

Evaluating the effect of new denture cleaners on the surface roughness of acrylic resin denture base material (An *in vitro* study)

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ABSTRACT

Three newly prepared denture cleaner solutions from materials available in our country [namely; oxalic, citric and tartaric acids dissolved in isopropyl alcohol (5% w/v)] were studied for their effect on 110 specimens of heat cure acrylic resin prepared according to ADA Specification for 7 days, 1 month, 6 months, and 12 months, compared with Steradent denture cleaner by two techniques (immersion and brushing techniques). The concentration (5% w/v) was selected according to the results of pilot study.

The results of this study showed that oxalic and tartaric acids have nearly the same effect on surface roughness in relation to Steradent by immersion technique for six months, but this result was increased to show high rough surface of samples treated by citric acid for one year.

Treatment with the four solutions led to reduction in weight (0.03 mg) except citric acid (0.49 mg).

Statistical analysis was performed using F-test two-sample. The results revealed that there was a significant difference at levels 1% and 5% between the brushing and immersion techniques, roughness of the surfaces, and period of using each solution.

الخلاصة

تم دراسة تأثير ثلاثة من غسول أطقم الأسنان البلاستيكية المحضرة محلياً (وهي حامض الأوكزاليك وحامض الستريك وحامض الطرطريك مذابة في كحول الأيزوبروبيل بتركيز ٥% وزن/ حجم) على ١١٠ نموذج من الراتنج الأكريلي المبلمر بواسطة تقنية الفرن المائي لمدة سبعة أيام وشهر وستة أشهر واثنى عشر شهراً ومقارنتها مع غسل "ستيرادنت" المعروف عالمياً باستخدام طريقتين هما طريقة الغمر وطريقة استخدام فرشاة الأسنان (الطريقة الكيميائية والميكانيكية).

أظهرت نتائج الفحوصات المختبرية أن لمحلول حامض الأوكزاليك وحامض الطرطريك تأثير موازي أو مقارب لتركيبه "ستيرادنت" من حيث تأثيره على خشونة السطح بطريقة الغمر ولمدة ستة أشهر، ولكن هذا التأثير يزداد بعد سنة من استخدامه وخاصة لمحلول حامض الستريك.

أدت كافة المحاليل إلى نقصان في الوزن وبمعدل ٠.٠٣ ملغم ما عدا محلول حامض الستريك (٠.٤٩ ملغم).

أجري التحليل الإحصائي باستخدام اختبار (F-test two-sample). وأظهرت النتائج أن هناك فرق معنوي إلى مستوى ١% و ٥% بين الطريقتين المستخدمتين، الفترات الزمنية وخشونة السطح لكل محلول.

Changes in weight in relation to surface area were ranged between 0.01–0.03 mg/cm² for Steradent and oxalic acid in immersion technique, while the result was 0.05–0.23 mg/cm² for brushing technique of the other solutions except citric acid.

Oxalic acid showed complete removing of the stain within 8–10 minutes, Steradent and tartaric acid need 6–8 hours, while citric acid did not show the same result.

Key Words: Denture cleanser, weak oxalic acid, surface roughness.

إن التغيير في نسبة الوزن إلى المساحة السطحية كانت تتراوح بين ٠.٠١ إلى ٠.٠٣ ملغم/سم^٢ لمحلول "ستيرادنت" وحمض الأوكزاليك بطريقة الغمر، وبمعدل ٠.٠٥ إلى ٠.٢٣ ملغم/سم^٢ بطريقة استعمال الفرشاة ما عدا محلول حامض الستريك.

أما من حيث إمكانية إزالة اللون من على السطح، فقد أظهرت النتائج أن محلول حامض الأوكزاليك يزيل اللون بمدة لا تزيد على ٨ - ١٠ دقائق يومياً؛ في حين يحتاج محلول حامض الطرطريك ومحلول "ستيرادنت" مدة تتراوح بين ٦ - ٨ ساعات في اليوم، بينما لم تظهر مثل هذه النتائج على محلول حامض الستريك.

INTRODUCTION

Prosthesis has been identified as a source of cross contamination because of the increased risk of infection through constant exposure to debris, plaque and saliva, which harbor pathogenic organisms that adhere to prosthesis.⁽¹⁾ Adequate plaque control is essential for the maintenance of a healthy oral mucosa.^(2,3)

Denture cleaners are used as a popular method by denture wearers for cleaning. To clean their dentures, patients may use proprietary cleaners, or household cleaning materials. This is in order to keep the denture free of plaque, staining and calculus.⁽³⁾

The denture cleaner's constituents, efficiency, adverse effects and safety are very important because such denture cleaner may affect the denture surface and rough surface produced make it difficult to maintain clean surface.⁽⁴⁾

A smooth acrylic denture base surface is more desirable in terms of cleaning ability, and infection control due to the effectiveness of denture cleaning agents against microorganisms, since roughened surface will facilitate the retention of yeast.⁽⁴⁻⁶⁾

The most commonly used diluted acidic cleaner is household vinegar. Other chemical cleaners which are classified under this heading include weak solutions of hydrochloric, phosphoric and sulfuric acids.⁽⁷⁾

Oxalic acid, citric and tartaric acids (weak organic acids) found in many plants and vegetables. Oxalic acid found parti-

cularly in buckwheat (family Polygoniaceae), rhubarb and oxalis (family Oxalidaceae); used as a hemostatic in vete-rinary medicine, and it is used in removal of stains.^(8,9)

All three organic acids used in this study are naturally occurring carboxylic acids present in citrus foods with a moderate solubility in water and alcohol besides its bleaching effect. Oxalic acid is present in small amounts in many plants such as oxalis and spinach, and used as rust remover.⁽⁸⁻¹⁰⁾

The aims of this study were to evaluate the effect of newly prepared denture cleaners on hot cure acrylic resin denture surface regarding roughness, weight in relation to surface area and staining removal; and to compare them with other commercially available cleaners.

MATERIALS AND METHODS

Materials used in this study were:

- 1) Chemical materials used (tartaric acid, citric acid, oxalic acid and isopropyl alcohol), were purchased from Fluka chemicals and were of high purity. Isopropyl alcohol was chosen as solvent due to its antiseptic effect moderate boiling point (97 °C).^(8,9)
- 2) Denture base: Acrylic denture base material (Quayle Dental, Ltd) heat cured acrylic powder CI I and liquid pink colour Batch No. BS2487.
- 3) Steradent denture (Alkaline Peroxide) cleaning tablets (Reckitt

GmbH for Reckitt and Colman products Ltd. Hull/England).

Five different concentrations (1–5%) w/v of each oxalic, citric and tartaric acids were dissolved in isopropyl alcohol. Each solution was diluted with distilled water (50:50) prior to use. Steradent tablet was dissolved in distilled water according to manufacturer's instructions.

Dry tea (4 g) was boiled in 500 ml of distilled water for four minutes, and then allowed to cool at room temperature, then decanted from its leaves. Fresh tea solution was prepared daily.⁽¹¹⁾

A total of 110 heat cured acrylic resin specimens were prepared from wax plated ($65 \times 10 \times 2.5 \pm 0.3$ mm) dimensions according to ADA specifications. Curing was done in the conventional method using long cycle water bath technique, then the acrylic specimens were finished and polished according to Hatim and Kazanji.⁽¹²⁾ The specimens were placed in a thermostatically controlled incubator at $37^\circ\text{C} \pm 1^\circ\text{C}$ to simulate mouth temperature for 7 days before treatment for conditioning of the samples.⁽¹³⁾

A pilot study was done to determine the significant concentration of acid to be used. Thirty specimens of heat cured acrylic resin were divided into six groups, each group of 3. The specimens were immersed in tea solution for twenty-four hours. Then each specimen was immersed in one of the solutions prepared with different concentrations. The sixth group of specimens was immersed in distilled water only as a control group.

Timer was used to determine the significant time to clean the specimens (complete removal of the staining) from 5 minutes to 8 hours daily.

The results of this study showed that the favorable time for complete cleaning of the specimens was 8–10 minutes daily by using 5% concentration of oxalic acid, while the other solutions need more time to remove the stain.

The results of surface roughness of heat cured acrylic denture base showed slight effect of 5% concentration of the prepared acid solution in relation to control group of distilled water.

Two techniques were followed for all specimens to measure surface roughness,

weight loss and linear dimensional changes using a computerized surface texture measuring and recording machine (perthometer) M3P Perthen–West (Germany) with accuracy up to $0.001 \mu\text{m}$, electronic balance (Mettler, West Germany), and optical measuring micrometer microscope (Leitz, Wetzlar, GmbH, West Germany) with accuracy up to 0.001 mm at magnification power ($\times 10$). The two techniques were:

1) Immersion Technique: Forty specimens were divided into four groups randomly. Each group consists of 10 specimens. The specimens were immersed in tea solution overnight, then washed with distilled water and immersed in the tested solutions; i.e., oxalic acid, citric acid, tartaric acid and Steradent solution (prepared by dissolving a Steradent tablet in distilled water according to the manufacturer's instructions). Daily immersion of specimens in solutions for 10 minutes was done for 1 year. After each immersion, the specimens were washed with distilled water and stored in an incubator. The samples were examined after 1 month, 6 months and 12 months.

2) Brushing Technique: Another 40 specimens were divided in the same way as in immersion technique. For each specimen a special brush was used for 1 week only. The brush head was fixed to the bur of a handpiece of micromotor engine in order to obtain a constant pressure, speed and time. The surface of the specimens was brushed with test solution for 10 minutes, and then the specimens were washed with distilled water and measured.

Visual examination of staining removal was assessed by visual inspection in a daylight by five observers (complete or incomplete cleaning). Measurements of the samples were done after treatment with solutions (immersion and brushing techniques) at 1 month, 6 months and 12 months, in addition to the measurement of the samples before treatment at 7 days.

RESULTS AND DISCUSSION

Mean and standard deviation of the surface roughness of the acrylic resin samples before and after treatment with four solutions for 1 month, 6 months and 12 months were listed in Table (1).

Oxalic and tartaric acids have almost nearly the same effect on surface roughness in relation to Steradent by immersion technique for six months (Figures 1, 2 and

3). But this result was increased to show high rough surface of samples treated by citric acid (immersion and brushing techniques) for one year (0.421–0.583 μm).

The results also showed that all denture cleaners have the ability to attack the surface of acrylic resin depending on the length of treating time, type of solution and the technique in agreement with other studies.^(2, 14-17)

Table (1): Mean and standard deviation of surface roughness of acrylic resin denture base

Time	Oxalic Acid Ra (μm)		Steradent Ra (μm)		Citric Acid Ra (μm)		Tartaric Acid Ra (μm)	
	Br	Im	Br	Im	Br	Im	Br	Im
	Mean \pm SD							
7 Days	0.288 \pm 0.00105	0.288 \pm 0.00081	0.261 \pm 0.00105	0.262 \pm 0.00193	0.291 \pm 0.00087	0.290 \pm 0.0017	0.372 \pm 0.00081	0.377 \pm 0.00124
1 Month	0.290 \pm 0.00124	0.289 \pm 0.00128	0.263 \pm 0.001054	0.263 \pm 0.00099	0.313 \pm 0.00163	0.305 \pm 0.00205	0.380 \pm 0.0041	0.380 \pm 0.00124
6 Months	0.293 \pm 0.00144	0.290 \pm 0.00047	0.265 \pm 0.00105	0.264 \pm 0.00194	0.552 \pm 0.00124	0.411 \pm 0.00149	0.383 \pm 0.00149	0.385 \pm 0.00163
12 Months	0.297 \pm 0.00254	0.291 \pm 0.00078	0.268 \pm 0.00175	0.264 \pm 0.0021	0.583 \pm 0.00210	0.421 \pm 0.00128	0.391 \pm 0.0017	0.388 \pm 0.00105

Ra: Arithmetical mean deviation.

Br: Brushing technique.

Im: Imme

SD: Stand

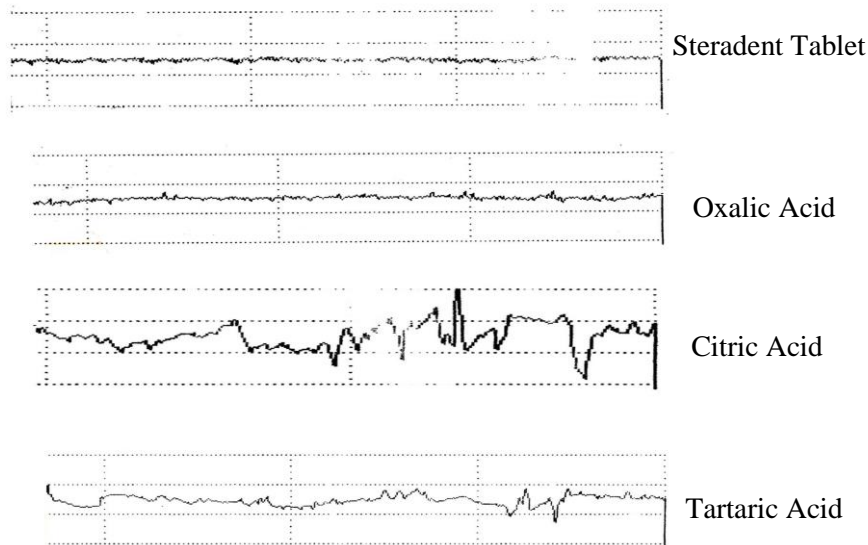


Figure (1): Graphic drawing of roughness (immersion technique) after surface treatment with Steradent tablet, oxalic acid, citric acid and tartaric acid respectively

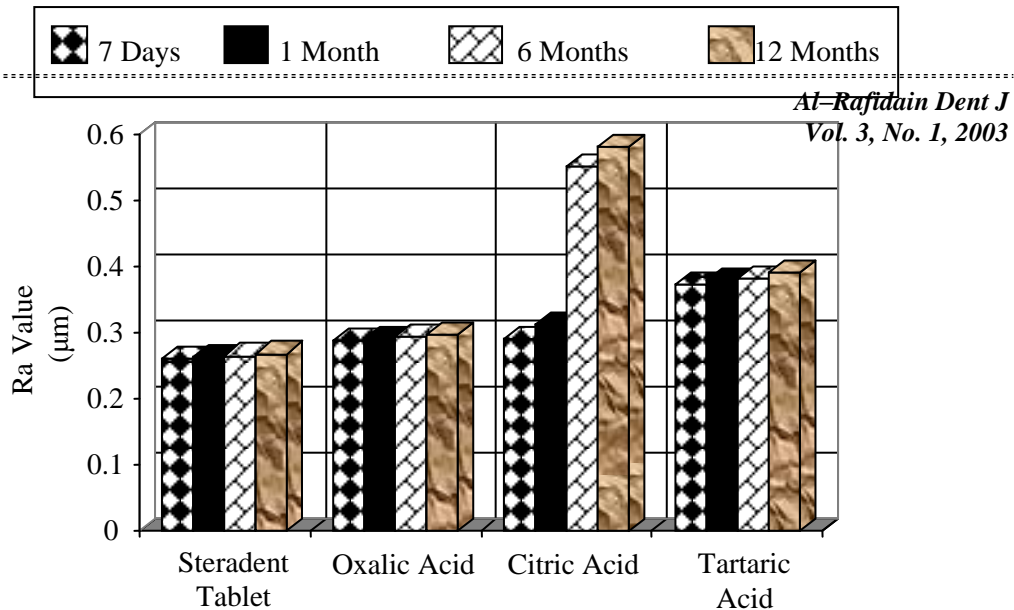


Figure (2): Surface roughness of acrylic resin denture base of brushing technique (Ra: Arithmetical mean deviation)

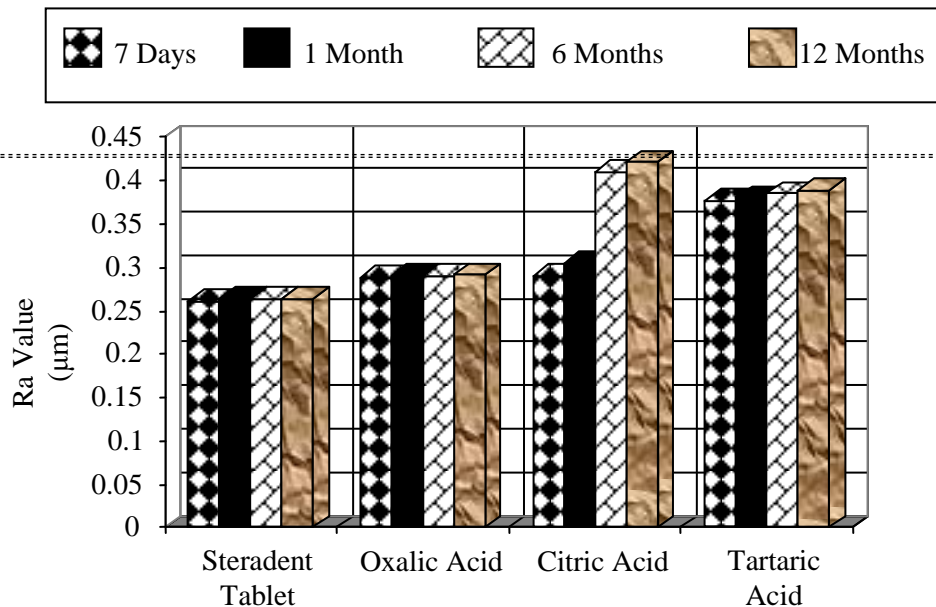


Figure (3): Surface roughness of acrylic resin denture base of immersion technique (Ra: Arithmetical mean deviation)

The results of this study showed a loss in weight of the samples treated by solutions (0.03 mg) except citric acid (0.49 mg) (Table 2). Change in weight in relation to surface area were ranged between 0.01–0.03 mg/cm² for Steradent

and oxalic acid in immersion technique which is near to the ADA Specification No. 12 (0.04 mg/cm²), while the result was 0.05–0.23 mg/cm² for brushing technique of the other solutions except citric acid (Figures 4 and 5).

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These results were attributed to the fact that oxalic acid is the weaker acid.^(6-8,18,19) The results revealed that there was a significant difference at level

1% and 5% by using F-test two-sample between the two techniques, roughness of the surface and period of using each solution (Table 3).

Table (2): Mean and standard deviation of weight of specimens before and after treatment

Treatment Time	Oxalic Acid 5%		Steradent Tablet		Citric Acid 5%		Tartaric Acid 5%	
	Br	Im	Br	Im	Br	Im	Br	Im
	Mean Weight (mg)							
	± SD							
7 Days (Control)	7.634 ± 0.0021	7.586 ± 0.0016	7.534 ± 0.0027	7.494 ± 0.0033	7.642 ± 0.0416	7.634 ± 0.0029	7.680 ± 0.0017	7.599 ± 0.0153
1 Month	7.630 ± 0.0083	7.586 ± 0.0024	7.534 ± 0.0013	7.494 ± 0.0034	7.627 ± 0.0016	7.611 ± 0.0015	7.672 ± 0.0013	7.591 ± 0.0011
6 Months	7.620 ± 0.0010	7.584 ± 0.0015	7.531 ± 0.0066	7.493 ± 0.0024	7.580 ± 0.0013	7.600 ± 0.0021	7.665 ± 0.0018	7.585 ± 0.0032
12 Months	7.613 ± 0.0059	7.580 ± 0.0042	7.527 ± 0.0024	7.490 ± 0.0038	7.531 ± 0.0021	7.581 ± 0.0063	7.660 ± 0.0015	7.581 ± 0.0065

Br: Brushing technique.
Im: Immersion technique.
SD: Standard deviation.

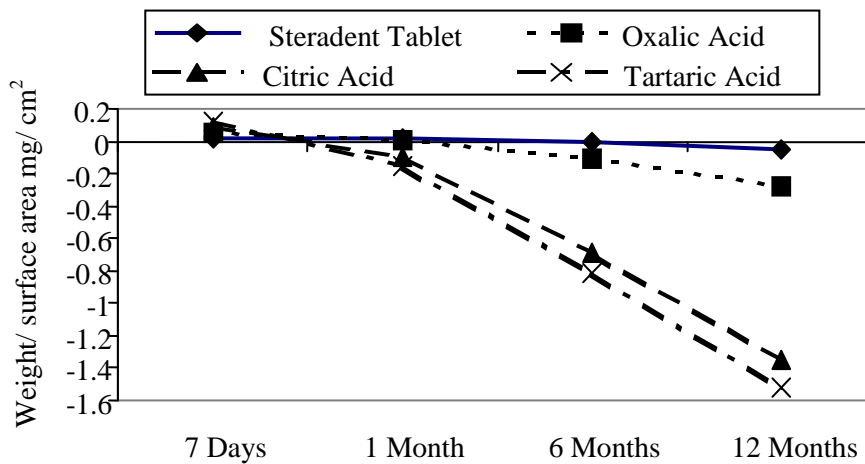


Figure (4): Weight to surface area change in samples (brushing technique)

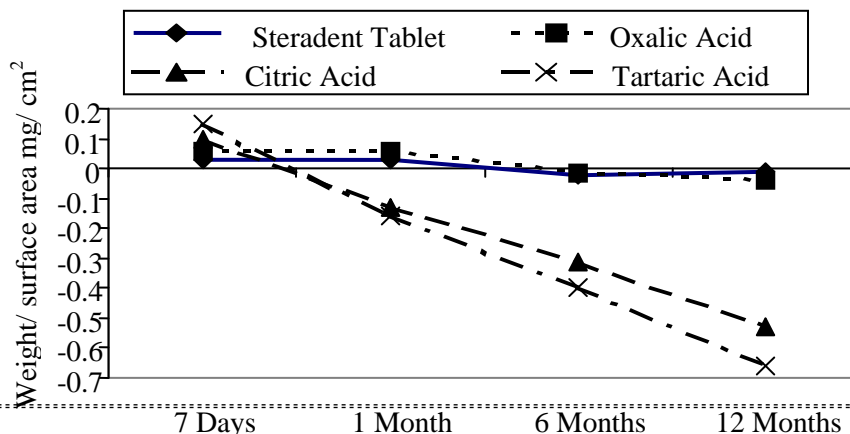


Figure (5): Weight to surface area change in samples (immersion technique)
 Table (3): F-test two-sample for immersion and brushing techniques

Denture Cleanser	F-value			
	7 Days	1 Month	6 Months	12 Months
Oxalic Acid 5%	1.6667*	0.93959**	9.45**	10.42857**
Steradent Tablet	0.297619*	1.123596*	0.294118*	0.657143**
Citric Acid 5%	0.26538*	0.63157**	0.7**	2.684564*
Tartaric Acid 5%	0.42857**	1.29285*	0.8333**	2.6*

* Significant at level 5%.

** Significant at level 1%.

Chemical denture cleansing methods have several advantages over the mechanical method. Chemical denture cleansing solutions can easily reach all areas of the denture and result in complete cleaning; damage from mishandling of the denture is minimized; abrasion is not possible and since the procedure is simple, it is easily carried out by handicapped persons or by individuals lacking the physical coordi-

nation to adequately clean their dentures by brushing.^(2, 15-17, 20)

Oxalic acid showed complete removing of the stain within 8–10 minutes daily, Steradent and tartaric acid need 6–8 hours daily.

Citric acid solution need more time to remove the stain completely (Table 4).⁽²¹⁻²³⁾

Table (4): The effect of denture cleaners on staining removal

Materials	Steradent 5%	Oxalic Acid 5%	Citric Acid 5%	Tartaric Acid 5%
Complete Removal of Staining (8–10 Minutes)	No	Yes	No	No
Complete Removal of Staining (6–8 Hours)	Yes	Yes	No	Yes

CONCLUSIONS

Preparation of new Iraqi denture cleansers (oxalic, citric and tartaric acids 5%); oxalic and tartaric acids have almost nearly the same effect on surface roughness in relation to Steradent by immersion technique for six months.

Treatment with the four solutions lead to reduction in weight (0.03 mg) except citric acid (0.49 mg).

The results revealed that there was a significant difference at level 1% and 5% between the brushing and immersion techniques, roughness of the surfaces and

period of using each solution.

Changes in weight in relation to surface area were ranged between 0.01–0.03 mg/cm² for Steradent and oxalic acid in immersion technique, while the result was 0.05–0.23 mg/cm² for brushing technique of the other solutions except citric acid.

Oxalic acid showed complete removing of the stain within 8–10 minutes, Steradent and tartaric acid need 6–8 hours, while citric acid needed more time to give the same result.

REFERENCES

- 1) Grant AA, Walsh GF. Reducing cross contamination in prosthodontics. *J Prosthet Dent.* 1975; 34: 324-328.
- 2) Sheen SR, Harrison A. Assessment of plaque prevention on denture using an experimental cleanser. *J Prosthet Dent.* 2000; 84(6): 594-601.
- 3) Morgan TD, Wilson M. Anti-adhesive and antibacterial properties of a proprietary denture cleanser. *J Appl Microbiol.* 2000; 89(4): 617-623.
- 4) Faraj AS, Al-Dabagi R. The effect of denture cleaners on surface roughness of denture base material. *Iraqi Dent J.* 2000; 25: 121-136.
- 5) Verran J, Maryan CJ. Retention of *Candida albicans* on acrylic resin and silicone of different surface topography. *J Prosthet Dent.* 1997; 77: 535-539.
- 6) Kazanji MN, Al-Kazzaz NH. The effect of disinfectant solutions on the surface topography of acrylic denture base materials. *Al-Rafidain Dent J.* 2002; 2(1): 65-71.
- 7) Craig RG, O'Brien WJ, Power JM. Dental Materials: Properties and Manipulation. 6th ed. CV Mosby Co. 1996; Pp: 97-113, 242-265.
- 8) Finar IL. Organic Chemistry. The Fundamental Principles. Volume 1. 6th ed. Longman Group Ltd. Assemental Co. 1973; Pp: 446-448.
- 9) Fessenden RJ, Joans F. Fundamental of Organic Chemistry. Published by Harper and Row. New York. 1990; p: 367.
- 10) Majeed S, Mohammad JM. Iraqi Medical Plants Between Folk Usage and Scientific Research. 10th ed. 1988; Pp: 27, 75.
- 11) Kareem RA. The effect of denture cleaners on transverse strength and deflection of acrylic resin denture base materials. *Iraqi Dent J.* 2001; 27: 171-184.
- 12) Hatim NA, Kazanji MN. Effect of some finishing and polishing techniques on the degree of roughness of heat cure acrylic surface. *Iraqi Dent J.* 1999; 24: 153-168.
- 13) Anusavice KJ. Phillip's Science of Dental Materials. 10th ed. WB Saunders Co. 1996; Pp: 237-267.
- 14) Budtz-Jorgensen E. Prevention of plaque formation by an enzyme denture cleanser. *J Biol Buccale.* 1977; 5: 239-244.
- 15) Jagger DC, Harrison A. Denture cleansing: The best approach. *Br Dent J.* 1995; 178: 413-417.
- 16) McCabe JF, Pavidmurry J, Kelly PJ. The efficacy of denture cleansers. *Eur J Prosthodont Res Dent.* 1995; 3(4): 203-207.
- 17) Oizumi M, Suzuki T, Uchida M, Furuya J. *In vitro* testing of a denture cleansing method using ozone. *J Med Dent Sci.* 1998; 45(2): 135-139.
- 18) Louis FF, Mary F. Advanced Organic Chemistry. 2nd ed. New York Chapman and Hall Ltd. London Reinhold Publishing Corp. 1963; p: 465.
- 19) Ernst CP, Willershausen B, Driesen G, Warren PR, Hilfinger P. A robot system for evaluating plaque removal efficiency by tooth brushes *in vitro*. *Quintessence Int.* 1997; 28(7): 441-445.
- 20) Abere DJ. Post placement care of complete and removable partial dentures. *Dent Clin North Am.* 1979; 23(1): 143-150.
- 21) Budtz-Jorgensen E. Materials and methods for cleaning denture. *J Prosthet Dent.* 1979; 42: 619-623.
- 22) Stedman's Concise Medical Dictionary. 3rd ed. Williams & Wilkins. A Waverly Co. Novel Inc. 1997.
- 23) Subhi MD. The effect of disinfectant solutions on some properties of acrylic denture base material. MSc Thesis. College of Dentistry. University of Baghdad. 1999.

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