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EFFECT OF DENTURE CLEANSERS ON SURFACE ROUGHNESS AND COLOR STABILITY OF POLYAMIDE AND ACETAL DENTURE BASE (AN IN-VITRO STUDY)

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ABSTRACT

Objective: The objective of this study was to evaluate effect of denture cleansers on surface roughness and color stability of polyamide and acetal denture base material. **Material and methods**: Fittydent and Clinsodent cleansing agents were used in this study and a total of (36) samples from polyamide and acetal denture base material were fabricated equally to evaluate their surface roughness and color stability after immersion in the test cleansing agent for immersion periods of 15, 30, and 45 days, respectively. **Results:** The results of this study revealed that there was no statistical significant difference in surface roughness and color stability of polyamide and acetal thermoplastic resin after immersion in the test cleansing agent for the test period. **Conclusion:** Usage of Fittydent and Clinsodent cleansing agents will adversely affect surface roughness or color stability of polyamide and acetal denture base material.

KEY WORDS: Denture cleansers, denture base, surface roughness, color stability, thermoplastic resin

INTRODUCTION

Acetal and polyamide thermoplastic polymers have become a popular alternative to acrylic resin denture base because of their hypoallergenic nature and favorable chemical and physical properties [1]. They can be used when conventional acrylic dentures cause discomfort to patients that cannot be solved through relining [2,3].

Acetal resin have a flexible nature which offers stress breaking design to removable partial dentures as well as enhanced aesthetics [4,5]. However, Acetal does not have the natural translucency and vitality of thermoplastic acrylic and polycarbonate [6,7].

Polyamide has a transparent property; it reflects the color of gingival and oral tissue [1]. It can be used for patients with PMMA allergy, bruxism, cases with thin mucosa and excessive bone resorption [8].

Angular cheilitis, denture stomatitis, unaesthetic staining and ozostomia all may result from long wearing of the denture without serviceability. Intensive oral and denture hygiene are vital for denture wearers. They should use mouth wash regularly and clean their denture daily by using non-abrasive brush and denture cleaning agent; this agent should be compatible with the denture base material; without unexpected adverse effect on the properties of the prosthesis [9-12].

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Some studies revealed that immersion of dentures in commercially available cleaning agent twice daily may be effective than manual cleaning by brushing; however it was reported that it might have some detrimental effect on the physical properties of acrylic resin as it can affect color, surface roughness, flexural strength and the hardness of resins [13,14].

The purpose of this in vitro study was to evaluate the effect of two commercially available denture cleansers on surface roughness and color changes of polyamide and acetal denture base material. The hypothesis was that the two different cleansers will have the same effect on the physical properties of the polyamide and acetal resin at different storage time.

MATERIALS AND METHODS

Two commercially available denture base thermoplastic resins; polyamide resin (Lucitone FRS, Dentsply India Pvt. Ltd.), and acetal resin (Vertex-Detal; Zeist, Netherlands), and two commercially available denture cleansers of sodium perborate-based cleansing solutions (Fittydent denture cleanser solution (Actipharma, Cairo, Egypt) and Clinsodent denture cleanser solution (ICPA Health Products Ltd.) were used in this study.

Samples construction

A total of (36) samples were fabricated equally from two different thermoplastic denture base (polyamide and acetal). For the surface roughness test stainless-steel metal milled disc of (20 mm × 2 mm) dimension were used [15]. While for color stability stainless-steel metal milled disc of (20 mm × 1 mm) dimension were used [16]. Metal discs invested in injection molding flask and sprued with modeling wax in a manner that each disc was connected with the sprue so that polyamide and acetal denture base materials could flow into each mold space. After spruing, the flask was counter poured. The flask was kept for de-waxing after setting of dental stone; the metal discs were removed to obtain the mold space. Flask was closed and tightened with the screws and then placed on the bench press. The cartridge of thermoplastic denture base resin was kept in the heating unit and heated according to manufacturer's instruction and then was placed on the flask. The pressure was applied to the cartridge so that the material flew into the mold space through sprues. Once processed, the flask was allowed to bench cool. Specimens were ground using progressively smoother aluminum oxide paper (200, 600, 800, and 1000 grit) [17].

Sample grouping

Samples were divided into two main groups (n=18) according to the thermoplastic resin. Each main group was subdivided into two equal subgroups (n=9) according to types of the immersed solution used (Fittydent, and Clinsodent). Then, each subgroup further subdivided into three equal categories (n=3) according to period of immersion (15, 30, and 45 days) respectively.

Samples of each type of thermoplastic resin were immersed in 50 ml of each denture cleaning solution in 200 mL glass beakers, while taking great care to avoid contact between the samples within the beaker. The beakers with the immersed samples were stored in a dark room at room temperature for 15, 30, and 45 days of immersed periods respectively [15,16].

Assessment steps were as follows:

1. Baseline measurement; recorded before immersion in the tested cleansing agent
2. Measurements recorded after 15, 30 and 45 days of immersion where upon samples were removed, rinsed with distilled water, and dried with tissue paper.

Surface Roughness Test:

Samples area with 10µm × 10µm were photographed using USB Digital microscope (Scope Capture Digital Microscope, Guangdong, China) with a built-in camera connected with an Asus with windows OS computer using a fixed magnification

of 90X. The cropped images were analyzed using WSxM software. Within the WSx-M software, all limits, sizes, frames and measured parameters are expressed in pixels. Therefore, system calibration was done to convert the pixels into absolute real-world units. WSxM software was used to calculate average of heights (Ra) expressed in μm, which can be assumed as a reliable indices of surface roughness [15]. Fig (1)

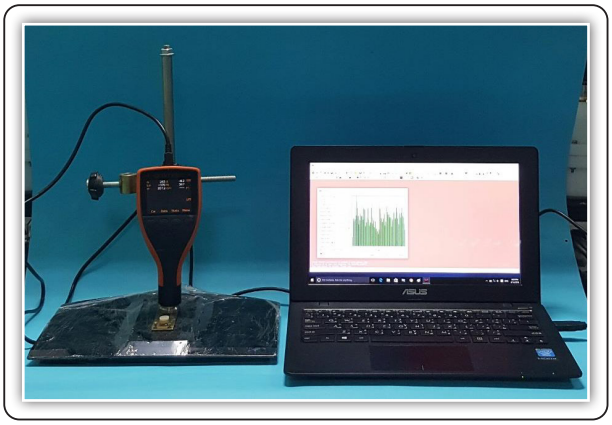

FIG (1) Computer controlled roughness tester.

Color Stability Test:

Samples colors were measured with a spectral colorimeter (U.V-Vis. UV 3101 PC, Shimadzu scanning spectrophotometer). At the different test periods, each sample was measured three times at randomly selected spots and the mean value was recorded to reduce potential error due to measurement at various areas [16].

The differences between the baseline and post-immersion colors were measured according to the CIE Lab system. These differences are expressed as CIE color difference (ΔE) values. The method for calculating these values is described in the following section.

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

L^*: indicate White-Black, $\Delta L = L_t - L_0$

a^*: indicate Redness - Greenness, $\Delta a = a_t - a_0$

b^*: indicate Yellowness - Blueness, $\Delta b = b_t - b_0$ (Lt, at, bt: values at the time of measurement after immersion / L_0, a_0, b_0: values before immersion).

RESULTS

Data were collected, tabulated, and statistically analyzed to detect whether significant differences existed between the means of the various studied groups.

Surface roughness:

Data from (**Table 1**) showed that; Statistical analysis of surface roughness of all tested groups for polyamide and acetal thermoplastic resins after immersion in Fittydent and Clinsodent cleansing solutions for (15, 30, 45) days revealed that; polyamide thermoplastic resin recorded a higher surface roughness value than acetal thermoplastic resin at the different immersion times with differences considered as statistically significant as indicated by Two-way ANOVA test (P=0.0001). Additionally, the effect of Clinsodent cleansing solution on the polyamide and acetal thermoplastic resins was higher than that of Fittydent cleansing solution with differences considered as statistically significant as indicated by Two-way ANOVA test (P=<0.0001).

Color Stability:

- Acetal Thermoplastic Resin:

The statistical analysis of color change (ΔE) for the tested groups of acetal thermoplastic resin at different times of immersion revealed that; the difference between all tested groups at the different immersion times was statistically non-significant as indicated by Two-way ANOVA test (P=0.1345). Additionally, the effect of different immersed solutions on the polyamide thermoplastic resin was statistically non-significant as indicated by Two-way ANOVA test (P= 0.2657), **(Table 2)**. The immersion of acetal thermoplastic resin in the different immersed cleansing solution insignificantly increase its color change (ΔE) in respect to time.

TABLE (1) Surface roughness in polyamide and acetal thermoplastic resins following immersion periods of (15, 30, 45) days in the Fittydent and Clinsodent cleansing solutions.

Variable		Polyamide	Acetal	*p*-value
		Mean ± S.D.	Mean ± S.D.	
Fittydent	Base-line	0.2514 ±0.00088^{Ca}	0.25045 ±0.00095^{Aa}	0.0001*
	15 days	0.2529 ±0.00110^{Ba}	0.25008 ±0.00143^{Ab}	
	30 days	0.2538 ±0.00195^{Ba}	0.2502 ±0.001282^{Ab}	
	45 days	0.2558 ±0.00085^{Aa}	0.2511 ±0.00054$^{7\,A}$b	
		p-value <0.0001*		
Clinsodent	Base-line	0.2514±0.0007^{Ca}	0.2509 ±0.00141^{Aa}	<0.0001*
	15 days	0.2543±0.00159^{Ba}	0.251 ±0.00078^{Ab}	
	30 days	0.2555±0.00197^{Ba}	0.2510 ±0.0009^{Ab}	
	45 days	0.2574±0.0038^{Aa}	0.2513 ±0.000$^{9\,A}$b	
		p-value <0.0001*		

**; significant (p < 0.05) ns; non-significant (p>0.05)*

Different capital letters in the same column indicating statistically significant difference (p < 0.05)

Different small letters in the same ro w indicating statistically significant difference (p < 0.05).

TABLE(2) Color change (ΔE) in the acetal thermoplastic resin following immersion periods of 15, 30, and 45 days in the different cleansing solution.

Color	Artificial Saliva	Fittydent	Clinsodent	*p*-value
	Mean±S.D.	Mean±S.D.	Mean±S.D.	
15 days	4.03666 ±0.7017	4.5667 ±1.4153	4.32833 ±1.7528	0.1345
30 days	4.315 ±1.8802	5.68 ±0.7009	6.89833 ±2.9027	
45 days	6.46666 ±3.1331	6.0866 ±2.0230	7.0216 ± 2.6511	
p-value		0.2657		

Polyamide Thermoplastic Resin:

The statistical analysis of color change (ΔE) for the tested groups of polyamide thermoplastic resin at different times of immersion revealed that; the difference between all tested groups at the different immersion times was statistically non-significant as indicated by Two-way ANOVA test (P=0.1242). Additionally, the effect of different immersed solutions on the polyamide thermoplastic resin was statistically non-significant as indicated by Two-way ANOVA test (P=0.3338).

TABLE (3) Color change (ΔE) in the polyamide thermoplastic resin following immersion periods of 15, 30, and 45 days in the different cleansing solution.

Color	Artificial saliva	Fittydent	Clinsodent	p-value
	Mean±S.D.	Mean±S.D.	Mean±S.D.	
15 days	3.7766 ±1.124823	4.54833 ±1.49119	4.4117 ±1.3598	0.1242
30 days	4.2966 ±1.394585	5.005 ±0.729157	4.91 ±2.47068	
45 days	5.09833 ±1.17101	5.89333 ±1.86256	5.21666 ±1.4951	
p-value		0.3338		

**= significant (p < 0.05)*

ns = non-significant (p>0.05)

DISCUSSION

Thermoplastic resins have many advantages over the PMMA "conventional powder-liquid systems". They provide superior esthetics with tooth or tissue colored materials and are very comfortable for the patient [3,19]. Flexible denture material is so strong that it can be made very thin which makes it comfortable to wearer and esthetically pleasing[3]. As the flexible dentures are fabricated using the injection molded technique, they exhibit better accuracy compared to conventional techniques [20]. Being flexible, the denture base adapts well in the undercut areas. Also,

this reduces post insertion complaints of denture induced trauma (ulceration)[21].

An ideal chemical denture cleanser should be readily available, effective, affordable, non-abrasive and simple to use [1]. There are numerous reports on the detrimental effect of denture cleansers on the physical properties of acrylic resin, as daily use of such solutions can affect the color, surface roughness, flexural strength and the hardness of resins [9,13,14].

Various investigations indicate the positive correlation between alteration in surface roughness when using sodium perborate-based cleansing solutions when compared to other cleansing solutions [1,22]. Therefore, in this study we tested the effect of two types of sodium perborate-based cleansing solutions (Fittydent and Clinsodent (denture cleaning solutions) on the changes of the surface roughness of two thermoplastic resins.

In this study, the polyamide thermoplastic resin specimens exhibited an increase in surface roughness as compared to acetal thermoplastic resin after immersion in the Clinsodent and Fittydent cleansing solutions for different period of immersion. This may be due to the fact that; the acetal thermoplastic resin is composed of poly (oxy-methylene) polymer which has higher chemical stability and resistance to solubility in the chemical solvents as compared to the polyamide [23,24]. However, the insignificant increase in the values of the surface roughness of the both tested thermoplastic resin specimens in the present study may be due to the high chemical resistance of the two tested types to the action of solvent due to their crystalline structure [23].

The effect of Clinsodent and Fittydent cleansing solutions on color change of the polyamide and acetal resins was insignificant in the results of this study, however, there are insignificant change in color with increasing the period of immersion from 15 days, to 30 days, and 45 days respectively. This may be due to that; the acetal thermoplastic resin is monomer free resin with the lesser amount of surface porosity [9,29]. Moreover, this may be due to the lower water sorption of the acetal thermoplastic resin, as the water sorption rate of materials affects their color stability [16,22]. However, the polyamide thermoplastic resin, was resistant to hydrogen bonding, thereby demonstrating lower color changes rates as the polar property of the resin molecules determine the proportion of hydrogen bonds formation and hence staining adsorption [16].

Additionally, the insignificant change in color in the both tested thermoplastic resin in the present study may be related to their similar pressure injection processing method [16]. This presumably explains why the acetal and polyamide thermoplastic resin showed a lower color change in our study.

CONCLUSION

Within the limitations of this in-vitro study and based on its result, it was concluded that; the sodium perborate-based cleansing solutions (Clinsodent and Fittydent) could insignificantly affect the surface roughness and color stability of the polyamide and acetal thermoplastic denture base resins. In addition surface roughness and color stability of polyamide thermoplastic resin was adversely affected by denture cleaners more than acetal resin. Further investigations may be required to examine properties of polyamide and acetal thermoplastic denture base resins.

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