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ORIGINAL ARTICLE

Effect of different polishing time on the color stability of provisional materials: An *In vitro* study

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Abstract

Background: Provisional fixed restoration is an essential component in prosthodontics treatment. These materials may experience color change for surface roughness. To reduce it, a polishing technique is required with a time setting specified.

Aims and Objectives: The aim of this study was to evaluate the effect of different polishing time on the color stability of provisional materials.

Materials and Methods: One hundred and forty-four resin blocks were prepared, divided into Group A, PMMA acrylic resin and Group B, bis-acryl resin. They were polished with goat hairbrush and diamond paste. Twenty-four hours stored in distilled water and 12th day on the staining solution coffee and wine. They were measured with a spectrophotometer, analyzed, and processed with the CieLab system, to calculate color difference ΔE.

Results: On the 3rd day of the immersion period, the lowest mean value was showed with 1 min polishing on Group A, showing to be statistically significant, $P = 0.011$. In Group B, the lowest mean value was showed with 1 min 30 s. At the 7th and 12th days immersion period, the lowest mean value was showed with 30 s polishing among the groups.

Conclusions: Polishing 30 s showed the lowest ΔE values on PMMA and bis-acryl resin. Mean color differences were above the clinical acceptability threshold ΔE > 3.3. Regarding the staining agent, the highest ΔE values were observed in coffee.

Introduction

Provisional fixed restoration is an essential component in prosthodontics treatment[1] designed for a limited period, to be replaced by a definitive dental prosthesis.[2] These restorations must meet specific biologic, mechanical, and esthetic requirements to be adequate to maintain patient health.[3] The most commonly used are polymeric resins divided into two subclasses: Acrylic resin[4] and composite resin.[1] Acrylic resins are polymethylmethacrylate (PMMA) resin, polyethylmethacrylate, and combinations of unfilled methacrylate resins. Resin composites represented by bis-acryl resin, a hydrophobic material that has an improvement over the acrylics because they shrink less, give off less heat during setting, excellent esthetics, and minimal odor.[5]

Provisional restoration may experience color alteration due to polishing techniques, type of material, food, drink habits, oral hygiene, and incomplete polymerization.[1] Color stability of interim crowns is a concern despite being used for a limited period.[6] Discoloration may negatively affect a patient's perception of treatment,[4] mainly when the restoration is in the esthetic zone for an extended period.[6] These should exhibit a good shade match[5] and a highly polished surface[7] because increased surface roughness was directly related to increased bacterial adhesion[8] and color changes overtime.[9] A well-established polishing method is necessary to achieve color stability and smooth surface roughness.

Polishing is a process of a series of steps that progressively develop a smoother and more natural looking external surface on the provisional restoration.[10] The act of polishing constitutes a treatment on the surface using appropriate materials and techniques. The most commonly used systems are the silicone tips, abrasive tips of different particle sizes, and the use of chemical substances.[11] The findings showed that the goat hairbrush with diamond paste[11,12] and pumice powder[13] was the most effective polishing system for both bis-acryl and acrylic resins.

The polishing process is not only tricky but it is also extremely time consuming, often taking 5–15 min of chair time. If there are many polishing steps and mainly if each step takes much time,

the dentist's practice overhead can be substantially increased. Besides, mistakes can occur at every step, so the fewer the steps, the lower the chance for error, achieving a comparable result in less time becoming inherently worthwhile.[10] Patel *et al.*,[14] in 2014, concluded that 29% of patients felt that the dentist took more time to finish the treatment procedure. Setting the time will make the dentist's work smarter getting more results with limited time, supporting successful dental practice.[15]

Table 1: Composition and manufacturers of the materials used in the study

Material (shade)	Manufacturer	Components
Acrylic resin Alike (65)	GC América	Powder: Poly (methyl methacrylate) Liquid: Ethyl methacrylate (MMA) Methanol Dimethacrylate Accelerant UV light absorber
Protemp 4 (A2)	3M ESPE, St Paul, MN, USA	Dimethacrylate polymer. Bis-GMA, zirconium particles, silica, silane, pigments
Diamond polishing paste	Diamond Excel, Dentscare LTDA, Joinville - SC, Brazil	Micronized diamond with extra fine grit (2–4 μ)
Goat hairbrush	Becht®, Labordental Ltda, São Paulo, SP, Brazil	Goat hair

GMA: Glycidyl methacrylate

The need for a design protocol of polishing is required because there is no consensus regarding time and color stability after polishing.[7,16] Most studies[11,12] recommended the diamond polishing paste with a goat hairbrush on a constant rotation of 18,000 rpm for 1 min. Şen,[12] in 2002, recommended polishing at a rotational speed of 5000 rpm for 30 s with rag wheels[12] and a moist muslin wheel for 2 min.[9,13] Meanwhile, other authors[12,17] suggest polishing the specimens with a prophylactic cup mounted on an electric handpiece at 15,000 rpm using diamond polishing paste for 15 s. Hence, this descriptive observational study aims to evaluate the effect of polishing time management on the color stability of provisional materials.

Materials and Methods

All materials are commercially available and commonly used [Table 1]. One hundred and forty-four resin blocks (15 mm × 15 mm × 2 mm) prepared using silicone molds. A power analysis determines the number of specimens required in each test group to establish if statistical differences exist. For the accepted effect

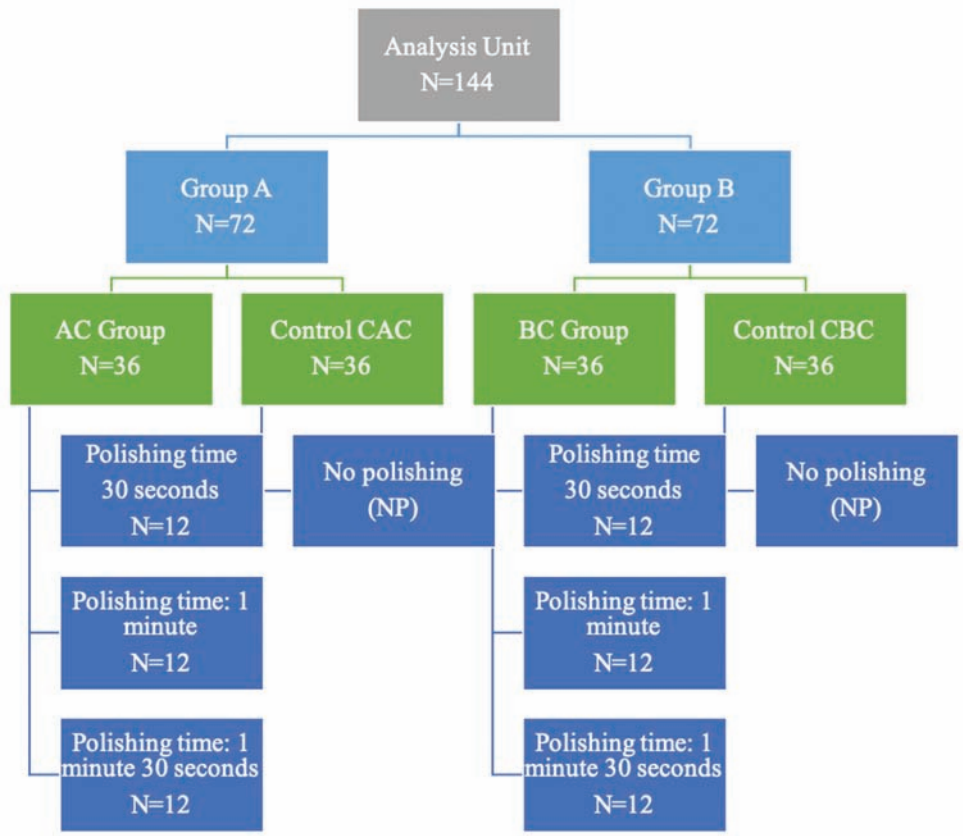

Figure 1: Groups division

size *f* parameter, a 0.80 power, and 0.05 alpha error probability, the number of specimens required in each group was determined to be 72, and the minimum six specimens were necessary for each group to achieve a 95% confidence interval. Group A uses PMMA acrylic resin and Group B, bis-acryl composite resin. Each group divided into 36 samples (N) for the experimental group and 36 samples for the control group [Figure 1].

Inclusion criteria were resin block 15 mm × 15 mm long × 2 mm wide, resin block with 24 h of manufacturing and polished. Exclusion criteria were resin blocks with porous, fractured, old, bubble, and stained surfaces.

Sample preparation

The silicone molds performed with Zhermack silicone Zetalabor, mixed according to the manufacturer's instructions. Group A constructed with PMMA acrylic resin mixed in a 2:1 ratio. Group B constructed with a self-mixing bis-acryl composite resin. Once polymerized, ethyl alcohol 95° (Laboratorios Collado) was applied between Group B disks and at the bottom to remove the oxygen-inhibited layer.

Surface treatment

Samples from both experimental groups polished with a SHIGANF III low-speed handpiece at different times. They polished the specimens with a goat hairbrush (Becht®, Labordental Ltda, São Paulo, SP, Brazil) plus diamond paste with 2–4 micron extra fine grain diamond polishing paste (Diamond Excel, Dentscare LTDA, Joinville SC, Brazil) in a constant rotation of 8000 rpm for different times, then subdivided in $n = 12$ samples for each time, 30 s ($n = 12$), 1 min ($n = 12$), and 1 min 30 s ($n = 12$).

Sample staining

Samples were stored in distilled water for 24 h, simulating the 1st day of restorative restorations in the oral environment. Samples were immersed for 12 days in *Santo Domingo* machine coffee solutions and merlot red wine [Figure 2] at 37°C ± 1 in an incubator simulating the oral cavity for 1 year. According to coffee makers, the average consumption time of one cup is 15 min, and among regular drinkers, it is 3.2 cups/day. For this reason, 24 h of storage simulates the consumption of a drink for a month.[18] These samples were washed with distilled water and changing the solutions on the 3rd, 7th, and 12th days, avoiding the microorganism growth. After the established time, the samples were prepared to proceed with color evaluation.

Color evaluation

The discs were dried with absorbent paper and measured on a positioned black background 3 times at their center. The same operator made all the color measurements with a Vita Easyshade spectrophotometer Advance 4.0 [Figure 3] on the 3rd, 7th, and 12th days previously calibrated, before and after the samples were subjected to staining agents. After results, they were analyzed and processed with the CieLab System 1976, calculating color difference ΔE using the following formula:

$$\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_2)^2}$$

$0 < \Delta E < 1$ – the difference is unnoticeable.
$1 < \Delta E < 2$ – an experienced observer only noticed the difference.
$2 < \Delta E < 3.5$ – an inexperienced observer also noticed the difference.
$3.5 < \Delta E < 5$ – the difference is noticeable.
$5 < \Delta E$ – observer notices two different colors.[19]

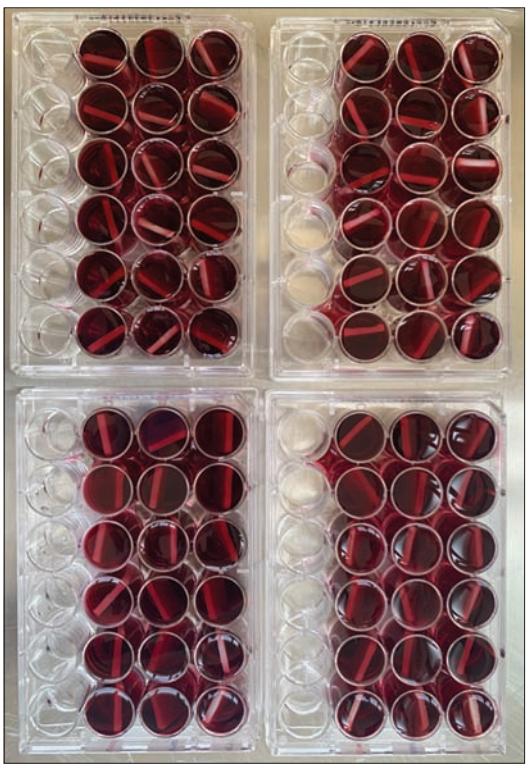

Figure 2: Samples immersed in Merlot red wine

Figure 3: Vita Easyshade 4.0

Data analysis

For data analysis, we use a three-way analysis of variance (ANOVA) and a Tukey test. Three study factors considered: Polishing time at 30 s, 1 min, and 1 min 30 s. Provisional restorative material: Acrylic and bis-acrylic resin immersed in coffee and wine at the 3rd, 7th, and 12th days. The program SigmaPlot 12.0 (Systat Software, San José, CA, USA) submitted the statistical analysis of the ΔE values.

Results

The results of a three-way ANOVA test are shown in Table 2 and Figure 4. Mean color differences Δ*E* values among the groups at the 3rd, 7th, and 12th days for the conventionally polished with two staining agents at different times were above the clinical acceptability threshold level 2 < Δ*E* < 3.5.

At the 3rd day immersion period, the lowest mean value was showed with 1 min polishing on Group A with 2.510, and it showed

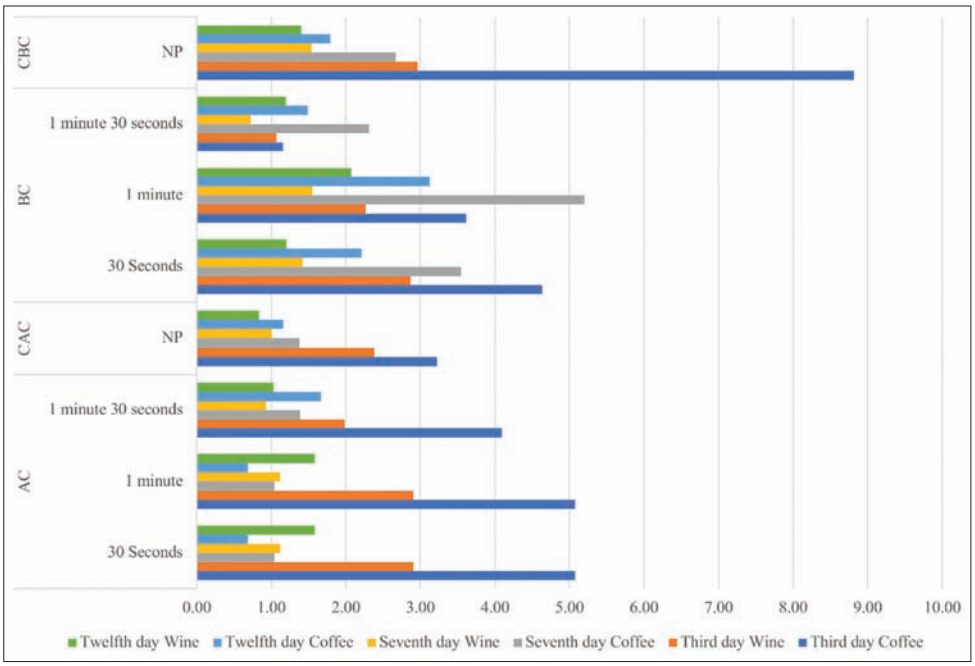

Figure 4: The mean color change ΔE values. AC: Acrylic resin, CAC: Control acrylic resin, BC: Bis-acryl, CBC: Control bis-acryl, NP: No polished

Table 2: Color changes (Mean±SD) of provisional materials analyzed in different staining agents and polishing time

Groups	Material	Staining agent	Storage at 37°C	Polishing time			
				30 s	1 min	1 min 30 s	Control
A	PMMA acrylic resin	Coffee (mean±SD)	3rd day	5.08±0.64	3.73±0.90	4.10±1.05	3.22±1.50
			7th day	1.04±0.62	1.70±0.91	1.38±1.92	1.38±0.55
			12th day	0.68±0.52	1.72±0.80	1.66±0.98	1.16±0.77
		Wine (mean±SD)	3rd day	2.90±1.20	2.04±0.27	1.98±0.67	2.38±1.37
			7th day	1.12±1.21	0.92±0.49	0.92±0.63	1.00±0.91
			12th day	1.59±1.18	0.71±0.18	1.03±0.88	0.83±0.73
B	Bis-acryl	Coffee (mean±SD)	3rd day	4.63±0.33	3.61±1.19	3.34±1.40	8.82±1.82
			7th day	3.54±0.01	5.20±4.97	8.16±4.67	1.38±0.55
			12th day	2.21±0.46	3.12±2.14	3.85±0.97	1.79±0.75
		Wine (mean±SD)	3rd day	2.86±0.57	2.26±0.43	2.67±0.47	2.96±0.97
			7th day	1.42±0.32	1.54±1.75	1.66±1.09	1.54±1.19
			12th day	1.20±0.30	2.07±2.08	1.51±0.74	1.40±1.45

SD: Standard deviation, PMMA: Polymethylmethacrylate

to be statistically significant, $P = 0.011$. In Group B, the lowest mean value was 1 min 30 s with 4.294; it showed not to be statistically significant. At the 7th and 12th days immersion period, the lowest mean value was showed with 30 s polishing among groups.

All pairwise multiple comparison procedures (Tukey Test) find out that polishing time is not necessary on Group B. However, it showed to be statistically significant the polishing between Group B and control group, $P < 0.001$.

Regarding the staining agent, among the groups tested, the highest ΔE values were observed in coffee. The coffee control group observed the most significant differences. The effect of different polishing time does not depend on the staining agent presented, showing statistically insignificant interaction ($P = 0.589$). There is a statistically significant interaction between acrylic resin and staining agents ($P = 0.040$). Concerning Group B, the highest ΔE value was showed with control group coffee with a mean of 9.330.

Discussion

Provisional restorations play an essential role in restoring interim esthetics appearance throughout service.[20] This study revealed that the color change of provisional prosthodontic materials was influenced by staining agents and polishing. The color perception by visual assessment is a subjective and physiologic process. The use of a standardized instrument would potentially eliminate such errors. A spectrophotometer is a reliable tool for such measurements.[18] This study used a Vita Easyshade spectrophotometer Advance 4.0.

Color stability is a significant criterion in the selection of a particular provisional material. Clinically perceptible color changes are expected after accelerated aging.[20] In this study, both materials change their original color after being immersed in different staining agents. Mean color differences ΔE values of acrylic and bis-acryl resin materials were above the clinical acceptability threshold $2 < \Delta E < 3.5$.

The provisional restorative material more susceptible to clinically unacceptable color change after immersion in a staining solution in our study was bis-acryl resin. These results agreed with Soares *et al.*[21] but differ with a study made by Macedo *et al.*,[22] where they concluded that bis-acryl resin presented lower chromatic alterations above acrylic resin.

Bis-acryl resins, as indicated by the manufacturer, do not need polishing, but the surface roughness may be a factor that affects their color stability.[23] In this study, we find that determining a polishing time is not necessary on bis-acryl, but polishing it showed to be statistically significant among experimental and control groups. The findings showed that the goat hairbrush with diamond paste and pumice powder[13] was the most effective polishing system for both bis-acryl and acrylic resins.[11,12]

Macedo *et al.*[22] concluded that the size of the particles employed in the polished specimens did not influence the optical behavior of the evaluated resin. On this study was used 2–4 micron extra fine grain diamond polishing paste.

After a literature revision about different polishing techniques, authors differ in time and velocity factors.[9,11-13,17] In our study, the polishing time related to color stability on acrylic and bis-acryl resin was 30 s at 8000 rpm with the goat hairbrush and diamond paste Excel after accelerating aging.

After immersion, the coffee solution resulted in unacceptable discoloration for all the materials.[24] In this study, the chromogenic drink that produces the greatest color change on both materials was coffee. These days, coffee drinking is an important part of daily life.[25] For this reason, patients should be advised of the propensity of such materials to stain by coffee.[26]

Conclusions

Within the limitations of this study, we concluded the following:

- Thirty seconds polishing showed the lowest values color change with goat hairbrush and diamond paste Excel in both PMMA and bis-acryl resin after the 12th day.
- Mean color differences ΔE values of PMMA and bis-acryl resin materials on the 3rd, 7th, and 12th days were above the clinical acceptability threshold $\Delta E > 3.3$.
- The provisional restorative material that presented greater color stability was acrylic resin.
- The staining agent that produced the most significant color change according to the exposure time was coffee.

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