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Spectrophotometric assessment of tooth bleaching under orthodontic braquets bonded with different materials

Avaliação espectrofotométrica do clareamento dental sob braquete ortodôntico fixado com diferentes materiais

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Resumo

Introdução: pacientes estão sendo submetidos ao clareamento durante tratamento ortodôntico com finalidade estética ou para antecipar a troca de restaurações após finalização do tratamento ortodôntico. **Objetivo**: avaliar a efetividade do clareamento dentário sob braquete ortodôntico fixado com diferentes materiais. **Material e método**: cem blocos de esmalte bovino foram divididos em dois grupos, clareamento de consultório e clareamento caseiro. O de clareamento de consultório foi subdividido em cinco (n=10): HP (controle – sem braquetes); SA(t) – braquetes fixados com Transbond XT, sem clareamento; SA(fm) – braquetes fixados com Fill Magic Ortodôntico, sem clareamento; HP(t) – braquetes fixados com Transbond XT submetidos ao clareamento e HP(fm) – braquetes fixados com Fill Magic Ortodôntico submetidos ao clareamento. O clareamento caseiro seguiu a mesma divisão descrita para o clareamento de consultório substituindo-se o agente clareador. Foram realizadas avaliações da cor através do espectrofotômetro nos tempos: 1) antes do manchamento (baseline); 2) após o manchamento; 3) após fixação dos braquetes e procedimentos clareadores. Os dados foram submetidos à ANOVA e diferenças analisadas através do teste de Tukey ($p<0,05$). **Resultado**: Para os dois tipos de clareamento o grupo controle teve ação clareadora efetiva. Grupos fixados com Transbond XT apresentaram maior potencial clareador dentre os grupos que apresentaram acessório ortodôntico, mas com ação clareadora diferente do controle positivo. Grupos fixados com Fill Magic Ortodôntico não apresentaram ação clareadora, assemelhando-se aos grupos controle negativo (saliva artificial). **Conclusão**: o braquete ortodôntico prejudicou a efetividade do tratamento clareador caseiro e de consultório, independente da resina utilizada para a fixação.

Descritores: Braquetes ortodônticos; clareamento dental; colagem dentária.

Abstract

Introduction: patients have been submitted to tooth bleaching during orthodontic treatment for aesthetic purposes or to anticipate the replacement of restorations after completion of the treatment. **Objective**: to evaluate the effectiveness of tooth bleaching under orthodontic brackets bonded with different materials. **Material and method**: a hundred bovine enamel blocks were divided into two groups, at-home and in-office tooth bleaching. In-office bleaching was subdivided into five groups (n = 10): HP (control - without brackets); SA(t) - brackets bonded with Transbond XT, without bleaching; SA(fm) - brackets bonded with Orthodontic Fill Magic, without bleaching; HP(t) - brackets bonded with Transbond XT subjected to bleaching; and HP(fm) - brackets bonded with Orthodontic Fill Magic subjected to bleaching. At-home bleaching followed the same treatments, only replacing the bleaching agent. Spectrophotometric assessment was used for tooth color determination at three moments: 1) before staining (baseline); 2) after staining; 3) after bonding the brackets and bleaching procedures. Data were submitted to ANOVA and analyzed by Tukey's test ($p < 0.05$). **Result**: For both types of bleaching, the control group had an effective bleaching action. Groups using Transbond XT presented greater bleaching potential among the groups with orthodontic accessory, but the bleaching action differed from the positive control. Groups using Orthodontic Fill Magic presented no bleaching action, resembling the negative control groups (artificial saliva). **Conclusion**: the orthodontic bracket impaired the effectiveness of the at-home and in-office bleaching treatment, regardless of the resin used for bonding.

Descriptors: Orthodontic brackets; tooth whitening; dental bonding.

INTRODUCTION

One of the reasons of discontentment among orthodontic patients is the enamel color change that occurs during treatment[1,2]. The staining of the teeth in this period may be associated with the color instability of the resinous material used to bond the bracket[3], or even by demineralization of the enamel[4] or the direct absorption of food colorants[2].

The mechanism of action of tooth whitening involves an oxidation-reduction reaction where the hydrogen peroxide reduces organic pigments impregnated in the enamel and dentin, thus allowing their elimination. When hydrogen peroxide gets in contact with the enamel surface, it releases unstable oxygen, which binds to other substances that are free or weakly bound to a particular substrate, for stabilization[5].

Dental enamel is a highly mineralized crystalline tissue that presents some permeability, allowing the diffusion of substances and the ionic exchange with the buccal environment[6]. Tooth whitening is only possible because of this permeability and the low molecular weight of some active chemical components of bleaching agents, such as hydrogen peroxide[7].

Dental whitening can be performed by two techniques: at-home and in-office[6,8]. At home, bleaching agents of low concentration in flexible trays are used in daily basis and supervised by the dentist. The in-office technique uses high concentrations of bleaching agents for short periods of exposure[6,9].

Hydrogen peroxide is the active compound of the whitening process. Thus, when bleaching is required, hydrogen peroxide-based bleaching agents must be used, an option widely used in the in-office technique. Carbamide peroxide-based products provide hydrogen peroxide in a gradual and continuous way; however, 10% of carbamide peroxide results in approximately 3.6% hydrogen peroxide[9].

Aware of the diffusion capacity of bleaching agents in dental tissues, orthodontists have subjected their patients to dental bleaching during orthodontic treatment for aesthetic purposes or to anticipate the exchange of dental restorations after orthodontic treatment is completed. However, the real effectiveness of the diffusion of the bleaching agent under the orthodontic accessory is not fully understood so far, and more, if after whitened, there is any difference in the effectiveness of the treatment depending on the material used to bond the brackets.

In order to address these questions, the present study aimed to evaluate through reflectance spectrophotometry the effectiveness of tooth whitening under orthodontic brackets bonded with different materials.

MATERIAL AND METHOD

Preparation of Specimens

One hundred bovine incisor teeth were extracted in a slaughterhouse and refrigerator in Alagoas (MAFRIAL), stored in 1% thymol solution and kept under refrigeration until use. The teeth were cleaned with a scalpel blade, in order to remove the periodontal ligament. They then had the coronal portion separated from the root (Figure 1A) with the double-sided diamond disk (KG Sorensen, Barueri, SP, Brazil) at low rotation under constant irrigation, removing the coronal pulp and discarding the root.

A high concentration diamond wafering blade (4" x 0.12 x 0.5, Extec, Enfield, USA) coupled to a metallographic cut-off machine (Figure 1B) (South Bay Technology Inc. San Clemente, CA, USA) was used to perform four cuts in the coronal portion, in the mesio-distal and incisor-cervical directions, obtaining dental blocks with dimensions of 8.0 x 8.0 mm (Figure 1C) with a variation of ± 0.3 mm. The size of the blocks was checked with a digital micrometer (Mitutoyo, Aurora, Illinois, USA) (Figure 1D). The dental blocks were kept in distilled water.

The blocks were bonded with sticky wax in acrylic bases to facilitate handling. For this, the vestibular enamel surfaces were placed in contact with the wax, that is, facing downwards, and the dentin facing upwards, so that the dentin was exposed. Dentin planing was done with 320 grit silicon carbide sandpaper in a metallographic polish (APL 4, Arotec, Cotia, SP, Brazil) (Figure 1E) for due evenness, at low speed for 15 seconds. Then, the dental blocks were repositioned on the acrylic bases, this time with the surfaces of the buccal enamel facing upwards and pressed with the aid of a parallelogram (Figure 1F), constituting the specimens.

Whitening Test

The acrylic bases were painted with matte black paint (Figure 1G) to prevent the passage of external light during the color reading process, which could interfere with the final result of the assessment. The specimens showing cracks, hypoplasia and spotting were excluded from the sample and replaced.

The specimens were randomly assigned to two groups: in-office bleaching (Whintness HP Blue, FGM, Joinville, Santa Catarina, Brazil) and at-home bleaching (Whitness Perfect, FGM, Joinville, Santa Catarina, Brazil). Each group was divided into five subgroups (n = 10).

In-office bleaching:

1. HP - positive control: no brackets;
2. SA(t) - negative control: brackets bonded with Transbond XT (3M Unitek, São José do Rio Preto, SP, Brazil), without bleaching;
3. SA(fm) - negative control: brackets bonded with Orthodontic Fill Magic (Vigodent, Rio de Janeiro, RJ, Brazil), without bleaching;
4. HP(t) - brackets bonded with Transbond XT subjected to bleaching;
5. HP(fm) - brackets bonded with Orthodontic Fill Magic subjected to bleaching.

At-home bleaching:

1. WP - positive control: no brackets;
2. SA(t) - negative control: brackets bonded with Transbond XT, without bleaching;

Figure 1. Sequence of methodology. (**A**) Coronal portion of the teeth after root excision; (**B**) Metallographic cut-off machine used for all dental cuts; (**C**) Dental blocks with dimensions of 8.0 x 8.0 mm; (**D**) Size checked with digital micrometer; (**E**) Metallographic polishing machine used for polishing; (**F**) Teeth pressed with the paralellometer; (**G**) Acrylic bases painted with matte black paint; (**H**) Specimens after staining; (**I**) Bonding of metal brackets; (**J** and **K**) Application of the respective bleaching treatments.

3. SA(fm) - negative control: brackets bonded with Orthodontic Fill Magic, without bleaching;
4. WP(t) - brackets bonded with Transbond XT subjected to bleaching;
5. WP(fm) - brackets bonded with Orthodontic Fill Magic sub-ected to bleaching.

Then the specimens were submitted to the staining stage (Figure 1H) with black tea (Maratá, Itaporanga D'Ajuda, SE, Brazil), prepared in the proportion of 10 g of tea to 1 L of distilled water boiled for two minutes) for five consecutive days with two daily exchanges, being kept in an orbital shaker table (Termoagitator TE-420, Tecnal, Piracicaba, SP, Brazil) at 37°C and 100 rpm. Before each new exchange, the specimens were washed in distilled water and immersed in artificial saliva for one hour, until they were re-immersed in the tea.

After this, stainless steel brackets (Morelli, SP, Brazil) (Figure 1I), Roth, for lower incisors, with slot 022" x .030" in 1.7 mm x 2.3 mm base mesh, were bonded with the resins corresponding to each group, according to the manufacturers' guidelines. The application of bleaching treatments began (Figures 1J and 1K) following the indications of the manufacturers. Before the application of all the treatments, the specimens were washed in distilled water, placed in artificial saliva and kept in an orbital table. The groups that did not undergo bleaching remained immersed in artificial saliva throughout the experiment.

Color assessment was performed using a digital spectrophotometer (CR-321, MINOLTA Co., Tokyo, Honshu, Japan) at three moments: Initial - before staining; Intermediate - after staining; and Final - after bleaching. The spectrophotometer describes the three-dimensional color through the CIELAB scale, which makes use of a mathematical system where all colors are defined by the coordinates of the three axes: L*, a* and b*. The L* axis corresponds to the brightness and varies from 0 (black) to 100 (white). The a* and b* axes are related to color and saturation, but a* varies from red (positive) to green (negative) and b* from yellow (positive) to blue (negative). The color reading was always performed at the central point of the block, in the same environment and with the same type of illumination.

Statistical Analysis

The values of the parameters L*, a* and b* obtained by spectrophotometric analysis were submitted to one-factor analysis of variance (ANOVA) and any differences were evaluated through the Tukey test ($p < 0.05$).

RESULT

After the staining stage, no discrepancy in the total color variation (ΔE) was seen between the experimental groups, either in the in-office bleaching (ANOVA, p = 0.31) Figure 2A, or in the at-home bleaching (ANOVA, p = 0.28) Figure 2B.

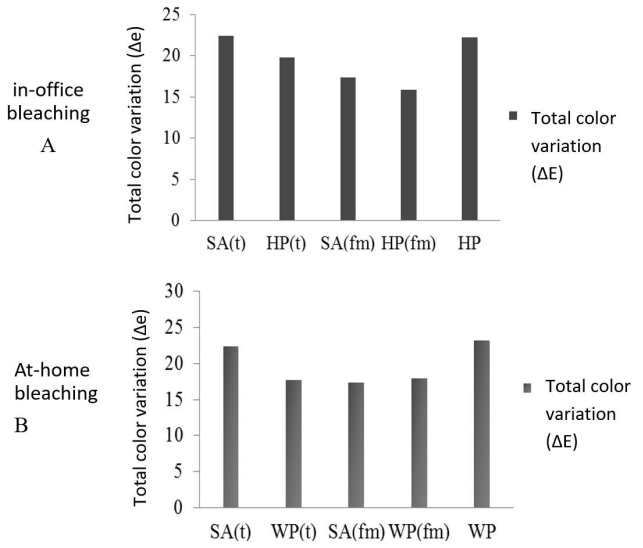

Figure 2. Total color variation (ΔE) between the baseline and staining phases. (**A**) Experimental groups submitted to in-office bleaching; (**B**) Experimental groups submitted to at-home bleaching. Both results indicate homogeneity.

IN-OFFICE BLEACHING

When comparing ΔE after the bleaching stage Figure 3, the groups were found to be heterogeneous, and therefore statistically different from each other (ANOVA, p = 0.0007). Thus, it was necessary to apply the Tukey test to identify the relationship between the groups. The HP group diverged from the others and triggered the greatest variation among all groups tested. The HP(t) group was statistically different from all groups and caused a significant change in total color variation. The HP(fm) group was statistically different from the groups that presented the highest bleaching action, i.e. the group with brackets HP(t) and without brackets (HP), and was similar to the negative controls SA(t) and SA(fm).

AT-HOME BLEACHING

When comparing ΔE after the bleaching stage Figure 4, the groups were found to be heterogeneous, and therefore statistically different from each other (ANOVA, p = 0.0000001). Thus, it was necessary to apply the Tukey test to identify the relationship between the groups. The WP group diverged from the others and triggered the greatest variation among all groups tested. The WP(t) group was statistically different from all groups and caused a significant change in total color variation. The WP(fm) group was statistically different from the groups that presented the highest bleaching action, i.e. the group with brackets WP(t) and without brackets (WP), and was similar to the negative controls SA(t) and SA(fm).

DISCUSSION

In order for the study to be carried out in an adequate manner, it was essential that the specimens behave homogeneously in relation to the ΔE parameter (in the staining stage), which was confirmed in both at-home and in-office bleaching.

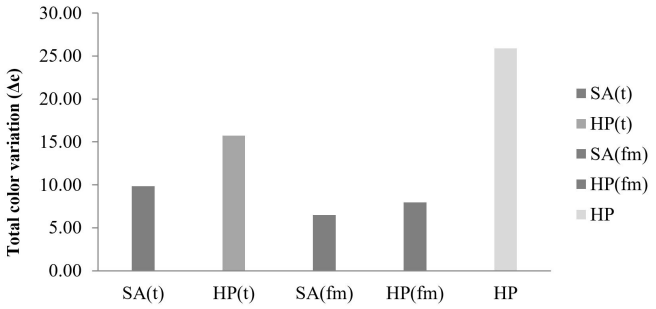

Figure 3. Total color variation (ΔE) between the staining and in-office bleaching stages of the experimental groups. There was evidence of heterogeneity among groups (ANOVA, p = 0.0007).

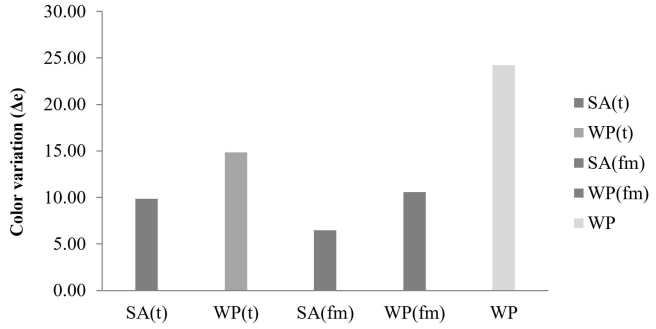

Figure 4. Total color variation (ΔE) between the staining and at-home bleaching stages of the experimental groups. There was evidence of heterogeneity among groups (ANOVA, p =0.0000001).

As the main objective of the research was to analyze the chemical bleaching potential in the presence of orthodontic brackets bonded with different materials, it was necessary that the specimens were stained to be then subjected to bleaching. The stain is intended to simulate the accumulation of pigments adhered to the surface of the teeth, usually from food, the so-called extrinsic stains. According to Téo et al.[10], of all the substances that have potential of pigmentation, the one that promoted greater staining was black tea. For this reason we used this substance in the present study. The staining was effective in both at-home and in-office bleaching groups, since the L* value decreased in all groups. Furthermore, after staining, the experimental groups were homogeneous when compared to each other.

The spectrophotometric assessment showed that although there was bleaching in the groups where the orthodontic brackets were bonded, these groups differed statistically from their positive control groups (HP and WP).

The greater bleaching action of the positive control groups is explained by the fact that the hydrogen peroxide is in direct contact with the surface to be cleared, which was not the case with the other groups. Therefore, the former was used as a positive control because it has clinically and scientifically proven whitening action.

The HP(t) and WP(t) groups were statistically different from both their negative and positive controls. This can be explained by the fact that the exposure to the whitening agent in the pores and periquimacies of the enamel surface did not occur uniformly

in the areas below the bracket, what is the case of bleaching in the absence of brackets. However, the bleaching action observed in the HP(t) and WP(t) groups showed that the bleaching agent was able to infiltrate into the bonding material, thus allowing bleaching, although statistically different from the positive controls[11,12].

In turn, the groups HP(fm) and WP(fm) were statistically different from the groups that had bleaching action with brackets - HP(t) and WP (t) - and without brackets - HP and WP. The similarity with its negative controls show that the Fill Magic Orthodontic resin negatively influenced the potential of the bleaching agents in the in-office and at-home methods, preventing it to infiltrate, resulting in less bleaching.

The results of this study agree with those found by Lunardi et al.[13], who showed in their study that the resin used to bond the orthodontic brackets in contact with the enamel affects the effectiveness of the dental bleaching, as if the bleaching gel were unable to penetrate uniformly throughout the sample, resulting in a poorly lit area under the orthodontic bracket.

Hintz et al.[14] observed in their study the difficult diffusion of the bleaching agent where the bracket had been placed and then removed. According to these authors, it is possible that the tags of the resin remaining after the removal of the brackets act preventing the diffusion and action of the bleaching agent.

The results of this study lead the authors to agree Consolaro et al.[12] who stated that bleaching during orthodontic treatment should only be performed in indispensable cases, such as for professional reasons, and that this procedure must be a artifice and not a general rule, since it is known to which extent bleaching in the presence of orthodontic brackets can lead to color irregularities.

It was found, therefore, that the bonding of the brackets and the lack of direct contact of the enamel with the bleaching gels affects the result of the bleaching treatment, as the bleaching agent does not penetrate uniformly throughout the specimen, causing the area under the bracket to be less effectively cleared.

CONCLUSION

Considering the limitations of this *in vitro* study and based on the results, we can conclude that orthodontic brackets impair the effectiveness of at-home and in-office bleaching treatment, regardless of the resin used for bonding.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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