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Evaluation of the Effect of Different Bleaching Techniques on Surface Roughness and Color Change in New and Aged Composites

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DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

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LIST OF ABBREVIATIONS

µm	Micrometer
Nm	Nanometer
Bis-GMA	Bisphenol A glycidyl methacrylate
Bis-EMA	Ethoxylated bisphenol-A dimethacrylate
UDM	Urethan dimethacrylate
Anova	Analysis of variance
HP	Hydrogen peroxide
CP	Carbamide peroxide
ΔE	Delta E color variation
SR	Surface roughness
SD	Standard deviations
H	Hour
CIE	Commission Intérnationale de l’Eclairage

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ABSTRACT

Objectives: The aim of this study was to investigate the effect of 35% hydrogen peroxide (Whiteness HP) and 16 % carbamide peroxide (Whiteness Perfect) on the surface roughness and color change of new and aged microhybrid composites (Filtek Z 250).

Materials and Methods: A Teflon matrix (10 x 2 mm) was used to fabricate 120 specimens which, after polishing with 600 and 1200 grit silicon carbide paper and 24 hours stored in distilled water divided into 2 main groups (n 60). Afterward, the specimens of one group were placed on 1000 cycles in thermocycling device and the specimens of the other group were placed on 10000 cycles. After the thermocycling, the initial color and surface roughness readings were performed by using the spectrophotometer and profilometer respectively. The specimens of each group were then randomly divided into three subgroups (n 20) according to surface treatments: distilled water (control), 16% Carbamide Peroxide (CP), and 35% hydrogen peroxide (HP). The 16% CP agent was applied 4 h daily for 2 weeks and 35% HP agent was applied 45 minute/week. After 14 days of treatment, the color change (ΔE1) and the surface roughness readings were performed. After bleaching procedure, half of each 20 subgroup were polished with Sof-Lex pop-on system while the other half were kept without polishing. After that, the polished and unpolished specimens were immersed in vials containing 5 ml of coffee solution for one week at room temperature. The second color changes (ΔE2) were then assessed.

Results: There was a significant increase in the surface roughness values of the bleached and the control groups for the new tested composite, but no significant changes were detected for the aged composite group. Bleaching of the new and aged composite groups did not show any significant change in the surface roughness when compared the bleached groups with the control groups. As regarding the color variation, the color change (ΔE1) differences between the new and aged composite groups were statistically significant; as the means in the aged composite group was higher. The color change differences between the bleached and control groups for the new and aged tested composite were insignificant.

Conclusion: It can conclude that in this study both the bleaching systems used had minimal effects on the surface roughness and the color change of the new and aged tested composites.

Keywords: Bleaching; composite resin; color; surface roughness

Özet

Amaç: Bu çalışmanın amacı, %35'lik hidrojen peroksit ve %16'lık karbamid peroksit ajanlarının yeni ve yaşlandırılmış mikrohibrit kompozitlerin yüzey pürüzlülüğü ve renk değişimleri üzerine etkilerinin incelenmesidir.

Gereç ve yöntem: Çalışmada, 120 adet örnek teflon kalıp yardımıyla hazırlandı. Örnekler, 600 ve 1200 gritlik silikon karbid zımpara kağıtları ile zımparalanıp 24 saat distile suda bekletildi. Daha sonra örnekler, termosiklus döngü süreleri 1000 ve 10000 olacak şekilde 2 ana gruba ayrıldı. Termosiklus döngüleri sonrasında, örneklerin spektrofotometre ile başlangıç renk ölçümleri ve profilometre ile yüzey pürüzlülükleri ölçüldü. Daha sonra örnekler, uygulanacak yüzey işlemlerine göre 3 alt gruba ayrıldı (distile su (kontrol), %16CP ve %35HP). CP beyazlatma ajanı, 2 hafta boyunca günde 4 saat uygulanırken; HP beyazlatma ajanı haftada 45 dakika olacak şekilde 2 hafta uygulandı. Uygulamalar sonrasında, renk değişimi (ΔE1) ve yüzey pürüzlülüğü ölçümleri yapıldı. Beyazlatma işlemi sonrasında, her alt grup Sof-Lex diskler ile cilalanıp cilalanmaması yönünden tekrar 2 alt gruba ayrıldı. Cilalanan ve cilalanmayan örnekler, 1 hafta boyunca, 5 ml kahve solüsyonu içeren kaplar içinde oda sıcaklığında bekletildi. Daha sonra, ikinci renk değişim ölçümleri yapıldı (ΔE2).

Bulgular: Yeni kompozit grubu içinde, beyazlatma alt grupları ve kontrol alt grubu arasında yüzey pürüzlülüğü yönünden anlamlı fark gözlenirken, yaşlandırılmış kompozit grubu içindeki alt gruplar arasında fark görülmemiştir. Yeni ve yaşlandırılmış kompozit grupları içinde beyazlatma ajanı uygulanan alt gruplar ile kontrol alt grupları karşılaştırıldığında aralarında yüzey pürüzlülüğü yönünden fark gözlenmedi. Renk değişim değerleri karşılaştırıldığında (ΔE1), yaşlandırılmış kompozit grubu istatistiksel olarak yeni kompozit grubundan yüksek değerler göstermiştir. Renk değişim farkı, yeni ve yaşlandırılmış kompozit gruplarında, beyazlatma alt grupları ile kontrol alt grupları arasında anlamlı bulunmamıştır.

Sonuç: Çalışmada, yeni ve yaşlandırılmış kompozit materyalleri üzerine her iki beyazlatma sisteminin yüzey pürüzlülüğü ve renk değişimi açısından etkisinin az miktarda olduğu görülmüştür.

Anahtar Kelimeler: beyazlatma; kompozit; renk; yüzey pürüzlülüğü

1. THE AIM OF THE STUDY

The aesthetic appearance of a person’s smile is influenced largely by the shape, color, and position of the teeth. Correction of discolored, malformed, crooked teeth often results in improved confidence, personality, and social life (1). Discolored teeth can be esthetically treated with bleaching, microabrasion, macroabrasion, veneering, and placement of porcelain crowns (2).

Due to advantages such as the availability of materials, low cost, high safety, and low post-treatment side effects, bleaching is very welcomed and is widely used in cosmetic dental treatment. There are two main categories of in-office and at-home bleaching treatments. In at-home method, the materials are prescribed by a dentist and used by the patient at home inside a tray mainly containing hydrogen peroxide (up to 10%) and carbamide peroxide (up to 16% or more concentration). While in in-office bleaching treatment, materials containing high concentrations of hydrogen peroxide (30-35%) or carbamide peroxide (35%) are used only for professional use in an office environment (3,4).

Many people have restored teeth in the mouth. It is reported that about 40% of people have at least one restored tooth in their mouth (5). Moreover, composites which are tooth-colored materials have been welcomed by the public and are widely used in dental restoration (4). Frequently, teeth restored with esthetic materials are submitted to bleaching, which may cause an alteration in the restorative material, so that it no longer mimics the color of the tooth, making it one of the most frequent reasons for replacing restorations after bleaching (6).

Some patients with recently placed or patients with long-lasting direct composite restorations would seek teeth whitening after having such restorations. A question has arisen as to whether the effect of bleaching treatment by different bleaching agents and different concentration would be equal on new placed or aged composite resin restoration.

Although bleaching agents are frequently used, there is a disagreement about the effects of these products on restorative materials, particularly those that have already been in function for some time (8.9.10). Therefore, the aim of this study was to evaluate the effect of home bleaching and office bleaching agents on surface roughness and color change in new and aged microhybrid composites.

2. INTRODUCTION

2.1. Aesthetic Concept in Dentistry

Aesthetic dentistry is concerned with the aesthetic appearance of teeth and entire lower face and lip. It is concerned with improving size, color, shape and alignment of teeth to enhance person smile and confidence. The name of aesthetic dentistry refers to the application of tooth-colored restoration in anterior and posterior regions with consideration of function during replacement of teeth substant (11). In addition to reconstruction of the chewing function by using conservative and prosthetic and endodontic, aesthetic dentistry has become recently the focus of attention for dentist and patient to have a smile that is authentic in whole facial Picture (12). With more demanding to attractive teeth, dentist nowadays must become more familiar with other dental disciplines like orthodontics, periodontics, restorative dentistryi and maxillofacial surgery (13).

Many years ago, an aesthetic revolution started in restorative dentistry. Before that time, functional restorations were the main goal of restorative dentistry. The esthetic dentistry revolution has been evolving and a lot of patients nowadays request that their dental restoration not only functions well, but they have the appearance of natural teeth (14).

Many techniques exist for dental aesthetics to improve color, shape, position, size, alignment and overall smile appearance. From porcelain veneers to tooth-colored filling, patients can select a variety of dental solutions to restore their smile. Aesthetic dental treatments can be performed to correct minor flaws in the smile to severe tooth discoloration and missing teeth. The following is some of the common aesthetic procedures (15).

- Bleaching: It is the most effective and conservative aesthetic procedure in dentistry for lightening the discolored teeth. It can be performed at the dentist's clinic or at home (16).

- Resin bonding: composite resins can be considered the most popular materials that have been used in esthetic restorative dentistry. Since their introducing in dentistry, evolution has made and it became the most commonly used filling material in restorative dentistry (17).

- Porcelain veneer: This allows for change of color, tooth shape and gives the illusion of change in tooth position. Variety of porcelains are existed and used to fabricate a veneer, which incorporates the optical properties of fluorescence and opalescence to maintain a natural tooth appearance. Bleaching teeth can sometimes be more acceptable than placing porcelain veneers. Certainly, it is more desirable to bleach when possible, thereby retaining natural tooth contour and avoiding tooth cutting when possible. However, the porcelain can provides excellent restorations with long-term optimum esthetics (14).

2.2. Composite Resins

Composite resins have been introduced into the field of restorative dentistry to minimize the drawbacks of the acrylic resins that replaced silicate cements in the 1940s. Due to their properties like aesthetic and adhesive technology, the composite has taken over the place of the amalgam (18).

Since their introduction, composite resins have gained popularity as restorative materials, particularly due to their aesthetic properties and reduction of sound tissue removal. Currently, composite resin is the first choice material to restore anterior and posterior teeth (19).

2.2.1. History

Silicate restorations during the first half of the twentieth century were the tooth-colored material of choice for cavity restorations. Acrylic resins replaced silicate restoration due to their tooth appearance, insoluble in oral fluids, and low cost. However, they have poor wear resistance and tendency to severe shrink during curing, thereby producing gaps that facilitate leakage (20).

In 1962, Raphael Bowen synthesized a new resin, a dimethacrylate (2,2-bis-[4 2-hydroxy-3-methacryloxypropyloxy-phenyl] propane, referred to as bis-GMA). Bis-GMA is a reaction product of bisphenol A and a glycidyl methacrylate. This type of resin largely overcome the problems of acrylic resin. Light-activated composite resins were reported by Michael Buonocore in 1970 and introduced by L.D. Caulk in 1971. This form allowed adequate working time as the setting time was under the control of the clinician. Composite resins have undergone continuous development, but they still remain similar to the original formulation by Bowen (21).

2.2.2. Composition and Structure

Modern composite materials consist of a number of components. The major components are the resin matrix, the inorganic particles, silane coupling agent, and other components that promote or modulate the polymerization reaction (22).

2.2.2.1.Resin Matrix

The monomer system can be viewed as the backbone of the composite resin system. Bis GMA (2,2-bis[4-(2-hydroxy-3-methacry yloxypropoxy) phenyl]propane) continues to be the most-used monomer for manufacturing present-day composites. Due to its chemical structure and its large molecular size, it shows lower polymerization shrinkage, more rapid hardening, and production of stronger and stiffer resins. Because of its high viscosity, it diluted by mixing with low viscosity monomers to attain a viscosity that is appropriate for incorporating fillers. The monomers commonly used as diluents are Ethyleneglycol dimethacrylate (EGDMA)Triethylene glycol dimethacrylate (TEGDMA), however, the dilution of BisGMA increase the polymerization shrinkage (23,24).

Urethan dimethacrylate resin has almost molecular weights similar to that of BisGMA but has minimal viscosity. It has been utilized alone or mixed with another monomer such as BisGMA and TEGDMA. The advantages of urethan dimethacrylate resin are its viscosity and greater flexibility that may enhance toughness (24,25).

2.2.2.2.Filler

Mixing of fillers with resin matrix improves highly the material properties, provided that filler particles are bonded to polymer matrix or otherwise it may weaken the resin. The size of filler particles incorporated in the resin matrix of commercial dental composites has continuously decreased over the years from the traditional to the nano-composite materials (26).

The size of filler particles incorporated in the resin matrix of commercial dental composites has continuously decreased over the years from the traditional to the nano-composite materials. Filler beside determining the mechanical properties of composite materials, it allows reduction in the monomer content and the polymerization shrinkage, optimizing wear, translucency, opalescence, radiopacity, as well as enhancing aesthetics and improving handling properties (26,27).

Filler particles are commonly manufactured by grinding or milling quartz or glasses to produce filler particles ranging in size from 0,1-100 µm. Pure silica found in several form, crystalline (crystobalite, tridymite, quartz) and noncrystalline glass. Because crystalline forms are stronger harder and difficult to polish, silicate glasses are most used. Filler compositions are modified by additions of lithium and Aluminum (Li, Al) to make the glasse easier to crush. Some glasses filler particles with heavy metal atoms are added to impart the radiopacity, like ytterbium fluoride, barium (Ba), strontium (Sr), zirconium (Zr), and zinc glasses (28,29).

Silica particles of colloidal size, 04 um are produced by apyrolytic or precipitation process where the silicon particles e.g. SiCl4 are burned in a oxygen and hydrogen environment to form macromolecule chains of SiO2 (30.31).

2.2.2.3.Silane Coupling Agent

Bonding the filler particle with matrix is attainable by using an organic silicon compound, or silane coupling agent. At both its ends there are reactive groups and is coated on the filler particle surface by the manufacturer before mixing with the oligomer. During polymerization, double bonds on the silane molecule also react with the polymer matrix. A bond between filler and matrix allows the distribution of stresses generated under function (32). Without a coupling agent, the strength of the cohesive mass is reduced, and the filler particles tend to be lost, or plucked from the surface (33).

2.2.2.4.Activator-Initiator System

2.2.2.4.1.Chemically Activated Resin

Chemically activated resins are supplied as two pastes, one composite paste contains an initiator which when attached by an amine molecule of an aromatic tertiary amine activator from the second paste divided to two active free radical molecules which able to start the polymerization reaction (34).

2.2.2.4.2.Light Activated Resin

This technology presents many advantages: [1] a single-paste system needing no mixing, [2] control the working time. The first light-activated systems were used UV light to initiate free radicals. Currently, the visible blue light UV have been replaced the UV light (35).

A photoinitiator is a molecule which can absorb light and generate a reactive species that can then initiate polymerization. Camphorquinone is an example of a photoinitiator that requires a co-initiator for an efficient polymerization process to occur. A co-initiator does not absorb light but interacts with an activated photoinitiator to produce a reactive species (35). Camphorquinone is most sensitive to visible light in the range of 460 to 480 nm (blue light) (34). There are four types of lamps that may be used to initiate the polymerization process, Light-emitting diode (LED) lamps, Quartz-tungsten-halogen (QTH) lamps, Plasma arc curing (PAC) lamps, and Argon laser lamps (20).

2.2.2.5.Inhibitor

Inhibitors like phenols,e.g.2,6-di-tert-butyl-methylphenol (BHT) and hydroquinone monomethylether (MEHQ) are added to the matrix resin in amounts of 200 to 1000 ppm in order to prevent the polymerisation during storage of the composite and to avoid uncontrolled photo polymerisation from the light of room during the preparation of the filling to use in the cavity (30).

2.2.2.6.Pigments

Inorganic oxide color pigments are added to composites in amounts of 0.001 to 0.05% to provide a range of standard shades for composite fillings (32). A mixture of different pigments (yellow, red, white, and black) are most commonly used to mimic the natural teeth color (30).

2.2.3. Properties of Composite Resins

2.2.3.1. Polymerization Shrinkage

The main drawback of utilizing the composite resin as a direct restoration is the polymerization shrinkage. It contracts by 2% to 5% by volume during setting. With high filler content, less shrinkage achieved. Polymerization shrinkage may cause marginal gaps, marginal staining, recurrent caries and promoting postoperative sensitivity (29). There are many techniques to overcome the shrinkage, some of them include using an intermediate layer of resin modified glass ionomer cement between dentin and filling restoration (36,37), and using the incremental placement technique of composite and introduce changes in chemistry and composition of composite (38).

2.2.3.2.Water Absorption

Composite in an aqueous environment can absorb water and elute unreacted monomers (39). The water intrusion in the dental material can lead to a deterioration of the physical/mechanical properties, decreasing the life of resin composites mainly by silane hydrolysis and microcrack formation (40). Excessive water uptake can promote breakdown causing a filler–matrix debonding (41). However, water entry may has beneficial effects regarding the expansion of the composite; compensating the polymerization shrinkage with improving marginal sealing and relaxation of the stresses set up within the matrix during shrinkage (42).

2.2.3.3. Surface Roughness and Wear

Over time, surface roughness develops in response to abrasion (as well as acid erosion) of composite surfaces. The toothbrushing and mastication are responsible to cause the surface roughness. Polishing composite resins at recall appointments can help to reduce surface roughness that has developed and to impart a smooth surface (43). Surface roughness is also positively correlated with staining of composites (44).

Wear defined as the unwanted removal of solid material from surface due to mechanical action (45). The amount and the mechanism of surface wear differ among the composite resins. Very small particles contained in microfilled resins result in an even wear pattern and thus retention of a smoother surface. During the wear, the combination of nanofillers around nanoclusters results in the removal of the very small nanofilled particles that are packed in the nanocluster surface, which results in an even pattern of wear and a smoother surface. Scanning electron micrographs (SEM) have demonstrated the removal of individual small nanofiller particles from larger zirconia-silica nanoclusters (46). In contrast, SEM of microhybrid resins show larger defects at the surface following wear, proposed to be due to the removal of larger individual particles that leave voids and a less even pattern of wear, resulting in a rougher surface than observed with microfilled and nanofilled composites (46).

2.2.3.4.Optical Properties

The color and translucency of the composite resins are affected by its shade, thickness background color, matrix composition, filler particle size and pigment additions (47). Opacity and translucency are considered as a vital characteristic of the composite resins (48). Four phenomena can be occuring when light interacts with translation substance like a tooth or aesthetic materials: [1] light transmission, [2] light reflection [3] diffuse light reflection at the surface, and [4] absorption and scattering of the light within the substance (49). The Inorganic filler is the main component of composite resins that significantly affect the translucency (48). Because the size of the nanoparticles filler between 5 and 100 are below the wavelengths (380–780 nm) of visible light nanofilled composites provide favorable translucency, polishability, and surface-gloss retention. The conventional hybrid composite has a reduction in translucency because it has a large particles size which mismatche with resin matrix in refractive index and scatters the light. Scattering means refraction or reflection of the light at the interface between resin matrix and particles or voids that might be contribute to low translucency. The amount of light scattering based on the surface area and dimension of the particles (52). It has been showed that opacifiers in composite resins can act as scattering centers and affect their translucency. Individual refractive index of the filler and resin matrix should be perfectly matched to obtain the translucency that is close to the tooth structure. For that reason, the refractive index is widely used for selecting the composite materials (53).

2.2.4.Classification of Composite Resins

2.2.4.1.Classification Based on the Size of Filler Particle

2.2.4.1.1.Traditional or Conventional Composite Resins

Traditional microfillers are produced by grinding and crushing large pieces of the materials into smaller particles. The particles are purely inorganic, usually have splinter shape. They mainly composite of quartz, glass, borosilicate or ceramic. Metal glasses also are added for radiopacity (54). This composite was widely used in the late 1960 and early 1970. Clinically they have poor wear resistance and color stability (54).

2.2.4.1.2.Microfilled Composite Resins

Microfilled composite resins contain 0.04 um pyrogenic silica particles in an organic matrix to obtain a filler content of 38% to 65%. To increase filler loading, the resin containing the colloidal silica may be pre-polymerized, ground into particle and incorporated as fillers (26). Filler load is lower in microfilled composite resins, and internal bonding between the matrix resin and the prepolymerized filler resin is weak, resulting in lower strength. This is an important consideration in stress-bearing areas. Also because its high resin content they absorb more water and decrease in long –term color stability. The very small particle sizes in microfilled resins, however, offer excellent esthetics with high polishability and a long-lasting surface gloss (55, 56).

2.2.4.1.3. Hybrid Composite Resins

These composites contain a mix of colloidal silica and ground glasess and constitute approximately 75 to 80% wt (54). The characteristic properties of these materials are summarized as availability of a wide range of colors and ability to mimic the dental structure, less curing shrinkage, low water absorption, excellent polishing and texturing properties, abrasion and wear very similar to that of tooth structures, similar thermal expansion coefficient to that of teeth, universal formulas for both the anterior and posterior sector, different degrees of opaqueness and translucency in different tones and fluorescence (57,58).

2.2.4.1.4. Nanocomposite Resins

Nanocomposite described by having nanoparticles with approximately 25 nm and nanoaggregates with around 75 nm. The filler particles are made from zirconium, silica or nanosilica. The filler loading of nanofiller (aggregates and nanoparticles) is up to 79,5% (59). Due to its smaller size particle, this restoration shows a better finish, high translucency and exhibit outstanding esthetics with high polishing retention (60). Also smaller particles size reduce the polymerization shrinkage, create less deflection of the cusp wall, and minimize the microfissures in the enamel edges (61). Because the particles are so small they do not reflect light. So they are accompanied by larger particles with diameter within visible light wavelengths in order to enhance their optical characteristic (61).

2.2.4.2. Classification According to the Manipulation Characteristics:

2.2.4.2.1.Flowable Composites

Flowable composites are released in 1990. They have been termed flowable due to their low viscosity and their capability to be syringed into the cavity with a needle tip. The lower viscosity comes from reducing the filler content or by addition of modified agents like surfactants to enhance the fluidity and avoid reducing in filler content that would highly reduce trhe mechanical properties and increase the shrinkage (62). Flowable composites can be useful to build up a cavity preps, to block out small undercuts and to use as an indirect or direct pulp capping (63).

2.2.3.2.2.Condensable Composites

These type of composite resins have a high level of filler. They have advantages of condensation (similar to silver amalgam), achieving a better contact point and production of occlusal anatomy. The physical and mechanical properties of these type of composites are like that of amalgam and better than that of hybrid composite (64). However, they have less aesthetic in anterior region and difficulty in adaption between two layers (65).

2.2.5. Indication and Requirement of Composite Resins:

Resin composites are the direct restorative materials that comply with the requirements of tooth conservation, durability, and excellent esthetics.

- used to treat tooth caries as well as to solve aesthetic problems like diastema, peg-shaped lateral incisors, misaligned teeth, and discoloration.
- To veneer metal crowns and bridges
- To build up cores(post core)
- Cementation of orthodontic brackets, Maryland bridges, and ceramic crowns, inlay, onlays and. laminates
- Pit and fissure sealant
- Esthetic laminates
- Repair of chipped porcelain restoration.

However, modern resin-based composites have many clinical negative effects that are still observed. These include marginal discrepancies (22,66), marginal, staining, white lines around the restoration, cusp fractures, debonding (67), microleakage (68), secondary caries, and postoperative sensitivity or pain. These are usually connected with the polymerization shrinkage stress (66,69).

Choosing a suitable resin-based composite for a restoration in modern dentistry requires balancing a large number of requirements. This requires functional properties, including enhanced longevity of the restoratives by excellent mechanical properties such as high strength, fracture toughness, surface hardness, optimized modulus of elasticity, low wear, low water sorption and solubility, low polymerization shrinkage, low fatigue and degradation, high radiopacity and a better detection of the material during removal of a composite restoration (27). At the same time, biological properties resembling a good biocompatibility (systemic and local), no postoperative pain or hypersensitivity, preservation of tooth integrity in terms of not causing fractures or cracks, as well as caries-inhibiting abilities are required. In addition, aesthetic considerations, such as good color matching and color stability (translucency, shades), optimum polishability, long-term surface gloss, absence of marginal or surface staining and a good long-term anatomical form should also be fulfilled (27).

2.2.6. Polishing

Maintenance the smooth surface of a restorative material is important to improve the esthetics appearance as well as reducing the plaque retention and stain formation. All resin-based composites should be polished after polymerization because rough, unpolished restorations increase the coefficient of friction and may increase the rate of wear (70). Composites can be polished by using one -step or two -step systems. These can involve using of silicon tips , rubber cup and polishing paste, Sof-Lex discs and liquid polisher (71) .

2.3. Color and Tooth Color

The color is all about the light. To see the color, the light is reflected from an object and stimulate the neural sensors in the eye’s retina to send a signal that is interpreted in the visual cortex of the brain. When a light beam contacts an object, the pigments inside can do one of the three things; [1] absorb all the colored beam and so produce the color black, [2] reflect all the light beams and produce white or selectively absorb or reflect different beams and produce some sort of color (72).

2.3.1. Dimensions of the Color

There are many color order systems described the color as being three-dimensional (73). In 1915 Albert Henry Munsell proposed a new system that bases the arrangement of color on three aspects: Hue, Chroma, and Value. This classification has been the most accepted and useful for understanding color in dentistry. This scheme is universally recognized as the basis for other color systems such as CIELAB (L,A,B,color space).

- Hue: the degree of mixture of the three primary colors, the name of the color, for example, red, yellow or blue.
- Chroma: the degree of color saturation; pure colors have a high chromaticity and week colors have a low chromaticity.
- Value: the degree of color brightness: the whiter the color is, the more value it has, and the darker the color is, the less value it has (72).

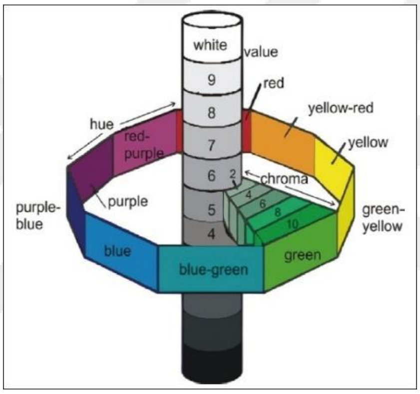

Figure 2.1: Three Color Dimension

2.3.2. Color Notation Systems

Various color notation systems have been used in dentistry. Historically, these include the Munsell hue-value-chroma (HVC) system and two formula developed by the International Commission on Illumination (Commission Intérnationale de l’Eclairage [CIE]), CIE 1931 (xyY) and CIE 1964 (XYZ). However, the most frequently used color notation system in dentistry is the CIELAB (CIE L*a*b* or CIE 1976) system (74).

2.3.3.CIE L*a*b* Color Space

In this system, which is now far more widely used than the 1931CIE system, the tristimulus values X,Y,Z of the sample are transformed into L, a and b coordinates as mutually perpendicular axes (Figure 2). In this three-dimensional color space, lightness is represented by L* on a scale of 0 for black to 100 for white. The hue and chroma of a sample are represented on an a* versus b* plot. a* is the red/green coordinate with +a* indicating red and -a* indicating green. b* is the yellow/blue coordinate, with +b* indicating yellow and -b* indicating blue (74).

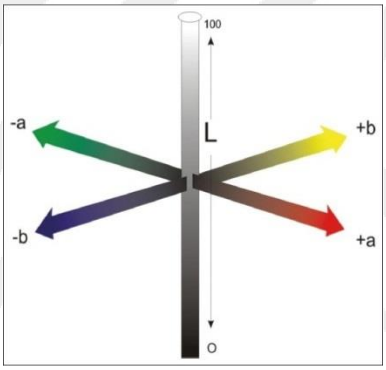

Figure 2.2: Representation of CIEL* a* b* Space

2.3.4.CIE L*a*b* Color Difference:

The CIE L*a*b* color space can be used to specify color differences via the equation: ΔE (L*a*b*) = [(ΔL*)2 + (Δa*)2 + (Δb*)2]0,5 where ΔL*, Δa* and Δb* represent the differences between the corresponding coordinates of two samples. According to this system, a color difference of one ΔE unit or greater is just perceivable (74).

2.3.5. Tooth Color

Teeth are made up of many colors, with a natural gradation from the darker gingival third to the lighter incisal third of the tooth. This variation is affected by the thickness and translucency of enamel and dentine, as well as by the reflectance of different colors. The color of teeth is primarily determined by the dentine but is influenced by the color, translucency and varying degrees of calcification of enamel as well as its thickness, which is notably greatest at the occlusal or incisal edge. The color of a tooth can be determined by a combination of its optical properties (75) where teeth color has been shown as a result of scattering of light (76).

2.4.Tooth Discolorations

In relation to the origin of the statin, tooth discoloration has been divided into intrinsic and extrinsic staining. Teeth staining are formed during tooth formation or after tooth eruption in enamel and dentin. (77). Preeruptive stains emerge because of tetracycline staining, hematologic. Disorder, dental fluorosis, and developmental defect (78).

Tetracycline staining is associated with systemic administration of tetracycline during tooth formation that leads to precipitation of tetracycline into dental hard tissue (79). The stain varies widely in their extent and coloration from light yellow to blue or Brown (73). It is divided into mild stain moderate stain and severs stain; mild stain can be light yellow, light brown, or light gray, moderate staining is more intense than mild stain, and sever intensive color with the horizontal color band. The sever type not respond to bleaching treatment (29).

Dental fluorosis is a subsurface hypomineralization result from excessive exposure to high fluoride concentration during enamel formation (80). It appears as white or brown patches of irregular shape. Staining due to fluoride appear in three different forms: simple fluorosis which manifests as a brown stain on enamel, opaque fluorosis that appear as grey or white spot, and fluorosis with pitted (81).

Developmental defects are connected with amelogenesis imperfecta, dentinogenesis imperfect and enamel hypoplasia. Discolorations due to developmental defects often become worse over time as the rough surfaces allow stains to accumulate more easily. Other factors such as nutritional deficiencies, hemolytic diseases before birth, ingestion of chemical local infection, trauma to the developed teeth, metabolic diseases, and other genetic factors can Adversely affect the ameloblast and cause enamel hypoplasia (78).Also local stain can be acquired after tooth eruption. The severity of the discoloration varies depending on the cause and may appear mild yellow-orange to very dark brown or black (78).

Extrinsic discoloration is caused by accoumulation of residues from food and beverages on the external tooth surface and cause brown, green and black stain. Also, industrial exposure to iron and silver may cause tooth staining.

2.5. Tooth Bleaching

Tooth bleaching is one of the most requested treatments by the patients. Teeth whitening with proper aligning are the main factors for a perfect smile. With increasing the popularity of bleaching materials, more bleaching agents are found in the market for either self-using or professional use (82).

Due to advantages such as the availability of materials, low cost, high safety, and low post-treatment side effects, bleaching is very welcomed and is widely used in cosmetic dental treatment. This procedure can be performed in the office by the dentist using high concentrations of hydrogen peroxide [HP] or can be applied by the patient at-home using low concentrations of carbamide or hydrogen peroxide (83).

2.5.1. History of Tooth Bleaching

Tooth whitening in dentistry has been practiced for many centuries. Based on Bwinelle 1850 (84) tooth whitening goes back to the period of Romans and Ancient Egyptian. Romans used urine because it contains ammonia, a cleaning agent now found in many household products. Egyptians used a paste of vinegar and pumice, combining the eroding effect of acetic acid with the abrasive effect of pumice.

Nonvital teeth bleaching started in 1848 with the use of chloride of lime (Dwinelle, 1850). Around that time, Truman introduced chlorine from a calcium hydroxide and acetic acid solution for bleaching nonvital teeth; this was supplied commercially as a liquid chloride of soda. Other agents are used in the 1800s for nonvital tooth bleaching such as aluminum chloride , oxalic acid, Pyrozone Generally. Most effective yet safe bleaching agents were direct oxidizers or an indirect oxidizer such as a chlorine derivative (34).

Vital tooth bleaching began in 1868, with using of oxalic acid or Pyrozone. In 1911 the using of high concentrated HP accompanied with heat and light was the most effective methods used in the office treatment (85).

Carbamide peroxide was used as an anti inflammatory antiseptic during the first world war. The lightning efficiency of carbamide peroxide was discovered by Dr. Klusmier (81) when he noted teeth brightness associated with using Glyoxide as mouthwash to help the healing of post–traumatic tissue. However, this technique was just accepted worldwide in 1989 when Haywood & Heyman used 10% carbamide peroxide in the custom fitted tray for night use (86).

2.5.2.Mechanism of Tooth Bleaching

Tooth whitening mechanism is clarified by chromophore theory which is based on the interaction of hydrogen peroxide with the organic chromophores inside the tooth structure. These organic chromophores are colored molecules that consist of either conjugated pi systems, such as aromatic compounds that have electron-rich areas (87). When the reactive oxygen species encounter stain molecules, they either alter the stain chains to simpler structures or alter the stain optical molecules and diminish the appearance of the stain. These reactions will also yield products that are both more polar and lower in molecular weight than the original stain molecule. Both of these properties will make the products easier to remove in an aqueous environment (88).The rate of decomposition and type of active oxygen specious formed are based on concentration and temperature of the peroxide as well as on the pH and the presence of metallic reaction (89).Many reactive oxygen species can be formed by decomposition of HP. Depending on which chemical bond breaks, hydrogen peroxide can give rise to a number of reactive oxygen species. These include hydroperoxyl radical the hydroxyl radical, hydroperoxyl radical anion, superoxide radical anion, and superoxide radical cation. (90).

However, studies using Raman spectroscopies and Fourier Transform Infra-Red (FTIR) failed to detect the chromophore or their products in the enamel. this result is inconsistent with the chromophore theory (91,92,93).

2.5.3. Composition of Commercial Bleaching Agents

Current whitening agents consist of an active and inactive ingredient. The active ingredient includes hydrogen peroxide or carbamide peroxide compounds.

The main inactive ingredients may consist of :

- Thickening agents: Carbopol is the most used agents.It raises the viscosity of the whitening agents for good retention of the gel in the tray. and also increases the releasing time of active oxygen.
- Carrier: Glycerin and propylene glycol can maintain moisture and dissolve other ingredients.
- The surfactant is the wetting agent which allow the active bleaching ingredient to diffuse.
- Methyl, propylparaben, and sodium benzoate are used as preservative substances. And prevent the growth of bacteria within the whitening materials.

  Flavoring used to enhance the taste (94).

2.5.4. Biocompatibility of Tooth Bleaching

2.5.4.1. Systemic Effects

The concerns from tooth whitening agents come from its peroxide compounds (reactive oxygen species) that are capable to induce many toxicities such as hydroxyl free radicals (95). It is believed that the mechanism of H2O2 toxicity makes damage in cells by reactive oxygen species. Cell culture studies revealed that H2O2 at the concentration from 1,7 to 19.7ug/mL is highly cytotoxic (96). However, in the human body various defense mechanisms at cellular and tissue level prevent any potential damage to cells during oxidative reactions also sustain any damage. Many enzymes like catalase and peroxidas that exist in the body fluids, organs and tissue can metabolize H2O2. The acute toxicity from H2O2 varies widely, depending on H2O2 concentration and application mode. Common symptoms of acute toxicity include chest and stomach pain, foaming at the mouth, gastric hemorrhage loss of consciousness and liver damage (95,97). Many critical reviews were conducted on the carcinogenicity of H2O2. Several investigators found no evidence of carcinogenicity of H2O2 or carbamide peroxide (98).

2.5.4.2. Effect on Oral Soft Tissues

When the bleaching gel directly comes into contact with soft tissue may cause chemical burns and produce gingival ulcers (99). HP also may change the periodontal tissue that can lead to gingival recession. The extent of these effects is proportional to the contact time and concentration of HP in the bleaching product (100). Prolonging contact with oral mucosa cause significant epithelial change and acute inflammation of the underlying connective tissue. Applying gingival barrier in office bleaching regime can prevent this negative impact (101).

2.5.4.2. Effect on Oral Hard Tissues

The reactive oxygen species producing during whitening process can rapidly reach pulp-dentin complex and cause change in the pulp condition by triggering the biological reaction (102). The penetration of HP in dental pulp results in the release of biochemical mediators involved in the inflammatory process, which sensitize the pulp nociceptors and play a role in pain modulation by causing an increase in vascular permeability and vasodilation. There are many factors that may influence the HP penetration ability and resultant damage. For instance, the size and depth of restoration have a significant effect on the amount of penetration and teeth with thinner enamel and dentin may allow faster passage of HP to the pulp (103).

There are some parameters that should be evaluated when applying in-office and at home bleaching. These parameters involve the following:{1} HP concentration {2} the contact time of bleaching gels with tooth surface {3} the need to reapplication of the product {4} the composition of the product (HP or CP) {5} combined use of in office and at home whitening techniques.

2.5.5.Types of Dental Bleaching Technique

2.5.5.1. In-office Bleaching

The material agent used is hydrogen peroxide (H_2O_2) which is a colorless liquid and has viscosity slightly higher than water with a molar mass of 34.01 g/mol. Because of its low molecular weight, it can penetrate dentin, where it releases oxygen and thereby breaks the double bonds of the organic and inorganic compounds inside the dentinal tubules. (104).

This type of bleaching is accompanied with using high concentration of HP that varies from 15 to 40 % (105). Office bleaching is indicated for attaining fast outcome or for the patient who may have trouble with the regimen of the home bleaching. In some cases, in-office bleaching is performed to motivate patients before starting an at-home protocol in the combined or jump-start technique (34).

In the dental market, there are many choices of in-office bleaching products, which may make their selection, quite hard. They differ in hydrogen peroxide concentration from 15% to 40% and also in their PH concentration. Additives like desensitizing agents, calcium gluconate may be added to some products (106).

2.5.5.1.1. Treatment Regimen

Before starting bleaching procedure, It is important to record the baseline color to monitör the color change during bleaching treatment. The degree of whitening result depends on the tooth baseline color, the darker baseline color is the more whitening results obtained. There is also a negative relationship between the age of the patient and whitening degree (107). Due to the high concentrations of hydrogen peroxide using in office bleaching, it is quite common to use a light-cured gingival barrier with lip and cheek retractors to avoid contact hydrogen peroxide with soft tissue (108).

It is important to follow the manufacturer's instructions after selection the whitening products. Renewing the bleaching gel is required for most of the in-office products. However, other products need an only single application for 40-50 minutes without replenishing. This may attribute to its alkaline PH which enable them to be used for long period of time without enhancing tooth sensitivity (109,110).

A recent clinical trial (Reis et al. 2011) (110) evaluated the impact of changing the bleaching protocol of a high-concentration (35 %) in-office bleaching product. Instead of performing three 15-min applications as suggested by the manufacturer, the product was kept for 45 min without replenishment. A reduction of the bleaching speed and increase in the TS intensity was observed, probably as a result of the slow but significant reduction of the pH of the product throughout the 45-min application.).

Within the office bleaching treatment, the dehydration from isolation contributes temporary in part of the bleaching effect. It is shown that the dehydration alone cause temporary color change which is almost the difference between A2 and B4 on vita classic shade guide (111). Beside the dehydration, low PH of the most bleaching products causes transient enamel demineralization. The majority of bleaching material has low PH because the storage of hydrogen peroxide needs usually add weak acids to prevent the solution from decomposition (112).

2.5.5.1.2. Effect of Heat and Light on In-office Bleaching

The rate of chemical reaction can be raised by increasing the temperature, where a 10 C rise can double rate of reaction (113). Abbot in 1918 reported that using of high- intensity light act by elevating the temperature of the bleaching materials and accelerating the rate of material decomposition (114). lamps like quartz–tungsten–halogen (QTH) lamps, plasma arc lamps, laser sources with a different wavelengths as well as light emitting diodes (LED) are proposed (115).

Many literature findings reported that there is no benefit of associating of light or heat with high concentrations of HP gels (116, 117, 118). However, randomized clinical trials showed a rapid whitening degree associated with low HP concentration (119, 120).

2.5.5.2. Home Bleaching

This technique is applied by the patient and supervised by the dentist. The technique involves the application of bleaching gel in a custom fitted tray for at least 2 weeks. Night–guard home bleaching basically requires use a low concentration of carbamide peroxide varies from 10 to 20 % (equal to 3,5 to 6,5 hydrogen peroxide). Using 10% carbamide peroxide for 8 hours and of 20% for 3 to 4 hours daily is recommended (121). The main adavantages of at home bleaching are its low cost, stability of posttreatment color and its efficiency (122). However, the major disadvantages are patient complain and longer treatment time (123). Carbamide peroxide has a good whitening result when used for mild yellow, brown or orange stains, fluorosis, tetracycline, and smokers stain. Highly dark blue-grey stains will not respond to the bleaching therapy (123).

2.5.5.2.1.Bleaching Material:

For at home whitening, carbamide peroxide in concentrations between 10 and 22 %, and hydrogen peroxide in concentrations from 4 to 8 % have been used for different periods of time (124,125). The study using systematic review and meta-analysis of at-home bleaching concluded that carbamide peroxide results in a slightly better lightening efficiency than hydrogen peroxide when applied in a custom-fitted tray (126). Chemically, carbamide peroxide is a crystalline materials consist of a molecule of urea complexed with a single hydrogen peroxide molecule. 10 % carbamide peroxide have about 3,3 to 3,5%hydrogen peroxide (127,75). There is a weak link between hydrogen peroxide and urea. When CP contact with water it release about 3.3-3.5 % hydrogen peroxide and urea which subsequently break down to carbon dioxide and ammonia (124). Some home whitening products have a carbopol to thicken carbamide peroxide to boost tooth adherence and make releasing of oxygen 2.5 times slower than non-carbopol containing products (124).

2.5.5.2.2.Treatment Regimen

Home bleaching gel in a custom fitted tray is considered the safest and more effective whitening methods. Wearing the tray with 10% carbamide peroxide for 8 hours overnights is the treatment of choice (128). Right diagnosis is essential before starting the home bleaching process. Full mouth examination and intraoral photograph are important to evaluate the color change. A clear 5 mm vacuum –formed mouth – guard is fabricated, it should be 5-1 mm shorter than free gingiva to prevent possible irritation yield from contacting the gel with soft tissue (129,130). It is suggested that wearing a tray on only one arch might improve patient’s compliance, as the patient can directly observe the color change in one arch compared to the arch that is not undergoing treatment. Additionally, the interocclusal thickness of both maxillary and mandibular trays may exacerbate TMJ disorder symptoms (131).

Besides at-home whitening with carbamide peroxide in a custom-fitted tray, there are currently other techniques that involve at-home whitening:

1-waiting–room whitening: in this technique, a dentist administer a high concentration of carbamide peroxide 35% in custom-fitted tray for periods from 30 minutes to one hour. The patient wears the tray while waiting in the dental office.

2- Jump start technique: In-office bleaching is performed first by a dental professional to provide an initial jump-start bleaching effect. Then, the patient is prescribed at-home whitening, usually 10–20 % carbamide peroxide gel for daily application, which is to be used until the desired shade is obtained. The aim of this technique is to enhance the bleaching effectiveness with in-office therapy to attain more esthetic result (132). However, this technique is not supported by a clinical evidence. Two recent clinical studies were conducted and reported that the whitening result of this technique was the same result of using the home procedure alone (133).

3- Over-the-counter (OTC) tooth-whitening products for home use without professional supervision. The active bleaching agent of that products is similar to normal bleaching agents that are either carbamide peroxide (10-18%) or hydrogen peroxide 1.5-14%. These products found in many forms like bleaching strips, varnishes, gels, paint on liquids, toothpastes and mouthwashes. However, using of these products without professional guidance raise the worry about potential adverse effects (134).

2.5.5.3.Intracoronal Bleaching

30% HP (superoxol) and sodium perborate are most used for intracoronal bleaching. There are two main techniques for bleaching the endodontically treated tooth named, the thermocatalytic technique and the walking bleach technique (135).

- Thermocatalytic Technique :

This technique involves placement of 30%–35% hydrogen peroxide in the pulp chamber followed by application of heat through electric heat device or special lump (136).

- Walking Bleach Technique :

In this technique, sodium perborate is mixed with water or HP without using heat. Instead of water can use saline or anesthetic solution (137).

Swift et al. (138), evaluated the effectiveness of two years tray whitening with carbamide peroxide. maxillary teeth of 29 patients were treated for 2 weeks with a 10 % carbamide peroxide gel. The result was that the teeth became eight shades lighter after two weeks of treatment when measured the color with Vita Classical 24 patients were recalled after two years. Teeth in 20 patients had darkened of two shades(83,3 %), during the first 6 weeks after treatment. The whitening result stayed statistically significant during two years. Overall, the patients were pleased with the shade.

Matis et al. (139), conducted in vivo study that evaluated eight in-office bleaching products with different hydrogen peroxide concentration ranging from 15 to 35%. The contact treatment time varied from 15 to 60 minutes. The color was evaluated at baseline, immediately after bleaching and after 1, 2, 4, and 6 weeks after treatment. The result showed changes in L and b parameters after the single in-office bleaching session. The color change in L and b parameters were much noticeable when measured immediately with a significant reduction in L and increase in b after one to two weeks of the procedure. It was concluded that the real bleaching effects can only be measurd after one to two weeks after finishing the bleaching treatments.

2.6. Aging of the Composite Resins

Oral environment is considered one of the hardest environments for industrial material. The existe of bacteria and their products, liquid and warms environment, excessive chewing forces, and changing of pH of the mouth are the main causes of many complexities. Composite restoration in the mouth has change with time during the clinical life. After polymerization of composite resin in the oral cavity, water molecules with some ions penetrat into the polymeric matrix and the monomers that have not reacted exit from composite. Withdrawing these materials, results in shrinkage and weight loss while water absorption increases the material weight. These processes can make change in the material properties like changing the material hardness (140). Tooth-colored resin restoration have been unable to keep the shade developed at the insertion time. Water sorption, stain accumulation, and the chemicals breakdown of unreacted component and are factors contributing" to color instability (140, 141).

2.7. Composite Color Stability

Color change of composite restoration is influenced by an intrinsic and extrinsic factores. The intrinsic factors include the resin matrix composition, percentage and type of filler particles, the photo-initiator and resin matrix-filler bond. The external factors include foods and physical stimulus such as light environment (142). Comphorquinone/amine is the most used photo-initiator that are incorporated into the composite resins in an amount of 0.1%- 1%. The yellow color of comphorquinon adds yellow color to the composite shade so adversely affects the aesthetics appearance of the composite restorations. However, decreasing its percentage minimize the degree of polymerization which lead to a increase water sorption, and lowering optimal mechanical properties. To control the undesirable effects of CQ, incorporate amine accelerator into composites; however, it can lead to darkening of composite resin over time. TEGDMA resin monomer is another component that affects the color stability, It has greater hydrophilicity than UDMA and BIS-GMA which cause higher water sorption **(**142).

Uchida H et al. (143), characterized the color changes in composites as a function of shade through environmental effects such as ultraviolet light exposure. Five shades of two composites were subjected to ultraviolet light exposure at 37° C for 24 hours after initial storage for 24 hours in distilled water at 37° C. The lightness and chromaticity values of color were measured both before and after ultraviolet light exposure with a Minolta Chromameter. It was shown that the lighter shades of composites were likely to be subject to higher color degradation through environmental effects of ultraviolet light exposure.

2.8. Color Measurement

Currently, there are many methods to evaluate the tooth color which range from visible subjective comparisons such as shad guides of acrylic resin or colored porcelain to objective instrumental measurement like colorimeter and spectrophotometers (76). The instrumental color analysis is an objective measurement and is rapidly obtained. It simulate that of the human eyes in using red, green and blue primaries (additives). The additive color mixing based on that when the light of the 3 primary colors (red, green and blue) are superimposed, produce white light color (144).

2.8.1.Colorimeters

Colorimeter is the first type of color measuring instruments and attempt to copy the process of human visual by using 3 light filters. The earlier colorimeters were used to visually compared the strength of two colored transparents solutions. Colorimeters is still used for measurements of transparent objects (transmission) and opaque objects (reflectance). In case of the reflectance, the important features of the colorimeter are light source which is reflected from the samples and passe through three or four filters and then are detected by photodetector (145).

2.8.2.Spectrophotometers

Spectrophotometer is the measurement of the amount of intensity of light at selected wavelenght. The significant advantage of spectrophotometric measurement is that it has the ability to analyze the principal components of a series of spectra and the ability to convert spectrophotometric measures to various color measures.

Spectophotometer measure the spectral reflectance or transmission of objects and it involve light source, monochromator and a photodetector. Many light sourcese can be used like tungsten halogen bulbs or xenon flash tubes either filtered or unfiltered. In case of measuring the color of an opaque sample, the reflectance of the sample is measured, typically in the range 380 to 760 nm, at distinct wavelengths (146,147).

3. MATERIALS AND METHODS

This study is a in vitro experimental study to evaluate the effect of different bleaching systems on light-cured microhybrid composite. It was conducted in the Hard Tissue Laboratory in the Faculty of Dentistry at the University of Yeditepe.

Table 3.1: showing the materials used in this study according to the manufactures, composition, the mode used, and the PH.

Material	***Mnufacture***	***Composition***	***Use mode***	***PH***
Microhybrid Filtek Z 250, shade A2	3M ESPE. USA	Resin matrix: Bis-GMA, UDMA, and Bis-EMA Filler: Zirconia/ silica (0,01-3.5um) Filler by volum 60%	Single increment 2mm thick	-
Whitness perfect, 16% (CP) carbamid peroxid	FGM products. Brazil	16%(CP),carbopol, glycol, water, potassium nitrate, sodium fluoride	4h Daily for 14 days	İnitial: 5.64 After4h: 6.11
Whitness PH, 35% (HP) hydrogen peroxide	FGM products. Brazil	35% (HP) ,thickner, dye, glycol, Load and distilled water	3 sessions every 7 days with 3 (15) minute application evey session	İnitial: 5.51 After 15 of use : 5.26

Figure 3.1: The composite and bleaching materials, 1: 35% hydrogen peroxide, 2: Thickener, 3: 16% carbamide peroxide, 4: Microhybrid Filtek Z 250, shade A2

3.1. Grouping the Samples

A total of 120 Filtek Z 250 resin composite specimens were prepared and divided into two groups; the first group: composite material (C1), which was further subdivided into 3 subgroups containing 20 specimens each (C1HB, C1OB, C1Control). The second group: composite material (C2), which was further subdivided into 3 subgroups containing 20 specimens each (C2HB, C2OB, C2Control). Group C1 was subjected to 1000 thermocycling, and group C2 was subjected to 10000 thermocycling.

As regarding the three subgroups, the first 20 specimens (C1OB, C2OB) were subjected to office bleaching, the second 20 specimens (C1HB, C2HB), were subjected to home bleaching and the third 20 specimens (C1Control, C2Control) with no bleaching. These three subgroups were further subdivided into two division; one division was subjected to polishing and the other was not polished (Figure 3.2)

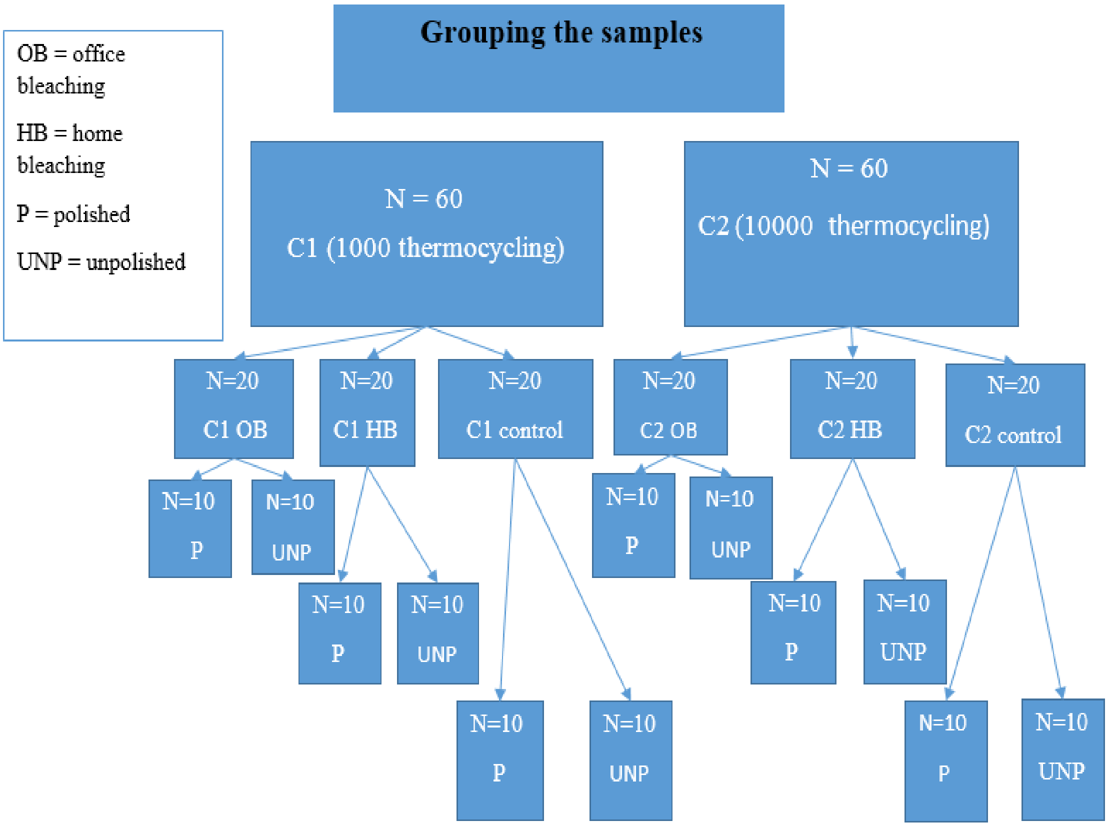

Figure 3.2: Grouping the samples

3.2. Preparation of the Specimens:

The 120 specimens were fabricated using a flexible mold (125 polyamid DIN) of a disc shape with a thickness of 2 mm and diameter of 10 mm (Figure 3.3 and 3.4). As regarding the method of specimen fabrication, the mold was positioned on the top of a clear transparent matrix strip and rested over a clean glass slide. The selected resin composite material was packed in a single increment into the mold by the aid of a composite insertion instrument. After application of the tested material in the mold, the top of the mold was covered by another transparent matrix strip to prevent the formation of an oxygen inhibition layer. Another glass slid was then placed over the transparent matrix strip, and a gentle pressure was applied in order to expel excessive resin material, and to create a flattened surface. Finally, the material was cured from both sides; top and bottom surfaces through the glass slaps with halogen based light curing unit (Optilux 501) for 40 minutes on both side (Figure 3,5). The distance between the light tip and specimen was standardized by the use of 1 mm glass slide. Specimens were then polished with a 600 and a 1200 grit silicon carbide papers for 30 seconds under running water, using a polishing machine (Phoenix Beta, Buehler, USA) (Figure 3.6). The fabricated specimens were incubated in a special container in distilled water at 37°C for 24 hours to ensure maximum polymerization. After storage for 24 hours, half the fabricated specimens (60 specimens) were thermocycled for 1000 cycles, the other half (60 specimens) was thermmocycled for 10000 cycles.

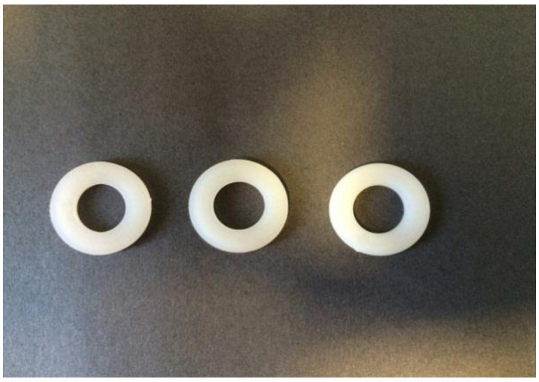

Figure 3.3: A flexible mold

(125 polyamid DIN)

Figure 3.4: The shape of the composite

samples

Figure 3.5: Tungsten halogen curing light unite (Optilux 501)

Figure 3.6: Polishing machine (Phoenix Beta, Buehler, USA)

3.3. Surfce Treatment of the Specimens:

All the procedures were conducted by the same operator according to the manufactures instructions, in the same laboratory under the same room conditions, including light, temperature and humidity.

3.3.1. Bleaching Agents Application

After aging, the 20 specimens of the main groups (C1 OB and C2 OB) were subjected to the bleaching treatments with hydrogen peroxide 35% gel (whitness PH). Peroxide and thickener were mixed 3 to 1 respectively. The gel was then applied on the top surface of the dry specimen to cover the whole surface for 15 minutes (Figure 3.7). After 15 minutes, the gel was removed by a soft cotton pellet and new bleaching agent was reapplied for another 15 minutes. The bleaching gel was applied to the surface of the specimen for three cycles of 15 minute each for two sessions according to manufacturer instruction. The specimens were rinsed with tap water for one minute, dried and stored in distilled water for the next session. The time interval between the two sessions was one week. The other 20 specimens (C1HB and C2HB) were subjected to the home bleaching agent, 16% Carbamid Beroxide (Whiteness Perfect FGM). The agent was applied on the top surface of the specimens for 4 hours every day for 14 days. After completing the treatment period, the specimens were rinsed for one minute, dried and stored in distilled water for the next application. The last 20 specimens of each half were stored in distilled water for 14 days without bleaching treatment. The distilled water was renewed every day. After that, half of each 20 group were polished with Sof-Lex pop-on system (3M Espe, St.Paul, MN, USA), fine, and superfine aluminum oxide discs (Al2O3) for 20 seconds for each disc, while the other half were kept without polishing.

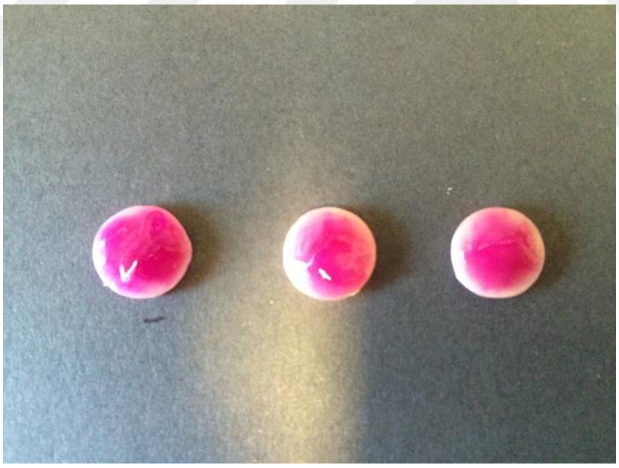

Figure 3.7: Application of the in-office bleaching material

(red gel) on the top surface of 3 specimens

3.3.2: Staining Procedure:

After bleaching procedure, each polished and unpolished specimen was immersed in vail (Figure 3.8) containing 5 ml of coffee solution for one week at room temperature, and the staining solution was renewed daily. For staining solution preparation, boiling 2 g of the coffee (Nescafe Classic) in 200 ml of boiled distilled water and then filtered and kept to cool at room temperature. At the end of the staining period, all specimens were washed with tap water and stored in distilled water at room temperature for 24 hours.

3.4.: Color Evaluation:

The color assessment was performed using Spectrophotometer CM– 2600D (Figure 3.8) which was calibrated before every session with a standard white card following manufacturer instruction. The spectrophotometer displayed the different color parameters (L.a.b) according to CIE color space system; L describe the luminance reflected, a and b describe the red-green and yellow-blue color coordinates respectively. For the color evaluation, all the specimens were blotted dry with tissue paper and then placed on the spectrophotometer. The L.a.b values of each specimen were measured after the thermocycling period as a baseline measurement. The change in the color from the baseline was calculated after subjecting the specimens to the office and home bleaching (ΔE1) according to the following formula: ΔE= [(ΔL)2+ (Δa)2+ (Δb)2]1/2 Also, the change in the color after staining in comparison to the color after bleaching (ΔE2) was calculated for each specimen by the same operator.

Figure 3.8: Spectrophotometer CM– 2600D

3.5. Surface Roughness Assessment:

The assessment of the surface roughness for all 120 specimens was done after the thermocycling as baseline measurements and after different surface bleaching treatment. The assessment was carried out with the profilometer (perthometer M1, Mahr, Germany) (Figure 3.9). The surface roughness parameter measured was Ra, which is the arithmetic mean deviation of the profile. It is important to highlight that smoother surface have lower Ra value and vice versa. Each specimen was measured with three random readings with traversing lengths and speed 1.75 mm, 0.5 mm/s respectively, and 0.25 mm Cutoff. The mean Ra value of the three readings in um for each specimen was recorded, and statistically analyzed.

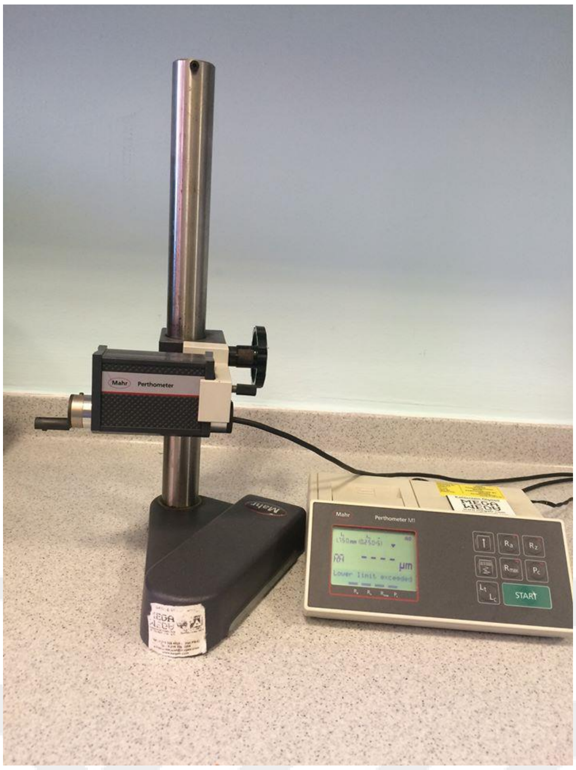

Figure 3.9: Surface Roughness tester (perthometer M1, Mahr, Germany)

4.1. Data Analysis:

All statistical analysis were performed with (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) program for Windows. Besides standard descriptive statistical calculations (mean and standard deviation), one way ANOVA was used in the comparison of groups, post Hoc Tukey multiple comparison test was utilized in the comparison of subgroups, unpaired t test was used in the comparison of two groups, paired t-test was employed in the assessment of Before and After treatment values. Statistical significance level was established at p<0,05.

4. RESULTS

4.2. Surface Roughness:

The surface roughness values of the experimental and control subgroups before and after bleaching in different thermocycling aging were calculated (Table 4.1).

Table 4.1: Mean (M) and Standard Deviation (SD) for the surface roughness values of the 1000 and 10000 thermocycling groups before and after bleaching

Surface Roughness		**1000 Thermocyling Group**	**10000 Thermocyling Group**
Office Bleaching	**Before**	0,077±0,018	0,083±0,017
	After	0,087±0,015	0,086±0,017
Home Bleaching	**Before**	0,070±0,012	0,102±0,029
	After	0,079±0,014	0,103±0,027
Control	**Before**	0,075±0,013	0,083±0,024
	After	0,082±0,013	0,085±0,021

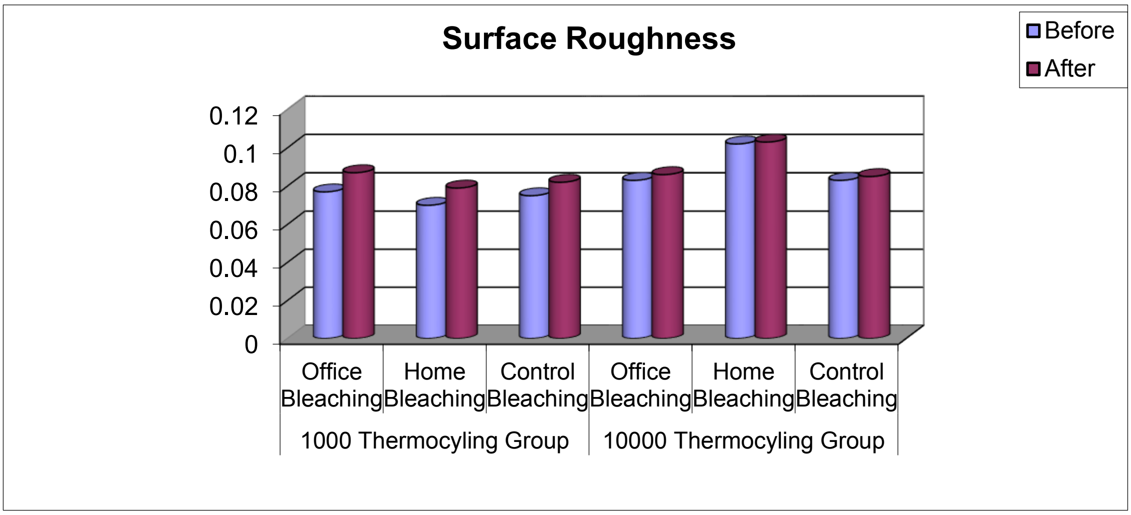

Figure 4.1: A bar chart showing the surface roughness mean values and standard deviations (SD) for the 1000 and 10000 thermocycling groups before and after bleaching procedures.

The statistical analyses of the effect of the home and in-office bleaching agents on the two aged thermocycling composite groups are presented in the (Table 4.2) and (Figure 4.2**)**. For 10000 thermocycling group; the p-value was insignificant in all the subgroups (home bleached, in-office bleached, and control subgroups). For the 1000 thermocycling group; there were significant differences in surface roughness values after exposure to the different bleaching agents. As regarding the control subgroup, there was a statistically significant difference in the average surface roughness value after storage.

Table 4.2 : Mean (M), Standard Deviation (SD), and P-value (*p*) for statistical evaluation of the surface roughness values of experimental and control subgroups before and after bleaching in different thermocycling groups.

Surface Roughness		**Before**	**After**	**p**
1000 Thermocycling Group	**Office Bleaching**	0,077±0,018	0,087±0,015	**0,016***
	Home Bleaching	0,070±0,012	0,079±0,014	**0,0001***
	Control	0,075±0,013	0,082±0,013	**0,006***
10000 Thermocycling Group	**Office Bleaching**	0,083±0,017	0,086±0,017	0,068
	Home Bleaching	0,102±0,029	0,103±0,027	0,548
	Control	0,083±0,024	0,085±0,021	0,785

*P-value p<0,05 is accepted as statistically significant.

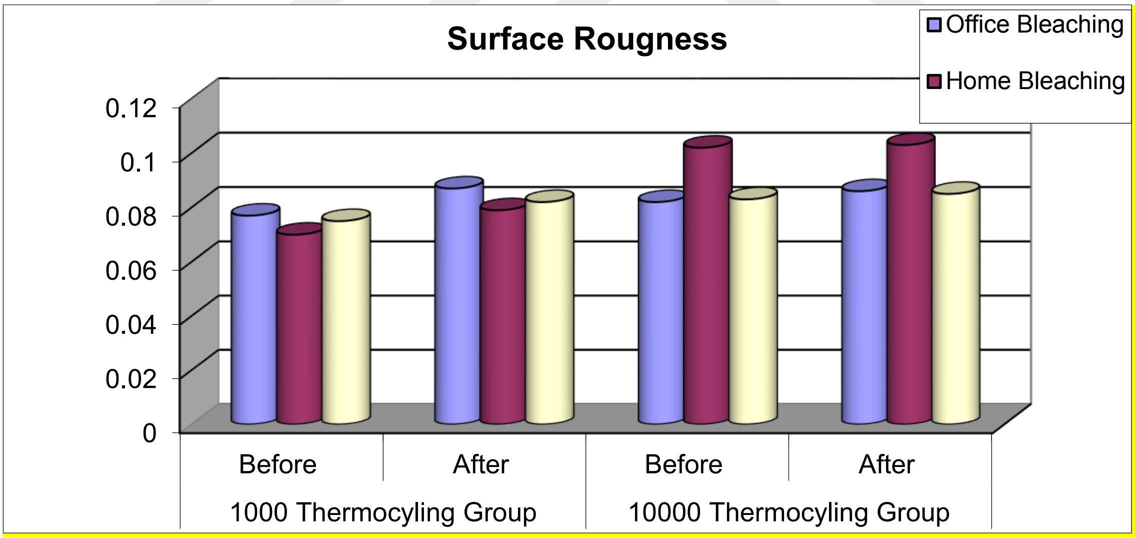

Figure 4.2: A bar chart showing the surface roughness mean values of the testing groups (office bleached, home bleached and control) at different thermocycling applications.

According to One-Way ANOVA Test, there were no statistically significant differences in the surface roughness mean values among the office bleached, the home bleached and the control subgroups for the two thermocycling groups (Table 4.3).

Table 4.3: One-Way ANOVA Test for comparsion between the surface roughnes mean values of control, home bleached and office bleached subgroups

Groups	**Offic bleaching**	**Home bleaching**	**Controls**	**P value**
1000 thermocycling	0.00965 ± 0.01632	0.00895±0.009064	0.00695±0.01013	0.7711
10000thermocycling	0.0031 ± 0 .007174	0.001395± 0.0102	0.0022 ± 0.0356	0.9698

*P-value p<0,05 is accepted as statistically significant.

4.3. Color Change:

4.3.1. Color Change after Bleaching:

The means (M) and standard deviations (SD) of the color variation (ΔE1) of the samples related to bleached and control subgroups of 1000 and 10000 thermocycling were calculated (Table 4.4) and (Figure 4.3).

Table 4.4: Mean values (M) and standard deviations (SD) of the samples' color variations (ΔE1) of the office bleached (OB), home bleachrd (HB) and control subgroups.

groups	**1000 thermocycling group**	**10000 thermocycling group**
Office bleaching	0,492±0,22	1,341±0,31
Home bleaching	0,727±0,42	1,260±0,26
Control	0,529±0,25	1,197±0,20

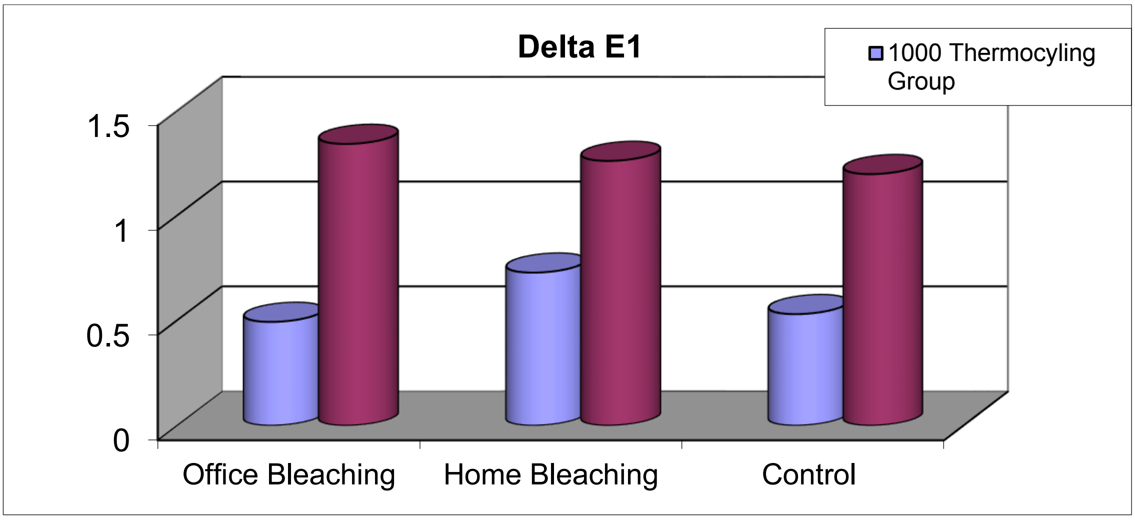

Figure 4.3: A bar chart showing the mean color variation (ΔE1) values of different bleached and control subgroups of the 1000 and 10000 thermocycling group.

According to ANOVA statistical test, the results related to the color change difference (ΔE1) mean values for bleached and control subgroups between the two thermocycling aged composite groups were statistically significant; as the means in the 10000 thermocycling group was higher (Table 4.5).

Table 4.5: Anova statistical test showing Mean (M), Standard Deviation (SD), and p value (*p*) for color change difference (ΔE1) values in the subgroups bleached (office, home) and control subgroups between 1000 thermocycling and 10000 thermocycling groups.

ΔE 1	**1000 Thermocyling Group**	**10000 Thermocyling Group**	**p**
Office Bleaching	0,492±0,22	1,341±0,31	**0,0001***
Home Bleaching	0,727±0,42	1,260±0,26	**0,001***
Control Bleaching	0,529±0,25	1,197±0,2	**0,001***

*P-value p<0,05 is accepted as statistically significant.

The color change (ΔE1) values differences between the office bleached, home bleached and control subgroups related to thermocycling groups were analyzed with One-Way ANOVA statistical test. As regarding the 10000 thermocycling group; there were no significant color change differences between the office and home bleaching and the control subgroups (Table 4.6).

As regarding the 1000 thermocycling group; there was a significant difference among the subgroups. So, Tukey Multiple Comparison Test was applied to determine which subgroups caused the difference. According to this test, the post-treatment color changes of home bleaching treatments was significantly higher than the office bleaching, whereas no significant differences were found between the two bleached groups and control subgroup.

Table 4.6: One-Way ANOVA statistical test showing Mean (M), Standard Deviation (SD), and p value (*p*) for the color change difference (ΔE1) values between the office bleaching, home bleaching and control subgroups related to thermocycling groups.

ΔE1	**Office Bleaching n:20**	**Home Bleaching n:20**	**Control n:20**	**p**
1000 Thermocyling Group	0,492±0,22	0,727±0,42	0,529±0,25	**0,042***
10000 Thermocyling Group	1,341±0,31	1,260±0,26	1,197±0,2	0,227

One-Way ANOVA

1000 Thermocyling Group	**p**
Office Bleaching / Home Bleaching	**0,049***
Office Bleaching / Control	0,924
Home Bleaching / Control	0,114

Tukey Multiple Comparison Test

4.3.2 Color Change Result after Staining

As regarding the polished and unpolished specimens, the means and standard deviations (SD) of color variation (ΔE2) values of the specimens after the staining period were calculated (Table 4.7) and (Figure 4.4).

Table 4.7: Mean values **(M),** and standard deviations (SD) of the samples' color variations (ΔE2) after staining period.

Groups	1000 thermocycling group	10000 thermocycling group
Office bleaching + unpolished	2,109±0,83	5,057±1,36
Office bleaching + polished	3,285±0,84	4,512±0,83
Home bleaching + unpolished	2,1±0,72	5,274±0,89
Home bleaching + polished	4,333±1,02	4,073±0,52
Control + unpolished	2,496±0,83	4,217±1,26
Control + polished	3,573±0,72	3,98±0,69

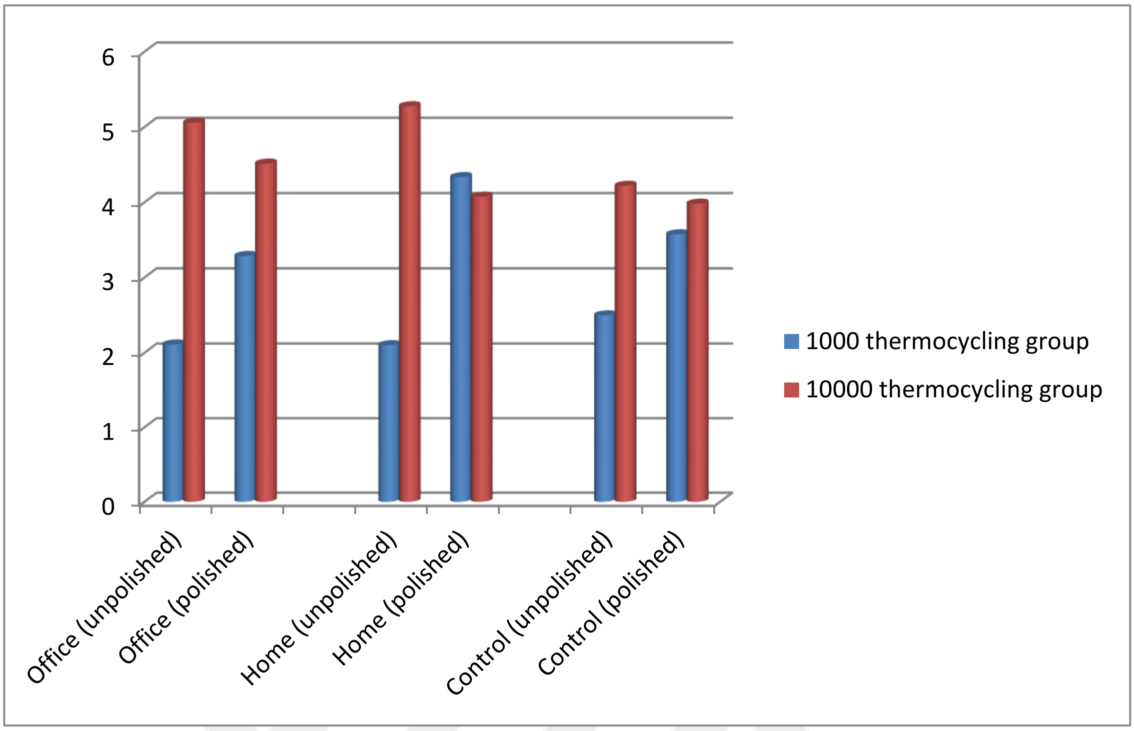

Figure 4.4: A bar chart showing the means of color variation (ΔE2) of the specimens in regards of being polished or unpolished after bleaching (home / office) and control subgroups at 1000 and 10000 thermocycling after the staining period.

In the office bleaching subgroup, both the polished and unpolished specimens for the 10000 thermocycling group showed statistically significant higher color changes (ΔE2) than the specimens for the 1000 thermocycling group after staining (Table 4.8). As regarding the home bleaching and control subgroups, there was a statistically significant difference between the main groups for the unpolished subgroups (Table 4.8).

Table 4.8: Mean values (M), standard deviations (SD) and p value (p) for color changes (ΔE2) of polished or unpolished samples of the subgroups after staining for each thermocycling groups.

ΔE2 after staining		**1000 Thermocyling Group**	**10000 Thermocyling Group**	**p**
Office Bleaching	**Polished**	3,285±0,84	4,512±0,83	**0,004***
	Unpolished	2,109±0,83	5,057±1,36	**0,0001***
Home Bleaching	**Polished**	4,333±1,02	4,073±0,52	0,483
	Unpolished	2,100±0,72	5,274±0,89	**0,0001***
Control	**Polished**	3,573±0,72	3,980±0,69	0,212
	Unpolished	2,496±0,83	4,217±1,26	**0,002***

*P-value p<0,05 is accepted as statistically significant.

In the 10000 thermocycling group, as regarding the difference between the office bleaching and home bleaching, and the control subgroups, there was no statistically significant difference in ΔE2 values between the bleached and control specimens after immersion in the coffee solution (Table 4.9).

In the 1000 thermocycling group, there was a significant difference among the subgroups for the polished group, so Tukey Multiple Comparison Test was applied to determine which group caused the difference. According to the test, there was a significant difference between the office and home bleaching subgroups (p=0,031 p < 0,05).

Table 4.9: one way anova test analysis and tukey multiple comparsion test showing Mean values (M), standard deviations (SD) and p value (p) for color changes (ΔE2) of experimental and control subgroups (polished or unpolished) related to thermocycling types.

ΔE2			**Office Bleaching**	**Home Bleaching**	**Control Bleaching**	**p**
1000 Thermocyling Group	**Polished**	**Stained**	3,285±0,84	4,333±1,02	3,573±0,72	**0,033***
	Unpolished	**Stained**	2,109±0,83	2,100±0,72	2,496±0,83	0,457
10000 Thermocyling Group	**Polished**	**Stained**	4,512±0,83	4,073±0,52	3,980±0,69	0,202
	Unpolished	**Stained**	5,057±1,36	5,274±0,89	4,217±1,26	0,13

One-Way ANOVA

1000 Thermocyling Polished Group	**p**
Office Bleaching / Home Bleaching	**0,031***
Office Bleaching / Control	0,742
Home Bleaching / Control	0,144

Tukey Multiple Comparison Test

The comparison evaluation of the polishing on the color susceptibility of the composite specimens for the 1000 thermocycling group revealed that there was the statistically significant difference between polished and unpolished specimens; where ΔE2 values in the unpolished specimens were significantly higher than that in the polished groups. On the other hand, for the 10000 thermocycling group; there was no significant difference between polished and unpolished specimens for office bleaching and control subgroups, however, there was the statistically significant difference for home bleaching subgroup (Table 4.10) and (Figure 4.5).

Table 4.10: Mean values (M), standard deviations (SD) and p value (p) for color changes (ΔE2) of polished and unpolished samples of experimental and control subgroups related to thermocycling aging.

			Polished	**Unpolished**	**p**
1000 Thermocyling Group	**Office Bleaching**	**Staining**	3,285±0,84	2,109±0,83	**0,006***
	Home Bleaching	**Staining**	4,333±1,02	2,1±0,72	**0,0001***
	Control	**Staining**	3,573±0,72	2,496±0,83	**0,006***
10000 Thermocyling Group	**Office Bleaching**	**Staining**	4,512±0,83	5,057±1,36	0,292
	Home Bleaching	**Staining**	4,073±0,52	5,274±0,89	**0,002***
	Control	**Staining**	3,98±0,69	4,217±1,26	0,608

*P-value p<0,05 is accepted as statistically significant.

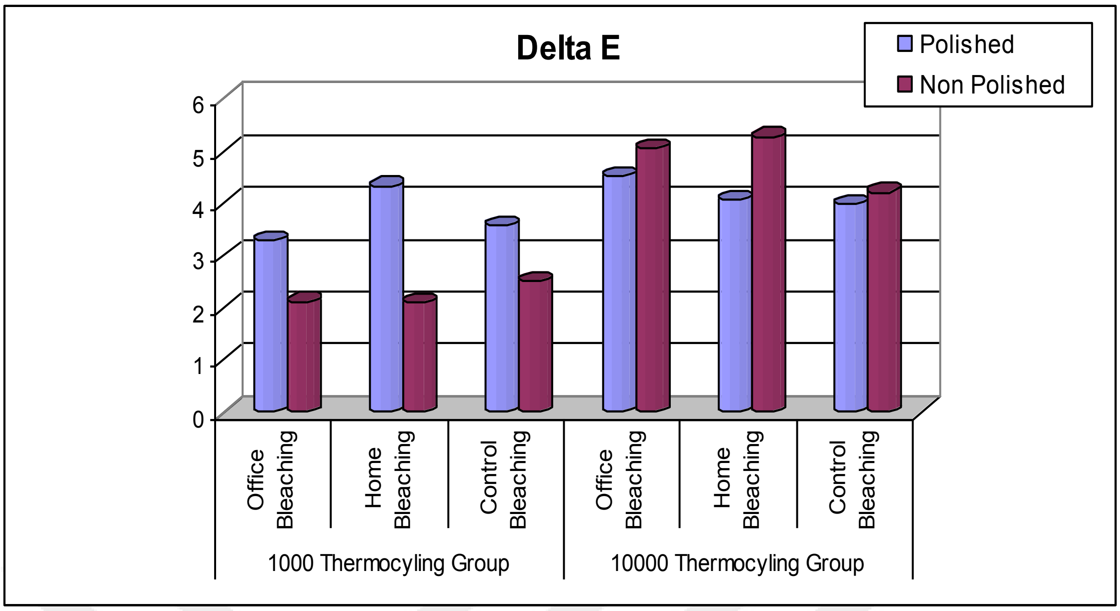

Figure 4.5: A bar chart showing the statistical evaluation of color changes (ΔE2) of polished and unpolished specimens of experimental and control groups related to thermocycling aging.

5. DISCUSSION

Over the past decade, the tooth-colored restorations have been under a remarkable change and became an indispensable part of the modern dentistry. Meanwhile, today “whiter teeth” is the most common aesthetic request from dental patients and tooth whitening is a relatively noninvasive approach to achieving this goal. The widespread popularity of tooth bleaching raised concerns about their effect on the aesthetic appearance of the tooth-colored restorations. (148, 149). Due to their organic matrix, the composite restorative materials tend to be subjected to chemical alterations compared to inert metal or ceramic restorations (150). It is possible that chemical softening resulting from bleaching application may affect the clinical durability of this material. For that reason, the effectivness of tooth bleaching materials on the aesthetic appearance of the resin composite material should be taken into consideration (151). Therefore, the aim of this study was to evaluate the influence of two different bleaching regimes on the surface roughness and color change of new and aged microhybrid composite.

Carbamide peroxide or hydrogen peroxide are used for effective bleaching therapy. The application of these agents is performed in the office by dentists or at home by patients, ultimately, resulting in high patient satisfaction (152,153). Two factors have been reported as keys to determine the whitening efficiency of bleaching agents: the application time and peroxide concentration (154,155). Therefore, In this study two different marketed tooth whitening agents are used with different hydrogen peroxide concentration (16% carbamide peroxide and 35% hydrogen peroxide).

It is known that composites undergo degradation in the oral environment. While in clinical service, several types of aging have been suggested to simulate situations to which restorative materials are subjected. The most frequently used aging protocols are thermocycling, immersion in liquid media such as ethanol or water, brushing simulation, and light aging (156,157). Thermocycling is an experimental process in which thermal conditions are simulated very similar to the real oral conditions such as thermal stresses created in the teeth and in the dental material during the treatment (158). Many studies were conducted to examine the association between physiological aging and number of cycles in thermocycling process (159,160). Gale and Dravel (161) suggested that 10000 thermocycling is equivalent to one year of aging. Stewardson et al. (162) proposed that 500 cycles, corresponds to less than 2 months in the mouth. It is proposed that on the basis that such cycles might occur between 20 and 50 times in a day, 10 000 cycles might represent a service year (163). In this study 1000 and 10000 thermocycling was used for aging the tested microhybroid composite.

5.1. Surface Roughness

The surface roughness of restorative materials is an important characteristic of the aesthetic appearance. When the restoration is properly polished, the plaque retention will be lower and the aesthetic appearance and the longevity of the restoration become betters (164). Any softening of the chemical process resulting from the bleaching process might have implications on the clinical durability of tooth restoration. Thus, surface roughness is an important factor to consider, while examing the effect of bleaching materials (165).

Many methods have been used to characterize the surface roughness. These included atomic force microscopy, contact stylus tracing profilometry, scanning electron microscopy, and non-contact profilometry (166). In this study surface roughness of the composite specimens was determined by mechanical profilometry. Surface roughness (Ra) is the mathematics mean height of the surface roughness irregularities along the traverse length (167). In the present study, surface roughness was measured after thermocycling and after the bleaching sessions.

Time application of bleaching materials on the surface of composite resin showed different outcomes in every study. Some studies preferred exaggerated time application while others preferred clinical application time (168). The bleaching material application time in this study followed the instruction of the manufacturer, 4 hours for two weeks for home bleaching and three sessions of 15 minutes with one week interval for office bleaching treatment.

The effectiveness of bleaching materials on surface roughness of restorative materials is controversial. A slight change in the roughness of hybrid materials after office bleaching therapy (169) and microscopic cracks formation on the surface of the composite (170) have been reported. Bleaching agents may change the surface morphology, as well as the chemical and physical properties of the composite resin. Hydrogen peroxide with their oxidation and reduction ability may cause softening of composite surface, and free radicals induced by peroxide may affect the resin-filler interface and result in the deponding (171) which causes microscopic cracks formation and, subsequently, increases surface roughness (8). Bleaching agent may mainly affect on resin matrix, whereas the inorganic particles may be still inert even in a highly acidic environment (151).

The results obtained from this study showed that both the bleaching materials, home bleaching agent 16% carbamide peroxide and office bleaching 35% hydrogen peroxide had a minimal effect on the new and aged composite groups and did not show any significant change in the surface roughness when compared with the control groups.

The results also showed that the difference between prebleach and postbleach surface roughness for 10000 thermocycling composite group was not significant and almost negligible. On the contrary, for the 1000 thermocycling group, there were significant increases in surface roughness mean values, however, the control group had a mean increase in surface roughness that was almost near or greater than those of the bleached groups. Therefore, this increase in surface roughness may not be clinically significant. Increase in surface roughness of the control group may be considered as a normal variation that may result from profilometer probe placement, which is difficult to be placed exactly the same location every time, this may cause measurement variation, and may result in the decrease or increase in surface roughness (172). Although the mechanical profilometry is common in detecting surface roughness, measurement variation can be considered as a limitation of this method.

In investigating the effect of home bleaching (carbamide peroxide) on composite restoration, the results of this study found to be in agreement with those of previous studies (173, 174, 175, 176). They concluded that there was no significant difference between the surface roughness of control groups and bleached groups after application of home bleaching agents. Baily and Swift (173) demonstrated that Proxigel and White and Brite bleaching, agents which contain 10% carbamide peroxide caused only slight changes to the surface of microfilled composite after an immersion period of 4 hours daily in fresh bleaching gel. Although it was noted that there are some softening in the surface of both hybrid and microfilled, this impact was low and not statistically significant. They also reported some areas of cracking on the surface of microfilled composites by using SEM micrographs, and suggested that the surface changes could have been caused by complex interactions within multicomponent bleaching products. Turker and Biskin (175) demonstrated the same result where they tested 10% and 16% carbamide peroxide on micorfilled composite and on feldspathic porcelain and modified glass ionomer and showed that composite was not affected by different carbamide peroxide concentration. Although there was no significant difference in surface roughness they showed extensive shallow pitted surface which suggested that the bleaching agent caused erosion on the composite matrix surface.

On the other hand, Gurgan et al.(177) evaluated the effects of 10% carbamide peroxide and 6.5% hydrogen peroxide strip band on surface roughness of three different tooth colored restoration, packable composite, flowable composite and ormocer. They showed that both bleaching systems increased the surface roughness of the tested materials. This contradicts the result of the present study. It may be attributed to different bleaching materials, different restorative material, and protocols used. Cooley and Burger (172) have demonstrated that after bleaching process the hardness and surface roughness of the composite restoration was increased. However, they also reported that all the composite control groups showed near or greater surface roughness changes than those changes of the bleached composite groups.

Various researches were performed to assess the effect of high peroxide concentration on the surface roughness of composite restorative materials (167.171.178). In the present study, the results are inconsistent with results of these studies. Wattanapayungkul (171) found small difference in surface roughness between control and bleached groups after application of 35% hydrogen peroxide. Silva et al (178) conducted an in situ study and showed that 35% hydrogen peroxide had no significant effect on the surface roughness of posterior composite. lansgsten et al. (167) examined the effects of 35% carbamide peroxide on the surface roughness of composite resin and reported that no significant changes in surface roughness were found for neither hybrid nor microfiled composite. However, the study of Morae et all.(179) contradicted the result in the present study; they examined the effect of 10% and 35% CP bleaching agents on the surface roughness of enamel, feldspathic porcelain, microfilled and microhybrid resin composites and they reported that 35% CP bleaching agent caused a significant surface roughness change on enamel, porcelain, and microhybrid composite. Microfilled resin composite samples showed no significant alteration. The difference between the result of our study and that study may attribute to use of higher carbamide peroxide concentration than that used in this study, as well as using different bleaching protocol. Dogan et al.(180) investigated the effect of three bleaching agents (Whiteness Perfect, Whiteness Super, Whiteness HP) on roughness of three dental resin composites (Admira, Durafill VS, Gradia Direct) and concluded that the unbleached control specimens showed more irregular areas compared with those of the bleached ones. Moreover, roughness values were decreased in bleached groups to some extent depending on the bleaching agents used.

In common, if the surface roughness of the composite resin is above 2 um, the plaque accumulation is high, which raises the risk of periodental inflammation and caries. Chung (181) reported that when Ra was lower than1um, the smooth surface were visible. For that reason, in this study, the surface roughness evaluated after bleaching therapy has shown a smooth surface.

The pH value of bleaching agent is important for clinicians, because it may adversely affect tooth structure and restoration. Also, the pH is important for the reaction rate in the bleaching process; as the higher the pH the more perhydroxyl free radicals produced. Price et al (182) measured the pH of 26 tooth bleaching products that available in the market and found that home bleaching products have a pH range from 5.61 to 7.37, while the pH range of in-office products was from 3,6 to 6.53. In this study the PH of in-office bleaching was 5.51 and carbamide peroxide was 5.64 which decomposes to hydrogen peroxide and urea. This constitutes is a strong base tha elevates the pH and, accordingly, produces strong free radicals.

5.2. Color Change:

The succession of an esthetic restoration depends on their color stability (183,184). It has been clear that the extrinsic and intrinsic environment play an important role in the color change of the aesthetic restoration. Intrinsic factors include chemical changes of the restoration due to oxidation of the monomer or catalysts and also due to water or many energy sources (185,186). Furthermore, the intrinsic color of aesthetic materials may change when the materials are aged under various physical chemical conditions, such as ultraviolet exposure thermal changes and humidity (197). The extrinsic factors involve staining of the restoration by absorption or adsorption of colorants due to exogenous sources such as tea, coffee and other staining beverages (188). The recent composite resins simulate the tooth color, therefore it is important to evaluate this property after tooth whitening therapy.

In this study the color evaluation was performed by using spectrophotometer that expresses the color coordinate in accordance with the CIE lab color system (189). The most color measuring devices used in dentistry utilize the ΔE from the Commission

International de I Eclairage CIE (L*a*b*) color system to detect color changes. In this study, the color is measured in three coordinate dimensions; L* represents lightness (from white to black), a* corresponds to the green-red axis (negative value indicates green, positive value indicates red), and b* corresponds to the blue yellow axis (negative value indicates blue, positive value indicates yellow) (190). In this study the color difference ΔE is expressed as a relative color change between successive color measurement. Color change (ΔE) value represents relative color changes that an observer might report for the materials after bleaching. Thus, ΔE is more meaningful than the individual L*, a* and b* values (151).

The interaction between the restorative material and bleaching agent is of clinical significance, because the color change may be observed by the patient. Some authors have reported that color difference ΔE more than 1 unit was considered visible by 50% of observers, and ΔE value greater or equal to 3.3 was considered as clinically unacceptable (151). In consideration, the composite groups in this study did not have a perceptible color change and none of the bleaching regimes resulted in color changes with ΔE ≥3.3.

The color change of the composite resin after whitening therapy can be affected by many factors, such as: properties of resin initiator and inhibitor, the properties of the chemical activator, polymerization activation process, quality of the polymer, type and quantity of filler particles, oxidation of unreacted carbon-carbon double bonds, and concentration of bleaching agents (151,191.192).

Many previous studies have shown controversial outcomes regarding the effectiveness of the bleaching agent on the color stability of tooth-colored restorations (151,192.,149,193 -198). In this study, after application of the two bleaching regimens on the tested composite, the results showed that the bleaching agents created slight color changes in the composite resin restorative materials with no clinically perceptible color change. This was observed in new and aged composite groups when comparing the bleached composite groups with its control groups.

Hydrogen peroxide is an aggressive oxidant capable of degrading the polymer matrix of resin-rich composite materials. It breaks down into water and oxygen, as well as free radicals resulting in oxidation of the pigments or amine compounds within the structure (195). In addition to its reactivity, hydrogen peroxide demonstrates an extensive ability for diffusion (199). Oxidation of the pigments may occur as a result of direct interaction with hydrogen peroxide on the resin surface (187). Peroxides might induce oxidative cleavage of polymer chains. Therefore, any unreacted double bonds are expected to be the most vulnerable parts of the polymers. Furthermore, free radicals induced by peroxides may impact the resin-filler interface, and cause filler-matrix debonding. Accordingly, microscopic cracks are formed, resulting in surface roughness and leading to diffusion of agents (200).

In the present study, The low discoloration rate of Filtek Z250 is probably related to its high inorganic content that provides this composite with a lower water sorption (201). Also, the resin composite used was tightly cross-linked with high-molecular-weight polymer molecules. This could be a reason why there was not much color change (202). The dissolution effects of the bleaching agent on the materials depend on the penetration depth of the bleaching agent into the restorative materials (203). If the restorative material is tightly cross-linked by high-molecular weight polymer molecules, the bleaching agent may need more time to diffuse through the link (204).

Comparing the effect of bleaching treatment on the color of the two aged composite groups, the different color behaviors could be found between the new and aged composite. The color change of the aged composite was higher than the new composite with a significant difference. This fact demonstrated that the action of the bleached agents was more effective on the aged composite. Clinically, the perceptible color change was observed in tested aged composite with ∆E mean value higher than1 unite. This may be related to the aging process. It is known that thermocycling process may create internal tensions in resin structure due to differences in the linear thermal expansion coefficient of the organic matrix and filler components, leading to degradation and possible surface microcracks (205,206). Moreover, water can, continuously, cause changes in optical properties of resin composite, as it might lead to degradation of the silane layer between the filler and organic matrix (207). In the same regards, and based on the available literatures, this is the first study to compare aging composite with new composite in relation to color.

According to the application of 16% carbamide peroxide, our results are in agreement with the results reported by previous studies. Hubbezoglu et al. (193) used three different bleaching agents; Whiteness Perfect (16% carbamide peroxide), Whiteness Super (37% carbamide peroxide) and 35% hydrogen peroxide, and demonstrated that there was no perceptible color change with a microhybrid composite resin. Monaghan et al. (195) evaluated the effect of two commercial composite resin after exposure to bleaching gels for 312 hours, they revealed that none of the tested bleaching agents made any significant clinical effect and all the color changes were less than 2 unit. Al Qahtan et al.(187) stated that after application of 10% carbamide peroxide the amount of color change was not visually detectable for microhybrid, nanofilled, and hybrid. Whereas, it was slightly noticeable for polyacidmodified resin-based composite. Furthermore, kime et al.(208) determined that the influence of tooth whitening was negligible for both nanofill and microhybrid composites. Moreover, Cany and Cerhreli (151) examined the effect of two different home bleaching agents (10% CP and 10% HP) on the color stability of different types of composite resin restorations after an 8 hours application for 14 consecutive days. This result showed that color change after bleaching with CP was not detectable whereas bleaching with 10% HP caused a clinically detectable color change for all the materials tested with ΔE higher than 3.3.

In contrast, other studies: (Madhukar Rao et al 2009, Q.Li et al 2009, and Kamangear et 2014) have found that the home bleaching agent is effective in composite color change. Madhukar Rao et al. (209) evaluated the whitening effect of carbamide peroxide at concentrations of 6%, 16% and 20% on the color stability of composite resin and have found a profound color change. Q.Li et al. (196) conducted in-vivo study to evaluate the effect of 15% CP on nanohybrid and pacable composite resin and showed a significant color change after bleaching agent application. Moreover, Kamangear et al. (210) studied the effect of 40% HP and 15% CP on the color change of 2 methacrylate based composite Z250 and Z350XT and concluded that ∆E color change for the composite resin tested was not in the clinically accepted range. These results are incompatible with the result of our study. This difference may attribute to the use of different types of composite resins, different bleaching brands and different CP concentrations.

In investigating the effect of hydrogen peroxide office bleaching, the result in the present study is in agreement with that of Hussain et al. (211) study. More specifically, they revealed that none of the bleaching systems notably changed the color of any of the composites tested after the bleaching application (∆E<2). A similar result was found by Hubbezoglu et al (193), who reported that color change in both microfill and microhybrid resins, after bleaching with 35% hydrogen peroxide for a total of 30 minutes. In contrast, Monaghan et al (198) found that in-office bleaching significantly affected the color of different composites; they reported ∆E values greater than 3.14 However, their bleaching protocol consisted of a pre-etching procedure using phosphoric acid, followed by four cycles (30 minutes each) of bleaching using 30% hydrogen peroxide along with infrared light activation. The procedure that they used is much more aggressive than those followed in the current study, which may explain the discrepancy between the findings. Moreover, Torres et al (2012) (212) tested the effectiveness of 20% and 35% hydrogen peroxide on different composite resins and observed that the greatest color change was for 35% hydrogen peroxide with a mean value of 3.4.

Furthermore, in the result of the present study; there was no significant difference between the two bleaching agents (HP, CP) for the aged composite, whereas there was a significant difference for the new composite, as the 16% CP bleaching agent caused more color change. This difference may be releated to the fact that the contact time between the resin surface and CP bleaching agent was much longer than that of the HP bleaching agent.

The staining susceptibility of many restorative materials has been widely investigated (183, 184, 213, 214), and the effect of bleaching material on the restoration has received attention. For that reason, the staining susceptibility of the composite material after bleaching has been investigated in this study. The staining solution used was the coffee, as it is a common consumption with the ability to stain dental restorations (201) .

Overall, the result of this study showed that the composite groups presented clinincal perceptible color alteration after being immersed in the coffee solution for 7 days. The result of this study also concluded that the bleaching treatment used had no significant impact on the staining susceptibility of the tested composite, where there was no sgnificant difference in color change ΔE values between bleached groups and control groups amongst the new and aged composite. Despite the conflicting results of other studies in regarding to the effect of bleaching agent on composite restorations, it has been documented that the surface degradation and surface roughness caused by bleaching therapy could make the surface more prone to staining (215,216). However, in this study, there was no significant change in surface roughness of the tested composite as a consequence of this there was no significant color change.

The result was also showed that both the bleached and control composite groups for the aged composite group had higher staining susceptibility than those for the new aged composite groups. This may be attributed to the aging process, where the thermocycling aging process caued the formation of microcracks through repeated sorption/desorption cycles, leading to hydrolytic degradation of the polymer (217). Eventually, this facilitates staining penetration and discoloration (142).

Another aspect that may have an influence on composite color stability, is polishing techniques (218, 219). Polishing is an important clinical procedure to attain smoother surface to reduce plaque retention, and staining susceptibility. It is known that smoother resin composite is more comfortable for the patient (187). Ther are several polishing systems; in this study, 3M soflex finishing discs were used to polish the specimens after bleaching treatment.

Studies have suggested that polished composite resin restorations exhibit better resistance to discoloration (220, 221, 222). For that reason, it is expected that the repolishing procedure after bleaching may decrease staining susceptibility. In contrary to the expectation, the effect of polishing on the color stability of the bleached composite specimens, in this study, was not significant. For the new group, the unpolished composite specimens had more color stability than polished groups. This result may be attributed to scratching of the composite resin during the polishing (219, 223) and the repolishing the soften resin matrix after bleaching agent application, that may increase the discoloration. On the contrary, in the aged composite group there was no significant difference between the polished and unpolished groups.

Based on the finding of this study the effect of polishing on discoloration of the tested composite resin is not consistent. This is in accordance with Imamura et al.(219) who demonstrated that the effect of polishing was not a strong influential factor in composite discoloration. Moreover, Hannig et al. (224) claimed that the deeper layer of composite are also affected and the subsurface layer is softening that explained that the repolishing after bleaching may not re-establising the physical properties of the composite material.

As a clinical implication, this may indicate that the polishing of new composite restorations after in-office bleaching and home bleaching may induce high rates of discoloration or color instability.

6. CONCLUSION

1- As the aging of composite resins increases, the surface roughness also increases.

2- In new composite resins, both home and office bleaching increase the surface roughness significantly.

3- For aged composites, no bleaching technique provides a statistically significant increase in surface roughness.

4- In the new composites, no bleaching technique showed a significant difference in terms of color change when compared to unbleached composites.

5- However, in new composites, the home bleaching technique causes statistically significant color change compared to the office bleaching technique.

6- In aged composites, it was observed that the color change was not dependent on the use of bleaching techniques or not.

7- If the new composites are polished after bleaching, polishing after the home bleaching application causes more coloration than the polishing after office bleaching.

8- In aged composites, polishing after bleaching did not make a significant difference in terms of coloring.

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8. CURRICULUM VITAE

I was born in Sebha - Libya on march the 12 th 1975. I completed my secondary education in Tanaway of banat School – Sebha - Libya in 1993. I joined Sebha University, Faculty of Dentistry in1994-1995. Then, I was awarded the degree of B.D.S in 2000. I completed one year of compulsory internship rotation work in all clinical departments of Dentistry in Sebha University from September 2000 till June 2001.Then, I was posted as a postgraduate student in the same faculty. And I was awarded a scholarship for a master degree in 2005. As regarding language skills, I attended many English courses. I also attended Turkish language courses at Tömer Center - Ankara University (TEMEL 4). On 2014, I got an accepted in a master degree program in Restorative dentistry in Yeditepe University Istanbul - Turkey.