Received: 20th January 2015 Accepted: 03rd April 2016 Conflict of Interest: None

Source of Support: Nil

Original Research

Doi: 10.2047/jioh-08-06-14

Effect of Denture Cleansers on the Color Changes of Thermoplastic Denture Base Material

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How to cite the article:

Hafezeqoran A, Ghanizadeh M, Rahbar M, Koodaryan R. Effect of denture cleansers on the color changes of thermoplastic denture base material. J Int Oral Health 2016;8(6):716-719.

Abstract:

Background: The aim of this study was to investigate the effects of three denture cleaners (sodium hypochlorite, professional, and dentipur) on the possible color changes of thermoplastic denture base materials.

Materials and Methods: A total of 88 thermoplastic resins samples were randomly divided into four groups (n = 22) for computer-assisted analysis of photographs within the L* a* b* color space system. The high-resolution digital images of the samples were taken using a digital camera under standardized conditions and saved in RAW format; then the images were imported into Adobe Photoshop CS4 for shade analysis. Mean and standard deviations were calculated for all cleansers. One-way ANOVA with Tukey's HSD post-hoc analyses was performed to compare all the chromatic ordinates L*, a* and b* of the study groups. $P < 0.05$ was considered statistically significant.

Results: One-way ANOVA showed that the type of denture cleanser influenced the color changes and the differences among the study groups were statistically significant ($P < 0.001$).

Conclusions: All three cleansers showed observable color changes up to very much level and thus were unacceptable for cleaning thermoplastic materials.

Key Words: Color changes, denture cleanser, thermoplastic polymer

Introduction

Denture cleaning methods are classified into mechanical and chemical cleaning. In mechanical cleaning, plaque is removed with brushes, toothpastes, powders, and ultrasonic methods;[1,2] while chemical cleaners such as hydrochloride alkaline, alkaline peroxide, diluted acids, disinfectants, and enzymes attack microorganisms.[3,4] Chemical cleansers are more effective in removing dental plaque and thus the prevention of denture stomatitis compared with mechanical cleaners, and is particularly suited for the elderly and disabled.[5-7] Nonetheless, daily uses of chemical cleansers adversely affect the physical and mechanical properties of denture base materials and may also cause permanent discoloration.[1,5,8] Color stability is an important factor for dental materials; color alterations due to the aging process or any damage to the denture base material affect the esthetic results. Thus, selection of proper cleansing agents for a specific denture base material is essential to the success of the treatment.[9]

Color changes of denture base resins are affected by the type of cleanser. Sodium hypochlorite as a denture cleanser results in the whitening of acrylic resins and leaves many patients dissatisfied with the esthetic results. According to Hong *et al*., alkaline peroxide type denture cleaner caused more color stability of acrylic denture base resins than other types of cleansers; while acid type cleanser resulted in the least denture base discoloration.[9-11] Peracini studied color changes of heat-polymerized acrylic resins after exposure to various denture cleanser solutions and found no significant differences.[12]

In recent years, thermoplastic polymers are widely used as denture base materials due to their translucency, flexibility, higher strength, lack of free monomers, and biocompatibility.[13] Based on the literature review, studies have mainly focused on the mechanical properties of these materials, but limited published information is available on the color stability of thermoplastic polymers after aging.[14-16] The aim of this study was to investigate the effect of three denture cleaners on the possible color changes of the thermoplastic denture base materials. The null hypothesis of the study was that the cleansers would not change the color of thermoplastic denture base materials.

Materials and Methods

One commercial available thermoplastic polyamide resin (Vertex-Detal; Zeist, The Netherlands) was evaluated in this study. Pink colored resin was chosen due to its common application in prosthetic rehabilitation.

88 Wax patterns (5 mm × 5 mm × 10 mm) were prepared and invested according to manufacturer's instructions. After wax elimination softened thermoplastic resin was injected into the flask at a temperature of 270-288°C, and then the flask was left

to bench cool for 2 h. After completion of the polymerization, the samples were removed from the molds and polished.

Samples were finished by using tungsten steel bur (MaxiCut; Malleifer SA, Ballaigues, Switzerland) and 180-, 220-, 360-, and 400-grit silicon carbide abrasive papers (Norton, Saint-Gobain Abrasivos Ltd., Guarulhos, Brazil). Then all surfaces were polished with pumice slurry. To standardize surface roughness, all polishing procedures were performed by only one person and gentle hand pressure for 60 s.[17] Polished samples were evaluated under a ×20 magnifier and randomly divided into four groups ($n = 22$).

The high-resolution digital images of the samples were taken using a digital camera (Canon EOS 450D, 12.2 MP; Canon Inc, Tokyo, Japan) with a macro lens (Canon EF 100 mm F2.8 macro USM) under standardized conditions (Exposure: 1/200 s, aperture: f/22; white balance flash: 5500 Ko) from a distance of 20 cm. The images were saved in RAW format. Images were imported into Adobe Photoshop CS4 for shade analysis within the CIE L* a* b* system.[18,19] ANOVA test was performed to evaluate the initial shade matching of all samples, and the results proved that all the chromatic ordinates L*, a* and b* of the study groups, had no significant difference ($P > 0.05$). Therefore, initial color of all the samples was the same.

On the basis of the denture cleanser, samples were randomly divided into four groups ($n = 22$). Three different denture cleansers were selected with distilled water as the control group. Samples of group S were immersed in 2.5% sodium hypochlorite, Group D in Dentipur (Helago-Pharma GmbH; Bonn, Germany), and group P in Professional (Bonyf GAC; Vaduz, Liechtenstein) solution for 15 min at 20°C in accordance with the manufacturer's instructions. Samples in the control group (C) were immersed in distilled water at 20°C. Then they were washed with tap water and distilled water, dried with paper absorbent, and stored in distilled water. This experiment was repeated each day for 2 months.

Color changes were calculated using CIE L* a* b* system after immersion period and were compared with the control group. The color difference (ΔE) of each sample was calculated by the following formulas:

$$\Delta E = \sqrt{(\Delta a)^2 + (\Delta b)^2 + (\Delta L)^2}$$

$$\Delta L^* = L_1 - L_0,\ \Delta a^* = a_1 - a_0,\ \Delta b^* = b_1 - b_0$$

b_0 = before immersion, L_1, a_1, b_1 = after 2-month cleaning

The color changes (ΔE) were quantified by the NBS (National Bureau of Standards) units of color difference and the following formula:[20]

$$\text{NBS unit} = \Delta E \times 0.92$$

Descriptions of color difference according to the NBS are summarized in Table 1. Statistical analysis was performed using SPSS statistical software. Mean and standard deviations (SD) were calculated for all cleansers. Normality of the data was evaluated by quantile-quantile plot (QQ plot) and Kolmogorove–Smirnov test. Then one-way ANOVA with Tukey's HSD *post-hoc* analyses was performed to compare the solution-based color changes. $P < 0.05$ was considered statistically significant.

Results

Mean color changes (ΔE) and SD are shown in Table 2. Group S yielded the highest ΔE values (13.83 ± 0.2.12), and control specimens yielded the lowest (0.28 ± 0.73). One-way ANOVA indicated that the type of denture cleanser influenced the color alterations, and the difference was statistically significant ($P < 0.001$). Further analyses using Tukey's HSD *post-hoc* test revealed that the color changes in group S were significantly higher than group P and D ($P = 0.034$ and $P < 0.001$, respectively). Moreover, color changes in group P were higher than group D ($P = 0.016$).

Table 3 shows the mean color changes of samples after conversion of the values to NBS units. All three groups showed clinically detectable color changes up to very much level.

Discussion

Color stability of denture base materials is an important factor affecting patient satisfaction and prosthesis acceptance.[9,21] In this study, the color changes of three different cleansers, sodium

Table 1: Descriptions of color difference according to the NBS.[20]

Description of color difference	NBS unit
Trace	0.0-0.5
Slight	0.5-1.5
Noticeable	1.5-3.0
Appreciable	3.0-6.0
Much	6.0-12.0
Very much	>12.0

NBS: National Bureau of Standards

Table 2: Mean color changes (ΔE) and SD of study groups (n=22).

Study groups	Mean (SD)
C	0.28 (0.73)[a]
S	13.83 (2.12)[b]
P	10.71 (2.58)[c]
D	7.28 (6.63)[d]

Means with the same superscript letters are not different (P>0.05). SD: Standard deviations

Table 3: Mean color changes of samples after conversion of the values to NBS units.

Study groups	NBS unit	NBS unit description
C	0.25	Trace
S	12.72	Very much
P	9.85	Much
D	6.69	Much

NBS: National Bureau of Standards

hypochlorite solution, Dentipur, and Professional tablets were evaluated using CIE L* a* b* colorimetric system and NBS parameters. A ΔE value higher than 3.3 is considered clinically perceptible.[22] In the current study, the ΔE values of vertex denture base material immersed in all three cleansers were above this value. Thus, the null hypothesis of study that denture cleaners have no effect on the discoloration of thermoplastic denture base materials was rejected.

Similar to thermosetting resins, thermoplastic denture base materials would change color due to internal and external factors.[9,11] Internal factor-induced color changes are mostly related to the structural alterations in the resin matrix. In general, internal color changes occur due to the physical-chemical conditions such as variations in temperature and moisture. However, externally induced discoloration is usually caused by the absorption and adsorption of colorants from exogenous sources.[1,11] Staining and discoloration may be related to other factors such as surface roughness, loss of water, oxidation, chemical degradation, and pigment formation.[11] Absorption and adsorption of pigments present in the oral environment accelerate the discoloration and have a greater effect on chromatic changes of material compared with intrinsic factors.[21,22]

Color changes in acrylic teeth and denture base resins are affected by the type of denture cleanser.[1,2,6] Hong *et al.*[9] evaluated the color stability of heat, auto and visible-light polymerized resins in eight different denture cleansing solutions. The highest color differences were obtained with auto polymerized samples after immersion in cleaning solution for 365 days. In addition, acid-based cleansing solution led to the lowest color changes.[5,9] In this study, sodium hypochlorite resulted in the highest color differences while Dentipur tablets promoted the lowest color changes. According to Douglas *et al.*,[23] ΔE values higher than 2.6 and 5.6 are considered visible and clinically unacceptable, respectively. Color changes observed in control groups were insignificant and clinically acceptable; however, ΔE values of test groups lied within the range 7.28-13.83 and thus were unacceptable. Goiato *et al.*[14] showed that ΔE value of Valplast, a thermoplastic denture base material, was higher than heat-polymerized and autopolymerizing acrylic resins after 1008 h of accelerated aging in cleansers. This pattern is confirmed by the results of this study; only the delta values were different which may be due to the difference in composition of the resin, cleanser, and the immersion duration. Durkan *et al.*[15] measured color differences of various denture base materials after 20-day immersion in available denture cleansers. Only rodex, a butadien styrene copolymer PMMA, showed significantly different values after immersion in cleansing solutions. This result could be due to the very short time immersion process.

It can be concluded that vertex thermoplastic resin material had significant color changes after immersion in denture cleansing solutions, particularly sodium hypochlorite. However, in terms of clinical application, the differences between the oral environment and extra-oral conditions must be considered. Further investigations should be conducted on various thermoplastic materials after immersion in denture cleansers over longer periods.

Conclusion

Color changes are affected by the type of denture cleanser; Vertex thermoplastic resin revealed greater color difference values after immersion in sodium hypochlorite solution compared to Professional and Dentipur denture cleaners. Based on NBS unit comparing parameters, all three cleansers showed observable color changes within the range 7.28-13.83 and thus were unacceptable for cleaning vertex thermoplastic materials.

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