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Evaluatıon Of The Effect Of Dıfferent Solutıons On Materıal Degradatıon

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ABSTRACT : Discoloration is still one of the major problems for the clinical success of the composite materials. The color stability affects the longevity of the composite resin restorations significantly. The aim of the study was to evaluate the impact of different staining solutions on the color stability of the resin composite materials. 72 composite disks were prepared as 8mm in diameter. These seventy-two samples were divided into 3 groups and they were immersed in 3 different solutions: coffee, tea and artificial saliva. The color parameters of the samples were measured and recorded before as well as 1, 2 and 4 weeks after immersion by spectrophotometry, using the CIELAB color space. A color change (ΔE) ≤ 3.3 was considered the acceptable threshold for visual perception. The results were analyzed using the one-way analysis of variance (ANOVA) ($p < 0.001$).

KEY WORDS: Extrinsic staining, discoloration, degradation,

I. INTRODUCTİON

Discoloration is a “trend subject” and there have been several articles within the last few years concerning with this matter.[1] The aims of this study were to evaluate the staining factors of different coloring drinks, and the staining susceptibility of the resin composites after polishing and immersion in these liquids. The results may help us to determine the staining of current composite resin materials and even if limited, as an in vivo indicator, it can be a distinct factor for the long-term clinical success.[2]

Changes in color can be affected by various etiologic factors; extrinsic discoloration can occur due to staining in the superficial layer of composite resin material, water absorption, surface roughness and etc. Intrinsic discoloration could occur as a result of physicomechanical phenomenon within the features of the resin matix and filler type of composite resin restorations. The structure of the resin matrix and characteristics of the filler particles directly affect the susceptibility to extrinsic staining.[3-4-5] The staining susceptibility may be determined by the nature of the matrix structure and also may be related with the dimension of the filler particles. The reaction in discoloration duration is accelerated by its conversion rate and its chemical characteristics, water sorption rate being particularly important. It is usually recommended that the composite fragments should be placed in 2 mm increments to acquire sufficient light transmittance and complete curing procedure of composite resins.[5] There is also an increasing possibility of air bubble inclusion or moisture contamination between fragments of resin composite restorations.[5-6]

Due to their good aesthetic features, resin composite materials are widely used in clinical procedures. Any aesthetic restorative material should duplicate the appearance of a natural color changes, and the success of an aesthetic restoration depends first on the color match and then on the color stability of the composite material.[7]

Discoloration can be examined visually. Instrumental techniques eliminate the subjective interpretation inherent in a visual comparison of color changes. Therefore, spectrophotometers and colorimeters are widely used to evaluate the color changes in restorative materials.[8]

Three types of discolorations are usually described as external discoloration due to the accumulation of plaque and stains on the surfaces, discoloration implying superficial deterioration or degradation and reaction of staining agents within the superficial layer of composite increments and intrinsic discoloration due to physicochemical phenomenons in the deeper part of the composite resin restoration.[9-10] Color changes of composite resin materials can be caused by intrinsic and extrinsic factors. Numerous studies *in vitro* have demonstrated that common drinks and food ingredients could cause discoloration in color of the surface. To make assessment with quantitative methods include the examinations of colorimetry or spectrophotometry.[11]

The first null hypothesis is that there is no difference in the color stability of composites after immersion in solutions. The second null hypothesis is that there is no difference in the measurements that calculated at the time of 1, 2 and 4 weeks.

II. MATERIAL METHOD

This was in vitro experimental study that was performed in the Marmara University, Faculty of Dentistry.

Sample Preparation : Seventy-two samples were prepared of each composite resin using a circular mold, 8 mm in diameter and 2 mm in height. The mold was placed on a glass slide and the composite material was applied into the mold. The samples were light-cured using the overlapping technique for 20 s on each side (40 s in total). Light- curing was performed using the LED light-curing unit (Valo, Ultradent, USA) at an intensity of 1000 mW/cm2. The tip of the light guide was put in contact with the glass slide during the light-curing process. The distance between the light source and the sample was standardized using a standard slide. Each sample was then attached to a thread and immersed in the respective solution. The samples were then placed in distilled water for 24 h to ensure complete polymerization. All samples were polished under a gentle stream of water using 1,000-, 1,500- and 2,000-grit abrasive papers to obtain a homogeneous polished surface and to eliminate possible contamination. This was done to minimize the color change due to the surface roughness of the samples and to ensure that the measured color change was due to the inherent properties of the composites. To ensure the uniformity of the surfaces of the samples at all stages, finishing and polishing were done by the same technician, with uniform pressure and the same number of movements; the final thickness of the disks after the completion of polymerization and polishing was 2 mm. A caliper was used to ensure a uniform thickness throughout the disks. The color parameters were then evaluated using the VITA Easyshade spectrophotometer. Using this device, the samples were studied in the CIELAB color space, and the 3 color parameters of L^* (brightness), a^* (red-green) and b^* (yellow-blue) were recorded as the baseline color parameters.

Immersion in Staining Solutions and Discoloration Process : The seventy two samples were randomly divided into three groups for immersion in 3 solutions (n=24) Each sample was completely immersed vertically in the respective solution using a piece of thread attached to it. The vertical position minimized the discoloration of the surface of the sample. The samples were immersed in the solutions in such a way so as to prevent them from touching each other. The samples were only in contact with the solution.

Preparing Staining Solutions : Coffee was prepared from 5 g of coffee (Nescafe) was added to 250 mL of water and removed before boiling (prepared according to the manufacturer's instructions); the solution was then filtered using a paper filter. Tea was prepared by tea bags (Earl Grey) were immersed in 250 mL of water of a temperature of 100°C for 60 s. Artificial saliva was prepared in the laboratory of the Dentistry Faculty of Yeditepe University, according to the standard procedure. The samples were exposed to these solutions during 4 weeks and 6 hours per a day as 168 hours totally. The solutions were prepared fresh daily. The samples were gently cleansed each time using water and a soft toothbrush for 60 s to remove any debris due to immersion, and were kept in artificial salvia during the intervals between immersions. The color parameters of the samples were measured at 1, 2 and 4 weeks after the start of the experiment using the VITA Easyshade spectrophotometer. The total ΔE of the samples was calculated according to the following formula shows $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$ where: L^* – lightness; a^* – red (+)/green (−) color coordinate; b^* – yellow (+)/blue (−) color coordinate.

Statistical Analysis : Following the normality analysis of data using Shapiro Wilk Test. The groups were compared one way analysis of variance. (p<0,001) SPSS 22,0 program was used for the analysis.

III. RESULTS

The one-way ANOVA showed that the results of the types of composite resins and the type of solution on discoloration were significant at all time determinants (p <0.001), but the interaction effect of these 2 variables (type of composite resins and type of solutions) on Δa^*, Δb^*, ΔL^*, and ΔE was not significant at the measurement done at 2nd week (p = 0.319), at 4th week (p = 0.170) or 8th week (p = 0.354). The determinants of this study showed that all the resins tested underwent discoloration in all agents, and that staining protocol increased over time. The lowest mean ΔE at the end of the study (8 weeks) was noted in Premise Flow following immersion in artificial saliva (ΔE = 2.25), whereas the highest mean ΔE was recorded for Vertise Flow following immersion in tea (ΔE = 27.24).

After 2 weeks of immersion, the one-way ANOVA showed that the interaction effect of the type of composite and the type of solution on color stability was not significant (p = 0.431), but the effects of the type of composite and the type of solution were significant (p <0.001). Tukey's test was used for the pairwise comparisons of the composite resins and showed that the difference between Vertise Flow and the 2 other composites was significant (p <0.001). There was no significant difference in the color stability of Filtek Z250 and Premise Flow (p = 0.949). The pairwise comparisons of the solutions showed that there was a significant difference between all solutions (p< 0.001), except for artificial saliva (p = 0.89).

The highest ΔE at the end of the 2nd week was related to the Vertise Flow composite following immersion in coffee and the slightest ΔE was noted in the Filtek Z250 composite following immersion in artificial saliva. After 4 weeks of immersion, the one-way ANOVA showed that the interaction effect of the type of composite and the type of solution was not significant (p = 0.170), but the effects of the type of composite and type of solution on color stability were significant (p < 0.001). There was no significant difference in this regard between Filtek Z250 and Premise Flow (p = 0.896). The results of the pairwise comparisons of the solutions in terms of the discoloration of different composites were similar to those obtained at 2 weeks. There was no significant difference between coffee and artificial saliva (p = 0.991), but significant differences were noted between the remaining solutions (p < 0.001).

At the end of the 4th week, the Vertise Flow composite in tea showed the highest discoloration and, as at the end of the 2nd week, the Filtek Z250 composite in artificial saliva showed the least ΔE. After 8 weeks of immersion, the two-way ANOVA revealed that the interaction effect of the type of com- posite and the type of solution on discoloration was not significant (p = 0.362), but the effects of the composite type and the type of solution on the discoloration of the composite resins were significant (p < 0.001). The results of the pairwise comparisons of the solutions in terms of the discoloration of different composites were similar to those obtained at 2 weeks. There was no significant difference between coffee and artificial saliva (p = 0.328), but significant differences were noted between the remaining solutions (p < 0.001). As noted earlier, the greatest ΔE was recorded for the Vertise Flow composite in tea and the slightest change was seen in the Premise Flow composite in artificial saliva.

IV. DISCUSSION

Rapid development of innovative restorative materials has met the rising need for esthetic dentistry. However, the success or failure of any esthetic restoration is determined on the discoloration of the restorative material, among other factors. Color changes in composite materials can be detected as a result of repeated contact with coloring foods consumed as part of the diet. Because of the rising esthetic demands of patients, discoloration of restorations is a big issue. Discoloration in composite resins varies based on numerous parameters, including filler particle size, polymerization depth, and coloring agents.[12-13] Numerous variables, including as inadequate polymerization, water absorption, food and beverage coloring properties, and surface roughness, have been shown in research to alter the color stability of composites.[14] Aside from the material components, other variables that influence the discoloration of composite resins include finishing and polishing techniques, and dental hygiene. Dental composite resins are widely used these days as esthetic restorative materials. However, the color change in composite restorations is one of the most common reasons for the replacement of these restorations. Color stability is a critical clinical property that affects the esthetic success and longevity of composite restorations. The color change can be considered as an indicator of aging or damage to restorations.[15]

A change in the color of composite restorations over time is a multifactorial process. The color stability of composite resins depends on the resin matrix, filler dimensions, polymerization type and duration, and color factor, and on biochemical variations in the resin fragments, such as the purity of monomers and oligomers, the type or concentration of the activator, initiator and inhibitor, and the oxidation of the carbon bonding. Studies have shown that physicochemical reactions, such as visible light radiation, ultraviolet radiation, temperature, and heat, can cause internal color variations in composites over time.[16] Composite resin materials are continuously exposed to saliva, foods and drinks.[16-17] These factors as well as oral hygiene and the smoothness of the surface can all affect the color stability of composite restorations. The aim of the present study was to assess the color stability of a self- adhesive composite resin after immersion in various solutions (coffee, tea, cola, and artificial saliva) as compared with conventional composites. Natural saliva has a protective effect. By creating a surface barrier, it prevents the staining of the teeth and dilutes staining solutions. In the present study, for the maximal simulation of clinical conditions, coffee, tea and artificial saliva were incubated at 37°C (oral temperature), and the samples immersed in cola were refrigerated at 4°C.

Simplifying the procedures involved in applying dental materials is useful to minimize errors and to save time. Recently, self-adhesive composites have been introduced to the market. Due to their acidic monomer composition, they bond to the dental structure without requiring an adhesive system. In this study, Vertise Flow, the first self-adhesive composite introduced to the market, was compared with other conventional composites. Vertise Flow has a glycerol phosphate dimethacrylate (GPDM) adhesive, which acts as a bonding agent.[17] This acid phosphate group is used for etching and chemical bonding to calcium ions in the tooth structure. Polishing may affect the quality of the composite surface, which means the polishing technique can also induce the color change of composite resins. In the present study, all samples were polished under the same conditions for the purpose of standardization. This was done to minimize the surface roughness and to ensure that the color change calculated at the end of the study was due to the inherent properties of the composite resins. The CIELAB color scheme was selected for color evaluation in this study, as it is a standard method for measuring color differences based on human perception. The assessment of composite discoloration can be done visually or using instruments. Instrumental techniques have the advantage of eliminating the subjective interpretations of the color change. According to previous studies, the ΔE values <1 are not recognizable by the human eye, which can detect $\Delta E > 1.25$–27 The ΔE values $1 < \Delta E < 3.3$ are clinically acceptable, whereas any $\Delta E > 3.3$ is not. The results of this study showed that the effects of the type of composite and the type of solution on color stability were significant ($p < 0.05$), but the interaction effect of these 2 factors on Δa^*, Δb^*, ΔL^*, and ΔE was not significant ($p > 0.05$). The ΔE value of a composite resin is especially important for anterior restorations. Composite resins decompose over time due to their polymer nature, which leads to their discoloration.

In the present study, the lowest ΔE value after 8 weeks of immersion was noted in Filtek Z250 in artificial saliva ($\Delta E = 1.02$), whereas the highest ΔE was noted in Vertise Flow in tea ($\Delta E = 35.42$). Also, significant differences were noted in the color stability of the composites in coffee and tea in comparison with other solutions ($p< 0.001$), and ΔE for coffee was significantly higher than that for tea and artificial saliva. At 2 weeks, ΔE for coffee was significantly higher than ΔE for the other 3 staining solutions. At 4 and 8 weeks, tea, coffee and artificial saliva caused discoloration in a descending order, and there were significant differences between the ΔE values for tea and coffee. All composites showed discoloration in all staining solutions, which increased over time. Composite discoloration is probably due to the external absorption of stains. Coffee and tea cause yellow stains with different polarization. The release of components of a higher polarity (tea) is greater over time. In the first 2 weeks, coffee caused greater discoloration, but at 4 and 8 weeks, the discoloration caused by tea was greater than that caused by other solutions. The discoloration caused by tea is due to the adsorption of polar colorants into the surface of composite resin materials and can be removed by tooth brushing, whereas the discoloration caused by coffee is due to both absorption and adsorption of polar colorants into the surface of the materials. The adsorption and penetration of colorants into the organic phase of the materials are probably due to the compatibility of the polymer phase with the yellow colorants of coffee.[18-19] Cola, despite having the lowest pH of the staining solutions tested, may possibly cause more degradation, but did not cause as much color change as coffee and tea did, probably due to the lack of yellow colorants in its composition.[19]

V. CONCLUSION

For more definitive results, the researches on this subject should be increased.

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