

## Bonding strength of ceramic laminates to dental enamel after bleaching treatment

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### Abstract

**Aim** - This study evaluated the influence of bleaching agents on bond strength of ceramic laminates bonded to dental enamel, at different time periods.

**Material and methods** - Eighty fragments of bovine incisors were divided into three groups: Group I - (control) without bleaching; Group II - At-home bleaching with 7.5% hydrogen peroxide (White Class, FGM) 1 hour-daily applications for 14 consecutive days; Group III - in-office bleaching with 35% hydrogen peroxide (Whiteness HP, FGM) (single session, 3 applications, 15 minutes). After bleaching, groups II and III were divided into 4 subgroups (n = 8), according to the cementation of the veneers. Specimens were subjected to shear bond strength testing after 24 hours, 7 days, 14 days and 28 days (EMIC, 20N load, 0.75mm/min cross-head speed). The specimens were analyzed in a magnifying glass (X20) for failure mode. The topography of the enamel surface of representative specimens was analyzed under SEM before and after bleaching.

**Results** - The results were evaluated by ANOVA and Tukey's test ( $\alpha = .05$ ). There was no statistically significant difference for the mean bond strengths of the tested groups. The results were similar to each other, except between the mean bond strengths of GII-24h and GII-28 days which presented a statistically significant difference.

**Conclusion** - The bond strength values for home bleaching had a more efficient recovery when compared to in-office bleaching after a 28-day period. Most of the failures were of the adhesive type. Both types of bleaching caused changes in the enamel surface.

**Key words:** Tooth Bleaching; Dental Enamel; Dental Bonding

### INTRODUCTION

Following the most demanding standards of beauty, Dentistry offers treatments that allow great aesthetic changes. On the other hand, there is also an appreciation of conservative procedures, where dental bleaching has been a great option (Suliman, 2008; Boushell *et al.*, 2012; Soares *et al.*, 2014). At-home tooth bleaching using a 10% carbamide peroxide gel was found to be the safest method with minimal adverse effects (Joiner 2006; Boushell *et al.*, 2012). Even though it is a conservative treatment, bleaching may cause some morphological changes in the enamel surface layer, in addition to a significant reduction of calcium and phosphorus content (Soares *et al.*, 2014; Pedreira de Freitas *et al.*, 2011; Tezel *et al.*, 2007). This fact may compromise some types of procedures, if performed soon after the end of the treatment, by interfering in the adhesion of resin-based materials, by inhibiting their polymerization (Attin *et al.*, 2004; Potocnick *et al.*, 2000).

In addition to the effects on mechanical and morphological characteristics, bleaching may also significantly decrease bond strength due to the accumulation of residual oxygen on the enamel surface after the use of peroxide-based solutions (Goldberg *et al.*, 2010; Pizani *et al.*, 2015). The aim of this study was to evaluate the shear bond strength of lithium disilicate ceramic laminate veneers cemented to enamel previously submitted to at-home and in-office bleaching with hydrogen peroxide at different periods of time; to analyze the topography of the enamel surface under SEM before and after the different bleaching treatments; and verify the failure mode.

### MATERIALS AND METHODS

This study was carried out with bovine teeth and approved by the Committee of Ethics in the use of animals (CEUA), Faculty of São Leopoldo Mandic (registration protocol # 2016/013, from 06/20/16).

Eighty-five lower bovine incisors were used. After the removal of organic debris, they were stored in 1.0% chloramine-T solution and kept for one week at room temperature. The teeth were then rinsed in an ultrasonic bath for 5 min, to eliminate any remnants. The enamel fragments were obtained in a machine for decorative cuts in glass (USE-F-02, USE-MAK, Diadema, Brazil), where a saw-cup type 10mm-diameter diamond drill was coupled for cutting the fragments under continuous irrigation. Circular 8mm-diameter fragments were obtained from the center of the buccal aspect of the crown (Figure 1).



Figure 1 - View of the fabrication of the specimens

Then the fragments were embedded in plastic cylinders (PVC<sup>®</sup> 3/4", Tigre S.A. Tubos e Conexões<sup>®</sup>, Joinville, Brazil), with epoxy resin (Redelease, São Paulo, Brazil). After embedding, they were stored in distilled water (37°C) until the moment of use. All the specimens were submitted to prophylaxis with pumice paste and water, followed by polishing of enamel with 600 and 1200 grit sandpaper disks in a polisher (Aropol 2V, Arotéc Indústria e Comércio, Cotia, Brazil). After this phase the specimens were divided into the following groups according to the surface treatments and testing time after the cementation of the veneers according to Table 1.

Table 1 - Division of groups according to the bleaching technique and testing time

Group	Bleaching Technique	Testing Time
G I	(n=8) control	Without bleaching
G II	At-home bleaching (White Class 7,5%)	G IIA (n=8)
		G IIB (n=8)
		G IIC (n=8)
		G IID (n=8)
G III	In-office bleaching (Whiteness HP 35%)	G IIIA (n=8)
		G IIIB (n=8)
		G IIIC (n=8)
		G IIID (n=8)

At-home bleaching was performed with vacuum-formed, custom-made trays (Vacuum forming machine, Bio Art, Bio Art Equipamentos Odontológicos Ltda, São Carlos, Brazil), with 1mm thick silicone sheets. The bleaching gel used was 7.5% hydrogen peroxide (White Class, FGM, Joinville, Brazil) for 1 hour daily for 14 days, according to the manufacturer's instructions. After each application, the specimens were rinsed in tap water and stored in distilled water until further application. After 14 days of bleaching, the groups were separated into subgroups according to the time of veneer cementation, i.e., 24h, 7 days, 14 days and 28 days.

In-office bleaching was performed with 35% Hydrogen Peroxide in a single session, following the manufacturer's instructions. The bleaching gel was applied to the enamel surface using a disposable applicator in three 15-minute applications for each session. After completion of the bleaching, the specimens were separated into subgroups for cementation of the veneers at the same periods determined for the at-home bleaching group.

A total of 144 lithium disilicate laminate veneers (IPS e.max Press, Ivoclar Vivadent, Schaan, Liechtenstein) were fabricated, measuring 3mm in diameter and 2mm in height. These were polished with polishing rubbers (EVE) until a visually smooth surface was obtained.

Two laminates were cemented in each specimen, in all groups.

For cementation, the fragments were conditioned with 37% phosphoric acid for 15 seconds and then rinsed for 30 seconds and dried with air jets. The adhesive was applied (Tetric N-Bond (Ivoclar Vivadent, Schaan, Liechtenstein) and light-cured for 10 seconds. The ceramic laminates were treated with 5% hydrofluoric acid for 20 seconds, rinsed and dried. The pretreated surfaces were cleaned with 37% phosphoric acid for 30 seconds. A silane coupling agent was applied, allowed to stand for 60 seconds and air-dried. The resin cement was applied inside the veneers (Variolink Veneer, Ivoclar Vivadent, Schaan, Liechtenstein) and light-cured for 60 seconds. The specimens were stored in artificial saliva in an oven (37°C) for 24 h before the mechanical test (ISO/TS 11405:2015).

The shear bond strength testing was performed in an universal test machine (EMIC DL 2000, Instron Scientific Equipment, São Carlos, Brazil), with a 20N-force and a cross-head speed of 0.75mm/min (ISO/TS 11405: 2015) until breakage.

After testing, the specimens were analyzed with a stereomicroscopic magnifying glass (ZX7, Olympus, Tóquio, Japão), with x20 increase, to determine the failure mode.

Statistical analysis was performed using a statistical package (Action Stat 3.1, for Windows® 10/2016). Mean bond strength values were subjected to analysis of variance (ANOVA) and Tukey's test (significance level  $p < 0.05$ ).

Four specimens from the home bleaching group and four from the office bleaching group were randomly selected for analysis of the enamel surface before and after the bleaching treatment. The analysis was performed through a Scanning Electron Microscope (JSM-6390LV, Jeol Instruments Brazil).

## RESULTS

The results represented by the averages of bond strength values for the different groups when submitted to the shear test are shown in figure 2.

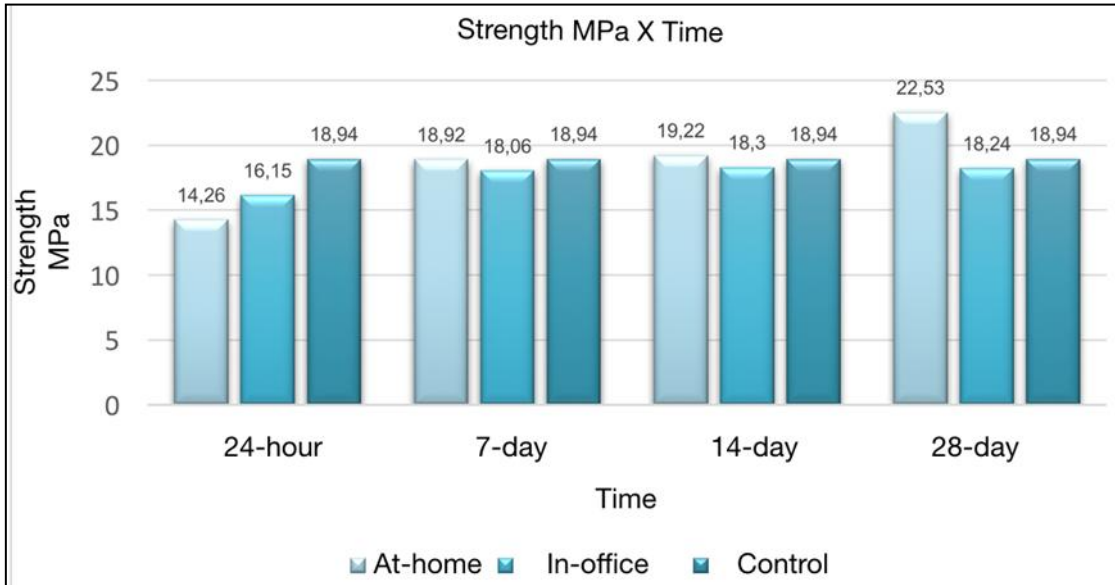


Figure 2 - Graphical representation of the mean values of bond strength (MPa), according to the bleaching treatment and the time of the test

There was no statistically significant difference between the mean bond strength of the specimens submitted to home bleaching and office bleaching. A statistically significant difference was observed between 24 h- (14.26 MPa) and 28-day (22.53 MPa) periods after conclusion of the home bleaching treatment. From the regression study, we found that the recovery bond strength was 0.2743 MPa/day whereas for in-office bleaching the recovery of bond strength was 0.0618 MPa/day. This means that the increase of 0.2743 MPa/day represents 22.5%, or less than 1/4 of the daily increase value that occurs after home bleaching. It was evident that the recovery of the bond strength for in-office bleaching is lower than that of home bleaching, considering a 28-day period (figure 3).

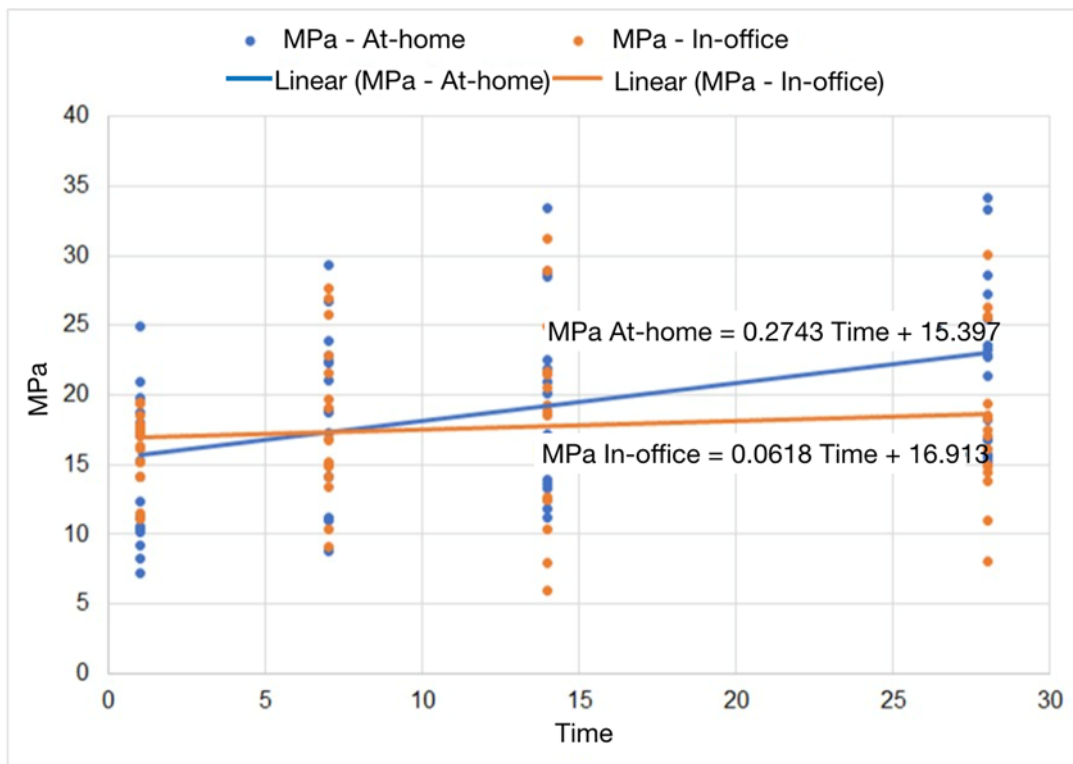


Figure 3 - Graphical representation of linear regression between bond strength (MPa) of home and in-office bleaching in relation to the time tested

Among the samples analyzed, most of the failures were of the adhesive type (93.75%). Only two specimens presented mixed type defects (6.25%), one of them subjected to at-home bleaching and tested after 14 days and another subjected to in-office bleaching and tested after 24h. In the control group 100% of the failures were of the adhesive type (figure 4).

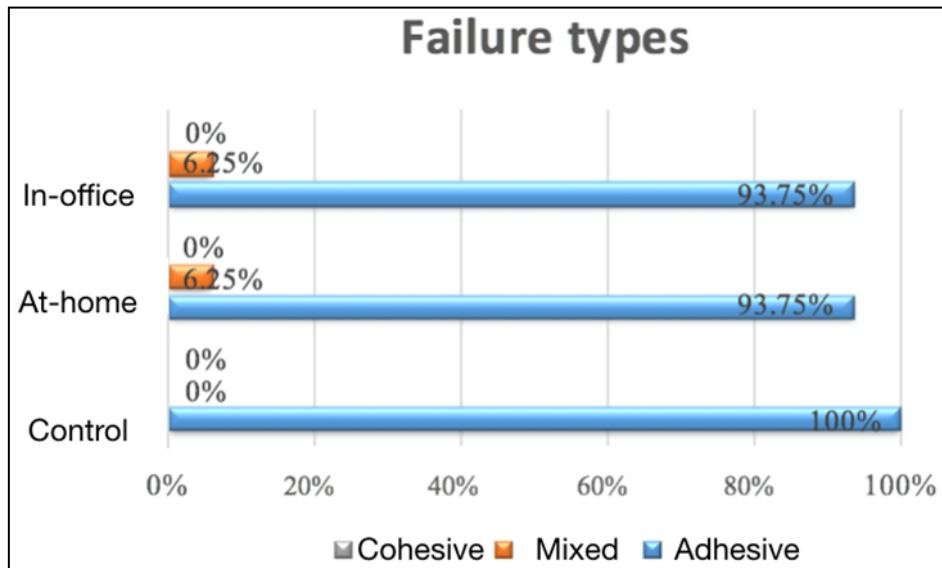


Figure 4 - Graphical representation of failure modes

Scanning Electron Microscopy (SEM) photomicrographs of the 8 representative samples showed that both at-home bleaching and office bleaching caused changes in the enamel surface. There was an increase in porosity, with the presence of severe and moderate irregularities in several regions, besides the exposure of enamel prisms.

Figures 5 and 6 show the SEM photomicrographs divided by specimens, where the first figure corresponds to the initial appearance before the bleaching treatment and the corresponding sample submitted to bleaching.

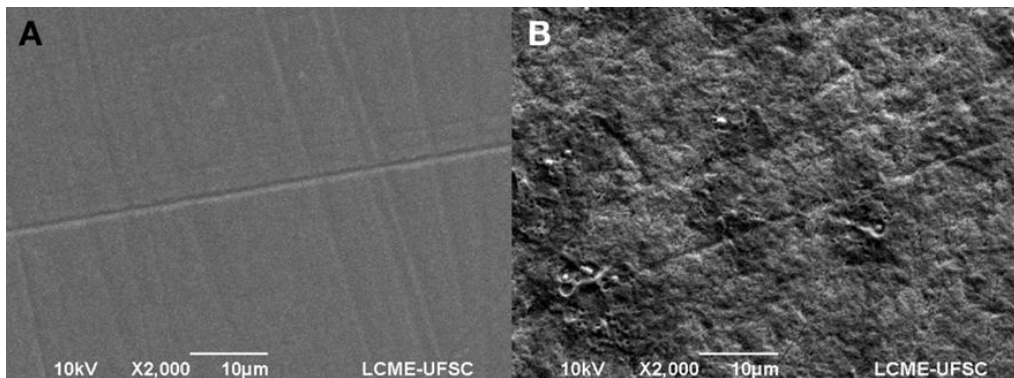


Figure 5 - A) Sample 2 before bleaching treatment; B) Sample 2 after the home bleaching treatment with 7.5% hydrogen peroxide

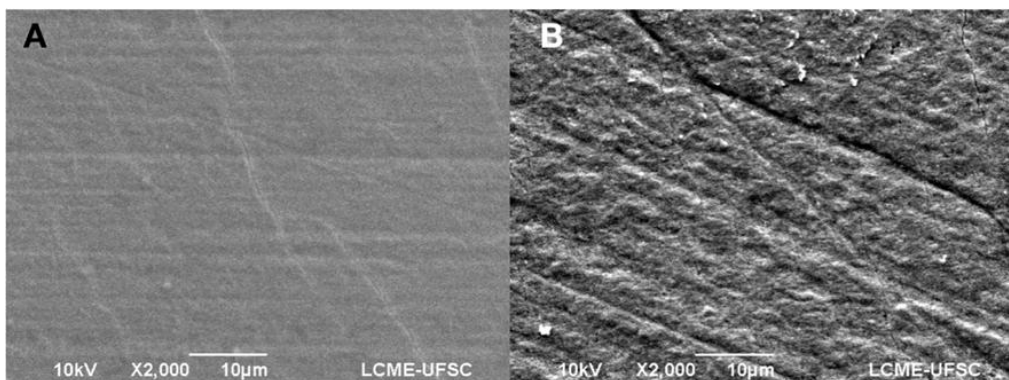


Figure 6 - A) Specimen #1 before the bleaching treatment; B) Specimen #1 after the in-office bleaching treatment with 35% hydrogen peroxide

## DISCUSSION

Hydrogen peroxide is the active compound of the peroxide bleaching substances commonly used for in-office bleaching. For home bleaching, carbamide peroxide is the most used substance (Titley, Torneck, Ruse, 1992; Rotstein *et al.*, 1996). In this study, the use of hydrogen peroxide in its purest form was chosen for the two groups in order to reduce variables, considering that carbamide peroxide is decomposed in urea and hydrogen peroxide.

One study tested reducing the concentration of a hydrogen peroxide-based bleaching agent from 35% to 17.5% when applied to enamel for 45 min (3 x 15 min - 4 sessions) and found the same bleaching pattern using 35% hydrogen peroxide (3x 15 min) (Soares *et al.*, 2014). Conversely, another study reported that a

bleaching agent with a higher concentration for a much shorter period, acts with greater intensity and lower frequency (Pizani *et al.*, 2015), concluding that the results obtained between the groups tested were equivalent, with no statistically significant difference.

In the present study, no significant difference was observed between the mean bond strength values obtained between the different types of bleaching treatments with hydrogen peroxide.

When the groups are evaluated in relation to recovery of the bond strength, the best result was for the home bleaching treatment, this means that its recovery is more efficient when compared to the office bleaching. This result can be attributed to the composition of the at-home bleaching agent, which presents sodium fluoride and calcium. Kim *et al.* (2011) claim that an ideal remineralization system should provide not only calcium ions, but also phosphorus and fluoride ions, which are lost during bleaching treatment. Therefore, Pizani *et al.* (2015) argue that not only the presence of calcium can inhibit demineralization, but also the concentration of the bleaching gel. In conclusion, factors such as gel concentration and composition may have favored the recovery of the bond strength values of at-home bleaching in relation to in-office bleaching.

There was also a statistically significant difference for the group of home bleaching in 24h and 28 days. Lago and Garone-Netto (2013), also demonstrated that the restorative procedures performed immediately after bleaching presented decreased bond strength values when compared to values at 7 and 14 days. In order to elucidate the results, it can be said that even when using a low concentration bleaching agent, i.e. at-home bleaching, the bond strength is also impaired shortly after the end of the treatment, recovering gradually until the 28 day-test group. Therefore, the use of a lower concentration of the bleaching agent may favor a more efficient recovery of the bond strength to enamel, but this does not mean that it does not cause deleterious effects at the beginning of the bleaching process. Failure mode analysis demonstrated most adhesive type failures. This corroborates the findings of Darzé *et al.* (2015), who also observed a predominance of adhesive failures in their studies, when using hydrogen peroxide.

By means of microscopic images, the topography of the enamel surface, before and after bleaching, shows that, both in the home bleaching and in the office bleaching, there was a change in surface texture, pore enlargement, erosion, presence of irregularities and exposure of enamel prisms. These structural changes analyzed by scanning electron microscopy were also found in several other studies, with different bleaching agents at different concentrations (Bitter, 1998; Potocnick *et al.*, 2000; Kaur, 2003; Pizani *et al.*, 2015).

There are a large amount of bleaching products, with different concentrations and protocols of use, making it difficult to standardize data. However, the literature is unanimous in reporting the decrease in adhesive strength shortly after the bleaching treatment, but still finds difficulty in defining the most adequate time to perform adhesive procedures. It is suggested that more studies be carried out, with standardization of the methodology, to obtain concise and comparable results.

## CONCLUSIONS

Considering the methodology used and the results obtained in the present experiment, it can be concluded that:

- There were no statistically significant differences between the mean bond strengths of the groups submitted to at-home bleaching and in-office bleaching
- There was a statistically significant difference between the specimens submitted to at-home bleaching, tested in 24 hours and those tested in 28 days after the end of bleaching
- Both at-home and in-office bleaching caused changes in the enamel surface, with a significant increase in porosity, presence of severe and moderate irregularities, and exposure of the enamel prisms in several regions;

There was a predominance of adhesive fractures.

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