



# 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<sup>1</sup>. 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.

Tradicionalmente, acrylic resins chemically activated has been used as chosen provisory material. They are divided into two main groups: PMMA (polymethylmethacrylic) 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<sup>2</sup>.

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<sup>3</sup>. In order to minimize the visual subjectivity of the color, spectrophotometers were developed and commercialized for clinical dentistry usage<sup>4</sup>. They eliminates subjective interpretations in the visual inspection,

as well as they present advantages, like repeatability, sensitivity and objectivity, despite some limitations<sup>5</sup>.

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<sup>6</sup>.

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 7 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 face diamond disk (10x10x3mm).

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.

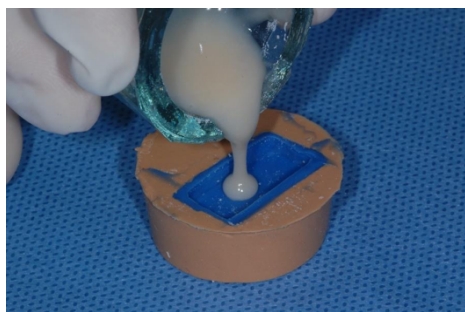


Figure 2. Filling the matrix with acrylic resin through the brush technique.



In the group o III, obtainment of specimens occurred with saturation of the set liquid (monomer) + powder (polymer) inside a Dappen pot with immediate filling the matrix, inserting the resin still in sand stage. A glass plate was positioned on the matrix until the end of polymerization.

In the Group IV, the resin was inserted inside the matrix using a dispenser and mixing points supplied by the manufacturer.

Further the variable material/ technique, we use 3 solutions for specimens' immersion in order to observe the stability of color behavior after determined evaluation time.

Three coloring solutions were used in this study: distilled water as control group, coke and chlorhexidine gluconate 0.12% (PerioGard, Colgate).

The four groups of specimens were exposed to the coloring solutions, each group total was 18 unities, divided equally among the different solutions (Table 1).

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 37° C, simulating the first day of provisory 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.

To minimize the influence of external light through the edge of specimens, as well as to hold the sample during the color measuring, a silicone matrix was used. This matrix was confectioned from a specimen that was involved by condensing silicone. An opening was made, with diameter similar to the spectrophotometer point in the superior part of the matrix with localization correspondent to the central

region of the specimen. Three measures were performed on the 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 descriptors.  $\Delta L$ ,  $\Delta a$  and  $\Delta b$  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  $\Delta E$  were observed in the group Bisacrylic in Chlorhexidine solution and Coke, and low values of  $\Delta E$  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.

|                      | Dencor Pot | Dencor<br>Manufacturer | Dencor Brush | Bisacrylic | Total |
|----------------------|------------|------------------------|--------------|------------|-------|
| <b>Water</b>         | 6          | 6                      | 6            | 6          | 24    |
| <b>Coke</b>          | 6          | 6                      | 6            | 6          | 24    |
| <b>Chlorhexidine</b> | 6          | 6                      | 6            | 6          | 24    |
| <b>TOTAL</b>         | 18         | 18                     | 18           | 18         | 72    |

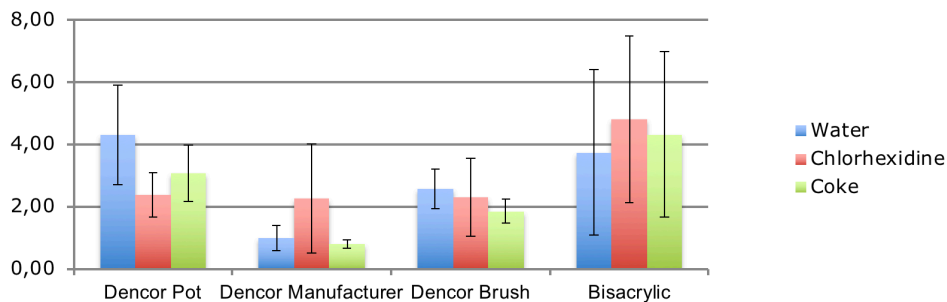
Figure 3. Groups immersed in three different solutions.



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

|                      | Sum of Squares | df | Mean Square | F     | Sig   |
|----------------------|----------------|----|-------------|-------|-------|
| <b>Among Groups</b>  | 120.440        | 11 | 10.049      | 0.582 | 0.837 |
| <b>Within Groups</b> | 1241.210       | 66 | 18,806      |       |       |
| <b>Total</b>         | 1361.650       | 77 |             |       |       |

Graph 1. Color variation ( $\Delta E$ ) and standard deviation of provisory 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.

|                      | Sum of Squares | df | Mean Square | F     | Sig   |
|----------------------|----------------|----|-------------|-------|-------|
| <b>Among Groups</b>  | 30.652         | 11 | 2.787       | 1.178 | 0.322 |
| <b>Within Groups</b> | 141.952        | 60 | 2.366       |       |       |
| <b>Total</b>         | 172.604        | 71 |             |       |       |

Graph 2. Color variation (ΔE) and standard deviation of provisory restorative materials after immersion for 7 days (T2).

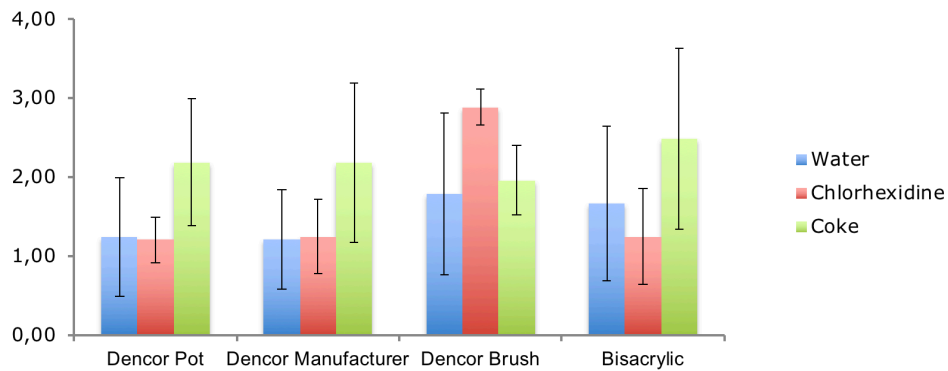
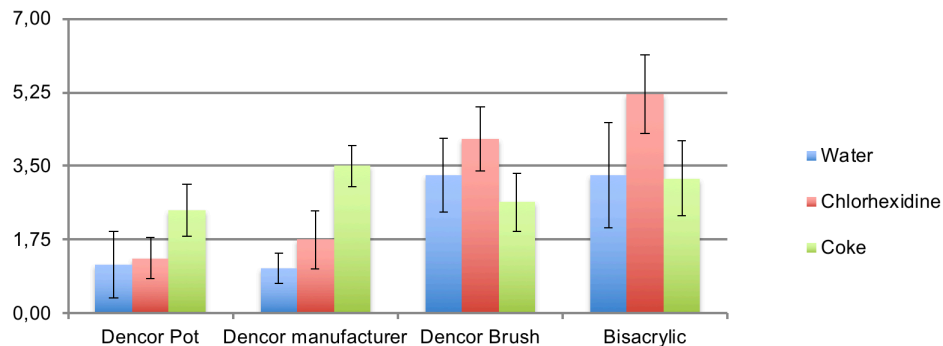


Table 4. Analysis of Variance at two criteria comparing the solutions in each group of material in T3.

|                      | Sum of Squares | df | Mean Square | F     | Sig   |
|----------------------|----------------|----|-------------|-------|-------|
| <b>Among Groups</b>  | 112.921        | 11 | 10.266      | 2.348 | 0.018 |
| <b>Within Groups</b> | 262.336        | 60 | 4.372       |       |       |
| <b>Total</b>         | 375.257        | 71 |             |       |       |

Graph 3. Color variation (ΔE) and standard deviation of provisory 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).

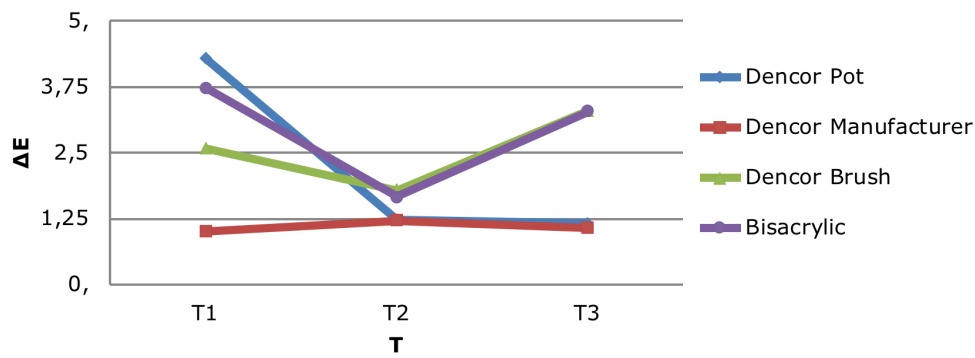
The graphs 4, 5 and 6 show the behavior of four groups of resins along the time in each solution they were exposed. In the graph 5, chlorhexidine solution, the increase in the value of ΔE

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.

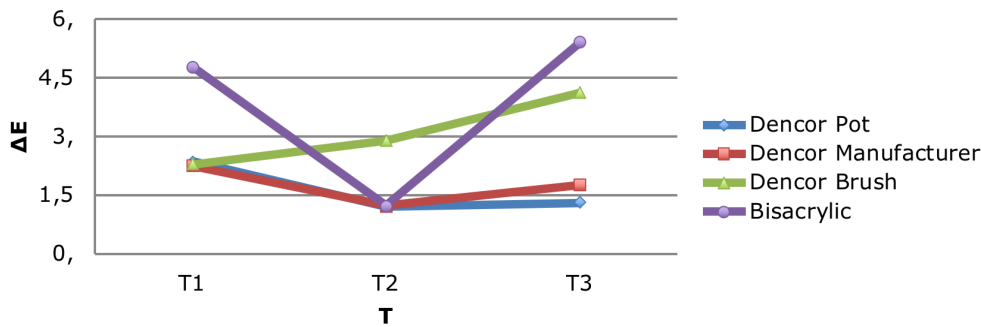
Table 5. Tukey test evaluating the difference among the solutions in each group of material.

|              | (I) MATERIAL  | (J) MATERIAL  | Mean     |            | Sig   | 95% Confidence Interval |             |
|--------------|---------------|---------------|----------|------------|-------|-------------------------|-------------|
|              |               |               | (I-J)    | Std. Error |       | Lower Bound             | Upper Bound |
| <b>Tukey</b> | BISACRYLIC    | MANUFACTURER  | 4.32000* | 1.20724    | 0.031 | 0.2153                  | 8.4247      |
| <b>HSD</b>   | CHLORHEXIDINE | WATER         |          |            |       |                         |             |
|              |               | POT           | 4.24500* | 1.20724    | 0.037 | 0.1403                  | 8.3497      |
|              |               | WATER         |          |            |       |                         |             |
|              |               | MANUFACTURER  | 3.64500* | 1.20724    | 0.004 | 1.2302                  | 6.0598      |
|              |               | CHLORHEXIDINE |          |            |       |                         |             |
|              |               | BRUSH         | 2.76167* | 1.20724    | 0.025 | 0.3458                  | 5.1765      |
|              |               | COKE          |          |            |       |                         |             |
|              |               | POT           | 4.09667* | 1.20724    | 0.001 | 1.6818                  | 6.5115      |
|              |               | CHLORHEXIDINE |          |            |       |                         |             |
|              |               | POT           | 2.94667* | 1.20724    | 0.018 | 0.5318                  | 3.3615      |
|              |               | COKE          |          |            |       |                         |             |
|              | MANUFACTURER  | MANUFACTURER  | 2.42667* | 1.20724    | 0.049 | 0.0118                  | 4.8415      |
|              | COKE          | WATER         |          |            |       |                         |             |
|              | POT           | MANUFACTURER  | 3.06000* | 1.20724    | 0.014 | 0.6452                  | 5.4748      |
|              | CHLORHEXIDINE | WATER         |          |            |       |                         |             |
|              |               | POT           | 2.98500* | 1.20724    | 0.016 | 0.5702                  | 5.399       |
|              |               | WATER         |          |            |       |                         |             |
|              |               | POT           | 2.83667* | 1.20724    | 0.016 | 0.5702                  | 5.3998      |
|              |               | CHLORHEXIDINE |          |            |       |                         |             |

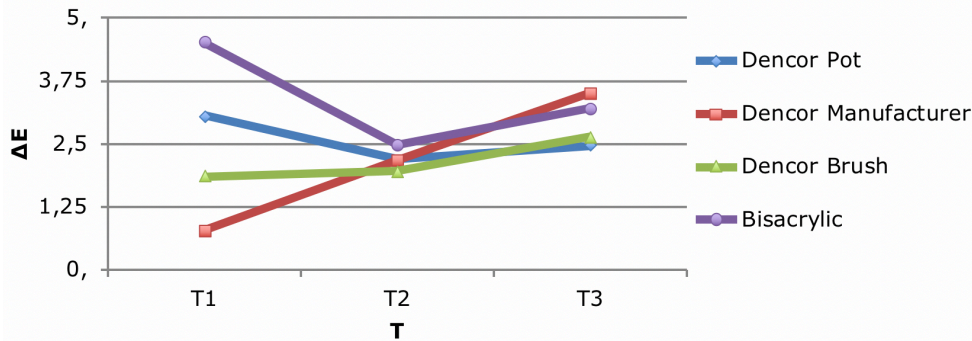
Graph 4. Water solution.



Graph 5. Chlorhexidine solution.



Graph 6. Coke solution.



## 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.<sup>7</sup>, 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<sup>5</sup>.

Burns et al.<sup>8</sup> 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<sup>9</sup>. 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.<sup>10</sup> 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<sup>11</sup>.

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.<sup>12</sup>, 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<sup>13</sup>.

$\Delta E$  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.<sup>14</sup> and Hazelton et al.<sup>15</sup> 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 resin 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.

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