

Evaluation of color stability of different temporary restorative materials

Avaliação da estabilidade de cor de diferentes materiais restauradores provisórios

José Vitor Quinelli MAZARO^{a*}, Luiz Miguel MINANI^a, Adriana Cristina ZAVANELLI^a,
Caroline Cantieri de MELLO^a, Cleidiel Aparecido Araújo LEMOS^a

^aFaculdade de Odontologia, UNESP - Universidade Estadual Paulista, Araçatuba, SP, Brasil

Resumo

Introdução: Os materiais restauradores provisórios são amplamente utilizados, porém pouco se sabe a respeito de sua estabilidade de cor. **Objetivo:** Avaliar a estabilidade de cor de materiais restauradores provisórios: resina acrílica e resinas bisacrílicas, após a imersão em soluções pigmentantes, durante diferentes períodos de armazenamento. **Material e método:** Quatro materiais foram testados (Dêncor/Clássico, Protemp 4/3M ESPE; Structur 2 SC/Voco; Luxatemp AM Plus/DMG) sendo confeccionadas 30 amostras (15 mm de diâmetro e 2 mm de espessura) por material. Estes foram divididos de acordo com o meio de imersão (saliva artificial, saliva + refrigerante tipo cola e saliva + café) e período de armazenamento (2, 5, 7 e 15 dias). As mensurações de cor foram realizadas antes e após as imersões, com auxílio de um espectrofotômetro, através do sistema CIE L*a*b*. Os dados foram analisados com análise de variância (ANOVA) e Tukey, com nível de significância à 5%. **Resultado:** A resina acrílica apresentou maior estabilidade de cor quando comparada às resinas bisacrílicas (p<0,001). Comparando as resinas bisacrílicas, não foi observado diferença significativa entre as resinas Structur e Luxatemp (p=0,767). Em relação as soluções testadas, o café apresentou os maiores valores de alteração de cor (p<0,001), sendo que quanto maior o período de armazenamento, maior foi a alteração de cor de todos os materiais provisórios analisados (p<0,001). **Conclusão:** A resina acrílica apresentou maior estabilidade de cor, quando comparada às bisacrílicas. O café causou a maior alteração de cor, e o tempo de imersão foi determinante na estabilidade de cor dos materiais provisórios analisados.

Descritores: Restauração dentária temporária; cor; prótese dentária.

Abstract

Introduction: Temporary restorative materials are widely used, however, little is know about their color stability. **Objective:** to evaluate the color stability of the following temporary restorative materials: acrylic and bis-acrylic resins after immersion in pigmenting solutions for different periods of storage. **Material and method:** Four materials were tested (Dêncor/Clássico, Protemp 4/3M ESPE; Structur 2 SC/Voco; Luxatemp AM Plus/DMG) and 30 test specimens (15 mm in diameter and 2 mm thick) per material were fabricated. They were divided according to the storage medium (artificial saliva, saliva + cola type soda, and saliva + coffee) and storage time intervals (2, 5, 7 and 15 days). Color measurements were made before and after immersions, with use of a spectrophotometer, by means of the CIE L*a*b* system. The data were analyzed by the analysis of variance and the Tukey Test, at a level of significance of 5%. **Result:** Acrylic resin presented greater color stability in comparison with bis-acrylic resins (p<0.001). When bis-acrylic resins were compared no significant difference was observed between the resins Structur and Luxatemp (p=0.767). As regards solutions tested, coffee showed the highest color change values (p<0.001), and the longer the storage time interval, the greater was the color change in all the temporary restorative materials analyzed (p<0.001). **Conclusion:** Acrylic resin presented greater color stability in comparison with bis-acrylic resins (p<0.001). Coffee caused the greatest color change, and immersion time was determinant in color stability of the temporary materials analyzed.

Descriptors: Dental restoration temporary; color; dental prosthesis.

INTRODUCTION

The principle of using temporary restorations is to meet requisites such as pulp protection, marginal integrity, wear resistance, esthetics¹ and to reestablish masticatory function for a limited period, until it is possible to insert the definitive dental prosthesis².

In this context, it is important to select a temporary material with greater color stability and resistance to different pigmenting liquids to which they are subjected, with the purpose of optimizing the esthetics of the restorations made³.

Among the various materials available, are polymethyl methacrylate (PMMA), methyl methacrylate, polyvinyl siloxane, bis-acrylic resins and resin composites, polymerized by means of chemical processes, light, or even dual polymerization⁴.

Heat polymerizable acrylic resins deserve to be pointed out due to their high resistance capable of guaranteeing significant longevity of the restorations⁵. However, bis-acrylic resins have been increasingly widely used because of their practicality, in addition to showing minimal polymerization shrinkage, low exothermic reaction, and a highly satisfactory esthetic appearance⁶.

However, no exactness has been observed in the literature as regards the most appropriate material for fabricating temporary restorations, due to the innumerable materials available for this prosthetic purpose. Some authors have related that PMMA-based resins undergo less color change over time, when compared with the other resins^{2,7}, while other studies have observed similarity in the color stability of different temporary materials^{8,9}.

In view of the foregoing, the aim of this study was to evaluate the color stability of different temporary prosthetic restorative materials (acrylic and bis-acrylic resins) immersed in different solutions for different time intervals. The hypotheses formulated for the study were as follows: (1) there is no difference in color stability of acrylic and bis-acrylic resins; (2) bis-acrylic resins present similar color stability; (3) the type of solution and time would have no influence on the color stability of temporary materials.

MATERIAL AND METHOD

Experimental Design

For each temporary material analyzed, 30 test specimens were fabricated, which were divided into three subgroups (n=10) according to the immersion medium in which they were stored, as shown in Table 1.

Sample Fabrication Method

The samples were fabricated with the use of a circular metal matrix, 15 mm in diameter and 2 mm thick, in accordance with Specification No.27 of the American Dental Association (ADA)¹⁰, in shade A2. The acrylic resin was manipulated in accordance with the manufacturer's instructions, and bis-acrylic resins were taken to the metal matrix in a dispenser, with corresponding mixer tips for each material. After this, the period of polymerization of each material was awaited, in accordance with the manufacturers' recommendations, with polymerization also being controlled according to the consistency of the material surface.

The next step was to perform polishing of the samples, in accordance with previously performed methodologies^{11,12}, by using silicon carbide abrasive papers (3M ESPE, St. Paul, MN, USA), in decreasing order of grits #320, #600, #800 and #1200 in an automatic polishing machine (EcoMet Pro Grinder/Polisher (Buehler – USA). Polishing was performed for 60 seconds at each abrasive paper grit, under water cooling. In the interval of each abrasive paper, the samples were washed in an ultrasonic bath (Cristófoli, Campo Mourão, Brazil) for 2 minutes, in order to remove possible residues present on the surface.

After polishing, the samples were immersed in artificial saliva (2.2 g/L of gastric mucine, 0.381 g/L sodium chloride, 0.231 g/L calcium chloride, 0.738 g/L potassium phosphate, 1.114 g/L potassium chloride, 0.02% sodium azide, sodium hydroxide until a pH 7.0 was obtained)¹³. Afterwards the samples were kept in an oven at 37° ± 1 °C for 24 hours. After this, initial readouts (baseline) were performed by means of ultraviolet-visible spectrophotometry (Model UV-2450, Shimadzu, Kyoto, Kyoto, Japan).

Color Stability Evaluation

The immersion solutions tested were as follows: artificial saliva; saliva + cola type soda (Coca-Cola®, The Coca-Cola Company, Brazil) and saliva + coffee solution - 90g of powder to 1 liter of

Table 1. Experimental design

Provisional Material	Brand	Manufacturer / City - State, Country	Solution (n = 10)
Acrylic Resin	Dêncor	Clássico/ São Paulo – SP, Brasil	Artificial saliva
			Coke
			Coffee
Bis-acrylic	Protemp 4	3M ESPE/ St Paul – MN, EUA	Artificial saliva
			Coke
			Coffee
Bis-acrylic	Structur 2 SC	Voco/ Cuxhaven, Alemanha	Artificial saliva
			Coke
			Coffee
Bis-acrylic	Luxatemp AM Plus	DMG/ Englewood – NJ, EUA	Artificial saliva
			Coke
			Coffee

The materials are maintained in each of the immersion solutions for periods of 2, 5, 7 and 15 days.

water at 90 °C (Pilão Tradicional, São Paulo, Brazil). The coffee solution was prepared in accordance with the manufacturer's recommendations.

All the test specimens were immersed in their respective solutions at 37 °C, and all the solutions were diluted with artificial saliva with the main purpose of simulating the oral conditions as faithfully as possible^{4,14,15}.

Before performing the analysis, according to the methodology used by Haselton et al.⁴, each test specimen was manually cleaned with a soft bristled brush P-40 (ORAL-B) for 30 seconds, and was then washed in distilled water to remove the remaining sediments of immersion solutions.

Color stability (ΔE) was verified by means of an ultraviolet-visible spectrophotometer (Model UV-2450, Shimadzu, Kyoto, Kyoto, Japan) after a storage time interval of 2, 5, 7 and 15 days, in each of the previously mentioned solutions.

The color change calculations (ΔE) were made by means of the CIE L*a*b* system, established by the "Commission Internationale de l'Eclairage" (International Commission of Illumination) CIE. The "L" axial is known as luminosity and it extends from 0 (black) to 100 (perfect white). The "a" coordinate represents the quantity of red (positive values) and green (negative values) while the "b" coordinate represents the quantity of yellow (positive values) and blue (negative values). This system allows the value of ΔE (color variation) between two readings to be calculated by means of the formula: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$, in which the variables were: $\Delta L = L_{\text{initial}} - L_{\text{final}}$; $\Delta a = a_{\text{initial}} - a_{\text{final}}$; $\Delta b = b_{\text{initial}} - b_{\text{final}}$.

Data Analysis Method

For data analysis, three study factors were considered: temporary restorative material at two levels (acrylic and bis-acrylic resin); immersion solution at three levels (artificial saliva, saliva + cola

type soda, and saliva + coffee); and immersion time at four levels (2, 5, 7 and 15 days).

On conclusion of the calculations, the ΔE values were submitted to statistical analysis. By using the program SigmaPlot 12.0 (Systat Software, San Jose, CA, USA), three-way analysis of variance (ANOVA) was performed (Factor 1: Temporary material, Factor 2: Immersion solution; Factor 3: Storage time) and a complementary one-way analysis of variance, seeking to specifically compare the bis-acrylic resins studied, by using the Tukey post-test for multiple comparisons, at a level of significance of 5%.

RESULT

In a comparative analysis of color change between acrylic resin and bis-acrylic resins, a statistically significant and favorable difference was observed for the acrylic resins ($p < 0.001$). Afterwards, when specifically analyzing the bis-acrylic resins tested, a statistically significant difference was observed in the comparative analysis among all the resins, showing higher ΔE values for Prottemp 4 resin ($p < 0.001$). However, there was no statistically significant difference between the resins Structur 2 SC and Luxatemp AM Plus ($p = 0.767$).

After this, when seeking to analyze the influence of the different pigmenting solutions tested, on the color change in the temporary materials selected, coffee was found to present the highest color change values of all the materials, followed by cola type soda solution and artificial saliva, irrespective of the storage time intervals of the test specimens ($p < 0.001$). Moreover, it should be pointed out that the storage time interval was shown to be directly proportional to the change in color, in which the longer the storage period, the greater was the color change of the temporary material (Table 2).

Table 2. Color changes (Mean \pm Standard deviation) of temporary materials analyzed, in different immersion mediums and storage time intervals.

Provisional Materials	Solutions	Storage periods			
		2 days	5 days	7 days	15 days
Dêncor	Artificial Saliva	0.54 \pm 0.28 Aa	1.09 \pm 0.37 Ab	1.20 \pm 0.36 Ab	1.28 \pm 0.35 Ab
	Coke	1.07 \pm 0.43 Ba	1.36 \pm 0.41 Aa	1.85 \pm 0.44 Bb	2.26 \pm 0.47 Bb
	Coffee	1.65 \pm 0.42 Ca	2.66 \pm 0.41 Bb	3.62 \pm 0.40 Cc	4.38 \pm 0.38 Cd
Structur 2C	Artificial Saliva	0.58 \pm 0.35 Aa	0.90 \pm 0.34 Aa	0.92 \pm 0.36 Aa	0.98 \pm 0.38 Aa
	Coke	1.14 \pm 0.80 Aa	1.83 \pm 0.90 Bab	2.29 \pm 0.85 Bbc	2.72 \pm 0.91 Bc
	Coffee	3.03 \pm 0.43 Ca	5.42 \pm 0.44 Cb	6.32 \pm 0.61 Cc	7.07 \pm 0.67 Cd
Prottemp 4	Artificial Saliva	1.08 \pm 0.44 Aa	1.47 \pm 0.36 Aab	1.62 \pm 0.38 Ab	1.83 \pm 0.38 Ab
	Coke	1.83 \pm 0.37 Ba	2.69 \pm 0.38 Bb	3.39 \pm 0.35 Bc	3.87 \pm 0.36 Bc
	Coffee	3.07 \pm 0.66 Ca	4.65 \pm 0.49 Cb	5.43 \pm 0.48 Cc	6.04 \pm 0.45 Cd
Luxatemp AM Plus	Artificial Saliva	0.68 \pm 0.57 Aa	1.11 \pm 0.70 Aa	1.21 \pm 0.70 Aa	1.31 \pm 0.70 Aa
	Coke	1.26 \pm 0.39 Aa	1.95 \pm 0.29 Bab	2.19 \pm 0.32 Bb	2.45 \pm 0.34 Bb
	Coffee	3.21 \pm 0.89 Ba	5.07 \pm 0.68 Ca	5.80 \pm 0.64 Cb	6.28 \pm 0.62 Cb

Capital letters represent statistically significant difference in the same column ($p < 0.05$). Lower case letters represent statistically significant difference in the same line ($p < 0.05$).

DISCUSSION

Guaranteeing the color stability of temporary restorative materials is an essential factor with great influence on the success of prosthetic rehabilitations, considering that during the stage of temporary restorations, patients concentrate their concern on the function and esthetics of the restorations¹⁶.

In view of the study hypotheses initially formulated, the first hypothesis that color stability of acrylic resins is similar to that of bis-acrylic resins was rejected, since self-polymerizing acrylic resin presented greater color stability.

Similar results have been found in previous studies that also observed greater susceptibility to color change of bis-acrylic resins when in contact with pigmenting solutions^{2,7}. Moreover, studies conducted by Haselton et al.⁴ and Turgut et al.¹⁷ pointed out the capacity of absorption and adsorption of pigmenting solutions to influence the color stability of acrylic resins. This occurs because the PMMA-based materials have a more homogeneous composition, and consequently the capacity to absorb and adsorb solutions may have a direct influence on color stability. Due to the heterogeneity of bis-acrylic resins, the pigmenting solution is capable of infiltrating into the midst of the small particles of material, thus causing a greater level of pigmentation^{4,17}.

In a complementary analysis, evaluating only the bis-acrylic resins selected for this study, statistically significant difference was observed between the resins Structur 2 SC and Luxatemp AM Plus in comparison with Protemp 4, which presented the highest color change values, thus denying the second hypothesis formulated. These results corroborate the findings of previous studies that evaluated the color stability of different materials and observed that Protemp resin also presented high color change values^{2,16}.

It should be pointed out that the bis-acrylic resins have an organic matrix, inorganic filler particles, in addition to monomers such as bisphenol A-diglycidyl dimethacrylate (Bis-GMA) and triethylene glycol dimethacrylate (TEGDMA). Monomers and their derivatives tend to provide better mechanical properties, low changes in temperature, reduction in polymerization shrinkage, and excellent polishing, thereby increase the practicality of fabricating temporary dental prostheses^{4,16}.

However, as pointed out by Haselton et al.⁴, the mixture of monomers may be harmful to color stability, considering the majority of bis-acrylic resin polymers are more polar than the acrylic resin polymers. These chemical characteristics increase the affinity of bis-acrylic resins for polar liquid molecules, and consequently, greater absorption of substances that interfere in the color stability of the materials may be observed⁴.

Moreover, the oral cavity and temporary restorations are known to be subject to different pigmenting mediums^{4,14,18}, therefore, in this study it was also sought to evaluate the color alteration of temporary materials when submitted to immersion mediums such as saliva, cola type sodas and coffee, commonly consumed by the population. From the results obtained, the third hypothesis formulated was also rejected, since a significant difference was

observed in the color change of test specimens for each immersion medium, which increased progressively according to the longer time the test specimens remained in each solution.

The solution containing artificial saliva only, presented the lowest color change values, contributing to low ΔE values. Therefore, as in the case of distilled water used in some studies^{19,20}, since artificial saliva artificial was a solution that contained no pigmenting agents, it was expected to present the lowest color change values⁴. However, it should be pointed out that one of the limitations of this study is the fact that the intraoral environment has saliva with the presence of proteins and enzymes, in addition to being associated with innumerable temperature variations, factors not present in an *in vitro* study².

Among the solutions tested, coffee was the medium that led to the greatest color change in all the materials and time intervals evaluated. This greater alteration may be related to the degree of compatibility of the polymeric phase of resin with the yellow coloring present in coffee, increasing the trend towards positive values with reference to the coordinate b^* , responsible for detecting the shades of yellow and blue, which promoted staining of the test specimens²¹, since the cola type soda has no yellow coloring agents in its composition²². Furthermore, the coffee solution was observed to cause a significant change in color in a short period of immersion, corroborating the findings of previous studies that verified color change in test specimens in the first 24 hours of immersion²³.

As regards the storage time interval, an influence on color change in the materials tested directly proportional to the period of immersion was observed. The longer the period of test specimen immersion, the greater the color change presented, particularly in coffee solution.

However, it should be pointed out that only ΔE values higher than 3.7²⁴ are considered clinically unacceptable. Therefore, resins immersed in artificial saliva solution and cola type soda, with the exception of Protemp 4 for the cola type soda in the period of 15 days, were observed to present color changes below the clinically perceptible level. Furthermore, coffee exceeded the acceptable limits as from the 5th day of immersion.

Gupta et al.¹⁵, estimated the maximum time for use of temporary restorations should be up to 15 days, however, the definitive treatment plan for extensive rehabilitations may be subject to alterations, due to clinical and laboratory delays, intercurrent diseases, or even financial considerations²⁵. In this case, according to the results found in this study, and those of Doray et al.⁹, the shortest possible time of temporary restoration use is recommended, in addition to a shorter period of exposure of these materials to pigmenting solutions, in order to seek the least amount of color change, and thereby avoid the patient's dissatisfaction.

As limitations of this *in vitro* study, we may mention the maximum time interval of immersion of the test specimens was 15 days, while we know that temporary restorations may remain in the oral cavity for a longer period of time. However, as the results of this study demonstrated significant changes in color of the materials in the period of 15 days, the recommendation is that

new restorations should be made in clinical situations in which it is necessary for temporary restorations to remain in use for longer periods, or alternatively, a material with greater color stability should be chosen. Furthermore, it should also be pointed out that the use of the association of pigmenting solution with artificial saliva, in spite of approximating the simulated conditions of the intraoral environment, could influence the degradation and color change of the material. Therefore caution is required during interpretation of the data, and further studies that adequately simulate the oral conditions are necessary, in order to prove the findings shown in the results of studies available in the literature.

CONCLUSION

Acrylic resin presented greater color stability when compared with bis-acrylic resins. The bis-acrylic resins tested did not present the same color stability, since the resin Protemp 4 presented greater color changes in the mediums tested. Coffee was the solution responsible for the greatest color change in the temporary resins tested during the different immersion time intervals. The increase in immersion time of the test specimens had a significant influence on the reduction in color stability of the temporary materials.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

*CORRESPONDING AUTHOR

José Vitor Quinelli Mazaro, Departamento de Materiais Odontológicos e Prótese Dentária, Faculdade de Odontologia de Araçatuba, UNESP – Univ Estadual Paulista, Rua José Bonifácio, 1193, 16015-050 Araçatuba - SP, Brasil,
e-mail: zevitormazaro@foa.unesp.br

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