RESEARCH

Effect of Mouthwashes on the Color Stability of Artificial Gingival Materials Used in Implant Retained Hybrid Prostheses

Hatice Nalan Bozogullari(0000-0003-1370-5133)[α], Hande Citir Yucel(0000-0003-3440-6028)[α]

Selcuk Dent J, 2021; 8: 538-544(Doi: 10.15311/selcukdentj.949614)

Başvuru Tarihi: 08 Haziran 2021
Yayına Kabul Tarihi: 26 Temmuz 2021

ABSTRACT

Effect of Mouthwashes on the Color Stability of Artificial Gingival Materials Used in Implant Retained Hybrid Prostheses

Background: The aim of this *in vitro* study was to investigate the effect of different mouthwashes on the color stability of artificial gingiva materials that are used in implant retained hybrid prostheses.

Methods: The materials examined in terms of color stability are the gingival colored composite, pink heat polymerized acrylic resin and pink feldspathic porcelain. Forty disc-shaped (10×2 mm) samples were prepared according to the manufacturer's instructions (N=120). Samples of each material were divided into four subgroups (n=10) which immersed in three different mouthwash agents and distilled water (control group) for 14 days, at 37 °C. Color parameters were measured with a colorimeter before and after immersion and color differences were calculated according to the CIEDE2000 (ΔE_{00}) formula. The data were statistically analyzed with two-way analysis of variance (ANOVA) and Post Hoc Bonferroni tests ($p<0.05$).

Results: The effect of different mouthwashes on the color change of gingival materials was statistically significant and an increase in ΔE00 values was observed ($p<0.05$). The highest mean ΔE_{00} values were examined in composite gingival material for all mouthwash agents.

Conclusion: The color of gingival materials used in hybrid prostheses may be affected different levels by mouthwashes with different contents. A proper mouthwash choice for the gingival material is important.

KEYWORDS

Color stability, Gingival colored materials, Mouthwashes

ÖZ

İmplant Destekli Hibrit Protezlerde Kullanılan Yapay Dişeti Materyallerinin Renk Stabilitesi Üzerine Ağız Gargaralarının Etkisi

Amaç: Bu *in vitro* çalışmanın amacı, farklı içerikteki ağız gargaralarının implant destekli hibrit protezlerde kullanılan dişeti materyallerinin renk değişimine etkisini araştırmaktır.

Gereç ve Yöntemler: Renk stabilitesi açısından test edilen materyaller; dişeti renkli kompozit, ısı ile polimerize olan pembe akrilik resin ve pembe feldspatik porselendir. Her bir materyal için üretici talimatlarına uygun şekilde çapı 10 mm, kalınlığı 2 mm olacak şekilde kırk adet disk şeklinde örnek hazırlandı (N=120). Örnekler 3 farklı ağız gargarasında ve distile suda (kontrol grubu) 14 gün boyunca 37 °C de bekletme için 4 alt gruba ayrıldı. Renk ölçümleri solüsyonlarda bekletme öncesi ve sonrası kolorimetre ile yapıldı ve renk değişiklikleri CIEDE2000 (ΔE00) formülüne göre hesaplandı. Elde edilen veriler çift yönlü varyans analizi (ANOVA) ve Benferroni testleri ile değerlendirildi ($p<0.05$).

Bulgular: Farklı ağız gargaralarının, dişeti materyallerinin renk değişimindeki etkisi istatistiksel olarak önemlidir ve ΔE_{00} değerlerinde anlamlı bir artış gözlenmiştir ($p<0.05$). Tüm ağız gargaraları için en yüksek ortalama ΔE_{00} değerleri kompozit dişeti materyallerinde gözlemlenmiştir.

Sonuç: İmplant destekli hibrit protezlerde kullanılan dişeti materyallerinin rengi farklı içeriğe sahip ağız gargaralarından farklı seviyelerde etkilenebilmektedir. Kullanılan materyale uygun gargara seçimi önem arz etmektedir.

ANAHTAR KELİMELER

Ağız gargaraları, Dişeti materyalleri, Renk stabilitesi

The awareness and expectations of patients for dental aesthetics have increased in recent years. Therefore, rearrangement of aesthetics along with function in prosthetic treatments is important for patient satisfaction.[1]

Achieving optimal gingival aesthetics is an essential factor for implant retained restorations in cases of excessive alveolar bone resorption. In patients with severe vertical and horizontal hard and soft tissue loss and for who do not accept additional surgical operations, treatment with implant retained hybrid prostheses have become widespread. With this treatment approach, fixed prostheses with long crown lengths, that are not aesthetically pleasing, are prevented.[2,3] As well as gingival tissue reconstruction hybrid prostheses present aesthetically and functionally satisfactory results. Gingiva colored acrylic resin, flexible silicone based material, composite and feldspathic porcelain are used as the gingival material for implant retained hybrid prostheses.[4]

Color stability is a major property for the success of a dental restoration. To acquire a high level of esthetic quality, the gingival color is necessary.[5,6] Furthermore, ensuring color harmony in dental restorations and maintaining the harmony for a long time is essential for aesthetics, especially in the anterior region. In addition, the color stability gives an idea to the clinicians about the wear of the dental material.[7] The color of the restorative materials can be affected by

[α] Alanya Alaaddin Keykubat University Faculty of Dentistry, Department of Prosthodontics, Antalya, Turkey

different extrinsic and intrinsic factors. It has been reported that surface roughness, plaque accumulation, chemical degradation, beverages (drinking tea, coffee etc.) and mouthwashes can alter the optical properties of dental restorative materials.[8,9]

Chemical therapeutic agents are used for antimicrobial control in oral hygiene maintenance in addition to mechanical cleaning. Also, without any professional advice, many people prefer to use mouthwash due to the feeling of freshness and reducing halitosis.[10,11] Mouthwashes, that are available in the market, contain many components such as detergent, chlorhexidine gluconate, organic acids, dyes and ethanol. However it has been stated that mouthwashes cause color changes in teeth and restorations within the oral cavity.[12,13]

Calorimeters or spectrophotometer are used for color measurements to obtain precision, reliable and repeatable results. The colorimeter is a simple and inexpensive tool that measures color on the basis of three axes or stimuli using a filter that mimics the human eye. The spectrophotometer, which was developed to measure color through the reflection or transmission of an observed object, is a widely used instrument that records the color changes in restorative materials.[14]

In case of severe discoloration for gingival materials, the discoloration of the prostheses may not be removed by only polishing.[15,16] Therefore, the replacement of existing hybrid prosthesis may even be required. In order to avoid these problems, patients should be informed about the discoloration of the prosthesis due to mouthwashes and a mouthwash recommendation should be made according to the gingival material. Consequently, there is a requirement to evaluate the effect of mouthwash agents on artificial gingival materials used in hybrid prostheses.

The aim of the current study was to examine the effect of mouthwashes with different content, on the color stability of gingival colored materials such as gingival colored composite, pink porcelain and heat polymerized acrylic resin. The two hypotheses of the present study are: (i) the mouthwash agents would not affect the color stability of different gingival materials, (ii) different mouthwash agents have the same effect on the color stability.

MATERIALS AND METHODS

The three different gingival materials and three mouthwash agents were used in the present study. The properties of the studied materials were presented in Table 1.

Table 1.

Listing of gingival materials and mouthwash agents used in the present study

Material	Composition	pH	Manufacturer
Gradia Plus-Gum (Composite)	5-10 % TEGDMA, 1-5 % Bis-GMA, 1-5 % UDMA, ceramic filler	-	GC Europe, Belgium
Meliodent (Heat Polymerized Acrylic Resin)	Powder:Methyl methacrylate,Ethyl hexyl acrylate, N-octyl methacrylate Liquid: Methyl methacrylate, glycol dimethacrylate, dimethyl p-toluidine	-	Heraeus Kulzer, Germany
EX-3 Super Porcelain (Porcelain)	SiO_2 (65 %), CaO (< 1 %), K_2O (9 %), MgO (< 1%), Na2O (9 %), Li2O (< 1 %), Al2O3 (14 %),	-	Noritake, Kuraray, Japan
Farhex Forte	0.3 % Chlorhexidine Gluconate, Benzydamine hydrochloride	5.8	Angelini İlaç, Istanbul, Turkey
Listerine Cool Mint (Alcohol-containing mouthwash)	Thymol, methyl salicylate, eucalyptol, menthol, sorbitol solution, water, 30 % alcohol, benzoic acid, poloxamer 407, sodium saccharin, sodium benzoate, mint essence, green dye	3.7	Johnson & Johnson, Istanbul, Turkey
Colgate Plax (Alcohol-free)	Sodium fluoride, 21.6 % alcohol, glycerin, cetylpyridinium, chloride, water, propylene glycol, sorbitol, poloxamer 338, poloxamer 407, sodium saccharin, citric acid, sucralose, blue dye potassium, sorbate	5.05	Colgate Palmolive, Istanbul, Turkey

A total of 120 disc-shaped specimens, with 2 mm in thickness and 10 mm in diameter, were produced from three different gingival material (n=40).

The heat polymerized acrylic resin discs were fabricated for acrylic resin gingival material. The conventional lost-wax and flasking technique was used for the preparation of the samples according to the manufacturer's recommendations.

For composite groups, a teflon mold was used. After composite resin was filled into the mold, the cellulose strip band and a glass slide were inserted on it. Finger pressure was performed in order to allow excess composite material to escape and obtain a smooth surface. Then the composite discs were polymerized from both sides for 40 s using a LED light curing unit (Valo Cordless, Ultradent, USA). After the removal of the cellulose strip and the glass, samples were polymerized for another 20 s.

The samples of porcelain group were produced by mixing veneer porcelain powder with liquid and vibrated into mould according to the manufacturer's guidelines. The feldspathic pink porcelains were sintered in a porcelain furnace (TD, p200, Türkiye)

All of the specimens were stored in distilled water at 37° C for 24 h. They were polished with a SiC abrasive paper (360-grit and ending with 1200-grit) by an automatic grinder/polisher (Model AP 50; Leco, St Joseph, MI) for 30 s, under water cooling. After all, the samples were polished with universal polishing paste (Ivoclar Vivadent AG, Liechtenstein). The final

thickness of samples were measured with a digital caliper and cleaned ultrasonically in distilled water for 15 min.

Initially, the color values (L*, a*, b*) of all specimens were measured by colorimeter (Konica Minolta CR-321, Tokyo, Japan) for the baseline color according to the CIELAB system. L* shows the coordinates for lightness, ranging from 0 (black) to 100 (white), and a* and b* represents the coordinates for the red to green and yellow to blue axis.[17] Each measurement was repeated three times and the mean L_0*, a_0*, and b_0* values were recorded. Measurements were made under same conditions by a single operator. The colorimeter was recalibrated after the measurement of each group.

After determining the initial color, specimens of each group were divided into 4 subgroups (n=10) for the immersion process with three different mouthwash agents and distilled water (control group). The speciemens were immersed in 10 ml mouthwash agents for 14 day, 2 min. twice per day (12-hour interval between exposures).[18] One side of each disk was marked with a bur, thus always the same surface (unmarked) was measured for discoloration. After each immersion procedure, the disks were washed with running water and dried, then stored in distilled water at 37° C until next immersion. Specimen of control group were immersed in 10 ml distilled water.

Subsequent to the immersion procedure specimens were measured again with the same protocol as baseline measurements and the data were calculated as L1*, a1*, and b1*.

The color change of the specimens was calculated using the CIEDE2000 (ΔE_{00}) formula.[19]

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{K_L S_L}\right)^2 + \left(\frac{\Delta C'}{K_C S_C}\right)^2 + \left(\frac{\Delta H'}{K_H S_H}\right)^2 + R_T \left(\frac{\Delta C'}{K_C S_C}\right)\left(\frac{\Delta H'}{K_H S_H}\right)}$$

For this study the parametric factors of the CIEDE2000 color difference formula were set to 1. Likewise, the perceptibility threshold was set at $\Delta E_{00} \leq 1.30$ and clinical acceptability threshold was set at $\Delta E_{00} \leq 2.25$ units.[20]

The ΔE_{00} values were analyzed by two-way analysis of variance (ANOVA) to evaluate the effects of gingival colored materials, mouthwash agents and their interactions. The mean ΔE_{00} values were compared with the post-hoc Bonferroni tests. The SPSS 20.0 package program was used for the analysis of the data obtained in the study (IBM SPSS Statistics, NY, USA). A value of $p < 0.05$ was used as the criterion to evaluate the significance tests.

RESULTS

According to the two-way analysis of variance results (ANOVA) (Table 2), the types of gingival materials and mouthwash agents had a statistically significant influence on color change (ΔE_{00}) ($p<0.05$). The values of the mean color change (ΔE_{00}) ± standard deviation for the types of gingival materials and mouthwashes agents are listed in Table 3.

Table 2.

Two-way ANOVA results for ΔE_{00} values ($p<0.05$)

	Sum of Squares	df	Mean Square	F	Sig
Mouthwash	25.713	3	8.571	33.490	0.000
Material	28.044	2	14.022	54.790	0.000
Mouthwash×Material	3.018	6	0.503	1.966	0.077

Table 3.

Mean and standard deviations (SD) of the ΔE_{00} color change values obtained from gingival material specimens stratified by the type of mouthwash after immersion of 2 weeks

Mouthwash	Gingival Material		
	Composite	Acrylic	Porcelain
Distilled water	1.09 ± 0.49^{Aa}	0.62 ± 0.23^{Ba}	0.43 ± 0.15^{Ba}
Farhex Forte	2.90 ± 1.35^{Ab}	1.82 ± 1.47^{Bb}	1.20 ± 0.70^{Bb}
Listerine Cool Mint	1.99 ± 0.81^{Ac}	1.03 ± 0.82^{Bac}	0.78 ± 0.33^{Bab}
Colgate Plax	2.25 ± 1.15^{Abc}	1.77 ± 1.03^{Ab}	1.02 ± 0.46^{Bb}

Means followed by different superscript letters differ significantly, at the .05 confidence level. Upper case: significant differences between rows, lower case: significant differences between columns.

After immersion for 2 weeks in the distilled water or the mouthwash agents used in the current study, the highest mean ΔE_{00} was observed in composite gingival material (2.90±1.35), followed by acrylic (1.82±1.47) and porcelain material (1.20±0.70). The mouthwashes used in the study are listed in descending order in terms of discoloration potential: Farhex Forte, Colgate Plax, Listerine Cool Mint, distilled water.

Mean ΔE_{00} results for the gingival materials were lower than perceptibility threshold ($\Delta E_{00} \leq 1.30$) in distilled water for 2 weeks, which were within the clinically acceptable threshold ($\Delta E_{00} \leq 2.25$) after 2 week for all mouthwashes agents, except composite immersed in Farhex Forte.

In Farhex Forte, mean ΔE_{00} results for porcelain gingival material was lower than the perceptibility threshold after 2 weeks. Composite gingival material was showed higher ΔE_{00} value than the clinically acceptable threshold and ΔE_{00} value for acrylic material was higher than the perceptibility threshold.

The differences between composite and other gingival materials were statistically significant. No statistically significant difference was found between acrylic and porcelain.

Mean ΔE_{00} results for acrylic and porcelain materials were within the perceptibility threshold in Listerine Cool Mint. For composite, mean ΔE_{00} results was greater than the perceptibility threshold but lower than the clinically acceptable thresholds. The differences between composite and other gingival materials were statistically significant. No statistically significant difference was found between acrylic and porcelain.

For Colgate Plax, mean ΔE_{00} results for composite and acrylic gingival materials were greater than the perceptibility threshold, which were within the clinically acceptable threshold. Mean ΔE_{00} results for the porcelain was lower than the perceptibility thresholds after 2 weeks. The differences between porcelain and other gingival materials were statistically significant. No statistically significant difference was found between composite and acrylic.

DISCUSSION

The current in vitro study compared the color changes of gingival materials after storage in three different mouthwash agents for 2 weeks, which the distilled water used as a control solution. According to the results of this study, both hypotheses were rejected.

The discoloration of the prosthesis over time is the main reason for the renewal of the prosthesis.[21] Gingival restorations include pink heat polymerised or auto polymerised acrylic resins, composite resins, porcelains and thermoplastic acrylics for implant retained hybrid prosthesis.[5] Several intrinsic and extrinsic factors have been related to the color change of dental materials. Due to the formulations, mouthwashes have an effect on physical properties of dental materials which they are in contact. Previous studies have evaluated the color stability of tooth colored materials after storage in mouthwash agents.[1,22,23] There are limited studies[22,24] about the effect of different mouthwash agents on the color stability of gingival materials, and these are generally related to composite materials. On the other hand, a comprehensive literature review revealed that the color stability of gingival colored materials such as porcelain and acrylic resin has not yet been evaluated.

In accordance with the results of the present study, different mouthwash agents significantly affected the color stability of the tested gingival materials ($p<0.05$). The composite material showed more discolororation than the acrylic resin and the porcelain. Porcelain material was the material that preserved the color stability compared to the other materials.

The mouthwashes change the color of restorative materials, depending on the type of material.[25] Despite the homogeneous structure of acrylic and porcelain, the heterogeneous composition of the composite may be the reason for this. The superior physical properties of porcelains may influence the color stability compared to other gingival materials. Feldspathic porcelain contains grain and small particles that can reduce surface roughness and discoloration.[26]

The color stability of composite resins are related to the resin matrix structure, type, distribution and amount of filler, degree of polymerization, and water absorption. It has been reported that as the filler amount of the composite resin increases, resistance to discoloration of composite resin also increases. The performance of composites is affected by aqueous environments such as mouthwashes, as the voids at the filler-matrix interface of the composite increase water absorption.[27,28]

Furthermore, Mansouri et al.[29] reported that TEGDMA content negatively affects the color stability of composite resins, since TEGDMA can increase the water absorption of the composite resin and cause greater penetration of mouthwash and antiseptics into the composite resin structure. In the current study, the TEGDMA content of composite resin may also caused higher mean ΔE_{00} values. Additionaly, the immersion of composites in water for an extended period of time may cause irreversible color changes.[30] This may be the reason why even composite material kept in distilled water showed significantly higher discoloration compared to other materials.

In the present study, the color change of the acrylic resin material is lower than the composite. In comparation of methyl methacrylate based resins and composite based resins, composite can absorb water at a greater rate due to a higher diffusion coefficient.[31] This characteristic may explain the low ΔE_{00} values of acrylic material compared to composite material.

Color difference of gingival materials was determined with a colorimeter, and CIEDE2000 (ΔE_{00}) color difference formula was used to measure the color change in the current study. Colorimeters are accurate, repeatable and reliable for color change measurement. For instance, the repeatability of a colorimeter for measuring shade tabs in vitro has been shown to be 99.0 % with an accuracy of 92.6 %.[32] For studies about color, there are two commonly used thresholds: perceptibility and clinical acceptability. The perceptibility threshold was set at $\Delta E_{00} \leq 1.30$ units, and the clinical acceptability threshold was set at $\Delta E_{00} \leq 2.25$ units.[22] In the present study, the mean ΔE_{00} values of gingival materials ranged between 2.90 ± 1.35 and 0.43 ± 0.15. The mean ΔE_{00} values for all materials were within the clinically acceptable threshold, except composite immersed in Farhex Forte.

In previous studies, the application method was to immerse all samples in mouthwash for 12 uninterrupted

hours.[33,34] In this study, a more clinically appropriate immersion procedure was prefered to simulate the continual mouthwash hygiene method of the patients.[35]

The present study have shown that highest mean ΔE_{00} results (2.90±1.35) was observed when the composite gingival materials were immersed in Farhex Fort. These results are similar to the studies of Celik et al.[36] and Bagis et al.[37] Farhex Fort contains 0.3 % chlorhexidine gluconate. The discoloration potential of chlorhexidine gluconate has previously been reported in the literatüre.[37,38]

Mouthwashes are commercially available in two forms as with and without alcohol.[39] Villalta et al.[40] stated that alcohol concentration and low pH of mouthwash might affect the surface conditions of composite resins and cause color changes. Festuccia et al.[41] reported that Listerine causes significant discoloration in composite. Although Listerine has a high alcohol content and low pH, it had a lower effect on color change of the gingival materials tested than the other mouthwashes for the present study. These results are consistent with Diab et al.[42] and ElEmbaby Ael-S et al.[43] In this study, no correlation was observed between low pH, high alcohol content and discoloration of gingival materials. This results are in agreement with previous researches that examined color change of composite resin.[36,44]

Despite the fact that Colgate Plax has a lower alcohol content compared to Listerine, Colgate Plax induced more color change than Listerine in composite and acrylic resin materials. This may be attributed to the fluoride in composition.[45] The fluoride have negative effects on the matrix of the resin materials. Fluoride agents may increase color change of the resin materials.[1]

The effects of mouthwashes on gingival materials depend on many factors that can not be imitated in vitro conditions. Food, drink, saliva, brushing are among these factors that can affect color stability. Therefore, the results of this present study should be supported with *in vivo* studies.

CONCLUSION

Within the limitations of this in vitro study,

1. It was concluded that mouthwashes caused different levels of discoloration on gingival materials.
2. The gingival colored materials demonstrated acceptable color stability when stored in different types of mouthwash agents, except for composite immersed in Farhex Forte.
3. The least color change was expectedly observed in porcelain. Composite displayed the lowest color stability.

According to the results of this study, patients treated with implant retained hybrid prosthesis should be informed about the proper mouthwash agents for the type of gingival colored material. Because the mouthwash preferences of the patients may result in aesthetic loss due to discoloration of the prostheses.

REFERENCES

1. Al-Samadani KH. The effect of preventive agents (mouthwashes/gels) on the color stability of dental resin-based composite materials. Dent J 2017;15:18.
2. Thoma DS, Móhlemann S. Jung RE. Critical Soft-Tissue Dimensions with Dental Implants and Treatment Concepts. Periodontology 2000 2014;66:106–118.
3. Kubochi K, Komine F, Fushiki R, Yagawa S, Mori S, Matsumura H. Shear bond strength of a denture base acrylic resin and gingiva-colored indirect composite material to zirconia ceramics. J Prosthodont Res 2017;61:149-157.
4. Reshad M, Cascione D, Aalam AA. Fabrication of the mandibular implant-supported fixed restoration using CAD/CAM technology: a clinical report. J Prosthet Dent 2009;102:281-278.
5. Samra AP, Pereira SK, Delgado LC, Borges CP. Color stability evaluation of aesthetic restorative materials. Braz Oral Res 2008;22:205-10.
6. Belser UC, Grütter L, Vailati F, Bornstein MM, Weber HP, Buser D. Outcome evaluation of early placed maxillary anterior single-tooth implants using objective esthetic criteria: a cross-sectional, retrospective study in 45 patients with a 2- to 4-year follow-up using pink and white esthetic scores J Periodontol 2009;80:140-151.
7. Akay C, Çevik P, Duman AN. Farklı içeceklerde bekletilen yumuşak astar materyallerinin renk stabilitesinin in vitro olarak değerlendirilmesi. Atatürk Üniv Diş Hek Fak Derg 2016;26:261-7.
8. Dos Santos DM, da Silva EVF, Watanabe D, Bitencourt SB, Guiotti AM, Goiato MC. Effect of different acidic solutions on the optical behavior of lithium disilicate ceramics. J Prosthet Dent 2017;118:430– 436.
9. Buyukkaplan SU, Ozarslan MM, Barutcigil C, Arslan M, Barutcigil K, Yoldan EE. Effects of staining liquids and finishing methods on translucency of a hybrid ceramic material having two different translucency levels. J Adv Prosthodont 2017; 9:387– 393.
10. Coelho ASEC, Paula ABP, Carrilho TMP, da Silva MJRF, Botelho MFRR, Carrilho EVVF. Chlorhexidine mouthwash as an anticaries agent: a systematic review. Quintessence Int 2017;48:585-91.
11. Parkinson CR, Hara AT, Nehme M, Lippert F, Zero DT. A randomised clinical evaluation of a fluoride mouthrinse and dentifrice in an in situ caries model. J Dent 2018;70:59-66.
12. Cabrera C, Artacho R, Gimenez R. Beneficial effects of green tea – a review. J Am Coll Nutr 2006;25:79– 99.
13. Pelino JEP, Passero A, Martin AA, Charles CA. In vitro effects of alcohol-containing mouthwashes on human enamel and restorative materials. Braz Oral Res 2018;32:25.
14. Vichi A, Louca C, Corciolani G, Ferrari M. Color related to ceramic and zirconia restorations: a review. Dent Mater 2011;27:97–108.
15. Hollis S, Eisenbeisz E, Versluis A. Color stability of denture resins after staining and exposure to cleansing agents J Prosthet Dent 2015;114:709-714.
16. Hong G, Murata H, Li Y, Sadamori S, Hamada T. Influence of denture cleansers on the color stability of three types of denture base acrylic resin J Prosthet Dent 2009;101:205-213.
17. Valentini F, Oliveira SG, Guimarães GZ, Barbosa RP, Moraes RR. Effect of surface sealant on the color stability of composite resin restorations Braz Dent 2011;22;365-368.
18. Colucci V, dos Santos CD, do Amaral FL, Corona SA, Catirse AB. Influence of NaHCO3 powder on translucency of microfilled composite resin immersed in different mouthrinses J Esthet Restor Dent 2009;21:242-50.
19. Commission Internationale de l'Eclairage (CIE), CIE Technical Report: Colorimetry. 2004; CIE Pub No.15.
20. Rosenstiel SF, Land MF, Fujimoto J. Color science, esthetic and shade selection. In: Contemporary fixed prosthodontics. 5th ed. St Louis: Mosby; 2016. p. 624-30
21. Topcu FT, Sahinkesen G, Yamanel K, Erdemir U, Oktay EA, Ersahan S. Influence of different drinks on the colour stability of dental resin composites. Eur J Dent 2009;3:50-6.
22. Marchan SM, Lynch T, Bascombe K, Carty XJ, Smith WA, Rafeek RN. Color stability of gingiva-colored restorative materials: an in vitro study. Gen Dent 2020; 68:61-65.
23. Derafshi R, Khorshidi H, Kalantari M, Ghaffarlou I. Effect of mouthrinses on color stability of monolithic zirconia and feldspathic ceramic: an in vitro study. BMC Oral Healt 2017;17:129.
24. Değirmenci A, Değirmenci BÜ. Gargaraların dişeti rengindeki kompozitlerin mikrosertliği ve renk değişimi üzerine etkileri. J Int Dent Sci 2018;2:100-107.
25. Garoushi S, Lassila L, Hatem M, Shembesh M, Baady L, Salim Z, et al. Influence of staining solutions and whitening procedures on discoloration of hybrid composite resins. Acta Odontol Scand. 2013;71:144–150.
26. Vichi A, Louca C, Corciolani G, Ferrari M. Color related to ceramic and zirconia restorations: a review. Dent Mater 2011;27:97–108.
27. Macedo M, Volpato CAM, Henriques B, Vaz PCS, Silva FS, Silva C. Color stability of a bis-acryl composite resin subjected to polishing, thermocycling, intercalated baths, and immersion in different beverages. J Esthet Restor Dent 2018; 30: 449-56.

28. Skrtic D, Antonucci JM, McDonough WG, Liu DW. Effect of chemical structure and composition of the resin phase on mechanical strength and vinyl conversion of amorphous calcium phosphate-based composites. J Biomed Mater Res A 2004;68:763–72.
29. Mansouri SA, Zidan AZ. Effect of water sorption and solubility on color stability of bulk-fill resin composite. J Contemp Dent Pract 2018;19:1129-34.
30. Um CM, Ruyter IE. Staining of resin-based veneering materials with coffee and tea. Quintessence Int 1991;22:377-86.
31. Khan Z, von Fraunhofer JA, Razavi R. The staining characteristics, transverse strength, and microhardness of a visible light-cured denture base material. J Prosthet Dent 1987;57:38.
32. Chen H, Huang J, Dong X, Qian J, He J, Qu X, Lu E. A systematic review of visual and instrumental measurements for tooth shade matching. Quintessence International 2012;43:649-59.
33. Yap AUJ, Chew CL, Ong LFKL, Teoh SH. Environmental damage and occlusal contact are awear of composite restoratives. J Oral Rehabil 2002;29:87–97.
34. Cal E, Güneri P, Köse T. Digital analysis of mouthrinses' staining characteristics on provisional acrylic resins. J Oral Rehabil 2007;34:297–303.
35. Trauth KGS, de Godoi APT, Colucci V, Corona SAM , Catirse ABC. The influence of mouth rinses and simulated tooth brushing on the surface roughness of a nano-filled composite resin. Braz Oral Res 2012;26:209–14.
36. Celik C, Yuzugullu B, Erkut S, Yamanel K. Effects of mouth rinses on color stability of resin composites. Eur J Dent 2008;2:247–53
37. Bagis B, Baltacioglu E, Ozcan M, Ustaömer S. Evaluation of chlorhexidine gluconate mouthrinse-induced staining using a digital colorimeter:an invivo study. Quint Int 2011;42:213–23.
38. Lamba B, Lamba A, Ponnappa KC. Effect of mouth rinses on the color of three tooth-colored restorative materials. Int J Stomatol Occlusion Med 2012;5:104-9.
39. Vechiato-Filho AJ, Dos Santos DM, Goiato MC, Moreno A, De Medeiros RA, Kina S, et al. Surface degradation of lithium disilicate ceramic after immersion in acid and fluoride solutions. Am J Dent 2015;28:174–180.
40. Villalta P, Lu H, Okte Z, Garcia-Godoy F, Powers JM. Effects of staining and bleaching on color change of dental composite resins. J Prosthet Dent 2006;95:137–142.
41. Festuccia MS, Garcia Lda F, Cruvinel DR, Pires-De-Souza Fde C. Color stability, surface roughness and microhardness of composites submitted to mouthrinsing action. J Appl Oral Sci 2012;20:200–5.
42. Diab M, Zaazou MH, Mubarak EH, Olaa MI. Effect of five commercial mouthrinses on the microhardness and color stability of two resin composite restorative materials. Aust J Basic Appl Sci 2007;1:667–74.
43. ElEmbaby Ael-S. The effects of mouth rinses on the color stability of resin-based restorative materials. J Esthet Restor Dent 2014;26:264–71.
44. Baig AR, Shori DD, Shenoi PR, Ali SN, Shetti S, Godhane A. Mouthrinses affect color stability of composite. J Conserv Dent 2016;19:355.
45. Korkmaz YN, Bulut M. Effect of mouthwashes on the discoloration of bracket-bonded tooth surfaces: an in vitro study. Clinl Oral Investig 2020;24: 3855-3861.

Corresponding Author:

Hande CITIR YUCEL
Alanya Alaaddin Keykubat University
Faculty of Dentistry
Department of Prosthodontics,
Antalya, Turkey
Phone : +90 242 510 61 40
E-mail : hande.yucel@alanya.edu.tr