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Evaluation of Color Change of Acrylic and Bisacrylic Resins after Immersion in Different Solutions

Avaliação da Alteração de Cor das Resinas Acrílica e Bisacrílica Após Imersão em Diferentes Soluções

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Abstract

Temporary restorations are of great importance for success in the course and completion of dental rehabilitations. In the face of substances transiting the oral cavity, color stability becomes essential for success during its use, mainly for the maintenance of aesthetics. The objective of the study was to evaluate the influence of the solutions of routine consumption on the color change of two materials used in the preparation of temporary restorations, comparing the stability of the acrylic resin with the bisacrylic resin. For the research, 60 samples were made, 30 of which were made of conventional acrylic resin (DencôrLay, Clássico Ind. And Com., São Paulo, SP, Brazil) and 30 of Protemp 4 bisacrylic resin (3M ESPE, St. Paul, MN) TO 1. The samples were divided into three groups (n = 10) according to the immersion medium: distilled water (control), Cola-Cola® and Coffee. The evaluation of the color change (ΔE) was evaluated according to the difference of the initital and final color (after 7 days of immersion) through the spectrophotometer (Vita Easyshade Advance 4.0; Vita-zahnfabrik). The results showed that the solutions presented significant staining potential, and that coffee provided the greatest color change for both resins tested ($p < 0.05$). Regardless of the immersion medium, the bisacrylic resin presented the highest values of ΔE. It is concluded that coffee has a high staining potential over the provisional materials and that the bisacrylic resin has a lower color stability compared to the acrylic resin.

Keywords: Dental Restoration, Temporary. Acrylic Resins. Polymethyl Methacrylate. Prosthesis Coloring. Coloring Agents.

Resumo

Restaurações provisórias são de grande importância para obtenção de sucesso no decorrer e finalização de reabilitações dentárias. Frente às substâncias que transitam pela cavidade oral, a estabilidade de cor torna-se fundamental para obtenção de êxito durante seu uso, principalmente pela manutenção da estética. O objetivo do estudo foi avaliar a influência das soluções de consumo rotineiro na alteração de cor de dois materiais utilizados na confecção de restaurações provisórias, comparando a estabilidade da resina acrílica com a resina bisacrílica. Para a pesquisa foram confeccionadas 60 amostras, sendo 30 de resina acrílica convencional (DencôrLay, Clássico Ind. E Com., São Paulo, SP, Brasil) e 30 de resina bisacrílicas Protemp 4 (3M ESPE, St. Paul, MN, EUA). As amostras foram divididas em 3 grupos (n=10) de acordo com o meio de imersão: água destilada (controle), Cola-Cola® e Café. A avaliação da alteração de cor (ΔE) foi avaliada de acordo com a diferença da tomada de cor inicial e final (após 7 dias de imersão) através do aparelho espectrofotômetro (Vita Easyshade Advance 4.0; Vita-zahnfabrik). Os resultados mostraram que as soluções apresentaram significativo potencial de manchamento, e que o café foi o que proporcionou a maior alteração de cor para ambas as resinas testadas (p<0,05). Independente do meio de imersão, a resina bisacrílica apresentou os maiores valores de ΔE. Através dos resultados obtidos, conclui-se o café tem alto potencial de manchamento sobre os materiais provisórios, e que a resina bisacrílica apresenta uma menor estabilidade de cor comparada com a resina acrílica.

Palavras-chave: *Restauração Dentária Temporária. Resinas Acrílicas. Polimetil Metacrilato.*

1 Introduction

The provisory stages of prothesis dental restaurations are really important for obtaining success during and after the finalization of such rehabilitations. Since they are preceded by the definitive phases, they act as functional and esthetic tests as well as promote health and comfort to the patient during the period necessary for the conclusive resource to be able to be installed[1-3]. However, this time interval is variable and can extend beyond what is expected, which highlights the importance of adequate preparation in both biomechanical and esthetic aspects, which in an increasingly demanding society concerned with such demand, becomes essential for the patient satisfaction[4-6].

Acrylic resins are the main type of material used to make temporary crowns due to desirable characteristics that present, such as strength, color stability, simplicity of manipulation, repair and polishing possibility and relative low cost[1]. Among the types available in the market, self-polymerized polymethylmetrakylate - PMMA based resins, dimethacrylate photopolymerizable urethane resin and self-polymerizing bisacrylic resin ca be highlighted[7,8]. Traditionally, PMMA resins have been established as the most used and popular ones, but, with technological advances, bisacryl resin has been increasingly used and adopted, since it presents superior

aspects such as easy manipulation (self-handling), resistance, stability, lower exothermic reaction, greater durability and even better optical properties [9,10] .

However, once these materials are installed in the oral cavity, they inevitably share an environment where several substances pass through and then undergo changes in their properties[11]. Regardless of the chemistry at its disposal, the dental polymers that make up these resins suffer a certain amount of adsorption of the liquids from the oral cavity and therefore tend to change their coloring over time due to various influents, such as food dyes, beverages, oral habits and even oral rinsing that are commonly prescribed to patients for the maintenance of a healthy oral environment[8,10,12,13].

Thus, reinforcing the variability of time in which the temporary element may be in use and, although commonly for short periods, color stability becomes essential for maintaining the much desired esthetics of these restorations[8,12,13]. Thus, the objective of the study was to evaluate the influence of the solutions of routine consumption on the color change of two materials used in the preparation of temporary restorations, comparing the stability of the acrylic resin with the bisacrylic resin. The null hypotheses tested were: (1) immersion media will provide the same color change for tested resins. (2) the acrylic and bisacrylic resin will present the same color change in the different immersion media proposed.

2 Material and Methods

2.1 Preparation of samples

By means of a pre-fabricated acrylic matrix (10 mm wide by 2 mm thick), sixty discs of different provisional materials were made (Table 1), being thirty conventional acrylic resin based on polymethylmetracrylate (PMMA) (DencórLay, Classic Ind. E Com., São Paulo, SP, BR) color 62 and 30 bisacrylic resin Protemp 4 (3M ESPE, *St. Paul, MN, USA*) color A1. For this purpose, a glass plate was used to position a polyester tape (Maquira *Dental Products* , Maringá, PR, BR) and on the same a prefabricated matrix was placed on it. Then, with the help of dappen pot, the acrylic resin was manipulated in the proportion of 2 (powder) to 1 (liquid) and in its sticky phase it was inserted into the matrix. For greater compaction of the material as well as uniformity of the surfaces of the samples, a new polyester tape was positioned in this region and on it another glass plate, which was increased by 1kg of weight for 1 minute. After waiting for the polymerization time specified by the manufacturers, the discs were removed and examined for surface flatness and thickness pattern. Afterwards, the washing was done in running water and drying with soft paper (Mili S.A, Curitiba, PR, BR) from all samples and then stored individually in universal collectors. For the manufacturing of bisacrylic resin samples the same protocol mentioned previously (for PMMA acrylic resin), but the insertion was made through the universal dispenser (3M ESPE, *St. Paul, MN, USA*) and the discs were cleaned with soft paper (Mili S.A, Curitiba, PR, BR) soaked in alcohol 70% and then stored individually in universal collectors.

Table 1 - acrylic and bisacrylic resin, composition and manufacturer

Name of Product	Protemp 4	DencôrLay
Type of resin	Bisacrylic	Self-polymerizing acrylic
Composition	BIS-GMA, BHT, amines, benzoyl peroxide, dimethacrylate glass particles	Dust: olymethylmethacrylate, benzoyl peroxide and biocompatible pigments Net: Methylmethacrylate, EDMA, inhibitor, fluorescent and DMT
Manufacturer	3M ESPE, *St Paul, MN, USA*	Clássico Ind. E Com. São Paulo, SP, BR

Source: Research data.

2.2 Experimental groups and immersion Protocol

The samples were divided into three groups (n = 10) according to the immersion medium (table 2),namely: distilled water- AcA and BiA, Cola-Cola® - AcCC and Coffee - AcCF and BiCF.

Table 2 - schematic representation. Acrylic and bisacrylic resin and the immersion media used in the study

Temporary restorative material	Solutions	Abbreviation
Bisacrylic resin	Distiled water (n=10) Coca-Cola® (n=10) Coffee (n=10)	AcA AcCC AcCF
Self-polymerizing acrylic resin	Distilled water (n=10) Coca-Cola® (n=10) Coffee (n=10)	BiA BiCC BiCF

Source: Research data.

For the preparation of the coffee solution (Meridiano, Colatina, ES, BR), 40g of powder were used and subsequently added 425 ml of water at 100 C in boiling phase, coated in paper filter (Mellita, Sao Paulo, SP, BR). Then, the solution was cooled at room temperature to achieve the immersions. The universal collectors were taken by the solutions, which were kept in greenhouse (Quimis Científicas Equipamentos Ltda., Diadema, SP, BR) for seven days at a temperature of 37 degrees C. In the middle of the storage period, the solutions were exchanged for new content of the same composition. To ensure complete contact of the disks with the solutions, the samples were suspended inside their reservoirs by means of dental floss (Hillo, Aperibe, RJ, BR). After 7 days, the liquids were discarded and, with criteria and the aid of a clinical tweezers (Golgran Ind. Com. Instr. Dentistry, Sao Caetano do Sul, SP, BR) samples and containers were washed in running water and dried with soft paper (Mili S.A, Curitiba, PR, BR). Then each disk was returned to its proper container.

2.3 Color Evaluation

For the registration of the colors data of the samples the

CIE L* a* b* (*Commission Internationale de I'Eclairage*) colorimetry system was used , where the L* coordinate represents the luminosity, ranging from 0 (black) to 100 (white), the a* coordinate indicates the color (hue) and saturation (croma) in the red-green axis (-a* = green; a* = red), and the b* coordinate points to color and saturation in the blue-yellow axis (-b* = blue; b* = yellow).

The samples were placed on a white background and before being immersed in the solutions, initial color measurements were made using the spectrophotometer device (*Vita EasyshadeAdvance 4.0; Vita-zahnfabrik*). The equipment was calibrated before the reading methods were carried out following the manufacturer's instructions. In each sample, the color measurement was performed three times, and the arithmetic mean of each coordinate (L*, a* and b*) obtained by these readings was calculated. For the registration of the final color, after seven days of immersion in the solutions, the samples were submitted to a new color intake, following the same pattern of the initial intake. For the evaluation of the staining alteration, the ΔE was calculated according to the formula $\Delta E = [(\Delta L^*)^2 \ (\Delta a^*)^2 \ (\Delta b^*)^2]^{1/2}$.

It is considered a change in color that is noticeable to the human eye, ΔE equal to or greater than 1, however, clinically feasible. On the occasion that this value is higher than 3.3, it is considered undesirable at the clinical eye [14,16] . With the help of Bioestat 5.0 software (Bioestat, Maringá, PR, BR), the results were statistically evaluated. *The komolgorov-smirnov tests* were performed to assess normality and then the *kruskal-wallis and dunn tests were used* to examine the comparison of the effect of the different E solutions *the mann-whitney test* to compare the two resins immersed in the same solutions, adopting for the comparisons $p<0.05$.

3 Results and Discussion

In the comparison among the solutions, it is observed that the immersion medium significantly influenced the color change of both the provisional tested restorative materials ($p<0.05$). For both acrylic resin and bisacrylic resin, although no significant statistical difference was observed between water solutions and Coca-Cola®, it is possible to point out that the coffee solution provided the highest value of ΔE ($p<0.05$) (Tables 3 and 4).

Table 3 - Averages and standard deviations of the color change (ΔE) of each material submitted to immersion in different solutions

Provisional restorative material	Immersion medium	Group	ΔE
Acrylic resins	Water (control)	AcA	0.48 (0,16)^{A}
	Cola-Cola*	AcCC	1.35 (0.54)^{AB}
	Coffee	AcCF	2.25 (0.34)^{B}
Bisacrylic resin	Water (control)	BiA	1.77 (0,24)^{A}
	Coca-Cola*	BiCC	3.75 (0,82)^{A}
	Coffee	BiCF	14.23 (1.68)^{B}

Kruskal-Wallis and Dunn tests ($p<0.05$). *For each resin tested, similar vertical letters denote statistical similarity.

Source: Research data.

Table 4 - Comparison of the color change (ΔE) of provisional restorative materials when submitted to the same immersion media

Group	ΔE
AcA	0.48 (0,16)^{A}
BiA	1.77 (0.24)^{B}
AcCC	1.35 (0,54)^{A}
BiCC	3.75 (0.82)^{B}
AcCF	2.25 (0,34)^{A}
BiCF	14.23 (1.68)^{B}

Mann-Whitney test ($p<0.05$). *in comparison two to two, distinct vertical letters denote statistical difference.

Source: Research data.

Ensuring the color stability of the transitional prostheses directly influences the success of the definitive restorations. Thus, numerous discussions exist about the influence of coloring agents present in foods routinely consumed, in view of the color stability of the provisional materials[8,10,12,13,17,18] . Based on the results obtained, the two null hypotheses presented in the study were rejected, since the coffee provided the greatest change in the stains, and the bisacrylic resin independant of the immersion medium presented lower color stability.

Da Silva Muniz et al.[10] observed that bisacrylic resin was more stable in relation to this variable when compared to acrylic resin. However, the findings of the present study corroborate those of Givens et al.[19] , Bayindir et al.[18] and Mazaro et al.[12] since that they found higher susceptibility to color change of bisacrylic resins in relation to pigmentant agents in relation to base acrylic resin of polymethylmetracrylate.

The color change of the bisacrylic resin can be explained due to its heterogeneity, where pigmentant solutions are able to infiltrate small particles of the material, thus resulting in higher staining rates. This material has organic matrix composition, inorganic load particles, in addition to monomers such as bisphenol A-diglicidil dimethacrylate (bis-GMA) and triethyleneglycol dimethacrylate (TEGDMA), however the mixture of monomers can result in a disadvantage for color stability[12].

The staining of restorations may be associated with intrinsic and extrinsic factors, which are from adsorption or absorption of dyes. The diversity of types of drinks, especially in regions with higher consumption, as in tropical countries, leads to questions about the possibility of relation to the color changes observed in these types of restoration[20] . The oral environment is in constant contact with such agents that are very popular in the general population, such as cola and coffee. As in studies by Givens et al.[19] , Rutkunas et al.[17] , Bayindir et al.[18] , Mazaro et al.[12] and Mickevitiute et al.[13] , the present study showed that after a certain immersion time the coffee solution caused the greatest color change in both tested materials, followed by the cola soda. The coffee composition presents colorants of the yellowish color that contain chemical affinity with polymers of restorative materials, and these

elements are responsible for the ability to change color[11].

The cola-based soda has an acid PH (1,5-2,0) which can lead to non-characteristic corrosion on the surface of the material with resulting leaching of the same, becoming more or less hydrophilic depending on the composition, thus causing greater vulnerability to staining [11] . The exposed work showed that the cola soda caused a change in color and ΔE greater than 3.3 in the bisacrylic resin, but compared to the coffee the results were lower. According to Tekcze et al.[21] this is due to the lack of the yellow dye in the cola-based drink.

It is important to emphasize that time is a determining factor for color change, the more the provisional materials are in contact with solutions of potential pigmentant, the greater the change in the variable. Dos Santos Lopes et al.[20] concluded in their study that the provisional materials in contact with these agents in a 24-hour period did not cause changes in color noticeable to the human eye. However, Mazaro et al[12], Mickevitiute et al.[13] and Henriques et al.[22] assessed the color change at different time intervals,and they concluded that there was a change in color noticeable to the human eye after seven days and the ΔE values were higher according to the increase in the storage time of the samples.

According to the limitations of the present research, further laboratory and clinical studies are needed that allow the assessment of the color stability of the different temporary materials in the market, in contact with pigmentant solutions of routine consumption, so that it is possible to discuss results that support their indications and weights, because it is important that the information is based on scientific research.

4 Conclusion

Using the methodology employed in the present study and based on the results exposed, it is concluded that the bisacrylic resin presented higher staining potential when compared to the self-polymerized acrylic resin. Also, the coffee provided the greatest color change in both tested resins.

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