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The Effect of Denture Cleansers on Color Stability, Water Sorption and Solubility of Stained Denture Base Materials

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Abstract

Background and Objectives: Denture cleanser is the most widely used method by the patients to maintain clean and healthy dentures but the prolonged use of such cleansers may affect the properties of the denture. The present study was carried out to evaluate the effect of three prepared denture cleansers which were the 4% citric acid, 4% tartaric acid, and 4% oxalic acid in addition to the Protefix a commercially available denture cleansers, on some mechanical and physical properties (color stability, water sorption, and solubility) of acrylic resin (Stellon QC-20) and flexible nylon (Vaplast) denture base materials after immersion in tea solution. **Methods:** One hundred specimens (100) were prepared in two equal major groups: acrylic resin and Valplast. For each test of the physical and mechanical properties, 50 specimens were prepared, 25 from acrylic resin and 25 from Valplast. Later on, divided into five groups, one group used as a control and immersed in distilled water, and remaining 4 groups used as test groups; by immersing in one of the denture cleansers after staining in tea solutions for 10 days. The effect of denture cleansers on the properties was studied and compared with the control group. **Results:** Visual examination method showed no color changes for acrylic and slight color change for valplast specimens. Valplast specimens showed higher water sorption and solubility than acrylic. **Conclusions:** The findings showed that the 4 denture cleansers were equally effective, and did not cause significant alteration in the tested properties. Except acrylic specimens immersed in oxalic acid showed less color stability.

Key words: Denture cleansers, Acrylic resin, Valplast, Color stability, Water sorption and Solubility.

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تأثير منظفات الأطقم على بعض خواص مواد قاعدة أطقم الاسنان المصبغة

الخلاصة

الابقاء على نظافة، جمالية و منع الروائح الغير المرغوب بها فى أطقم الأسنان هو مهم لصحة المريض؛ و هذا يمكن الحصول عليه من خلال استعمال منظفات الاطقم. يعتبر منظف الأطقم الكيميائيه هى الطريقة الأكثر شيوعا لهذا الغرض ولكن الاستعمال الطويل لهذه المنظفات ربما يؤدى إلى تأثيرمضر على مكونات الأطقم. هذه الدراسة الحالية أجريت لتقييم تأثير ثلاث منظفات أطقم محضرة و أللتى كانت (٤٪ حامض ألستريك، ٤٪ حامض التارتاريك، و ٤٪ حامض الاوكزاليك) إضافة إلى استعمال منظف الأطقم بروتفكس المتوفر تجاريا على بعض الخواص الميكانيكية و الفيزيائية (ثباتية اللون، إمتصاص الماء و الإذابة فى الماء) لقاعدة طقم الأسنان الاكريلى الرا تنجي (QC-20) والنايلون المرن (فالبلاست) بعد الغمر فى محلول الشاي. تمَ تحضير مئتا عينة في مجموعتين رئيسيتين: الاكريليك و الفالبلاست. تمّ تحضير خمسون عينة لكل اختبار الخواص الفيزيائية والميكانيكية ، ٢٥ منها من الاكريليك ٢٥ من الفالبلاست. ثم قسّمت فيما بعد الى خمسة مجموعات، استعملت مجموعة كمجموعة القياسية (كونترول) و تم غمرها فى الماء المقطر، اما المجموعات الاربع المتبقية استعملت لمجموعات اختبارية؛ بغمرهن فى منظفات أطقم الأسنان بعد أن تم غمرهن فى محلول الشاي لمدة عشرة ايام لغرض التصبيغ. بعد ذلك تمت دراسة تأثير منظفات الأطقم على الخواص الفيزيائية والميكانيكية وتم مقارنتها مع المجموعة القياسية (كونترول). اظهرت النتائج ان منظفات أطقم الأسنان الأربع لم تسبب فى أي تغيير فى ثباتية اللون، إمتصاص الماء والإذابة فى الماء لكل من الاكريليك والفالبلاست. كلتا المادتين اظهرتا قابلية كافية من ثبات اللون بعد غمرهما فى منظفات الأطقم و الماء المقطر بعد فحصهم بواسطة طريقة سبكتروسكوب، ما عدا عينة الاكريليك التى غمرت فى حامض الاوكزاليك والتى أظهرت فرقاً معنوياً عالياً بالمقارنه مع المجموعة القياسية.

Introduction

Various materials have been used to construct dentures. Acrylic resin is now the material of choice: this material has a required aesthetic quality and is cheap and easy to process using inexpensive techniques [1]. Thermoplastic materials for dental prostheses, Valplast and

Flexiplast, were introduced in the 1950s. Both materials were similar grades of polyamides [2]. The chief advantage of nylon lies in its resistance to shock and repeated stressing [3]. It could be extremely useful in the treatment of patients who demonstrate repeated fracture of dentures and those that show tissue reactions of a proven allergic nature [4].

The maintenance of clean denture prostheses is important for the health of a patient, to maintain an aesthetic, odor free prosthesis, and to reduce the number of the microorganisms on the dentures [5]. Dentures can be cleaned mechanically (brushing), chemically (immersion), or through a combination of both [6]. The immersion cleansers are preferred by patients because they are easy to prepare and effective in removing deposits if used regularly [7].

Most immersion cleansers can be divided into three classes; alkaline peroxide, alkaline hypochlorite, and dilute mineral acid. Protefix Active cleanser is a peroxide type of denture cleanser. It has sufficient oxygen to clean the denture independently, thoroughly and quickly without attacking the denture material. It removes food remains, coffee, tea, and nicotine thoroughly.

Materials & Methods

Experimental design: One hundred specimens (100) were prepared in two equal major groups: acrylic resin and Valplast. They were evaluated for changes in color stability, sorption and solubility after immersion in four denture cleansers (4% Oxalic acid, 4% Tartaric acid & 4% Citric acid and Prefix tablets) in addition to distilled water. For each test of the physical and mechanical properties, 50 specimens were prepared, 25 from acrylic resin and 25 from Valplast. Later on, divided into five groups, one group used as a control and remaining 4 groups used as test groups as follow:

Group 1: specimens were immersed in 4% citric acid denture cleanser solution.

Group 2: specimens were immersed in 4% tartaric acid denture cleanser solution.

Group 3: specimens were immersed in 4% oxalic acid denture cleanser solution.

Group 4: specimens were immersed in Protefix denture cleanser solution.

Group 5: specimens were immersed in distilled water (control group).

All groups except group 5 were immersed in tea solution for 10 days for staining before they were immersed in denture cleansers.

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Metal pattern preparation: Metal disk specimens of (50 ± 1 mm in diameter and 0.5 ± 0.1 mm in thickness) were constructed for sorption and solubility tests. Concerning the color stability test rectangular metal specimens were constructed with the dimension of (25 × 4 × 0.5) mm length, width and thickness respectively to fit into the cuvette of the spectrophotometer.

Preparation of the specimens: The specimens were constructed by preparing molds by investing the metal patterns prepared with mentioned dimensions. The acrylic resin specimens were prepared by conventional compression mold technique, while the nylon specimens were prepared by injection mold technique.

After finishing and polishing, all the specimens were conditioned in distilled water at 37ºC ± 2ºC for 50 ± 2 hours before they were tested according to ADA specification No. 12 (1999) [8].

Preparation of the solutions

1. Tea solution: A standard solution of tea was prepared from 4 grams of dry tea which boiled in 500 ml of distilled water for 4 minutes and allowed to cool at room temperature, and then the solution was decanted from tea leaves [9]. This solution was used for staining the test specimens. (A fresh tea solution was prepared prior to use).

2. Protefix solution: The Protefix solution was prepared according to the manufactures instructions (1 tablet of Protefix added to 150 ml of lukewarm water).

3. The experimental denture cleanser solutions: A fresh denture cleanser solutions prepared by dissolving each of the citric acid, tartaric acid and oxalic acid in the isopropyl alcohol (the isopropyl alcohol was chosen as a solvent for the acid powder due to the antiseptic effect) [9] as follow:

4 gm of each acid powder + 100 ml. of isopropyl alcohol → 4% w/v of acid denture cleanser solution

Then, prior to the use, each prepared denture cleanser solutions was diluted with an equivalent volume of distilled water, as follow:

50 ml. of distilled water + 50 ml. of prepared denture cleanser solutions → 100 ml. of fresh diluted denture cleanser solution

The prepared denture cleanser solutions were stored in a closed container and inside the refrigerator to prevent evaporation, changes in concentration or any deterioration.

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Mechanical and physical tests which were used in this study:

1. Water sorption and solubility test: The specimens' preparation and testing procedure were done according to the ADA specification No. 12 for denture base resin (1999) [8]. The specimens were dried in a desiccator containing freshly dried silica gel arranged according to their specific group separated by filter paper. The desiccator was stored in an incubator at a 37ºC ± 2ºC for 24 hours. After 24 hours, the specimens were removed to a similar desiccator at room temperature for one hour then weighed with a digital balance on the precision of 0.0001 mg. This cycle was repeated until a constant mass (M_1) "conditioned mass" was reached. (Weight loss for each disk should not more than 0.5 mg in 24 hours period). Then the discs of a group (1, 2, 3, and 4) were immersed in fresh tea solution for 10 days, followed by 24 hours in denture cleanser solutions, while group 5 were immersed in distilled water at 37ºC ± 2ºC for 11 days. After that the discs in all groups were removed from the solutions with tweezers, they were wiped by a clean dry hand towel until they became free from moisture. The discs were then waved in the air for 15 seconds and weighed one minute after removal from the solutions. This mass was recorded as (M_2). After that to obtain the value of solubility test, the discs were reconditioned to a constant mass in the desiccator at 37ºC ± 2ºC as done previously for sorption test and the constant reconditioned mass was recorded as (M_3).

The values for sorption and solubility were calculated for each disc from the following equations. (The final value for sorption should be rounded to the nearest 0.1 mg/cm^2, and for the solubility was determined to the nearest 0.01 mg/cm^2).

$WSP = M_2 - M_1 / S$ $WSL = M_1 - M_3 / S$

Where:

WSP = Sorption mg/cm^2, WSL = Solubility (mg/cm^2)

M_1 = the mass of the disc before immersion (conditioned mass, Constant mass) (mg).

M_2 = the mass of the disc after immersion (mg), M3 = the reconditioned mass (mg)

S = Surface areas of the disc (cm^2).

2. Color stability test: The color stability test was measured by two methods:

Objective method (spectroscopic study) and Subjective method (visual examination).

A spectrophotometer device was used to measure the light absorption of each specimen at 500 nm (nanometer). For all groups, the light absorption for each specimen was measured before immersion of the specimens in the solutions.

Following immersion of tested groups in tea solution for 10 days, they were immersed in the denture cleansing solution for 24 hours. While the control group immersed only in the distilled water for 11 days. Light absorption of the specimens was measured before and after the immersion procedure by using a spectrophotometer at 500 nm and the difference between the two readings was measured.

The visual examination of staining removal was assessed by 10 independent observers (dentist). Each observer read the samples after their removal from the solutions. The samples were evaluated visually for stain removal by comparing the tested samples with the control group by placing the specimens on a white background and they were graded for the amount of staining on a scale of (No = 0, Slight = 1, Mild = 2, Moderate = 3, Severe = 4) [9]. The reading of the samples should not be delayed more than 3 days because with time the color of the samples will be affected.

The Statistical Package for Social Sciences (SPSS, version 15) was used for data entry and analysis, using ANOVA test, Dunnett test for multiple comparisons within the groups, and t-test for comparison between the groups.

If P-value ≤ 0.01 statistically was regarded as highly significant (HS).

If $0.01 <$ P-value ≤ 0.05 statistically was regarded as significant (S).

If P-value > 0.05 statistically was regarded as nonsignificant (NS).

Results

Color stability: by visual examination, one way ANOVA for both acrylic resin and Valplast statistically revealed a significant difference between the groups. (P=0.024 for acrylic, and P=0.031 for Valplast). The Dunnett test for acrylic reveals no significant difference between oxalic acid and Protefix, and significant difference between citric and tartaric acid compared with the control group. For Valplast it reveals a significant difference between citric acid, tartaric acid, and oxalic acid as compared with the control group, while Protefix showed no significant difference with a control group. The independent t-test statistically revealed no

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significant difference between citric acid and oxalic acid and significant difference between tartaric acid and Protefix solution, Fig (1).

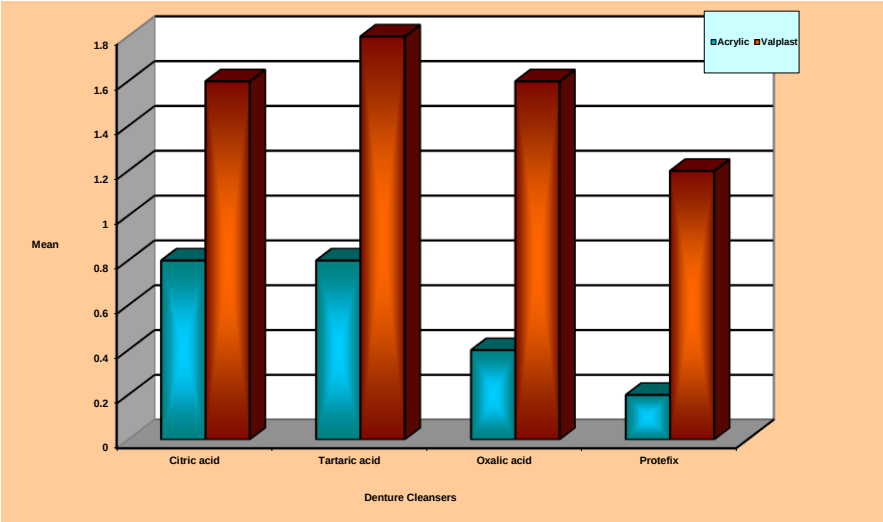

Fig (1): Bar chart of color stability test; visual examination method.

By the use of spectrophotometer device, the result of ANOVA test revealed a highly significant difference between the groups of the acrylic resin (P = 0.001) and no significant difference between the groups of Valplast (P = 0.057). The Dunnett test for the acrylic reveals that statistically citric acid, tartaric acid, and Protefix showed no significant difference, while, oxalic acid shows high significant difference comparing with control group. While for Valplast it reveals no significant difference. Finally, the independent t-test revealed no significant difference between citric acid, tartaric acid, Protefix, and distilled water, while oxalic acid shows a significant difference, Fig (2).

KJPS
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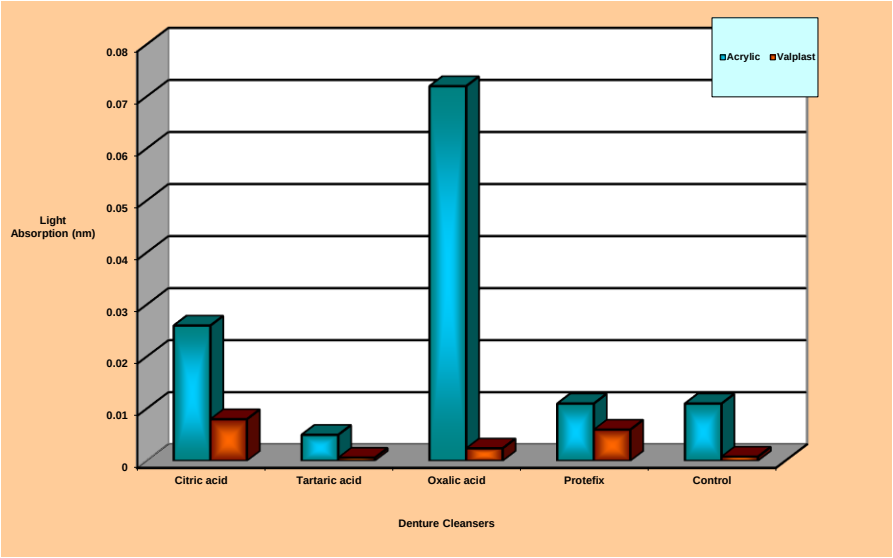

Fig (2): Bar chart of color stability test; objective method.

Water sorption: The sorption values for all groups of both denture base materials are within the ADA specification limit No. 12 for denture base polymers (the uptake should not be more than 0.8 mg/ cm^2). ANOVA test revealed that statistically there was a highly significant difference between the five groups for both types of denture base materials. (P = 0.000 for acrylic) and (P = 0.000 for Valplast). The result of the Dunnett test for both acrylic resin and valplast statistically revealed a highly significant difference between citric acid, tartaric acid, and oxalic acid with the control group and no significant difference between Protefix and distilled water. Finally, the result of t-test revealed that statistically there was a highly significant difference between two denture bases materials immersed in three prepared denture cleanser solutions, and no significant difference between two types of materials immersed in Protefix and distilled water, Fig (3).

KJPS
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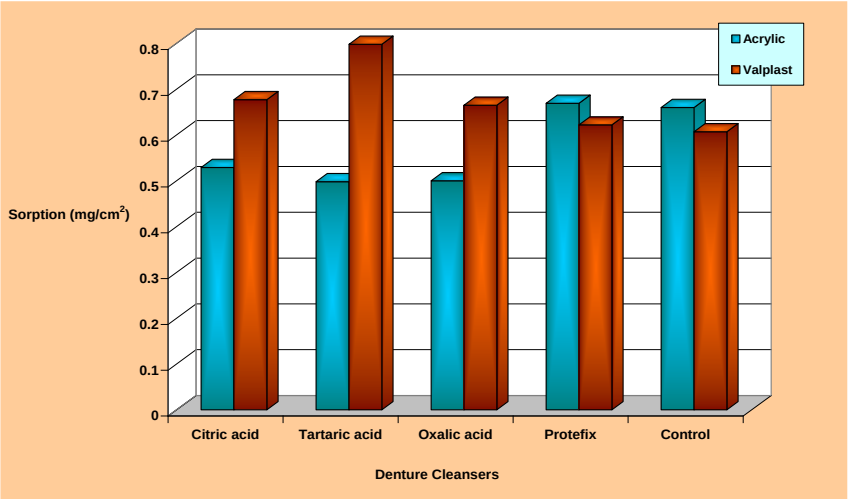

Fig (3): Bar chart of sorption test

Water solubility: The solubility values for both denture base materials have complied with the ADA specification limit No. 12 for denture base polymers (the loss in weight should not be more than 0.04 mg/ cm^2). ANOVA test for acrylic resin and Valplast materials statistically revealed no significant difference between the groups (P = 0.634 for acrylic, and P = 0.237 for Valplast). The result of the Dunnett test statistically revealed no significant difference for both acrylic resin and Valplast. Finally, the independent t-test showed a highly significant difference between two denture base materials, and acrylic specimens showed a lower value than Valplast, Fig (4).

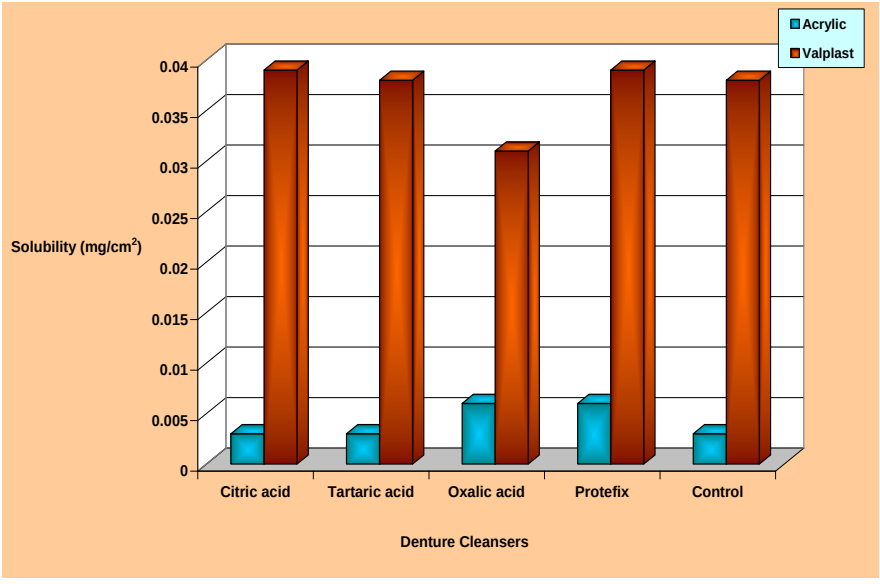

Fig (4): Bar chart of solubility test

Discussion

Color stability: In this study, color stability was measured by using two methods, visual examination, and spectrophotometer study.

In visual examination, there was no significant difference in color change of both acrylic resin and Valplast materials after immersion in citric and oxalic acids and significant color change after immersion in tartaric acid and Protefix. The mean values for acrylic specimens showed no color change (mean value < 1) among the tested groups. For Valplast it reveals a slight color change in all tested groups (mean value >1) comparing with control. These findings are in agreement with Goiato et al [10] when they found that Valplast presented the greatest chromatic alteration after accelerated aging, which was significantly different from Triplex (heat-cure acrylic). Also, Al-khafaji [9], [11] used the same denture cleansers and found no color change by visual examination in acrylic samples after immersion in the denture cleanser solutions and in the distilled water. However, Visual shade matching and color perception is a psychophysical phenomenon with variations, both between individuals and within an individual at different times so it is not more dependable and instrumental measurement has the advantage of obviating the subjective errors of color assessment [12].

The use of spectrophotometer method is an objective study, the result of this study revealed no significant color change at 500 nm levels between the acrylic resin and Valplast materials after immersion in distilled water and denture cleansers. Except for specimens immersed in oxalic acid which show a significant difference. These results are in agreement with Sato et al [13], Al-khafaji [9], [11], and Kortrakulkij [14]. The oxalic acid has a greater effect on the color of acrylic resin specimens; this may be due to that the oxalic acid absorbs at the same wavelength (500 nm), or it may react with our material (QC-20) and give a product which absorbs at the same wavelength and increasing the color intensity. Although no significant difference was observed concerning the same materials when the visual examination method was used.

Water sorption: The results of sorption test show that statistically there is a highly significant difference between acrylic and Valplast immersed in prepared denture cleanser solutions, Valplast specimens exhibited higher values of water sorption. This finding is in

agreement with Lai et al [15], and Takabayashi [16]. This phenomenon is explained by the water absorption occurring among the molecular chains due to the high hydrophilicity of the numerous amide bonds forming the main chains of the polyamide resin. It is also thought that the higher the amide group concentration, the greater the water absorption. For both materials regarding the sorption test statistically, there is a highly significant difference among the tested samples that were immersed in prepared denture cleansers compared to that immersed in distilled water. This is disagreeing with Al-khafaji [9], [11], used the same prepared denture cleansers. She found that the denture cleanser solution caused no effect on the sorption of light-cured acrylic resin and those cured by water bath and microwave.

Water solubility: The results of the solubility test shows that statistically there is a highly significant difference between acrylic and Valplast immersed in denture cleanser solutions and distilled water.Valplast specimens exhibited higher values of solubility, but, all have complied with ADA specification limit which stated that the loss of weight should not be more than 0.04 mg/cm^2. Regarding the effect of denture cleanser, the result reveals no significant difference between tested groups with a control group; this is in agreement with Al-khafaji [9], [11].

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