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Dose the Color of Nylon-Based Denture Change Over Time?

Tahereh Ghaffari, Fahimeh Hamedi Rad*, Mehrnaz Motiei ,Reza Danesteh

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Abstract

Aims: This study evaluated the color changes of heat-cured denture-base acrylic resins and nylon-based dentures subsequent to storage in four different beverages. **Methods:** Twenty specimens were prepared for each denture base material and stored in distilled water for 24 hours at 37°C in a dark environment. During that time (T0), the color parameters of all the specimens were determined using a spectrophotometer. Each material was immersed in coffee, tea, Cola, and saliva (control). After 7 days (T1) and 30 days (T2) of immersion, the color of each specimen was measured again. The CIE (Commission International de L'Eclairage) L*a*b* was compared using two-way ANOVA and Bonferroni test at 0.95. **Results:** In ΔET0T1 and ΔET0T2, significant color changes were detected in both materials in coffee ($P<0.05$). Tea and Cola were the second most stain-inducing beverages for both materials. Nylone xhibited more color changes in coffee,tea,and Cola compared to PMMA ($P<0.05$). In ΔET1T2, there was no significant color change. **Conclusion:** The color changes induced at all the intervals were perceived by the Human eye ($\Delta E>1$); however, they were in a clinically acceptable range ($\Delta E<3.3$) except for those in coffee.

Key words: Color stability, Denture base, Acrylic resin, Nylon-based resin, Beverage

Introduction

Different resins are used for the fabrication of denture bases. One of these materials is polymethylmethacrylate(PMMA)resin,which has a predictable esthetic appearance,good strength,low permeability in the oral environment,color stability,and proper conduction of thermal changes. (Goiato et al., 2010) It is available in different forms according to the polymerization reactionas heat-cured acrylic resin, rapid-cured auto polymerizing acrylic resin, light-cured resin,and specialized-form resins used for microwave processing (Pavan Kumar Bohra et al., 2015).

The use of flexible denture base materials in dentistry has increased in recent years. Nylon (polyamide)thermoplastic denture base is one of these flexible materials synthesized by condensation reactions between a diamine and adibasic acid. Initial forms of nylons exhibited disadvantages,including discoloration by stains,high water sorption,and the creation of a rough surface over a short time.Some advantages of these materials are the favorable esthetic outcome and toxicological safety for patients with allergies to resin monomers. (Yunus et al., 2005) Other advantages are the invisibility of clasp on the abutment tooth that can be made thinner because it has good strength;so it is more convenient to use and flexible and can adapt well to the undercut area and be unbreakable, resistant to heat,and free from residual monomers (Ariyani, Nasution and Agusnar, 2016).

Previous studies have shown that polymeric materials are susceptible to discoloration (Polyzois and Frangou, 2001). Acrylic resins are known to undergo color changes because of water sorption overtime, which can be affected by factors such as the polymerization process or the surface roughness of the denture base,as well as oral hygiene or the consumption of colorant foods and beverages (Altichini and Durakay, 2016).

In recent years, the methods for measuring color changes in dental materials consist of visual assessment spectrophotometry, colorimetry, and digital analysis (Joiner, 2004). Visual color assessment is not a reliable method because individuals have different perceptions of color; however,spectrophotometry is a proper technique for solving this problem.Spectrophotometric shade analysis of

Tahereh Ghaffari, Mehrnaz Motiei
Associated prof. Department of the Dental Faculty of Tabriz University of Medical Sciences, Tabriz, Iran.

Fahimeh Hamedi Rad*
Assistant prof, Dental materials research center, health research institute, Babol university of medical sciences, Babol Iran.

Reza Danesteh
Associated prof. Department of the Dental Faculty of Kemanshah University of Medical Sciences, Kermanshah, Iran.

dental materials has proven to be more accurate and more reproducible compared to visual shade assessment (Paul et al., 2002).

Although some studies have been carried out to assess the color stability of acrylic resin denture bases,no comparisons have been made between these resins and polyamides subsequent to storage in beverages such as Cola.This study was undertaken to determine the discoloration of polymethyl methacrylate (PMMA)and nylon base polymers in coffee,tea,and Cola,as well as in saliva as a control.The null hypothesis was that denture base acrylic and nylon resins have similar discoloration after immersion in beverages.

Materials and Methods

Two different types of denture base materials were assessed in the present study: heat-cured poly methyl methacrylate resin(IvoclarVivadent AG Scheanllichten stein) and nylon thermo-injectable resin(Bredent Flex, GmbH & Co KG, Senden, Germany).For each group,twenty disc-shaped specimens (Dogan et al., 2008) (10 mm diameter and 2 mm thickness) were prepared. Each acrylic resin specimen was processed in gypsum molds made by investing silicon disks (Zetalabor, Zhermack, BadiaPolesine, Rovigo, Italy) in the denture flasks (Brass flask, Kavo EWL, Germany) (Polyzois et al., 1997).

Triplex(PMMC) (IvoclarVivadentAGSchaan/Lichtenstein)was polymerized in a water bath at 70°C for 7 hours and at 100°C for 1 hour (Hamedirad, Ghaffari and Tamgaji, 2017). After deflasking, the specimens were abraded on both sides with 150- and 600-grit silicon carbide papers (Politriz APL-4 - Arotec, Cotia, SP, Brazil).The slurry of water and pumice (Kerr Corp, Orange, CA, USA)were applied to the specimen surfaces with a brush wheel, followed by tin oxide (DeFusco Industrial Supply,USA)with a cloth wheel (Qufan,USA).

The thermoplastic nylon resin specimens (Bredent Flex, GmbH & Co KG, Senden, Germany), were flasked using specially designed equipment (Injector press,Thermoplastic comfort system)for injection. They were finished with tungsten carbide trimmers (KOMET Brasseler,Bremen, Germany) and 120- and 220-grit sandpaper (Politriz APL-4 -Arotec, Cotia, SP, Brazil), followed by polishing with pumice on a black brush and the slurry of tin oxide. The specimen thickness was checked with a micrometer (PraecimeterS0.01 mm, Renfert Materials, GmbH, Hilzingen, Germany). All the specimens were stored in distilled water for 24 hours at 37°C.

The initial color parameters of specimens (T_0) were determined before immersion with the use of a spectrophotometer (Xrite sp64 Spectrophotometer, Michigan, USA).

Four different solutions were used (Table 1). The first solution served as the control. Five specimens from each group were immersed in each solution at 37°C. The color intensity of staining solutions held the same throughout the test. The second and third measurements of color parameters of specimens were done after seven (T1) and 30 (T2) (Sagsoz et al., 2014) days of exposure to the staining solutions. Before any recording, all the specimens were rinsed with distilled water, excess water on the surfaces was removed with tissue papers, and the specimens were left to dry. The color change (staining) parameters of all the specimens were determined by measuring the mean and standard deviation of ΔE values with the use of CIEL *a*b*color system. CIEL *a*b* is a rather uniform color space with coordinates for lightness,i.e.white-black (l*), redness-greenness (a*), and yellowness-blueness (b*).

The total color differences were expressed by the formula $\Delta E=\{(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2\}1/2$,where$\Delta L^*$,$\Delta a^*and\Delta b^*$were differences in the respective l*, a*,and b*values. In the present study, a ΔE value >1 was considered perceivable by the human eye (Bagheri, Burrow and Tyas, 2005) and values <3.3 were considered clinically acceptable (Altichini and Durakay, 2016).

The data were analyzed using the two-way ANOVA to compare the results from each denture base and beverage. Bonferroni adjustments were performed for pairwise differences between denture base resins within beverages and vice versa.

Results

Figure 1 depicts the mean ΔE values of the tested combination for each immersion time. Based on the two-way ANOVA and Bonferroni pairwise tests,at all intervals,the most severe staining was detected with coffee ($P<0.05$), followed by tea and Cola in comparison with the specimens stored in saliva.All the changes were significant ($P<0.05$).

Overall,staining of nylon was significantly more than that of PMMA ($P<0.05$). Color changes in nylon at T0T1 were clinically acceptable in all beverages except coffee ($\Delta E>3.3$); at T0T2, the changes were un acceptable in all beverages except saliva ($\Delta E<3.3$) and at T1T2, in all beverages, the changes were acceptable ($\Delta E<3.3$). Color changes in nylon atT1T2 were the same in tea and Cola.

Color differences (ΔE) in PMMA at T0T2 were clinically acceptable in all beverages except coffee ($\Delta E>3.3$); at T0T1 and T1T2, in all beverages, the changes were clinically acceptable ($\Delta E<3.3$).

Discussion

In this study, statistically significant color changes were detected in the groups in any beverage over time. The most severe staining was apparent with coffee while tea and Cola ranked as the second staining beverages for both acrylic and nylon denture base materials. At T_0T_1 and T_0T_2 intervals, the rate of staining of acrylic resin in coffee was significantly more than that in other solutions($P<0.05$).At T_0T_1 and T_0T_2 intervals, the rate of discoloration of acrylic resin in both tea and Cola was similar.The greatest discoloration of acrylic resin in tea was seen at T0T2. Tea contains noticeable amounts of flavor and taste. Flavoring agents in tea are responsible for staining ·At ΔET1T2, staining was not significant between the test groups in the four solutions.

In a research conducted by *Altinci et al.,it was shown that after 1 and 7 days of storage in black tea, sour cherry juice,and coke after aging, significant discolorations were seen on acrylic resin denture bases* (Altichini and Durakay, 2016) similar to our research in which coffee and tea caused significant changes after 7 days.

In a research by Imirzaloglu et al.It was shown that discoloration of acrylic resin samples after 1 and 30 days in coffee was more than that in tea (Imirzalioglu et al., 2010). In the present study, the same results are reported. The most color changes were seen in both materials in coffee,followed by tea and Cola showing the same color changes.Um and Ruyter demonstrated that in resin-based specimens,after 48 hours of immersion, tea produced more stains compared to coffee (Um CM and Ruyter, 1991), which is contrary to our results.

It can be noted that color changes due to tea are eliminated easily, which is probably attributed to the adsorption of polar discoloring agents of tea on the surface of materials. The staining by coffee was due to both adsorption and absorption of discoloring agents,as well as deeper penetration of these agents, with less polarity in coffee, into the resin. Keskin studied the color stability of PMMA after immersion in coffee and tea for7 days and showed that color changes in these materials increased initially and then decreased (Keskin, 2002). This finding was attributed to the removal of accumulated layers. As tea and coffee layers on specimens atitan a certain thickness, they tend to break away from the surface of specimens and return to the solution. The hydrophilic nature of heat-cured PMMA used in this study is attributed to the chemical action of its monomers and its polymerization linkages. Monomers are commonly used as cross-linking agents. However, the polymers are not significantly hydrophilic but might absorb water. A relationship has been reported between staining of resin-based materials, water sorption, and hydrophobicity/hydrophilicity of these materials.Lai et al.reported that hydrophobic materials exhibit more staining in hydrophobic solutions (Lai, Lui and Lee, 2003). In contrast, in the present study, coffee (hydrophobic solution) had a significant effect on the color of acrylic resins (hydrophilic material).Staining of polymers by coffee is attributed to the presence of yellow coloring agents with various polarities. It has been reported that tannic acid in coffee is responsible for staining. Other factors affecting staining by coffee are the addition of sugar and the processing method, such as filtering (Guler et al., 2005). Similarly, in this study, coffee produced significant staining in acrylic resin after 7 days of immersion ($P<0.05$). In addition, during T_0T_2 interval, the staining of PMMA in coffee was more than the clinically acceptable threshold ($\Delta E=4.7$).

Overall,staining in nylon was significantly more than that in PMMA ($P<0.05$). Color changes in nylon at all times for saliva were acceptable.Coffee was unacceptable except at T1T2. Tea and Cola were acceptable except atT0T1.

Then nylon denture base material is hygroscopic, with moisture content varying with the surrounding conditions (MahrooVojdani and Rashin Giti, 2015). Hargreaves reported that the frequency of amide groups along the chain affects water sorption and chemical properties of each type of nylon (Hargreaves, 1971). Kurtulmus et al. reported no significant difference in the mean values of liquid sorption among polymerization methods of some heat-cured and nylon resins; however, they found that the denture base material containing across-linking agent absorbed less solution compared to materials without cross-linking agents (Kurtulmus et al., 2018). Laietal.found that copolyamides(nylon denture base)produced more discoloration than heat-cured acrylic resin in coffee and tea (Lai, Lui and Lee, 2003) that was similar to the results of our study and might be attributed to variations in composition, processing, finishing,and polishing of this material. In our study, nylon in coffee exhibited the greatest staining. The color change of nylon in T_0T_2 in both tea and Cola was similar. The materials that have a well-polished surface exhibit the least color change compared to materials that have rough surfaces. Although the present study did not measure surface roughness, polyamide has different finishing methods, making it more susceptible to staining.Crispin et al.reported that the samples that had rough surfaces exhibited significantly more color changes (Crispin and Caputo, 1979). *Putranti et al.found that* thermal cycling for 70 and 300 cycles on any of thermoplastic denture base material could increase the dimensional change and lower its Color stability (Putranti and Triana, 2017). Hamedirad *et al.showed that* after 100 hours of irradiation with UV light and thermocycling, color changes were tangible in acrylic resin and nylon-based polymer. After 200 hours, both materials exhibited decrease in the glaze (Hamedirad, Ghaffari and Tamgaji, 2017).

In our study, Cola did not produce as much staining as coffee that may be because Coca-Cola does not increase the roughness of soft liners (UstaKutlu et al., 2016). Thus, it seems that Cola has the same effect on acrylic resins. Jang et al. showed that thermoplastic acrylic resin on metal clasp denture demonstrated an acceptable color stability in coffee and green tea for 1 and 8 weeks, water sorption,and

cytotoxicity (Dae-Eun Jang et al., 2015). However,the present study showed more color changes in nylon-based denture in coffee compared to other beverages, as well as in PMMA.Sagsoz et al.showed that the color stability of polymethylmethacrylate denture base resin in tea, coffee, water, and cleansing agent after 7 and 30 days is greater than that of polyamide denture base resin (Sagsoz et al., 2014) that is similar to our study results.

Acknowledgments

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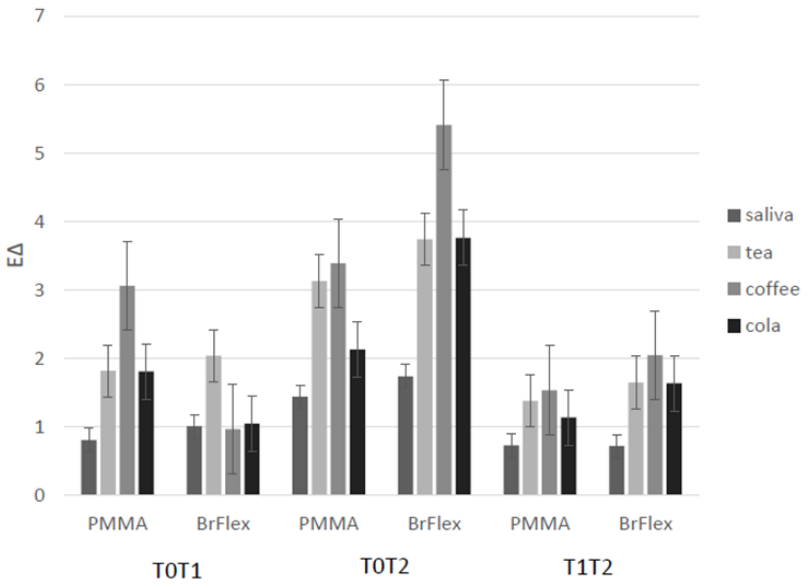

Figure 1. Mean color differences (ΔE) and standard errors (vertical lines) of Nylon and Triplex in T_0T_1, T_0T_2, and T_1T_2 immersion periods in the beverages.

Table 1. Contents of the solutions used

Solutions	Ingredients
Solution 1	Saliva; 49 mL (KCl 1.41 g, $NaHCO_3$ 0.95 g, kSNC0.35 , KSNC0 0.31 g, $NaH_2Po_4.H_2O$, 0.8 g distilled water)
Solution 2	Saliva; 330 mL + tea (160 mL; 4 g/500 mL, Lipton, Ahmad tea ltd, London, UK)
Solution 3	Saliva; 330 mL + coffee(160 mL; 1.5 g/100 mL, Nescafe classic, Nestle,Noisiel, France)
Solution 4	Saliva; 330 mL + Cola (160 mL of Coca Cola, Caspian Industrial City, Qazvin, Iran)