**Original Article**

# Evaluation of the Effect of Household Cleansers on the Color Change of Two Types of Permanent Soft Liners: An In Vitro Study

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## Abstract

**Introduction:** Many patients use household cleaners to clean denture which can cause discoloration and damage soft liners. The purpose of this study was to evaluate the effect of household cleansers on the color change of two types of permanent soft liners. **Methods:** In this interventional study, 80 permanent silicone soft liners, including 40 heat-cured liners (Molloplast-B, Detax Gmbh & Co. KG, Ettlingen, Germany) and 40 self-cure liners (Mucopren soft, Kettenbach GmbH & Co. KG, Eschenburg, Germany) were made in brass molds with dimensions of 15×2 mm in accordance with the manufacturer's instructions. The samples were immersed in distilled water for 24h and the initial color was determined using a colorimeter. Then, each group (n=10) was immersed for 8h daily in 2.5% vinegar, 2.5% hypochlorite, 2.5% hand washing liquid, and distilled water (control). Color measurements were performed after 7 and 30 days of immersion in solutions and data were analyzed using ANOVA, independent t-test, and Tukey's post hoc tests. **Results:** In distilled water, hypochlorite, and vinegar, the mean color change after one month was significantly lower in Molloplast-B than Mucopren (P=0.042, P<0.001, P=0.002); however, in Hand washing, the difference was not significant (P=0.780). **Conclusion:** The mean color change in Mucopren in all cleansers was higher than Molloplast-B, and the highest change in color was observed in both liners in hypochlorite.

**Keywords:** Soft liner material, Color change, Household cleansers

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## Introduction

Removable dentures are alternatives for missing teeth, and their success depends on aesthetics, function, and patients' comfort. In edentulous patients, denture's pressure is directly delivered to the underlying mucosa by means of acrylic resin, which causes tissue damage and bone resorption (1). Soft liners are substances introduced to the market in order to solve this problem and have been used extensively in removable dentures for over a century (2). Due to their elastic property, these substances are widely used in patients who cannot tolerate the prosthesis, or patients with ridge resorption, sensitive mucosa, bone resorption, and bruxism (3). Moreover, these substances can equally distribute the pressure of the prosthesis and reduce occlusal forces (4).

Soft liners can be classified into resin or acrylic, self-cured, or heat-cured. In addition, considering the time used, they are divided into two categories, namely permanent or provisional. Provisional soft liners are soft liners that can maintain their softness and elasticity for a maximum of 30 days, whereas permanent soft liners can

be utilized for more than 30 days even for months or years as some studies suggest (5). These substances require some properties, such as compatibility with the oral tissue, shape and colour stability, resistance to wearing, strong bond to the denture, and also resistance against the dynamic situation of the oral cavity. These properties should not be affected by cleaning methods (6).

The liners' color stability is an important criterion to assess their functional ability; moreover, color change indicates aging and damage which have a negative impact on patients' satisfaction (7).

Since the structure and surface roughness of these substances lead to the colonization of microorganisms (8), patients should regularly perform the cleaning methods which can cause alteration in some of the liners properties, such as discoloration, swelling and water absorption, imbibition, and microorganism's growth (9).

The most common and effective way to remove the biofilm from the denture's surface is the utilization of the chemical cleansers besides the mechanical methods (10). Household cleaners are among the cleansers which are used by many patients due to their accessibility. These cleansers are cheap and can normally be found at homes (11). Daily use of these cleaners affect the physical and mechanical properties of these liners and can lead to discoloration and esthetics defects which eventually results in spending more time and expense on their repair.

Sometimes, the patient is satisfied with the prosthesis and feels comfortable with it; however, the issue of aesthetics is the reason behind the patient's dissatisfaction (12, 13). Therefore, the color stability of the liners is of great importance, and it is necessary to choose the right and ideal cleansers to reduce possible alterations (14). Although these cleaners are used by the majority of people, there is a dearth of research investigating the effects of cleansers on the liners. Furthermore, it is of utmost importance to find a suitable therapeutic method to disinfect the dentures without harming their mechanical properties (15, 16). Therefore, this study was conducted to determine the effect of household cleansers on the color change of soft liners which was an important indicator for their replacement. To this end, this study also attempted to enhance the people's knowledge about the effect of household cleansers on the quality of the prosthesis.

## Materials and Methods

Table I presents the materials used in this study (i.e., 40 heat-cured and 40 self-cured silicon liners). In order to make the samples, 65×40×6 mm brass mold with 3 separate and attachable plates was made using screws (Figure 1). The upper and lower plates were flat in order to prepare a smooth surface for liners, and the middle plate had six 15×2 mm cylindrical spaces for soft liners (1).

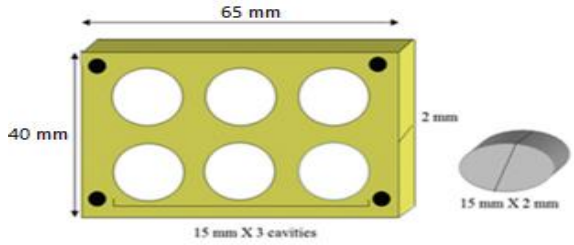


**Figure 1**. The dimension of a brass mold

***Fabrication of heat-cured soft liners is as follows:***

The inner surface of the mold was greased by Vaseline to facilitate the extraction of soft liners to make Molloplast-B samples. Then, the soft liners were placed in the spaces using a clean plastic spatula. Three plates of the mold were attached to each other, the excess liners were removed using a scalpel, and the molds were placed under a pressure of 100 KP for 10-15 min. For polymerization, the molds were placed in the cold water inside the curing units (Polymerizer FOR MUFLAS M-9 MESTRA, SPAIN). In this unit, the temperature gradually increases up to 100C/121F and remains in this situation for 2 h. Subsequently, the samples cool down slowly. It should be noted that the process of curing the soft liner was followed according to the manufacturers' instructions.

***Fabrication of self-cured soft liners is as follows:***

Soft liners were injected into the molds. The molds were put under pressure so that the excess liners would be evacuated to make Mucopren soft samples. Then, excess liners were removed using a scalpel. For completion of polymerization, molds were placed in the 45-50 °c water according to the manufacturers' instruction. After polishing the samples, 80 samples of soft liners with a size of 15×2 mm were made in this study. All samples were immersed in distilled water for 24 h (2).

***Colour measurement of the samples is as follows:***

After the determination of the initial color by a colorimeter device (Konica Minolta CR-400, JAPAN), each of the 40 self-cured and heat-cured samples of silicone soft liners were randomly divided into 4 groups. Each group was immersed in either distilled water, 2.5% white vinegar, 2.5% bleaching hypochlorite sodium solution, or 2.5% hand washing liquid for 8 h at the room temperature (Figure 2), and for the rest of the day, they were placed in distilled water (13,17,18) (Table I).

Solutions were changed daily, and samples were washed by distilled water and dried in the open air (2). The color of soft liners was measured after 7 and 30 days using a colorimeter device.

**Figure 2.** Samples distilled in cleansers

Colorimeter device determines the color variations using three indices, namely L*, a*, and b*. The L* indicates lightness and has a range between 0 (black) and 100 (white). Moreover, the positive and negative values of a* show red and green colors, respectively. Regarding b*, positive and negative values signify yellow and blue colors, respectively. Color change in samples was calculated using the following formula:

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

The data were analyzed using SPSS software (version 23). In addition, the Shapiro-Wilk test was used to evaluate the normal distribution of the data. Since the data were distributed normally, the analysis of variance (ANOVA) was applied for the analysis of the four sample groups. Furthermore, Tukey's post hoc and independent-sample t-test were employed for the paired comparison of the groups. A P-value less than 0.05 was considered statistically significant.

## Results

According to the results obtained from ANOVA to study the discoloration, an association was observed between the type of the liner and that of the cleanser (P<0.001). In addition, there was a statistically significant difference between the cleansers regardless of the soft liner type (P<0.001). Moreover, a statistically significant difference was found between the two types of soft liners regardless of the cleansers type (P<0.001) (Figure 3).

**The following results are obtained from independent t-test after one week and one month:**

The mean color change using distilled water, white vinegar, and hypochlorite sodium was significantly lower after one week in the Molloplast-B group, compared to the Mucopren soft group (P=0.001, P<0.001, and P<0.001, respectively). However, regarding the hand washing liquid, the Molloplast-B group obtained a higher number of discoloration, compared to Mucopren soft liner, which was not statistically significant (P=0.331, Table II).

Furthermore, the mean discoloration using distilled water, white vinegar, and hypochlorite sodium cleansers after a month was significantly lower in the Molloplast-B group, compared to Mucopren soft liner (P=0.004, P<0.001, and P=0.002, respectively). However, the mean discoloration was lower in the Molloplast-B group, compared to Mucopren considering hand washing liquid (Figure 4). It is worth mentioning that this difference was not statistically significant (P=0.780, Table III)

**Table I.** Commercial name, materials, and manufacturer used in the study

| Manufacturer | Curing type | Chemical type | Materials |
|---|---|---|---|
| Kettenbach GmbH & Co. KG, Eschenburg, Germany | Self-curing | Silicone-base material | Mucopren soft |
| Detax Gmbh & Co. KG, Ettlingen, Germany | Heat-curing | Silicone-base material | Molloplast-B 45g |
| Heinz Co, America | | Acetic acid | Heinz distilled white vinegar 5% |
| Agrado cosmetic Co, Spain | | Sodium lauryl sulfate | AGRADO cosmetic hand washing liquid 500ml |
| Clorox chemical Co, America | | Sodium hypochlorite | Clorox Bleach original (6% sodium hypochlorite) |

**Table II.** Comparison of discoloration between soft liners after a week sorted by the cleansers

| Results of independent t-test | Standard deviation | Mean | Soft liner | Cleanser |
|---|---|---|---|---|
| t=3.84 | 0.33 | 1.07 | Molloplast | Distilled water |
| P=0.001 | 0.38 | 1.68 | Mucopren | |
| t=10.47 | 0.21 | 1.22 | Molloplast | Sodium hypochlorite |
| P<0.001 | 0.35 | 2.58 | Mucopren | |
| t=13.79 | 0.21 | 1.30 | Molloplast | Vinegar |
| P<0.001 | 0.56 | 3.92 | Mucopren | |
| t=1.00 | 0.51 | 1.34 | Molloplast | Hand washing liquid |
| P=0.331 | 0.32 | 1.15 | Mucopren | |

**Table III.** Comparison of discoloration between soft liners after a month sorted by the cleansers

| Results of independent t-test | Standard deviation | Mean | Soft liner | Cleanser |
|---|---|---|---|---|
| t=2.19 | 0.516 | 1.32 | Molloplast | Distilled water |
| P=0.042 | 0.31 | 1.74 | Mucopren | |
| t=42.41 | 0.35 | 2.62 | Molloplast | Sodium hypochlorite |
| P<0.001 | 0.54 | 11.27 | Mucopren | |
| t=4.27 | 0.55 | 1.57 | Molloplast | Vinegar |
| P=0.002 | 2.72 | 5.32 | Mucopren | |
| t=0.28 | 0.92 | 1.68 | Molloplast | Hand washing liquid |
| P=0.780 | 0.51 | 1.78 | Mucopren | |

According to the results obtained from two-by-two comparisons of cleansers using Tukey's post hoc test for the Molloplast-B group, it was shown that the mean color change in sodium hypochlorite group was significantly higher than that in other cleansers. However, no significant difference was observed among the other cleansers. With regard to Mucopren soft liner, the results of Tukey's post hoc test suggested that the mean color change was significantly higher in the sodium hypochlorite group, compared to others. It should be noted that the difference between distilled water and handwashing liquid was not statistically significant (Table IV).

**Table IV.** Pairwise comparisons of the cleansers regarding the discoloration of the soft liners after one month using Tukey's post hoc

| Mucopren | Molloplast-B | Second cleanser | First cleanser |
|---|---|---|---|
| P-Value | P-Value | | |
| *<0.001 | *<0.001 | Sodium hypochlorite | Distilled water |
| *0.11 | 0.733 | Vinegar | |
| 0.997 | 0.706 | Hand washing liquid | |
| *<0.001 | *0.001 | Vinegar | Sodium hypochlorite |
| *<0.001 | *0.048 | Hand washing liquid | |
| *0.11 | 0/986 | Hand washing liquid | Vinegar |

***The difference between the two groups is significant.

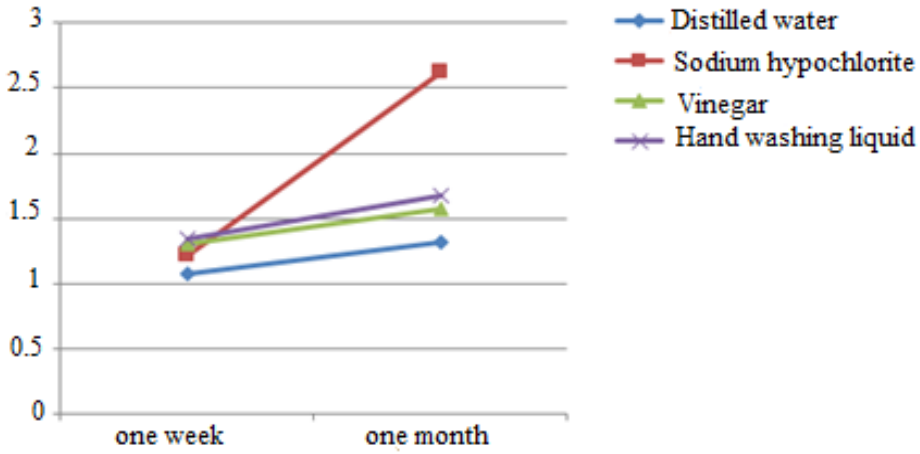


**Figure 3.** Effect of cleansers on the discoloration of Molloplast-B soft liner based on time

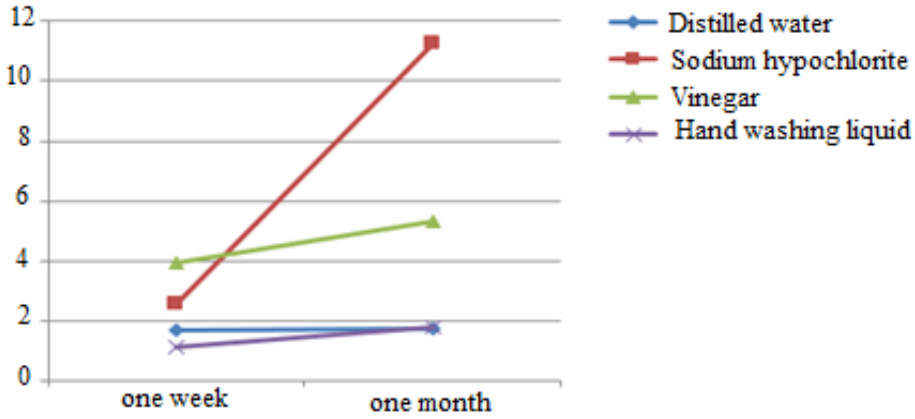


**Figure 4.** Effect of cleansers on the discoloration of Mucopren soft liner based on time

## Discussion

The process of denture cleaning is an important aspect of oral hygiene since denture is a place for the accumulation of food and also the growth of bacteria and fungi. This condition is aggravated in soft liners due to their increased porosity. In order to prevent these problems, the utilization of chemical cleansers is considered a matter of importance (2, 19). Moreover, mechanical methods are not effective enough to reduce the number of microorganisms solely, and the use of cleansers can affect the mechanical and chemical properties of the soft liners. Therefore, it is necessary to choose a suitable and ideal cleanser to reduce the number of possible changes (20).

Sodium hypochlorite (i.e., diluted home bleachers) is effectively utilized in cleaning dentures by removing plaque and mild stains which is able to break the bond of organisms to the denture. High concentrations of sodium hypochlorite solution can cause discoloration of the denture in the long term. Diluted acids, such as citric acid or household vinegar are used to clean the residues, disinfect wounds, as well as control the inflammatory processes of the oropharynx and anti-fungal solutions (12, 21).

With this background in mind, this study aimed to investigate the effect of these common, accessible, and affordable household cleaners. These cleansers are relatively easy to be utilized and are employed by most of the people (22), whereas the utilization of denture cleansers which have been assessed in most of the studies (4, 18, 23) is limited due to lack of information, high prices, and also low accessibility (10). In this study, the concentration of cleansers and the duration of immersion were determined based on the previous studies (13, 17, 18).

This study employed the CIE Lab system due to its wide use to assess color variations based on the recommendations by the American Diabetes Association. Color variations are demonstrated by ΔE in this system (2).

Based on this classification, after a week, the amount of color change was at a clinically acceptable level (ΔE=2.58) in Mucopren soft liners using a 2.5% sodium hypochlorite solution. In a study conducted by Pisani et

al. (3), the amount of color change was at a good level (ΔE=1.83) after one week of immersion in 1% hypochlorite sodium. Moreover, after one month in our study, the amount of color change in this solution was in the mismatch level which was clinically significant (ΔE=11.27). These results are in accordance with the findings of a study performed by Pisani et al. (3) (ΔE=5.17). The observed differences between these two studies regarding ΔE might be attributed to the concentration of sodium hypochlorite and the duration of immersion. In the present study, the highest color change in both soft liners was observed in sodium hypochlorite solution which is in accordance with the results obtained from a study by Pisani et al. (3).

An important factor in discoloration caused by sodium hypochlorite is the temperature of the solution. According to Devlin et al. (24), the number of discoloration increases as the temperature rises. Therefore, one of the reasons for variations among different studies can be attributed to diversities in chemical interactions at different temperatures. Accordingly, in order to prevent such interactions and also considering the fact that cleansers are normally used in the room temperature, the immersion method was employed in the room temperature.

In this study, in all cleansers, except hand washing liquid, the number of discoloration in self-cure silicone soft liners was significantly higher than that in the heat-cured silicon soft liners. There was also no significant difference regarding discoloration among all cleansers, except sodium hypochlorite in heat-cured silicone soft liners, whereas the color change of self-cured soft liners was significant in cleansers. Therefore, based on these findings, the application of heat-cured resins is recommended due to more stability of color. These results are in line with the findings of studies conducted by Anil et al. (25), Yanikog˘lu et al. (26) and Jin et al. (23).

Soft liner discoloration depends on internal and external factors. The internal discoloration occurs in the liner's polymer matrix due to physical and chemical reactions and external discoloration relates to the absorption of external stains and coarseness of the related surface (27). In the present study, all samples were finished to eliminate the superficial coarseness and had smooth surfaces. The reason behind the significant difference between the color of these two auto polymerized and heat-cured soft liners is due to the high rate of polymerization in heat-cured liners (26). Therefore, based on the results of this study, the employment of heat-cured soft liners is more recommended because they are less susceptible to discoloration.

The handwashing liquid used in this study led to little discoloration in both soft liners which is clinically acceptable. Due to the lack of similar studies regarding the effect of this cleanser on liners, this study can prepare the ground for further studies regarding the effect of this cleaner on the prevention of colonization of bacteria and fungi on the denture's surface, the strength of bond with acryl, and also other important properties of the liners. Despite the lack of similar studies, the main component of this cleanser is Sodium Lauryl Sulfate (SLS) which is similar to the Clinsodent® denture cleanser which was used in the studies performed by Kumar et al. (11) and Dhamande et al. (28). The results of these two studies suggested that this cleanser (i.e., Clinsodent®) effectively reduced the activity of fungi, especially Candida which was related to the presence of SLS in this cleanser.

The major limitation of this study was the in-vitro situation. Patients do not regularly clean their dentures, whereas this happens routinely in an in-vitro situation. Therefore, clinical findings must be less than what is observed in the in-vitro situation. Another limitation is the difference between the concentrations of solutions used by the patients. Moreover, this study only investigated the change of color in soft liners, whereas other important features, such as surface roughness, bonding strength to the acryl, and viscoelastic and anti-microbial properties of cleansers which are issues of clinical interest have not been investigated in this study.

## Conclusion

It can be concluded that the mean number of discoloration in all cleansers was higher in the Mucopren group, compared to Molloplast-B. Moreover, the highest amount of color change in both soft liners was observed in sodium hypochlorite and the lowest change was observed using vinegar in the Molloplast-B group.

Additionally, the mean number of discoloration after a period of one month was only in Mucopren soft liners which were immersed in sodium hypochlorite or vinegar which was clinically significant.


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## Conflicts of interest

None declared.

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