration and shape demanded by their clinical application. The benefits of a medical intervention must outweigh any potential harm. Apart from its benefits, orthodontic treatment can cause certain complications. During clinical orthodontic procedures, the use of various methods, devices, and materials can cause unwanted side effects, both local (e.g., tooth discoloration, decalcification, root resorption, and periodontal complications) and systemic (e.g., allergic reactions and crossinfections**( Graber *et al* .,2004)**.

### 1.2.1. Carious complications associated with the orthodontic intervention

As the orthodontic technique developed, concerns regarding tooth damage by carious lesions during treatment increased, this being seen today as one of the most frequent unwanted side effect associated with this particular medical intervention. Decay damage associated with orthodontic technique presents some specific particularities. They appear with increased frequency on the tooth's surface where the bracket is bonded, adjacent to its base, they usually have low severity (most of the times are encountered as white spot lesions, more frequently gingival and distal to the bracket's base than mesial or occlusal Evidence shows that the prevalence of this unwanted side effect is nearby 70% for white spot lesions and less than 5% for cavities **(Al Maaitah *et al*., 2011).**

**Figure 1.3.** White spot lesions and cavities related to the presence of orthodontic appliance**( Cristina *et al* .,2012).**

## 1.2.2 External apical root resorption in orthodontic therapy

Apical root resorption is, according to the present knowledge, an unavoidable complication of the orthodontic treatment, microscopic studies showing a prevalence of 100% after the treatment end, using meta- analysis, found a mean value of the root shortening after orthodontic treatment of 1.421 +/- 0.448 m**( Segal *et al.*, 2004).**

Usually, the process severity is low, root shortening beyond 2mm being present in 5-18% of cases, and beyond 4mm or 1/3 of tooth length in 1-5% of the cases **(Lopatiene and Dumbravaite, 2008).**

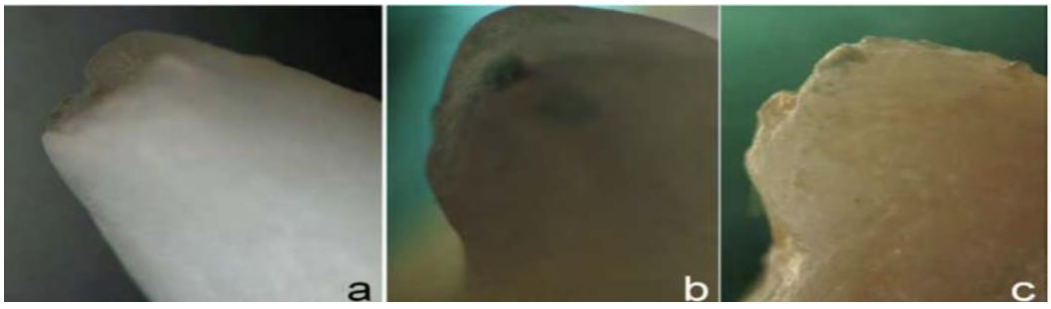


**Figure 1. 4:** Aspect of apical third of root of a newly erupted premolar (a), an included molar (b) and a premolar extracted for orthodontic purposes (c) – magnification 4X. (https://cdn.intechopen.com/pdfs/31388/InTechRisks_and_complications_associated_with_orthodontic_treatment.pdf)

### 1.2.3. Periodontal complications

Periodontal complications are one of the most actual side effects linked to the orthodontics, not rarely being the reason for malpractice complaints. It can be found in various forms, from gingivitis to periodontitis, dehiscence, fenestrations, interdental fold, gingival recession or overgrowth, black triangles (Fig. 1.5). Severe damage can considerably interfere with the teeth prognosis. Etiopathogeny is complex, involving factors related to the patient (e.g., previous condition present, increased susceptibility, poor oral hygiene) and to orthodontic technique. Gingivitis usually occurs due to the incorrect maintenance of the oral hygiene, in the presence of the orthodontic appliance, that seems to favor plaque accumulation**( Kouraki *et al*., 2005).**

**Figure 1. 5** Periodontal alteration present during orthodontic treatment( **Cristina et al .,2012)**

## 1.2.4 Color alterations linked to the orthodontic treatment

There are two methods to determine tooth color: visual determination and instrumental measurement. Visual determination is highly subjective but remains the most frequently applied method for color determination. However, several factors such as external light conditions, fatigue of the human eye, experience, and age and the inherent limitations of the contemporary shade guides can influence visual color selection **(van *et al* .,1990)**.

stating that-there was clinical development of dental discoloration during orthodontic treatment. Besides causing periodontal disease, plaque formed from fixed orthodontic devices could also leave colored marks on the surface of the tooth**( Graber *et al* .,2004).**

stating that there was a relationship between fixed orthodontic treatment and dental discoloration**( Un-Bong *et al* .,2017).**

Color alterations after orthodontic treatment are the result of several factors. More severe alterations occur when chemicallycured resins are used as bonding materials rather than light-cured composites. The resin tags cannot be removed by cleaning procedures without altering the enamel's surface. Irreversible changes occur to the enamel's surface morphology, rugosity, and texture, with negative consequences on its reflective properties, luminosity, and optical perception **(Fjeld *et al*.,2006).**

Evidence shows that the adhesive resins used for bracket bonding do not present good color stability with time. Ultraviolet light and corrosion products from the orthodontic appliance combined with food dyes induce color alterations, with a tendency to move toward the yellow tones. Orthodontic forces induce variations in pulp vascularization. It is a possible factor for the premature aging of teeth, and it is an endogenous factor for discoloration too. In situations where white spots and lesions are present, even if remineralization occurs, the outcome may be different from the initial enamel structure. This is because of the differences in the minerals in the treated enamel surface compared to the untreated enamel **(Santamaria ,2006 ; Øgaard and Fjeld, 2010).**

Leftover food, ultraviolet light, and corrosion products that come from fixed orthodontic devices affect discoloration with the tendency for teeth to turn into the yellowish color. According to the theory, the orthodontic treatment period varies according to the difficulty of the case. The average of estimated treatment time is 2 years but in fact the treatment time is often 50% longer than the predicted time, and it usually occurs in adolescents**(Yamaguchi and Kasai, 2007 ; Ramazanzadeh *et al* .,2009).**

Discoloration present after braces removal may have a negative impact on the aesthetics and patient's satisfaction in a split-mouth study on 26 orthodontic patients reported that teeth's color parameters changed after orthodontic treatment, 80% of the patients presenting at least one tooth with discolorations appreciated by authors as being unacceptable. Time had an aggravating effect on all color parameters evaluated according to the Commission Internationale de l'Eclairage system (L*-lightness; a*-red/green; b*- blue/yellow). There were observed more severe alteration when

chemically cured resins were used as bonding material compared to light cured composites **(Karamouzos *et al.*, 2010).**

Color alterations after orthodontic treatment present a multifactorial etiology, some variables being directly linked to the technique itself. Frequency of these alterations is considerably higher, with increased severity, when fixed appliances are used in comparison with the removable ones. When resins are used for bracket bonding enamel changes are unavoidable (Fig. 1.6). The resin tags cannot be removed by cleaning procedures without altering considerably the enamel surface. Irreversible changes regarding enamel surface morphology, its rugosity and texture are present, with negative influences on reflection properties, luminosity and optical perception. Evidence shows that adhesives resins used for bracket bonding don't present good color stability in time. Food dyes, ultraviolet light and corrosion products from the orthodontic appliance induce color alterations, with a tendency to modify toward the yellow tones **(Faltermeier *et al*., 2008)**.

After bracket removal patients frequently wish to increase their appearance by teeth whitening. This procedure presents particularities especially when resins were used as bonding material, due to the remained resins tags. The residual adhesive behaves different compared to adjacent enamel during whitening, being important to accurately evaluate the situation in order to avoid producing a more unpleasant outcome.

**Figure 1. 6:** Color changes integrated to usage of composite resins for bracket bonding **(Cristina *et al.*, 2012)**

## 1.3 Classification of stain

Normally, teeth composed of many colors and a gradation of colors occurs in a single tooth from gingival to the incisal edge. Because of the close contact of the dentin below the enamel and thinning of the enamel the gingival third of teeth is darker than incisal third. These differences in color may also be related to the thickness and translucency of enamel and dentine. In most cases canine teeth are usually darker than central and lateral incisors. Meanwhile, teeth become darker with age, so younger people have lighter teeth especially in the primary dentition. This discoloration may be caused by the deposition of secondary and tertiary dentine and pulp stones as a physiological senile change **(Watts and Addy 2001).**

Tooth staining can have an adverse psychosocial effect on a patient and can create an esthetic challenge for the clinician **'**stain' has been defined as the 'discoloration of a tooth surface or surfaces as a result of ingested materials, bacterial action, tobacco, and/or other substances. This may be intrinsic, extrinsic, acquired, or developmental **(Vogel, 1975).**

introduced two categories for tooth discoloration as extrinsic or intrinsic a introduced a third category called internalized discoloration. This classification depends on specific etiologic factors. Several factors affect the color of the tooth as seen by the human eye, some of which include: tooth's physiologic components (enamel, dentin and pulp), gradation of color based on specific location on the tooth (gingival shades are darker than incisal translucency), individual teeth (central and lateral incisors are lower in value than canines), age of the patient (teeth are lighter at a younger age than at an older age due to physiologic wear of enamel, secondary dentin deposition and staining), quality of the incident and reflected light (determining how the tooth is eventually viewed) **(Watts and Maddy ,2001)** .

Increases enamel porosity and consequently increases susceptibility to further staining via adsorption ,The accumulation of plaque around complex appliances has been shown to increase due to the difficulty in maintaining oral hygiene throughout orthodontic treatment, which leads to a potential risk of extrinsic staining. Indirect

extrinsic staining has been shown to be related to cationic antiseptics and metal salts, which can cause chemical reactions on the tooth surface **(Baharvand ,2014).**

Orthodontic metal brackets comprise various metals, and their corrosion might release large amounts of nickel and chromium ions, resulting in enamel discoloration .The resin used to attach clear appliances for orthodontic treatment can preclude the problems caused by the release of metal ions. Currently, no studies have been conducted on the effects of using resin for appliance attachment on tooth discoloration compared to those of using metal brackets**( Amini *et al.*, 2015).**

## 1.4 intrinsic and extrinsic staining

Extrinsic discoloration is defined as discoloration located on the outer surface of the tooth structure and is caused by topical or extrinsic agents**(Eriksen and Nordbø, 1978).**

This can be divided into two groups; direct and indirect. Direct staining is caused by compounds incorporated into the pellicle layer and the stain is a result of the basic color of the chromogen. Direct staining has multi-factorial etiology with the chromogens derived either from the diet or substances habitually placed in the mouth. Indirect staining on the other hand is caused by a chemical interaction at the tooth surface. It is usually associated with cationic antiseptics and metal salts. These agents are without color or a different color from the stain produced on the tooth surface **(Natto ,1997).**

Factors responsible for extrinsic discoloration such as Diet: Brown stains on the surface of the teeth could be due to the deposition of tannins found in tea, coffee and other beverages. Oral hygiene: Accumulations of dental plaque, calculus and food particles cause brown or black stains Chromogenic bacteria have also been suggested as an etiological factor in the production of stains typically at the gingival margin of the tooth**( Hattab *et al* .,1999).**

Habits: Tobacco from cigarettes, cigars, pipes, and chewing tobacco causes tenacious dark brown and black stains that cover the cervical one third to midway

on the tooth. Chewing of pan results in the production of blood red saliva that results in a red-black stain on the teeth, gingiva and oral mucosal surfaces **(Mirbod and Ahing, 2000).**

Medication factors: Cationic antiseptics such as chlorhexidine, cetylpyridinium chloride and other mouth washes can cause staining after prolonged use . Chlorhexidine, for example, produces brown to black discoloration. Some systemic medications (e.g. minocycline doxycycline, co-amoxiclav, linezolid) are also shown to cause extrinsic staining. Metallic compounds are also implicated in dental discoloration (e.g. Iron containing oral solutions, mouth rinses containing metal saltt)**( Good and Hussey, 2003)**.

Intrinsic Discoloration:There are several causes of intrinsic tooth discoloration which have either an endogenous or exogenous origin. These changes may occur during or after odontogenesis During odontogenesis, teeth may become discolored from the changes in the quality or quantity of enamel or dentin, or from the incorporation of discoloring agent into the hard tissues. Post-eruption discoloration occur when the discoloring agent enters the hard tissues. They may originate from the pulp or the tooth surface ( **Hayes *et al* .,1986).**

Pre-eruptive causes for intrinsic discoloration Metabolic: The diseases that have the potential to cause neonatal hyperbilirubinemia may cause the incorporation of bilirubin into developing teeth, producing jaundice like yellow-green tint within the dental hard tissue known as chlorodontia. Congenital erythropoietin porphyria (Günther's disease) is a rare, autosomal recessive disorder of porphyrin metabolism, resulting in an increase in the formation and excretion of porphyrins. The porphyrin pigments have an affinity for calcium phosphate and are incorporated into teeth during dental formation and these cause a characteristic reddish-brown discoloration of the teeth, called erythrodontia. The affected tooth shows a red fluorescence under ultra-violet light. Alkaptonuria, also known as phenylketonuria or ochronosis is an inborn error of metabolism of tyrosine and phenylalanine causing a build-up of homogenistic acid. This results in a brown discoloration of the permanent dentition **(Guimarães and Silva, 2003).**

## 1.5 Treatment of discoloration

The best strategies for the management of tooth discoloration seem to be those that prevent its occurrence. Currently, fluoride plays an important role in mitigating acid attacks **(Alexandria *et al*., 2019).**

The layer formed by fluoride varnish on the tooth surface can even act as a shield against tooth discoloration caused by food and drink. However, the different forms of fluoride agents, such as fluoride toothpaste, fluoride gel, and tooth protectors, usually are ineffective. This inefficiency is often associated with the low fluorine concentrations in the products as well as low patient cooperation **( Kumar *et al* .,2015 ; Reddy *et al* .,2019).**

Professional fluoride varnish is the preferred method of topical application because of its simple usage and lack of patient dependency. Currently, fluoride varnish is commonly available in conventional and light-curable forms. Conventional fluoride varnish is widely used; however, it must be reapplied every three months to maintain its effectiveness **( Shah *et al* .,2018).**

Recently, a light-curable resin-modified glass ionomer that can continuously release fluorine and calcium phosphate has attracted widespread clinical attention Moreover, the manufacturer claims that this light-curable varnish can provide a protective coating for up to six months, with the potential for more controlled and sustained fluoride release**( Reddy *et al* .,2019).**

Clean-up procedures cannot completely remove the composite remnants without damage to the enamel surface. Various quantitative and qualitative studies show that clean-up with tungsten carbide burs produces less enamel damage. The clean-up done only with burs was aggressive and resulted in surface irregularities, even with low-speed handpieces. Polishing produces a smooth surface. Following debonding, a smooth enamel surface is desirable to minimize color change **(Ryf *et al* .,2012*).***

The treatment of tooth discoloration consists of identifying the etiology and implementing the required therapy Scaling and polishing of the teeth using prophylactic paste applied with a rotating rubber cup may remove many extrinsic stains. For more

stubborn extrinsic and intrinsic stain, various bleaching techniques may be attempted Bleaching can be performed externally, termed night guard bleaching or vital tooth bleaching or intracoronally in root-filled teeth, called non-vital tooth bleaching Teeth discolored by dental caries or dental materials require the removal of the caries or restorative materials, followed by proper restoration of the tooth. Partial (e.g.laminate veneers) or full-coverage dental restorations may be used to treat generalized intrinsic tooth discoloration in which bleaching is not indicated or in which the esthetic results of bleaching fail to meet the patient's expectations**(Kerr ,2008).**

There are different treatment modalities for tooth discoloration such as bleaching ,enamel micro-abrasion and porcelain veneers . These may be used individually or in combination depending on the etiology and severity of the staining. Superficial treatments like bleaching and micro-abrasion have been used in conjunction but controversy exists whether or not high concentration hydrogen peroxide causes morphological alterations in enamel**( Azrak *et al*., 2010).**

## 1.5.1 Bleaching

Tooth whitening has been described by the chromophore concept **(Kwon and Wertz, 2015).**

The bleaching agent (hydrogen peroxide) by method of diffusion through tooth structure interacts with organic chromophores converting the latter's molecular chains to simpler units. This changes its optical properties and yields products with lower molecular weight which can be eliminated from the tooth surface. There are several bleaching agents available such as: hydrogen per- oxide, carbamide peroxide, sodium perborate and chlorine dioxide. In-office bleaching is most commonly carried out with hydrogen peroxide ranging from 15 - 38% **(Auschill *et al* .,2012).**

Hydrogen peroxide ($H_2O_2$) is able to penetrate dentinal tubules due its reduced molecular weight **(Seghi and Denry ,1992).**

It has the ability to release oxygen-free radicals capable of permeating through enamel and dentinal structures and eventually oxidizing organic pigments and chromogenic compounds **(Eimar *et al*.,2012).**

Carbamide peroxide (CH NO: 10 - 20%) is the agent mostly used for at-home bleaching Upon interaction with water it is broken down into hydrogen peroxide and urea eventually producing free oxygen**(Auschill *et al*.,2012).**

Carbamide peroxide has the advantage of providing good results with a lesser propensity for post-treatment side effects such as sensitivity, gingival inflammation and changes in surface micro-hardness **(Polydorou *et al*., 2007**).

Although a conservative treatment approach, bleaching is commonly associated with post-treatment tooth sensitivity being significantly dependent on the pH of the agent **(Loguercio *et al*.,2017).**

The advent of home bleaching involved a procedure with a milder peroxide, usually a 10 to 15 percent carbamide peroxide applied without heat. This technique was assumed to be entirely free of sensitivity and adverse palpal effects.clinical study on home bleaching, reported that mild transient tooth sensitivity was common to all participants. A more significant response to home bleaching who conducted a clinical study involving home bleaching with 10 percent carbamide peroxide. Of the 28 subjects in the study, four discontinued the procedure because of thermal sensitivity. But the remainder of the subjects showed no change in pulpal readings throughout the study.The reasons for sensitivity and discomfort are not totally clear. Microscopic examinations of enamel after bleaching do not show much alteration of its morphology**(Schulte *et al* ., 1992)**.

**Lima (2006 )** examined the effect of 30 percent hydrogen peroxide at various temperatures and found a significant reduction in micro- hardness of dentin and enamel that occurred after 15 minutes of application. They concluded that solubility and possibly permeability increased with prolonged bleaching. In a laboratory study

**Fujihara( 2004)** examined micro-leakage related to bleach- ing procedures and concluded that 10 percent carbamide per- oxide affected the marginal seal of restorations and increased micro-leakage around composite restorations bonded with any of the two dentin adhesives tested. This may be one mechanism by which home bleaching agents reach the dentinal tubules. It may also explain why some patients (perhaps those with restorations) experience more sensitivity than others.

## 1.5.2. Enamel micro-abrasion

Enamel micro-abrasion represents a conservative superficial approach which has been useful as definitive treatment only for mild to moderate stains **(Train *et al*.,1996)**

The materials used for this treatment include an abrasive paste, typically 6.6% hydrochloric acid with 20 - 160µ silicon carbide micro-particles and bristle cups. Teeth are cleaned with a pumice slurry and light pressure followed by multiple 20 seconds application of the micro-abrasive slurry. At-home bleaching using 10% carbamide peroxide can be used in conjunction with micro-abrasion to remove residual staining and improve tooth shade. Mild superficial stains can be removed with this technique. The depth of the stain lesion plays an important role in determining whether micro-abrasion will be an effective modality. Most common vivo methods for depth determination include ultrasound, transillumination and visual assessment**(Park *et al*.,2016).**

used an in vivo method of quantitative light-induced fluorescence (QLF) to assess the level of enamel hypoplasia in order to deter- mine the choice of treatment. Micro-abrasion can be used to treat: superficial enamel stains resulting from dental fluorosis, mineralized white spot lesions, surface irregularities, localized enamel hypoplasia and enamel polishing post-orthodontic treatment **(Pini *et al*., 2015).**

The micro-abrasion technique involves the following steps **(Hattab *et al*., 1999):**

1. Discolored teeth are cleaned with pumice and water slurry or prophylactic paste in a slow- rotating rubber prophylaxis cup.
2. Teeth are isolated with a rubber dam and seal around the gingival margin with Copalite varnish (Cooley and Cooley Ltd., Houston, Texas) to pre- vent seepage of the acid onto the gingiva.
3. The operator should wear gloves, and the operator, nurse, and patient must wear protective glasses.

4. Hydrochloric acid (HCl) 18% solution is mixed with fine pumice powder to make a thick slurry. The acid is obtained by diluting standard 35 to 38% hydrochloric acid with an equal volume of distilled water.

5. The acid-pumice slurry is applied to the stained area of the tooth with a wooden applicator. The slurry is rubbed over the affected buccal surfaces of the teeth with a firm erasing motion from the area of most intense stain toward normal enamel for 5 seconds.

6. The area is rinsed thoroughly with air-water spray directly into an aspirator tip.

7. The procedure is repeated until the stain is removed or to a maximum of 10 applications. It has been reported that the depth of enamel loss after ten 5-second applications of acid and pumice slurry with a rubber cup is 160 um,72whereas the loss of enamel with the use of a wooden applicator is 73.9 µm.

8. Neutral fluoride gel solution is applied for 4 minutes. Evidence indicates that an application time of 4 minutes increases enamel fluoride uptake 42% more than that of a 2-minute treatment, at 15-µm depth.

9. The rubber dam is removed and the enamel polished to a fine luster with fine polishing paste and superfine polishing disks. An alternative is the use of a rotating rubber cup lubricated with neutral fluoride gel. Polishing the enamel surface is important to prevent or minimize the formation of new extrinsic stains.

## 1.5.3. Porcelain Laminate Veneers or crowns

Deeper stains resulting from enamel hypoplasia or intrinsic causes cannot be treated with conservative methods like micro-abrasion and bleaching and need a restorative approach such as porcelain veneers and/or crowns. Veneers have long been used as a minimally invasive restorative approach for improving tooth form and shade. Reports indicate a high success rate and longevity of such restorations **( Petridis *et al.*, 2012).**

Materials most commonly used are feldspathic porcelain and lithium disilicate (LS2). Lithium disilicate can be fabricated with either a minimal cut-back or bi-layered technique. This is determined by the intensity of the underlying stain, amount of desired translucency and clinician's preference. Tooth preparations for veneers are conservative and remain predominantly in enamel for higher bond strength and reduced risk of post-treatment sensitivity. Severe forms of staining causing structural damage may require restoration with complete coverage crowns**( Arcangelo *et al.*, 2012).**

# Chapter two: Discussion

Compared to other orthodontic complications such as root resorption, gingival recession, white spot lesions, or root dehiscence, tooth discoloration rarely occurs. However, any orthodontist may encounter this complication. Mild discoloration may be overlooked without being detected, as in some cases, the discoloration may even disappear without any treatment. Thus, discoloration may be detected at a higher rate when teeth are examined under persistent clinical scrutiny.

There are two methods to determine tooth color: visual determination and instrumental measurement. Visual determination is highly subjective but remains the most frequently applied method for color determination. However, several factors such as external light conditions, fatigue of the human eye, experience, and age and the inherent limitations of the contemporary shade guides can influence visual color selection.

Clean-up procedures cannot completely remove the composite remnants without damage to the enamel surface. Various quantitative and qualitative studies show that clean-up with tungsten carbide burs produces less enamel damage. The clean-up done only with burs was aggressive and resulted in surface irregularities, even with low-speed handpieces. Polishing produces a smooth surface. Following debonding, a smooth enamel surface is desirable to minimize color change.

The treatment of tooth discoloration consists of identifying the etiology and implementing the required therapy Scaling and polishing of the teeth using prophylactic paste applied with a rotating rubber cup may remove many extrinsic stains. For more stubborn extrinsic and intrinsic stain, various bleaching techniques may be attempted Bleaching can be performed externally, teeth discolored by dental caries or dental materials require the removal of the caries or restorative materials, followed by proper restoration of the tooth. Partial (e.g. laminate veneers) or full-coverage dental restorations may be used to treat generalized intrinsic tooth discoloration in which bleaching is not indicated or in which the esthetic results of bleaching fail to meet the patient's expectations

An important aspect in the visual assessment of a finished orthodontic case is tooth color aesthetics. Color change of the enamel surface affects the clinical performance and patient satisfaction In the management of patients with discolored tooth, an understanding of the mechanism behind the discoloration is of relevance to the dental practitioner as it can be valuable in the decision-making process when considering how to treat the condition. It is clear that tooth discoloration has a multifactorial etiology, manifested as a result of complex physicochemical interaction between chromogens and tooth substance. With advances in bleaching techniques, only the deepest and most stubborn tooth stains now are resistant to bleaching. If the staining is accompanied by pitting and other surface defects, a combined approach of bleaching preceding esthetic restorations is recommended. In cases of severe enamel loss, bleaching is contraindicated.Bleaching can improve the appearance of discolored teeth while preserving tooth structure, and it avoids more costly invasive dental treatment. Mild thermal sensitivity is a common side effect associated with most vital bleaching techniques. Fluoride treatment and sealing of restorations may dampen sensitivity discomfort. It is essential for dental practitioners to update their knowledge of the etiologies, clinical presentations, and treatment modalities of dental discoloration.

While comparing the effect of the two adhesive systems, light cure and chemically cure, two of the studies showed that chemical cure resins produced increased color change in comparison to light cure The discoloration of the adhesive resins may result from endogenous changes such as the formation of oxidation by-products and decomposition of initiators and exogenous changes by the formation of stains. Resins with reduced particle size and hardness, low water sorption, higher filler-resin ratio, and optimal filler matrix resin system increase the color stability of composites.

The color of composites is known to change in the mouth over a certain period of time due to many extrinsic and intrinsic factors . Many factors influence the extent of discoloration of adhesives, such as incomplete polymerization, resin matrix composition, type of filler particles, light-curing devices.

The colored corrosion products and the crevice corrosion of the stainless steel result in enamel stains in the presence of voids and poor oral hygiene. the corrosion of

metal brackets occurs due to prolonged orthodontic treatment and low level of oral pH in some patients, leading to enamel discoloration The colored food and acidic drinks such as cola and citrus drinks also cause a damaging effect on tooth color and should be consumed minimally over the course of orthodontic therapy .

Discoloration has been classified as extrinsic or intrinsic ,extrinsic discoloration as that occurring when an agent stains or damages the enamel surface of the teeth and intrinsic tooth structure is pretreated by discoloring agent. However ,extrinsic staining that can be removed by a normal prophylactic cleaning. Where intrinsic discoloration is been incorporated into the tooth matrix and thus its removal by prophylaxis cannot be done. Some discoloration is a combination of both types of staining & may be multifactorial.

# Chapter three

## 3.1. Conclusion

1. There is a significant enamel color change following orthodontic treatment.

2. Tooth discoloration has multifactorial etiology.It may be extrinsic or intrinsic and both of them have specific method for treatment.

3. The dentist should clean up the teeth after removing the orthodontic appliance

4. The treatment of tooth discoloration consists of identifying the etiology and implementing the required therapy Scaling and polishing of the teeth using prophylactic paste applied with a rotating rubber cup may remove many extrinsic stains.

5. method were effective in brightening tooth color after orthodontic treatment. Home bleaching and laser-assisted in office bleaching produced the greater color alteration followed by conventional in office bleaching.

6. Enamel micro-abrasion represents a conservative superficial approach which has been useful as definitive treatment only for mild to moderate stains.

7. Deeper stains resulting from intrinsic causes cannot be treated with conservative methods like micro-abrasion and bleaching and need a restorative approach such as porcelain veneers or crowns.

## 3.2 Suggestions

1.conduct survey study among Iraqi orthodontist about most cause of stain after orthodontic treatment.

2.conduct survey study among Iraqi orthodontist about most reliable methods for treatment of discoloration after orthodontic treatment.

3.review study about most advance methods for detection and treatment of discoloration after orthodontic treatment.

# Reference

(A).

**Akarslan, Z. Z., Sadik, B., Erten, H., and Karabulut, E. (2009).** Dental esthetic satisfaction, received and desired dental treatments for improvement of esthetics. *Indian journal of dental research : official publication of Indian Society for Dental Research, 20(2), 195–200.*

**Atai, Z. and Atai, M. (2007)**. Side Effects and Complications of Dental Materials on Oral Cavity. *American Journal of Applied Sciences, 4(11*), 946-949.

**Ali, O., Makou, M., Papadopoulos, T., and Eliades, G. (2012).** Laboratory evaluation of modern plastic brackets. *European journal of orthodontics, 34(5), 59*5–602.

**Al Maaitah, E. F., Adeyemi, A. A., Higham, S. M., Pender, N., and Harrison, J. E. (2011).** Factors affecting demineralization during orthodontic treatment: a post-hoc analysis of RCT recruits. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, *139(2), 181–191. https://doi.org/10.1016/j.ajodo.2009.08.028*

**Alexandria, A. K., Nassur, C., Nóbrega, C. B. C., Branco-de-Almeida, L. S., Dos Santos, K. R. N., Vieira, A. R., Neves, A. A., Rosalen, P. L., Valença, A. M. G., and Maia, L. C. (2019).** Effect of $TiF_4$ varnish on microbiological changes and caries prevention: in situ and in vivo models. *Clinical oral investigations, 23(6),* 2583–2591. https://doi.org/10.1007/s00784-018-2681-x

**Auschill, T. M., Schneider-Del Savio, T., Hellwig, E., and Arweiler, N. B. (2012).** Randomized clinical trial of the efficacy, tolerability, and long-term color stability of two bleaching techniques: 18-month follow-up. *Quintessence international (Berlin, Germany* : 1985), 43(8), 683–694.

**Amini Fariborz, Saghar Harandi, Mobina Mollaei, Vahid Rakhshan(2015)** *European Journal of Orthodontics*, Volume 37, Issue 5, Pages 522–530, https://doi.org/10.1093/ejo/cju079

**Azrak, B., Callaway, A., Kurth, P., and Willershausen, B. (2010).** Influence of bleaching agents on surface roughness of sound or eroded dental enamel specimens. *Journal of esthetic and restorative dentistry : official publication of the American Academy of Esthetic Dentistry ...* [et al.], 22(6), 391–399. https://doi.org/10.1111/j.1708-8240.2010.00372.x

(B)

**Bentahar, Z., Bourzgui, F., Zertoubi, M., EL Adioui- Joundy, S. and Morgan, G. (2005).** *Dégradation électrochimique des matériaux métalliques utilisés en orthodontie. International Orthodontics*, Vol. 3, No.5, pp. 5–17, ISSN 1761-7227

(C)

**Chaturvedi, T. P., and Upadhayay, S. N. (2010).** An overview of orthodontic material degradation in oral cavity. *Indian journal of dental research : official publication of Indian Society for Dental Research*, 21(2), 275–284. https://doi.org/10.4103/0970-9290.66648

**Cristina Teodora Preoteasa., Ecaterina Ionescu and Elena Preoteasa.,(2012)** Faculty of Dental Medicine, "Carol Davila" University of Medicine and Pharmacy,

BucharestRomania
https://cdn.intechopen.com/pdfs/31388/InTechRisksandcomplications associated with orthodontic treatment.pdf

**Cao ,G., Wang ,Y., (2011)** Nanostructures and Nanomaterials. Synthesis, Properties and Applications, 2nd ed.; *World Scientific Publishing*: Singapore.

(D)

**D'Arcangelo, C., De Angelis, F., Vadini, M., and D'Amario, M. (2012).** Clinical evaluation on porcelain laminate veneers bonded with light-cured composite: results up to 7 years. *Clinical oral investigations*, 16(4), 1071–1079. https://doi.org/10.1007/s00784-011-0593-0

(E)

**Eimar, H., Siciliano, R., Abdallah, M. N., Nader, S. A., Amin, W. M., Martinez, P. P., Celemin, A., Cerruti, M., and Tamimi, F. (2012).** Hydrogen peroxide whitens teeth by oxidizing the organic structure. *Journal of dentistry*, *40 Suppl 2*, e25–e33. https://doi.org/10.1016/j.jdent.2012.08.008

**Eriksen, H. M., and Nordbø, H. (1978).** Extrinsic discoloration of teeth. *Journal of clinical periodontology*, 5(4), 229–236. https://doi.org/10.1111/j.1600-051x.1978.tb01916.x

**Eslamian, L,. and Leilazpour, A.P., (2006)**Tongue to palate contact during speech in subjects with and without a tongue thrust .*European Journal of Orthodontics* ,28 ,475 -479.

(F)

**Fjeld, M., and Øgaard, B. (2006).** Scanning electron microscopic evaluation of enamel surfaces exposed to 3 orthodontic bonding systems. American journal of orthodontics and dentofacial orthopedics : *official publication of the American Association of*

*Orthodontists, its constituent societies, and the American Board of Orthodontics, 130(5)*, 575–581. https://doi.org/10.1016/j.ajodo.2006.07.002

**Faltermeier, A., Rosentritt, M., Reicheneder, C., and Behr, M. (2008).** Discolouration of orthodontic adhesives caused by food dyes and ultraviolet light. *European journal of orthodontics*, 30(1), 89–93. https://doi.org/10.1093/ejo/cjm058

**Fujihara, K. (2004)** "Fibrous composite materials in dentistry and orthopaedics: review and applications." *Composites Science and Technology* 64.6: 775-788.

(G)

**Graber ,T., Eliades, T., Athanasiou, AE. (2004)** Risk Management in Orthodontics: *Experts Guide to Malpractice.* Quintessence Publishing Co,145-66

**Guimarães, L. P., and Silva, T. A. (2003).** Green teeth associated with cholestasis caused by sepsis: a case report and review of the literature. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics*, 95(4), 446–451. https://doi.org/10.1067/moe.2003.43

**Good, M. L., and Hussey, D. L. (2003)**. Minocycline: stain devil?. *The British journal of dermatology*, 149(2), 237–239. https://doi.org/10.1046/j.1365-2133.2003.05497.x

(H)

**Huang, G. J., Roloff-Chiang, B., Mills, B. E., Shalchi, S., Spiekerman, C., Korpak, A. M., Starrett, J. L., Greenlee, G. M., Drangsholt, R. J., and Matunas, J. C. (2013).** Effectiveness of MI Paste Plus and PreviDent fluoride varnish for treatment of white

spot lesions: a randomized controlled trial. *American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, 143(1), 31–41. https://doi.org/10.1016/j.ajodo.2012.09.007

**Hattab, F. N., Qudeimat, M. A., and al-Rimawi, H. S. (1999).** Dental discoloration: an overview. *Journal of esthetic dentistry*, 11(6), 291–310.

**Hayes, P. A., Full, C., and Pinkham, J. (1986).** The etiology and treatment of intrinsic discolorations. *Journal (Canadian Dental Association)*, 52(3), 217–220.

(K)

**Kumar Jena, A., Pal Singh, S., and Kumar Utreja, A. (2015).** Efficacy of resin-modified glass ionomer cement varnish in the prevention of white spot lesions during comprehensive orthodontic treatment: a split-mouth study. *Journal of orthodontics*, 42(3), 200–207.

**Kaphoor, A. A., and Sundareswaran, S. (2012).** Aesthetic nickel titanium wires--how much do they deliver?. *European journal of orthodontics*, *3*4(5), 603–609. https://doi.org/10.1093/ejo/cjr089

**Karamouzos, A., Athanasiou, A.E., Papadopoulos, M.A.and Kolokithas, G. (2010).** Tooth-color assessment after orthodontic treatment: a prospective clinical trial. *American Journal of Orthodontics and Dentofacial Orthopedics*, Vol.138, No.5, pp. 537.e1-8, ISSN 1097- 6752

**Kouraki, E., Bissada, N.F., Palomo, J.M., Ficara, A.J. (2005).** Gingival enlargement and resolution during and after orthodontic treatment. *New York State Dental Journal*, Vol.71, No.4, pp. 34-37, ISSN 0028-7571

**Kwon, S. R., and Wertz, P. W. (2015).** Review of the Mechanism of Tooth Whitening. *Journal of esthetic and restorative dentistry : official publication of the American Academy of Esthetic Dentistry ...* [et al.], 27(5), 240–257. https://doi.org/10.1111/jerd.1215

**Kerr, A.R., (2008).** Retrieved online Jan 9, 2009 from http://emedicine.medscape.com/article/1076389- overview.

(L)

**Littlewood, S, J., ( 2001).** "Orthodontics: The role of removable appliances in contemporary orthodontics". *British Dental Journal. BDJ* 191 (6):304-310. doi:10.1038/sj.bdj.4801170. PMID 11587502.

**Lopatiene, K. and Dumbravaite, A. (2008).** Risk factors of root resorption after orthodontic treatment. *Stomatologija, Baltic Dental and Maxillofacial Journal*, Vol.10, No.3, pp. 89- 95, ISSN 1392-8589

**Loguercio, A. D., Servat, F., Stanislawczuk, R., Mena-Serrano, A., Rezende, M., Prieto, M. V., Cereño, V., Rojas, M. F., Ortega, K., Fernandez, E., and Reis, A. (2017).** Effect of acidity of in-office bleaching gels on tooth sensitivity and whitening: a two-center double-blind randomized clinical trial. *Clinical oral investigations*, 21(9), 2811–2818. https://doi.org/10.1007/s00784-017-2083-5

**Lau, P.Y. and Wong, R.W.K. (2006).** Risks and complications in orthodontic treatment. *Hong Kong Dental Journal*, Vol.3, No.1, pp. 15-22, ISSN 1727-2300

**Lima, LM., Motisuki ,C., dos Santos-Pinto, L., dos Santos-Pinto, A., Corat ,EJ., (2006)** Cutting characteristics of dental diamond burs made with CVD technology. *Braz Oral Res*.20: 155-61.

(M)

**M. Baharvand.,( 2014)** "Colors in tooth discoloration: a new classification and literature review," *International Journal of Clinical Dentistry*, vol. 7, no. 1, pp. 17–27.

**MITCHELL ,L., (2007).** An introduction to orthodontics. 3rd ed. Chapter 19: Functional appliances. Pg 203-215.

**Mitchell, L., (2013)** An introduction to orthodontics. 4th ed. Great Clarendon Street, Oxford OX2 6DP, United Kingdom: Oxford University Press.

**Mandar Shah, Ganesh Paramshivam, Anurag Mehta, Surjit Singh, Ankita Chugh, Anil Prashar, Vinay Kumar Chugh, (2018**)comparative assessment of conventional and light-curable fluoride varnish in the prevention of enamel demineralization during fixed appliance therapy: a split-mouth randomized controlled trial, *European Journal of Orthodontics*, Volume 40, Issue 2, , Pages 132–139,

**Mirbod, S. M., and Ahing, S. I. (2000).** Tobacco-associated lesions of the oral cavity: Part I. Nonmalignant lesions. *Journal (Canadian Dental Association)*, 66(5), 252–256.

**Mahmood, R. A., Mohsin, M. K, Mohammad, M. H., and Shukr, M. M. (2021).** Evaluation of Metallic lon Release from Fixed Orthodontic Appliance in Two Different Mouthwashes and Distilled Water An In Vitro Study Dent J, 8(1), 61-66.

(N)

**Nathoo S. A. (1997).** The chemistry and mechanisms of extrinsic and intrinsic discoloration. *Journal of the American Dental Association* (1939), 128 Suppl, 6S–10S. https://doi.org/10.14219/jada.archive.1997.0428

**Norton S. A. (1998).** Betel: consumption and consequences. *Journal of the American Academy of Dermatology*, 38(1), 81–88. https://doi.org/10.1016/s0190-9622(98)70543-2

(O)

**Ogaard ,B., and Fjeld ,M., (2010)**The enamel surface and bonding in orthodontics. *Semin Orthod* ;16:37-48

(P)

**Polydorou, O., Mönting, J. S., Hellwig, E., and Auschill, T. M. (2007).** Effect of in-office tooth bleaching on the microhardness of six dental esthetic restorative materials. *Dental materials : official publication of the Academy of Dental Materials*, 23(2), 153–158. https://doi.org/10.1016/j.dental.2006.01.004

**Park, T. Y., Choi, H. S., Ku, H. W., Kim, H. S., Lee, Y. J., and Min, J. B. (2016).** Application of quantitative light-induced fluorescence to determine the depth of demineralization of dental fluorosis in enamel microabrasion: a case report. *Restorative dentistry & endodontics*, 41(3), 225–230. https://doi.org/10.5395/rde.2016.41.3.225

**Pini, N. I., Sundfeld-Neto, D., Aguiar, F. H., Sundfeld, R. H., Martins, L. R., Lovadino, J. R., and Lima, D. A. (2015).** Enamel microabrasion: An overview of clinical and scientific considerations. *World journal of clinical cases*, 3(1), 34–41. https://doi.org/10.12998/wjcc.v3.i1.34

**Petridis, H. P., Zekeridou, A., Malliari, M., Tortopidis, D., and Koidis, P. (2012).** Survival of ceramic veneers made of different materials after a minimum follow-up period of five years: a systematic review and meta-analysis. *The European journal of esthetic dentistry : official journal of the European Academy of Esthetic Dentistry*, 7(2), 138–152.

**Piel, C., Albrecht, A., Neubauer, C., Klampfl, C. W., and Reussner, J. (2011).** Improved SEC-FTIR method for the characterization of multimodal high-density polyethylenes. *Analytical and bioanalytical chemistry,* 400(8), 2607–2613.

**Pratten, D. H., Popli, K., Germane, N., & Gunsolley, J. C. (1990).** Frictional resistance of ceramic and stainless steel orthodontic brackets. *American journal of orthodontics and dentofacial orthopedics* : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics, 98(5), 398–403.

(Q)

**Øgaard ,B., and Fjeld, M. (2010)** The enamel surface and bonding in orthodontics. seminars in orthodontics.;16(1):37- 48.

(R)

**Ramazanzadeh, B. A., Sahhafian, A. A., Mohtasham, N., Hassanzadeh, N., Jahanbin, A., and Shakeri, M. T. (2009).** Histological changes in human dental pulp following application of intrusive and extrusive orthodontic forces. *Journal of oral science,* 51(1), 109–115.

**Russell J. S. (2005).** Aesthetic orthodontic brackets. *Journal of orthodontics*, 32(2), 146–163. https://doi.org/10.1179/146531205225021024

**R. Reddy, R. Manne, G. C. Sekhar, S. Gupta, N. Shivaram, and K. R. Nandalur, (2019 )**"Evaluation of the efficacy of various topical fluorides on enamel demineralization adjacent to orthodontic brackets: an in vitro study," *The Journal of Contemporary Dental Practice,* vol. 20, no. 1, pp. 89–93.

**Ryf, S., Flury, S., Palaniappan, S., Lussi, A., van Meerbeek, B., and Zimmerli, B. (2012).** Enamel loss and adhesive remnants following bracket removal and various clean-up procedures in vitro. *European journal of orthodontics*, *3*4(1), 25–32.

(S)

**Salehi, P., Zarif Najafi, H., & Roeinpeikar, S. M. (2013).** Comparison of survival time between two types of orthodontic fixed retainer: a prospective randomized clinical trial. *Progress in orthodontics*, 14, 25. https://doi.org/10.1186/2196-1042-14-25

**Santamaria, M., Jr, Milagres, D., Stuani, A. S., Stuani, M. B., and Ruellas, A. C. (2006).** Initial changes in pulpal microvasculature during orthodontic tooth movement: a stereological study. *European journal of orthodontics*, 28(3), 217–220. https://doi.org/10.1093/ejo/cji117

**Segal, G.R., Schiffman, P.H.and Tuncay, O.C. (2004).** Meta analysis of the treatment-related factors of external apical root resorption. *Orthodontics and Craniofacial Research,* Vol.7, No.2, pp. 71-78, ISSN 1601-6335

**Seghi, R. R., and Denry, I. (1992).** Effects of external bleaching on indentation and abrasion characteristics of human enamel in vitro. *Journal of dental research*, 71(6), 1340–1344.

**Schulte, J. R., Morrissette, D. B., Gasior, E. J., and Czajewski, M. V. (1994).** The effects of bleaching application time on the dental pulp. *Journal of the American Dental Association* (1939), 125(10), 1330–1335.

**Staderini, E., Patini, R., Meuli, S., Camodeca, A., Guglielmi, F., & Gallenzi, P. (2020).** Indication of clear aligners in the early treatment of anterior crossbite: a case series. *Dental Press Journal of Orthodontics*, 25(4), 33-43.

(T)

**Train, T. E., McWhorter, A. G., Seale, N. S., Wilson, C. F., and Guo, I. Y. (1996).** Examination of esthetic improvement and surface alteration following microabrasion in fluorotic human incisors in vivo. *Pediatric dentistry*, 18(5), 353–362.

**Tanimoto, Y., Inami, T., Yamaguchi, M., Nishiyama, N., and Kasai, K. (2015).** Preparation, mechanical, and in vitro properties of glass fiber-reinforced polycarbonate composites for orthodontic application. *Journal of biomedical materials research. Part B, Applied biomaterials*, 103(4), 743–750. https://doi.org/10.1002/jbm.b.33245

(U)

**Un-Bong Baik., Kim, H., Chae, H. S., Myung, J. Y., and Chun, Y. S. (2017)** Teeth discoloration during orthodontic treatment. *The Korean Journal of Orthodontics*, 47(5): 334-339

(V)

**Vogel R. I. (1975).** Intrinsic and extrinsic discoloration of the dentition (a literature review). *Journal of oral medicine*, 30(4), 99–104.

**van der Burgt, T. P., ten Bosch, J. J., Borsboom, P. C., and Kortsmit, W. J. (1990).** A comparison of new and conventional methods for quantification of tooth color. *The Journal of prosthetic dentistry*, 63(2), 155–162. https://doi.org/10.1016/0022-3913(90)90099-x

(W)

**Watts, A., and Maddy, M., (2001)**"Tooth discoloration and staining: a review of the literature". *British Dental Journal* 190.6: 309-316.

**Watts, A., and Addy, M. (2001).** Tooth discolouration and staining: a review of the literature. *British dental journal*, 190(6), 309–316.

(Y)

**Yamaguchi, M.,and Kasai, K., (2007)**The effects of orthodontic mechanics on the dental pulp. *Seminars Orthod.*;13:272–80.

(Z)

**Zinelis, S., Eliades, T., Eliades, G., Makou, M., and Silikas, N. (2005).** Comparative assessment of the roughness, hardness, and wear resistance of aesthetic bracket materials. *Dental materials : official publication of the Academy of Dental Materials*, 21(9), 890–894.

https://www.researchgate.net/profile/Faiez-Hattab/publication/227889905_Dental_Discoloration_An_Overview/links/5a189e044585155c26a956d7/Dental-Discoloration-An-Overview.pdf