Orginal Article

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Comparative analysis of adhesive remnant index of orthodontic adhesive systems

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ABSTRACT

Introduction: At the end of orthodontic treatment, enamel fractures and cracks are pointed out as potential risks related to the procedures for removing fixed appliances bonding to teeth.

Aim of the study: The objective of the present study was to analyze comparatively residual adhesive index of different adhesive systems used in Orthodontics for bonding brackets on the dental surface.

Materials and methods: The present in vitro study was performed with 120 healthy human extracted premolars randomly divided into two groups to receive the bonding of steel and ceramic brackets. Then, the teeth were divided into six subgroups according to adhesive system used: G1: Orthocem®; G2: Orthocem® + Ambar universal® adhesive; G3: Orthobond Plus®; G4: Biofix®; G5: Transbond XT® and G6: Ortholink VLC®. The analysis of the residual adhesive index was performed using a microscope under 20x magnification after removing the brackets. Data were analyzed with Mann-Whitney test. The level of statistical significance was set at $P < 0.05$.

Results and Conclusions: The score of the most prevalent adhesive index in steel brackets group was 2, while in ceramic brackets group was 3. Comparatively, Orthobond Plus®, Biofix® and Ortholink VLC® showed better performance of adhesive remnant index than Orthocem® + Ambar® in steel brackets group. For ceramic brackets, Biofix® and Transbond XT® adhesives performed better than Orthobond Plus®.

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INTRODUCTION

Research in dental materials has resulted in the improvement and simplification of clinical procedures making them faster, more efficient and effective.[1] Since the development of acid conditioning technique, great attention has been given to bonding and stability of orthodontic brackets in teeth surface.[2-6] However, an important point is the impact of brackets debonding on enamel surface.[7]

At the end of orthodontic treatment, brackets removal is a critical and essential condition for physiological maintenance of dental surface.[7-10] Fractures and cracks of enamel are pointed out as potential risks related to the procedures for removal of brackets bonded to teeth.[11]

During the process of debonding, the literature highlights that resin breaking at the bracket/adhesive interface or inside the adhesive with bonding material adhered to the tooth are important conditions to prevent damage to enamel, since these residues could be removed with suitable rotary instruments.[12] The bond failure can occur on the following surfaces: bracket, between the bracket and adhesive, on adhesive, between enamel and adhesive, on enamel or mixed type of bond failure may occur. It is desirable that, after removing brackets, adhesive completely remains on the surface of a tooth to avoid possibility of enamel microcracks and fractures.[9]

In Orthodontics, the Adhesive Remnant Index (ARI) is one of the most commonly system to evaluate the amount of adhesive left on the tooth after brackets removal.[13,14] According to this

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index, it is possible to precisely determine location of bond failure using different types of brackets and adhesive systems.[13, 14]

Although there are several adhesive materials available to bracket bonding, literature is still scarce of information about which adhesives have good ARI performances. The objective of this present study was to analyze comparatively ARI of six different adhesive systems used for bonding steel and ceramic brackets.

MATERIALS AND METHODS

Study design and sample

The present in vitro experimental study was approved by the local Research Ethics Committee under protocol number 2.663.969. For the experiment, 120 healthy human extracted premolar teeth, without dental enamel formation defects or coronal cracks and fractures were selected. The teeth were randomly divided into groups according to bracket and adhesive systems type (Table 1).

Preparation of specimens

PVC tubes were filled with acrylic resin (40mm in diameter and 20mm in height) and the teeth were fixed on them by the dental roots. Dental crowns were positioned 90o with PVC tube base according to a set-square measurement. After polymerization, the specimens were kept in distilled water at 37ºC for 72 hours.

Edgewise steel and ceramic brackets, slot .022mm (Morelli®, Sorocaba, Brazil) were bonded in center of clinical crown of buccal teeth surfaces. For bonding, the specimens were cleaned and brushed with pumice paste and rubber cup (Microdont®, São Paulo, Brazil) for 10 seconds, followed by washing for 30 seconds and surface drying. Subsequently, the enamel surface was conditioned with 37% phosphoric acid (Condac 37®, FGM, Joinville, Brazil) according to the manufacturer's specifications and washed thoroughly. Teeth drying were carried out with air jets. Then, brackets were bonded with orthodontic adhesives according to manufacturers' specifications by a single operator. The photoactivation was carried out by a calibrated photopolymerizer (Gnatus-Ld Max®, Ribeirão Preto, Brazil) and it was performed for 10 seconds on each bracket face (mesial, distal, cervical and occlusal). After bonding, the specimens were stored in distilled water for 48 hours at 37ºC.

A universal testing machine (EZ-Test-Shimadzu®, Kyoto, Japan) was used to debond the brackets at a cross head speed of 0.5 mm/min with an occlusal-gingival load applied to the bracket. The ARI analysis was performed after removing the brackets. The buccal surface of the teeth was analyzed using a microscope under 20x magnification to determine the location of bond failure. All examinations were carried out blindly by single properly calibrated researcher (Kappa = 0.81). The ARI score was considered as; 0 = no adhesive left on the tooth; 1 = less than half of the adhesive left on the tooth; 2 = more than half of the adhesive left on the tooth; 3 = all adhesive left on the tooth (Figure 1).

Data analysis

Statistics analyzes were performed using SPSS 17.0. Shapiro-Wilk test was performed to verify data normality and Mann-Whitney test to comparisons. The level of statistical significance was set at $P < 0.05$.

RESULTS

ARI evaluation showed that teeth that received bonding of steel brackets had a greater number of scores 2 (41.66%). Orthobond Plus® adhesive showed a higher prevalence of this score followed by Biofix®. In ceramic brackets group, there was a higher number of scores 3 (71.66%). Transbond XT® and Biofiox® adhesives had a higher prevalence of this score (Table 2).

The statistical analysis showed that, for steel brackets group, Orthobond Plus®, Biofix® and Ortholink VLC® adhesives showed better ARI results when compared to Orthocem® + Ambar® ($p<0.05$). For other comparisons, no statistically significant differences were observed among the groups (Table 3).

In relation to ceramic brackets group, the results showed that Biofix® and Transbond XT® adhesives showed better ARI results when compared to Orthobond Plus® ($p<0.05$). Additionally, for other comparisons, no statistically significant differences were observed among the groups (Table 3).

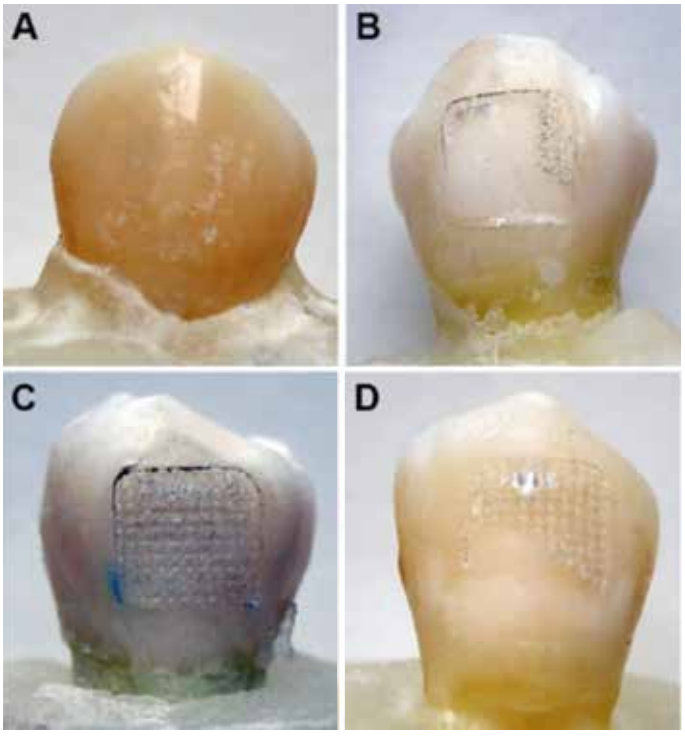

Figure 1. *Representation of ARI score. A) 0 = no adhesive left on the tooth; B) 1 = less than half of the adhesive left on the tooth; C) 2 = more than half of the adhesive left on the tooth; D) 3 = all adhesive left on the tooth.*

Table 1. Characterization of experimental groups.

Group (n)	Type of bracket	Adhesive	Manufacturer
Group 1 (n=10)	Steel	Orthocem®	FGM (Joinville/Brazil)
Group 2 (n=10)	Steel	Orthocem® + Ambar Universal®	FGM (Joinville/Brazil)
Group 3 (n=10)	Steel	Orthobond Plus®	MORELLI (Sorocaba/ Brazil)
Group 4 (n=10)	Steel	Biofix®	BIODINÂMICA (Ibiporã/ Brazil)
Group 5 (n=10)	Steel	Transbond XT®	3M (Sumaré/Brazil)
Group 6 (n=10)	Steel	Ortholink VLC®	ORTHOMETRIC (Marilia/Brazil)
Group 7 (n=10)	Ceramic	Orthocem®	FGM (Joinville/Brazil)
Group 8 (n=10)	Ceramic	Orthocem® + Ambar Universal®	FGM (Joinville/Brazil)
Group 9 (n=10)	Ceramic	Orthobond Plus®	MORELLI (Sorocaba/ Brazil)
Group 10 (n=10)	Ceramic	Biofix®	BIODINÂMICA (Ibiporã/ Brazil)
Group 11 (n=10)	Ceramic	Transbond XT®	3M (Sumaré/Brazil)
Group 12 (n=10)	Ceramic	Ortholink VLC®	ORTHOMETRIC (Marilia/Brazil)

DISCUSSION

Dental enamel surface integrity after orthodontic treatment by bonding fixed accessories is one of Orthodontics goals. Fixed apparatus removal is a critical treatment step due to risk of cracks and fractures on tooth surface. [7, 15, 16] The literature highlights that resin breaking at the bracket/adhesive interface or inside the adhesive with bonding material adhered to the tooth, are important conditions to prevent damage to enamel since these residues could be removed with suitable rotary instruments. [12] Studies indicate that the most favorable fracture site for maintaining enamel integrity is at the bracket/adhesive interface, with complete adhesive retention on dental surface. [10,17] This condition is due to cohesive force of adhesive to enamel be superior to adhesion force of bracket base to the adhesive. [12] In this way, the risk of enamel fractures or cracks during the bracket removal could be practically zero, since there is adhesive remnant attached to the tooth. [10]

In this context, the present study evaluated IAR of six brands of orthodontic adhesives used for steel and ceramic brackets bonding to dental surface. The most prevalent ARI in the steel bracket group was score 2, with more than half of adhesive remaining on the tooth. The ceramic brackets group had a higher prevalence of score 3, that is, the remaining adhesive was covering entire tooth area corresponding to the bracket. The literature points out that adhesive rupture in bracket/adhesive interface can occur both in steel and ceramic brackets. [18, 19]

Studies indicate that material type and bracket base design may be related to variations in ARI between the different bracket types. [20-22] The design of the bracket supporting base is an important factor for mechanical adhesive/bracket retention, which generates specific moments of force for takeoff of each type of part. [21] As long as more irregular bracket base, greater is the surface roughness and, consequently, greater is the adhesive mechanical retention. [23, 24] In the present study, steel brackets, with a micropine type base and sandblasted surface, showed a higher prevalence of residual resin in the accessory than ceramic brackets, with a microcavity type and sandblasted surface. It can be suggested that different types of brackets base surface may be directly related to the ARI.

In steel brackets group, Orthobond Plus®, Biofix® and Ortholink VLC® adhesives showed better ARI performance than Orthocem® + Ambar®. For ceramic brackets, Biofix® and Transbond XT® adhesives showed better IAR performance than Orthobond Plus®. Finnema et al. (2010) described that how longer the adhesive is cured, greater is the bond strength. There is an increase in bond strength of 0.077 Mpa with each additional second of light curing. [8] Although the photopolymerization time of the specimens in this study was standardized in 40 seconds, chemical formulation of the adhesives can generate different polymerization characteristics capable of impacting in their resistance and adhesion strength at the tooth/adhesive and bracket/adhesive interfaces. Several studies have pointed out specific characteristics of different adhesive systems for Orthodontics [3,9,21,25-27] and chemical peculiarities of adhesives tested in this present study could justify the differences in our results.

Table 2. Descriptive analysis of ARI scores in dental enamel among the different adhesives used for steel and ceramic brackets bonding.

	Groups	Score 0	Score 1	Score 2	Score 3
Parameters	Orthocem®	4 (40.0%)	2 (20.0%)	2 (20.0%)	2 (20.0%)
	Orthocem® + Ambar®	3 (30.0%)	5 (50.0%)	2 (20.0%)	0 (0.0%)
	Orthobond Plus®	0 (0.0%)	0 (0.0%)	9 (90.0%)	1 (10.0%)
	Biofix®	0 (0.0%)	1 (10.0%)	7 (70.0%)	2 (20.0%)
	Transbond XT®	2 (20.0%)	3 (30.0%)	1 (10.0%)	4 (40.0%)
	Ortholink VLC®	1 (10.0%)	1 (10.0%)	4 (40.0%)	4 (40.0%)
Ceramic Brackets	Orthocem®	0 (0.0%)	1 (10.0%)	2 (20.0%)	7 (70.0%)
	Orthocem® + Ambar®	0 (0.0%)	0 (0.0%)	3 (30.0%)	7 (70.0%)
	Orthobond Plus®	1 (10.0%)	3 (30.0%)	2 (20.0%)	4 (40.0%)
	Biofix®	0 (0.0%)	0 (0.0%)	1 (10.0%)	9 (90.0%)
	Transbond XT®	0 (0.0%)	0 (0.0%)	1 (10.0%)	9 (90.0%)
	Ortholink VLC®	0 (0.0%)	1 (10.0%)	2 (20.0%)	7 (70.0%)

Table 3. *Analysis of association of ARI scores in dental enamel among the different adhesives used for steel and ceramic brackets bonding.*

	Steel Brackets	**Mean rank**	***P* value**		**Ceramic Brackets**	**Mean rank**	***P* value**
	Orthocem®	11.00			Orthocem®	10.35	
	Orthocem® + Ambar®	10.00	0.692		Orthocem® + Ambar®	10.65	0.888
	Orthocem®	8.30			Orthocem®	12.35	
	Orthobond Plus®	12.70	0.067		Orthobond Plus®	8.65	0.122
	Orthocem®	8.30			Orthocem®	9.45	
Orthocem®	Biofix®	12.70	0.078	Orthocem®	Biofix®	11.55	0,255
	Orthocem®	9.30			Orthocem®	9.45	
	Transbond XT®	11.70	0.347		Transbond XT®	11.55	0.255
	Orthocem®	8.40			Orthocem®	10.50	
	Ortholink VLC®	12.60	0.100		Ortholink VLC®	10.50	1.000
	Orthocem® + Ambar®	10.00			Orthocem® + Ambar®	10.65	
	Orthocem®	11.00	0.692		Orthocem®	10.35	0.888
	Orthocem® + Ambar®	6.40			Orthocem® + Ambar®	12.60	
	Orthobond Plus®	14.60	0.001		Orthobond Plus®	8.40	0.079
Orthocem®	Orthocem® + Ambar®	6.65		Orthocem®	Orthocem® + Ambar®	9.50	
+ Ambar®	Biofix®	14.35	0.002	+ Ambar®	Biofix®	11.50	0.276
	Orthocem® + Ambar®	8.65			Orthocem® + Ambar®	9.50	
	Transbond XT®	12.35	0.143		Transbond XT®	11.50	0.276
	Orthocem® + Ambar®	7.20			Orthocem® + Ambar®	10.65	
	Ortholink VLC®	13.80	0.010		Ortholink VLC®	10.35	0.888
	Orthobond Plus®	12.70			Orthobond Plus®	8.65	
	Orthocem®	8.30	0.067		Orthocem®	12.35	0.122
	Orthobond Plus®	14.60			Orthobond Plus®	8.40	
	Orthocem® + Ambar®	6.40	0.001		Orthocem® + Ambar®	12.60	0.079
Orthobond	Orthobond Plus®	10.45		Orthobond	Orthobond Plus®	7.80	
Plus®	Biofix®	10.55	0.957	Plus®	Biofix®	13.20	0.016
	Orthobond Plus®	11.25			Orthobond Plus®	7.80	
	Transbond XT®	9.75	0.540		Transbond XT®	13.20	0.016
	Orthobond Plus®	9.90			Orthobond Plus®	8.65	
	Ortholink VLC®	11.10	0.591		Ortholink VLC®	12.35	0.122
	Biofix®	12.70			Biofix®	11.55	
	Orthocem®	8.30	0.078		Orthocem®	9.45	0,255
	Biofix®	14.35			Biofix®	11.50	
	Orthocem® + Ambar®	6.65	0.002		Orthocem® + Ambar®	9.50	0.276
	Biofix®	10.55			Biofix®	13.20	
Biofix®	Orthobond Plus®	10.45	0.957	Biofix®	Orthobond Plus®	7.80	0.016
	Biofix®	11.30			Biofix®	10.50	
	Transbond XT®	9.70	0.524		Transbond XT®	10.50	1.000
	Biofix®	10.05			Biofix®	11.55	
	Ortholink VLC®	10.95	0.705		Ortholink VLC®	9.45	0.255
	Transbond XT®	11.70			Transbond XT®	11.55	
	Orthocem®	9.30	0.347		Orthocem®	9.45	0.255
	Transbond XT®	12.35			Transbond XT®	11.50	
	Orthocem® + Ambar®	8.65	0.143		Orthocem® + Ambar®	9.50	0.276
Transbond	Transbond XT®	9.75		Transbond	Transbond XT®	13.20	
XT®	Orthobond Plus®	11.25	0.540	XT®	Orthobond Plus®	7.80	0.016
	Transbond XT®	9.70			Transbond XT®	10.50	
	Biofix®	11.30	0.524		Biofix®	10.50	1.000
	Transbond XT®	9.65			Transbond XT®	11.55	
	Ortholink VLC®	11.35	0.501		Ortholink VLC®	9.45	0.255
	Ortholink VLC®	12.60			Ortholink VLC®	10.50	
	Orthocem®	8.40	0.100		Orthocem®	10.50	1.000
	Ortholink VLC®	13.80			Ortholink VLC®	10.35	
	Orthocem® + Ambar®	7.20	0.010		Orthocem® + Ambar®	10.65	0.888
Ortholink	Ortholink VLC®	11.10		Ortholink	Ortholink VLC®	12.35	
VLC®	Orthobond Plus®	9.90	0.591	VLC®	Orthobond Plus®	8.65	0.122
	Ortholink VLC®	10.95			Ortholink VLC®	9.45	
	Biofix®	10.05	0.705		Biofix®	11.55	0.255
	Ortholink VLC®	11.35			Ortholink VLC®	9.45	
	Transbond XT®	9.65	0.501		Transbond XT®	11.55	0.255

It is important to notice that all adhesives tested in this study showed results clinically acceptable for shear resistance according to previous study. [28] Additionally, the majority of tested adhesives in this present study showed high scores of ARI, suggesting a good clinical performance to adhesive remnant index. Additionality, it is highlighted that limitations related to the design of in vitro studies must be considered before guiding the clinical decision of the orthodontists regarding the choice of the adhesive that might be used.

CONCLUSION

For steel brackets, Orthobond Plus®, Biofix® and Ortholink VLC® adhesives showed better ARI performance than Orthocem® + Ambar®, while for ceramic brackets, Biofix® and Transbond XT® adhesives showed better performance than Orthobond Plus ®.

CONFLICT OF INTEREST

The authors declare they have no potential conflict of interests.

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