Original Article

Influence of surface sealant agent on the color stability of denture teeth

Keng-Yu Cheng, DDS, MS[a]
Chun-Nan Lin, DDS, MS[b]
Liy-Yin Huang, MS[c]
Peng, Chiao-Yun ,MS[d]

[a]Resident Doctor, Division of Prosthodontics, Department of Dentistry, Shin Kong Wu Ho-Su Memorial Hospital, Taipei, 11101, Taiwan.
Tel: +886-2-2833-2211 ext. 2170

[b]Visiting Doctor, Dental Department, Shin-Kong Wu Ho-Su Memorial Hospital, Taipei, Taiwan
No.95, Wen Chang Road, Shih Lin District, Taipei city, 11101, Taiwan

cDental technician, Dental Department, Shin-Kong Wu Ho-Su Memorial Hospita l, Taipei, 11101, Taiwan.

[d]Dental technician, Dental Department Shin-Kong Wu Ho-Su Memorial Hospital Taipei, Taiwan

Running title: Surface Sealant and Denture Teeth Color Stability

*Corresponding author:
Chun-Nan Lin, DDS, MS
Visiting Doctor, Dental Department, Shin-Kong Wu Ho-Su Memorial Hospital, Taipei, Taiwan
No.95, Wen Chang Road, Shih Lin District, Taipei city, 11101, Taiwan
Tel: +886-2-2833-2211 ext. 2170
Email: lcn1124@yahoo.com.tw

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Abstract

Background/purpose: *Although various surface sealant agents are available for chairside or laboratory polishing procedures, their effect on the color stability of denture teeth is not clear. The purpose of this in vitro study was to evaluate the effect of sealant agents on the color stability of various denture tooth materials.*

Materials and methods: *40 specimens were prepared for each type of PMMA denture tooth material (SR Vivodent PE, Fx, EFUCERR-A). The specimens were assigned to 4 groups according to the surface treatment used (n=10): no surface treatment, conventional laboratory polishing technique, surface sealant agents Palaseal (Heraeus Kulzer GmbH) and surface sealant Optiglaze (GC Corp). After surface treatment were completed, specimens were immersed in coffee for 15 hours and were rinsed with running water and air-dried. Each group were then rinsed with distilled water for 8h. This cycle was repeated 42 times. The CIELab color parameters measured with spectrophotometer were performed every 7 cycles until 42 cycles were finished. Data were statistically analyzed with Generalized Estimating Equation(GEE). The significance level was 0.05.*

Results: *Optiglaze coating after grinding in SR vivodent S PE group and in Fx group would be more acceptable in color stability than coating with Palaseal after grinding by the naked eye after 6 weeks. In EFUCERR-A group, no matter which surface treatment was used, the color change would be acceptable by the naked eye after 6 weeks.*

Conclusions: *Type of teeth and surface coating with Palaseal have significant influences on color stability. Surface treatment agent may have the potential to reduce the occurrence of staining.*

Key words: denture, staining, surface sealing agent

Introduction

Removable prostheses can be used to restore the function and esthetic of edentulous areas. The components of removable prostheses include the denture base and artificial teeth. The characteristics of artificial teeth must meet some criteria,

including wear resistance and esthetic. Polymethyl methacrylate (PMMA) and porcelain are two materials currently used for removable prostheses.[1] Porcelain has better wear resistance, esthetic, and anti-discoloration than PMMA. However, it is hard to complete occlusal adjustment during the denture workflow. Therefore, PMMA has become the common material used for artificial teeth. The wear resistance of PMMA can be improved by adding an inorganic filler.[2,3]

Besides wear resistance, long-term color stability is important for denture teeth to maintain the esthetic.[4] Daily consumption of staining beverages such as tea, coffee, and red wine can discolor artificial teeth, leading to aesthetic concerns.[5] Increasing the color stability of artificial teeth is an important consideration in dental prosthetics. Various methods have been proposed to enhance color stability, including using surface sealants and fillers and modifying the material composition of artificial teeth.

This study aims to investigate the effect of various denture teeth and surface processing methods on long-term color stability. Its results can be a reference for dentists and dental technicians when polishing denture surfaces.

Materials and methods

This study used three types of commercially available denture teeth:

- SR vivodent S PE: Acrylic resin teeth with filler (Ivoclar Vivadent AG, Schaan, Liechtenstein)
- FX anterior: Acrylic resin teeth with filler (Yamahachi, Gamagori, Japan)
- Efucera-A: Composite resin teeth with filler (Yamahachi, Gamagori, Japan)

Each group comprised 120 maxillary central incisors and tooth models, with:

- Group V: Shade 1C and size A15
- Group F: Shade A2 and size S7
- Group E: Shade A2 and size T7

The groups were further divided equally into four subgroups according to surface treatment methods. The first subgroup involved no surface treatment (N), the second subgroup involved grinding followed by conventional polishing (G+P), the third subgroup involved grinding and sealing with the sealant agent Palaseal (Heraeus Kulzer GmbH, Wehrheim, Germany; G+SP), and the fourth subgroup involved grinding and sealing with the sealant agent Optiglaze (GC Corp, Tokyo, Japan; G+SO; Fig. 1).

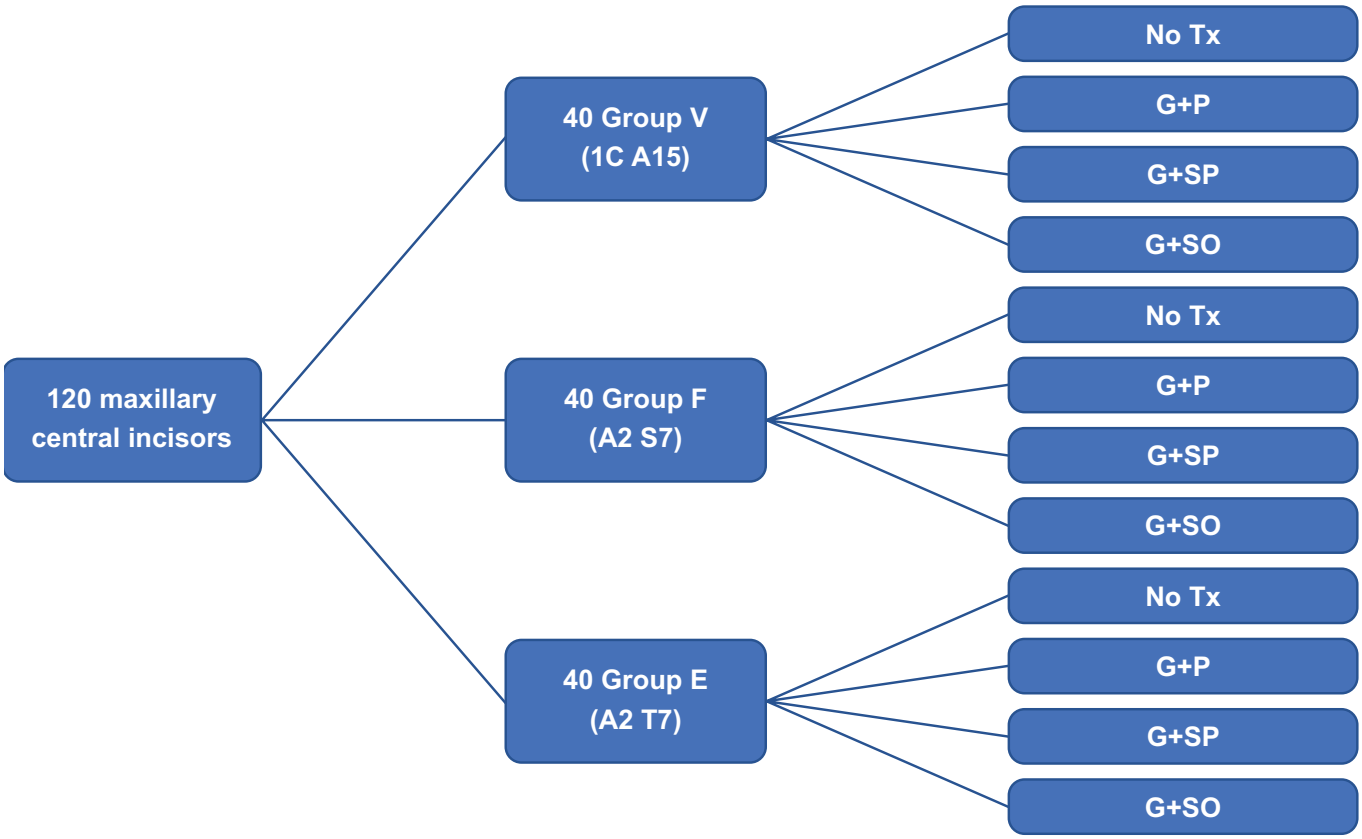

Figure 1. Distribution of denture teeth. V: SR vivodent S PE, F: Fx, E: EFUCERR-A, No Tx: no treatment, G: grinding, P: polishing, SP: Sealing agent Palaseal, SO: sealing agent Optiglaze.

For the grinding method, the labial surfaces of the denture teeth were ground using a Carborundum point HP#13 (Mani Inc., Kiryu City, Japan) on a straight handpiece with low speed (powered by a lab motor, UP500; URAWA Corp., Kuki, Japan) from the cementoenamel junction (CEJ) to the incisal edge, with 30 repetitions to eliminate all surface luster.

Conventional polishing consisted of three steps. Step 1 involved polishing the labial surfaces of the denture teeth using an acrylic polisher point on a straight handpiece with low speed (powered by a lab motor, UP500) from the CEJ to the incisal edge, repeated 30 times. Step 2 required polishing the labial surfaces of the denture teeth with wet pumice (coarse sand followed by wet fine sand) on a rag wheel attached to a dental lathe running at a slow speed. The teeth were lightly pressed against the wheel for 2 seconds. Step 3 applied rouge to the dry muslin buffing wheel and pressed the teeth lightly against the wheel for 2 seconds.

Regarding the surface coating procedure, Palaseal or Optiglaze was uniformly applied to the denture teeth using a soft brush. The denture teeth were allowed to dry for 20 seconds before being cured using a curing maching (Solidilite V, Shofu, Kakegawa, Japan) for 3 minutes. The same operator prepared all samples.

The samples were immersed in a coffee solution and placed in a 37°C constant temperature chamber for 15 hours in the dark to simulate the oral environment. After staining, the samples were rinsed with flowing water for 15 seconds, air-dried, and then immersed in distilled water for 8 hours. The coffee solution immersion and distilled water rinsing cycle was repeated 42 times (Fig. 2). According to the Saraç et al. study,[6] 15 hours of coffee immersion simulates the weekly exposure time to beverages or foods (2 hours × 7 days) and 8 hours of water immersion simulates overnight soaking. In this experimental design, one cycle represents one week. Since one cycle takes approximately one day, cycle 7 represents one week. Consequently, weeks 1, 2, and 6 represent 1.5, 3.0, and 9.0 months of use, respectively.

The CIE Lab* color parameters were measured and recorded using a colorimeter (VITA Easyshade; Vita Zahnfabrik, Bad Säckingen, Germany) before the experiment and after cycles 7, 14, and 42 of coffee solution immersion. The color difference (ΔE) was recorded between the pre- and post-experiment time points. A ΔE of >3.5 is easily perceived with the naked eye. A generalized estimating equation was used to investigate the effects of the type of denture teeth and surface treatment method on color stability with the SPSS statistical software (version 26.0; IBM Corp., NY, USA). A *p*-value of <0.05 was considered statistically significant.

This study used a colorimeter as the standard for color determination. Color stability studies often use colorimeters as a quantitative tool to measure the color change caused by the absorption of pigments after immersion in a colored solution. The ΔE provided by the colorimeter is an accurate and convenient way to measure color changes before and after an experiment. The colorimeter is also useful in dental clinics to help with color matching. After completing the experiment, the colorimeter retains its clinical value.

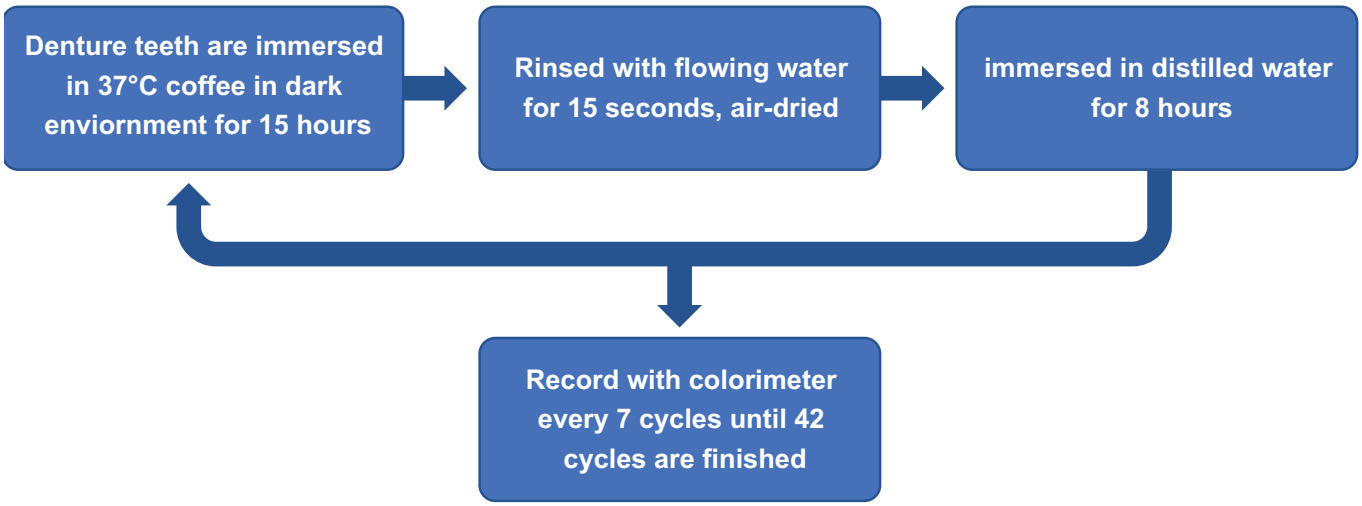

Figure 2. The process of each cycle

Results

The mean and standard deviation color changes (ΔE) in the 12 subgroups at one and six weeks are shown in Table 1. ΔE was calculated using the equation (ΔEab = [(L2 - L1)^2 + (a2 - a1)^2 + (b2 - b1)^2]^(1/2)), based on the lab color parameters of the upper central incisors before the experiment and at one and six weeks after.

In Group V, the mean ΔE of denture teeth at week 6 were 2.97 (±0.22), 2.89 (±0.03), 7.8 (±0.00), and 3.04 (±0.30) for the N, G+P, G+SP, and G+SO subgroups, respectively. The greatest color change was observed in the G+SP subgroup (ΔE > 3.5), followed by the G+SO (ΔE <3.5) and G+P (ΔE < 3.5) subgroups.

In Group F, the mean ΔE of denture teeth at week 6 were 0.38 (±1.20), 1.14 (±1.84), 5.10 (±0.00), and 2.60 (±1.84) for the N, G+P, G+SP, and G+SO subgroups, respectively. The greatest color change was observed in the G+SP subgroup (ΔE > 3.5), followed by the G+SO (ΔE <3.5) and G+P (ΔE < 3.5) subgroups.

In Group E, the mean ΔE of denture teeth at week 6 were 1.14 (±1.84), 1.90 (±2.00), 1.40 (±0.00), and 0.38 (±1.20) for the N, G+P, G+SP, and G+SO subgroups, respectively. The greatest color change was observed in the G+P subgroup (ΔE < 3.5), followed by the G+SP (ΔE < 3.5) and G+SO (ΔE <3.5) subgroups.

The analysis of the effect of the type of denture tooth and surface processing methods on color changes with generalized estimating equations, using Group V and group N as standard group, is shown in Table 2, and the interaction effects, using Group V+N as standard group, are shown in Table 3. Table 2 shows that when group V and group N are used as the standard groups, the color change was significantly affected by the three types of denture teeth and the denture with the Palaseal surface coating. Table 3 shows that when the group V+N is used as the standard group in comparison of the interaction, the color change was not significantly affected in Groups E+G+P and E+G+SO.

The analysis of the effect of the type of denture tooth and surface processing methods on color changes with generalized estimating equations considering an ΔE threshold of 3.5, using group V and group N as standard groups, is shown in Table 4. The color change was significantly affected by the Fx denture teeth and Palaseal coating when ΔE>3.5.

Table 1. Color changes (ΔE) at Week 1 and 6 for the three artificial tooth types, three surface treatment methods.

Color changes	SR Vivodent PE		Fx		EFUCERR-A	
(ΔE)	Week 1	Week 6	Week 1	Week 6	Week 1	Week 6
No surface treatment	2.09 (±1.97)	2.97 (±0.22)	0.76 (±1.60)	0.38 (±1.20)	1.14 (±1.84)	1.14 (±1.84)
polishing	4.00 (±0.00)	2.89 (±0.03)	1.14 (±1.84)	1.14 (±1.84)	1.90 (±2.00)	1.90 (±2.00)
Palaseal	6.16 (±1.49)	7.8 (±0.00)	3.80 (±0.00)	5.10 (±0.00)	0.00 (±0.00)	1.40 (±0.00)
Optiglaze	3.46 (±0.86)	3.04 (±0.30)	1.14 (±1.84)	2.60 (±1.84)	0.38 (±1.20)	0.38 (±1.20)

Table 2. Generalized estimating equations of the color changes (ΔE) between the three types of denture tooth and surface processing methods

Variable	B (95% CI)	p value
Type of teeth		
SR Vivodent PE	As control group	
Fx	-1.608	<0.001*
EFUCERR-A	-2.926	<0.001*
Surface treatment		
No treatment	As control group	
Convention polishing	0.588	0.112
Surface coating with Palaseal	2.360	<0.001*
Surface coating with Optiglaze	0.272	0.372

* A *P* value of <.05 denotes a significant difference.

Table 3. Generalized estimating equations of the color changes (ΔE) between the interaction of the types of denture tooth and surface processing methods

Variable	SR Vivodent PE		Fx		EFUCERR-A	
	B (95% CI)	p value	B (95% CI)	p value	B (95% CI)	p value
No surface treatment	As control group		-1.682	<0.001*	-1.652	0.003*
polishing	0.283	0.003*	-0.962	0.023*	-1.175	0.051
Palaseal	4.218	<0.001*	3.138	<0.001*	-4.495	<0.001*
Optiglaze	0.318	0.014*	1.257	0.008*	-1.078	0.108

* A *P* value of <.05 denotes a significant difference.

Table 4. Generalized estimating equations of the color changes (ΔE), using the color changes (ΔE)=3.5 as cutting point.

Variable	B (95% CI)	p value
Type of teeth		
SR Vivodent PE	As control group	
Fx	0.931	0.002*
EFUCERR-A	-0.838	0.118
Surface treatment		
No treatment	As control group	
Convention polishing	0.666	0.202
Surface coating with Palaseal	1.898	<0.001*
Surface coating with Optiglaze	0.335	0.502

* A *P* value of <.05 denotes a significant difference.

Discussion

This study used the CIE LAB color system[7,8] to compare color changes. According to Ghinea et al.[9], the perceptibility and the acceptability of ΔE_{ab} are 1.80 and 3.46, respectively. Clinically, a ΔE >3.5 will be unacceptable to the naked eye.[10] Our results show that the type of denture teeth and surface processing method significantly affect color stability. The color change in Group E after six weeks would not be perceived by the naked eye, regardless of which surface treatment was used.

While several factors affect the discoloration process, surface roughness is generally considered the main factor affecting stain absorption. A surface sealant is used to reduce surface irregularities and defects and enhance surface smoothness to improve stain resistance. The study by Şahin et al.[11] demonstrated that denture teeth polished using surface sealant are smoother than those polished using conventional polishing techniques. Similarly, several studies[12-15] have found that surface-penetrating sealant or glaze materials result in significantly lower roughness than conventional polishing techniques (aluminum oxide abrasive disks or silicone wheel systems). However, clinical studies have found that some removable dentures coated with surface sealant agents still experience apparent color changes in both their denture base and teeth during long-term use, contradicting the findings of previous studies.

In our study, the G+SP subgroup showed the greatest ΔE in Groups V and F, but the result differed for Group E. This result is consistent with our previous study.[16] There are several possible explanations for this difference. The compositions of surface sealants are important. Two surface sealants were used per the manufacturer's instructions, so operating errors must first be excluded. The study by Manabe et al.[17] showed that the composition of sealants can cause discoloration. Palaseal has multiple derivates from the reaction of bisphenol A and glycidyl methacrylate (GMA). Hatipoğlu et al.[18] and Fonseca et al.[19] showed that bisphenol A-glycidyl methacrylate (Bis-GMA)-based composite resins, which have higher water absorption, were more susceptible to staining. He et al.[20] and Sideridou et al.[21] also reported similar results. This finding might explain why Palaseal leads to a more apparent color change. The photoinitiator in Optiglaze is a trade secret and might explain why the Optiglaze coating shows

better color stability than the Palaseal coating.

The different color changes of resin teeth can be attributed to their manufacturing process and factors such as the degree of polymer conversion and the amount of remaining unreacted monomer and initiators such as dibenzoyl peroxide.[22] Water sorption of a methacrylate polymer depends on the resin network heterogeneity and its chemical structure. The hydrophilic nature of the polymer matrix could also affect water sorption of resin in the oral environment.[23] Composite resin teeth generally contain stain-causing components—urethane dimethacrylate, Bis-GMA, or a Bis-GMA analog—and filler. Kundu et al.[24] showed that hybrid composite teeth (particularly nano-filled) were more resistant to staining than acrylic teeth in staining solutions. In our study, EFUCERA-A denture teeth showed no significant color change in the Groups G+P and G+SO. The manufacturer adds a fiuorine-containing monomer, which acts as a tooth surface shield against stain-causing agents, into composite resin denture teeth to improve color stability. EFUCERA-A denture teeth can achieve good strength and color stability through this method.

Our study had some limitations. First, the temperature was constant in the thermal cycle, which differs from reality. Second, it only used a coffee solution as the staining agent, but many staining agents must be considered. Third, daily food consumption and cleaning techniques, which may make the denture teeth rougher and easier to stain, were not considered. These limitations must be considered for future studies.

Conclusions

Within the limitations of our study, the following conclusions can be made:

1. Coating SR vivodent S PE and in Fx anterior teeth with Optiglaze after grinding provides more acceptable visual color stability than coating with Palaseal after six weeks.
2. The color changes of EFUCERR-A teeth would be visually acceptable after six weeks, regardless of the surface treatment used.
3. The three types of denture teeth and Palaseal surface coating affected color changes significantly.
4. Fx anterior denture teeth and the Palaseal surface coating significantly affected ΔE when using a threshold of 3.5.

Our results show that surface treatment agents may reduce staining but also exacerbate the extent of staining after long-term use. These results can be a reference for dentists and dental technicians when choosing the surface coating on denture teeth. Future studies should examine other surface sealants and the relationship between surface treatment and color change.

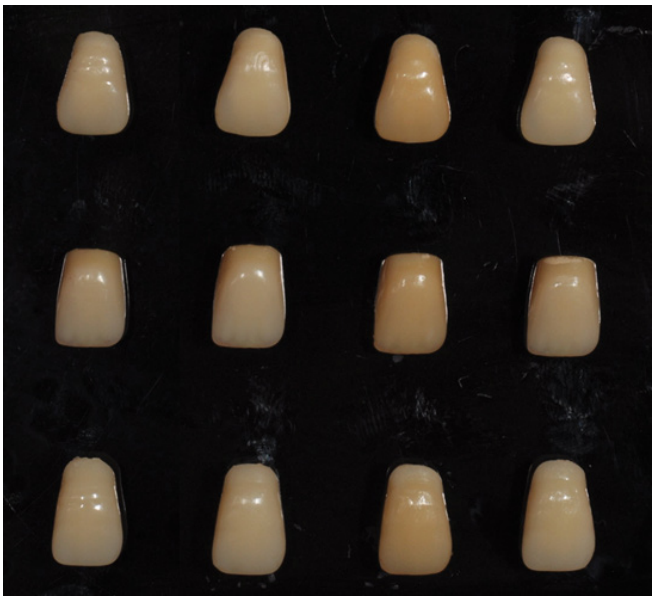

Figure 3. The groups from top to bottom are as follows: EFUCERR-A(E), SR Vivodent PE(V), Fx(F),. The groups from right to left are as follows: No surface treatment (Control), grinding and conventional polishing (G+P), grinding and palaseal (G+Ps) coating, grinding and Optiglaze (G+Og) coating.

References

1. Mutlu-Sagesen L, Ergun G, Ozkan Y, Bek B. Color stability of different denture teeth materials: an in vitro study. J Oral Sci 2001;43:193-205.
2. Powers JM, Sakaguchi RL. Craig's restorative dental materials. 13th ed., Elsevier, St Louis, 2012; pp 54-6.
3. Stober T, Lutz T, Gilde H, Rammelsberg P. Wear of resin denture teeth by two-body contact. Dent Mater 2006;22:243-9.
4. Gregorius WC, Kattadiyil MT, Goodacre CJ, Roggenkamp CL, Powers JM, Paravina RD. Effects of ageing and staining on color of acrylic resin denture teeth. J Dent 2012;40:47-54.
5. Imirzalioglu P, Karacaer O, Yılmaz B, Ozmen I. Color stability of denture acrylic resins and a soft lining material against tea, coffee, and nicotine. J Prosthodont 2010;19:118-24.
6. Saraç D, Saraç YS, Kurt M, Yüzbaşioğlu E. The effectiveness of denture cleansers on soft denture liners colored by food colorant solutions. J Prosthodont. 2007;16:185-91.
7. CIE (Commission Internationale de l'Eclair- age). Colorimetry-technical report. CIE Pub. No. 15. 3rd ed., Bureau Central de la CIE, Vienna, 2004; pp 16-20.
8. Hersek N, Canay S, Uzun G, Yildiz F. Color stability of denture base acrylic resins in three food colorants. J Prosthet Dent 1999;81:375-9.
9. Ghinea R, Pérez MM, Herrera LJ, Rivas MJ, Yebra A, Paravina RD. Color difference thresholds in dental ceramics. J Dent 2010;38:e57-64.
10. O'Brien WJ. Dental materials and their selection. 4th ed., Quintessence Publishing Co, Chicago, 2008; pp25-38.
11. Şahin O, Dede DÖ, Köroğlu A, Köro□lu A, Yılmaz B. Influence of surface sealant agents on the surface roughness and color stability of artificial teeth. J Prosthet Dent 2015;114:130-7.
12. Sarac D, Sarac YS, Kulunk S, Ural C, Kulunk T. The effect of polishing techniques on the surface roughness and color change of composite resins. J Prosthet Dent 2006;96:33-40.
13. Doray PG, Eldiwany MS, Powers JM. Effect of resin surface sealers on improvement of stain resistance for a composite provisional material. J Esthet Restor Dent 2003;15:244-50.
14. Köroğlu A, Sahin O, Dede DÖ, Yilmaz B. Effect of different surface treatment methods on the surface roughness and color stability of interim prosthodontic materials. J Prosthet Dent 2016;115:447-55.
15. Bertrand MF, Leforestier E, Muller M, Lupi-Pegurier L, Bolla M. Effect of surface penetrating sealant on surface texture and microhardness of composite resins. J Biomed Mater Res 2000;53:658-63.
16. Lin CN, Peng CY, Lin PY, Chang CL. Influence of surface treatment on the color stability of denture teeth. J Prosth Implant 2019;8:1-6.
17. Manabe A, Kato Y, Finger WJ, Kanehira M, Komatsu M. Discoloration of coating resins exposed to staining solutions in vitro. Dent Mater J 2009;28:338-43.
18. Hatipoğlu Ö, Turumtay EA, Saygın AG, Hatipoğlu FP. Evaluation of color stability of experimental dental composite resins prepared from bis-EFMA, a novel monomer system. J Photopolym Sci Technol 2021;34:297-305.
19. Fonseca AS, Labruna Moreira AD, de Albuquerque PP, de Menezes LR, Pfeifer CS, Schneider LF. Effect of monomer type on the CC degree of conversion, water sorption and solubility, and color stability of model dental composites. Dent Mater 2017;33:394-401.
20. He J, Kopperud HM. Preparation and characterization of Bis-GMA-free dental composites with dimethacrylate monomer derived from 9,9-Bis[4-(2-hydroxyethoxy)phenyl]fluorene. Dent Mater 2018;34:1003-13.
21. Sideridou I, Tserki V, Papanastasiou G. Effect of chemical structure on degree of conversion in light-cured dimethacrylate-based dental resins. Biomaterials 2002;23:1819-29.
22. Rosentritt M, Esch J, Behr M, Leibrock A, Handel G. In vivo color stability of resin composite veneers and acrylic resin teeth in removable partial dentures. Quintessence Int 1998;29:517-22.
23. Barszczewska-Rybarek IM. Characterization of urethane-dimethacrylate derivatives as alternative monomers for the restorative composite matrix. Dent Mater 2014;30:1336-44.
24. Kundu J, Kumar R, Seshan S. A study on evaluation of surface roughness and anti-staining propensity of nano-composite denture teeth. Int J Cur Res 2014;6:52.