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CLINICAL SCIENCE

Long-term clinical evaluation of the color stability and stainability of acrylic resin denture teeth

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ABSTRACT

Statement of problem. The color stability and staining of acrylic resin denture teeth remains an esthetic problem for complete denture wearers.

Purpose. The purpose of this study was to evaluate the long-term clinical color stability and stainability of acrylic resin denture teeth in complete denture wearers over a period of 5 years.

Material and methods. Fifty participants rehabilitated with complete dentures from February 2008 to December 2013 were selected. The demographic data and the clinical characteristics of participants were recorded. Color change (ΔE) in 3 regions of the denture teeth (incisal, middle, and cervical) was evaluated by spectrophotometry in the CIE L*a*b* system. Participants were asked whether they had noticed any changes in the coloring of the teeth in their dentures. Hierarchical clustering analysis was used to identify groups formed from variables related to demographic questions and color analysis. Two-way ANOVA among the color cluster groups was performed and the Tukey-Kramer test was used as a post hoc test (α=.05). A chi-square test and Fisher exact test were used to identify the association between the study variables and color changes in the participants' responses (α=.05).

Results. Four cluster groups from 50 participants were identified in the clustering analysis. The ΔE was statistically significant for the interaction between the dental third and cluster groups (P<.001). Cluster groups 1 and 4 exhibited statistically higher ΔE values than cluster groups 2 and 3 (P<.05). Greater chromatic alterations were noted in the incisal third of the teeth than in the cervical and medium thirds in the cluster groups 1 (ΔE=11.03 ±1.22) and 3 (ΔE=4.14 ±1.14) (P<.05). No relationship was found with the participants' personal opinions about color change (P>.05).

Conclusion. Although the acrylic resin denture teeth exhibited color instability and staining in vivo, the participants were unable to identify the color change. The cluster groups with higher color change values consumed more staining solutions. (J Prosthet Dent 2015;113:628-635)

Removable complete dentures have been used for many years to rehabilitate edentulous patients and can restore self-esteem, esthetics, masticatory function, and the capacity for socialization.[1] The selection of artificial teeth—made of either porcelain or acrylic resin—is important for denture esthetics. This choice can be made according to the patients' demands and finances and the dentist's good judgment.[2]

Acrylic resin denture teeth are popular because they bond chemically with the acrylic resin denture base and are easy to adjust occlusally.[3] They are also less likely to fracture when subjected to impact and resist thermal shock.[4] Nonetheless, acrylic resin has greater color instability,[1] poorer esthetics,

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Clinical Implications

Clinically, acrylic resin denture teeth are exposed to staining agents that cause color change. Participants wearing complete dentures could not distinguish the color change of their artificial denture teeth, even though ΔE units beyond clinical perceptibility and acceptability were noted.

and less wear resistance than porcelain teeth.[5] Moreover, its physical and chemical properties change in the oral environment.[6]

The color stability and stainability of dental composite resins and compomers,[7-14] composite resin interim restorative materials,[15] fluoride-containing restorative materials,[16] soft denture liners,[17] and acrylic resin denture teeth[2,3,18-22] have been investigated in vitro. Different beverages, accelerated aging, light activation, bleaching, cleaning agents, and smoking affect the color of such materials.

Changes in color can be measured using clinical methods or through instrumental techniques such as spectrophotometry or colorimetry.[5,7,23-25] Instrumental devices reduce errors and are more accurate when compared with measurement by eye.[15] The CIE L*a*b* system (established by the Commission Internationale de l'Eclairage, CIE) can be used to calculate color changes.[3] The CIE L*a*b* system specifies color perceptions in terms of a 3-dimensional space by comparing the color of the tooth surface with the color of the corresponding control groups through wavelength versus reflection. The "L" axis represents luminosity and extends from 0 (black) to 100 (perfect white). The "a" coordinate represents the amount of red (positive values) and green (negative values), while the "b" coordinate represents the amount of yellow (positive values) and blue (negative values).[26] The coordinates "a" and "b" coexist in the same plane of this 3-dimensional space. The CIE L*a*b* system calculates the color distance between 2 points with the following formula[3]: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$.

The color degradation of artificial teeth is one of the factors that influences the esthetic durability of dentures.[5] Some in vivo studies have reported that oral hygiene conditions associated with eating habits can lead to color changes of the artificial teeth in removable dentures.[27-29] They also show that the color stability of artificial teeth is important for the patient's acceptance of treatment and that restorative materials should possess color stability in the oral cavity over a long period.[27-29] A ΔE of 2.6 is considered perceptible and ΔE above 5.6 is considered clinically unacceptable.[25]

Additionally, demographic characteristics and the day-to-day behavior of the removable complete dentures wearers may be related to the color change and esthetics of dental restorative materials. Most studies have reported on the color stainability of acrylic resin denture teeth by using an in vitro model.[2,3,18-22] The highest ΔE units observed in these studies varied from 1.82 to 7.94.[2,3,18-22] Research on the color change of acrylic resin denture teeth in vivo is lacking. In addition, the color stability of denture teeth in complete denture wears remains unknown. Therefore, this study aimed to investigate the long-term clinical color stability and stainability of acrylic resin denture teeth in complete denture wearers over a period of 5 years. Whether color change is associated with the demographic characteristics and clinical variables of denture wearers was also investigated. The null hypothesis was that no color change in acrylic resin denture teeth would be observed.

MATERIAL AND METHODS

This study was approved by the Local Research Ethics Committee (#154620). Signed informed consent forms containing the issues that would be addressed during the research and the benefits and possible risks to the participants were obtained before starting the study.

This cross-sectional study considered 480 individuals rehabilitated with removable complete dentures between February 2008 and December 2013 in the Prosthodontics clinic (Sao Paulo State University [UNESP], Aracatuba Dental School, Brazil). All participants were first contacted by telephone. A total of 100 individuals returned for clinical evaluation. After a medical history and an initial clinical examination, 50 participants were included according to the inclusion criteria: only completely edentulous participants who were wearers of conventional complete dentures were included. The complete dentures were required to be in good condition, with intact dental anatomy of the maxillary central incisors and with no cracks or fractures in the denture base. Individuals wearing overdentures or who had ceased to wear conventional complete dentures for any reason were excluded from the sample. In addition, individuals whose dentures exhibited disunity of the central incisor in relation to the denture base or a central incisor with altered anatomy or cracks and fractures were also excluded.

A questionnaire was used to evaluate the possible causes of color change in the artificial teeth. Interviews were conducted by a single evaluator (E.S.O.), who used a questionnaire that contained open-ended and closed-ended questions. A brief heading above these questions explained participation willingness, the confidentiality of participant identity (although the identification of the interviewees was not requested), and the publication of data obtained in the interview, according to Resolution 196/96 of the Brazilian National Health Council.[30] A pilot

study was conducted to adapt the method of data collection, to measure the difficulties encountered, and to qualify the researchers involved in the study.

Color was evaluated with a portable spectrophotometer (Easyshade Advance; VITA Zahnfabrik H. Rauter GmbH & Co KG), and color changes were calculated through the CIE L*a*b* system. Prior to the color evaluation of the artificial right maxillary central incisor, prophylaxis was performed with a Robinson brush (Microdont; Microdont Micro Usinagem de Precisão Ltd) mounted in a low-speed handpiece with pumice paste (SS White) and water to remove biofilm from the tooth surface. This procedure did not remove the stains that had occurred on the acrylic tooth. Color was evaluated extraorally with a black background, standard ambient lighting and the temperature on the incisal, middle, and cervical one-third of the facial surface.

The color was evaluated before and after complete denture use. The "before" measurement was made on a commercially available unused tooth, while the "after" measurement was the color of the tooth after complete denture use. To obtain the variation in color of the artificial tooth after the period of use, the brand, model, and color of these teeth were collected from patient records. In addition, the color of each commercially available unused tooth was measured 2 weeks later and the color change was computed. Color differences between the 2 measurements were calculated with the following formula: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$.

A pilot study was conducted to verify the effects of the different lot numbers of each brand of acrylic resin denture teeth on color variation. A ΔE value of 0.35 ±0.11 was observed. In order to obtain the repeatability and reliability of the color-measuring instrument used in this study, 10 measurements were performed in the same tooth in 4 different periods (initial, 1 hour, 1 day, and 3 days). A good agreement among all color components L*, a*, and b* (repeatability >.95 and reliability >.92) was noted. Such data are in agreement with a previous study.[31]

The main purpose of this study was to assess color change within groups formed from demographic and clinical variables. In addition, participants were asked whether they had noticed any changes in the coloring of the artificial teeth in their dentures. Such subjective data were compared with the objective data obtained from the spectrometric analysis.

For all of the items evaluated in the demographic, clinical questions, and data about color change (ΔE), a descriptive statistical analysis was conducted (frequencies and percentage distributions). A hierarchical clustering analysis was used to identify color groups formed from variables related to demographic and clinical characteristics of interest and to assess the color change in each group afterward. Demographic and clinical variables were nominal data, and the color change variable was numerical data. If the measurement scale was not the same, a subset analysis was performed. Hierarchical clustering techniques proceed by a series of successive mergers starting with the individual objects. Thus, initially, there are as many clusters as objects. The most similar objects are first grouped, and these initial groups are merged according to their similarities for variables of the study. In addition, the results present homogeneous elements within each group for color change.

A software package (ClusterSim; The R Foundation for Statistical Computing, Department of Econometrics and Computer Science, University of Economics, Wroclaw, Poland) was used to define the number of groups and the method. This software uses an optimal clustering procedure for a dataset by varying all combinations of types of distance measures and clustering methods. The optimal clustering procedure considers a cluster quality index, which obtains optimal value for 4 clusters (number of groups). The clustering method chosen for this study was the Ward method,[32] in which the within-cluster ANOVA sum of squares was minimized over all partitions by merging 2 clusters from the previous generation.

The normality of ΔE values was checked with the Shapiro-Wilk test, Anderson-Darling, Lilliefors test, and Jarque-Bera test and was checked visually by using P-P plots and Q-Q plots. Results showed that the data followed a normal distribution. Subsequently, 2-way ANOVA (factor 1: cluster, factor 2: dental third) among the color cluster groups was performed. The Tukey-Kramer test was used to compare differences in the values obtained for the tests performed. A chi-square test and Fisher exact test were used to identify the association between the study variables and color changes in the participants' responses. Statistical software (SPSS v. 20.0; SPSS Inc) was used for descriptive and statistical analyses. All results were analyzed at an alpha level of .05.

RESULTS

The brand, model, color, and composition of the acrylic resin denture teeth used in this study are listed in Table 1. The frequencies of the participants' responses for the demographic characteristics and clinical variables of interest in this study are presented in Table 2. Most of the participants (80%) were female and aged between 61 and 80 years old. More than 50% had used their complete dentures for between 6 months and 4 years, had no parafunctional or drinking habit, did not drink wine, and were nonsmokers. The majority removed their complete dentures to sleep, cleaned their dentures with a toothbrush and paste, and consumed coffee and cola (Table 2).

Clustering analyses identified 4 groups from 50 participants (Fig. 1). In relation to the L* value, the majority

Table 1. Summary of acrylic resin denture teeth used (n=50)

Brand	Model	Color	Composition	Manufacturer
Biolux (n=23)	V12 (n=2); V13 (n=2); V21 (n=2); V22 (n=1); V25 (n=1); V2D (n=1); V32 (n=8); V36 (n=2); V3P (n=1); V64 (n=1); V66 (n=2)	60 (n=3); 62 (n=8); 65 (n=1); 66 (n=10); 67 (n=1)	PMMA, EDMA	Vipi Ind Com Ltd
Biotone (n=2)	3D (n=2)	62 (n=2)	PMMA, EDMA	Dentsply Ind e Com Ltd
Ivostar (n=5)	32 (n=1); 33 (n=1); 34 (n=3)	A3 (n=3); B2 (n=2)	PMMA	Ivoclar Vivadent Ltd
Trilux (n=20)	E3 (n=5); E4 (n=2); F4 (n=1); G3 (n=1); H3 (n=3); H4 (n=2); L2 (n=6)	1A (n=1); 1C (n=3); 1D (n=4); 2B (n=12)	PMMA, EDMA	Ruthibras Imp Exp Com de Materiais Odontol Ltd

PMMA, polymethyl methacrylate; EDMA, dimethacrylate of polymerized ethylene glycol.

Table 2. Sample characteristics in relation to demographic data and clinical variables (n=50)

Variable	Sample (%)
Sex	
Female	80
Male	20
Age (y)	
41-60	24
61-80	76
Time of maxillary/mandibular denture use	
6 mo - 4 y	52
>4 y	48
Parafunctional habit	
Yes	24
No	76
Removal of dentures to sleep	
Yes	56
No	44
Smoking	
Yes	18
No	82
Drinking habit	
Yes	28
No	72
Coffee consumption	
Yes	90
No	10
Wine consumption	
Yes	18
No	82
Cola consumption	
Yes	56
No	44
Sanitization of dentures	
Toothbrush and paste	82
Other means	18

of the cluster groups moved in the black direction. The groups' a* values approached the red, while their b* values approached the yellow. Therefore, the color change in the cluster and dental third group exhibited the same increasing whiteness/brightness of acrylic resin denture teeth over the long-term (Table 3). Results from 2-way ANOVA and data ranges are listed in Table 4. The color change (ΔE) was statistically significant for the interaction between the dental third and cluster groups ($P<.001$) (ANOVA, Table 4).

The study variables for the 50 participants in relation to the color change defined for ΔE in each third are presented in Table 5. Statistically higher values of color change ($P<.05$, Tukey-Kramer test) for the cluster groups 1 and 4 compared with the cluster groups 2 and 3 were noted (Table 5). The incisal third of cluster group 1 (ΔE = 11.03 ±1.22) and 3 (ΔE = 4.14 ±1.14) exhibited statistically higher color values than those of the cervical and middle thirds ($P<.05$; Tukey-Kramer test) (Table 5).

Figure 2 presents the percentage of the variable responses from the questionnaire for each cluster group. Interestingly, participant cluster groups 1 and 4 reported greater consumption of staining fluids than cluster groups 2 and 3. These groups also presented statistically higher values of color change according to ANOVA (Tables 4, 5). However, the sex, age, and other variables seemed similar regardless of the cluster groups.

Table 6 presents the results of the participants' perception of color change and their associations with the variables from the applied questionnaire. The majority of the participants evaluated (80%) reported that they did not observe any color changes in the artificial teeth ($P>.05$, Chi-square test and Fisher exact test).

DISCUSSION

In this study, alteration in the color of acrylic resin denture teeth was observed after the clinical use of complete dentures; the null hypothesis was rejected. In vivo studies on color changes of materials used for dentures are scarce in the literature. Koumjian et al[27] evaluated the discoloration of 7 types of acrylic resins used to fabricate interim partial fixed dental prostheses. All materials exhibited some degree of in vivo pigmentation after 9 weeks of use. Interim materials composed of polymethyl methacrylate, polyethyl methacrylate, and light-activated composite resin exhibited more color change than polyvinylethyl methacrylate, methyl methacrylate, or bis-acryl-composite resin.[27] The color stability of composite resin veneers and acrylic resin teeth in vivo has been evaluated.[29] The authors observed that the discoloration of the acrylic resin teeth was significantly less than that of composite resin veneers after a period of 18 months.[29] The high conversion rate and the low content of additional reagents such as dibenzoyl peroxide in the

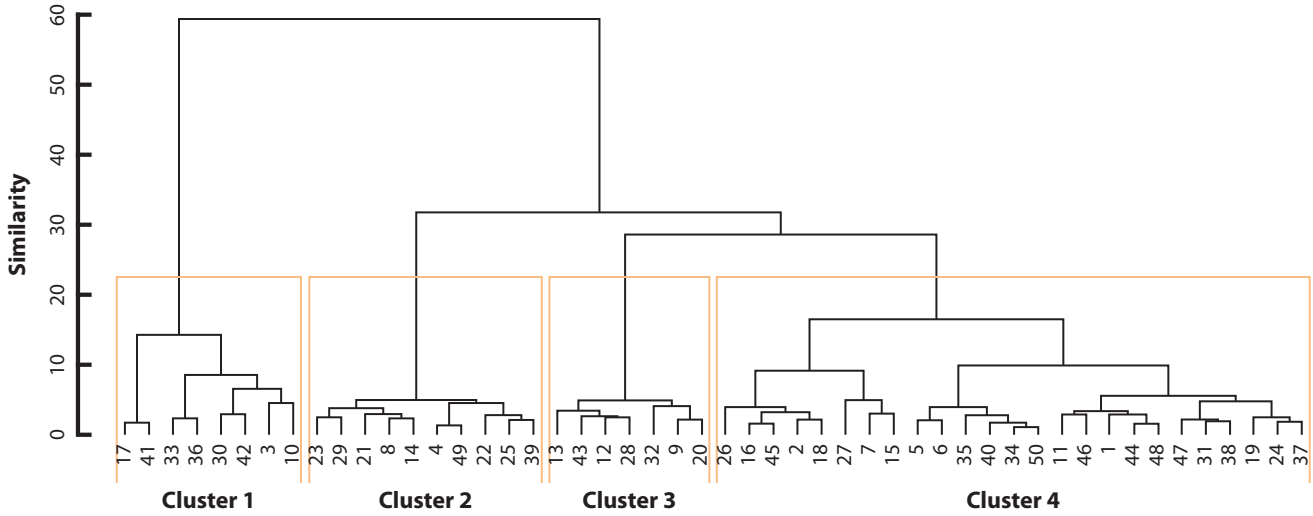

Figure 1. Cluster dendogram for cluster groups: cluster 1 (n=8); cluster 2 (n=10); cluster 3 (n=7); cluster 4 (n=25). Each number on horizontal line represents each person allocated into specific group.

Table 3. Summary of CIE L*a*b* measurements (before and after period of time) of acrylic resin denture teeth and color change in ΔL, Δa, and Δb

Cluster Group/ Dental Third	Time	L*	a*	b*	ΔL	Δa	Δb
1/ Cervical	Before	76.69	2.14	32.65			
	After	76.05	3.34	34.80	-0.64 (2.50)	1.20 (2.05)	2.15 (4.74)
2/ Cervical	Before	78.02	2.96	35.10			
	After	77.81	3.17	34.32	-0.21 (1.68)	0.21 (1.00)	-0.78 (1.48)
3/ Cervical	Before	76.03	4.61	35.53			
	After	75.54	5.17	35.39	-0.49 (1.21)	0.56 (0.42)	-0.14 (2.18)
4/ Cervical	Before	75.34	2.79	34.05			
	After	76.09	2.84	34.92	0.74 (2.47)	0.05 (1.61)	0.86 (4.18)
1/ Middle	Before	74.95	2.10	30.80			
	After	75.20	3.09	33.44	0.25 (2.89)	0.99 (2.47)	2.64 (5.40)
2/ Middle	Before	76.54	2.96	33.47			
	After	76.45	2.85	32.59	-0.09 (1.61)	-0.11 (0.90)	-0.88 (1.95)
3/ Middle	Before	74.43	4.71	35.21			
	After	74.16	5.40	36.19	-0.27 (1.03)	0.69 (0.46)	0.97 (1.38)
4/ Middle	Before	74.52	2.76	33.06			
	After	75.53	2.48	34.18	1.00 (2.28)	-0.28 (1.56)	1.11 (3.54)
1/ Incisal	Before	75.38	1.10	22.49			
	After	73.85	2.30	28.10	-1.53 (5.53)	1.20 (2.26)	5.61 (8.03)
2/ Incisal	Before	76.67	1.76	25.95			
	After	76.16	1.90	26.25	-0.51 (1.15)	0.14 (0.93)	0.30 (1.57)
3/ Incisal	Before	76.33	2.53	25.57			
	After	75.16	2.78	26.54	-1.17 (1.11)	0.25 (1.41)	0.97 (1.23)
4/ Incisal	Before	75.18	1.59	26.39			
	After	75.05	1.69	28.49	-0.14 (3.04)	0.10 (1.38)	2.10 (2.94)

polymethyl methacrylate denture teeth may explain such results.[29] Setz et al[28] conducted an in vivo study to evaluate the color changes in the composite resin veneers of 2 commercial brands (Licupast and Dentacolor) and concluded that both brands presented significant discolorations after 1 year of use.

Table 4. Results of 2-way ANOVA for ΔE values of 4 proposed clusters

Source	df	Sum of Squares	Mean of Squares	F	P*
Cluster groups	3	393.546	131.182	63.168	<.001
Dental third	2	60.280	30.140	14.513	<.001
Cluster groups × dental third	6	209.142	34.857	16.785	<.001
Error	138	286.587	2.077		
Total	149	949.554			

*$P<.05$ denotes statistically significant difference.

Table 5. ΔE values of 4 proposed clusters in cervical, middle, and incisal thirds

	Clusters			
Third Color ΔE	1	2	3	4
Cervical	5.59 (2.14)^{Aa}	2.32 (0.89)^{Ab}	2.28 (1.00)^{Ab}	5.05 (0.94)^{Aa}
Middle	6.23 (2.91)^{Aa}	2.56 (0.91)^{Ab}	1.83 (0.98)^{Ab}	4.44 (1.44)^{Aa}
Incisal	11.03 (1.22)^{Ba}	1.98 (0.82)^{Ab}	4.14 (1.14)^{Bc}	4.53 (1.75)^{Ac}

Same superscripted uppercase letters in same column and lowercase letters in same line represent statistically significant difference at 5% level of significance ($P<.05$) with Tukey-Kramer test.

Color changes in resin materials can be caused by both intrinsic and extrinsic factors.[8] Intrinsic factors are more related to the discoloration of the material itself and to changes of its matrix,[3] the type of photoinitiator, and inorganic materials such as amorphous silica and glass filler.[9,10] Most often, this discoloration was caused by physical and chemical conditions, such as thermal and humidity changes and ultraviolet exposure.[16] Smoking, chewing tobacco, medications, and diet may affect the chemical stability of materials. Oxidation in the structure of the material of unreacted pendant methacrylate, alteration of the matrix interface, matrix, and fillers, and chemical bonding breakdown are some examples of chemical changes.[16] Extrinsic factors, such as stain absorption and adsorption, may cause discoloration.[11,13]

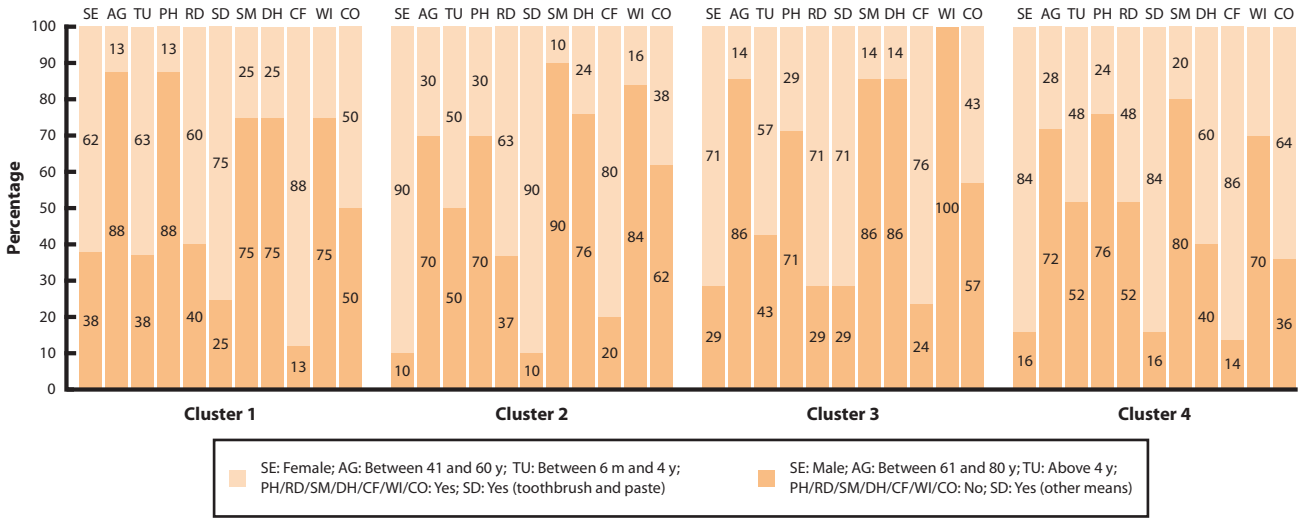

Figure 2. Percentage of answers on variables for cluster group differences (n=50). SE, sex; AG, age; TU, time of maxillary mandibular use; PH, parafunctional habit; RD, removal of dentures to sleep; SD, sanitization of dentures; SM, smoking; DH, drinking habit; CF, coffee consumption; WI, wine consumption; CO, cola consumption.

According to Anil et al,[17] the following factors may contribute to color changes: stain accumulation, dehydration, water absorption, rough surfaces, chemical/wear degradation, and oxidation during double carbon reactions, which produces peroxide compounds and the continuous formation of pigments due to the product's degradation.

Cluster groups 1 and 4 showed higher ΔE values and greater consumption of staining fluids when compared with cluster groups 2 and 3 (Fig. 2; Table 5). There may be some association between color change and pigmentation of acrylic resin. These solutions would make the material more porous, increasing the absorption and adsorption of substances. Soft drinks can be highly erosive because of their low pH, because the action of organic acids in beverages can induce softening of polymers.[14] In addition, the present results corroborate those of previous studies wherein coffee solution promoted the greatest color alteration.[14,15] The yellow dyes presented in coffee have chemical affinity with the polymeric chain of the resin, which induces color staining.[14,15] Red wine can stain resin materials because of the alcohol in its composition. The alcohol has a plasticizer effect on the polymeric matrix, diminishing the adhesion of the filler content to the resin matrix.[8] This may lead to the detachment of these particles, decreasing wear resistance and, consequently, facilitating staining.

Furthermore, a statistically significant difference ($P<.05$) was found in terms of color changes between the facial one third areas of acrylic resin teeth. However, this study failed to find any association between color change and the demographic variables of the study (data not shown). This result indicates that all variables can result in an additive color change. The greatest chromatic change was noted in the incisal third compared with the cervical and middle thirds. The incisal third is more in contact with food and beverages. Moreover, the incisal third is the thinnest portion of the tooth and can simply deteriorate, thus absorbing extrinsic stains more easily. According to Guler et al,[15] the thickness and smoothness of the tooth surface may influence its color.

Participants were asked if they had noticed change in the color of their denture teeth. Although ΔE values of up to 11.03 were noted, approximately 80% of the participants did not observe any color alteration. Douglas et al[25] determined that the mean color perceptibility tolerance for 50% of observers was 2.6 ΔE units and the acceptability tolerance was 5.6 ΔE units in the maxillary left central incisors in a clinical setting. As the participants in this study had nothing with which to compare the actual color change of their denture teeth, change was difficult to notice. No association was noted between the participants' responses and the variables present on the questionnaire ($P>.05$). Therefore, participants may have become confused when observing color changes in their teeth, because the results indicated color changes noticeable to the naked eye.

According to Johnston and Kao,[23] the human eye can perceive a variation of up to 3.7 ΔE units. Paul et al[24] reported that the spectrophotometer can transform the 3-dimensional information collected into 2-dimensional information, that the measurement can be conducted as closely as possible to the tooth, and that spectrophotometer analysis offers 33% greater visual acuity than does the human eye.

Why such color changes occurred remains unknown. Additionally, the color change of the denture teeth was compared with commercially available unused teeth; this

Table 6. Associations between study variables and color changes in participants' responses (n=50)

Variable	Color change (%)	No color change (%)	*P*
Sex			
Women	22.5	77.5	.66
Men	10	90	
Age (y)			
41-60	25	75	.68
61-80	18.4	81.6	
Time of maxillary/mandibular denture use			
6 mo - 4 y	19.2	80.8	.89
>4 y	20.8	79.2	
Parafunctional habit			
Yes	16.7	83.3	1.00
No	21.1	78.9	
Removal of dentures to sleep			
Yes	21.4	78.6	1.00
No	18.2	81.8	
Smoking			
Yes	11.1	88.9	.67
No	22	78	
Drinking habit			
Yes	14.3	85.7	.70
No	22.2	77.8	
Coffee consumption			
Yes	22.2	77.8	.57
No	0	100	
Wine consumption			
Yes	11.1	88.9	.67
No	22	78	
Cola consumption			
Yes	17.9	82.1	.67
No	22.7	77.3	
Sanitization of dentures			
Toothbrush and paste	19.5	80.5	1.00
Other means	22.2	77.8	

Chi-square test or Fisher exact test.
Nonsignificant, $P>.05$; significant, $P<.05$.

may have interfered with the results because the lot numbers of the used and unused teeth varied. However, based on a pilot study, the lot number only slightly influences the color variation of acrylic resin denture teeth. The participants included in this research were treated free of charge in a state-run school of dentistry; therefore a broad comparison with teeth from the international market was not possible because of cost. Because this study was conducted in vivo, which factor most influenced the staining of the acrylic resin denture teeth was difficult to judge. In vitro, cigarette smoking ($\Delta E=7.94$),[20] mechanical brushing with a soft brush and dentifrice ($\Delta E=7.59$),[19] and accelerate aging ($\Delta E=3.2$)[22] were the most significant factors affecting color alteration. Further investigation is needed to understand the role of each staining agent on the color stability and stainability of denture teeth. Studies investigating the perceptibility and acceptability tolerances of participants for color alteration in acrylic resin denture teeth are warranted. The interactions between the molecules of the denture tooth materials and those of the possible staining media may indeed be topics for future investigations.

CONCLUSIONS

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

1. The acrylic resin denture teeth exhibited color instability in a range of 1.83 to 11.03 ΔE units, depending on various factors.
2. The incisal third had the highest color change values compared with the remaining dental thirds.
3. In general, although the color changes were greater than the acceptable level, participants failed to notice it.
4. The cluster groups with greater consumption of the staining fluids produced greater changes in color.

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Noteworthy Abstracts of the Current Literature

Impact of loss of removable dentures on oral health after the great East Japan Earthquake: A retrospective cohort study

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Purpose. The Great East Japan Earthquake in March 2011 destroyed many communities, and as a result many older victims lost their removable dentures. No previous studies have documented the prevalence of denture loss after a natural disaster or examined its negative impact. Therefore, investigation of the consequences of such a disaster on oral health is of major importance from a public health viewpoint.

Materials and Methods. Three to five months after the disaster, questionnaire surveys were conducted in two coastal towns, Ogatu and Oshika, located in the area of Ishinomaki city, Miyagi prefecture. Among the survey participants, 715 individuals had used one or more removable dentures before the disaster, and these comprised the population analyzed. The effect of denture loss on oral health-related quality life (OHRQoL) was examined by a modified Poisson regression approach with adjustment for sex, age, subjective household economic status, dental caries, tooth mobility, psychological distress (K6), access to a dental clinic, physical activity, and town of residence.

Results. There were 123 (17.2%) participants who had lost their dentures. In comparison with participants who had not lost theirdentures, those lacking dentures showed a significantly higher relative risk for eating difficulties (RR = 2.65, 95%CI = 1.90-3.69), speech problems (RR = 4.37, 95%CI = 2.46-7.76), embarrassment upon smiling, laughing, or showing their teeth (RR = 5.32, 95%CI = 2.34-12.1), emotional distress (RR = 2.38, 95%CI = 1.41-4.03), and problems related to social interaction (RR = 6.97, 95%CI = 1.75-27.7).

Conclusions. Denture loss appeared to impair eating and speaking ability, thus discouraging communication with others. Public health intervention after major natural disasters should include dental care.