

ORIGINAL ARTICLE

EFFECT OF DISINFECTANTS ON THE COLOUR STABILITY OF HEAT CURE ACRYLIC RESIN

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Background: Contaminated dentures need to be disinfected as a part of denture hygiene regimen. This study was conducted to determine the colour stability of heat cure acrylic resin after treatment with two disinfectants. **Methods:** This in-vitro experimental study was conducted at Dr Ishrat-ul-Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences and Al Karam Textiles Karachi, from January to April 2012. Total 72 rectangular shaped specimens; 18 specimens were measured at baseline (control group) of the study (0 day), 18 specimens were immersed in distilled water. Eighteen (18) specimens were placed in 1% Sodium Hypochlorite solution for 20 minutes and eighteen (18) specimens were placed in Alkaline Gluteraldehyde for 10 minutes. All specimens were polished, stored in distilled water for 24 hours prior to experiment. All the specimens were immersed twice daily for total of 60 days. After 60 days of immersion the specimens were tested for colour changes with spectrophotometer. SPSS-16 was used for statistical analysis. **Results:** There was statistically significant difference in the colour change (ΔE) between all groups ($p < 0.001$) after 60 days of immersion. At baseline (0 day), trace amount of colour change was observed whereas when specimens immersed in distilled water undergo slight change in colour after 60 days of immersion. Furthermore, specimens immersed in 1% Sodium hypochlorite for 20 minutes and 2% Alkaline Gluteraldehyde for 10 minutes for 60 days twice a day showed noticeable changes in colour. **Conclusion:** There results of the study advocated that the colour stability of denture base acrylic resin is affected by the disinfectants used.

Keywords: Heat cure acrylic resin. Colour stability. Spectro photometer. Disinfectants.

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INTRODUCTION

The most widely used material for making dentures since 1937 is polymethyl methacrylate (PMMA). They are the material of choice for removable complete dental prosthesis because of low cost, relative ease of manipulation and construction methods.¹

During repair, relining or adjustment, dental practitioners and dental auxiliaries commonly come in contact with the dentures. These dentures may be infected with loads of viruses, fungi and bacteria.^{2,3} Prosthesis that have not been sterile are the major risk for dental laboratory personnel because of the infection from micro-organisms. Infections of dental personal occur due to the contagion of micro-organisms between dentist's offices and laboratories.^{2,3}

Dentures act as an indwelling device that provides an ideal atmosphere to the micro-organisms for adhesion and multiplication in human mouth.⁴ There is a simultaneous increase in the occurrence of denture stomatitis and other infections due to the increase in the use of dentures.⁴ Contaminated dentures need to be disinfected as a part of denture hygiene regimen.⁵

For the disinfection of the dentures several disinfectants have been suggested.⁶ They are

Sodium Hypochlorite, Alkaline Gluteraldehyde, Formaldehyde and chlorhexidine. The ideal disinfectant should not change the characteristics of denture base resins. Sodium Hypochlorite require shorter period of disinfection, cost effective and have broad antibacterial spectrum.⁶ According to Chau *et al*⁷ ten minutes immersion in 1% Sodium Hypochlorite is required for the disinfection of inner surface of denture base resins.⁷ In dentistry Alkaline Gluteraldehyde is most commonly used for disinfection of materials.⁶ For more efficient removal of microorganisms from denture, McCabe *et al*⁸ observed that chemical cleaning agents are complementary for maintaining the hygiene of prosthesis and should be associated with mechanical cleaning.⁸

It is of scientific importance to determine whether properties of acrylic resins altered by the use of these chemical solution.^{9,10} Some authors have stated that the properties of denture acrylic resin will be affected by daily use of denture cleaning solutions.^{9,10} If the cleaning solutions are not correctly used, denture base polymers might undergo change in colour.^{9,10} Whitening of the prosthesis occurs because of high temperature of the water.¹¹ Similarly, chemicals, like hot alkaline peroxide solutions, produce water sorption, results in irreversible surface whitening.¹²

Visual assessment can lead to variability of results because of many factors like the observed object, aging, illuminant position relative to the observer and to each other, fatigue, illuminant colour characteristics, metamerism, and observer emotional state.⁹ Spectrophotometers and Colourimeters are more widely used today to eliminate subjective interpretation of visual colour comparison. These instruments use the CIE $L^*a^*b^*$ (CIELAB) colour system, which was developed by the Commission International de L'Éclairage in 1978.¹³ Therefore, in this study a computerized ultraviolet-visible spectrophotometer was used for instrumental assessment of the colour. It is a photometric tool used for the specific material to measure the light transmitted or absorbed. The absorbed light is measured with accuracy up to 0.001.¹³

The objective of this study was to assess the effect of disinfectants on the colour stability of heat cure acrylic resins. Interaction of disinfectants with regard to colour stability of poly-methyl methacrylate is important as colour damage will lead to un-aesthetic appearance of the prosthesis which will not be accepted by most of the patients. It is the prime responsibility of the dentist to prescribe only those cleansers that remove microbial load but would not compromise the colour of prosthesis. The null hypothesis was that the disinfectants did not affect the colour stability of heat cure acrylic resin determined in the study.

MATERIAL AND METHODS

This was an *in vitro* experimental study conducted at Dr Ishrat-ul-Ebad Khan Institute of Oral Health Sciences and testing was performed at Al Karam Textiles Karachi, Pakistan from April to July 2012. The material tested in the study was heat-cure acrylic resin (Vertex rapid simplified, Holland).

Seventy two rectangular specimens 13.0 mm in length and 4.0 mm thickness were prepared from stainless steel mould.¹⁴ These dimensions were according to the American Society for Testing and Material Standard D 256-O6a. Material was polymerized according to manufacture instructions. After heat polymerization, specimens were removed from the mould; the flash was trimmed with a carbide bur and smoothed by the 200 grit sandpapers with the help of sandpaper holder. The specimens were polished on a wet rag wheel with pumice slurry. After polishing, all specimens were placed in distilled water at room temperature for 24 hours.

The samples were divided into three groups: Eighteen specimens were measured at baseline (0 day) without immersion in any solution.

This was the control group of the study. Eighteen specimens were measured after 60 days of immersion in distilled water; eighteen specimens were measured after 60 days of immersion in 1% Sodium Hypochlorite solution for 20 minutes, (according to ADA specification) and eighteen specimens were measured after 60 days immersion in 2% Alkaline Gluteraldehyde solution for 10 minutes each day. (According to ADA Specification).

All specimens were placed in their respective containers and filled with distilled water. After 24 hours the distilled water was discarded and the container was filled with their respective denture cleansers. All the specimens were completely immersed in solution for above mentioned time period. The specimens were washed with distilled water and the container was again filled with distilled water. This was repeated twice a day for total of 60 days. During the time period when disinfection was not carried out, specimens were stored in distilled water. After 60 days, colour measurements were carried out using spectrophotometer (Data colour 650 plus 9661). The measurements were performed according to the CIE $L^*a^*b^*$ system and mean values for the material was calculated. The level of colour change has been quantified by the National Bureau of Standards (NBS). Critical marks of colour difference according to NBS are shown in table-1. Following formula is used to express NBS units.¹⁵

$NBS\ unit = \Delta E \times 0.92$

Where ΔE stands for colour change

Data analysis was performed by using Statistical Package for Social Sciences (SPSS) version-16. The data was analyzed by using one way analysis of variance-one way (ANOVA) for a quantitative dependent variable by a single factor (independent) variable. To identify which of the mean differed significantly, Tukey's HSD (Honestly significant difference) was used at 0.05 significance level.

RESULTS

The 1% Sodium Hypochlorite solution showed highest value of colour change as compared to baseline (control) specimens. This was followed by 2% Alkaline Gluteraldehyde which was then followed by distilled water in which specimens were immersed for 60 days twice a day simulating 120 cycles. One way ANOVA showed that significant difference was observed between all the groups (table 3). It was further confirmed by post Hoc Tukey test which stated that significant difference was found when distilled water and baseline (control) was compared with 1% Sodium

Hypochlorite solution ($p < 0.001$) in which specimens were immersed for 60 days twice a day simulating 120 cycles. When distilled water and baseline (control) was compared with 2% Alkaline Gluteraldehyde solution statistically significant difference was observed ($p < 0.001$) in which specimens were immersed for 60 days twice a day simulating 120 cycles.

Table-1: Critical marks of colour difference according to National Bureau of Standards

Critical Marks of Colour Difference	Textile Terms (NBS unit)
Trace	0.00–0.5
Slight	0.5–1.5
Noticeable	1.5–3.0
Appreciable	3.0–6.0
Much	6.0–12.0
Very much	>12.0

Table-2: The colour measurement of material before and after exposure to different media.

TIME	MEDIUM	Mean ΔE (SD)
At day 0	Baseline (Control)	0.00(±0.00)
	Distilled water	1.42(±0.08)
	1% Sodium Hypochlorite	2.36(±0.11)
At day 60	2% Alkaline Gluteraldehyde	2.02(±0.04)

Table-3: Mean (SD) and NBS regarding colour measurement of material before and after exposure to different media

Groups	MeanΔE (SD)	NBS		
Baseline (Control)	0.00±0.00	0.00 (Trace)		
Distilled water	1.42±0.08	1.30 (Slight)		
1% Sodium Hypochlorite	2.36±0.11	2.17 (Noticeable)		
2% Alkaline Gluteraldehyde	2.02±0.45	1.85 (Noticeable)		
One Way ANOVA				
Baseline (control)	Distilled water	Fittydent	Dentipur	p-value <0.00

DISCUSSION

The effectiveness of chemical disinfectants for denture cleaning has been highlighted due to their ability to reduce microorganisms.¹⁶ However, one of the adverse effects caused by these chemical solutions on the acrylic resin is colour change.^{9,17} In this study, colour changes in heat cure acrylic resin were measured by measuring instruments called

Spectrophotometer^{18,19} instead of visual evaluation. Subjective interpretation of visual colour alteration can be eliminated by the Spectrophotometer. To record colour changes the CIE L*a*b* system was chosen. This system is well suited for decisive minor differences in the colour.¹⁷ Greenness (negative a*) or redness (positive a*) is calculated from the a* value. The whiteness or brightness of an object is determined by the L* value. Blueness (negative b*) or Yellowness (positive b*) is measured by b* value. Colour differences can be expressed in units that

can be related to clinical significance and visual perception is the advantage of the CIE L*a*b* system.²⁰

The relative colour changes in the materials reported by the observer after treatment or between time periods can be determined by ΔE value. Hence as comparison to the individual value, ΔE is more meaningful.¹⁷ Therefore in the present study only ΔE results were selected for investigation.

Based on the data obtained through the Spectrophotometer measurement procedure, the null hypothesis tested in this study was rejected. In the present study the colour of heat cure acrylic resins showed noticeable changes in 1% Sodium Hypochlorite and 2% Alkaline Gluteraldehyde whereas slight changes were observed in distilled water.

After immersion for 60 days simulating 120 cycles the results of this study indicate that heat cure acrylic resin was affected more by 1% Sodium Hypochlorite as compared to 2%. Alakline Gluteraldehyde and distilled water. This might be because according to the Reis *et al*²¹ sodium hypochlorite induced whitening effect on the surface of acrylic denture resin.²¹ It is proven from literature that polymers always undergo water sorption.^{22,23} Irreversible damage to acrylic may cause by the water. This results in the formation of micro-cracks because of repeated sorption/desorption cycles. These cycles results in the destruction of ester linkages and deterioration of the infrastructure of the polymer.²³ This phenomenon may contribute to form acrylic zones with different optical properties⁵, which can be visibly detected or aesthetically unacceptable.

This water sorption ultimately deteriorates the infrastructure of the polymer and damages the ester linkages of the polymer network. These damages to acrylic resins are irreversible and they occur because of repeated sorption/desorption cycles resulting in micro crack formation in the resins.²³ This procedure resulted in formation of different acrylic zones with different optical properties.²⁴ Possibly for this reason, almost all disinfectants used in the study caused alteration in the colour of heat cure acrylic resin. Lee *et al*²⁵ reported that water sorption, chemical degradation, leakage, staining effect of external colourants, solubility and surface roughness may also be the factors for colour change in denture base materials.²⁵

Saracetal²⁶ and Purnaveja *et al*²⁷ found that denture cleansers caused bleaching and whitening, water absorption in resin materials and loss of soluble component.^{26,27} The acrylic resin evaluated in this study tend to change colour even in distilled

water. This might be due to leaching out of the colouring material. Change in colour might be due to leaching of the monomer content and by the absorption of water.²⁷ The results of this study opposes the results of the study conducted by Fernandes *et al*²⁸ and MA *et al*²⁹ in which the authors did not found any significant colour changes after immersion in sodium hypochlorite solution. This might be because in both the studies the specimens were immersed for 10, 30, 60 min, 24 h and 7 days. Whereas in the present study, specimens were immersed in sodium hypochlorite for 60 days twice a day simulating 120 cycles. The exposure of acrylic resins in disinfectants for longer period might cause greater sorption of liquid in the polymer resulting in greater colour alteration.³⁰

The results of this study indicate that the colour stability of denture base acrylic resin was affected by disinfectants and distilled water. As specimens were tested at room temperature the present study did not completely simulate clinical behaviour. To overcome the limitation of this in vitro study denture base material actually used by the patients should be evaluated. Additional investigations regarding effect of disinfectants on other properties should be evaluated in future. Furthermore, additional studies on the relationship between colour stability and composition of denture base resins are necessary to appreciate the effects of aging of denture cleansers on the colour change mechanism.

CONCLUSION

Within the limitations of this study, it can be concluded that when the specimens of heat cure acrylic resins were not immersed in any solution (control) they show negligible amount of colour change. Whereas when specimens were immersed in distilled water for 60 days slight change in the colour was observed. When the specimens were immersed in 1% Sodium Hypochlorite for 20 minutes and 2% Alkaline Gluter aldehyde for 10 minutes for 60 days twice a day simulating 120 cycles can cause noticeable change in the colour of denture base resins.

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