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Colour Stability of Denture Base Materials after Soaked in Different Denture Cleansers and a Mouthwash

SUMMARY

Purpose: *The aim of this study was to evaluate the effects of disinfectants on the colour stability of 3 different denture base materials.*

Material and Methods: *In this study 2 heat-polymerized resins (Impact, Meliodent) and 1 auto-polymerizing denture base resin (Meliodent) were investigated after treatment with 6 different disinfecting agents (Corega, Efferdent, Efferdent plus, Janina, Polident, Steradent). The specimens were exposed to disinfecting agents for 1, 7, 14, 21 and 28 days. The treatment results were investigated with the use of a spectrophotometer. Colour stability was quantitatively measured, and colour differences (ΔE*) were calculated.*

Results: *After 28 days, Meliodent was found to have the best colour stability (ΔE* = 1.12). The greatest colour change was noted for Impact (ΔE* = 2.4).*

Conclusions: *All materials tested showed clinically acceptable colour changes after 28 days of exposure to the disinfectants tested.*

Key Words: Colour Stability; Denture Base Resin; Disinfectant

Yasemin Kulak-Ozkan, Akkan Akkaya, Buket Akalın, Ender Kazazoglu

Marmara University, Faculty of Dentistry, Department of Prosthodontics
Istanbul, Turkey.

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Introduction

Colour stability is an important clinical behaviour for all dental restoration materials, which is one of the criteria that provide information on the serviceability of these materials[1-3]. The whitening effect has been observed in several types of denture base[4]. Faulty handling and attack by external agents, such as denture cleanser or solvent, were explanations for the observed effects given by Robinson et al[4]. They also stated that the whitening effect in some extent depends on the nature of the resin and it has been photo-micrographically shown that the appearance of the interstitial matrix phase has altered in all cases of whitening, while the beads of polymer are not affected. The chemical composition, physical and mechanical properties, and clinical behaviour of hard direct denture relines (HDDR) have been investigated and it has been reported that the materials present several shortcomings and undesirable properties; hence, they have been deemed temporary expedients for short to intermediate time periods. Heat-polymerized denture base materials have exhibited satisfactory colour stability, but auto-polymerized denture base materials have shown relatively poor colour stability[5]. The residual monomer content could be one explanation for the colour changes observed. Denture base materials processed with a rapid-polymerize method have demonstrated up to 7 times the level of residual monomer found in conventional heat-polymerize materials[6]. This problem may provide information on the serviceability of these materials. Brauer et al[7] investigated the colour stability of 6 hard direct auto-polymerizing relines according to ADA (American Dental Association) specification No: 12. Only 1 of the products passed the colour stability test. Bunch at al[8] studied the colour changes of 5 hard direct auto-polymerizing relines after accelerating aging. Wide range of colour changes were found after their test (1.4 to 17.6 ΔE*) and it occurred after only 24 hours of accelerated aging. The quantitative test results in colour difference for 5 of the 3 products were also continued after visual examination. Sekine at al[9] conducted a clinical trial on 101 patients with ill-fitting dentures that were relined with a hard direct auto polymerizing reliner, and after 3 months of use, the material showed staining (12%), but not discolouration. The staining resistance of polymers depends on both the modes of polymerization and their chemistry, and time was also found to be a critical factor for the colour stability of relining materials[10].

Discolouration of the denture base polymers may be caused by the oxidation of the amine accelerator or by the penetration of coloured solutions[1]. Colour changes of denture base materials during exposure to oral fluids and denture cleaners have been reported[11-13]. Even denture cleanser is often implicated in the whitening process, which has often been erroneously referred to as "bleaching"[4], especially if the cleansers were used in high temperature water. The temperature of soaking is therefore an important consideration[14-16]. The use of clear un-pigmented resin for the soaking test enabled a simple bleaching effect to be eliminated. The results of extended and accelerated soaking tests, followed by light transmission test, indicate that the denture cleansers of alkaline-peroxide type, when used alone, do not cause a significant deterioration of heat polymerize resin or cold-polymerized repair materials[4].

Mouthwashes have been used for centuries as breath fresheners, medicaments, antiseptics and, in more recent time, preventive agents. Over-the-counter and prescription mouthwashes, which often contain alcohol in high-volume percentages, have increased in sales. In addition to alcohol, these agents contain other ingredients, such as detergents, emulsifiers, organic acids and dyes. These ingredients may cause degradation, softening and discolouration of prosthetic materials. Since patients use mouthwashes routinely, the dental profession needs to know whether these agents may affect the colour of denture materials[17].

The **purpose** of this study was to determine the effect of 5 alkaline-peroxide types of denture cleansers and 1 mouthwash on 2 conventional heat-activated denture base materials and 1 conventional chemically activated denture base material.

Material and Methods

In this study, 2 heat-polymerized and 1 auto-polymerized denture base materials were investigated. Denture base materials were evaluated after immersion in 5 different disinfectants and a mouthwash. Information about these materials is given in table 1.

A total of 108 discs (10 mm diameter and 1.5mm thickness), 36 for each type of the resin, were prepared according to manufacturer's instructions. After being processed, the specimens were abraded on both sides with 600-grit silicon-carbide paper to a final thickness of 1.5 ± 0.1 mm. The specimens were divided into 6 groups for each test solution, and coded from 1 to 6. Specimens from each denture resins were immersed in sample solutions. The sample solutions of the cleansers were prepared by dissolving one tablet in 200 ml of sterile distilled water. Samples were in contact with each solution for manufacturer's recommended time, and fresh solutions were prepared for each day in a day. Prepared solutions were poured into sealable 200 ml jars and 6 specimens were placed in each jar. A 1mm-diameter hole was placed in each sample and stainless steel wire placed in the hole of each sample that the holder held them, so that 6 specimens were immersed into selected solutions. In this procedure, specimen to specimen contact was avoided. 6 specimens from each denture resin were treated with Janina disinfectant that is sprayed on the surface of the specimens (10 times and 5 cm away from the specimen; 1 shut=150mcl.) then the specimens were kept on the bench 15 minutes after sprayed. This procedure was repeated 3 times a day.

Table 1. Materials used in this study

Trade name	Code	Manufacturer
Impact®åHC (heat-polymerized	IH	Dental Export of London Harrow, England
Meliodent®åH (heat-polymerized)	MH	Heraeus Kulzer GmbH&Co, Wehrheim/Germany
Meliodent®åRR (Rapid Repair)	MC	Heraeus Kulzer GmbH&Co, Wehrheim/Germany
Corega	C	Stafford-Miller Dungarvan, Co, Waterford-Ireland
Efferdent	E	Warner-Lambert Co. Morris plains, NJ
Efferdent Plus	EP	Warner-Lambert Co. Morris plains, NJ
Janina	J	Beckhengham Kent BR3 12J, London
Polident	P	Block Drug Co. Inc, Jersey city, NJ
Steradent	S	Reckitt GmbH for Reckitt&Colman Products Ltd, Hull, England

Colour measurements were made after 1, 7, 14, 21, and 28 days. After each specimen had been immersed for specified time, it was cleansed in distilled water and dried using a tissue paper. Following colour measurements at time intervals indicated, the specimens were re-immersed in fresh solutions.

Colour was measured according to CIE L*a*b* colour scale relative to standard source C against a white background on a reflection spectrophotometer (Spectra flash SF 600 CT). According to this system, all colours in nature are obtained through the blending of 3 basic colours, namely, red, blue and green, in certain proportions. The CIE Lab system has been developed on the basis of this system. In examining various materials with regard to colour, this technique is also being used quite extensively by researches in dentistry[1,18,19]. Colour differences $(\Delta E^*)= [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$. Colour measurements were made at the centre of each sample. The colour of each sample was measured 3 times, and the mean values were calculated and recorded.

Colour changes at each of five intervals [ΔE^*_1 (colour change resulting from 1 day immersion), ΔE^*_2

(colour change resulting from 7 day immersion), ΔE^*_3 (colour change resulting from 14 day immersion), ΔE^*_4 (colour change resulting from 21 day immersion), ΔE^*5 (colour change resulting from 28 day immersion)] were compared. A colour change of ΔE^* greater than 3.3 was considered visually perceptible[20]. Means and standard deviations of colour change (ΔE^*) were calculated. Values of (ΔE^*) were analyzed by 3-way ANOVA of denture base materials, treatments, and intervals. A Scheffe S multiple range test at the 0.05 significance level compared means.

Results

Colour change (ΔE^*) of 3 denture base resins after treatment of disinfectants are listed in table 2. A 3-way ANOVA showed statistically significant differences among the denture base materials (P=0.0001), disinfectants (P=0.0001) and intervals (P=0.0001). There were statistically significant interactions (material-treatment. P=0.0001; material-interval, P=0.0237 and treatment-interval, P=0.0001).

Table 2. 3-way ANOVA of colour measurements of 3 acrylic denture bases with disinfectant solutions

Source	Df	Sum of square	Mean square	F test	p value
Base materials (A)	2	140.853	70.426	605.825	0.0001
Time (B)	4	12.196	3.049	26.227	0.0001
AB	8	2.083	0.26	2.24	0.0237
Disinfectants (C)	5	3.817	0.763	6.567	0.0001
AC	10	21.83	2.183	18.779	0.0001
BC	20	94.491	4.875	41.932	0.0001
ABC	40	36.452	0.911	7.839	0.0001
Error	450	52.312	0.116		

Table 3. Colour change (ΔE^*) of denture base materials after disinfectants immersion at five intervals

Material	Disinfectants	ΔE^*_1	ΔE^*_2	ΔE^*_3	ΔE^*_4	ΔE^*_5
IH	C	2.75 (0.17)	1.80 (0.24)	2.52 (0.23)	1.94 (0.23)	1.51 (0.19)
	E	2.21 (0.55)	3.53 (0.74)	2.71 (0.74)	2.37 (0.94)	2.09 (0.78)
	EP	2.77 (0.14)	1.71 (0.37)	1.55 (0.21)	1.38 (0.23)	2.91 (0.23)
	J	2.94 (0.23)	2.72 (0.37)	1.80 (0.30)	1.71 (0.34)	3.19 (0.33)
	P	0.65 (0.26)	0.39 (0.24)	2.42 (0.43)	1.80 (0.16)	2.98 (0.19)
	S	3.07 (0.28)	2.47 (0.25)	1.91 (0.18)	2.17 (0.14)	1.73 (0.13)
MH	C	2.12 (0.16)	1.43 (0.21)	1.95 (0.2)	1.25 (0.34)	1.12 (0.25)
	E	1.39 (0.17)	2.50 (0.24)	1.88 (0.43)	1.39 (0.24)	1.19 (0.08)
	EP	2.13 (0.20)	1.20 (0.19)	1.22 (0.13)	1.12 (0.98)	2.29 (0.39)
	J	2.09 (0.23)	1.86 (0.17)	0.75 (0.23)	0.75 (0.31)	2.13 (0.25)
	P	0.44 (0.15)	0.56 (0.22)	0.69 (0.43)	2.60 (0.54)	2.61 (0.57)
	S	1.97 (0.19)	1.58 (0.33)	1.19 (0.20)	1.31 (0.33)	1.02 (0.24)
MC	C	1.45 (0.18)	1.05 (0.13)	1.63 (0.28)	0.85 (0.19)	1.05 (0.15)
	E	0.64 (0.25)	0.90 (0.12)	0.39 (0.32)	0.58 (0.17)	0.91 (0.11)
	EP	1.16 (0.21)	0.87 (0.13)	0.89 (0.18)	0.86 (0.19)	1.42 (0.22)
	J	1.02 (0.24)	0.73 (0.19)	0.41 (0.21)	0.51 (0.20)	1.19 (0.22)
	P	0.98 (0.59)	1.04 (0.54)	1.06 (0.56)	1.37 (0.86)	1.36 (0.94)
	S	0.90 (0.25)	0.66 (0.18)	0.91 (0.18)	0.62 (0.20)	0.82 (0.15)

ΔE^*_1= colour change after 1-day immersion in a disinfectant;
ΔE^*_2= colour change after 7-day immersion in a disinfectant;
ΔE^*_3= colour change after 14-day immersion in a disinfectant;
ΔE^*_4= colour change after 21-day immersion in a disinfectant;
ΔE^*_5= colour change after 28-day immersion in a disinfectant
* Means with standard deviations in parentheses (n=6).

Results of 1 day immersion (ΔE_1* values) ranged from 0.44 to 3.07 (Tab. 3). Highest colour change was seen with Steradent, and lowest colour change was seen with Polident denture cleaning agents (Tab. 3). Impact, a heat-polymerized denture base material (IH), showed highest overall colour change (Tab. 4). Detailed comparison amongst denture materials and cleaning agents are shown in table 5.

Table 4. The colour change values of acrylic resins used in this study in each time intervals

Material	ΔE^*_1	ΔE^*_2	ΔE^*_3	ΔE^*_4	ΔE^*_5
MC	1.02* (0.38)	0.87* (0.28)	0.88* (0.51)	0.79* (0.46)	1.12* (0.44)
IH	2.39** (0.88)	2.10** (1.05)	2.16** (0.56)	1.89** (0.52)	2.4 ** (0.74)
MH	1.68* (0.64)	1.52** (0.63)	1.28* (0.56)	1.40* (0.66)	1.73** (0.71)

Critical remarks of colour difference
Trace (0.0-0.5) *Slight (0.5-1.5) **Noticeable (1.5- 3.0)

Table 5. Significance as determined by Scheffe S tests between materials and disinfectants

Base materials	Disinfectants	1. day	7. day	14. day	21. day	28. day
	P-E	*	*	-	-	*
	P-S	*	*	-	-	*
	P-J	*	*	-	-	-
	P-C	*	*	-	-	-
	P-EP	*	*	*	-	-
	E-S	*	*	-	-	-
	E-J	*	-	*	-	*
I	E-EP	-	*	*	*	*
H	E-C	-	*	-	-	-
	S-J	-	-	-	-	*
	S-EP	-	-	-	-	*
	S-C	-	-	-	-	-
	J-EP	-	*	-	-	-
	J-C	-	*	-	-	*
	EP-C	-	-	*	-	*
	P-E	*	*	*	*	*
	P-S	*	*	-	*	*
	P-J	*	*	-	*	-
	P-C	*	*	*	*	*
	P-EP	*	*	-	*	-
	E-S	*	*	*	-	-
M	E-J	*	*	*	-	*
H	E-EP	*	*	*	-	*
	E-C	*	*	-	-	-
	S-J	-	-	-	-	*
	S-EP	-	-	-	-	*
	S-C	-	-	*	-	-
	J-EP	-	*	-	-	-
	J-C	-	-	*	-	*
	EP-C	-	-	*	-	*
	P-E	-	-	*	-	-
	P-S	-	-	-	-	-
	P-J	-	-	-	*	-
	P-C	-	-	-	-	-
	P-EP	-	-	-	-	-
	E-S	-	-	-	-	-
M	E-J	-	-	-	-	-
C	E-EP	-	-	-	-	-
	E-C	*	-	*	-	-
	S-J	-	-	-	-	-
	S-EP	-	-	-	-	-
	S-C	-	-	*	-	-
	J-EP	-	-	-	-	-
	J-C	-	-	*	-	-
	EP-C	-	-	*	-	-

* Significance at the level 0.05

Results of 7 day immersion (ΔE^*_2 values) ranged from 0.39 to 3.53 (Tab. 3). Highest colour change was seen with Efferdent, and lowest colour change was seen with Polident denture cleaning agents (Tab. 3). Impact, a heat-polymerized denture base material (IH), showed highest overall colour change (Tab. 4). Detailed comparison amongst denture materials and cleaning agents are shown in table 5.

Results of 14 day immersion (ΔE^*_3 values) ranged from 0.41 to 2.71 (Tab. 3). Highest colour change was seen with Efferdent, and lowest colour change was seen with Janina denture cleaning agents (Tab. 3). Impact, a heat-polymerized denture base material (IH), showed highest overall colour change (Tab. 4). Detailed comparison amongst denture materials and cleaning agents are shown in table 5.

Results of 21 day immersion (ΔE^*_4 values) ranged from 0.51 to 2.60 (Tab. 3). Highest colour change was seen with Polident, and lowest colour change was seen with Janina denture cleaning agents (Tab. 3). Impact, a heat-polymerized denture base material (IH), showed highest overall colour change (Tab. 4). Detailed comparison amongst denture materials and cleaning agents are shown in table 5.

Results of 28 day immersion (ΔE^*_5 values ranged from 0.82 to 3.19 (Tab. 3). Highest colour change was seen with Janina, and lowest colour change was seen Steradent denture cleaning agents (Tab. 3). Impact, a heat-polymerized denture base material (IH), again showed highest overall colour change (Tab. 4). Detailed comparison amongst denture materials and cleaning agents are shown in table 5.

Comparison of the 1, 7, 14, 21, and 28-day results of each acrylic resin showed the highest colour changed with IH, higher than MH and MC. Colour stability of MC was found to be better than that of other resins. None of the resins showed visually perceptible colour changes ($\Delta E^* < 3.3$) after the treatment with disinfectants (Tab. 4).

Discussion

Colour changes become an aesthetic problem when a long service is required and are affected by many parameters, including type of the base resin, polymerization process, using denture cleansers, diet, and oral hygiene

of patients. Discolouration of denture base resins can be evaluated visually or by colorimetry. Johnston and Kao[19], evaluating the assessment of appearance, matched by visual observation and clinical colorimetry, stated that the mean colour difference between compared teeth that were rated as a match in the oral environment was 3.7 ΔE*. They observed that, if ΔE* less than 1, this chromatic value is deemed to be slight, and between 1 and 2, and the situation is clinically acceptable. Seghi et al[18] also presumed that an acceptable colour difference can often be 2 or 3 times greater than the detectable limits. The upper limit of acceptability in subjective visual evaluations has been confirmed by Ruyter et al[20] and Um and Ruyter[3], who suggested that a perceptible discolouration must be referred to as acceptable up to value of ΔE*=3.3. In this study, discolouration below or above value of ΔE*=3.3 was referred to as "acceptable" or "unacceptable" respectively. In our study, the colour changes exhibited by all specimens after 28 days were in clinically acceptable levels.

All 3 resins used in this study had basically the same structure, however, each of them contained small quantities of different cross linking agents, plasticisers, and pigments, which may explain the difference in staining properties of resins[1].

It has been reported that heat-polymerized denture base materials exhibited satisfactory colour stability but auto-polymerized did not[6]. Such discolouration of auto-polymerized systems has been explained by the change or oxidation of the amine accelerator[3], and recently, auto-polymerized denture base materials that are available, have a more stable activator. Such polymerized systems are claimed to have better colour stability[5]. In this study, obtained data showed that auto-polymerizing resin Meliodent has a lower colour shift than the conventional heat-polymerized Meliodent and Impact resins. This principal difference between them is that less colourants is present in the former. It seems that promotion of polymerization by means of chemical activation as initiators increase colour resistance of this material. Therefore the colouring resistance of polymers depends on both the mode of polymerization and their chemistry[10]. Other possible reason for the changes observed could be attributed to colourants added for characterization[6]. Robinson et al[4] showed that denture cleanser of alkaline peroxide type, when used alone, do not cause significant deterioration of heat-polymerized resin or cold polymerize repair materials. Our study also supports this statement.

It has been shown in previous studies that the use of water at too high temperature may result in damage to acrylic denture base; therefore the temperature of soaking processing denture base is critical[14-16]. From a previous survey of the cleaning procedures used by the patients with a bleached or whitening dentures, 2 common factors emerged: first, the use of cleaning material with a potential for bleaching (this being either household bleach or more commonly a proprietary denture cleaning agent) and second, the use of boiling water or water at a very high temperature[16]. Crawford et al[14], used laboratory tests to simulate the claiming procedures used by patients presenting with bleached or whitened dentures, carried out on specimen strips of acrylic denture base materials. Acrylic strips were immersed in solution at different temperature (15°C, 50°C, 100°C,) and hot water at 100°C. They found that no visual changes were observed in tested and than in stored in air, or where subsequently immersed in cold water after 100 treatment cycles. Following the manufacturers' instructions, or using cold water with the proprietary denture cleanser had no significant effect on the physical properties studies. Therefore we also used distilled water with denture cleansers in this study and we did not observe clinical colour change in tested solutions.

Conclusions

Within the limitations of this study, the following conclusions were drawn:

1. All the resins used in this study showed colour change after the treatment with disinfectants; however, this colour changes found to be clinically not significant.
2. Differences in colour change and the rate of colour change were observed within and between materials after the treatment with disinfectants.
3. In this study Impact HC (IH) exhibited the greatest chromatic change (2.58) for Efferdent. IH also exhibited noticeable chromatic colour changes in all other disinfectants. Meliodent H (MH) showed noticeable colour changes in Efferdent, Efferdent plus and Corega respectively. Meliodent RR (MC), showed slight discolouration in all disinfectants tested in this study.

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Correspondence and requests for offprints to:

Dr. Yasemin Kulak-Ozkan
University of Marmara, School of Dentistry
Güzelbahçe Büyükçiftlik sok. No. 6
80200 Nişantaşi, Istanbul
Turkey
E-mail: yasyas@superonline.com