The Effectiveness of Denture Cleansers on Soft Denture Liners Colored by Food Colorant Solutions

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Purpose: **The aim of this study was to investigate the color stability of soft denture liners and the effectiveness of denture cleansers on soft denture liners colored by food colorants in different time periods.**

Materials and Methods: **A plasticized acrylic resin soft liner (Viscogel) and a silicone-based soft liner (Mollosil) were used in this study. From each material 30 specimens (a total of 60 specimens) were prepared in a Teflon mold 15 mm in diameter and 3 mm thick. The prepared specimens were stored in distilled water for 24 hours at 37°C. Initial color measurements of the specimens were made using a small-area colorimeter. The specimens of the two soft liners were divided into three groups each containing 10 specimens. The specimens of the first, second, and third group were immersed for 14 hours (2 hours × 7 days) in 3% erythrosine, tartrazine, and sunset yellow food colorant solutions, respectively. Then the second color measurements were made. After the second measurements, the specimens of each group were divided into two subgroups ($n = 5$) and were immersed in denture cleansers (Fittydent and Curadent Weekly) for 8 hours, and the third measurements were made. At the end of these procedures, the weekly simulation period was completed. The fourth, fifth, and sixth color measurements were made at the end of the simulation periods for 1, 2, and 3 months, respectively. Color difference (ΔE) values were calculated, and the derived data were analyzed using repeated measures analysis of variance for three-way classification and Bonferroni multiple comparison tests ($\alpha = 0.05$).**

Results: **There were significant differences between soft liners and cleansers in terms of color change. Mollosil demonstrated mean discoloration values (ΔE) between 0.81 and 2.66, Viscogel showed ΔE between 1.26 and 12.83. Viscogel exhibited slightly greater color changes than Mollosil and the results showed significant differences ($p < 0.001$). There was no significant difference between the food colorants ($p > 0.05$). Denture cleansers showed significant differences ($p < 0.001$). Fittydent demonstrated lower ΔE values than Curadent.**

Conclusion: **Silicone-based soft denture lining material seems to be more resistant to staining. With respect to denture cleansers, Fittydent was more effective than Curadent in this trial.**

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INDEX WORDS: denture cleanser, soft denture liner, color difference

THE USE OF SOFT denture liners has become increasingly popular for providing comfort for denture wearers. Soft denture liners are often used for patients who cannot tolerate a conventional denture base. These materials have several disadvantages, including color stability, long-term resiliency, abrasion resistance, bond strength, and porosity.[1-4]

There are many types of soft denture lining materials used for prosthetic purposes. Acrylic resins and silicone rubbers are often preferred. The acrylic resin materials are acrylic copolymers to which plasticizers may be added. Acrylic soft resins may absorb water, swell, and harden because of plasticizer leaching. For these reasons, their intraoral efficacy is short-lived.[5]

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Silicone rubber material is composed of polymers of dimethyl siloxane, which is a viscous liquid, cross-linked to give good elastic properties. These materials excel in their resiliencies and in their initial resistance to water absorption.[6] There is evidence that beverages like tea, coffee, and wine significantly increase the stain development on denture base polymers and soft denture liner materials.[7-9] Also, there is some knowledge about the changes in color stability of soft denture lining materials caused by denture cleansers;[10,11] however, there is no report on the effectiveness of denture cleansers on denture liners colored by food colorant solutions. Three commonly used food and beverage colorants, erythrosine, tartrazine, and sunset yellow, were used to measure discolorations of dentures. These three dyes are used in beverages, beverage powders, jellies, jams, candies, pudding, ice cream, and in many other food formulations. In general, these colorants are used at 0.02% to 0.1% concentration in foods and are highly soluble in water. Since they have electrostatic charges on their structures, they may stain surfaces.[9]

Difficulty in cleaning soft liners remains a disadvantage of these materials. Common daily methods for cleaning dentures include brushing and use of immersion cleaners.[10] Soft denture liner materials are known to undergo color changes through the use of denture cleansers and from the intake of fluids and foods.[6] The solutions used for denture cleaning can be divided according to their chemical compositions or mode of action: alkaline peroxide, alkaline hypochlorites, acids, disinfectants, mouth rinses for dentures, and enzymes.[12-16]

Tan et al[10] stated that after silicone resilient denture liner treatment with certain denture cleansers containing perborate, a greater amount of components could leach from the liner, leading to a loss of color if the liner surface is rough.

Jin et al[11] used denture cleansers as a simulative aging agent to soft liners, and they found that silicone soft liners were more stable in surface roughness and in color change than the acrylic soft liners.

Color stability is an important clinical property for all dental restorative materials[17-20] and is one of the criteria that provide information on the serviceability of these materials.[21] Color changes can be assessed by visual and instrumental determination. Visual color assessment depends on the observer's psychological responses to radiant energy stimulation.[22] Inconsistencies may result from uncontrolled factors such as fatigue, aging, emotions, lightening conditions, previous eye exposure, object and illuminant position, and metamerism;[22-28] however, visual color determination has been found to be unreliable, inconsistent, and also is a continuing problem in dental practice.[29] Instrumental color analysis offers a potential advantage over visual color determination, because instrumental readings are objective, can be quantified, and are more rapidly obtained.[30]

In assessing chromatic differences, generally two color systems are used: the Munsell Color System and Commission Internationale de L'Eclairage (CIE L*a*b*). According to these systems, all colors in nature are obtained through blending of three basic colors (red, blue, and green) in certain proportions. The CIE L*a*b* system represents three-dimensional color space having components of lightness (L*), red-green (a*), and yellow-blue (b*). An important aspect of the CIE L*a*b* system is that color differences between specimens can be given as a single parameter—ΔE. In examining various materials with regard to color, this technique is also used in dentistry research quite extensively.[31-34]

The aim of this study was to investigate the changes in color stability of soft denture liners and the effectiveness of denture cleansers on soft denture liners colored by food colorants in different time periods.

Materials and Methods

The materials used in this study are listed in Table 1. Mollosil is supplied as a base and catalyst system vulcanized at room temperature. Viscogel is composed of powder and liquid, also polymerized at room temperature. From each material 30 specimens were processed according to the manufacturers' instructions, in Teflon molds 15 mm in diameter and 3 mm thick, suitable for the head of the small-area colorimeter (Croma Meter II, Minolta Inc., Osaka, Japan). After polymerization the specimens were removed from the molds and trimmed with a sharp blade. They were stored in distilled water for 24 hours at 37°C. Then the excess water on the surface of the samples was removed using tissue paper, and the samples were allowed to dry. Subsequently, initial color measurements of the specimens were taken.

The dyes, which are used in food coloring, were prepared by dissolving 3 g of dye in 100 ml of distilled

Table 1. Materials Used

Type of Material	*Product*	*Code*	*Manufacturer*
Silicone polymer-based denture liner	Mollosil	M	Detax Karl Huber GmbH Co. KG, Ettlingen, Germany
Polymethyl/ethyl methacrylate polymer-based denture liner	Viscogel	V	Dentsply De Trey, GmbH Konstanz, Germany
Sodium perborate, sodium bicarbonate, potassium monopersulphate, trisodium phosphate	Fittydent	F	Fittydent International GmbH A-7423, Pinkafeld, Austria
Water, alkyethersulfate, citric acid, eucalyptus oil, methyldibromo glutaronitrile phenoxyethanol	Curadent	C	Curadent AG, Postfach 74, CH-6010, Kriens, Germany

water[9] (Table 2). Ten specimens of each material were used for each food colorant solution, and these specimens were subdivided into two groups to investigate the effect of two commercial denture cleansers on the discoloration of the soft denture liners (n = 5). To immerse the specimens into food colorant solutions and denture cleansers, 60 plastic containers were used, and all containers were coded so as not to misidentify the specimens.

The specimens were immersed in food colorant solutions for 14 hours to simulate the weekly exposure time with beverages or foods (2 hours × 7 days). After the samples were taken out of the solutions, they were rinsed with distilled water, and the excess water on the surface was removed using tissue paper and allowed to dry. Then the second color measurements were made. After measurements, the samples were immersed in denture cleansers for 8 hours, and the third measurements were made. In this manner, the weekly procedure was completed. Subsequently, the specimens were immersed in food colorant solutions preceding the immersion in denture cleansers as described previously. This cycle was repeated 12 times to simulate the 3-month usage of soft denture liners. In this period, the other color measurements were made at the end of the 4th, 8th, and 12th cycle.

The color measurements of the specimens were determined by a small-area colorimeter (Croma Meter II). The colorimeter was calibrated according to the manufacturer's instructions before each measurement period using the white calibration cap (CR-A43, Minolta Inc.) supplied by the manufacturer. Color changes (ΔE) were calculated by measuring tristimulus values at several wavelengths in the visual spectrum with the use of CIE L*a*b* color space. The color differences between the two specimens, each given in terms of L*, a*, and b* are calculated as follows:[25,35]

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

The color measurements (L*, a*, and b*) were analyzed using repeated measures analysis of variance for three-way classification (ANOVA), then the multiple comparison test (Bonferroni) was used to compare the mean differences.

Results

Means and standard deviations of the groups are presented in Table 3. Repeated measures ANOVA showed that there were significant differences between soft denture liners for color change

Table 2. Dyes Used

Dyes	*Chemical Name and Formula*	*Code*	*Manufacturer*
Erythrosine E 127 (200 mg/kg)	Xanthine, Disodium salt of 9-*o*-carboxyphenyl-6-hydoxy-2,4,5,7-tetraiodo-3-isoxanthone	e	FD&C Red no. 3 Warner Jenkinson, Chicago, IL
Tartrazine E102 (500 mg/kg)	Pyrazolone, Trisodium salt of 3-carboxy5-hydrozy-1-*p*-sulfophenyl-4-*p*-sulphophenylazo-pyrazole	t	FD&C Yellow no. 5 Warner Jenkinson, Chicago, IL
Sunset yellow E 110 (500 mg/kg)	Monoazo, Disodium salt of 1-*p*-sulfophenylazo-2-naphthol-6-sulfonic acid	s	FD&C Yellow no. 6 Warner Jenkinson, Chicago, IL

Table 3. Means and Standard Deviations of the Color Change (ΔE) of the Soft Lining Materials at Different Time Periods

Groups	*Initial—Colorant Mean ± SD*	*Initial—1 Week Mean ± SD*	*Initial—1 Month Mean ± SD*	*Initial—2 Month* Mean ± SD	*Initial—3 Month Mean ± SD*
MtF	2.02 ± 1.32	1.57 ± 0.87	1.21 ± 0.58	0.98 ± 0.46	1.68 ± 1.05
MtC	2.44 ± 1.12	1.91 ± 0.82	2.03 ± 0.58	1.91 ± 0.25	1.88 ± 0.84
MeF	2.66 ± 0.97	1.46 ± 0.88	0.93 ± 0.14	1.48 ± 0.54	1.69 ± 0.80
MeC	1.88 ± 1.10	1.20 ± 0.80	1.17 ± 0.60	1.79 ± 0.95	1.39 ± 0.85
MsF	1.58 ± 0.41	1.08 ± 0.78	0.93 ± 0.61	0.95 ± 0.44	1.22 ± 0.42
MsC	1.66 ± 0.74	0.96 ± 0.66	1.41 ± 0.76	1.03 ± 0.50	0.81 ± 0.42
VtF	11.37 ± 1.86	2.52 ± 1.58	1.26 ± 0.48	1.56 ± 0.93	1.76 ± 1.32
VtC	12.83 ± 5.69	3.11 ± 1.23	3.57 ± 1.26	3.52 ± 0.80	3.49 ± 1.66
VeF	11.61 ± 2.89	1.46 ± 0.72	2.39 ± 0.96	3.17 ± 1.29	2.25 ± 0.99
VeC	9.89 ± 2.35	3.05 ± 0.60	4.28 ± 1.43	4.16 ± 1.31	3.50 ± 1.77
VsF	11.40 ± 3.49	2.00 ± 1.15	1.95 ± 0.88	2.91 ± 1.21	2.12 ± 1.15
VsC	8.86 ± 1.88	3.78 ± 0.91	5.22 ± 0.71	5.24 ± 0.83	3.09 ± 0.68

($p < 0.001$) (Table 4). Mollosil demonstrated mean discoloration values (ΔE) between 0.81 and 2.66; Viscogel showed ΔE between 1.26 and 12.83. Viscogel exhibited slightly greater color changes than Mollosil, and the results showed significant differences ($p < 0.001$). There was no significant difference between the food colorant solutions ($p > 0.05$) (Fig 1). The result of the statistical analysis showed that there was a significant difference between the effects of denture cleansers ($p < 0.001$). Generally, Fittydent demonstrated lower ΔE values than Curadent. When the ΔE values were compared according to different time periods, only the first ΔE values, which were obtained with the initial color measurement, and the measurement after the immersion in food colorant solutions were found significant. However, there were no significant differences between the other time periods ($p > 0.05$) (Fig 2).

Discussion

In the present study, the effects of denture cleansers and food colorant solutions on the color stability of two soft denture liners were investigated and compared with the values obtained after 1-week, and 1-, 2-, and 3-month storage times. The color change of soft lining materials are attributed to changes in the colorants used, a change in color of the elastomer, or both.[19]

The results of this study showed that soft denture liners and the denture cleansers affected color change ($p < 0.001$), while there was no significant difference among the food colorant groups ($p > 0.05$). Viscogel stained more than Mollosil with all food colorant solutions. This result could be explained by the chemical structure of soft denture liners. Viscogel is a polymethyl/ethyl methacrylate with a plasticizer, dibutyl phthalate.

Table 4. Repeated Measures Analysis of Variance for Three-Way Classification

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	p
Intercept	2797.212	1	2797.212	1017.522	0.001
Reliner materials	696.318	1	696.318	253.295	0.001
Dyes	3.110	2	1.555	0.566	0.572
Denture cleansers	36.268	1	36.268	13.193	0.001
Reliner*dyes	7.869	2	3.934	1.431	0.249
Reliner*denture cleansers	18.324	1	18.324	6.665	0.013
Dyes*denture cleansers	5.799	2	2.899	1.055	0.356
Reliner*dyes*denture cleansers	0.499	2	0.249	0.091	0.913
Error	131.954	48	2.749		

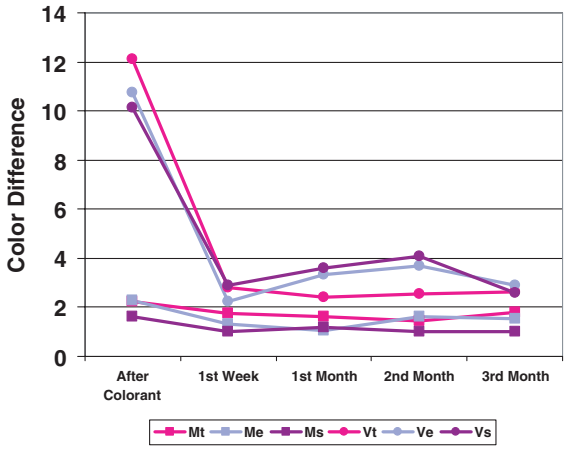

Figure 1. The color changes of soft denture liners in food colorants (Mt = Mollosil in tartrazine; Me = Mollosil in erythrosine; Ms = Mollosil in sunset yellow; Vt = Viscogel in tartrazine; Ve = Viscogel in erythrosine; Vs = Viscogel in sunset yellow) for different time periods.

Polymethyl/ethyl methacrylate polymer is hydrophilic, attracting water soluble dyes to the surface of the lining material as a result of electrostatic charges;[9] however, silicone-type polymer Mollosil is a hydrophobic and inert nonwettable polymer, so it could be more resistant to color change than Viscogel.

The staining observed with Viscogel may also be related to the differences in water sorption exhibited by the liner. The degree of absorption is dependent upon the chemical composition of the polymer. Water or saliva can be absorbed into the material, and plasticizers or other constituents of the soft lining material can be leached.[36,37] Canay et al[9] evaluated the color changes of soft lining materials in food colorant solutions and reported that polymethyl/ethyl methacrylate-based soft denture liner produced slightly larger color changes than silicone-based soft liners.

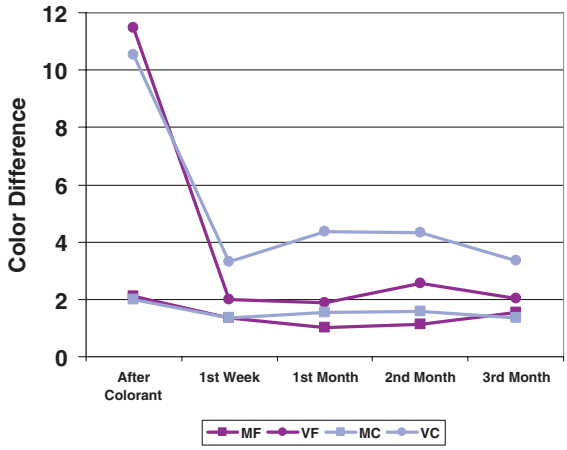

Figure 2. The color changes of soft denture liners in denture cleansers (MF = Mollosil in Fittydent; VF = Viscogel in Fittydent; MC = Mollosil in Curadent; VC = Viscogel in Curadent) for different time periods.

Johnston and Kao[33] observed that if ΔE is less than 1, this colorimetric value is deemed to be very small and is clinically undetectable. Between 1 and 2, the color difference is clinically acceptable; however, there is some controversy in the literature with regard to which ΔE values can actually be seen by the naked eye or are clinically relevant.[38] Some investigators assume that ΔEs from 2 to 3 are just visible;[38] Seghi et al[39] state a ΔE value of 1 as a distinguishable value. Ruyter et al[40] described discoloration of $\Delta E > 3.3$ as no longer clinically acceptable. In the present study, after food colorant solutions, Mollosil specimens had a ΔE between 1.58 and 2.66, and were at clinically acceptable levels. However, Viscogel had ΔEs between 8.86 and 12.83, which may be clinically noticeable.

The solutions tested in this study are used in beverages and may cause staining. Canay et al[9] used the same dyes in their study that investigated the effect of dyes on the color changes of soft liners. They reported that sunset yellow was the more staining dye. In the present study, there was no significant difference between the food colorant solutions (Fig 1); however, the samples were immersed in denture cleansers after dye exposure. Denture cleansers could affect this result, since it has been reported that denture cleansers can cause loss of soluble components and plasticizers, or absorption of water or saliva by the soft lining materials.[37,41-43]

Significant differences were found between the two denture cleansers, with Viscogel being more affected. This result could also be attributed to more water absorption due to Viscogel's methylmethacrylate structure. It was stated that plasticized acrylic resin soft liners had higher solubility and sorption than silicone-based soft liners.[44]

With respect to denture cleansers, Fittydent was more effective than Curadent on removing coloration of the soft liners (Fig 2). This is probably related to an effervescent tab form of Fittydent and its chemical composition, which includes sodium perborate, sodium bicarbonate, etc. When

these effervescent tabs dissolve in water, sodium perborate decomposes to form an alkaline peroxide solution. This peroxide solution subsequently releases oxygen, which is reported to loosen debris via mechanical means.[45] Curadent contains citric acid, eucalyptus oil, and alkyethersulfate. Citric acid releases plaque from the prosthesis, the microscopically fine eucalyptus oil film seals the surface of the prosthesis, and alkyethersulfate stabilizes and strengthens the action of the citric acid.

When the effects of food colorants and denture cleansers were examined according to different time period, it was seen that there was a significant difference between the first ΔE values which were obtained after immersion in food colorant solutions, and the other ΔE values; however, after the use of denture cleansers, little or no color differences were found between the different time periods ($p > 0.05$) (Fig 2).

Conclusions

Under the conditions of the present study, the following conclusions were drawn:

1. Silicone-based soft lining material (Mollosil) seemed to be more resistant to staining ($p < 0.001$).
2. Fittydent denture cleanser was more effective than Curadent on removing discoloration of the colored soft liners ($p < 0.001$).
3. The colors of soft denture liners were found to be stable, and few changes occurred with the use of denture cleansers for different time periods ($p > 0.05$).

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