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

Munther N Kazanji
BDS, MSc (Assist Prof)
Department of Prosthetic Dentistry
College of Dentistry, University of Mosul

Zina M Ahmad
BDS, MSc (Assist Lect)

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 ≤ 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 طقم الأسنان. حاولت الأبحاث أخذ تأثير تغيير جزيئية الأكريليك وخشونة سطح المواد reassuring أكريليكية على تغير لونها. تم تحضير 34 من العينات الأكريليكية من الثلاثة أنواع من مادة الراتنج الأكريليك وقياس 20×30×1.5 มม (طول×عرض×سمك، على التوالي). وبعد عملية التمديد في الماء المغطر غمرت هذه الأنواع الثلاثة في ثمانية أنواع من غسول الفم لمدة سبعة أيام. تم قياس تغيير اللون باستخدام مقياس طيف الأشرعة فوق البنفسجية المريح بمجرد تصل إلى 0.001. تم اختبار البصري لتغيير اللون بواسطة ثلاثة فحوصين مستقلين. أجبر تحليل جزيئات الأكريليك باستخدام جهاز المغلفة. تم قياس خشونة سطح العينات الأكريليكية باستخدام جهاز قياس وتسجيل خشونة السطح المريح. أجري التحليل الإحصائي باستخدام اختبار تحليل التباين والاختبارات الأخرى المتعددة. أظهرت النتائج أن هناك فرقا معنويًا عند مستوى معنوي 1% بين المحاليل المحتملة وكذلك بين الأنواع الثلاثة لمواد الراتنج الأكريليكية.

استنتج بان غسول طقم الأسنان تسبب تغيير لون مواد طقم الأسنان الراتنجية وأكريليك ذو التصلب الذاتي أظهر التغيير الأعلى في اللون. كما أن صغر حجم جزيئات الأكريليك ونعومة السطح لمواد الراتنج الأكريليكية قلل من تغيير 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 [CE–CIL (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 Perhometer 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-
RESULTS

Analysis of variance indicated that the optical density of acrylic specimens was highly significantly different ($p < 0.01$) 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).

| 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 $p < 0.01$

| 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.

| 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 $p < 0.01$
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 \( p < 0.01 \)

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).

Analysis of variance of the surface roughness of acrylic resin material indicated that the Ra values (average roughness) of acrylic specimens were significantly different \( (p < 0.05) \) 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).

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

| Source                | 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 | 4.12    | 27 | 0.484  | 0.017  | 0.89    |
| Total                 | 29 | 0.014  |     |         | 29 | 0.516  |     |         |

df: Degree of freedom.
SS: Sum of squares.
MS: Mean squares.
Ra: Average roughness.
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          | Duncan’s Group* | Rz          | Duncan’s Group* |
|-------------------------|-------------|-----------------|-------------|-----------------|
| Quayle–Dental           | 0.057       | 0.005           | B           | 0.316           | 0.035           | A           |
| Major–Base              | 0.071       | 0.005           | BA          | 0.379           | 0.054           | A           |
| Medicus                 | 0.083       | 0.007           | A           | 0.390           | 0.033           | A           |

SE: Standard deviation.
Ra: Average roughness.
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 significantly lower than that of the Major–Base heat–curing acrylic. The probable explanation 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 followed 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 discoloration 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.

### REFERENCES

1. Academy of Prosthodontic. Glossary of prosthodontic terms. *J Prosthet Dent*. 1994; 71(1): 61.
2. Craig RG. Restorative Dental Materials. 10th ed. The CV Mosby Co. St Louis. 1997; Pp: 30-52, 500-532.
3. Skinner EW. The Science of Dental Material. 4th ed. WB Saunders Co. Philadelphia. 1956; Pp: 99-135.
4. McCabe JF. Anderson’s Applied Dental Materials. 6th ed. Blackwell Scientific Publication, Oxford. 1985; Pp: 1-26, 75-97.
5. Engelmeier RL. Complete denture aesthe-tic. *Dent Clin North Am*. 1996; 40: 71-83.
6. Pipko JD, El-Sadeek M. An *in vitro* investigation of abrasion and staining of dental resin. *J Dent Res*. 1972; 15: 689-693.
7. Dills SS, Olshan AM, Goldener S, Brogdou C. Comparison of antimicrobial capability of an abrasive paste and chemical soak cleansers. *J Prosthet Dent*. 1988; 60: 467-470.
8. McCabe JF, Davidmurry J, Kelly PJ. The efficacy of denture cleaners. *Eur J Pros-
Kazanji MN, Ahmad ZM

9. Nikawara H, Yamamoto T, Hamada T, Sadamori S. Cleansing efficacy of commercial denture cleansers: Ability to reduce Candida albicans biofilm activity. *Int J Prosthod*. 1995; 8: 527-534.

10. Haselden CA, Hoblink JA, Pearson GI, Davis EH. A comparison between the we-ar resistance of three types of denture resin to three different dentifrice. *J Oral Rehabil*. 1998; 25: 335-339.

11. Budtz-Jorgensen E, Loe H. Chlorhexidine as a disinfectant in treatment of denture stomatitis. *Scand J Dent Res*. 1972; 80: 457-464.

12. McNeme SJ, Von-Gonten AS, Woolsey GD. The effect of laboratory disinfecting agent on color stability of denture acrylic resin. *J Prostheth Dent*. 1991; 66: 132-136. (Abstr)

13. Craig RG, O'Brien WJ, Power JM. Dental Materials: Properties and Manipulation. 6th ed. The CV Mosby Co, St Louis. 1996; Pp: 97-113, 242.

14. Polyzois GL, Yannikakis SA, Zissis AJ, Demetrion EP. Color change of denture base material after disinfection and sterilization immersion. *Int J Prosthodont*. 1997; 10(1): 83-89.

15. Anusavice KJ. Phillip's Science of Dental Material. 10th ed. W.B. Saunders Co, Philadelphia. 1996; Pp: 33-47, 217-271.

16. Hatim NA, Kazanji MN. The effect of some finishing and polishing techniques on the degree of roughness of heat cure acrylic surface. *Iraqi Dent J*. 1999; 24: 153-168.

17. Parikh VM. Absorption Spectroscopy of Organic Molecules. Addison–Wesley Co. 1974; Pp: 1-43.

18. Subhi MD. The effect of disinfectant solutions on some properties of acrylic denture base material. MSc thesis. College of Dentistry. University of Baghdad. 1999.

19. Ma T, Johnson GH, Glenn E, Gordon GE. The effect of chemical disinfectants on the surface characteristics and color of denture resin. *J Prostheth Dent*. 1997; 77: 197-204.

20. Asmussen E. Factors affecting the color stability of restorative resin. *Acta Odontol Scand*. 1983; 41: 11-18.

21. Polyzois GL, Zissis AJ, Yannikakis SA. The effect of glutaraldehyde and microwave disinfection on some properties of acrylic resin. *Int J Prosthodont*. 1999; 8: 150-154.

22. Hassu JE, El–Ameer SS. The influence of human saliva and / or tea on the staining effect as a mouthwash and its staining effect as a disinfectant solution. *Iraqi Dent J*. 2001; 27: 185-200.

23. Baker FL, Rivera–Hidalgo F, Kolstad RA. Color and surface alteration of denture material after immersion disinfection. *J Dent Res*. 1990; 69: 943-947. (Abstr)

24. Prescott LM, Harley JP, Klein DA. Microbiology. 3rd ed. WMC Brown Publisher. 1996; Pp: 145-150.

25. Stafford GD, Bates JF, Hugnet R, Handley RW. A review of the properties of some denture base polymers. *J Dent*. 1980; 8: 292-306.

26. Keller JC, Lautenschlager EP. Porosity reduction and its associated effect on the diametral tensile strength of activated acrylic resin. *J Prosthodont*. 1985; 53(3): 374-397.

27. Kazanji MN, Al–Kazzaz NH. The effect of disinfectant solution on the surface topography of acrylic denture base materials. *Al–Rafidain Dent J*. 2002; 2(1): 65-71.

28. Ortman HR, Ortman LF. Denture refitting with today’s concepts and materials. *Dent Clin North Am*. 1975; 19(2): 274-277.

29. May KB, Razzoog ME, Koran A, Robinson E. Denture base resin: Comparison study of color stability. *J Prosthodont*. 1992; 68: 78-82.

30. Combe EC, Grant AA. The selection and properties of materials for dental practice. *Br Dent J*. 1973; 134: 289-292.

31. Combe EC. Notes on Dental Materials. 4th ed. Churchill Livingstone, Edinburgh. 1981; Pp: 189-205, 295-302.

Received: 11/5/2004

Accepted for Publication: 2/6/2004