

Color stability of artificial teeth after exposure to acid and staining agents

Estabilidade de cor de dentes artificiais após a exposição a agentes ácidos e corantes

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ABSTRACT

Objective: Changes in color of artificial teeth mainly occur due to ingestion of beverages and use of products for cleaning and disinfection. More aggressive solutions must be identified and the patient provided with explanations in order to avoid or reduce the frequency of their use, to higher longevity of dentures. The purpose of this study was to evaluate changes in color of artificial teeth before and after immersion in beverages and disinfectants.

Material and Methods: 96 artificial resin teeth were randomly divided into 8 groups. Each group was immersed for 10 min into a test solution (coffee, lemon juice, chlorhexidine gluconate, red wine, cola-based soft drink, vinegar or antiseptic with and without alcohol) and then the specimens were stored in artificial saliva for 23 h and 50 min, completing a period of 24 h. This procedure was performed for 14 consecutive days and after this period the second color measurement was made. Data obtained with the spectrophotometer using the CIEL*a*b* system were statistically analyzed using ANOVA non parametric, Kruskal-Wallis and the Dunn test. **Results:** There were found differences in color variation for each experimental group after the challenge. Statistically significant differences were found among coffee, red wine and lemon juice groups. **Conclusion:** All substances changed the color of artificial teeth; coffee was the substance that caused most staining of artificial teeth, altering color and luminosity; the oral antiseptics with and without alcohol promoted whitening of the artificial teeth.

KEYWORDS

Artificial tooth; Denture; Oral rehabilitation; Staining.

RESUMO

Objetivo: Alterações na cor dos dentes artificiais ocorrem principalmente devido à ingestão de bebidas e uso de produtos de limpeza e desinfecção de próteses. Soluções mais agressivas de limpeza devem ser identificadas e o paciente deve ser informado, a fim de evitar ou reduzir a frequência de seu uso, para maior longevidade de próteses. O objetivo deste estudo foi avaliar as alterações na cor de dentes artificiais antes e após imersão em bebidas e soluções desinfetantes. **Material e Métodos:** noventa e seis dentes artificiais de resina foram aleatoriamente divididos em 8 grupos. Cada grupo foi imerso por 10 min em uma solução de teste (café, suco de limão, gluconato de clorexidina, vinho tinto, refrigerantes à base de cola, vinagre ou antisséptico com e sem álcool) e, em seguida, os espécimes foram armazenados em saliva artificial durante 23 horas e 50 min, perfazendo um período de 24 h. Este procedimento foi realizado durante 14 dias consecutivos e depois desse período a segunda medição de cor foi feita. Os dados obtidos com o espectrofotômetro usando o CIEL * a * b * foram analisados através de ANOVA não paramétrico, Kruskal-Wallis e o teste de Dunn. **Resultados:** Foram verificadas diferenças na variação de cor para cada grupo experimental após o desafio. As diferenças estatisticamente significativas foram encontradas entre os grupos de café, vinho tinto e suco de limão. **Conclusão:** Todas as substâncias mudaram a cor dos dentes artificiais; café foi a substância que causou mais descoloração dos dentes artificiais, alterando a cor e luminosity; os antissépticos bucais com e sem álcool promoveram clareamento dos dentes artificiais.

PALAVRAS-CHAVE

Dente artificial; Dentição; Reabilitação oral; Coloração.

INTRODUCTION

Esthetic standards are highly appreciated by society and their compromise affects patients' self-esteem and even their social integration. Thus, it has become most important to conduct research and evaluate solutions related to the re-establishment of esthetics within clinical conditions and the economic situation of patients. In addition, there is the possibility of maintaining dentures for long periods without compromising changes.

Partial and complete partial dentures are excellent means to resolving clinical situations. Among their advantages are the relative procedure simplicity, allowing patients to have function and esthetics rapidly restored, at accessible cost, and little clinical discomfort caused by the procedure.

These types of dentures are made up of artificial resin teeth and an acrylic resinbase, and in the case of removable denture, a metallic structure. Artificial teeth and denture base are subject to constant exposure to food and beverages, and consequently, to their acids and staining agents [1-7]. This frequent interaction compromises the color of artificial teeth and denture bases, and it is reflected in esthetic damage [8-14].

Hersek et al. considered that the color and translucence of acrylic resin must be maintained, and that staining or color changes must not occur during the clinical use of the material [11]. May et al. verify that in accelerated aging the color of acrylic resin base is affected [15,16]. Color stability is an important property for all dentures. Its alteration may indicate aging or damage to the material [8,14].

Changes in color of artificial teeth may occur due to intrinsic (degree of polymerization and proportion of monomers) and extrinsic (foods, beverages, cleaning products, lack of oral hygiene and smoking) factors [17]. Color instability may be related to the ingestion of acid

beverages (ph < 5) such as wine, soft drinks and artificial or natural juices. Alterations may also be triggered by products used in oral hygiene, because they favor plaque adhesion when come into contact with the artificial teeth and the denture base acrylic resin.

Shotwell et al. and Hersek et al. described that color changes may be caused by alteration in the material matrix, and there may even cause solubility, water sorption, microleakage, surface roughness and chemical degradation [11,14]. Purnaveja et al. and Saraç et al. related that cleaning agents could cause whitening of acrylic resin, with loss of soluble components from the material, or water absorption [13,17].

Beverages such as soft drinks, artificial or natural juices may be considered acidic, as they have a pH lower than 5. The low pH of these beverages may be one of the factors responsible for the degradation of artificial teeth, inducing color changes, wear and irregularities, consequently reducing the useful life of the denture.

Color changes in natural or artificial teeth can be measured with the use of colorimeters [8,13,19] or spectrophotometers [11,20,21]. Colorimeters and spectrophotometers are based on the color systems of Munsell and the Commission Internationale de l'Éclairage (CIE). The CIEL*a*b* system is recommended by the American Dental Association (ADA) and according to it all the colors in nature are based on three colors: red, blue and green [22].

Based on that, the purpose of this study was to evaluate the color of artificial teeth used in dentures before and after immersion in beverages and disinfectant rich in staining agents, and with low pH by measurement with a spectrophotometer.

MATERIAL AND METHODS

A total of 96 artificial teeth (incisors and canines) Biotone 3P 69 (Dentsply, Petrópolis, RJ, Brazil) were embedded in a silicone device

using chemically activated acrylic resin (Jet-Clássico, Artigos Odontológicos Clássico, São Paulo, Brazil), so that the vestibular surface remained exposed. The acrylic resin bases measuring 2.5 cm wide, 5.0 cm long and 1 cm thick each received 3 artificial teeth.

The 96 specimens were submitted to initial color measure with a spectrophotometer (VITA EasyShade Compact, Vita Zahnfabrik, Bad Säckingen, Germany), and afterwards received one of the 8 the treatments described below:

GCof: Instant coffee (Nescafé, Nestle Brasil Ltda, Araras, Sao Paulo, Brazil) – prepared according to manufacturer’s instruction (pH 5.1).

GJui: Light artificial juice powder, lemon flavored (Clight, Mondelez Brasil Ltda, Sao Paulo, Brazil) - – prepared according to manufacturer’s instruction (pH 2.1).

GChl: 0.12% Chlorhexidine gluconate (PerioGard, Colgate-Palmolive, Sao Paulo, Sao Paulo, Brazil) (pH 5.5);

GWine: Red table wine (San Tomé, Alberto Belesso Indústria e Comércio de Bebidas, Itupeva, Sao Paulo, Brazil) (pH 3.5);

GCola: Cola-based soft drink (Coca-Cola; Coca-Cola FEMSA Brasil, Jacareí, Sao Paulo, Brazil) (pH 2.6);

GVin: White wine vinegar (Castelo, Castelo Alimentos, Jundiaí, Sao Paulo, Brazil) (pH 2.5);

GAnt: Oral antiseptic with fluoride, mint flavored, without alcohol (Colgate Plax Soft Milk, Colgate-Palmolive, Sao Paulo, Sao Paulo, Brazil) (pH 5.4);

GAntAlc: Oral antiseptic mint flavored, with alcohol (Listerine, Johnson & Johnson do Brasil Ltda, Sao Paulo, Sao Paulo, Brazil) (pH 6.6).

All the test specimens were exposed to the respective products for 10 min, and were stored in artificial saliva for 23 h and 50 min, completing the 24 h period. This procedure was

performed for 14 consecutive days, and after this period the specimens were cleaned in an ultrasonic bath containing distilled water for 5 min. Then the 2nd color measure was performed with the spectrophotometer.

To record the color of samples, the intraoral dental spectrophotometer Vita EasyShade Compact (VITA-Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen-Germany), was used, which consists of a module with a hand piece fitted with three separate spectrometers and 19 fiber optics of 1 mm in diameter, protected by stainless steel. The external fibers transmit light of the tooth and the internal fibers receive the reflected light and work as sensors. The equipment has a central processing unit that analyzes the data from the spectrophotometer, determining the color in comparison with the VitaPAN Classical Scales (Vita Zahnfabrik, Bad Säckingen, Germany) and VITA Toothguide 3D-MASTER® (Vita Zahnfabrik, Bad Säckingen, Germany), providing the values of the chromatic coordinates L^* , a^* , b^* , L^* , C^* and h^* [20].

The spectrophotometer was calibrated in accordance with the manufacturer’s specifications, and constant illumination and standardization was maintained throughout the entire measurement procedure. All color measurements were made with the reading frame of the spectrophotometer adjusted to contact the vestibular surface of each tooth. Three consecutive measurements were carried out always at the same laboratory, with the lights off, and with the spectrophotometer covered by a black paper case with the aim to maintain constant the luminosity.

The results obtained were submitted to statistical analysis by means of the Students-t test, Kruskal Wallis and Dunn’s tests at a level of significance of 5%.

RESULTS

The results presented refer to the measurements of the values obtained during

the readouts in the spectrophotometer, corresponding to the values of ΔL - luminosity: the difference from light to dark, Δa - alteration from red to green and Δb - alteration from yellow to blue.

To obtain the results, the Student's-t test was initially applied to visualize in which axis of the coordinates (L^* , a^* e b^*) the variation in color occurred, separately for each experimental group. In Table 1, the values of significance of the coordinates of the CIEL*a*b* system may be observed for each experimental group, showing that in Groups GCof and GWine the three coordinates presented statistically significant difference. In Groups GCola and GVin only coordinate b^* presented difference; in Group GJui the difference occurred in coordinate L^* ; in Group GAntAlc this occurred in coordinates a^* and L^* , in Group GAnt in coordinates b^* and L^* and in Group GChl this difference is shown in coordinates a^* and b^* .

To test the hypothesis of equality among the groups with regard to color alteration, the Kruskal-Wallis analysis of variance and Dunn's tests were performed (5%), from the calculation of $\Delta E = (\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2$ for each of the groups. The result is shown in Table 2. Also in Table 2 the similarity among the experimental groups may be visualized, and it is verified that Groups GJui and GWine differed from Group GCof. With regard to the other groups, similar behavior was observed.

Table 1 - Initial values, final values and difference between the a^* , b^* and L^* coordinates

Group		Δa^*	Δb^*	ΔL^*
GCof	Initial	2.26	36.74	71.54
	Final	2.71	39.73	69.90
	Difference	0.45	2.99	-1.63*
GJui	Initial	2.05	36.41	71.53
	Final	1.91	38.12	71.07
	Difference	-0.14	1.70	-0.45*
GChl	Initial	2.37	37.93	71.7
	Final	2.07	39.51	71.68
	Difference	-0.30	1.58	-0.01
GWine	Initial	2.11	37.00	71.68
	Final	1.90	38.50	71.02
	Difference	0.20	1.50	-0.65*
GCola	Initial	2.22	37.40	71.22
	Final	2.44	39.42	70.99
	Difference	0.21	2.01	-0.23
GVin	Initial	2.18	37.10	71.75
	Final	2.29	39.32	71.40
	Difference	0.10	2.22	-0.34
GAnt	Initial	2.31	36.90	70.62
	Final	2.45	40.48	71.20
	Difference	0.13	3.58	0.58**
GAntAlc	Initial	2.23	36.62	70.93
	Final	1.90	38.21	71.32
	Difference	-0.33	1.59	0.39**

Table 2 - Comparison between final and initial results, using the Student's-t test for paired samples per groups and Cie $L^*a^*b^*$ coordinates. *p < 0.05

Coordinates	Groups							
	GCof	GJui	GChl	GWine	Gcola	GVin	GAnt	GAntAlc
a^*	0.0001*	0.430	0.003*	0.026*	0.103	0.115	0.180	0.020*
b^*	0.0001*	0.102	0.012*	0.002*	0.003*	0.000*	0.000*	0.051
L^*	0.001*	0.006*	0.932	0.010*	0.205	0.064	0.018*	0.033*

DISCUSSION

Studies for color evaluation may be conducted visually or by measurement with instruments, using spectrophotometers or colorimeters, thus eliminating subjective interpretations of choice and color perception, common in visual evaluations [7,8,11,13,19-21]. With the use of the mentioned instruments, it was possible to attribute numerical values during evaluation, facilitating the comparison and statistical analysis of the data.

Koksal et al. correlated the values of L^* , a^* e b^* separately, with the goal of defining the greatest or least variation in luminosity L^* of the object [23]. The values of a^* correspond to the predominance of red (a^* positive) and scarcity of green (a^* negative), whereas the values of b^* refer to the predominance of yellow (positive b^*), and scarcity of blue (negative b^*). The values of ΔE , combination of L^* , a^* and b^* values, represent the perceptibility of the differences in color and are obtained by means of the mathematical formula: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$, capable of being converted into clinical significance.

The products used to challenge color change were those considered the ones most consumed by the population (coffee, artificial juice, wine, vinegar) or used as mouth washes (chlorhexidine, oral antiseptic with or without alcohol) and some have been used in researches of this nature [11,17,24-28]. In the case of chlorhexidine, this was associated with the experiment because it is a cationic antiseptic with a high staining potential, according to Jagger and collaborators, in 2002 [29].

The results pointed towards significant changes in color and luminosity in all the study groups when the coordinate ΔL^* , Δa^* and Δb^* were evaluated separately, as shown in Table 1. When comparing the final and initial results, an alteration in luminosity ΔL^* negative may also be observed in Groups GCof, GJui and GWine, allowing the conclusion that there was darkening of the specimens in these groups,

and a positive variation in Groups GAnt and GAntAlc, representing discoloration of the specimen. This finds corroborate with Purnaveja et al. and Saraç et al. studies, who related that cleaning agents may cause whitening of acrylic resin [13,18]. When analyzing the values of ΔE , only Groups GCof, GJui and GWine presented statistically significant difference (Table 2).

In the present study it was verified that the coffee solution (GCof) presented significant color alteration in comparison with the group submitted to wine (GWine) and artificial juice (GJui), and there is consensus among the studies presented in the literature, which have demonstrated that coffee solutions are responsible for the greatest variation in color confirming the results of the present research, Table 2 and Table 1, in which one observes that in the GCof, all the coordinates showed statistically significant alteration, and the same behavior occurred in the Gwine [11,23,30,31].

With regard to Groups GChl, GCola, GVin, GAnt and GAntAlc, no statistically significant difference was observed in comparison with the coffee, red wine and artificial juice groups (GCof, GJui and GWine).

On the other hand, it was noted that ΔL^* values were significantly lower in (GJui and GWine), when compared with GCof. It is believed that this difference may have occurred, in the case of GJui, due to the acid pH, discoloring the test specimen, and in the case GWine, particles of red pigmentation may have been deposited on the acrylic resin stock teeth, determining the color alteration, with predominance of red (a^* positive) and alteration in the final color ΔL .

With respect to the period of immersion of the test specimens, the immersion time was found to be a determinant factor in staining, discoloring and pigmentation of the artificial teeth. This factor has also been identified in the literature consulted [7,16,23,24,32,33].

Staining has also been perceived by dental professionals over the course of years of following up their patients, depending on biofilm acquired, dietary habits, beverages consumed,

products used for oral hygiene, and these factors may interfere in the mechanical properties of the materials, and consequently with their durability [5,28]. In a short period of time, this is a great inconvenience that compromises esthetic function. Therefore patients should always be informed of the possible changes in color and instructed to avoid substances with greater potential to cause this type of damage.

CONCLUSION

It could be concluded that all substances tested altered color of artificial teeth, but coffee causes the higher staining, changing both color and luminosity. Oral antiseptics with and without alcohol promoted whitening of artificial teeth.

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