

# Effect of Calcium Hydroxide and Antioxidant Agents Filling the Pulp Chamber after Internal Bleaching

## Keywords

Calcium Hydroxide Spectrophotometer Non-Vital Bleaching Antioxidants Agents

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## ABSTRACT

To evaluate the effect of calcium hydroxide (CH), sodium ascorbate (SA) and sodium thio-sulfate (ST) filling the pulp chamber on color stability and longevity of teeth after internal bleaching. Crowns of bovine incisors were submitted to internal bleaching and divided into groups according the material used in the pulp chamber: Control, CH, SA, ST. Each group was divided into two subgroups according to the time to perform restorative procedures (7 or 15 days). Color measurement was performed with a spectrophotometer at nine periods. The darkening ( $\Delta E$ ) values were calculated. The Mann-Whitney test was used to statistically analyze the data ( $p < 0.05$ ). After bleaching,  $\Delta E$  values were higher than 3.5, showing that the procedure was effective. After 24 hours, no difference was observed between groups. After 7 days, SA showed higher  $\Delta E$  than the control group ( $p < 0.05$ ). CH and TS did not differ from the control group. In restorations performed after 7/15 days, SA group showed higher values of darkening after 1 and 4 months than the control group ( $p < 0.05$ ). SA induced perceptible darkening after bleaching and should not be used to fill the pulp chamber. ST and CH show color stability and longevity after 12 months.

## INTRODUCTION

Endodontically treated teeth can show discoloration due to pulpal hemorrhage, dental trauma, presence of pulp tissue remains, and filling material in the pulp chamber due to inadequate access or cleaning of the cavity,<sup>1,2</sup> and for some materials used during endodontic treatment<sup>3,4</sup> promoting aesthetic damage. Thus, internal tooth bleaching is widely used, as it represents a conservative, effective, and low-cost method when compared to veneers or crowns.<sup>5</sup>

The most described bleaching agents were hydrogen peroxide, carbamide peroxide, and sodium perborate,<sup>5-7</sup> that act by an oxy-redox reaction, where the peroxide diffuses through the dental structure promoting the breaking of macromolecules into small ones, reducing the discoloration of pigment and released oxygen (free radical) on the enamel surface.<sup>6,8,9</sup>

The reactive oxygen released could promote undesirable side effects in the structure of the tooth as bond strength reduction of composite resin to dentine.<sup>10-12</sup> Therefore, it is recommended that the final restoration should be performed between 7 and 14 days after bleaching procedures.<sup>13</sup> To prevent delayed restoration after bleaching, the use of antioxidant agents, like sodium ascorbate<sup>14-18</sup> and sodium thiosulfate<sup>19,20</sup> have been proposed immediately after the bleaching to eliminate the residual oxygen and have

Received: 13.09.2023

Accepted: 18.12.2023

doi: 10.1922/EJPRD\_2628Prado09

demonstrated improvement of bond strength between restorative materials and dentine, allowing the final restoration to be performed immediately after bleaching.<sup>19-21</sup> In addition, according to Feiz *et al.*<sup>21</sup> the use of 10% sodium ascorbate gel for 40 hours in the pulp chamber increased the bond strength of composite resin to bleached dentin, showing results like non-bleached teeth, and teeth restored after one week of bleaching. Also, the use of sodium ascorbate 10% inside the pulp chamber for 24 hours can reverse the decreased fracture resistance of endodontically-treated teeth after bleaching.<sup>11</sup>

Furthermore, the reactive oxygen could also cause cervical root resorption, probably due to the passage of bleaching materials to periodontal tissue through the dentinal tubules.<sup>6,22</sup> To avoid this resorption, the use of calcium hydroxide paste in the pulp chamber is indicated, to promote an alkalization of the pH, reducing clastic activity.<sup>23</sup> A previous study demonstrated that calcium hydroxide does not interfere in the adhesion of the composite resin to bleached dentin.<sup>21</sup> Also, the use of calcium hydroxide did not increase the microleakage of bleached teeth.<sup>24,25</sup>

Although adhesion is an important factor to be considered, another aspect that must be evaluated, especially in vestibular face of anterior teeth associated with restorations, is color stability, which is achieved after 7 to 14 days after bleaching.<sup>26,27</sup> Studies were concerned evaluating the effect of the antioxidant agent on adhesion, but esthetic issues are as important as adhesive ones. Thus, it is important to analyze the effect of these agents in the time required to find the color stability and longevity.

Since the literature shows that it is important to wait 7 to 14 days after bleaching not only because of adhesion,<sup>13</sup> but also for color stability,<sup>26,27</sup> and that the use of reducing agents remove residual oxygen and that it is not known whether this removal would have any relationship with color stability and in our research, no studies have evaluated the behavior of the antioxidant agents and calcium hydroxide on color stability and longevity of teeth after bleaching. Thus, this study aimed to evaluate the effect of calcium hydroxide and oxidizing agents (sodium ascorbate and sodium thiosulfate) used to fill the pulp chamber in relation to color stability and longevity of teeth after internal bleaching. The research hypothesis is that the color stability after bleaching procedures depends on the agent used as filling agent on pulp chamber.

## METHODS

This study was approved by the Ethics Committee for Test Animals (n. 114/17). Eighty freshly extracted bovine incisors (Abatedouro Vangelio Mandelli, Bauru, SP, Brazil) were used.

### SAMPLE SIZE CALCULATION

The effect size for this study (4.24) was based on a previous study.<sup>28</sup> The analysis was performed by the software G \* Power 3.1 (Henrick Heine-Universität) with  $\alpha = 0.05$  and a power of 0.95. 6 per group was considered the ideal sample size to observe a significant difference between groups. In addition, 4 samples were added to each experimental group, totaling 10 samples per group (n = 10) to compensate possible sample loss (Figure 1).

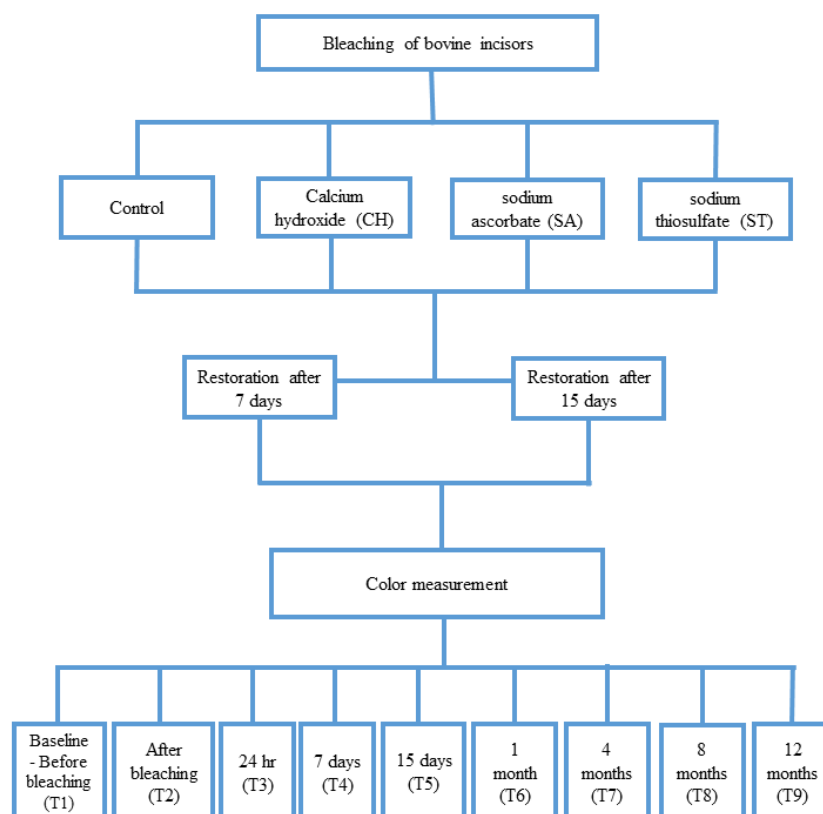


Figure 1: Flowchart of study.

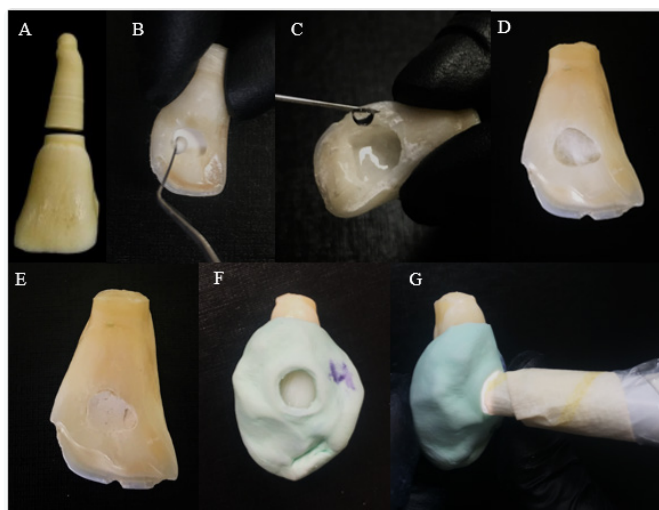
## SAMPLE PREPARATION

Teeth with similar sizes, absence of stains, cracks and fractures were divided into different groups. The teeth underwent prophylaxis for coronal polishing. The roots were cleaved 1.5 mm below the cemento-enamel junction, with a double-sided diamond disc (KG Sorensen, Barueri, SP, Brazil), coupled to a benchtop micromotor (Beltec, Araraquara, SP, Brazil) (Figure 2). Then, the root surfaces of the samples, referring to the root canal, were restored with composite resin (Opallis A2, FGM, Joinville, SC, Brazil), by the total acid etching technique, simulating the cervical plug. Then, the coronal access was performed with a diamond bur (1016, KG Sorensen, Barueri, SP, Brazil), in high rotation and the teeth remained at 37°C, with 100% relative humidity throughout the experiment.

## BLEACHING PROCEDURE

After access, the teeth were submitted to internal bleaching using sodium perborate associated with 20% hydrogen peroxide (Whiteness perborate, FGM, Joinville, SC, Brazil), which was manipulated in a proportion of 2:1 (power/liquid) and inserted into the cavity along the entire length of the buccal wall of the pulp chamber and then, a cotton pellet was placed over the cavity. After insertion of the bleaching agent, the access cavity was sealed with cotton and temporary restorative material (Villevie, Joinville, SC, Brazil) as the manufacturer's recommendations. The bleaching agent was changed every seven days for a period of three weeks.

After this period, the eighty teeth were randomly divided into 8 groups (n=10) according to the material used in the pulp chamber and the time elapsed to perform the restorative procedures, as described in Table 1.



**Figure 2:** Experimental steps: (A) Roots cleaved 1.5 mm below the cemento-enamel junction (B and C) application of agents in the pulp chamber (D and E) cavity sealing with cotton pellets and non-eugenol temporary restorative material apparatus and (F and G) apparatus and color measurement with Easy Shade spectrophotometer.

**Table 1.** Groups evaluated.

Groups	Treatment	Restorative procedures
C7	Control	After 7 days
C15	Control	After 15 days
CH7	Pulp chamber filled with calcium hydroxide paste for 7 days	After 7 days
CH15	Pulp chamber filled with calcium hydroxide paste for 15 days	After 15 days
SA7	Pulp chamber filled with 10% sodium ascorbate for 7 days	After 7 days
SA15	Pulp chamber filled with 10% sodium ascorbate for 15 days	After 15 days
ST7	Pulp chamber filled with 5% sodium thiosulfate for 7 days	After 7 days
ST15	Pulp chamber filled with 5% sodium thiosulfate for 15 days	After 15 days

## APPLICATION OF ANTIOXIDANTS AND CALCIUM HYDROXIDE

After removing the bleaching agent from the dentin, the pulp chamber was washed with 10 mL of distilled water, dried, and filled with 10% sodium ascorbate (Fórmula e Ação, São Paulo, SP, Brazil) or 5% sodium thiosulfate (Formúla e Ação, São Paulo, SP, Brazil) or calcium hydroxide paste, according to the groups described above. Calcium hydroxide paste was produced with calcium hydroxide powder associated with distilled water. Sodium ascorbate and sodium thiosulfate applications were performed with a 5 mL syringe and disposable needle. For calcium hydroxide a spatula number 1 (SSWhite Produtos Odontológicos, Rio de Janeiro, RJ, Brazil) was used. In the control group, no material was applied after bleaching procedures (Figure 2).

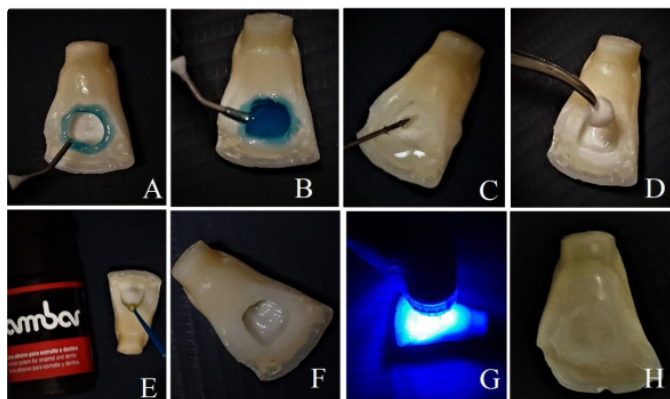
Then, the cavities were sealed with dry cotton pellets and non-eugenol temporary restorative material (Villevie, Joinville, SC, Brazil) until the restorative procedures (7 or 15 days).

## RESTORATIVE PROCEDURES

Restorative procedures were performed 7 (C7, SA7, ST7 groups) or 15 (C15, SA15, ST15 groups) days after the bleaching procedures.

The dentin surface was etched with 37% phosphoric acid (Condac 37%, FGM, Joinville, SC, Brazil) for 15 seconds and enamel for 30 seconds, rinsed with 10 mL of distilled water, and dried with absorbent paper. Two layers of adhesive were applied with a microbrush for 20 seconds and the photoactivation was performed for 20 seconds (Radii-cal, SDI, São

Paulo, SP, Brazil). The restoration was performed by the incremental technique, with increments of up to 2 mm of composite resin, with each increment being light cured for 20 seconds (Figure 3).



**Figure 3:** Restorative procedure steps: (A) acid etching on enamel, (B) etching on dentin, (C) washing, (D) drying, (E) adhesive application, (F) tooth after adhesive application, (G) adhesive photoactivation, (H) restored tooth.

## COLOR MEASUREMENT

The Easy Shade spectrophotometer device (EasyShade Advance, Vita Zahnfabrik, Bad Säckingen, Germany) was used in “single tooth” mode for all color coordinate evaluations ( $L^* a^* b^*$ ), where  $L^*$  indicates lightness and varies between 0 for black and 100 for white,  $a^*$  indicates the red (positive values) or green (negative values) color components, and  $b^*$  indicates the color components yellow (positive values) or blue (negative values). The active tip of the spectrophotometer was positioned on the middle third of the buccal surface of each tooth, with a silicone guide.

The CIE Lab color coordinates ( $L^* a^* b^*$ ) were used to calculate the color changes ( $\Delta E$ ), as follows:  $\Delta E_{ab} = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{0.5}$ . The values of  $\Delta E_{ab}$  greater than 3.5 indicates that the alterations were visible to human eyes and positive values of  $\Delta L$  indicate whitening, while negative values indicate darkening.<sup>29-33</sup>

The color difference ( $\Delta E_{00}$ ) between measurements was also estimated using the CIEDE2000 formula:

$$\Delta E_{00} = [(\Delta L'/K_L S_L)^2 + (\Delta C'/K_C S_C)^2 + (\Delta H'/K_H S_H)^2 + R_T (\Delta C'/K_C S_C) (\Delta H'/K_H S_H)^2]^{1/2}$$

in which  $\Delta L'$ ,  $\Delta C'$ , and  $\Delta H'$  are the differences in lightness, chroma, and hue for two readings.  $R_T$  is the rotation function that accounts for the interaction between chroma and hue differences in the blue region.  $S_L$ ,  $S_C$ , and  $S_H$  are weighting functions used to adjust the  $\Delta E_{00}$  for variation in perceived magnitude, with variation in the location of the color coordinate and differences between the two-color readings; and  $k_L$ ,  $k_C$ , and  $k_H$  are the correction terms for the experimental conditions.  $\Delta E_{00} \geq 1.8$  is the acceptable color difference threshold for the CIEDE2000 method.<sup>34</sup>

The shade was measured by the same calibrated operator, at nine time periods: baseline (T1), immediately after bleaching (T2), 24 hours, 7 and 15 days after bleaching (T3, T4, and T5, respectively), and 1 month (T6), 4 months (T7), 8 months (T8) and 12 months (T9) after restorative procedures.

## STATISTICAL ANALYSIS

The values were tabulated in Excel and the values of  $\Delta E_{ab}$ ,  $\Delta L$  and  $\Delta E_{00}$  were calculated. The Kolmogorov-Smirnov test was used to analyze the normality of the data, where a non-normal distribution was found. Thus, the non-parametric Mann-Whitney test was used to compare the experimental with the control group in all analysis. The significance level was 5%.

## RESULTS

The  $\Delta E_{ab}$  values of the tooth immediately after bleaching (T2), 24 hours, 7, and 15 days after bleaching (T3, T4, and T5, respectively) were described in Table 2. In all groups, immediately after bleaching,  $\Delta E_{ab}$  values were higher than 3.5, showing that the bleaching was effective, with noticeable changes to the human eye. After 24 hours, no significant difference was observed between the groups regardless of the time to perform the restoration ( $p > 0.05$ ), however, after 7 days (T4) of bleaching, the sodium ascorbate (SA) group showed higher  $\Delta E_{ab}$  than the control group ( $p < 0.05$ ) only on teeth restored after 7 days. After 15 days (T5) of bleaching, the SA group showed higher  $\Delta E_{ab}$  than the control group ( $p < 0.05$ ) on teeth restored after 7 and 15 days. There was no difference between the calcium hydroxide and thiosulfate groups with the control group for any of the evaluated periods of bleaching and restoration ( $p > 0.05$ ).

Regarding  $\Delta L$ , it was observed that bleaching was effective, with positive values, in all groups. In the first 24 hours, although a certain darkening was observed ( $\Delta L$  negative), there was no difference between the groups ( $p > 0.05$ ) regardless of the time to perform the restoration. After 7 and 15 days of bleaching, the ascorbate group showed a significantly higher darkening when compared to the control group ( $p < 0.05$ ). (Table 2).

Table 3 shows the color longevity after 1, 4, 8, and 12 months after restoration. The ascorbate group showed significantly higher values of darkening, in the periods of 1 and 4 months, for both restoration after 7 and 15 days, and after 8 months of bleaching, for restoration after 7 days when compared to the control group ( $p < 0.05$ ). Moreover, in the ascorbate group, the  $\Delta E_{ab}$  values were greater than 3.5, showing changes in darkening perceptible to the human eye, demonstrated by the negative values of  $\Delta L$ . This darkening is characterized by yellow pigmentation, which can be clearly observed in graphs of  $b$  values, where the sodium ascorbate group showed a greater increase when compared to the other groups ( $p > 0.05$ ), regardless of the restoration time, as shown in Figure 4.

**Table 2. Tooth ΔE and ΔL values immediately after bleaching and 24 hours, 7, and 15 days after bleaching.**

	Restoration after 7 days				Restoration after 15 days			
	Control	HC	SA	ST	Control	HC	SA	ST
<b>ΔE tooth immediately after bleaching</b>	12.38 (11.20)	12.19 (12.99)	8.84 (11.02)	11.82 (11.75)	8.54 (9.50)	9.50 (10.37)	10.70 (12.58)	11.01 (11.55)
<b>ΔE 24h</b>	1.85 (3.40)	2.13 (2.98)	4.64 (6.01)	2.52 (3.91)	2.10 (1.97)	1.32 (1.53)	3.44 (3.43)	1.16 (1.23)
<b>ΔE 7d</b>	0.94 (3.17)	3.00 (4.24)	8.01* (8.17)	2.90 (3.27)	1.80 (2.40)	1.49 (2.62)	6.02 (6.51)	1.33 (1.60)
<b>ΔE 15d</b>	1.52 (1.38)	2.54 (2.53)	2.04* (2.10)	1.72 (2.45)	4.34 (3.50)	2.14 (3.16)	7.53* (7.42)	2.42 (2.81)
<b>ΔL tooth immediately after bleaching</b>	5.60 (5.32)	7.15 (7.12)	6.60 (6.18)	8.30 (8.27)	6.00 (6.50)	6.10 (6.67)	6.20 (5.06)	6.05 (5.96)
<b>ΔL 24h</b>	0.00 (-0.02)	0.00 (-0.80)	-0.30 (-1.01)	-0.80 (-2.13)	0.00 (0.00)	0.00 (-0.17)	-1.30 (-1.89)	0.00 (0.00)
<b>ΔL 7d</b>	0.00 (-0.16)	0.00 (-1.02)	-3.05* (-3.64)	-1.35 (-1.30)	0.00 (-0.14)	0.00 (-0.87)	-3.15* (-2.86)	0.00 (-0.11)
<b>ΔL 15d</b>	0.00 (-0.16)	-0.75 (-1.41)	-0.15* (-1.15)	0.05 (0.14)	0.00 (0.00)	0.00 (0.71)	-3.00* (-2.85)	0.00 (0.05)

\* Statistically significant values when compared to the control group (Mann-Whitney U test, p < 0.05)

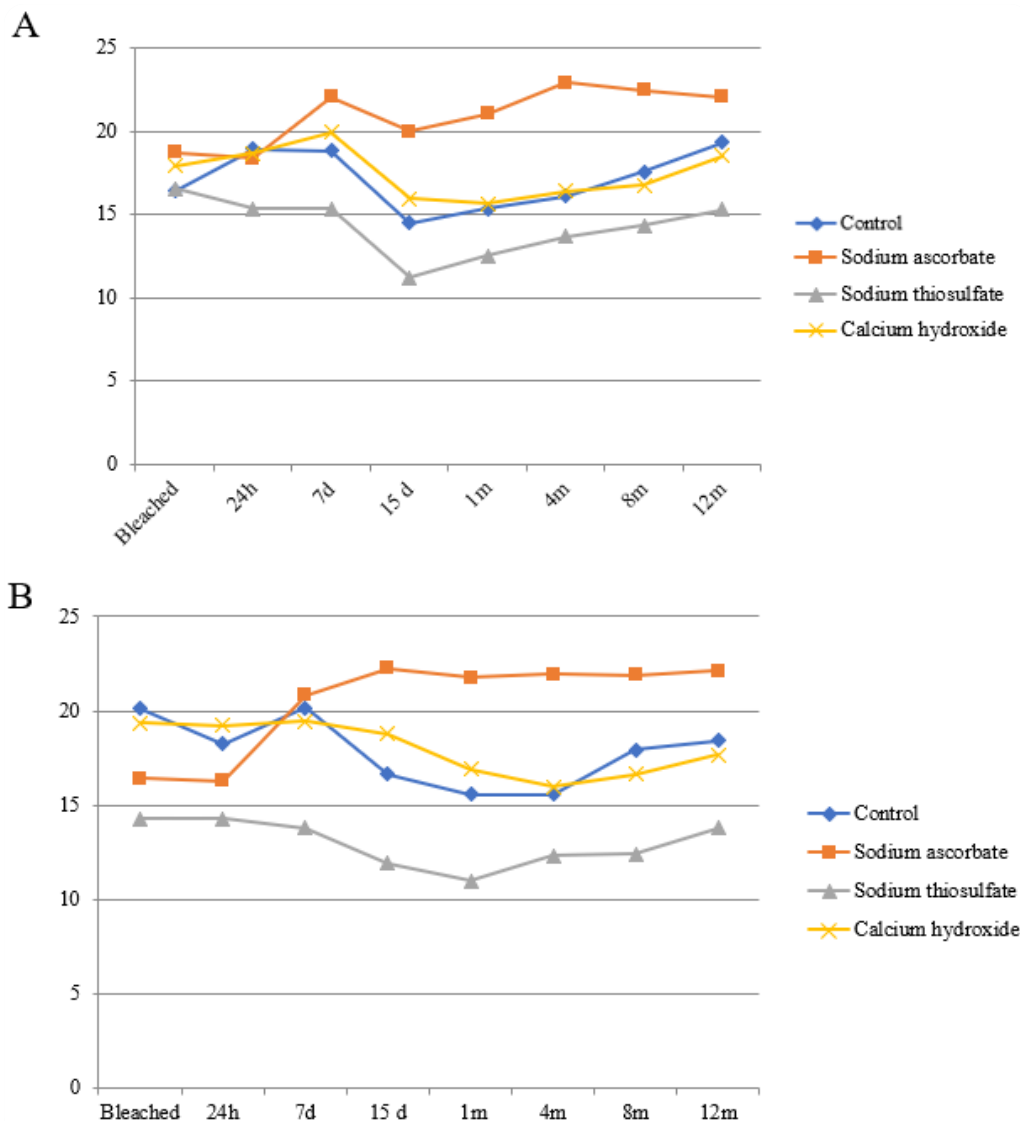
**Table 3. ΔE and ΔL values after 1, 4, 8, and 12 months after restoration.**

	Restoration after 7 days				Restoration after 15 days			
	Control	HC	SA	ST	Control	HC	SA	ST
<b>ΔE</b>								
<b>1 month</b>	1.64 (1.51)	3.14 (3.13)	3.73* (3.89)	1.54 (1.71)	1.54 (2.05)	2.63 (3.37)	3.80* (3.79)	1.96 (3.32)
<b>4 months</b>	2.00 (2.02)	2.14 (3.20)	6.76* (7.32)	1.08 (1.81)	2.47 (4.01)	2.82 (2.81)	5.03* (6.01)	2.57 (3.36)
<b>8 months</b>	3.43 (3.45)	3.45 (4.18)	7.02* (7.55)	2.69 (2.78)	4.69 (5.61)	3.95 (3.73)	5.50 (5.90)	2.55 (3.53)
<b>12 months</b>	4.98 (5.24)	3.78 (4.08)	7.12 (8.26)	2.46 (3.25)	3.30 (5.29)	3.81 (3.52)	4.73 (5.38)	3.07 (3.66)
<b>ΔL</b>								
<b>1 month</b>	-1.40 (-1.10)	-2.35 (-1.81)	-2.65 (-2.31)	-0.25 (-0.39)	-0.00 (-1.00)	-1.60 (-1.49)	-3.70 (-3.15)	-0.80 (-0.19)
<b>4 months</b>	-1.30 (-1.42)	-1.30 (-1.48)	-5.70* (-5.31)	-0.55 (-0.89)	-0.79 (-1.00)	-1.50 (-1.42)	-4.65* (-5.01)	-1.55 (-0.87)
<b>8 months</b>	-2.90 (-2.10)	-2.40 (-2.55)	-5.45* (-5.93)	-2.15 (-2.03)	-1.90 (-2.52)	-2.80 (-2.64)	-4.25 (-4.92)	-1.50 (-1.15)
<b>12 months</b>	-3.20 (-2.96)	-1.80 (-2.67)	-5.30* (-6.18)	-1.60 (-1.36)	-1.40 (-2.20)	-2.20 (-2.28)	-3.50 (-3.14)	-1.20 (-0.88)

\* Statistically significant values when compared to the control group (Mann-Whitney U test, p < 0.05)

In the ΔE00 analysis (Table 4), values superior to acceptable color difference threshold were observed in different moments. However, it was considered significant only in the

group SA (restoration after 7 days), when compared with control, in the period of 4 months.



**Figure 4:** Values of b coordinate in different periods in teeth restored after 7 and 15 days of bleaching procedures.

## DISCUSSION

The present study evaluated the effect of calcium hydroxide, sodium ascorbate, and sodium thiosulfate used in the pulp chamber in relation to color stability and longevity of bovine teeth after internal bleaching.

The color measurement, in the different periods, was performed with the spectrophotometer, which is a digital method, more accurate to detect small color differences when compared to the visual method, which is a subjective technique, dependent on the detection of color by the human eye.<sup>29,31</sup> The color parameters were recorded in the L\*a\*b\* color space as established by the Commission Internationale de L'Eclairage (CIE). Also, CIEDE2000 formula was used in the present study. CIEDE2000 is a more sophisticated formula, developed by CIE, in 2001, to improve the CIELab formula.<sup>35</sup> This formula was created to improve the correction between computed and perceived color difference.<sup>36</sup> According to literature, this formula seems better than the preceding one, but its use is more complex.<sup>34</sup>

The bleaching procedures were performed with sodium perborate and hydrogen peroxide, because this association promotes an increase in pH and better predictability in the bleaching of discolored teeth after endodontic treatment,<sup>5,9</sup> which was confirmed since the  $\Delta E_{ab}$  values were greater than 3.5 and the  $\Delta L$  values were positive in all groups, demonstrating that the teeth have been whitened (Table 2). Values superior to 3.5 indicates changes visible to human eyes, although these delta E values can serve as approximate tolerances, some individuals perceive colour differences as low as 0.5, whereas others do not see differences of 4.<sup>32,33</sup>

In an attempt to perform the final restoration immediately after the bleaching procedures, the use of antioxidant agents in the pulp chamber, like sodium ascorbate, has been indicated because they showed improvement of bond strength between restorative materials and dentine.<sup>13</sup> According to Freire *et al.*<sup>16</sup> five minutes is enough for the sodium ascorbate to eliminate free radicals.

**Table 4. Median (Mean) values of CIEDE2000 analysis.**

Restoration after 7 days							
$\Delta E_{00}$ Groups	24h	7d	15d	1 month	4 months	8 months	12 months
Control	0.83 (2.34)	0.94 (2.32)	1.02 (1.10)	0.81 (0.95)	1.06 (1.15)	1.95 (1.72)	2.60 (2.60)
HC	1.30 (1.63)	1.83 (2.35)	1.23 (1.13)	1.20 (1.66)	1.20 (1.79)	1.77 (2.00)	1.92 (2.02)
SA	2.06 (3.47)	3.83 (3.73)	0.85 (1.07)	1.90 (1.97)	3.25* (3.69)	3.31 (3.73)	3.67 (4.13)
TS	1.70 (3.71)	1.31 (1.76)	1.02 (1.60)	0.68 (0.94)	0.73 (1.03)	1.27 (1.35)	1.45 (1.81)
Restoration after 15 days							
$\Delta E_{00}$ Groups	24h	7d	15d	1 month	4 months	8 months	12 months
Control	1.25 (1.13)	1.20 (1.51)	2.35 (2.03)	2.80 (3.14)	3.17 (4.24)	2.08 (3.29)	2.20 (3.20)
HC	0.93 (1.01)	0.90 (1.52)	1.71 (1.70)	1.62 (1.88)	2.65 (2.44)	2.03 (2.17)	1.51 (1.61)
SA	1.45 (1.76)	3.66 (4.00)	5.48 (4.92)	1.16 (1.83)	2.23 (2.72)	2.00 (2.74)	1.73 (2.77)
TS	0.84 (0.84)	0.92 (1.12)	1.71 (2.03)	1.93 (2.26)	1.60 (1.68)	1.56 (1.74)	1.22 (1.20)

\* Statistically significant values when compared to the control group (Mann-Whitney U test,  $p < 0.05$ )

Studies suggested that 10% sodium ascorbate was not suitable when higher concentration of hydrogen peroxide is used.<sup>17,18</sup> However, Khoroushi *et al.*<sup>11</sup> observed that the use of sodium ascorbate 10% inside the pulp chamber for 24 hours reversed the fracture resistance after bleaching.<sup>11</sup> In the present study, the agents were proposed filling the pulp chamber, to evaluate time required for color stability and its effect on color longevity.

The results of this study demonstrated no difference in  $\Delta E_{ab}$  and  $\Delta E_{00}$  values among groups after 24 hours. However, from 7 days, sodium ascorbate (SA) group showed higher  $\Delta E_{ab}$  than the control group, demonstrating a darkening of bleached teeth, regardless of whether the restoration was performed 7 or 15 days after bleaching. No significant differences were observed in the  $\Delta E_{00}$ . Regarding color stability, the ascorbate group showed significantly higher values of darkening for the restored teeth after 7 days of bleaching, in the periods of 1, 4, and 8 months after the restorative procedure, and in  $\Delta E_{00}$  after 4 months, which can be explained by the oxidation of the sodium ascorbate over time, which in contact with dentin, led to its darkening.<sup>11</sup> Thus, despite reestablishing the adhesion between the restorative material and the dentin after bleaching,<sup>21</sup> the use of sodium ascorbate after 7 or 15 days should be avoided as it directly influences the stability and longevity of the color after 1 month of the restoration.

It has previously been demonstrated that sodium thiosulfate is capable to neutralize oxidative agents in endodontically teeth irrigated with sodium hypochlorite, to improve the polymerization of resin materials and reestablishes the bond strength of

dentin after internal bleaching.<sup>19,20</sup> In the present study, sodium thiosulfate showed similar results regarding color stability and longevity when compared to the control group.

Our study evaluated if the use of antioxidant agents filling the pulp chamber could eliminate the residual oxygen earlier and allows faster color stability. However, in 24h, it was not verified. In sodium thiosulfate groups, color stability was similar with control group. In the sodium ascorbate group, there was still a negative effect of discoloration from 7 days, due to its oxidation.<sup>11</sup>

It was demonstrated that the calcium hydroxide promoted an alkalization of the pH, reducing clastic activity and, possibly, the root cervical resorption<sup>23</sup> and did not interfere in bond strength between composite resin to dentin.<sup>21</sup> The results of the present study demonstrated that CH promoted color stability and longevity similar to control group. This fact corroborates with a previous study that verified that the use of a calcium hydroxide paste (calcium hydroxide and saline solution) does not have the potential to induce discoloration of the bovine tooth.<sup>28</sup>

Previous studies have used human teeth to evaluate bleaching. However, the significant variability in tooth morphology combined with small sample sizes was observed. The present *in vitro* study used standardized bovine teeth, with similar characteristics. Although bovine root dentine has a significantly higher tubule density than human, coronal dentine does not differ significantly in density or diameter of the tubules. Also, they are of easier acquisition.<sup>28</sup> An important limitation is that this is a laboratory study, that did not simulate the oral environment.<sup>37</sup>

The color analysis was conducted under standardized conditions using a custom fabricated mold to ensure that the consecutive measurements were taken at the same region of sample. For color determination, Easy Shade spectrophotometer device was chosen, because of its high data stability and excellent repeatability, however it is a clinical spectrophotometer and deviations from the spectrophotometric reference may occur with most commercially available devices.<sup>28,38</sup>

According with the data of the present study sodium ascorbate must not be used filling pulp chamber, however sodium thiosulfate and calcium hydroxide paste did not show negative effects on color longevity for 12 months. Since the positive effect of calcium hydroxide used after bleaching, clinical studies with higher longevity time are suggested to confirm this result.

## CONCLUSION

Within the limitations of this current study, it was concluded that the color stability after bleaching procedures depends on the agent used as filling agent on pulp chamber. Sodium ascorbate induced perceptible darkening. Sodium thiosulfate and calcium hydroxide paste did not show negative effects on color longevity for 12 months of evaluation, when compared with control group.

## FUNDING SOURCE

This study was funded by Carlos Chagas Filho Foundation for Research Support of the State of Rio de Janeiro - FAPERJ - number E-26/202.784/2019, SEI-260003/009670/2021

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