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Evaluation of the effect of some denture cleansers on the colour of acrylic resin denture base materials

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ABSTRACT

The aims of this study were to evaluate the effect of denture cleansers on the colour of acrylic resin denture base material, and to evaluate the effect of particle size and surface roughness of acrylic resin material on their colour change.

Sixty four acrylic specimens were prepared from the three types of acrylic resin materials of 30×20×1.5 mm (length× width× thickness, respectively). After the conditioning in distilled water, they were immersed in eight types of denture cleansers for 7 days. The colour changes were assessed using a computerized ultraviolet–visible spectrophotometer with accuracy up to 0.001. Visual examination of colour change was done by three independent examiners. The analysis of particle size was performed with a sieving machine. The surface roughness of acrylic specimens was measured using a computerized surface texture measuring and recording machine (Perthometer). A statistical analysis was performed using analysis of variance and Duncan's Multiple Range Test. The results revealed that there was a significant difference at $p \leq 0.01$ between the tested solutions and also between the three types of acrylic resin materials.

It was concluded that denture cleansers induced colour change of acrylic resin denture base materials. The self–curing acrylic exhibited the highest colour change. The smaller particle size and the smoothest surface of resin materials decreased the amount of colour change.

Key Words: Dental cleansers, colour, acrylic resin denture base.

الخلاصة

كانت الأهداف من هذه الدراسة هي تقييم تأثير غسول طقم الأسنان على لون مواد قاعدة طقم الأسنان الراتنج اكريليّة ولتقييم تأثير حجم جزئية الأكريل وخشونة سطح المواد الراتنج أكريلية على تغير لونها.

تم تحضير ٦٤ من العينات الأكريلية من الثلاثة أنواع من مادة الراتنج الأكريلي وبقياس ٣٠×٢٠×١.٥ (طول×عرض×سمك، على التوالي). وبعد عملية التكيف في الماء المقطر غُمرت هذه الأنواع الثلاثة في ثمانية أنواع من غسول الفم ولمدة سبعة أيام. تم تقييم تغّير اللون باستخدام مقياس طيف الأشعة فوق البنفسجية المرئية المبرمج وبدقة تصل إلى ٠.٠٠١ . تم الاختبار البصري لتغير اللون بواسطة ثلاثة فاحصين مستقلين . أنجز تحليل حجم جزيئة الأكريل باستخدام جهاز الغربلة . تم قياس خشونة سطح العينات الأكريلية باستخدام جهاز قياس وتسجيل خشونة السطح المبرمج. اجري التحليل الإحصائي باستخدام اختبار تحليل التباين واختبار "دنكن" المتعدد المديات . أظهرت النتائج بان هناك فرقا معنويا عند مستوى معنوية ١% بين المحاليل المختبرة وكذلك بين الأنواع الثلاثة لمواد الراتنج الأكريلية.

استنتج بان غسول طقم الأسنان تسبب تغّير لون مواد قاعدة طقم الأسنان الراتنج اكريليّة وأن الأكريل ذو التصلب الذاتي أظهر التغير الأعلى في اللون . كما أن صغر حجم جزيئة الأكريل ونعومة السطح لمادة الراتنج الأكريلي قللت من تغّير اللون.

INTRODUCTION

Colour is one of the optical properties of dental restorative materials and it is the quality of the object or substance with respect to the light reflected or transmitted through it.[1, 2]

Discolouration of acrylic resins may occur which result in aesthetic problem. The denture base polymer should have good aesthetics with a smooth, glossy surface and be capable of matching the natural appearance of the soft tissues.[3–5] Chemical cleansing is recommended for denture plaque control.[6–10] However, some denture cleansers may have harmful effects on the plastic and metallic components of the denture and it may adversely affect the colour and surface luster of acrylic resin materials.[11–14]

Therefore this study has been carried out to evaluate the effect of some denture cleansers on the colour of acrylic resin denture base materials, and to evaluate the effect of particle size and surface roughness of acrylic resin on the colour change.

MATERIALS AND METHODS

Sixty four acrylic specimens were prepared from each of the three types of acrylic resin material, two types of heat–curing acrylic [Quayle Dental (Quayle Dental Ltd. Sussex, UK) and Major Base (Major Prodotti Dentari, SPA, Italy)] and one type of self–curing acrylic [Medicus (DMP Ltd. EU)] in a uniform dimensions of 30×20×1.5 mm (length× width× thickness respectively).

The polymerization process of the heat–curing resin was done in a boiling water for 30 minutes as recommended by manufacturers' instructions.[2] While for the self–curing resin the polymerization process was established at room temperature with the flask remained under the clamp press for 24 hours.[15] The surface of acrylic specimens was finished and polished using pumice and muslin buffing wheel.[16] The acrylic specimens were immersed in the tested solutions (0.5% sodium hypochlorite, 3% hydrogen peroxide, 6% vinegar, 5% hydrochloric acid, 0.2% chlorhexidine gluconate, 0.05% glutaraldehyde, 0.5% povidone iodine and tap water) at room temperature (25 ± 2°C) for 7 days. This long period of immersion represents the cumulative effect of repeated short immersion of the dental prosthesis during its life service.[14]

Instrumental assessment of the colour was performed using a computerized ultraviolet–visible spectrophotometer [CECIL (CE1021, England)], which is a photometric device used to measure the light transmitted or absorbed within a specific material. The absorbed light is measured with accuracy up to 0.001 and it is also termed the optical density.[17] Spectrophotometric analysis of the colour of acrylic denture base materials, before and after one week of immersion in different denture cleansers, was conducted. The colour change of acrylic specimens was assessed by visual inspection in a day light by three independent observers.[18] The specimens were graded for the amount of discolourations on a scale of no change, slight, moderate and severe.[13]

Estimation of particle size was accomplished by separating the polymer particles according to their size through the sieving process. The sieving procedure was performed by mixing the acrylic powder thoroughly to ensure the proper dispersion of the different particles through the acrylic powder. After that, 100 gm of powder was placed on the uppermost sieves with the remaining sieves arranged successively according to their descending size sequence (250, 150, 90 and 45 μm respectively). After that, the acrylic powder retained in each sieve was collected and weighted).

The measurement of the surface roughness of acrylic denture base materials was carried out by adjusting microtracer of Perthometer to start the recording in the mid line of the acrylic specimen at about 1.5 cm from its upper border, the microtracer traversed across the surface of acrylic specimen for a distance of 1.5 mm and an amplified trace of the profile was recorded.

The pretest optical density of acrylic specimens showed a wide range of variation, therefore the percentage of change in the optical density from the pretest reading for each specimen was calculated. After that, the mean and the standard deviation were calculated. The results were comp-

ared statistically using analysis of variance (ANOVA) followed by Duncan's Multiple Range Test.

RESULTS

Analysis of variance indicated that the optical density of acrylic specimens was highly significantly different ($p \leq 0.01$) among the different tested solutions. For both types of heat curing acrylic (Quayle–Dental and Major–Base), chlorhexidine produced the highest increase in the optical density of acrylic specimens (1.844 and 3.306, respectively), sodium hypochlorite produced the highest decrease in their optical density (–2.018 and 0.787, respectively), while for the self–curing acrylic denture base materials (Medicus), hydrogen peroxide produce the highest increase in optical density of acrylic specimens (8.105) (Tables 1–6).

Table (1): Analysis of variance for the optical density of Quayle–Dental heat–curing acrylic

Source	df	SS	MS	F–value
Denture Cleansers	7	131.878	18.839**	103.51
Error	56	10.192	0.182	
Total	63	142.071		

df: Degree of freedom.
SS: Sum of squares.
MS: Mean squares.
** Highly significant difference at $p \leq 0.01$

Table (2): Duncan's Multiple Range Test for the mean optical density of Quayle–Dental heat–curing acrylic

Denture Cleansers	No.	Mean	±SE	Duncan's Group *
Sodium Hypochlorite	8	–2.018	0.220	D
Hydrogen Peroxide	8	–1.906	0.159	D
Vinegar	8	1.177	0.137	BC
Hydrochloric Acid	8	1.409	0.121	B
Chlorhexidine Gluconate	8	1.844	0.181	A
Glutaraldehyde	8	1.115	0.113	BC
Povidone Iodine	8	1.366	0.125	B
Water	8	0.86	0.113	C

SE: Standard error.
*Means with different letters are significantly different.

Table (3): Analysis of variance for the optical density of Major–Base heat–curing acrylic

Source	df	SS	MS	F–value
Denture Cleansers	7	127.634	18.233**	53.91
Error	56	18.939	0.338	
Total	63	146.573		

df: Degree of freedom.
SS: Sum of squares.
MS: Mean squares.
** Highly significant difference at $p \leq 0.01$

Table (4): Duncan's Multiple Range Test for the mean optical density of Major–Base heat–curing acrylic

Denture Cleansers	No.	Mean	±SE	Duncan's Group *
Sodium Hypochlorite	8	–0.787	0.327	D
Hydrogen Peroxide	8	–0.706	0.329	D
Vinegar	8	2.160	0.039	B
Hydrochloric Acid	8	2.417	0.134	B
Chlorhexidine Gluconate	8	3.306	0.189	A
Glutaraldehyde	8	2.119	0.087	B
Povidone Iodine	8	2.447	0.198	B
Water	8	1.304	0.140	C

SE: Standard error.
*Means with different letters are significantly different.

Table (5): Analysis of variance for the optical density of Medicus self–curing acrylic

Source	df	SS	MS	F–value
Denture Cleansers	7	106.490	15.212**	15.3
Error	56	55.514	0.991	
Total	63	162.004		

df: Degree of freedom.
SS: Sum of squares.
MS: Mean squares.
** Highly significant difference at $p \leq 0.01$

Table (6): Duncan's Multiple Range Test for the mean optical density of Medicus self–curing acrylic

Denture Cleansers	No.	Mean	±SE	Duncan's Group*
Sodium Hypochlorite	8	7.435	0.166	A
Hydrogen Peroxide	8	8.105	0.224	A
Vinegar	8	5.007	0.274	C
Hydrochloric Acid	8	5.772	0.179	BC
Chlorhexidine Gluconate	8	6.156	0.325	B
Glutaraldehyde	8	5.347	0.320	BC
Povidone Iodine	8	6.043	0.756	BC
Water	8	3.686	0.157	D

SE: Standard error.
*Means with different letters are significantly different.

For the acrylic resin denture base materials, ANOVA and Duncan's Multiple Range Test have been carried out to isolate the material that exhibited the highest change in optical density (Tables 7 and 8). The results explained that the Medicus self–curing acrylic showed the highest increase in the optical density (5.944) and the Quayle–Dental heat–curing acrylic exhibited the least change (0.481). The results of visual examination of acrylic resin materials showed that the heat–curing resin did not exhibit any observable colour change, while the self–curing resin showed an observable colour change especially those specimens immersed in hydrogen peroxide solution.

Table (7): Analysis of variance for the optical density of acrylic resin materials

Source	df	SS	MS	F–value
Acrylic resin materials	2	1075.571	537.785**	225.54
Error	189	450.650	2.384	
Total	191	1526.221		

df: Degree of freedom.
SS: Sum of squares.
MS: Mean squares.
** Highly significant difference at $p \leq 0.01$

Table (8): Duncan's Multiple Range Test for the mean optical density of acrylic resin materials

Denture Cleansers	No.	Mean	± SE	Duncan's Group*
Quayle–Dental	64	0.481	0.187	C
Major–Base	64	1.532	0.190	B
Medicus	64	5.944	0.200	A

SE: Standard error.
*Means with different letters are significantly different.

The results of particles size analysis of the two types of heat–curing acrylic denture base materials indicated that, on comparing between the particles size of Quayle–Dental heat–curing acrylic and those of Major–Base heat–curing acrylic, the particles size of 90 μm and higher than 90 μm were smaller in weight percentage in Quayle–Dental heat–curing acrylic and those of 45 μm and less than 45 μm were greater in weight percentage in the Quayle–Dental type than the Major–Base heat–curing acrylic. This indicates that the particles of the Quayle–Dental heat–curing acrylic are generally smaller in size than the particles of Major–Base heat–curing acrylic (Figures 1 and 2).

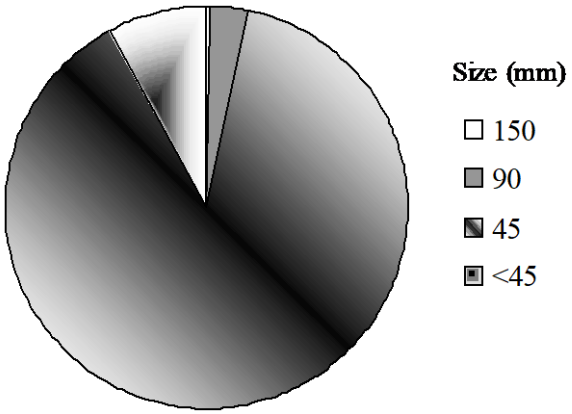

Figure (1): Weight percentage of particle size of Quayle–Dental heat–curing acrylic

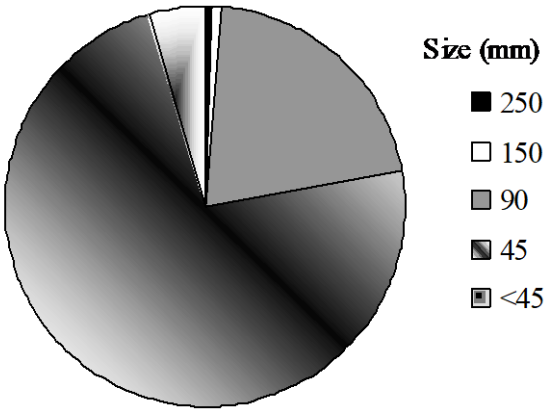

Figure (2): Weight percentage of particles size of Major–Base heat–curing acrylic

Analysis of variance of the surface roughness of acrylic resin material indicated that the Ra values (average roughness) of acrylic specimens were significantly different ($p \leq 0.05$) among the three types of acrylic resin. The acrylic specimens which were prepared from Quayle–Dental heat–curing acrylic had the least roughness value (smoothest surface) followed by Major–Base heat–curing acrylic and Medicus self–curing acrylic. The results are listed in Tables (9) and (10).

Table (9): Analysis of variance for Ra and Rz values of acrylic resin material

Source	Ra				Rz			
	df	SS	MS	F–value	df	SS	MS	F–value
Acrylic Resin Materials	2	0.003	0.001*	4.12	2	0.031	0.015**	0.89
Error	27	0.011	0.0004		27	0.484	0.017	
Total	29	0.014			29	0.516		

df: Degree of freedom.
SS: Sum of squares.
MS: Mean squares.
Ra: Average rouphness.
Rz: Average roughness depth.
*Significant difference at $p \leq 0.05$
** No significant difference

Table (10): Duncan's Multiple Range Test for the mean of Ra and Rz values of acrylic resin materials

Acrylic Resin Materials	Ra				Rz			
	No.	Mean	± SE	Duncan's Group*	No.	Mean	± SE	Duncan's Group*
Quayle–Dental	10	0.057	0.005	B	10	0.316	0.035	A
Major–Base	10	0.071	0.005	BA	10	0.379	0.054	A
Medicus	10	0.083	0.007	A	10	0.390	0.033	A

SE: Standard deviation.
Ra: Average rouphness.
Rz: Average roughness depth.
*Means with different letters are significantly different

DISCUSSION

Sodium hypochlorite and hydrogen peroxide denture cleansers produced a significant decrease in the optical density of heat–cured acrylic resin materials. This indicated that the concentration of coloured substance was reduced by immersing the acrylic specimens in these solutions. These results are supported by Ma *et al*.[19] However, the results of visual examination still showed no any observable colour change. This is in agreement with Polyzois *et al*.[14] While for the self–curing acrylic, sodium hypochlorite and hydrogen peroxide produced a significant colour change so that it can be detected visually and graded as severely discoloured especially for the hydrogen peroxide solution. This may be related to the strong oxidizing property of these solutions so that the liberated oxygen caused oxidation of the tertiary amine accelerator or the unreacted double bonds that are presented in the resin matrix and this is proved by other studies.[20, 21]

Acidic denture cleansers (vinegar and hydrochloric acid) were shown to affect insignificantly the colour of acrylic resin materials. These findings are in agreement with Asmussen.[20] Although chlorhexidine gluconate was shown to be significantly affect the colour of the heat–curing acrylic especially Major–Base type, the results of visual examination still showed no any observable colour change. This is in agreement with Hassu and El–Ameer.[22] Immersion of acrylic specimens in glutaraldehyde solution had insignificant effect on the colour of acrylic resin materials. This finding is supported by the results of previous studies.[12, 14, 19, 23] Povidone iodine (an iodophor based disinfectant solution) had insignificant effect on the colour of acrylic denture base materials, with no observable colour change especially on heat–curing acrylic. The non–staining behaviour of this solution was related to its property of being water soluble as proved by Prescott *et al*.[24] This result is in agreement with Baker *et al*.[23] and Ma *et al*.,[19] but disagreed with McNeme *et al*.[12] who reported that the immersion of acrylic specimens in iodophor disinfectant solution

caused a detectable colour change.

The colour change of acrylic specimens resulting from their immersion in water was also recorded in this study. This change in colour was found to be insignificant and this is in agreement with other studies.[14, 20, 21]

For the heat–curing acrylic denture base materials, the results revealed that the percentage of colour change of the Quayle–Dental heat–curing acrylic was signifi-cantly lower than that of the Major–Base heat–curing acrylic. The probable explana-tion of this result is that the particle size of the Quayle–Dental heat–curing acrylic is smaller than that of the Major–Base heat–curing acrylic. The smaller particle size will improve the surface wetting of the particles by the liquid components follow-ed by subsequent interaction with larger particles. Thus, the optimized properties are due to the enhanced matrix formation which is characterized by lower porosity level and this is in line with other studies.[25, 26] Furthermore, the surface roughness of the Quayle–Dental heat–curing acrylic was found to be lower than that of the Major–Base heat–curing acrylic. This result could be explained by the fact that the smaller particle size of the acrylic denture base materials provides the positive advantage to the topography of the denture base plastic, a result which is in agreement with Kazanji and Al–Kazzaz.[27]

Regarding the self–curing acrylic denture base material, the results indicated that the self–curing acrylic resin material exhibited higher percentage of colour change compared with that of the heat–curing acrylic. These results are supported by the findings of previous researchers.[20, 28, 29] Another possible explanation for the discolouration is related to the higher porosity level associated with the self–curing resin as proved by other studies.[29–31] The higher porosity level of the self–curing resin would adversely affect the aesthetic properties of the processed resin. Finally, the surface roughness of the self–curing resin was found to be higher than the heat–curing resin (Tables 9 and 10). This result is in agreement with Kazanji and Al–Kazzaz.[27] Thus, the increase surface roughness of the self–curing resin will increase the susceptibility of the material to receive coloured substance and this increases their discolouration potential.

CONCLUSIONS

The denture cleansers which cause reduction in the optical density of acrylic resin materials are more harmful to the denture base materials than those cause increasing in the optical density as they cause reduction in the original concentration of coloured substance of the materials. However, each denture cleanser have a specific use for a specific situation; i.e., sodium hypochlorite and hydrogen peroxide are recommended for removing stain, acidic denture cleansers are recommended for removing heavily calculus deposits. Chlorhexidine is recommended for disinfection of the denture especially in case of denture stomatitis. Generally speaking, the patients should constrict the use of the hypochlorite and peroxide cleansers to a limited degree.

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