EVALUATION OF COLOR CHANGE IN ACRYLIC AND BISACRYLIC RESIN RESINS IN DIFFERENT SOLUTIONS

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ABSTRACT

**Aim:** This work aimed to evaluate the color stability of an acrylic resin chemically activated (ARCA) using different handling techniques, and a bisacrylic resin when exposed to different pigmentation solutions.

**Material and Methods:** Silicon matrixes were confectioned (10x10x3mm) to be used as specimens. The groups were designed as follows: Group Pot, Group Brush, Group Manufacturer and Group Bisacrylic (n=18). Each group was exposed to three different pigmentation solutions: distilled water, coke and chlorhexidine digluconate 0.12%. Three readings were performed for each specimen using a spectrophotometer, and the evaluations were carried out in three different time. After the color reading, three averages and the standard deviation of variation were performed after 24 hours (T1), 7 days (T2) and 14 days (T3). Data were submitted to the ANOVA and 2 criteria and Tukey (P<0.05) in the statistical software SSPS 18 for Macintosh (SPSS Inc., Chicago, USA).

**Results:** When compared the solutions in each group of material, there was no statistically significant difference, except for T3, where the group Dencor Brush and Bisacrylic demonstrated higher color variation in all the solutions, even in the control group, and the values in Chlorhexidine higher than the other, showing greater instability after 14 days.

**Conclusions:** With the results, bisacrylic resin used as provisory prosthesis material presents greater color instability than the ARCA, when submitted to different solutions. Bisacrylic resin and Dencor Brush present significantly visible color changes in chlorhexidine solution after 14 days. All the materials in coke solution present homogeneity in the color change after 7 days exposition to the solution, with no visible color change.

**KEYWORDS:** acrylic resin, bisacrylic resin, color, provisory restoration

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INTRODUCTION

Restorations with provisory crowns are important elements on clinical attention, used during the interval between the tooth preparation and the installation of definitive restoration. They have several functions, among them the aesthetic, devolve the masticatory function, help to
determinate the therapeutic efficiency of
treatment plan, thermal protection and
avoid dental tissue exposition to the
severe conditions found in the mouth.

Traditionally, acrylic resins
chemically activated has been used as
chosen provisory material. They are
divided into two main groups: PMMA
(polyethylmethacrylic) and PEMA
(polyethylmethacrylic). Nowadays,
bisacrylic composites became the most
common choice, and many problems
associated to the traditional acrylic resins
were eliminated with these materials,
which are easy to use, flexible during the
insertion and removal, radiopaque and
they have color stability.

Material selection, as well as the
confection technique must to respect the
patient clinical needs and the limitations
of the operator. To choose the material, a
series of requirement must be respected,
which include strength, rigidity,
reparation capacity, exothermal reaction,
contraction in the polymerization,
marginal integrity and color stability.

Despite the subjectivity on the
aesthetical factor, color is even more a
necessary attribute to restorations,
provisory or definitive ones, and the color
stability is an additional issue to be
faced. In order to minimize the visual
subjectivity of the color,
spectrophotometers were developed and
commercialized for clinical dentistry
usage. They eliminates subjective
interpretations in the visual inspection,
as well as they present advantages, like
repeatability, sensitivity and objectivity,
despite some limitations.

The device makes the color
evaluation and expresses in color
coordinates \((L^*a^*b^*)\), using the system
CIELAB, widely used in researches with
optical properties. This system consists
in parameters in which \(L^*\) refers to the
luminosity coordinate; values \(a^*\) and \(b^*\)
are the coordinates regarding to the
colon in the axis red-green and yellow-
blue, respectively.

As we know that acrylic resin
exposed to different pigmentation
solutions influence the color stability,
and the market brands have different
quality, the study aimed to evaluate the
color stability of PMMA acrylic resin
using different handling techniques, and
the bisacrylic composite when exposed to
different solutions.

**MATERIAL AND METHODS**

To obtain specimens, confecting
a matrix in addition silicone
(HydroXtreme, Vigodent/Coltene SA)
was necessary. To confect the matrixes, a
wax model was used, in rectangle shape
with 20mm length, 10mm width and
3mm thickness. Then, the model in wax
was involved in addition silicone to form
a mold (matrix) to be used in specimens'
confection. Posteriorly, each specimen
was divided into two, in equal size, using
a double faced diamond disk
\((10\times10\times3\text{mm})\).

The specimens were
confectioned using an Acrylic Resin
Chemically Activated (ARCA) (Dencor -
Artigos Odontológicos Clássico Ltda, São
Paulo - SP) and a bisacrylic resin
(Protemp™ 4 3M ESPE).

The specimens referent to the
ARCA were confectioned according to 3
resin handling techniques, forming the 3
groups to be evaluated. A fourth group
was formed by bisacrylic resin handling:
GROUP POT – self polymerization under
pressure in silicone matrix; GROUP
BRUSH – self polymerization using the
brush technique; Group MANUFACTURER – self
polymerization using the dappen mixture in pot
technique; Group BISACRYLIC – self
polymerization using the self-mixture
system.

For each group, 18 specimens
were confectioned, 72 in total.

In the group I, acrylic resin
was appropriately mixed according to the
manufacturer indications (proportion
equivalent to the volume 3:1 indicated by
the manufacturer). The polymer was
weigh with a precision scale to use 1.50g
of powder mixed to 0.70 ml monomer,
measured through a pipette. Inside a
dappen pot, firstly, the liquid was poured,
followed by the powder. Then they were
softly mixed during 5 seconds. After
appropriately handled, the resin was
inserted in the matrix. It was positioned
against a plaster platform and stabilized
with elastic (Figure 1). The set matrix +
plaster platform was taken to the
polymerizer under pressure \(3 \times 10^5 \text{N/m}^2\)
during 15 minutes.

In the Group II, the monomer
and the polymer were distributed in pots
type Dappen, separately. A brush used
routinely for provisory crown confection
had its extremity wet with liquid and put
in contact with powder. Then, powder
particles incorporated by the wet brush
formed a small sphere in resin mass,
which was put inside the silicone matrix
(Figure 2).
Figure 1. Insertion of matrix resin.

Figure 2. Filling the matrix with acrylic resin through the brush technique.

Specimens were maintained in small standardized plastic containers covered (Figure 3), and they were bind in the bottom plastic container with glue to ensure their constant contact with the solution they were exposed in order to keep an exposition pattern for all the groups.

Specimens were stored in distilled water during 24 hours at 37º C, simulating the first day of provisional restoration functions in the oral environment stage. Subsequent color measuring was taken after one day (T1), a week (T2) and two weeks (T3) of immersion in the solutions.

After 24 hours inside the solution and each interval of immersion, the color evaluation of specimens were performed with a spectrophotometer (Easy Shade VITA - VITA Zahnfabrik H. Rauter GmbH & Co.KG). Before each measure, solutions were removed of samples after washing with distilled water. Water excess on the surface was removed with absorbing paper. Previously the measure, the spectrophotometer was calibrated according to the manufacturing instructions, using the white calibration pattern provided. Three measures were performed in a point that corresponded to the central region of designation surface of each specimen.

Color changes were characterized by the International Commission d’Eclairage L* a* b* color space (CIE L* a* b*).

Initial and final mass are color describers. ΔL, Δa and Δb are differences of L*, a* and b* before and after immersion in each time interval.

After obtain the color variations, they were submitted to the statistical test ANOVA at 2 criteria and Tukey test. For statistical evaluation, the software SPSS 18.0 for Macintosh (SPSS Inc., Chicago, USA) was used.

RESULTS

After the color reading, the averages and the standard deviation of color variation were performed after 24 hours (T1), 7 days (T2) and 14 days (T3) and the ANOVA was carried out to evaluate whether there was differences among the groups (material and solution) after the time previously described.

In T1 there was no statistically significant difference when compared to the solutions in each group of material (Table 2).

Bisacrylic resin and Dencor Brush presented higher uniformity among the solutions. Higher values of ΔE were observed in the group Bisacrylic in Chlorhexidine solution and Coke, and low values of ΔE in the group Dencor Manufacturer immersed in Coke and water, as showed in the graph 1.

In T2 neither there was no statistical significant difference when compared the solutions in each group of material (Table 3).
Table 1. Distribution of specimens according to the variables material/technique and solutions.

<table>
<thead>
<tr>
<th></th>
<th>Dencor Pot</th>
<th>Dencor</th>
<th>Dencor Brush</th>
<th>Bisacrylic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Coke</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Chlorhexidine</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>TOTAL</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>72</td>
</tr>
</tbody>
</table>

Figure 3. Groups immersed in three different solutions.

Table 2. Analysis of Variance at two criteria comparing the solutions in each group of material in T1.

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Groups</td>
<td>120.440</td>
<td>11</td>
<td>10.049</td>
<td>0.582</td>
<td>0.837</td>
</tr>
<tr>
<td>Within Groups</td>
<td>1241.210</td>
<td>66</td>
<td>18.806</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1361.650</td>
<td>77</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graph 1. Color variation ($\Delta E$) and standard deviation of provisional restorative materials after immersion for 24h (T1).

Groups Bisacrylic, Dencor Pot and Dencor Manufacturer had higher values of $\Delta E$ in Coke solution. In the group Dencor Pot there was greater variation in Chlorhexidine solution, as showed by the graph 2.

In T3, after the analysis by the ANOVA, statistically significant difference was verified when compared to the solutions in each group of material (Table 4).

When compared the groups in isolation (variable = solution), in the groups Pot and brush, there was no statistically significant difference when compared the three solutions. In the group manufacturer, the values for coke were higher than the other two, significantly. The group Bisacrylic presented higher value for chlorhexidine, as showed in the graph 3.
Table 3. Analysis of Variance at two criteria comparing the solutions in each group of material in T2.

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Groups</td>
<td>30.652</td>
<td>11</td>
<td>2.787</td>
<td>1.178</td>
<td>0.312</td>
</tr>
<tr>
<td>Within Groups</td>
<td>141.952</td>
<td>60</td>
<td>2.366</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>172.604</td>
<td>71</td>
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</tbody>
</table>

Graph 2. Color variation ($\Delta E$) and standard deviation of provisional restorative materials after immersion for 7 days (T2).

In T3, the groups Dencor Pot and Dencor Manufacturer had a low color variation in all the solutions, a greater one for coke, mainly when compared to the other two groups. Dencor Brush and Bisacrylic demonstrated higher values of color variation in all the solutions, even in the control group, the values for Chlorhexidine higher than the other, showing higher color instability after 14 days.

Table 4. Analysis of Variance at two criteria comparing the solutions in each group of material in T3.

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Groups</td>
<td>112.921</td>
<td>11</td>
<td>10.266</td>
<td>2.348</td>
<td>0.018</td>
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<tr>
<td>Within Groups</td>
<td>262.336</td>
<td>60</td>
<td>4.372</td>
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<tr>
<td>Total</td>
<td>375.257</td>
<td>71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graph 3. Color variation ($\Delta E$) and standard deviation of provisional restorative materials after immersion for 14 days (T3).

In T3, the groups Dencor Pot and Dencor Manufacturer had a low color variation in all the solutions, a greater one for coke, mainly when compared to the other two groups. Dencor Brush and Bisacrylic demonstrated higher values of color variation in all the solutions, even in the control group, the values for Chlorhexidine higher than the other, showing higher color instability after 14 days.
In the Chlorhexidine solution, Bisacrylic resin and Dencor Brush presented higher values for ΔE than Dencor Manufacturer and Pot, statistically significant. Other statistically difference occurs between the group Bisacrylic in chlorhexidine solution compared to all the other groups of resin in water solution (Table 5).

The graphs 4, 5 and 6 show the behavior of four groups of resins along the time in each solution they were exposed. In the graph 5, chlorhexidine solution, the increase in the value of ΔE for the group Bisacrylic and Dencor Brush when immersed in solution for 14 days (T3). The graph 6, coke solution, shows homogeneity in T2 and a slight increase in values of ΔE for each groups in T3; however, also in homogeneous way.

<table>
<thead>
<tr>
<th>(I) MATERIAL</th>
<th>(J) MATERIAL</th>
<th>Mean</th>
<th>Std. Error</th>
<th>Sig</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>BISACRYLIC</td>
<td>CHLORHEXIDINE</td>
<td>4.32000*</td>
<td>1.20724</td>
<td>0.031</td>
<td>0.2153 - 8.4247</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>WATER</td>
<td>4.24500*</td>
<td>1.20724</td>
<td>0.037</td>
<td>0.1403 - 8.3497</td>
</tr>
<tr>
<td>POT</td>
<td>WATER</td>
<td>3.64500*</td>
<td>1.20724</td>
<td>0.004</td>
<td>1.2302 - 6.0598</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>CHLORHEXIDINE</td>
<td>2.76167*</td>
<td>1.20724</td>
<td>0.025</td>
<td>0.3458 - 5.1795</td>
</tr>
<tr>
<td>BRUSH</td>
<td>COKE</td>
<td>4.09667*</td>
<td>1.20724</td>
<td>0.001</td>
<td>1.6818 - 6.5115</td>
</tr>
<tr>
<td>POT</td>
<td>CHLORHEXIDINE</td>
<td>2.94667*</td>
<td>1.20724</td>
<td>0.018</td>
<td>0.3318 - 3.5615</td>
</tr>
<tr>
<td>MANUFACTURER</td>
<td>COKE</td>
<td>2.42667*</td>
<td>1.20724</td>
<td>0.049</td>
<td>0.0118 - 4.8415</td>
</tr>
<tr>
<td>POT</td>
<td>CHLORHEXIDINE</td>
<td>3.06000*</td>
<td>1.20724</td>
<td>0.014</td>
<td>0.6452 - 5.4748</td>
</tr>
<tr>
<td>POT</td>
<td>WATER</td>
<td>2.98500*</td>
<td>1.20724</td>
<td>0.016</td>
<td>0.5702 - 5.399</td>
</tr>
<tr>
<td>POT</td>
<td>CHLORHEXIDINE</td>
<td>2.83667*</td>
<td>1.20724</td>
<td>0.016</td>
<td>0.5702 - 5.3998</td>
</tr>
</tbody>
</table>

Table 5. Tukey test evaluating the difference among the solutions in each group of material.
DISCUSSION

The results found in this study demonstrated that bisacrylic resin presented great color variation in all the solutions it was exposed, as well as in the course of time, demonstrating color instability. This found was consistent to the study by Borchers et al., justifying the result the fact that bisacrylic resins have a high diffusion coefficient are more polar, then they can absorb water and other polar liquids in higher velocity when compared to the PMMA resins. This high diffusion coefficient can be justified by the great amount of bisphenol glycidyl methacrylate.

Burns et al. report that the bisacrylic composites have a more heterogeneous composition, an organic matrix that include a disperse particles system. Its color variation has been attributed to the matrix oxidation of polymer or oxidation of double links that do not react. Superiority of PMMA regarding to the color change can be attributed to a distribution of methyl polymethacrylate particles sizes, of monomers polarity, to the instability of pigments and the efficiency of initiating system of provisory resins.

The results obtained after 7 days (T2) immersion in different solutions show there is equality of color variation in all the resins, regardless the solutions used. The result is probably due to the instability of polymerization of acrylic and bisacrylic resins, because the residual monomer release is already stabilized, and the reactions of polymerization are not occurring any more. Lopez et al. reports there is an stability of polymerization after the early 7 days evaluation, from time, the water sorption by the acrylic resin decreases considerably. Residual monomer is
gradually released by the material until its stability of polymerization, causing porosity that allows liquid, coloring and fluids infiltration, present in the mouth, generating color changes in the material caused by infiltration

The coke was the solution that demonstrated higher homogeneity in the results, even when compared to the groups immersed in water. This result was also observed by Pereira et al., when the resins maintained a homogeneous pattern of color change along the time when exposed to the coke solution; this variation is considered non-visible to the human eye.

The groups Bisacrylic and Dencor Brush, in 14 days (T3), when in chlorhexidine solution, showed high valued for $\Delta E$ consistent to the color changes visible to the human eye. This result points to the need to evaluate material choose, to be used in provisory prosthetic restorations when there is indication of chlorhexidine digluconate 0.12% for more than 7 days. The literature shows that several patients make a mouthful with chlorhexidine for more than a week are pre and post-operative cases, in acute necrotizing ulcerative gingivitis (ANUG) and as supporting in periodontal treatment. They also use continuous chlorhexidine when the mechanical removal of biofilm is impossible, as in situations of physical and motor deficiencies or hospital internment

$\Delta E$ value represents the color change that an observer can report for materials after treatment, or between periods of time, than $\Delta E$ is more significant than $L^*$, $a^*$ and $b^*$ individually. Several studies report different threshold values of color difference above those the color change is noticeable to the human eye.

Bayindir et al.¹⁴ and Hazleton et al.¹⁵ used the value of $\Delta E = 3.7$ or superior to it as color change noticeable and clinically acceptable. In the early 24 hours (T1) immersion in solution, the groups Bisacrylic (water, chlorhexidine and coke) and Dencor Pot (water) showed there is noticeable color variation. In 7 days (T2) any group showed visible change. In 14 days (T3), only the Bisacrylic and Dencor Brush in chlorhexidine solution had noticeable color change.

**CONCLUSIONS**

There were difference in $\Delta E$ in 7 to 14 days; however, non-statistically significant among the materials and solutions evaluated.

Bisacrylic resin and Dencor brush presented significant visible color change in chlorhexidine solution after a period of 14 days. The importance of the color change in this solution was above the level clinically acceptable.

Bisacrylic resin used as provisory prosthetic material present lower color stability than ARCA when submitted to different solutions.

All the materials in coke solution presented homogeneity in color change from 7 days exposition to the solution, without visible color change.

**REFERENCES**
