DENTAL STAINING AFTER ORTHODONTIC DEBONDING: EFFECTIVENESS OF TWO BLEACHING TREATMENT PROTOCOLS - *IN VITRO* STUDY

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Palavras-chave: Descolagem dentária. Estética dental. Clareamento dentário. Agente clareador.

RESUMO

Objetivo: O objetivo deste estudo foi comparar a eficácia de dois protocolos de tratamento clareador para manchas dentárias causadas após a descolagem ortodôntica. **Materiais e Métodos**: Vinte e quatro dentes bovinos foram submetidos à colagem e descolagem de braquetes ortodônticos (Morelli, Prescrição Edgewise, Slot 22") (Transbond XT, 3M), que foram divididos em três grupos de acordo com o protocolo de clareamento: peróxido de hidrogênio 10% (Whiteness, FGM) simulando protocolo de clareamento caseiro (grupo clareamento caseiro), peróxido de hidrogênio 35% Whiteness, FGM) simulando protocolo de clareamento de consultório (grupo clareamento de consultório) e Grupo Controle, que não foi exposto a nenhum protocolo de clareamento dental, armazenado em água destilada a 37ºC. Os corpos de prova foram submetidos aos seguintes processos: envelhecimento das resinas remanescentes por ultravioleta (UV), manchamento em solução de café e clareamento dental com peróxido de hidrogênio 10% (G1) e peróxido de hidrogênio 35% (G2). A análise de estabilidade de cor (sistema CIE L* a* b*) foi realizada com espectrofotômetro Vita Easyshade Compact antes da colagem (T0), após os processos de envelhecimento e manchamento (T1) e após o tratamento clareador (T2). Todos os dentes foram armazenados em água destilada a 37 °C entre os tempos experimentais. A comparação entre os grupos e a avaliação do efeito do tempo foram realizadas utilizando ANOVA/ Tukey (α=0,05) e ANOVA-MR com correção de Bonferroni (α=0,016), respectivamente. **Resultados**: Os parâmetros de estabilidade de cor L *, a* e b* indicaram, com exceção do GC, tendência de aumento em T1 (G1 - L*: 76,72 ± 13,39; a*: 6,68 ± 3,71; b*: 43,14 ± 4,04 / G2: - L* : 75,78 ± 4,66; a*: 8,13 ± 2,75; b*: 43,42 ± 8,87), o que refletiu a tendência de diminuição do brilho em T1, seguido de uma tendência de retorno aos valores de T0 (G1 - L*: 82,92 ± 12,16 ; a*: 4,25 ± 3,68; b*: 39,40 ± 9,49 / G2: - L*: 83,76 ± 8,02; a*: 8,76 ± 4,08; b*: 47,90 ± 5,88). Foram observadas diferenças significativas no G2 em a* (T1: 8,13 ± 2,75, T2: 8,76 ± 4,08) e b* (T1: 43,42 ± 8,87; T2: 47,90 ± 5,88), indicando que esse grupo não retornou aos valores apresentados em T0 (a*: 1,81 ± 1,70; b*: 35,40 ± 5,08) (p<0,05). **Conclusão**: Com base nos resultados deste estudo, pode-se concluir que o protocolo de clareamento caseiro apresentou melhor desempenho para o clareamento da superfície dentária em um eventual manchamento após a descolagem ortodôntica.

Keywords: Dental Debonding. Dental Aesthetics. Tooth Bleaching. Tooth-bleaching Agent.

ABSTRACT

Objective: The aim of this study was to compare the effectiveness of two bleaching treatment protocols to treat dental staining after orthodontic debonding. **Materials and Methods**: Twenty four bovine teeth were submitted to orthodontic bracket (Morelli, Edgewise Prescription, Slot 22) bonding (Transbond XT, 3M) and debonding, which were divided into three groups according to the bleaching protocol: hydrogen peroxide 10% (Whiteness, FGM) simulating home bleaching protocol (Home Bleaching Group), hydrogen peroxide 35% Whiteness, FGM) simulating dental office bleaching protocol (Office Bleaching Group) and Control Group, which was not exposed to any dental bleaching protocol, and stored in distilled water at 37°C. The specimens were submitted to the following processes: aging of resin remaining tegs by ultraviolet (UV), staining with coffee solution and tooth bleaching with 10% hydrogen peroxide (G1) and 35% hydrogen peroxide (G2). The color stability analysis (CIE color space L* a* b* was performed with Vita Easyshade Compact spectrophotometer before bonding (T0), after aging and staining processes (T1) and after bleaching treatment (T2). All teeth were stored in distilled water at 37°C between experimental times. The comparison between the groups and time effect evaluation were performed using ANOVA / Tukey (α=0.05) and ANOVA-MR with Bonferroni correction (α=0.016), respectively. **Results**: The color stability parameters L *, a * and b * indicated, with the exception of GC, a tendency of increase in T1 (G1 - L *: 76.72 ± 13.39; a *: 6.68 ± 3.71; b *: 43.14 ± 4.04 / G2: - L *: 75.78 ± 4.66; a *: 8.13 ± 2.75; b *: 43.42 ± 8.87), which reflected the tendency to decrease brightness in T1, followed by a tendency to return to T0 values (G1 - L *: 82.92 ± 12.16; a *: 4.25 ± 3.68; b *: 39.40 ± 9.49 / G2: - L *: 83.76 ± 8.02; a *: 8.76 ± 4.08; b *: 47.90 ± 5.88). Significant differences were observed in G2 in a * (T1: 8.13 ± 2.75, T2: 8.76 ± 4.08) and b * (T1: 43.42 ± 8.87; T2: 47.90 ± 5.88), indicating that this group did not return to the values presented in T0 (a *: 1.81 ± 1.70; b *: 35.40 ± 5.08) (p <0.05). **Conclusion**: Based on the results of this study, it can be concluded that home bleaching protocol presented better performance for dental surface whitening in an eventual staining after orthodontic debonding.

Submitted: December 08, 2021
Modification: April 07, 2022
Accepted: May 05, 2022

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INTRODUCTION

After orthodontic treatment, individuals usually look for aesthetic solutions because of teeth color, whose surfaces probably have been stained after bracket's debonding. In general, this color change results from diet and pigments of materials applied at the tooth-bracket interface during the bonding procedure at the beginning of orthodontic treatment.[1]

Since Buonocore[2] first described the acid etching technique which was adopted for orthodontic bonding protocol, one of the main concerns is that, at the end of the orthodontic therapy, individual's enamel color surface would be similar to its color before the treatment.[3] Several studies have shown that irreversible resin penetration occurs in the enamel structure during bracket adhesion protocol. For some authors,[4-5] the resinous component, during this bonding protocol, can infiltrate the enamel from 11.8µm to 18.9µm, with the possibility of reaching up to 100µm. Sometimes this resin penetration can reach 50µm and cannot be removed after bracket's debonding and tooth surface polishing procedures,[6] thus the residual material may remain on the tooth surface even if a layer of enamel is removed.[7]

After orthodontic debonding, the material that remain on the tooth surface may obstruct the movement of bleaching agents within this substrate, which can influence the result of tooth bleaching treatment.[8-9] In addition, composites are not whitened as enamel surfaces, thereby the presence of composites may cause color changes on the tooth surface, resulting in a not homogeneous tooth color surface at the end of the bleaching protocol.[10]

Several factors can modify dental color, such as the consumption of coffee and other substances, as well as the frequency of tooth brushing. It can be directly related to the result of a possible bleaching treatment. The in vitro study model can control the sample standardization and the difficulty of managing external factors in a clinical study. Thus, the aim of this study was to compare, in an in vitro model, the effectiveness of two bleaching treatment protocols to reduce dental staining condition after orthodontic debonding.

MATERIALS AND METHODS

This project had been previously approved by the Ethics Committee for Animal Research at the Health Sciences Center of the Federal University of Rio de Janeiro.

According to the preliminary pilot study, the power sample was calculated based on Pandis study.[11] The calculation for difference between means (α=5% and study power = 80%) for the L* variable (CIEL*a*b* system) suggested the use of 8 specimens per group.

Twenty-four bovine incisors were used in this study (extracted from certify slaughterhouse) and the tooth crowns were separated from the root using a diamond disc (KG, Cotia, Sao Paulo, Brazil) for sample preparation.

The bovine crowns were inserted in a PVC cylindrical fragment (25mmx20mm – Lusafilm - Dispafilm do Brasil Ltda) using self-curing acrylic resin (JET® Classic Dental Articles LTDA, Campo Limpo Paulista, SP, Brazil). The surface of the crown was positioned perpendicular to the PVC. Then the buccal surface of the crown was polished with sandpaper Numbers 400, 600 and 1200 (3M®, Sumaré, São Paulo, Brazil) for the same period of time (30 seconds each) under water on a Politriz machine (Ecomet II, Buehler®, Illinois, USA) until obtain a flat, smooth, polished surface. The samples were stored in distilled water at 37°C. The entire procedure was performed by the same operator (F.M.C).

The sample was divided into three groups (n = 8) according to the bleaching protocol adopted:

• Home Bleaching Group (G1): hydrogen peroxide 10% (Whiteness, FGM®) simulating home bleaching protocol;

• Office Bleaching Group (G2): hydrogen peroxide 35% (Whiteness, FGM®) simulating dental office bleaching protocol;

• Control Group (CG): without orthodontic bonding procedure nor exposure to the any dental bleaching protocol.

All sample was storage in distilled water at 37 °C.

Edgewise Slot 22" brackets (Morelli®, Sorocaba, SP, Brazil) were bonded to the specimens of groups G1 and G2. Phosphoric acid 37% Alpha Etch Gel (Nova DFL®, Rio de Janeiro, RJ, Brazil) was applied to the enamel tooth surfaces (30 seconds each). After that, the specimens were washed with water for 10 seconds and dried for 15 seconds each. In sequence, the primer adhesive (Transbond XT Light Cure Adhesive Primer, 3M Unitek®, Monrovia, CA, USA) was applied with a microbrush (Dentsply®, Rio de Janeiro, Brazil) for 10 seconds of brush movement and it was light cured for 10 seconds. The paste resin (Transbond XT Light Cure Adhesive Paste Resin, 3M Unitek®, Monrovia, CA, USA) were applied the buccal surfaces of the samples for the bracket's bonding procedure (40 seconds of light cure time) (Figure 1).

The sample aging protocol was performed by irradiation with a tungsten filament ultraviolet lamp and mercury vapor atmosphere[12], with a wavelength of 254 nm at a temperature of 45 °C and 65% relative humidity on a specific machine (Darkroom, Model SL-204, Solab®, Piracicaba, Brazil) for 12 hours, equivalent to 3 years of natural aging (ISO 3336-1977).

The brackets were removed using a curved how plier

(Starlet®, Sao Paulo, SP, Brazil), the remaining bonding material was removed with a tungsten burr at low rotation (Brasseler®, Savannah, GA, USA), and the enamel surface was polished with a rubber burr and prophylactic paste (SS White®, Rio de Janeiro, RJ, Brazil) at low rotation.

For the external staining protocol, the samples from both experimental groups were submerged in coffee solution (Melitta®, São Paulo, SP, Brazil), in an appropriate container and kept at 37ºC, to simulate the buccal cavity temperature. This protocol was performed for 21 days, the coffee solution was changed once a week. After the staining cycle, the samples were placed in the ultrasonic vat for 380 seconds (Cristófolli®, Campo Mourão, PR, Brazil) to remove the coffee residue that remained on the tooth surface.[13]

For the home bleaching protocol, it was necessary to simulate a silicone tray (FGM®, Joinville, SC, Brazil) used for this technique. An individualized silicone tray was made for each sample. Impressions of G1 specimens were performed with alginate (Orthoprint®, Zhermack, Italy) and the casts, for each sample, were immediately obtained with Paris plaster (Dentsply®, Rio de Janeiro, Brazil). Then, each cast was taken to a vacuum machine (PlastVac P7®, Bio-Art, São Carlos, SP, Brazil) to obtain the whitening. Fifteen bleaching cycles with 10% hydrogen peroxide agent using the individualized trays were performed during 40 minutes per cycle (company protocol). After this period, the remaining bleaching material was removed. Each cycle simulated one day of home bleaching protocol (Figure 2).

To simulate office bleaching protocol, the bleaching agent was prepared according to the manufacturer's recommendations. The material was prepared in the container provided by the manufacturer and then applied to the dental surface. The bleaching material was kept on the dental surface for 40 minutes and shaken with a microbrush every 10 minutes to remove bubbles, as recommended. This protocol was repeated three times, simulating three office bleaching sessions (maximum of sessions recommended by the manufacturer).

During all protocols for both G1 and G2, the procedures were performed at 37ºC to simulate oral conditions.

To perform color stability analysis, the Vita EasyShade Compact® spectrophotometer (Bad Säckingen Germany) was used to determine the tooth color before orthodontic bonding protocol (T0), after aging/staining (T1) and bleaching procedures (T2). The spectrophotometer and samples were placed on a specific area for standardization of the color stability analysis, then the tip of the device was positioned perpendicular to the surface of the teeth (Figure 3). The color data were made using the L* a* b* system which characterizes the three-dimensional color, where the three axes are: L* - measure of luminosity of an object, a* - variation on the red-green axis and b* - variation on the yellow-blue axis (Figure 3).

Statistical analysis was performed with the SPSS software (version 22, SPSS Inc, Chicago, IL, USA). For all analyzes, the level of significance was set at 5%, and the normality of the sample was verified using the Shapiro-Wilk test.

The comparison between the groups and time effect evaluation were performed with ANOVA/Tukey ($p<0.05$) and ANOVA-MR with Bonferroni correction ($\alpha=0.016$), respectively.

RESULTS

Descriptive data analyses of color stability are described in Table 1 according to the time of assessment during the study, groups and color parameters (L*, a* and b*).

In the intergroup analysis, there was no statistical difference in T0 (before bonding) for all color parameters. At T1 (after aging and staining processes), only the CG remained in the pattern related to T0, for the parameter L *. At T2 (after bleaching treatment), statistical difference was observed in the G2, for the parameters a * (8.76 ± 4.08) and b * (47.90 ± 5.88) when compared to the CG.

Considering the color parameter a*, the G1 tended to return to T0 values (1.91 ± 1.79) at T2 (4.25 ± 3.68). This condition did not occur in the G2, comparing T2 values (8.76 ± 4.08) close to T1 values (8.13 ± 2.75). Similar evolution was observed for color parameter b *, where in the G1, T2 values (39.40 ± 9.49) tended to return to T0 values (37.17 ± 3.74) after aging and staining procedures at T1 (43.14 ± 4.04), which was not observed in the G2.

At T1, for the color parameter a *, the G1 and the G2 showed statistical difference when compared to the control group. Regarding the color parameter b *, both bleaching groups were similar to each other when compared to the CG.

At T2, for parameter L*, the G1 and the G2 showed statistical similarity in relation to the CG. Considering the color parameters a * and b *, there was a tendency to the color returns to the baseline when comparing the CG with the G1.

Considering the analysis of the study interval, T2-T0, significant difference was found in the G2 in relation to the baseline values for color parameter b * (12.50 ± 7.47).

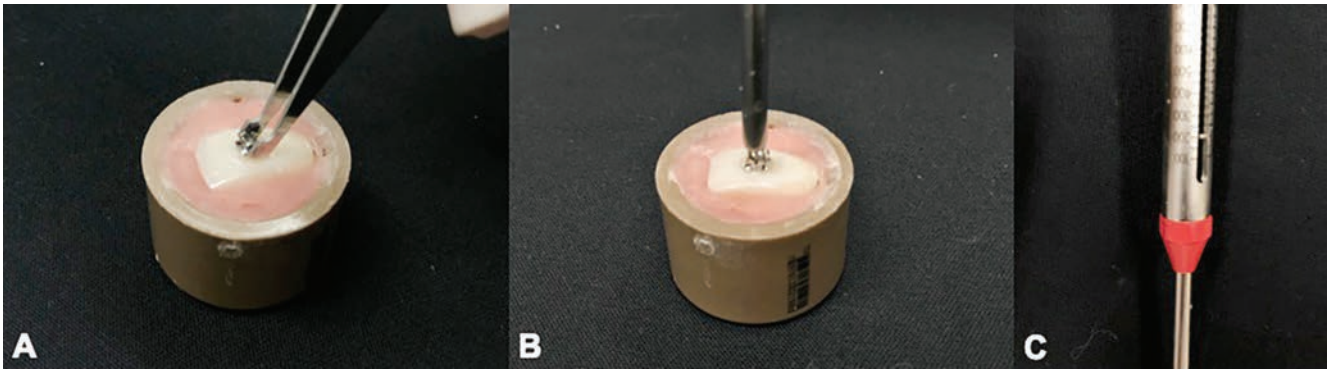

***Figure 1**: Bracket's bonding procedure: A) Bracket positioning with tweezers. B) Pressure standardization using a tensiometer at 200gF. C) Illustration of tensiometer under 200gF force.*

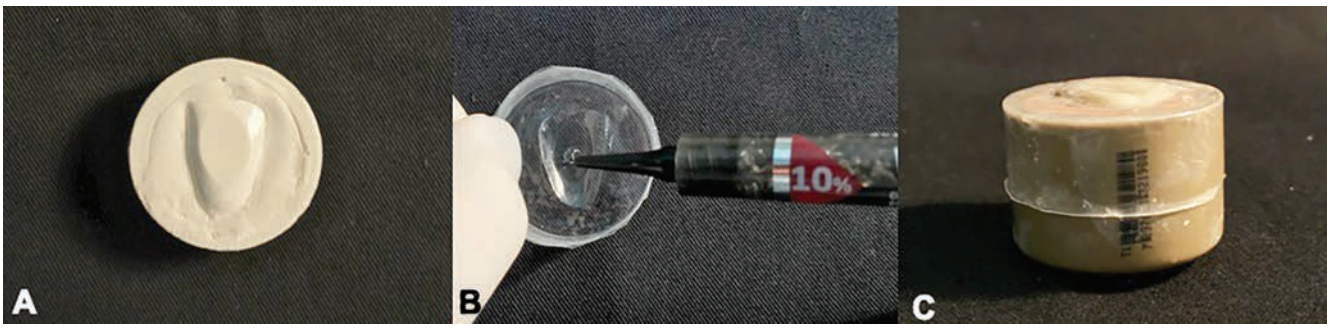

***Figure 2**: Home bleaching protocol. A) Sample cast with the silicone tray. B) Bleaching material. C) The individual silicone tray with the bleaching material on the sample.*

***Figure 3**: Color Stability analysis. A) Positioning of the device on the tooth surface. B) Results displayed on the spectrophotometer display.*

Table 1: *Descriptive statistics (mean ± SD), intergroup analysis and intragroup analysis for the parameters L*, a*, b* (L* - measure of luminosity of an object, a* - variation on the red-green axis, b* - variation on the yellow-blue axis) throughout the study.*

Groups	L*				
	T0	T1	T2	T1-T0	T2-T0
Home Bleaching	89.66 ± 3.91[a]	76.72 ± 13.39[a]	82.92 ± 12.16[a]	-12.94 ± 14.26	-6.74 ± 12.49
Office Bleaching	90.38 ± 3.80[a]	75.78 ± 4.66[a]	83.76 ± 8.02[a]	-14.59 ± 8.01[†]	-6.62 ± 10.08
Control	89.17 ± 3.42[a]	89.42 ± 8.48[b]	87.23 ± 7.80[a]	0.25 ± 8.05	-1.94 ± 6.31
	a*				
	T0	T1	T2	T1-T0	T2-T0
Home Bleaching	1.91 ± 1.79[a]	6.68 ± 3.71[b]	4.25 ± 3.68[ab]	4.77 ± 3.57	2.33 ± 3.84
Office Bleaching	1.81 ± 1.70[a]	8.13 ± 2.75[b]	8.76 ± 4.08[b]	6.32 ± 4.21[†]	6.94 ± 4.66
Control	2.51 ± 1.38[a]	0.71 ± 2.99[a]	2.83 ± 3.54[a]	-1.79 ± 2.47	-2.02 ± 2.80
	b*				
	T0	T1	T2	T1-T0	T2-T0
Home Bleaching	37.17 ± 3.74[a]	43.14 ± 4.04[ab]	39.40 ± 9.49[ab]	5.96 ± 4.53	2.23 ± 10.66
Office Bleaching	35.40 ± 5.08[a]	43.42 ± 8.87[b]	47.90 ± 5.88[b]	8.02 ± 8.68	12.50 ± 7.47[†]
Control	38.31 ± 2.59[a]	35.30 ± 5.02[a]	36.40 ± 5.44[a]	-3.01 ± 4.14	-1.91 ± 6.04

Note: Different letters indicate statistically significant difference between the groups (ANOVA / Tukey; p<0.05). [†] indicates statistically significant difference within each group in the time interval (MR-ANOVA with Bonferroni correction (α=0.016).

DISCUSSION

The in vitro study model was chosen for this research because of the control over the sample standardization and due to the difficulty of managing external factors in a clinical study, mainly the influence of conditions such as hygiene habits, frequency of tooth brushing, and commitment during the bleaching treatment.

Spectrophotometry technique as a method of colorimetric analysis allows reliable color assessment based on quantitative parameters, while visual analysis relates to subjective parameters.[14] The vast majority of spectrophotometers make use of the CIE L * a * b * system, which is widely used in Dentistry and was defined in 1976 by the Commission Internationale L 'Eclairage (CIE). The color spectrum is filtered as perceived by the human eye and thus processed to result in the parameters of L*, a* and b*. This system allows measuring the composites pigmentation[15-16] ceramics,[14] teeth and the color change after tooth bleaching protocols.[17]

In the present study, after bleaching protocols applied in T2, there was a tendency to return to baseline values (T0), except for parameters a* and b* in the office bleaching group. This event could be attributed to the fact that, in the home bleaching group, the specimens underwent 15 washes in the ultrasonic machine, simulating dental cleaning after each whitening cycle, while in the office bleaching group, only 3 washes were performed. Thus, it could be suggested that home bleaching protocol, with 5 times more cycles of cleaning and removal of pigments in the ultrasonic machine, offered better results in the return to initial values than office bleaching protocol. In analogy to the clinical interpretation of the presented data, the mechanical vibration of the ultrasonic bowl was equivalent to the mechanical cleaning achieved through tooth brushing.

The T1-T0 interval was associated to dental staining. It is relevant to understand that late staining is directly related to the influence of resin tegs on the dental surface, a condition reported in the literature in previous studies.[4,5,18-21] Authors agree with this point of view that resin residues can change tooth color through internal and external reactions. The reason for internal discoloration is associated to ultraviolet radiation and thermal energy present in the environment. Ultraviolet light can induce physicochemical reactions of the polymer that cause irreversible color changes[21] and external discoloration can occur by direct absorption of pigments from food.[21,22] Thus, the aging protocol with ultraviolet radiation was adopted to simulate the internal staining in the present study.

Previous studies have been done to analyze the color changes of orthodontic bonding materials and their interference with tooth color change.[21-23,3] However, Attin *et al.*[24] observed that there is no information in the literature regarding the effects of dental bleaching on the possible residual resins after orthodontic debonding. According to these authors, there are only studies that analyze the effects of bleaching materials on resins as restorative material, which contributes to the importance of the results of this current research.

The study by Claudino *et al.*,[25] observed that the debonding protocol and the tooth surface treatment after debonding may interfere with the bleaching treatment results. This study evaluated premolars aged by thermocycling and coffee solution, as well as the present study. The present study determined that the removal method would be standardized, since the primary outcome is the result of the bleaching agent protocol.

The randomized clinical trial by Aharari *et al*.,[26] showed that bleaching treatment improves the condition of tooth staining after orthodontic debonding, but did not find statistically significant result between the two types of protocols (home and office bleaching). It corroborates the results of the present study, which shows that there was an improvement in the coloring of both protocols, but with better effectiveness in the home bleaching protocol.

The influence of orthodontic bracket bonding and debonding using home bleaching protocol was also addressed by Gomes *et al.*[27] In the present study, the staining cycle (T1) included 21 days in coffee solution, while Gomes *et al.*[27] applied 4 days in aqueous solution containing 250 mL of black tea, 250 mL of coffee, 250 mL of red wine, 250 mL of tobacco solution, 250 mL of coca cola and 250 mL of artificial saliva at 37ºC. In both studies, there was a decrease in the L* parameter. The home bleaching protocol applied in the study presented herein was with 10% hydrogen peroxide - 40 min daily for 15 days; while Gomes *et al.*[27] used carbamide peroxide - 6 hours per day for 14 days. These differences in the methodology revealed the most intense staining in our study, due to the longer immersion time in the coffee solution and the shorter total time of home bleaching protocol, when compared to the study by Gomes *et al*.[27] Based on the data from the present study, the L* parameter at T2 tended to return to baseline at T0, while in the study by Gomes *et al*.,[27] the whitening of the specimens was effectively achieved due to the shorter staining time and longer bleaching protocol time.

Once there is a lack of studies analyzing tooth bleaching after orthodontic debonding, the present study can be useful as a baseline for further research. In the future, another group may be included in the methodology, combining the home bleaching and office bleaching protocols. The authors should also consider the limitation of not having different types of staining protocols in the present study, since only coffee solution was used for this purpose. In addition, the use of the ultrasonic machine to simulate toothbrushing can be considered a limitation, despite being standardized, but it does not simulate the intervals between toothbrushes in a person's routine. Furthermore, the results of this study should be evaluated with caution since human teeth were not used and the polishing of bovine teeth was not standardized. Clinical controlled research may be developed to add knowledge to the relevant data collected from in vitro studies, including, as suggested here, different staining protocols such as tea, coffee, wine and tobacco, and also associating the home and office bleaching protocols as a new experimental group.

CONCLUSION

Based on the results of the present study, it can be concluded that home bleaching protocol presented better performance for dental surface whitening in an eventual staining after orthodontic debonding.

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