REMNANT ADHESIVE FLASH IN ORTHODONTIC BONDING SYSTEMS WITH DIFFERENT CHARACTERISTICS

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Palavras-chave: Colagem Dentária. Adesivo Ortodôntico. Materiais Dentários.

RESUMO:
Introdução: O excesso de material de colagem que permanece ao redor dos bráquetes impacta negativamente a saúde bucal dos pacientes ortodônticos. **Objetivo:** Avaliar a influência dos sistemas de colagem ortodônticos na remoção de excesso de adesivo ao redor de bráquetes. **Métodos:** Baseado em suas características, quatro sistemas de colagem ortodônticos foram selecionados: adesivo fotopolimerizável (G1 – Transbond™ XT); adesivo fotopolimerizável com pigmentação rosa (G2 - Transbond™ Plus Color Change); cimento de ionômero de vidro reforçado com resina (G3 - FujiOrtho™ LC); e adesivo autopolimerizável (G4 - Concise™). Para cada grupo (n=10), um único operador posicionou os bráquetes em dentes bovinos (n=40) e utilizou uma sonda exploradora para remoção visual do excesso de material de colagem. Após a polimerização / tempo de cura, as amostras foram levadas ao estereomicroscópio e o software Axio Vision 4,4 foi utilizado para mensurar a área de excesso de adesivo remanescente ao redor de cada bráquete. Os dados quantitativos obtidos foram analisados pelos testes de Kruskal-Wallis e post-hoc de Dunn em significância de α= 0,05. **Resultados:** O cimento de ionômero de vidro reforçado por resina (G3) apresentou a maior área de remanescente de excesso. Não houve diferença estatisticamente significativa entre os demais grupos (G1, G2 e G4), independente da pigmentação ou do método de polimerização. **Conclusão:** O uso de cimento de ionômero de vidro reforçado por resina resulta em maior área de excesso remanescente, o que pode impactar negativamente a saúde bucal. A pigmentação e o método de polimerização não influenciaram no excesso de material remanescente.

Keywords: Dental Bonding. Orthodontic Adhesive. Dental Materials.

ABSTRACT
Introduction: Excess of adhesive around brackets negatively impact oral health of orthodontic patients. **Objective**: Evaluate the influence of orthodontic bonding system in removal of adhesive flash around orthodontic brackets. **Methods:** Based on their characteristics, four orthodontic bonding systems were selected: light-curing adhesive (G1 - Transbond™ XT); pink pigmented light-curing adhesive (G2 - Transbond™ Plus Color Change); resin-modified glass ionomer cement (G3 - FujiOrtho™ LC); and auto-curing adhesive (G4 - Concise™). For each group (n=10), a single operator placed metal brackets on bovine teeth (n=40) and used an explorer tip to visually remove flash excess. After curing / setting, the samples were taken to a stereomicroscope and the Axio Vision 4.4 software was used to measure the area of remnant adhesive flash around each bracket. The quantitative data obtained was analyzed by the Kruskal-Wallis and Dunn's post hoc test at α= 0.05. **Results**: The results show that the resin-modified glass ionomer cement (G3) had a larger area of remnant material than the other groups. There was no statistical difference between the other groups (G1, G2, and G4), independently of pigmentation or curing technique. **Conclusion**: It was concluded that the use of a resin-modified glass ionomer cement results in a larger area of remnant flash excess, which can negatively impact oral health. Pigmentation and curing technique did not influence on remnant flash excess.

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INTRODUCTION

Since the introduction of orthodontic bonding systems, some new materials have been developed to improve clinical results.[1] Many studies focused on adhesive bond strength[2] and properties such as: stiffness,[3] color stability,[4] fluoride release,[5] inhibition of microbiological growth,[5] cytotoxicity,[6] amongst others. The goals of new adhesives are oral health maintenance, patient and professional satisfaction, and enhancing treatment. Dental literature is rich in articles that analyze residual orthodontic adhesive after bracket debonding, as well as enamel surface characteristics, which must be smooth and polished after treatment to inhibit biofilm aggregation. Many factors are involved in these procedures, such as the instruments used to clean dental surfaces, adhesive removal protocols, the orthodontic bonding system used and the operator's ability.[7]

However, the concern for changes in oral health caused by orthodontic appliances should be present since the beginning of the treatment. The choice of accessories and bonding systems to be used should consider potential for biofilm aggregation, ease of oral hygiene practice, aesthetics, and possibility for staining. Regarding accessories, the industry concentrates effort in enhancing surface roughness, polish and size. For orthodontic bonding systems, it is well-known that, during the bonding step, orthodontists must carefully remove adhesive excess around brackets before curing / setting. The goal of this step is to avoid that flash remnants harm oral health, due to plaque accumulation, leading to teeth staining and decay. Nevertheless, there is a lack of literature that analyze the techniques of bonding the brackets and removing excess adhesive. There is also a lack of studies that analyze if different bonding materials result in more flash excess around brackets.[8,9] Focusing on obtaining a "flash-free" enamel surface should be considered a step as important as bracket positioning for the overall treatment outcome.

The objective of the present work is to quantify the amount of remnant material on tooth surface around brackets after visual flash removal with an explorer tip, comparing four widely-used orthodontic bonding systems: Transbond™ XT Light Cure Adhesive (3M Unitek, Minnesota, USA); Transbond™ Plus Color Change Adhesive (3M Unitek, Minnesota, USA); GC Fuji ORTHO™ Light-cured Orthodontic Cement (GC America Inc., Illinois, USA), and Concise™ Orthodontic Bonding System (3M Unitek, Minnesota, USA). These systems were selected to include materials with different colors, properties and curing techniques, respectively. This study hypothesizes that different bonding material characteristics can influence easiness of flash removal. The null hypothesis is that similar amount of flash remains around the brackets regardless of the bonding material used, suggesting easiness of flash removal is not related to the material chosen.

MATERIALS AND METHODS

Sample preparation

For sample size calculation, a pilot study was performed with 4 samples per group. Considering the data obtained of variance of 26.11 between-groups and error variance of 30.87, it was determined a large effect size of 0.9196. Considering an alpha of 0.05 and a power of 80%, these data indicated the need for 5 specimens in each group. However, we decided to increase sample size to 10 specimens per group, based in previous similar studies.[8,9]

Forty bovine incisors without cracks or color changes were selected and stored in timol 0.1% solution. The crowns were separated from the roots using a diamond metal disc and were positioned on a glass surface, so that that the most plane area of the facial surface was leaning against the glass. Then, a 3/4 inches PVC cylindrical tube was positioned surrounding each crown and acrylic resin (JET Clássico, São Paulo, Brazil) was poured. The samples were grounded with wood sandpaper number 180 and water sandpaper number 600 and 1200 using a polishing machine to standardize smoothness and size of the plane area to a diameter of 6 mm. An insulating tape mask with 6 mm of diameter was positioned over the smooth surface, to expose only the enamel surface for evaluation.[10,11]

Bonding step

Edgewise slim mandibular incisor metal brackets (Morelli Ortodontia, São Paulo, Brazil) were selected due to their smaller size and flatter base, in order to minimize the possibility of gaps between the bovine teeth's flat surface and the bracket base. To simulate the clinical situation, prophylaxis with rubber cup, pumice stone and water was carried out for 10 seconds and, at every 5 samples, a new rubber cup was used. Then, the samples were rinsed for 10 seconds with air and water spray and dried with air spray for 10 seconds. Phosphoric acid 37% (CONDAC 37, FGM Produtos Odontológicos, Santa Catarina, Brazil) was used to condition the enamel surface for 20 seconds, followed by water rinsing and drying as previously described[12].

The samples were randomly distributed amongst the groups (n=10):

- Group 1 - Transbond™ XT Light Cure Adhesive (G1);
- Group 2 - Transbond™ Plus Color Change Adhesive (G2);
- Group 3 - GC Fuji ORTHO™ Light-cured Orthodontic Cement (G3), and
- Group 4 - Concise™ Orthodontic Bonding System (G4).

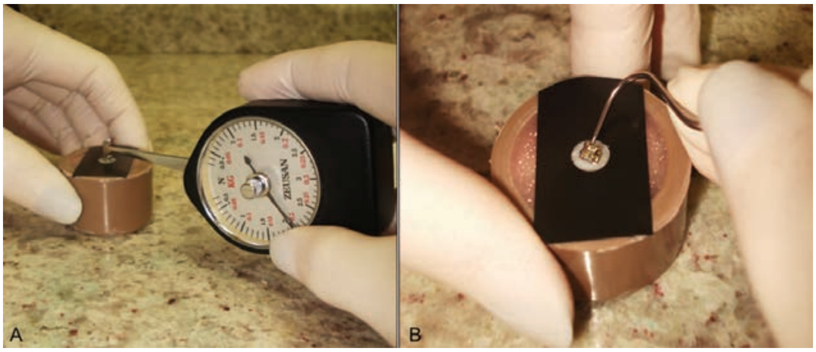

***Figure 1**: A) Illustration of the measurement of the application of a load of 2 N on the bracket. B) Visual flash excess clean-up using an explorer number 5 tip.*

The bonding step was standardized to provide consistent and reliable results. Each material was stored in proper conditions, according to manufacturers' instructions and were left in room temperature for 24 hours before the study. A single operator, a 2nd year orthodontic resident, performed all the procedures, on the same day and under the same conditions. A precision scale was calibrated with the weight of the spatula used to apply the adhesive to the bracket base. Then, the amount of desired material was scooped with the spatula and a new weighting step took place. This procedure was carried out 5 times, and the mean weight of the material was 0.0114 g, varying from 0.0112 g to 0.0124 g.

A tensiometer (Zeusan Exporting Ltda., São Paulo, Brazil) was used to measure the application of a 2 N load at the time of bracket placement (Figure 1A). Then, the tip of an explorer number 5 was used to remove flash excess (Figure 1B) until the operator considered that, visually, all the excess material had been removed, simulating a clinical situation of a "flash-free bonding". G1, G2 and G3 were light-cured, while the G4 was left to auto-cure. Due to the different characteristics of each material making them easily recognizable, the operator was not blinded when performing the bonding step. The samples were kept in 100% humidity for 24 hours, until surface analysis was performed.

***Figure 2**: Stereo microscope Zeiss and AxioVision software showing the 20x magnification to determine the area of remnant material.*

Surface analysis

Analysis of dental surface was performed by a different operator, also a 2nd year orthodontic resident, using a stereo microscope (Carl Zeiss, Göttingen, Germany) with 20x magnification (Figure 2). The outer area of remnant flash around each bracket was delineated and quantified using the software AxioVision v. 4.4 (Carl Zeiss, Göttingen, Germany) (Figure 3). To find only the area of flash excess, the bracket area was calculated and subtracted from the total area. The operator performing the surface analysis was not blinded. To check for any bias, after seven days, a new measurement step was carried out in 5 randomly selected samples and the intraclass correlation coefficient was 0.974, confirming operator reliability.

Statistical analysis

The software program SPSS v. 13.0 (SPSS Inc., Chicago, IL, USA) was used to analyze the data. The Shapiro-Wilk test and histograms were used to analyze sample distribution. Due to irregular distribution, the Kruskal-Wallis test followed by Dunn's post-hoc was used to compare the groups to a level of 5% significance.

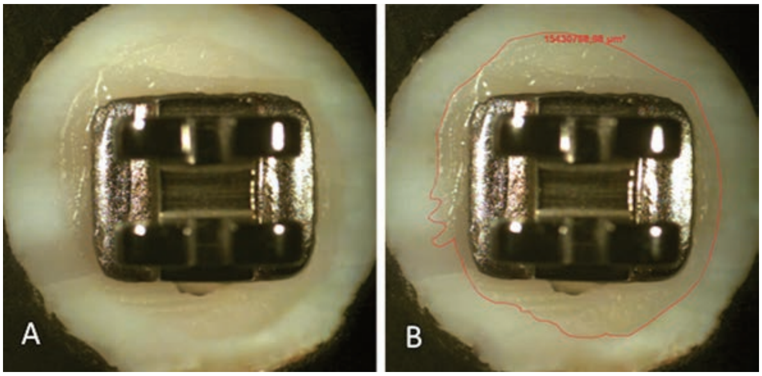

Figure 3: *A) Visualization of the area of remnant material using stereo microscope with a 20x magnification. B) Determining the area of remnant material around the bracket with the software AxioVision, v. 4.4.*

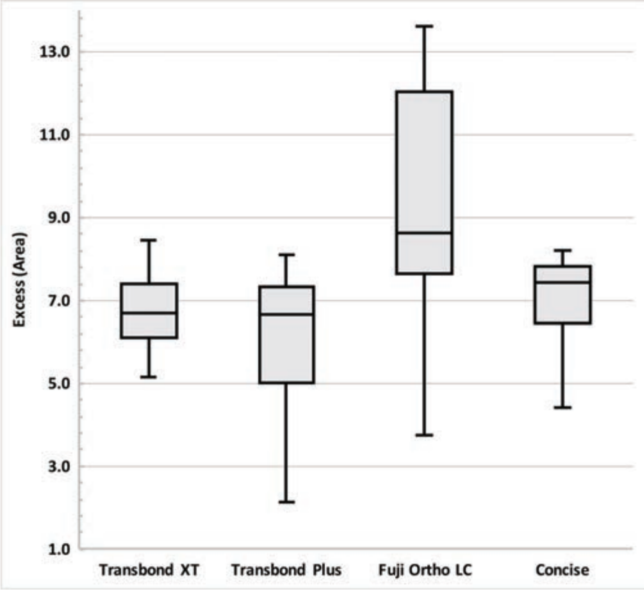

Figure 4: *Box-Plot comparing the excess areas measured: Transbond™ XT (G1, Md = 6.68 mm²), Transbond™ Plus Color Change (G2, Md = 6.65 mm²), Fuji ORTHO™ LC (G3, Md = 8.60 mm²) e Concise™ (G4, Md = 7.40 mm²), respectively.*

RESULTS

The results are relayed in the box-plot (Figure 4). Statistically significant difference ($p<0.05$) in the remnant material area was observed between G3 (Median (Md) = 8.60 mm^2, Minimum (Min) = 3.72 mm^2, Maximum (Max) = 13.61 mm^2) and the other groups: G1 (Md = 6.68 mm^2, Min = 5.15 mm^2, Max = 8.43 mm^2), G2 (Md = 6.65 mm^2, Min = 2.11 mm^2, Max = 8.09 mm^2), and G4 (Md = 7.40 mm^2, Min = 4.93 mm^2, Max = 8.18 mm^2). There was no statistically significant difference between G1, G2, and G4.

DISCUSSION

The present study assessed if orthodontic bonding systems characteristics such as pigmentations, properties and curing could influence in obtaining a "flash-free" bonding. The null hypothesis would be the similarity in remnant flash excess in all the materials used, suggesting that the remnant excess is independent of particular characteristics of each systems. The results showed that, when bonding with resin composites, the pigmentation or curing technique does not influence on remnant flash area after excess removal with an explorer tip. However, the use of resin-modified glass ionomer cement results in a larger area of remnant flash, which might have clinical implications.

It is still common to observe in clinical practice some excess of bonding material around brackets. Some orthodontists do not take the necessary time and attention needed to remove excess adhesive after bracket bonding, which might lead to carious lesions, gingival hyperplasia, compromised aesthetics, and enamel staining. Considering that there is an effort to enhance brackets' and accessories' industrial quality and size to market better appliances, investment in these aspects seems contradictory if the chosen bonding system leaves more remnant flash excess, which might jeopardize plaque control and favor biofilm aggregation.[5,8,13] According to Lee et al., orthodontics adhesives have a higher microbial retaining capacity than brackets.[14] Therefore, focusing on obtaining a "flash-free" enamel surface should be considered a step as important as bracket positioning for the overall treatment outcome.

The analyzed materials in this research were chosen because they include a range of different orthodontic bonding system characteristics. Transbond™ XT (G1) is a light-curing adhesive considered to be the gold-standard in research and clinical practice in Orthodontics.[8] Transbond™ Plus Color Change (G2) also is a light-curing adhesive and, according to the manufacturer, has the advantage of fluoride release and moisture tolerance, besides being a pink paste before light-curing, which enhances brackets positioning and flash clean-up. GC Fuji ORTHO™ Light-Cured Orthodontic Cement (G3) is a glass ionomer light-curing cement well-known for its fluoride release and bonding strength[5]. And lastly, Concise™ Orthodontic Bonding System (G4) is an auto-curing resin with satisfactory mechanical properties that does not require a light-curing stage.

In orthodontic bonding procedure with light-curing adhesives, usually 3 steps are carried out consecutively: enamel etching, dental adhesive spread, and bonding the bracket[12]. However, many studies have shown that there is no statistically significant difference in regard to bonding strength and the use of dental adhesive when there is humidity control.[15,16] Therefore, in this research the dental adhesive step was excluded to limit possible interferences in visual assessment of flash excess and also because there is no comparative dental adhesive step for Concise™ Orthodontic Bonding System (G4).

According to the manufacturer, Transbond™ Plus Color Change (G2) is similar to Transbond™ XT (G1) in regard to bonding strength, with added advantages such as the pink color before light-curing and fluoride release. The manufacturer's premise is that the pink color provides visual contrast between the enamel surface and the bonding material, making flash more visible and easier to remove, without altering characteristics such as tolerance to moisture and bond strength.[17]

However, this research showed that G2 was not statistically significantly different in concern to flash removal from the other resin groups, G1 and G4, which have a color similar to enamel surface, contradicting the manufacturer's premise. This result confirms the previous findings of Alencar et al.[8] and Armstrong et al.[9] that suggested that the addition of a coloring agent to assist in visualization did not reduce the amount of flash around the brackets.

Among the tested materials, Fuji ORTHO™ LC (G3) is the most distinct because it is a resin-modified glass ionomer cement. Its biggest advantage described in the literature is the fluoride release property.[5] Other advantages found in the literature and indicated by the manufacturer are: better working time, because it is light-cured; satisfactory mechanical strength; moisture tolerance; bonding durability; and easy clinical removal after end of treatment.[11,18] However, in concern to remnant flash excess after clean-up, G3 presented a statistically significant difference to the other groups. This finding might be explained by the material's low viscosity compared to the other adhesives, making it harder to remove and more attached to the etched enamel surface.[19]

As flash excess around brackets must be avoided due to aforementioned reasons, one must consider that the fluoride release advantage of Fuji ORTHO™ LC can be overcome by the amount of biofilm aggregated to the material excess. Literature also shows that microorganisms adhere more firmly to resin materials and components present in the adhesive matrix might favor bacterial growth.[5,20] Caldeira et al. assessed the surface of bonding materials submitted to biofilm of *S. mutans*, *L. casei*, and *C. albicans*, and found that Fuji ORTHO™ LC presented the highest microorganism adherence and fixation[5].

Concise™ Orthodontic Bonding System (G4) is an auto-curing paste-paste resin, with its working time restricted by its setting time. Regarding their mechanical properties, both auto-curing and light-curing resins present good debonding strength and bonding adhesive failure rates.[21,22] The setting time of auto-curing resins may reduce the available time for flash removal. Hence, one might expect that light-curing materials would have an advantage in that matter, since their working time is controlled by the operator. However, this hypothesis was not confirmed in this research, as there is no statistically significant difference between G4, and G1 and G2. In this study, the operator removed the excess until visually considering that the sample was "flash-free" and setting time was not considered a limiting factor. However, in clinical practice, the orthodontist takes some time properly positioning the bracket and only then proceeds to flash removal. The time spent in correctly positioning the bracket might limit the time for flash excess removal before the material sets. This situation was not reproduced in this *in vitro* evaluation.

It is important to emphasize that, in this study, bovine teeth were used to prepare the samples, based on several studies that prove that these animals' mandibular incisors are excellent substitutes to human teeth in Dentistry-related research for their microstructural characteristics, surface roughness, bonding strength, and size[23-26]. However, studies that compare the color of human and bovine teeth have shown that bovine enamel has a darker shade.[27,28]

We hypothesize that adhesives that are similar in color to human enamel might have a higher contrast against bovine enamel. Therefore, visualization might have been easier even for these adhesives than it would have been in human teeth, eliminating the advantage of the pink colored resin Transbond™ Plus Color Change (G2). This bias might also have occurred in Armstrong et al.[9] research, due to the use of typodont teeth, which also differ in color from human teeth.

Continuing the rationale, the contrast would also have benefitted the resin-modified glass ionomer GC Fuji ORTHO™ LC (G3), due to its whiter color, which did not occur, favoring the hypothesis that the nature of the adhesive and its adherence to etched enamel had higher influence in remnant excess than color itself. Possibly, G1 and G2 showed similar results due to their similar structures.

The results and conclusion of this study suggest validation of the hypothesis that materials' properties influence in flash excess removal. Limitations of this study to be pointed out are: (1) the *in vitro* experiment, which does not fully represent the clinical situation, with its particularities; (2) using only one operator to standardize the excess removal technique and limit the variable to the orthodontic bonding system; and (3) results limited to the materials tested. These limitations, however, do not jeopardize the findings. On the contrary, it stimulates new studies on this scarcely researched topic. It is suggested that more research on this subject is carried out with *in situ* or *in vivo* methodology, with more than one operator, and including other materials, such as the flash-free orthodontic adhesive systems. One must consider other reasons for remnant flash on the enamel surface after clean-up, such as: the chosen material, operators ability and visual accuracy, difficulty in identifying the flash excess, type of instrument used for clean-up procedure, time available for bonding, and quantity of material applied to the bracket base. Obtaining a "flash-free" bonding is of major importance when starting an orthodontic treatment and this subject must be given the proper importance, such as debonding techniques do.

CONCLUSION

Based on experimental tests of the present work, the following results were found:

1. The orthodontic bonding system properties can influence in flash excess removal.
2. Bonding with a resin-modified glass ionomer cement resulted in a larger area of remnant adhesive material, even after flash excess removal with an explorer tip, demanding higher attention when this is the material of choice.
3. The curing technique and the addition of pigment to the bonding adhesive do not influence on remnant flash excess.

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