Influence of polishing after bleaching on color change, enamel surface morphology and sensitivity: a randomized clinical trial

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Research Article

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Abstract

Objective

This trial evaluated the influence of polishing on enamel color change after in-office bleaching treatment. In addition, it evaluated the influence of polishing on tooth morphology and sensitivity.

Materials and methods

Fifty volunteers were randomized into two groups (n = 25): In-office bleaching with 35% hydrogen peroxide gel for 45 min without polishing (GSEM) or with polishing (GP). The color analysis was performed four times, at baseline, and immediately after the 1st, 2nd, and 3rd session of bleaching with Easyshade spectrophotometer (Vita-Zahnfabrik), using the CIELAB ($\Delta E$) and CIEDE2000 ($\Delta E_{00}$) formulas, and whiteness index ($\Delta WI_D$). A qualitative analysis of enamel morphology was performed using replicas obtained with epoxy resin observed in a scanning electron microscope (277× and 554× magnification). The tooth sensitivity was assessed daily using the visual analog scale ($\alpha = 0.05$).

Results

There was no statistically significant difference ($p > 0.05$) in tooth color change when comparing $\Delta E$, $\Delta E_{00}$, and $\Delta WI_D$ between groups. The enamel surface showed greater areas of irregularities and depressions in the GP group than in the GSEM group. There was no difference in tooth sensitivity ($p > 0.05$) between groups.

Conclusions

Polishing after in-office tooth whitening does not change the tooth color and sensitivity and promotes greater changes in enamel surface morphology.

Clinical relevance: Polishing immediately after tooth whitening causes greater changes in enamel surface morphology.

Introduction

The purpose of tooth whitening is to improve the esthetics of teeth, and there is strong evidence proving the effectiveness of whitening treatment [1]. Preliminary studies have investigated the concentration of peroxides, the time and form of application to achieve efficient whitening [2]. However, according to some studies, this treatment may result in changes in the surface roughness of tooth enamel [3, 4].
Considering that bleaching causes changes on enamel surfaces, which are observed in the form of scratches, debris and depressions of different diameters and depths [5, 6], we can assume that polishing could improve the surface of bleached enamel, resulting in brighter teeth. According to Fondriest (2003) [7], surface texture is the most important parameter in determining color because it affects the interaction of light with the tooth surface, and consequently the quality and quantity of light that returns to the observer's eyes. Heintze [8] demonstrated clinically that the finishing and polishing procedures of a restoration influenced the appearance of the color. Similarly, in the case of whitening procedures, surface texture can influence the esthetic result of the treatment.

As already mentioned, structural changes in enamel are evident when exposed to tooth whitening, compromising its morphology and resulting in the presence of erosions, porosities, increased surface roughness, and tooth demineralization [9–12]. Polishing, therefore, would help restore the enamel surface morphology after whitening; however, investigations are needed to validate its effectiveness.

Although there are protocols that reduce the contact time between the bleaching agent and the tooth structure, adverse effects have been reported in the literature, the most common being tooth sensitivity [13], which is usually associated with the ability of hydrogen peroxide to rapidly diffuse through the enamel and dentin and penetrate the pulp [14]. Previous studies have demonstrated the clinical effectiveness of desensitizing therapies with neural action [15] and/or obliterating action [16] in preventing sensitivity after in-office tooth bleaching. However, to the best of our knowledge, there are no previous reports exploring the influence of polishing on tooth characteristics after bleaching, which renders the present study important in demonstrating the efficacy and safety of this intervention.

Therefore, this randomized clinical trial aimed to evaluate the influence of polishing on color change after tooth whitening. Additionally, its influence on enamel morphology and tooth sensitivity after bleaching was evaluated. The null hypotheses tested in this study were as follows: H0, no significant difference in color change for bleached enamel with or without polishing; H01, no significant difference in enamel morphology after bleaching with or without polishing; and H02, no significant difference in tooth sensitivity between groups with bleached enamel with or without polishing.

**Materials And Methods**

**Ethical aspects**

This clinical, randomized, single-blind study followed the guidelines of the Consolidated Standards of Reporting Trials (“CONSORT”) [17] and was approved by the Ethics Committee [number 5.257.238]. This study is available at Brazilian Clinical Trials Registry (http://www.ClinicalTrials.gov) research register number: NTC05635253. The participants were informed of the risks, methods, and objectives of the study. The study was conducted in accordance with the Declaration of Helsinki [18].

**Study design**
This investigation was conducted as a randomized, single-blind clinical trial in which the evaluator responsible for the statistical analysis was unaware of the interventions performed in the groups. Each research participant was coded to maintain confidentiality in the allocation process of the participants during the sample randomization for the different groups studied: (1) GSEM, no intervention after bleaching treatment; and (2) GP, application of polishing paste (Diamond Excel, FGM, Santa Catarina, Brazil) on the vestibular surfaces of bleached teeth. Dental color was evaluated using an Easyshade Advanced spectrophotometer (Vita-Zahnfabrik, Bad Säckingen, Germany) at different evaluation time points. SEM photographs were taken to visualize the enamel morphology before starting treatment and immediately after each treatment session in both groups. Daily assessment of pain sensitivity was self-reported by the research participants during the 14-day follow-up using the visual analog scale (VAS).

Sample size

The sample size was calculated during a pilot study using the t-test available in the G Power 3.1 software (Heinrich-Heine-Universität, Düsseldorf, Germany), with an effect size of 0.85 for testing differences in means. The calculations were performed considering 80% statistical power, a two-sided significance level of 5%, and a 10% loss in sample size, resulting in 50 patients.

Sample selection

Adult patients were recruited from January 10, 2022, to March 28, 2022. Participants were examined and selected based on the following inclusion criteria: individuals aged 18–30 years of both sexes, with good oral hygiene, no sensitivity to tactile and evaporative stimuli, no previous bleaching treatment, and no carious lesions. The following patients were excluded: patients undergoing fixed orthodontic treatment; patients allergic to the bleaching product; drug users or pregnant women; patients with carious lesions, defective restorations, and/or periodontal disease; patients with systemic diseases, pulpitis, or patients using analgesics.

All participants received oral hygiene kits containing a toothbrush (Oral B, São Paulo, Brazil) and toothpaste (My First Colgate®, Colgate-Palmolive Company, São Paulo, Brazil) without desensitizing action and without fluoride, to avoid possible interference in the evaluations. The participants were instructed to use the kit three times a day.

Randomization

Sample randomization was performed by a researcher who did not participate in the clinical intervention stages of the study. Each participant’s medical records were stored in coded envelopes to maintain confidentiality during sample randomization. The randomization process was performed using the computer program BioEstat 5.0 (Civil Society, Mamirauá, Pará, Brazil), which generated a random table with 50 participants allocated into two blocks (n = 25): a block (GSEM group) with participants who did not undergo any intervention after bleaching and another block (GP group) with participants who underwent polishing after bleaching with felt discs (Diamond Flex, FGM, Santa Catarina, Brazil) and polishing paste (Diamond Excel, FGM, Santa Catarina, Brazil) (Table 1).
### Table 1
Treatment used in different groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Tooth Bleaching</th>
<th>Polishing Paste</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSEM</td>
<td>Soft tissue protection was performed with a light-cured gingival barrier Top Dam (FGM, Santa Catarina, Brazil). Next, bleaching gel was applied to the vestibular surface from premolar to premolar in the upper and lower arches. A total of three 45-minute sessions were performed with a seven-day interval between them.</td>
<td>-</td>
</tr>
<tr>
<td>GP</td>
<td></td>
<td>Polishing of the vestibular surfaces was performed for 20 s on each bleached tooth with polishing paste and felt disc (Diamond Flex, FGM, Santa Catarina, Brazil) in low rotation.</td>
</tr>
</tbody>
</table>

### Blinding

In this single-blind study, the evaluator performing the statistical analysis did not know to which group the collected data belonged.

### Intervention

#### Tooth whitening

Prophylaxis with a rubber cup and pumice stone was administered prior to the start of the bleaching treatment in all participants. In both groups, tooth whitening was performed using Whiteness HP 35% (FGM, Santa Catarina, Brazil). Soft tissue protection was performed using a Top Dam light-curing gingival barrier (FGM, Santa Catarina, Brazil), following the manufacturer's recommendations. Subsequently, the Whiteness HP product was manipulated (six drops of hydrogen peroxide for two measures of thickener), and a whitening gel was applied on the vestibular surface from the premolar to the premolar in the upper and lower arches. The product was maintained for 45 min, followed by aspiration of the gel using a suction device and extensive washing with water. Three bleaching sessions were performed at an interval of seven days.

#### Polishing

The GP group underwent polishing immediately after bleaching. Participants received a small amount (0.1 g) of polishing paste (Diamond Excel, FGM, Santa Catarina, Brazil) on the vestibular surface of the bleached teeth, and with the aid of felt disks (Diamond Flex, FGM, Santa Catarina, Brazil) the surface of each bleached tooth was polished for 20 s using low rotation.

### Outcomes Primary

#### Color assessment

Color assessment was performed on the upper incisors and canines of each participant using an Easyshade Advanced spectrophotometer (Vita-Zahnfabrik, Bad Säckingen, Germany) with the CIELAB...
system and CIEDE2000. The color change values (ΔE) for the CIELAB system were obtained using the following formula [19]:

$$\Delta E = ((\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2)^{1/2},$$

where: \(\Delta L^* = L^*- L^*; \Delta a^* = a^*- a^*; \) and \(\Delta b^* = b^*- b^*\). Computations for CIEDE2000 color difference (\(\Delta E_{00}\)) metric was used, according to the following equation [20]:

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T \frac{\Delta C'}{k_C S_C} \frac{\Delta H'}{k_H S_H}}$$

Where \(\Delta L', \Delta C', \) and \(\Delta H\) are the differences in lightness, chroma, and hue, respectively, for a pair of points. The weighting functions \((S_L, S_C, \) and \(S_H))\) adjust the total color difference for variations in the location of the color-difference pair in \(L', a', b'\) coordinates. The parametric factors \((k_L, k_C, \) and \(k_H))\) are the correction terms for the experimental conditions. For the calculations, all parametric factors were set to 1 \((k_L = k_C = k_H = 1)\). \(R_T\) is a rotation function that accounts for the interaction between the chroma and hue differences in the blue region.

To standardize the position of the device during color measurement, an additional silicone barrier (President Coltene, Rio de Janeiro, Brazil) was made with a circular cutout on the vestibular surface with a diameter equivalent to the tip of the spectrophotometer. The color assessment was performed at four time points: before the whitening treatment, serving as a baseline, and after the 1st, 2nd and 3rd session of whitening treatment.

The whitening index \((WI_D)\) was used to assess the level of “whiteness” based on color coordinates \((L^*, a^*, \) and \(b^*))\) of the CIELAB system. This index follows a simple linear equation obtained from the following formula [21]:

$$WI_D = 0.511L^* - 2.324a^* - 1.100b^*$$

The initial \((WI_{Dinitial})\) and final \((WI_{Dfinale})\) bleaching indices were obtained from readings of the color coordinates \((L^*, a^*, b^*))\) before starting the bleaching treatment (baseline) and at the end of the 3rd session, respectively. The difference in the whitening index \((\Delta WI_D)\) was obtained from the following equation [21]:

$$\Delta WI_D = WI_{Dfinale} - WI_{Dinitial}$$

Outcomes Secondary

Enamel morphological analysis

High-precision impressions were made of the right maxillary incisor before starting the bleaching treatment and immediately after each treatment session in both groups using a polyvinylsiloxane-based material (Elite H-D, Zhermack, Rovigo, Italy). Replicas were prepared by pouring the impressions into an epoxy resin (Eposs EL 20; Prochima, Pesaro, Italy).
Images were captured using a TESCAN electron microscope (Mira3 model) equipped with an electron gun. The replicas were mounted on aluminum supports with 12 mm diameter, using a carbon-faced double sided adhesive tape, and coated with Au for 2 min 30 sec, which deposited a film with a thickness of 10–15 nm on the sample. The images were generated by detecting the secondary electrons using a voltage acceleration of 5 kV and a working distance of approximately 15 mm.

Sensitivity assessment

Sensitivity was assessed using a questionnaire provided to the participants from the first session of in-office tooth whitening treatment. Volunteers answered the questionnaire daily during the 14 days of treatment according to their perception of the pain threshold, level of sensitivity, or discomfort caused by the whitening treatment. A Visual Analog Scale (VAS) ranging from 0 (no pain) to 10 (severe pain) was used.

Data analysis

The data obtained in this study were tabulated in an Excel spreadsheet (Microsoft Windows 2010) and analyzed using the BioEstat® software to verify the normality of the distribution using the Kolmogorov-Smirnov test. Data from the dental color assessment (primary outcome) did not show a normal distribution; therefore, the Mann-Whitney test was used to compare the difference in color between groups (GSEM and GP) using the CIELAB ($\Delta E$) and CIEDE2000 ($\Delta E_{00}$), and the Wilcoxon test was used to compare the difference in the whiteness index ($\Delta W_{1D}$) between groups (GSEM and GP). For intragroup evaluations of different systems ($\Delta E, \Delta E_{00}, \Delta W_{1D}$), the Friedman test was used. Secondary outcome: Qualitative analysis of the images was performed using scanning electron microscopy to evaluate the surface morphology of the enamel. The Mann-Whitney U test was used to assess sensitivity, which did not show a normal distribution. The mean sensitivity reported by participants using the VAS were used to compare the two groups (GSEM and GP). A significance level of 95% was considered for all analyses.

Results

Participants Flow

Seventy-two participants were evaluated initially, of whom 50 were finally selected, randomly allocated to the groups, and underwent treatment and follow up (Fig. 1).

In the final sample, there was a higher proportion of female (N = 34, 68%) than male participants (N = 16, 32%). The mean age of the participants was 24 years (standard deviation [SD] = 4.3, range = 18–30). No significant differences were found in any of these characteristics among the treatment groups (p > 0.05).

Color assessment

The color assessment results are shown in Fig. 2. Tooth bleaching resulted in an increase in the $\Delta E$ value in both the CIELAB and CIEDE2000 systems after the 1st, 2nd and 3rd session (Figs. 2A and 2B), with a
significant difference in the intragroup assessments (p < 0.05). In the intergroup evaluations, ΔE showed no statistically significant difference in color change between the evaluation time points.

The whitening index results are illustrated in Fig. 2C. Intragroup comparisons revealed a statistically significant difference (p < 0.05) before starting the bleaching treatment and after the 3rd bleaching session. There was no significant difference in the intergroup assessments.

**Enamel morphological analysis**

Images of the enamel surface morphology in the GSEM and GP groups are shown in Fig. 3. In both groups, at baseline, SEM images demonstrated the appearance of the enamel without alteration, with a smooth and regular surface (Figs. 3A and 3E).

Both groups showed changes in enamel morphology after bleaching. However, the GP (with polishing) group showed greater irregularities, depressions, decalcification, and surface roughness than the GSEM (without polishing) group (Figs. 3F, 3G, and 3H).

**Sensitivity Assessment**

The GSEM and GP groups exhibited sensitivity throughout the bleaching treatment. There were no statistically significant differences between the groups (p > 0.05) over the evaluation period (Figs. 4).

**Discussion**

Polished tooth surfaces are essential to prevent debris, plaque, and pigments from accumulating and interfering with surface integrity and esthetics [22]. However, although polishing is part of several clinical protocols in dentistry [23–25], few reports have evaluated its effects after tooth whitening.

The findings of the present study showed that polishing did not influence tooth color after whitening, thus supporting the null hypothesis, H0. No previous studies have evaluated the influence of polishing on tooth color, morphology, and sensitivity after whitening. Initially, it was expected that polishing would promote surface smoothness and, in turn, cause greater gloss and light reflection on the whitened surface, promoting a greater color change in the GP group; however, this was not observed.

Prathap [26] reported that polishing pastes available in the market are formulated to enable smoother dental substrates, good aesthetic appearance, and the prevention of chromatic alterations by extrinsic pigments. It is likely that the micronized diamond particles present in the paste had the opposite effect on the whitened surface. Nevertheless, they did not interfere with the effectiveness of the bleaching agent, since the perceptibility thresholds were exceeded, i.e., ΔE > 1.2, ΔWI > 0.72, and ΔE₀₀ > 0.8 [27].

Qualitative analyses of the electron microscopy images showed that the group that underwent polishing (GP) exhibited greater morphological changes on the surface, rejecting the null hypothesis H01.
previous laboratory study showed changes in roughness and the creation of some ridges on the whitened enamel surface [28]. In addition, other studies [29–31] analyzing the enamel surface after tooth whitening showed similar slight morphological changes. Although the bleaching agent promotes demineralization of the tooth enamel structure, it is less than that caused by some routine dental procedures, such as enamel acid etching [32]. Moreover, this demineralization is compensated by exposure to saliva or by the formation of fluorapatite [33]. According to Justino [34], it is important to avoid polishing the tooth structure immediately after bleaching to allow the biochemical recovery of enamel by saliva; polishing could be performed in subsequent sessions. Therefore, it is possible that the immediate contact with abrasives causes greater morphological changes on the whitened tooth surface.

The results for the evaluation of sensitivity showed no statistically significant difference between the groups, supporting hypothesis H02. However, when observing the averages of the levels of sensitivity reported, it was possible to verify higher values for the group that received polishing compared to the group that underwent only bleaching. The permeability of dental tissues makes it easier for the oxygen molecules released during whitening to penetrate and reach the pulp chamber, resulting in inflammatory response to the pulp tissue [35] and pain perception [36]. According to Costa [37], modifications on enamel surfaces increase the penetration of hydrogen peroxide through dental tissues. Thus, it is possible that polishing, by promoting greater changes in enamel surface morphology, increased permeability and facilitated faster penetration of the bleaching gel into the dental structure of the GP group.

The results of this trial necessitate future studies comparing different polishing pastes with and without active ingredients to evaluate their effects on the whitened tooth structure, aiming at further clarification of this intervention in clinical practice.

**Conclusion**

Polishing after in-office tooth whitening does not change tooth color, promotes greater changes in enamel surface morphology, and does not influence sensitivity.

**Declarations**

**ETHICAL APPROVAL**

The research ethics committee of the Institute of Health Sciences of the Federal University of Pará reviewed and approved the trial (Approval no. 5.257.238). No animals were used in this research. All human research procedures were followed in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013. It was registered in the Brazilian Clinical Trials Register (https://ensaiosclinicos.gov.br) under identification number NCT05635253.

**INFORMED CONSENT**
All persons gave their informed consent prior to their inclusion in the study.

COMPETITIVE INTEREST

Antonia Patricia Oliveira Barros declares that he has no conflict of interest. George Monteiro da Silva declares that he has no conflict of interest. Cristiane de Melo Alencar declares that he has no conflict of interest. Milton Carlos Kuga declares that she has no conflict of interest. Jesuína Lamartine Nogueira Araújo declares that she has no conflict of interest. Cecy Martins Silva declares that she has no conflict of interest.

AUTHORS’ CONTRIBUTIONS

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Antonia Patricia Oliveira Barros, George Monteiro da Silva, Cristiane de Melo Alencar, Milton Carlos Kuga, Jesuína Lamartine Nogueira Araújo, Cecy Martins Silva. The first draft of the manuscript was written by Antonia Patricia Oliveira Barros and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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AVAILABILITY OF DATA AND MATERIALS

Data is available when request for the authors.

References


Figures
Figure 1

Study flow diagram
Figure 2

Color evaluation results for ΔE (A), ΔE₀₀ (B), and ΔW₁₀ (C). *Different capital letters represent statistically significant difference between groups for color differences ΔE and ΔE₀₀, according to the Mann-Whitney test (p ≤ 0.05); **Different capital letters represent statistically significant difference between groups (p ≤ 0.05) for ΔW₁₀, according to the Wilcoxon test; ***Different lowercase letters represent statistically significant intragroup difference (p ≤ 0.05) with the Friedman test.
Figure 3

(A-D) Aspect of the enamel surface of the GSEM group at baseline, and immediately after the 1st, 2nd, and 3rd session of bleaching, respectively (277×); (E-H) (A-D) Aspect of the enamel surface of the GP group at baseline, and immediately after the 1st, 2nd, and 3rd session of bleaching, respectively (277× and 554×)
Figure 4

Means (standard deviation) of reported sensitivity level data using the visual analog scale. *Calculated by the Mann-Whitney test

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- CONSORT2010Checklist.docx