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Original Research Article

Color Stability of Heat-Cured Versus Self-Cured Provisional Restorative Materials

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ABSTRACT

Objective: The aim of this study was to compare the color stability of two different types of provisional restorative materials.
Materials and Methods: Two types of commercially available provisional restorative materials, one was self-cured resin composite utilizing the direct technique and the other was heat-processed acrylic resin utilizing the indirect technique. Discs prepared from the two tested materials were immersed in distilled water for six months. Color change "ΔE" was detected after one month and six months of storage to evaluate the color stability of the two tested materials using Easyshade spectrophotometer.
Results: For both tested materials, there was a significant difference in the color change between the two storage periods. However, there was no significant difference between the two tested materials at each storage period. Both tested materials showed imperceptible color change.
Conclusions: The method of polymerization as well as the compositional pattern of the tested provisional restorative materials plays a principal role in the improvement of the color stability of the investigated provisional materials.

Keywords: Provisional Restoration, Color Stability, Spectrophotometer

INTRODUCTION

Provisional restorations have become essential in the success of any fixed partial denture procedure, as they fulfill this goal by providing protection, stabilization, function and esthetics before fabrication of the definite prosthesis. So, efficient fabrication of a clinically acceptable provisional restoration for a fixed partial denture is important for the success of the final restoration. The use of such restorations has become important in the past few years. [1,2]

Many years ago, the interim dental restorations were used for temporary protection of the prepared abutment teeth till final prosthetic restoration was fabricated. However, the role of such restorations has changed dramatically in the past several years. [1,3]

The use of the term *temporary* is controversial and may be considered inappropriate as "temporary" treatment may be interpreted as one of less importance or value. Nowadays, the terms *provisional, interim, or transitional* have been routinely used interchangeably as provisional restorations serve many functions and purposes becoming an important part of any successful treatment for fixed prosthesis. [4-7]

Provisional restorations are generally necessary to restore lost function and esthetics during the implant integration period which may reach six months or in some cases may exceed one year. [3] Moreover, they maintain occlusal and proximal contacts, thus preventing supereruption or drifting of teeth. [8] When properly fabricated, provisional restorations can assist in maintenance of the periodontal health and can promote guided tissue healing. This is especially useful with treatment involving highly esthetic areas. [5,9]

Various materials based on acrylic and composite resins are available for fabricating provisional fixed partial dentures, they are heat-processed, light-cured or self-cured. Accordingly, there are three main techniques of construction of provisional restorations, which are direct (chair-side), indirect (laboratory work) or a combination between direct and indirect techniques (indirect direct technique). [4]

Provisional restorations may remain in the patient mouth for a period of twelve to eighteen months to maintain proper occlusion and function. [10] Thus prolonged insertion of provisional restorations is often necessary for extensive dental treatments that involve occlusal rehabilitation, change in vertical dimension of occlusion, treatment of temporomandibular disorders or when the abutment teeth require periodontal, orthodontic or endodontic treatment. [9,10] Also, prolonged insertion of provisional restorations is important in implant therapy. Provisional restorations allow gradual occlusal loading of the implant supported prosthesis as they prevent immediate loading of submerged implants during healing phase which is likely to occur with removable partial denture. [11,12] Long-term use of such restorations requires more durable materials for serving longer periods. [11]

Indirect provisional restoration showed improved marginal fit, density, fracture and wear resistance, especially laboratory heat-processed provisional prosthesis. In addition, potential pulpal damage is diminished since polymerization is performed extraorally. [13-15] However, time constraints and inadequate laboratory support has led to the continued use of the direct technique. [16] But still, from a biomaterial and clinical perspective, the fabrication of direct provisional restorations with adequate quality to ensure a healthy, functional, and esthetic dentition is a challenging task, even for the most experienced dentist. [17]

In esthetically critical areas, it is desirable for provisional restorations to provide an initial accurate color shade match and to remain color-stable over the course of provisional treatment. [5,18] Perceptible color change of provisional materials can produce serious esthetic complications, especially when long-term provisional treatment is required. This may compromise the acceptability of the provisional restoration. [19]

Tooth-colored provisional restorations are fabricated from acrylic resins and dimethacrylate resin composites. These provisional materials use stabilizers that decrease chemically-induced color changes. However, they are susceptible to other factors that may promote staining. When provisional materials contact pigmented solutions such as coffee or tea, discoloration is possible. Porosity and surface quality of provisional restorations, incomplete polymerization, as well as oral hygiene habits and patient’s diet can also influence color changes. [12, 18, 20]

During the last three decades, many studies have been done to determine the color stability of different provisional restorative materials. There is still a controversy between the color stability of acrylic resin-based and resin composite-based provisional restorative materials.

MATERIALS AND METHODS

One type of commercially available self-cured resin composite provisional restorative materials, utilizing the direct technique, another type of commercially available heat-processed acrylic resin provisional restorative materials utilizing the indirect technique were used in this study.

The materials used are listed in Table I

Table I: Materials used.

Product name	**Manufacturer**	***Mode of activation & Resin type***	***Presentation & Manipulation***	***Shade***
Protemp II (S)	3M-ESPE dental products D-10337 seafeld – Germany	Self-cured resin composite (Bis-acryl composite)	*3-paste system* 2 catalyst pastes were hand mixed together on a mixing pad, then mixed with the base paste. The whole mix was introduced to a special syringe supplied by the manufacturer for ease of application.	A_3
Acrostone (H)	Anglo-Egyptian company. Hegaz, Cairo, Egypt.	Heat-cured acrylic resin (Methyl Methacrylate)	*Powder and liquid* were used in a ratio of 2: 1 by weight, hand mixed and applied in the dough stage. Then, the material was placed in a pressure chamber (Ivomat) for heat processing.	A_3

A total of 20 discs (10±1mm in diameter and 2±0.1 mm in thickness) were prepared which were divided into two groups (10 each) according to the type of provisional restorative material used.

The discs made from resin composite provisional material, utilizing the direct technique, were prepared using a split Teflon ring with a central hole of 10 mm diameter and 2 mm thickness (Fig. 1). The provisional material was packed into the mold over a Mayler strip on a glass slab, covered by another Mayler strip and a glass slab. Gentle pressure was applied to extrude any excess material and to produce a flat smooth surface. The specimen was left for curing, and then was removed from the split mold where any flashes were removed to avoid loose particles attached to the samples during Color measurement.

While the discs made from heat-cured acrylic resin provisional material, utilizing indirect technique, were prepared similarly but by using a split metallic ring to withstand the curing temperature. The specimen was then placed in the Ivomat (pressure-chamber) for heat curing according to the manufacturers' instructions (20 minutes). After the curing cycle was completed, the specimen was left to cool to room temperature (bench cooling), then removed from the split mold and all flashes were trimmed.

The polymerized specimens were transferred into a glass desiccator maintained at 37 ^{o}C ± 1°C and stored for one hour then they were maintained for another hour at 23±1°C. Each disc was tested three times, immediately before immersion in water "T0" (baseline or control group), one month "T1" and six months "T2" after immersion in distilled water at 37°C ± 1°C in separate containers.

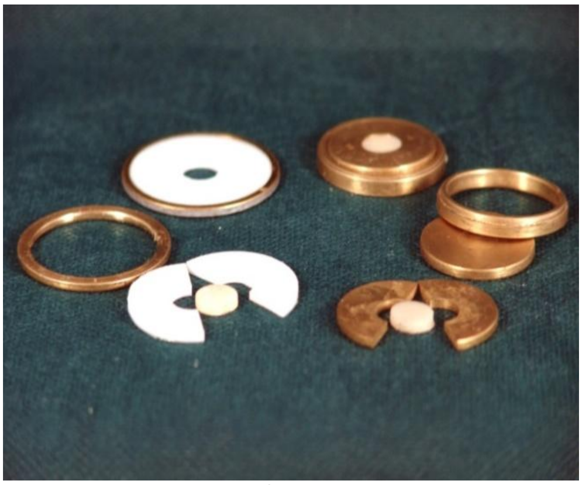

Figure 1: Split Teflon and metallic rings

The color and color difference of each specimen were measured by spectrophotometer (VITA Easyshade, Zahnfabrik, Bad Sackingen, Germany) was used to record the baseline color measurements of all specimens prior to distilled water storage according to the CIE L*C*h* system. A small mark was made with a graphite pencil to repeat the tested surface and measurement was taken away from that mark.

CIE L*C*h* scores were calculated against a white background relative to a standard illuminant, with L representing lightness (lighter or darker), C representing chroma (brighter or duller), and h representing hue angle. Specimens color was measured and the mean value of three measurements for L*, C*, and h* was recorded. Color measurements were acquired again after 1 and 6 months of distilled water storage at 37 ± 1°C, and color difference ΔE was calculated from mean ΔL*, ΔC* and Δh* values for each specimen from the following formula:

$$\Delta E = \sqrt{\Delta L^{*2} + \Delta C^{*2} + \Delta h^{*2}}$$

Where ΔL*, ΔC* and Δh* are the differences in L*, C* and h* values before immersion "T0" and after immersion at each time interval (T1 and T2).

$$\Delta E_1 = \sqrt{(L_1 - L_0)^2 + (C_1 - C_0)^2 + (h_1 - h_0)^2}$$ at T1 interval

$$\Delta E_2 = \sqrt{(L_2 - L_0)^2 + (C_2 - C_0)^2 + (h_2 - h_0)^2}$$ at T2 interval

The color stability of each material was evaluated by the color difference between the values obtained from each testing interval.

Statistical Analysis

Statistical analysis of this study was carried out using S-Plus Statistical Software (SPSS – Release 23) for Windows.

One-way Analysis Of Variance (ANOVA) test was used to compare between mean colors changes of the two tested materials. *Duncan's test* was used when ANOVA renders a significant result in order to determine the difference between the means.

Statistical significance is achieved when the *(P-value≤0.05)*

RESULTS

The color parameters means, standard deviations and their statistical analysis are presented in Tables II.

Table II: Means of color change (ΔE) of the two tested materials after one & six months immersion in water.

	Self-cured *resin composite* (S)		**Heat-cured *acrylic resin (H)***			
Storage Period	Mean (n=10)	S.D.	Mean (n=10)	S.D.	*f-value*	*P-value*
1 Month	1.57^a	0.43	1.24^a	0.45	1.279	0.315
6 Months	2.13^b	0.51	1.64^b	0.48	5.111	0.011*

**: Significant at P < 0.05, Means with different letters are statistically significantly different.*

As can be seen the color difference before and after one month immersion "ΔE" of the investigated materials showed that self-cured resin composite exhibited higher "ΔE" (1.57) than heat-cured acrylic resin "ΔE" (1.24).

The ANOVA indicated that there was *no significant difference (P < 0.05)* between "ΔE" for the two tested materials.

Similarly, it can be seen that the color difference before and after six months immersion "ΔE" of the investigated materials showed that the self-cured resin composite exhibited higher color change "ΔE" (2.13) than the heat-cured acrylic resin exhibited lower color change "ΔE" (1.64).

The ANOVA indicated that there was no significant difference (P < 0.05) between "ΔE" for the two tested materials after six months immersion in water. On the other hand, there were significant difference among each tested material from one to six months immersion indicating that the color change increased by time.

DISCUSSION

Color changes in provisional restorative materials have been attributed to a wide variety of possible causes. Many color changes were described as the result of physical adsorption or physico-chemical reactions of the ingredients of the restorative materials during exposure to the oral environment. [5] Among the causative factors that may contribute to the change in color of any esthetic restorative material are stain accumulation, dehydration, chemical degradation, leakage, water sorption and surface roughness. [21]

In assessing chromatic differences, generally two color systems are utilized, Munsell color system (visual technique) and Standard Commission Internationale de L'Eclairage (CIE) color system (instrumental technique). [22-25] The latter was used to evaluate color stability in the present study. The CIE L* C* h* color system can transform spectrophotometer data to an approximately uniform color space (L*, C* and h*). It was reported that the spectrophotometer was more sensitive to changes in luminous reflectance (value) than a visual system but both have similar sensitivity to changes in dominant wavelength and excitation purity. As in natural teeth, value difference had the greatest influence on the overall color differences. Therefore, the major factor contributing to the color difference in this study was found to be the value rather than the hue and chroma. [25-27]

The value of ΔE represents relative color changes that an observer might report for the materials after treatment or between time periods. Thus, ΔE is more meaningful than the individual L*, C* and h* values. [12,28] L*, C* and h* values are usually used while comparing the translucency of the materials which is out of the scope of this study. [25,29]

In this study, interest was directed to observe whether the tested materials had showed perceptible color changes or not and whether the color differences were statistically significant or not. Color changes that are perceptible may compromise the clinical acceptability of a provisional restoration. [30]

There was then the question of what value of ΔE measuring the color difference that may represent a perceptible color change. Previous reports related a range of values of ΔE to perceptible color difference: [19,31,32]

A value of ΔE of 1 unit is approximately equivalent to color difference that is just visually perceptible to 50% of observers under controlled conditions.

Values of ΔE between 0 and 2 represent imperceptible color differences, whereas value in the range of 2 to 3 represent color differences that are just perceptible. Also the ADA proposed the acceptable limit of ΔE on dental shade guides as 2 units.

Values of ΔE greater than or equal to 3.3 are visually perceptible and clinically unacceptable to 50% of the observers.

On the other hand, *Ruyter, et al., in 1987,* considered the relationship between perceptibility and acceptability as the measured color differences that are only just perceptible visually under experimental conditions, are not necessarily unacceptable clinically. [32] This is especially true for provisional restoration in which a limited range of color mismatch may be considered acceptable because of interim nature of the restoration. [19-22] Therefore, in the present study a color change (ΔE) less than 3.3 was considered visually imperceptible as well as clinically acceptable.

By analyzing the values of ΔE after one month of immersion of the tested materials in distilled water, it can be seen that there was no statistically significant difference between ΔE of the two tested materials. However the self-cured resin composite provisional material showed higher color change “ΔE” (1.57) than that of the heat-processed acrylic resin which exhibited lower “ΔE” (1.24). Same results were obtained after six months of immersion in distilled water, the values of “ΔE” increased with significant difference among the two tested materials indicating that the color change increased by time as the materials absorbed more water (2.13) and (1.64) respectively.

This color changes have been attributed to the oxidation of the polymer matrix or oxidation of the unreacted double bonds in the residual monomers with the subsequent formation of degradation products which results from water diffusion. [5,20,33,34]

The heat-cured acrylic resin exhibited lower color change as it is properly packed, dense and less porous due to its processing under heat and pressure resulting in lower water sorption than other tested provisional materials.

Finally, all the above tested materials showed clinical acceptable (imperceptible) color changes even after six months of immersion in distilled water based on the assumption of *Ruyter, et al. in 1987*. [32]

CONCLUSION

Based on the results of this study, it can be concluded that, the method of polymerization as well as the compositional pattern of the tested provisional restorative materials play principal role in the improvement of the color stability of the investigated provisional materials.

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