Original Article

Influence of surface treatment on the color stability of denture teeth

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Abstract

Objective: *Although various surface sealants are available and for use in chairside or laboratory polishing procedures, their effect on the color stability of denture teeth is unclear, as is the effect of denture cleansers on stain removal. The purpose of this study was to evaluate the effect of sealant agents on the color stability of denture teeth and the effect of denture cleanser on stain removal from denture teeth.*

Material and methods: *For each type of denture tooth material (SR Vivodent, PMMA; Vitapan, reinforced-PMMA), 72 specimens were prepared. The specimens were assigned to six groups according to the surface treatment used and cleaning solution used. The surface treatments employed were (1) grinding only (control group); (2) grinding and conventional laboratory polishing; and (3) grinding, conventional laboratory polishing technique and application of surface sealant (Palaseal). After surface treatment, the specimens were immersed in coffee for 14 hours at 37°C and then were rinsed with running water and air-dried. Each surface treatment group was then divided into two subgroups according to the cleaning solution: distilled water or denture cleanser (Polident). The specimens were immersed in cleaning solution for 30 minutes and then in water for 8.5 hours. This cycle was repeated for 6 weeks. CIELab color parameters were measured using a digital spectrophotometer at baseline and after 1st and 6th weeks. Data were statistically analyzed using t-tests and 3-way analysis of variance.*

Results: *The group of teeth to which surface sealant was applied had the lowest color stability. The group of teeth cleaned using denture cleanser had higher color stability.*

Conclusion: *Surface sealant provides an immediate smooth and glossy surface to denture teeth but gives the surface poor color stability. The use of denture cleanser can reduce denture staining.*

Key words: cleanser; denture; staining; surface sealing agent

Introduction

A removable denture consist of a denture base and denture teeth, and the denture teeth are generally made of poly methyl methacrylate (PMMA) or porcelain.[1] Compared with those made of PMMA, porcelain teeth are more aesthetically pleasing and resistant to wear and staining. However, repairing and adjusting porcelain teeth is more difficult than PMMA dentures teeth, which thus become commonly used than porcelain teeth. Inorganic fillers can be added to dentures teeth to enhance their resistance to wear.[2,3] Maintaining the physical appearance of denture teeth at an aesthetically pleasing state for a long period of time can be difficult because daily drinks such as tea, coffee, and red wine all stain denture teeth. Therefore, denture users should select denture teeth that are favorably resistant to staining.[4]

A study [5] demonstrated that tea, coffee, and nicotine (in cigarettes) can cause stains on denture teeth and that the color differences (ΔE) created by these stains can be perceived by the naked eye. The color differences can also be measured using scientific instruments to obtain accurate and objective data. The CIE Lab color system[6,7] developed by the International Commission on Illumination uses color space coordinates to determine color differences. In the system, L, a, and b signify brightness, green–red, and blue–yellow, respectively. In the color space, the distance between two color coordinates is referred to as the color difference. O'Brien (2008)[8] noted that a color change greater than 3.5 can be perceived by the naked eye.

When arranging teeth or adjusting the occlusion of removable dentures, dental technicians must generally grind the dentures teeth to adjust the occlusion and the size of denture teeth. When ground denture teeth lose their smoothness, and the dental technician must then polish and brighten them to restore their texture and decrease the likelihood of staining (because rough surfaces stain more easily). Numerous commercially available surface sealant agents can be applied to the surface of PMMA to reduce its surface roughness and increase luster. Studies[9-11] have demonstrated that surface sealant agents can reduce surface roughness and enhance denture color stability. However, clinical findings revealed that removable dentures coated with surface sealant agents become darker in both their denture base and denture teeth during long-term use, contradicting the findings of previous studies.

Denture cleansers can be employed to clean and sterilize dentures. Kurtulmus-Yilmaz and Deniz[12] discovered that soaking removable dentures in a denture cleanser decreased the severity of stains and enhanced color stability. Nonetheless, some scholars have contended that soaking dentures in denture cleansers for an extended period of time will result in a change to the dentures' base color.

This study investigated whether different surface treatment procedures influence the color stability of denture teeth and whether soaking denture teeth in denture cleansers affects their color stability. The results can serve as a reference for dentists and dental technicians when polish denture surfaces in the future.

Materials and Methods

Two commercially available denture tooth brands—SR Vivodent PE (Ivoclar Vivadent AG, no inorganic filler) and Vitapan (Vita Zahnfabrik, with inorganic filler)—were used. Upper central incisors with color A2 were selected. The tooth models used for the SR Vivodent PE and Vitapan were A17 and T9L, respectively. A total of 144 upper central incisors were selected as the study sample. All the sample were prepared by the same dental technician and the sample was divided into three groups that were differently surface treatment. The first group was the grinding only (G) group; the second, the grinding and conventional polish (G+P) group; and the third, the grinding, conventional polish and sealing with surface sealant agent (G+P+S) group. Each group was further divided into two subgroups; after being soaked in coffee, one subgroup was soaked in denture cleanser, whereas the other was not. Concerning the grinding method, denture tooth luster was removed by operating the Carborundum point HP#13 on the denture teeth surface with low speed. Regarding the conventional polish method, the denture teeth were polished using a silicon point with low speed. The surface sealant agent employed was Palaseal (Heraeus Kulzer GmbH), which was coated uniformly on the denture teeth using a soft brush. The denture teeth were left to dry for 20 seconds before being cured using a curing machine for 90 seconds.

The sample was soaked in coffee and then placed in a water bath (i.e., a constant

Table 1. Color changes (ΔE) at Weeks 1 and 6 for the two denture types, three surface treatment methods, and two cleaning methods

			ΔE from Baseline	
Brand	Surface treatment	Clean	Week 1	Week 6
Vita	Grinding	water	1.62 (±0.65)	2.95 (±0.58)
		cleanser	1.37 (±0.62)	1.54 (±0.54)
	Grinding & Polish	water	1.44 (±0.83)	1.43 (±0.78)
		cleanser	1.11 (±0.42)	1.07 (±0.46)
	Grinding& Polish& Sealing	water	2.29 (±0.78)	10.51 (±1.01)
		cleanser	1.61 (±0.84)	5.39 (±1.47)
Ivoclar	Grinding	water	1.21 (±0.36)	1.81 (±0.47)
		cleanser	1.84 (±0.85)	1.81 (±1.06)
	Grinding & Polish	water	1.50 (±0.49)	1.62 (±0.54)
		cleanser	1.29 (±0.45)	1.10 (±0.66)
	Grinding& Polish& Sealing	water	4.56 (±0.78)	10.10 (±3.33)
		cleanser	3.42 (±1.80)	5.52 (±0.53)

temperature water tank; BU410D) at 37°C for 14 hours. Subsequently, the samples were washed using running water, blow dried, and divided into subgroups; one subgroup was cleaned using distilled water and the other using Polident denture cleaner. All samples were soaked for 30 min before being soaked in tap water for 8.5 hours. The samples were repeatedly soaked in coffee, their respective cleanser, and tap water for 6 weeks.

The colors of the midsections of the denture teeth were then measured using a digital spectrophotometer (Vita Easy-shade; Vita Zahnfabrik).

The length from incisal edge to root portion of the sample (SR Vivodent PE: A17 and Vitapan: T9L) were around 15 mm. The length of the middle part was matched with the diameter of measured cone of the digital spectrophotometer. Additionally, the middle part is the most flat area and the measured cone could touch the teeth surface perpendicularly. The teeth were put into putty block which exposed the measured area of the middle part of the teeth when measurement was performed. The tooth shape of the same brand was consistent and the same measured area were restricted by the putty (Fig.1).

The CIE L*a*b*color parameters of the midsections before the experiment, 1 week after the start of the experiment, and 6 weeks after the start of the experiment were compared, and the color changes were calculated.

The color changes were analyzed using the t-test and 3-way analysis of variance (ANOVA).

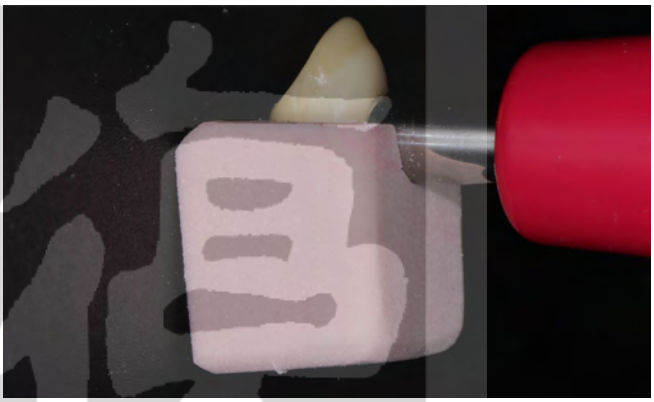

Fig 1: The tooth were put into putty block which exposed the measured area of the middle part when measurement was performed.

Results

In this study, upper central incisors manufactured by two denture tooth brands were used. The surfaces treatments of the denture teeth were processed using one of three methods and cleaned using one of two cleaning methods. The 144 upper central incisors were divided into 12 groups of 12 incisors. The mean and standard deviation color changes (ΔE) of the 12 groups at Weeks 1 and 6 are detailed in Table 1. The color changes were calculated using an equation and the L*a*b* color parameters of the upper central incisors at three time points: before the experiment, 1 week after the start of the experiment, and 6 weeks after the start of the experiment. Clinically, a color change greater than 3.5 (ΔE>3.5) is easily perceived by the naked eye. According to Table 1, the color changes of the Vita denture teeth cleaned by soaking in distilled water at Week 6 were 2.95 (±0.58), 1.43 (±0.78), and 10.51 (±1.01) for the G, G+P, and G+P+S

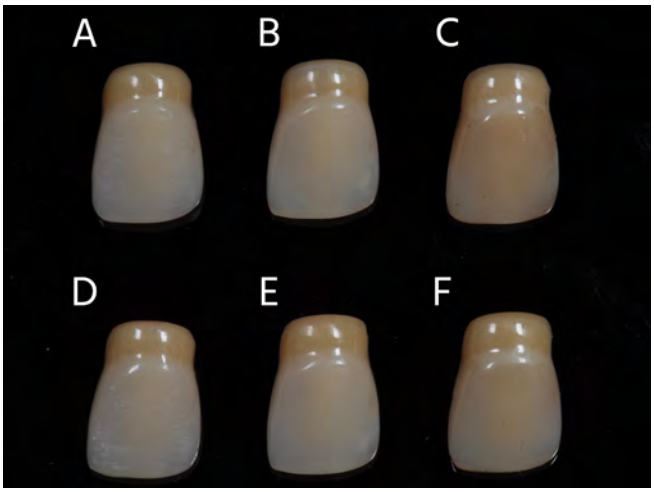

Fig 2: Final result of Ivoclar denture teeth,
A: G group cleaned by distilled water;
B: G+P group cleaned by distilled water;
C: G+P+S group cleaned by distilled water;
D: G group cleaned by denture cleanser;
E: G+P group cleaned by denture cleanser;
F: G+P+S group cleaned by denture cleanser.

groups, respectively. The greatest color change was that of the G+P+S group (ΔE > 3.5), followed by the G(ΔE < 3.5) and G+P groups(ΔE < 3.5). The color changes of the denture teeth cleaned by soaking in denture cleanser were 1.54 (±0.54), 1.07 (±0.46), and 5.39 (±1.47) for the G, G+P, and G+P+S groups, respectively. The greatest color change was that of the G+P+S group (ΔE > 3.5), followed by the G (ΔE < 3.5) and G+P (ΔE < 3.5) groups.

For the Ivoclar denture teeth (Fig.2), the color changes of the denture teeth cleaned by soaking in distilled water at Week 6 were 1.81 (±0.47), 1.62 (±0.54), and 10.10 (±3.33) for the G, G+P, and G+P+S groups, respectively. The greatest color change was that of the G+P+S group (ΔE > 3.5), followed by the G group (ΔE < 3.5) and G+P (ΔE < 3.5) group. The color changes of teeth cleaned by soaking in the denture cleanser were 1.81 (±1.06), 1.10 (±0.66), and 5.52 (±0.53) for the G , G+P, and G+P+S groups, respectively. The greatest color change was that of the G+P+S group (ΔE > 3.5), followed by the G (ΔE < 3.5) and G+P (ΔE < 3.5) groups.

Both the Ivoclar (without inorganic filler) and Vita (with inorganic filler) denture teeth were made of PMMA. The color change differences between the two denture tooth brands were obtained using differential analysis [*t*-test]) and displayed in Table 2. The Ivoclar denture teeth exhibited a color change of 3.82 (±3.47), whereas the Ivoclar denture teeth had a color change of 3.66 (±3.33). The *p* value of the *t*-test was 0.782, signifying no significant difference between the two brands in terms of their color changes. The results revealed that the presence of inorganic filler, which is generally believed to improve teeth resistance to wear, had no effect on denture teeth color stability.

Table 2. Differential analysis results of the color changes (ΔE) between denture tooth brands

			95% CI for Mean		T test
	Mean	SD	Lower Bound	Upper Bound	*P* Value
Vita	3.82	3.47	-0.963	1.276	0.782
Ivoclar	3.66	3.33			

In this study, denture teeth surfaces treatment were processed using three methods (i.e., G , G+P, and G+P+S). Multiple comparison analysis of the differences in color changes between the three groups is presented in Table 3, with pairwise comparisons being made. The *p* value for all pairs was <.05, signifying the significant effect of surface treatment method on color change and that the color changes were significantly different between the three groups.

Table 3. Multiple comparison analysis of the color changes (ΔE) between the three types of denture tooth surface processing methods

Dependent variable: ΔE LSD (1) Grinding		Average difference	Standard deviation	Significance	95% CI for Mean Lower Bound	95% CI for Mean Upper bound
Grinding	Grinding& Sealing	-5.85*	0.33998	0.000	-6.53	-5.18
	Grinding& Polish	0.73*	0.33998	0.034	0.05	1.40
Grinding& Sealing	Grinding	5.85*	0.33998	0.000	5.18	6.53
	Grinding& Polish	6.58*	0.33998	0.000	5.91	7.25
Grinding& Polish	Grinding	-0.73*	0.33998	0.034	-1.40	-0.05
	Grinding& Sealing	-6.58*	0.33998	0.000	-7.25	-5.91

* A *p*-value of <.05 denotes a significant difference.

The denture teeth soaked in coffee were cleaned using two types of cleaning solution: distilled water and denture cleanser. In this study, whether denture cleanser could remove denture tooth stains and enhance denture tooth color stability was investigated. Table 4 shows the differences in color changes between denture teeth soaked in denture cleanser and those that were not (data were obtained using differential analysis [*t*-test]). The color changes of denture teeth soaked in distilled water and those soaked in denture cleanser were 4.74 (±4.06) and 2.74 (±2.14) ($p < .001$), respectively. The denture teeth soaked in denture cleanser had superior color stability after 6 weeks, whereas those soaked in distilled water were darker ($\Delta E > 3.5$).

Table 5 shows the color changes and 3-way ANOVA results. Significant differences were discovered in the color changes between the teeth subject to different cleaning solutions and different denture surface treatment methods. In addition, the interaction between denture teeth brand and cleaning solution as well as that between denture surface treatment method and cleaning solution had a significant effect on color change.

Discussion

The staining of denture material is a complex process that is affected by factors such as material surface roughness and the interaction between chemical and physical elements. However, surface roughness is generally considered to be the main factor affecting the absorption of stains. Grinding changes the surface roughness of denture teeth, and study[13] have demonstrated that denture teeth polished using surface sealant are smoother than those polished using conventional polishing techniques. Ground denture teeth that do not contain inorganic fillers are smoother than ground denture teeth containing inorganic fillers. Study[12] have shown that smaller color changes were observed in denture teeth processed with surface sealant agent and those without inorganic fillers were after the teeth were soaked in colored solutions. In the present study, denture teeth coated with surface sealant underwent greater color changes, and inorganic filler did not have a significant effect on denture teeth color change; both these findings fail to support the findings of other studies. The difference may be because this study's denture teeth coated with surface sealant agents (i.e., Palaseal), despite having decreased surface roughness caused by grinding, are still stained by the colored solutions for the involved chemical and physical factors. However, this inference must be verified by subsequent studies.

Denture cleansers are believed to diminish denture stains[14] because they contain chemicals such as perborate that can induce oxidation, achieving the effects of bleaching and destaining. Studies [14-16] have demonstrated that denture cleansers enhance denture color stability. In the present study, the denture teeth soaked in denture cleanser and distilled water exhibited an average

Table 4. Differential analysis of the color changes between denture teeth soaked in denture cleanser or distilled water

			95% CI for Mean		T test
	Mean	SD	Lower Bound	Upper Bound	*P* Value
Distilled water	4.74	4.06	0.925	3.070	0.000***
Denture Cleanser	2.74	2.14			

Table 5. Color changes and 3-way ANOVA results

Dependent variable:ΔE					
Source	SS	df	MS	F	*P*
Brand	0.886	1	0.886	1.285	0.259
Clean	143.626	1	143.626	208.293	0.000
Surface treatment	1249.426	2	524.7131	905.991	0.000
Brand X Clean	3.162	1	3.162	4.586	0.034
Brand X Surface treatment	1.777	2	0.889	1.289	0.279
Clean X Surface treatment	146.920	2	73.460	106.535	0.000
Brand X Clean X Surface treatment	3.759	2	1.879	2.725	0.069
Error	91.019	132	0.690		

$p < .05$ denotes a significant difference.

color change of 2.74 (±2.14) and 4.74 (±4.04), respectively. The denture teeth soaked in denture cleanser thus had superior color stability, causing a color change that could not be perceived by the naked eye.

Conclusion

The results of this study support the clinical observation that coating the surface of denture teeth with surface sealant agent improves their luster but results in more staining after long-term use. These results can serve as a reference to dentists and dental technicians. In future studies, scholars may employ other surface sealants in discussion of the relationship between surface treatment and color changes. In this study, denture teeth soaked in denture cleanser exhibited superior color stability.

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