INFLUENCE OF CIGARETTE SMOKE ON ENAMEL COLOR STABILITY AFTER ORTHODONTIC DEBONDING: AN IN VITRO STUDY

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Palavras-chave: Descolagem Dentária. Estética Dentária. Fumar Cigarros. Ortodontia.

RESUMO

Objetivo: O objetivo deste estudo foi avaliar a estabilidade da cor do esmalte dentário exposto à fumaça de cigarro após a descolagem ortodôntica. **Métodos**: Trinta e dois incisivos bovinos foram alocados nos grupos controle (C_1 and C_2) e experimental (n = 8) de acordo com protocolos de colagem ortodôntica distintos: com adesivo (B_1) e sem adesivo (B_2) e expostos à fumaça de cigarro. Amostras do B_1, B_2 e C_2 foram expostas a dez ciclos de fumaça em uma câmara específica e hermética, enquanto o C_1 permaneceu armazenado em saliva artificial. A análise da estabilidade de cor foi realizada com um espectrofotômetro de acordo com o sistema L* a* b*. As comparações intergrupos e o efeito do tempo foram verificados com ANOVA / Tukey e testes t de Student, respectivamente (a=0,05). **Resultados:** Não foram observadas alterações de cor estatisticamente significativas no C_1 (L*: -0,69 ± 0,80; a*: 0,36 ± 0,23; b*: 0,17 ± 0.50) e sem adesivo (B_2) (L*: -3,74 ± 2,85; a*: 0,93 ± 0,73; b *: 1,13 ± 1,16) durante o tempo de estudo (p>0,05). No entanto, o grupo com adesivo (B_1) apresentou alterações significativas de cor em L*: - 5,55 ± 2,28, a*: 2,33 ± 0,77 eb*: 3,30 ± 1,37, o que significa, mais escuro, mais verde e mais amarelo, respectivamente (p<0,05) e o grupo controle exposto à fumaça de cigarro (C_2) apresentou alterações significativas de cor em L*: -1,72 ± 0,28 e b*: 1, 82 ± 0,22, o que significa, mais escuro e mais amarelo, respectivamente. **Conclusão**: A estabilidade da cor do esmalte foi afetada pela exposição à fumaça de cigarro após a descolagem ortodôntica, principalmente quando o protocolo de colagem incluía a aplicação de adesivo.

Keywords: Dental Debonding. Dental Esthetics. Cigarette Smoking. Orthodontics.

ABSTRACT

Objective: The aim of this study was to evaluate the color stability of dental enamel exposed to cigarette smoke after orthodontic debonding. **Methods**: Thirty-two bovine incisors were allocated into control (C_1 and C_2) and experimental groups (n=8) according to distinct bonding protocols: with adhesive (B_1) and without adhesive (B_2) and exposure to cigarette smoke. Samples from B_1, B_2 and C_2 were exposed to ten cycles of smoke in a specific and hermetic chamber while the C_1 remained stored in artificial saliva. Color analysis was performed with a spectrophotometer according to the L*a*b* system. Intergroup comparisons and effect of time were estimated with ANOVA/Tukey and paired Student t tests, respectively (a=0.05). **Results**: Statistically significant color changes have not been observed in C_1 (L*: -0.69 ± 0.80; a*: 0.36 ± 0.23; b*: 0.17 ± 0.50) and without adhesive (B_2) (L*: -3.74 ± 2.85; a*: 0.93 ± 0,73; b*: 1.13 ± 1.16) through the study time (p>0,05). However, the group with adhesive (B_1) presented significant color changes in L*:-5.55 ± 2.28, a*: 2.33 ± 0.77 and b*: 3.30 ± 1.37, what means, darker, greener and more yellow, respectively (p<0,05) and the control group that was exposed to the cigarette smoke (C_2) presented significant color changes in L*: -1.72 ± 0.28 e b*: 1.82 ± 0.22, what means, darker and more yellow, respectively. **Conclusion**: Enamel color stability was affected by exposure to cigarette smoke after orthodontic debonding, especially when bonding protocol comprised the application of primer adhesive.

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INTRODUCTION

The introduction of the acid etching technique in Orthodontic field improved the evolution of orthodontic brackets bonding. In this perspective, one of the main concerns is that at the end of the orthodontic therapy, the enamel surface presents similar conditions as before treatment.[1]

After orthodontic debonding, composite residues remain on enamel surface and some studies have shown that irreversible penetration of resin tags in the enamel structure occurs during brackets bonding protocol. The composite material can infiltrate dental structure from 11.8 µm to 18.9 µm, sometimes reaching up to 100 µm.[2-4] Residual adhesive can remain on the tooth even if an enamel layer is removed during debonding protocol.[5]

Despite composite resins are the first choice when dental aesthetics is required, these materials present limitations such as surface roughness and porosity, associated to staining[6] and infiltration of food dyes and cigarette residues, reducing the longevity of aesthetic treatments.[7]

It is known that there are about 1 billion of smokers all over the world, of which high consumption rates are related to teenagers. And it is associated with oral cancer and enamel staining[8]. There some studies reporting the influence of cigarette smoke as a staining agent for aesthetic biomaterials,[9-11] study by Omar et al. 2020[12] investigated the influence of cigarette smoke on shear bond strength regarding to brackets, but there are no studies relating cigarette smoke with orthodontic bonding materials and the effects on aesthetic after debonding procedures.

It is hypothesized that patients undergoing orthodontic treatments with fixed appliances, and, who are also cigarette users may have a higher chance of enamel staining after orthodontic brackets debonding. Thus, the aim of this study was to evaluate, in vitro, the color stability of dental enamel exposed to cigarette smoke after orthodontic brackets debonding.

MATERIAL AND METHODS

Sample

This study was approved by the Animal Ethics Committee of the Center of Health Sciences of the Universidade Federal do Rio de Janeiro under protocol number 01200.001568/2013-87.

According to a prior pilot study, a power sample analysis based on the formula described by Pandis[13] considered a minimum of eight samples per group for detecting difference between means of 5 (for parameter L of color stability from the CIL*a*b* system) with standard deviation of 2.1 (a=5% and study power = 80%).

Thirty-two bovine incisors, obtained from a certified slaughterhouse, were selected for this study. Dental crowns were separated from the root using a diamond disc (KG Sorensen, Cotia, São Paulo, Brazil), inserted in a PVC cylindrical fragment (25 mm x 20 mm - Lusafilm- Dispafilm do Brasil Ltda, São Paulo, Brazil) so that the buccal crown surface was perpendicular to the PVC matrix; and fixed with a self-curing acrylic resin (JET, Classic Dental Articles LTDA, Campo Limpo Paulista, São Paulo, Brazil). Then the buccal surface was sanded with sandpapers No. 400, 600 and 1200 (3M, Sumaré, São Paulo, Brazil) under water irrigation (30 seconds each) on a Politriz machine (Ecomet II, Buehler, Illinois, USA) so that flat, smooth and polished surfaces were obtained. The samples were stored in distilled water at 37°C. The entire procedure was performed by the same operator (A.R.S.).

Samples were allocated into control and experimental groups (n = 8) according to orthodontic bonding protocol and cigarette smoke exposure (Table 1). Edgewise brackets (0.022-in) (Morelli, Sorocaba, SP, Brazil) were bonded to experimental groups, under the following protocols: B_1 - phosphoric acid 37% (Nova DFL, Rio de Janeiro, RJ, Brazil), primer adhesive (Transbond XT Light Cure Adhesive Primer, 3M Unitek, Monrovia, CA, USA) and Transbond XT Light Cure Adhesive Paste composite (3M Unitek, Monrovia, CA, USA); and B_2 - phosphoric acid 37% (Nova DFL, Rio de Janeiro, RJ, Brazil) and Transbond XT Light Cure Adhesive Paste composite (3M Unitek, Monrovia, CA, USA) (Figure 1). Control groups were not submitted to orthodontic bonding, and allocated into C_1 and C_2 according to non-exposure and exposure to cigarette smoke, respectively.

***Table 1**: Groups division according to bonding protocol and exposure to cigarette smoke.*

GROUPS	BONDING PROTOCOL	SMOKE EXPOSURE
B_1	Bonding protocol with primer adhesive	Yes
B_2	Bonding protocol without primer adhesive	Yes
C_1	No bonding protocol	No
C_2	No bonding protocol	Yes

Note: B_1, Bonding protocol with primer adhesive exposed to cigarette smoke; B_2, Bonding protocol without primer adhesive exposed to cigarette smoke; C_1, No bonding protocol without smoke exposure; C_2, No bonding protocol with smoke exposure.

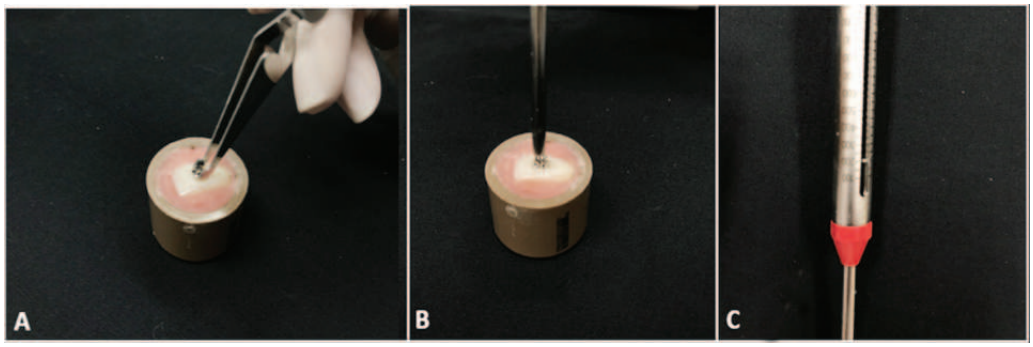


***Figure 1**: Photographs illustrationg bonding brackets procedure: A) Bracket positioning with bracket holder tweezers. B) Standardization of bonding pressure by using a tensiometer with 200gF. C) Tensiometer scale set at 200gF.*

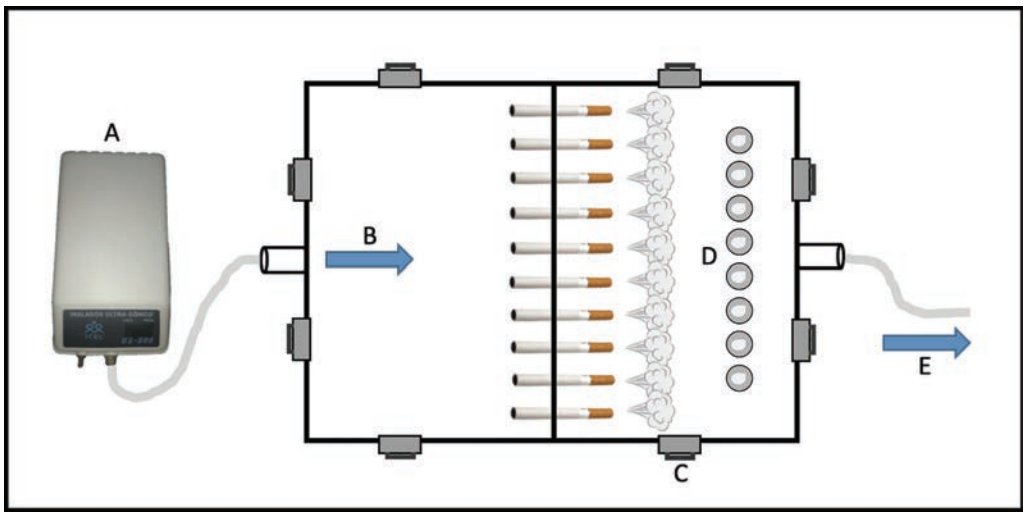


***Figure 2**: Illustrative drawing of the hermetic chamber used for cigarette smoke exposure. A) Nebulizer used to oxygen injection into the chamber. B) Entrance of oxygen enabling cigarettes to remain lit. C) Clamps for keeping hermetic environment inside the camera. D) Samples positioned in front of the cigarettes smoke. E) Cigarettes suction system.*

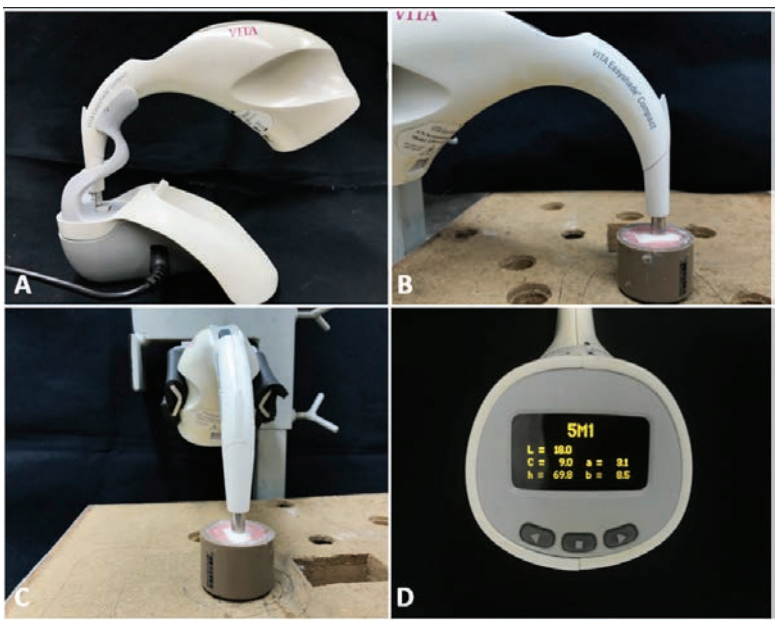


***Figure 3**: Photographs illustrating colorimetric analysis. A) Previous device calibration. B) Equipment positioning on the dental surface. C) Device holder enabling a standardized position during the analysis. D) Results displayed in spectrophotometer display.*

***Table 2**: Descriptive statistics as mean and standard deviation for the parameters L*, a*, b* and its conversion to NBS units.*

Groups		L *		
	T0	**T1**	**T1-T0**	***p-value* (T1-T0)**
C_1	89.01 ± 1.56[a]	88.32 ± 1.67[c]	-0.69 ± 0.80	0.195
C_2	88.28 ± 1.27[a]	86.56 ± 0.28[b]	-1.72 ± 0.28*	0.001
B_1	87.77 ± 2.26[a]	82.21 ± 1.21[a]	-5.55 ± 2.28*	0.000
B_2	87.32 ± 1.66[a]	84.96 ± 2.15[b]	-3.74 ± 2.85	0.892
		a *		
	T0	**T1**	**T1-T0**	
C_1	3.13 ± 0.51[a]	3.80 ± 0.68[a]	0.36 ± 0.23	0.977
C_2	2.98 ± 0.26[a]	3.04 ± 0.33[a]	0.69 ± 0.82	0.248
B_1	2.68 ± 0.94[a]	4.27 ± 0.88[b]	2.33 ± 0.77*	0.001
B_2	2.86 ± 0.63[a]	3.49 ± 0.50[a]	0.93 ± 0.73	0.806
		b *		
	T0	**T1**	**T1-T0**	
C_1	35.11 ± 1.16[a]	35.29 ± 1.03[a]	0.17 ± 0.50	0.432
C_2	34.12 ± 0.98[a]	36.28 ± 1.29[b]	1.82 ± 0.22*	0.000
B_1	35.54 ± 0.89[a]	38.85 ± 1.23[b]	3.30 ± 1.37*	0.002
B_2	35.19 ± 0.87[a]	36.83 ± 0.83[b]	1.13 ± 1.16	0.345
		NBS		
C_1		0.99 ± 0.55[a]		
C_2		2.98 ± 1.23[a]		
B_1		6.49 ± 1.98[b]		
B_2		3.07 ± 2.31[b]		

*Note: Different letters indicate significant intergroup differences (ANOVA/Tukey) (a= 0.05). *Indicates significant differences between study timepoints within each group (RM ANOVA) (a= 0.05). B_1, Bonding protocol with primer adhesive exposed to cigarette smoke; B_2, Bonding protocol without primer adhesive exposed to cigarette smoke; C_1, No bonding protocol without smoke exposure; C_2, No bonding protocol with smoke exposure.*

Exposure to cigarette smoke

An airtight chamber, designed specifically for this study purpose, was used to samples exposure to cigarette smoke. The chamber was divided into two compartments: one side where bovine teeth was positioned, and the opposite side, containing ten holes where the cigarettes were inserted with its filters facing the compartment in which the sample was positioned. Cigarette suction process was performed with a conventional suction cannula that was inserted into one of the compartments. Oxygen was injected in order to keep the cigarettes lit during the experiment. Five cigarette boxes (Rothmans cigarette, Souza Cruz, Rio de Janeiro, Brazil) were used in the study, as the samples went through ten cycles of exposure to cigarette smoke, and therefore comprising a total of 100 cigarettes (Figure 2).

Color Stability Analysis

The spectrophotometer Vita EasyShade Compactâ (Bad Säckingen Germany) was used to determine the initial color and detect possible color changes between the study timepoints. For this purpose, the spectrophotometer tip was positioned perpendicular to the buccal surface of the teeth (Figure 3). Color data were registered using the L* a* b* system, which comprises variation in the three-dimensional color axes: L* (luminosity), a* (red-green axis) and b* (yellow-blue axis). Color changes (ÄE) after exposure to smoke were calculated by the following equation: $ÄE^*ab=[(ÄL)^2 + (Äa)^2 + (Äb)2]^{1/2}$, where ÄL, Äa and Äb correspond to the differences between L*, a* and b* values assessed before and after the smoke exposure.

Clinical perception of color changes was calculated using the National Bureau of Standards (NBS) by the equation, NBS = ÄE* x 0.92, in which critical observations of color differences were expressed in NBS units. The higher the NBS, the greater was the clinical perception of color change.

Statistical Analysis

Statistical analysis was performed with the SPSS software (version 22, SPSS Inc, Chicago, IL, USA). Normality

of the sample was verified with the Shapiro-Wilk test. Intergroup comparisons and effect of time were performed with one-way ANOVA/Tukey and RM ANOVA tests. The level of significance of 5% was adopted for all analyses.

RESULTS

Color stability results are presented in Table 2. In T0 there was no statistical difference between the groups. Significant color changes were observed in B_1 (bonding protocol with primer adhesive) parameters: L* (T1-T0: -5.55 ± 2.28), a* (T1-T0: 2.33 ± 0.77) and b*(T1-T0: 3.30 ± 1.37) (P = 0.000), whereas no significant color changes were noticed in B_2 samples (bonding protocol without primer adhesive) (T1-T0: L*: -3.74 ± 2.85; a*: 0.93 ± 0.73; b*: 1.13 ± 1.16) (P>0.05). Regarding control groups, no statistically significant color changes were observed in C_1 (T1-T0: L*: -0.69 ± 0.80; a*: 0.36 ± 0.23; b *: 0.17 ± 0.50), which was stored in artificial saliva. However, C_2, that did not undergo orthodontic bonding protocol but was exposed to cigarette smoke had a statistically significant color change in parameters L * and b * (T1-T0: L *: -1.72 ± 0.28; b *: 1.82 ± 0.22) (P = 0.001 and 0.000, respectively).

Both B_1 and B_2 presented higher NBS values compared to C_1 and C_2 (B_1: 6.49 ± 1.98; B_2: 3.07 ± 2.31; C_1: 0, 99 ± 0.55; C_2: 2.98 ± 1.23) (P<0.05).

DISCUSSION

In this perspective, enamel and restorations staining resulting from smoking is the most immediate perceived clinical manifestation in smokers.[14] Once adolescents and young adults represent a large part of patients undergoing orthodontic treatment, this study is important because it is related to smile aesthetics.

Since color perception is subjective it requires quantitative parameters to be measured. Such parameters can be provided by spectrophotometry. Vita Easyshade Compact spectrophotometer is widely used for color evaluation of some materials, including aesthetic orthodontic wires.[15-17]

The literature agrees that resin residues can change tooth color through internal and external reactions, and that external discoloration may be associated to food-derived pigments absorption.[18,19] Furthermore, in addition to food, other pigments may be responsible for teeth extrinsic staining, such as cigarette smoke.[20] Probably the complex composition of cigarette smoke, comprising thousands of substances such as nicotine, carbon monoxide, tar, among others,[21] when in contact and subsequently deposited in the composite resin surface, would be responsible for the color and luminosity change. The greatest color and brightness change in B_1 could be attributed to the application of a primer adhesive during orthodontic brackets bonding protocol.

A study by Omar et al.[12], showed that cigarette consumption may influence the orthodontic brackets shear bond strength, and this is probably associated with the contact of the smoke with the bonding material exposed to the oral cavity. This shows that the cigarette can modify these bonding materials, and the present study shows that after debonding procedures, the residual material can also be modified, changing the color stability.

According to Manuja[21], the bonding interface between tooth and restoration remains the most susceptible area when exposed to the oral environment. This interface, known as the hybrid area, consists of a network of adhesive microleakages, which after polymerization become rigid, providing the micromechanical retention of the restoration. The difference of results between B_1 and B_2 seems to be related to the addition of the primer adhesive layer in bracket bonding protocol, since after light curing, the adhesive tags becomes rigid and difficult to be completely removed even after orthodontic debonding. Also, the porous surface inherent to resinous materials, might contributed to increased staining in B_1 than in B_2. Therefore, it may be suggested not to use the primer in smoker patients, since the contraindication for all patients may not be the best choice since the primer is associated with the success of the adhesive system, depending on the commercial brand.

Samples from control group exposed to cigarette smoke (C_2) also showed color changes, indicating that despite dental enamel is the most mineralized and, therefore, the hardest tissue in the human body, it has a certain degree of permeability.[22]

Evidences provided by this study are relevant for clinical practice, once it contributes to patients awareness of the influence of cigarette smoke on teeth staining during and after orthodontic treatment. Therefore, this information also contributes to cigarette use reduction, due to its aesthetic appeal, which is highly regarded by patients undergoing orthodontic treatment. Due to inherent limitations of in vitro studies, future studies using clinical controlled design are encouraged to confirm present study results.

CONCLUSION

Enamel color stability was affected by exposure to cigarette smoke after orthodontic debonding, especially when bonding protocol comprised the application of primer adhesive.

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