ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 08, Issue, 03, pp.19284-19289, March, 2018

ORIGINAL RESEARCH ARTICLE

OPEN ACCESS

EVALUATION OF DENTAL ENAMEL UNION RESISTANCE CONTAINING REMAINING RESINS FROM DEBONDED ORTHODONTIC BRACKET AFTER DIFFERENT TREATMENTS AND TIME PERIODS

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ARTICLE INFO

Article History:

Received 10th December, 2017
Received in revised form
26th January, 2018
Accepted 24th February, 2018
Published online 30th March, 2018

Key Words:

Composite Resin,
Orthodontic Bracket,
Shear Strength.

ABSTRACT

Dental treatment takes place in a multidisciplinary way, being fundamental the association between different specialties to reach aesthetic and functional excellence. The aim of this study was to evaluate dental enamel bond strength from resinous extensions remaining from orthodontic bracket debond, after different treatments and periods of storage. 60 dental units were randomly divided into 3 treatment groups: MD (multilaminated drill), MD + B (multilaminated drill followed by aluminum oxide blasting) and C (control). All groups had orthodontic brackets bonded and then debonded. After each treatment, they were restored with composite resin. Subsequently, all groups were stored in distilled water: T1 (24 hours) and T2 (30 days). After storage, all groups were submitted to the mechanical shear test. According to the results, group C obtained the lowest shear values (T1 = 8.22 MPa and T2 = 8.63 MPa), followed by MD group (T1 = 10.42 MPa and T2 = 10.72 MPa) and, with the highest values, the MD + B group (T1 = 14.93 MPa and T2 = 15.63 MPa). It can be concluded that there are statistically significant differences between surface treatments, however, storage time, did not show changes in strength values.

Citation: Eduardo Martinez Martinez, Andrea Nobrega Cavalcanti and Paula Mathias. 2018. "Evaluation of dental enamel union resistance containing remaining resins from debonded orthodontic bracket after different treatments and time periods", *International Journal of Development Research*, 8, (03), 19284-19289.

INTRODUCTION

Orthodontics has the principle of tooth movement for the correction of occlusal, functional or aesthetic problems. Advances in the planning of treatments and the technology of the materials used have made the procedure increasingly biological and corresponding to the demands of each patient. The desire for a perfect smile is one of the major reasons why patients seek dental treatment, so a multidisciplinary approach is the most efficient (Pini *et al*., 2010). The incorporation of adhesive techniques in the bonding of orthodontic brackets made the treatment more aesthetic and comfortable for the patient when compared to the metallic bands (Vieira *et al*., 2002). Thus, is offered to the patient a better condition to perform dental hygiene, reducing plaque accumulation and reducing the number of appointments at de dental office (Fonseca *et al*., 2010).

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Adhesive procedures are often performed on the enamel where orthodontic brackets have been debonded, either for rebonding brackets, perform functional or aesthetic restorations or ceramic procedures (Ogaard and Fjeld, 2010). Several indications may be listed for this procedure, such as: fractures, color change, need for improvement of dental anatomy, use of laminates, micro infiltration at the adhesive interface, bone base discrepancies and mesio-distal size of teeth, among others (Silva *et al*., 2013). These new adhesive procedures are often performed on a dental tissue which contains resinous extensions (tag), since complete removal of the adhesive used to bond brackets is practically impossible without significant wear of the dental enamel (Boncuk *et al*., 2014). The bond strength of an old polymer to a new polymer exhibits reduced values when compared to the first adhesion values made directly on the dental enamel and often requires a specific chemical or physical treatment in the old polymer prior to performing further restoration (Cavalcanti *et al*., 2004). Rathke *et al*. (2009) and Bacchi *et al*. (2010) studies indicate that the blasting with aluminum oxide of an old resin prior to the union of a new resin is a possible alternative to improve the adhesion strength between the two composites. Therefore, surface treatments made in the old resin seem to be important for the success of the union of a new resin to a resinous material previously inserted in the oral cavity, depending on the roughness of the surface or the bonding material used (Vianna, 2016). Effective bonding occurs not only by the mineralized structure of the tooth, but also by the existing adhesive material (Bektas *et al*., 2012). However, the excessively high enamel bond strength associated with the depth of penetration of the tags, makes it difficult to remove the bracket at the end of treatment, eventually leading to enamel fracture (Savariz and Mezomo, 2011). Therefore, with few information on the interference of the tags from orthodontic bracket debonding on new adhesive restorations, it is important to evaluate the bond strength and the effect of treatments such as the use of multilaminated drills associated or not to the blasting with aluminum oxide.

MATERIALS AND METHODS

Obtaining Dental Units

Sixty upper and lower human molars were donated by the Metropolitan Union of Education and Culture (UNIME), with the approval of the Health Science Institute of the Federal University of Bahia ethics committee under the Brazil Platform number: 1.632.903. The samples were cleaned and then stored in distilled water (KOP PHARMA & SPECIALTIES, Simões Filho, Brazil) to avoid dehydration (Silva *et al*., 2006) until visual inspection with magnifying glass (MAQUIRA DENTAL PRODUCTS, Maringá, Brazil) in order to eliminate specimens with carious lesions, enamel cracks, fluorosis, corrosion or abrasion. (Kumar *et al*., 2011)

Preparation of Specimens

All dental units were fixed in colorless acrylic resin (JET® CLÁSSICO, São Paulo, Brazil), inside plastic cylinders (TIGRE®, São Paulo, Brazil), 25 mm in diameter and 20 mm in height (Figure 01).

Figure 1. Plastic cylinders with 25mm in diameter and 20mm in height

The teeth were included in the cylinder in the plastic phase of the colorless acrylic resin through a stainless steel clinical clamp (QUINELATO, Rio Claro, Brazil), always leaving the vestibular face exposed. Three groups (n = 20 each) were randomly formed: multilaminated drill (MD), multilaminated drill and aluminum oxide blasting (MD + B) and control (C).

Bracket Bonding

All groups had the most central portion of the vestibular face of their specimens conditioned with 37% phosphoric acid (FGM, Joinville, Brazil) for 30 seconds, then washed with water continuously until the acid is completely removed. Dental surfaces were air-dried, free of oil and water, for three seconds. A single layer of the Single Bond Universal Adhesive System (3M ESPE, Sumaré, Brazil) was applied with the aid of a disposable brush (KG BRUSH ™, KG SORENSEN, SP, Brazil) on dental surfaces after light jet drying of free air, free of oil and water, being photoactivated with a light emitting diode with intensity of 750 mw / cm^2 (LED LD MAX - GNATUS, Ribeirão Preto, Brazil) for 20 seconds. The metal brackets (MAX, DENTAL MORELLI LTDA, Sorocaba, Brazil), containing composite resin Transbond XT (3M UNITEK, California, USA) were bonded to the dental vestibular surfaces already treated and then photoactivated for 20 seconds (5 seconds per face) (Figure 2)

Figure 2. Test specimens with their respective brackets adhered

Bracket Debonding

Brackets adhered to the enamel structures of the vestibular surfaces of all specimens (n = 60) were removed using orthodontic bracket remover pliers, (QUINELATO, São Paulo, Brazil). The fins were pressed so that the fittings were deformed, leaving much of the resin adhered to the dental structures (Figure 3).

Figure 3 - Composite resin remnant after bracket take-off

Remanescent resin Removal and Treatment of Dental Surfaces

The MD group had the remaining visible resins removed with the help of multilaminated drills (Ø 2.35mm carbide DENTAURUM, Langhorne, USA), used in low angle rotation (KAVO 500, Moema, Brazil) (Figure 4).

Figure 4. Removal of the remaining resin with multilaminate drill

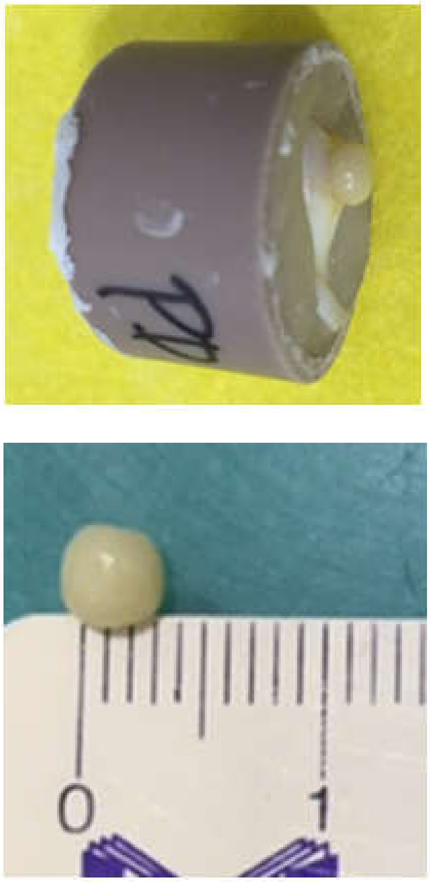
It is recommended by the manufacturer to replace the drill with every ten teeth, since there is a loss in cut of the blades. Thus, for every ten specimens, the drill was replaced by a new one. The MD + B group received similar treatment to MD group. After removing the resin, the vestibular surfaces were blasted with aluminum oxide, with the tip of the apparatus (BIO-ART STANDARD JET, São Carlos, Brazil) positioned 10 mm away from the enamel surfaces, using 50 µm / 60Psi (BIO - ART DENTAL EQUIPMENT, São Carlos, Brazil) for 10 seconds (Derech *et al*., 2008). For the removal of possible residues, air and water jets were applied on the treated dental surface. Group C, did not have the remaining resin removed from the specimens.

Insertion of Composite resin Increments

All groups were once again conditioned with 37% phosphoric acid (FGM, Joinvile, Brazil) for 30 seconds, then washed with continuous water jet until total acid removal. After this step, the dental surfaces were air-dried, free of oil and water, for three seconds. A single layer of the Single Bond Universal Adhesive System (3M ESPE, Sumaré, Brazil) was applied with the aid of a disposable brush (KG BRUSH ™, KG SORENSEN, São Paulo, Brazil) on dental surfaces after light air jet drying, free of oil and water, being photoactivated with a light emitting diode with an intensity of 750 mw / cm^2 (LED LD MAX - GNATUS, Ribeirão Preto, Brazil) for 20 seconds.
Composite resin (FILTEK Z350 XT A3.5, 3M-ESPE, California, USA) increments of approximately 4mm in diameter and 2mm thickness, measured with a millimeter plastic ruler (TRIDENT, Itapuí, Brazil) were applied to these surfaces, simulating the restoration procedure. The restorations were photoactivated with a light emitting diode with light intensity of 750 mw / cm^2 (LED LD MAX - GNATUS, Ribeirão Preto, Brazil) for 20 seconds (Figures 5 and 6).

Samples Storage

All specimens (n = 60) were submitted to storage in distilled water (KOP PHARMA & SPECIALTIES, Simões Filho, Brazil) at 37ºC in a greenhouse (Quimis, SP, Brazil) for 24 hours (T1) or 30 days (T2) (Carsoso *et al*., 2014).



Figures 5 e 6. Resin increase of 3mm measured on the ruler and applied to the specimens

Shear Tests

All samples were submitted to shear test in the universal test machine EMIC DL 2000 (INSTRON BRASIL EQUIPAMENTOS CIENTÍFICOS LTDA, São José dos Pinhais, Brazil) at a constant speed of 0.5mm / min, until the previously established union rupture.

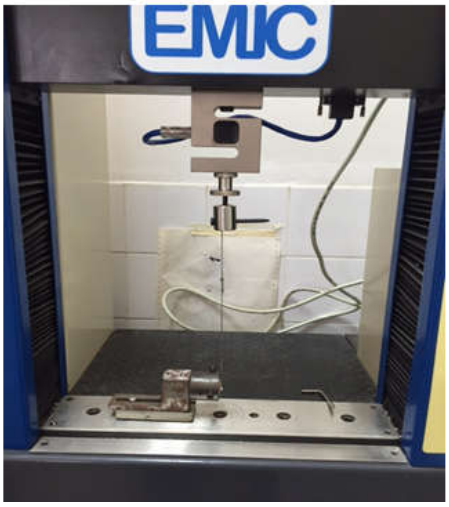


Figure 7. EMIC universal testing machine running the mechanical shear test

The specimens were inserted and bolted vertically with the surfaces containing the resin increments facing away from the universal testing machine fitting, which has a cylindrical and metallic shape. Positioned in this way, the specimens did not move during the mechanical test (Figure 7).

The shear tests performed on the EMIC machine utilized a 0.016 "diameter steel wire that involved the resin increments that, during the mechanical test, caused the rupture of the adhered structures. At the other end of the wire, there are pressure and motion sensors that pick up the exact moment of rupture and the force being used. The obtained values of the forces were transformed into mega pascal (MPa). Averages and standard deviations were calculated from the 10 evaluations of each group studied.

RESULTS

Initially, the exploratory data analysis was performed to verify the parameters of the analysis of variance (ANOVA). Inferential statistical analysis was performed by ANOVA 2-criteria, having as main factors the conditions: group / treatment (3 levels) and time (2 levels). For multiple comparisons between means, the Tukey test was used. All analyzes were performed in the statistical program SAS, version 9.1, with significance level of 5%. Table 1 shows the mean and standard deviation obtained in the experimental groups.

Table 1. Mean and standard deviation of the shear strength values in MPa of the experimental and control groups

Grupo	Tempo	
	24h	30 dias
C	8,22 ± 0,91 C	8,63 ± 0,99 C
MD	10,42 ± 0,95 B	10,71 ± 1,08 B
MD + B	14,93 ± 1,20 A	15,63 ± 1,11 A
	a	a

Lowercase letters compare the time factor. Upper case letters compare the treatment factor, within each time interval tested. Different letters identify significant statistical differences. (ANOVA 2-criteria and Tukey test, 5% significance)

According to the statistical analysis, there was no statistical significance of the interaction between the main factors ($p = 0.81$); therefore, the levels within each factor were analyzed independently. According to the analysis, it is verified that, regardless of the time of observation, significant differences between the treatment groups were found ($p < 0.0001$). The highest mean was observed in the calculations obtained with the MD + B group, followed by the values of group MD and, finally, the values obtained by group C. On the other hand, no statistical differences between the experimental times tested were not noticed ($p = 0.08$).

DISCUSSION

Historically, classical research has confirmed that residual resin removal after orthodontic bracket removal is a critical clinical challenge. The present study evaluated two alternatives of enamel surface treatment after orthodontic bracket debond, which were the use of multilaminated drills associated with or without aluminum oxide blasting and its influence on bond strength evaluated in two different time periods. The results showed that the use of the multilaminated drills followed by the aluminum oxide blasting was able to significantly increase the bond strength regardless of the time interval considered. These results are not in agreement with the studies of Lynch *et al*. (2012), which used diamond drills and acid etching as a treatment of the enamel surface after bracket debond and consider the use of resources such as aluminum oxide blasting and use of the multilaminated drill because, according to the authors, raises the cost and operational time of the clinical procedure.

The values of the union strength obtained in the mechanical tests in the control group were statistically lower than the values observed for the experimental groups, where some kind of superficial mechanical treatment was performed. Thus, it is observed that only a new acid conditioning on the resinous remnants associated to the use of the adhesive system is not sufficient to guarantee adequate values of bond strength. In the works of Yesilyut *et al*. (2009) and Spyrou *et al*. (2014), it is found that the role of 37% phosphoric acid conditioning under an already restored tooth surface is to clean, thereby facilitating the penetration of the new adhesive system. The MD group showed, in 24 hours of storage, mean force values of 10.42MPa, significantly higher than the average presented by the control group, which was 8.22MPa. These results show that the removal of the resin from the remaining adhesive with multilaminated drill was efficient to improve the adhesion forces between the structures when compared to the control group. Similar results were also described in the in vitro study conducted by Oliveira *et al*. (2013), who reported that the presence of adhesive residue prevents a good demineralization of the enamel leading to a poor penetration of the new inserted material.

Derech *et al*. (2008) and Almeida *et al*. (2013), in an in vitro study evaluating the adhesive resistance at the resin / bracket interface, concluded that the blasting of the dental enamel surface with aluminum oxide, prior to bracket bonding, was the most effective mechanical surface treatment tested. In the present study, in agreement with the previous one, statistically high values were found in the group in which the aluminum oxide jet was used after the multilaminated drill. Sousa *et al*. (2013) tested the bond strength on enamel surface after composite resin repair in samples submitted to different storage methods. The authors concluded that in the 24 hours and 30 days groups the bond strength did not change significantly as compared to other groups. This research corroborates the results found in the present study when, in different storage times, results were found with no significant difference for union strength ($p = 0.08$).

In the same way, Silva *et al*. (2006) did not report significant differences between the resistance values obtained with the variation of storage time. However, the findings of Cooley and Dodge (1989), Bianchi *et al*. (1991), Goodis *et al*. (1993), Gwinnett and Yu (1995); Sobrinho *et al*. (2002) and Balbinot (2015) revealed that the storage time in distilled water was able to change the bond strength between the composite resin and the dental enamel. The average values of bond strength to tooth enamel, with remaining resinous stretches of MD group brackets (10.42 and 10.71 MPa), were high, especially when compared to values found by Mondelli and Freitas (2007); Romano *et al*. (2004) and Imbery (2014) investigated this same bond strength in healthy enamel (5.6 to 7.8 MPA). Although these values cannot be directly compared, since different methodologies of mechanical tests were employed, they indicate an interesting direction. Where, once the enamel has resinous remnants properly treated (mechanically and chemically), this substrate offers excellent conditions for new adhesion to be carried out on it safely. This finding ensures an even more conservative restorative dentistry, since it shows that the incomplete removal of resinous remnants from dental enamel, when properly treated, does not reduce the bond strength to the dental substrate. Zhang *et al*. (2014) recommend that, when bonding brackets on dental enamel surface, the bond strength values do not exceed 11 MPa.

Ribeiro *et al*. (2013), however, recommend that these values should be around 6 to 8MPa. Excessive bond strength is not desired in orthodontic clinical practice, since at the end of treatment, orthodontic brackets will be removed. Unlike these limits, after orthodontic treatment, composite resin restorations should achieve sufficient union values to make the procedure reliable and long-lasting. Thus, according to the results of the present study, clinical procedures such as orthodontic bracket rebonding could dispense the use of aluminum oxide blasting, since high bond strength values are not recommended. When comparing all studied groups (C, MD and MD + B), it was observed that the complete non-removal of the visible composite resin interfered in the bond strength between the studied structures. Agreeing with these results, Janiszewska-Olszowska *et al*. (2014) draw a similar conclusion. However, other studies are necessary to evaluate and define adhesive protocols according to the materials used and the objectives of the adhesive procedures that will be executed. Further studies on the long-term effects of remaining resinous extensions after orthodontic bracket removal also need to be developed. In view of the results found, it is important for dental practice to create reliable protocols for composite resin restoration, or another procedure that involves adhesion between polymers, on dental surfaces that have undergone orthodontic bracket debonding.

Conclusion

With the data collected and the statistical analysis applied to the results, it can be concluded that:

- Treatment of the resin remnant after removal of the orthodontic bracket with multilaminated drills associated or not with aluminum oxide blasting is able to raise the bond strength of the composite resin to the enamel containing resinous extensions after orthodontic bracket debonding.
- Among the strategies for the treatment of enamel containing resinous extensions, after the orthodontic bracket debonding, the use of the multi-laminated drill associated with aluminum oxide blasting was the technique that resulted in higher bond strength values.
- Different storage times (24h and 30 days) did not significantly interfere in bond strength values.

Acknowledgement

We thank the Dental Laboratory of the Faculty of Dentistry of the Federal University of Bahia, the Postgraduate Program in Interactive Processes of the Organs and Systems of the Institute of Health Sciences, the Bank of Teeth of the Metropolitan Union of Education and Culture, CAPES and all involved in this research.

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