

Original Research

In-vitro analysis of adhesive remnant index (ARI) of different metal brackets after tensile bond testing

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ABSTRACT:

Introduction: Assessment of ARI scoring is important because of its importance in the selection of orthodontic adhesive. Adhesive systems that show less ARI score help in easier and safer removal of residual resin after debracketing. The ARI score system is a simple method that needs no special equipment. The aim of this study was to analyse the mode of adhesive failure after debonding under tensile forces. **Materials and methods:** Brackets with four different base features were tested: polymer coated base {Nu Edge (TP Orthodontics)}, Foil mesh pad { Mini Diagonali (Leone)}, Photochemically etched base {Minimaster (American Orthodontics)}, Laser structured base {Discovery (Dentaurum)}. An optical microscope was used to study the adhesive remnants present on the bracket base. **Results:** Brackets with four different base features were tested: polymer coated base {Nu Edge (TP Orthodontics)}, Foil mesh pad { Mini Diagonali (Leone)}, Photochemically etched base {Minimaster (American Orthodontics)}, Laser structured base {Discovery (Dentaurum)}. An optical microscope was used to study the adhesive remnants present on the bracket base. **Conclusions:** Polymer coated ,sintered meshpads and photochemically etched base showed most of the fracture at bracket-adhesive interface proving the low retention of these bracket bases under tension.

Key words: tensile bond strength, bracket base design, adhesive remnant index

Received: 27 October, 2021

Accepted: 30 November, 2021

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This article may be cited as: Firdous W, Mohammad M. In-vitro analysis of adhesive remnant index (ARI) of different metal brackets after tensile bond testing. Int J Res Health Allied Sci 2022; 8(1): 43- 47.

INTRODUCTION

Assessment of ARI scoring is important because of its importance in the selection of orthodontic adhesive. Adhesive systems that show less ARI score help in easier and safer removal of residual resin after debracketing.¹ The ARI score system is a simple method that needs no special equipment. However, its reliability requires investigation especially in respect to the effects of magnification on evaluation of the adhesive remnant.²

Accurate assessment of the adhesive remnant is important in the final process of tooth cleaning after debracketing so it's correct evaluation is needed for satisfactory removal and restoration of the tooth surface to as close to pretreatment condition as possible. Clinical evaluation of ARI after debracketing can be done by naked eye. However, most studies on the bond strength of orthodontic brackets have examined teeth and brackets under 10× magnification to score the adhesive remnant,³⁻⁶ and various laboratory studies have used methods such as scanning electron microscope, 3-dimensional profilometry and finite element analysis.⁷⁻⁹

AIMS AND OBJECTIVES

1. Apply a tensile force to debond the brackets 24hours post bonding.

Analyzing the mode of adhesive failure after debonding by using Adhesive Remnant Index score.

MATERIALS AND METHODS

This study was cleared by the Ethical Committee of the institute. It was conducted on 60 extracted human premolar teeth which were non-carious and had intact buccal tooth surfaces with no fracture lines on the enamel surface. The extracted teeth that were collected were cleaned, washed, debrided and stored in a solution of 0.1% (wt/vol) thymol to prevent dehydration and bacterial growth.

Brackets under study:

Sixty orthodontic brackets with different bracket retention mechanisms were chosen for evaluation.

1. Fifteen Minimaster brackets with **photochemically etched** base (Fig 1A and Fig 2A)
2. Fifteen Discovery brackets with **laser structured** base (Fig 1B and Fig 2B)
3. Fifteen Mini-Diagonali brackets with **sintered foil mesh** pads (Fig 1C and Fig 2C)
4. Fifteen Nu-Edge brackets with **polymer coated** base (Fig 1D and Fig 2D)

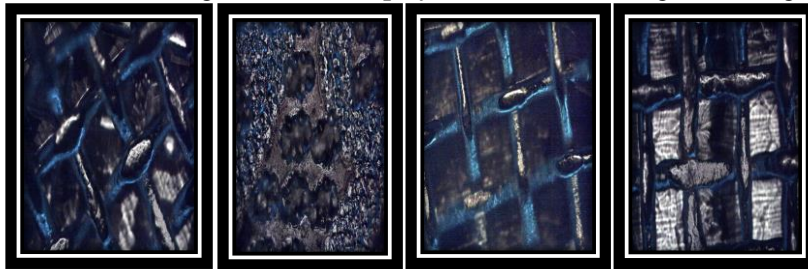


Fig 1. Under 10X Optical microscopy A) Photochemically etched base B) Laser structured base C) Sintered foil mesh pad base D) Polymer coated base

Field emission scanning electron microscopy photographs at 500X magnification for the different bracket bases, in the “as received” condition, are presented in Fig 2.

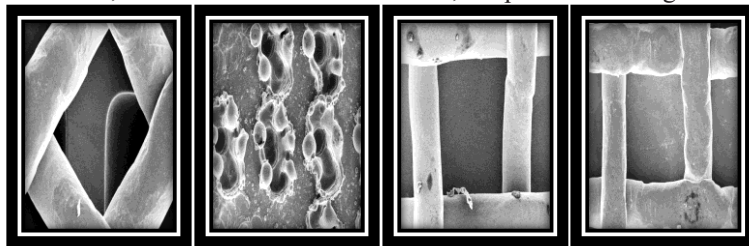


Fig 2. A) Photochemically etched base B) Laser structured base C) Sintered foil mesh pad base D) Polymer coated base

The teeth taken into study have been divided into four groups:

Grouping of sample: A2) Polymer coated base B2) Sintered foil mesh pad base C2) Photochemically etched base D2) Laser structured base . To help in easy identification, the sample groups were color coded with different colors. The acrylic blocks belonging to group A2, B2, C2 and D2 were color coded with black, orange, blue and pink respectively. Before assessing the ARI scores the samples underwent tensile strength testing .

ARI scoring:

ARI score was evaluated with the naked eye. This scale ranges from 0 to 3. And to confirm these findings an optical microscope (LEICA DM6000 M) at 10X magnification was used. Fig 3

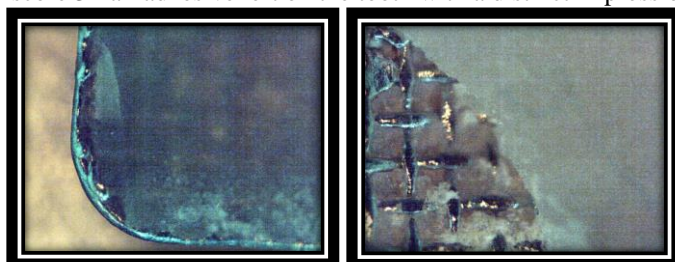
ARI is calculated using a four point scale given by Artun and Bergland.

score 0= no adhesive left on the tooth.

score 1 =less than half of the adhesive left on the tooth.

score 2 =more than half of the adhesive left on the tooth.

score 3= all adhesive left on the tooth with a distinct impression of the bracket mesh.



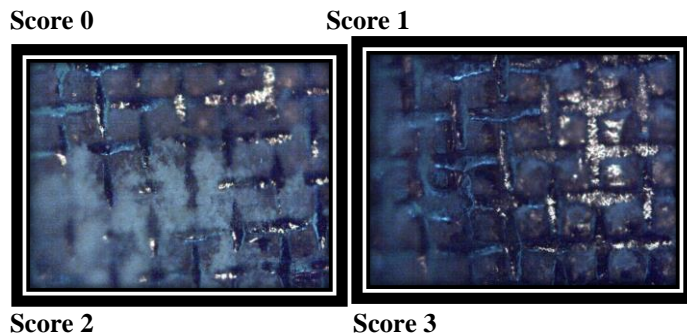


Fig 3. ARI Scoring

Results and Discussion:

ARI scores after tensile bond strength under naked eye were listed in **Table 1A** and Fig 3.

Chi-squared comparisons of the ARI indicated a highest frequency of ARI score of 2 (more than half of the adhesive has remained on the substrate and been removed from the bracket) in all of the groups. Group A2 (10 (66.7%)), B2 (9 (60%)), C2 (8 (53.3%)) and D2 (7 (46.7%)). This indicated a lesser trend for most of the adhesive to separate from the bracket base of different types, leaving a distinct impression of the bracket mesh on the tooth surface.

In group A2, ARI scores were in following order 2 (66.7%) > 1 (26.7%) > 0 (6.7%) > 3 (0.0%).

In group B2, ARI scores were in following order 2 (60.0%) > 3 (40.0%) > 1 (0.0%) = 0 (0.0%).

In group C2, ARI scores were in following order 2 (53.3%) > 3 (33.3%) > 1 (13.3%) > 0 (0.0%).

In group D2, ARI scores were in following order 2 (46.7%) > 1 (26.7%) > 3 (20%) > 0 (6.7%).

ARI Score	A2		B2		C2		D2	
	No.	%age	No.	%age	No.	%age	No.	%age
0	1	6.7	0	0.0	0	0.0	1	6.7
1	4	26.7	0	0.0	2	13.3	4	26.7
2	10	66.7	9	60.0	8	53.3	7	46.7
3	0	0.0	6	40.0	5	33.3	3	20.0
Total	15	100	15	100	15	100	15	100

Chi-square=12.988; P-value=0.163

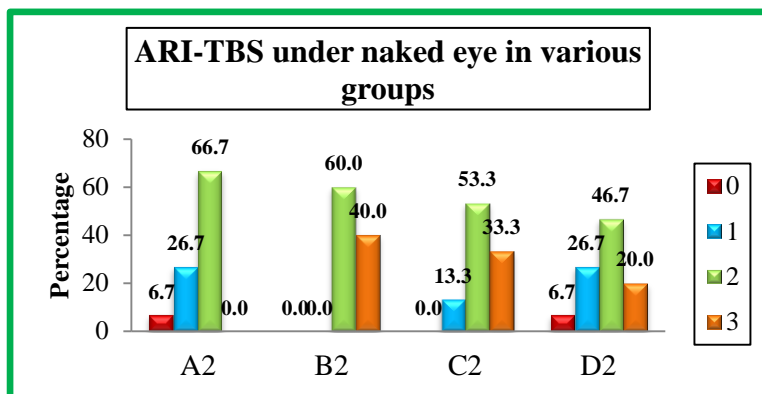


Fig. 3: ARI-TBS under naked eye in various groups

ARI scores after tensile bond strength under 10X magnification were listed in **Table 1B** and **Fig 4.**

Chi-squared comparisons of the ARI indicated a highest frequency of a ARI score of 3 (all of the adhesive has remained on the substrate and been removed from the bracket) in B2 (9(60%)) and C2 group (8(53.3%)).

In group A2 (11 (73.3%)) and D2 (9 (60%)) score 2 (more than half of the adhesive has remained on the substrate and been removed from the bracket) showed the highest frequency.

In group A2, ARI scores were in following order 2 (73.3%) > 3 (20%) > 1 (6.7%) > 0 (0.0%).

In group B2, ARI scores were in following order 3 (60.0%) > 2 (40.0%) > 1 (0.0%) = 0 (0.0%).

In group C2, ARI scores were in following order 3 (53.3%) > 2 (40.0%) > 1 (6.7%) > 0 (0.0%).

In group D2, ARI scores were in following order 2 (60.0%) > 3 (26.7%) > 1 (6.7%) = 0 (6.7%).

ARI Score	A2		B2		C2		D2	
	No.	%age	No.	%age	No.	%age	No.	%age

0	0	0.0	0	0.0	0	0.0	1	6.7
1	1	6.7	0	0.0	1	6.7	1	6.7
2	11	73.3	6	40.0	6	40.0	9	60.0
3	3	20.0	9	60.0	8	53.3	4	26.7
Total	15	100	15	100	15	100	15	100

Chi-square=10.583; P-value=0.305

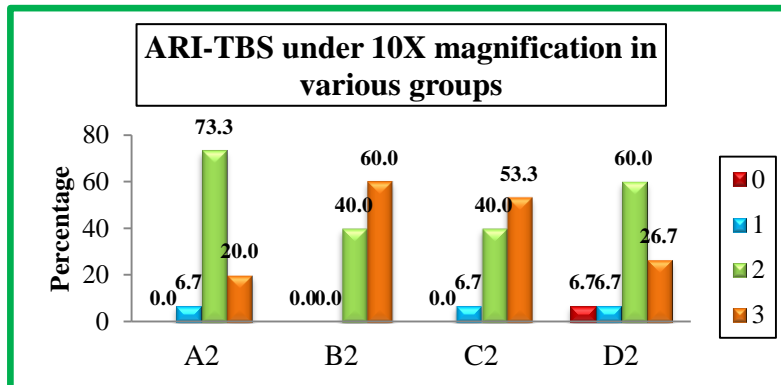


Fig. 4: ARI-TBS under 10X magnification in various groups

TYPE OF ADHESIVE FAILURE:

When ARI scores were calculated after tensile bond testing, no significant differences were found between the various bracket groups. Bishara et al.¹⁰ in their study found no significant difference in ARIs when bond strength of two different mesh-base designs was evaluated. None of the fractures were seen to occur at the level of enamel-adhesive interface in brackets with polymer coated base, simple foil mesh pads and photochemically etched base. Even in group laser structured base brackets only 6.7% fractures occurred at this interface. In foil mesh pads and photochemically etched base, maximum fractures were seen at the interface of bracket-adhesive interface (ARI-3). While as in polymer coated and laser structured bases, maximum number of fractured occurred were of mixed type (ARI -2). It was suggested that the resin was precured to the base of the bracket, and hence the weak link in the bonding system may have been at the precured filled resin tooth surface interface, the failure occurring within the unfilled resin. The photochemically etched and simple foil mesh pad brackets had a greater trend for almost all of the adhesive to remain on the tooth after debracketing (60% of the teeth had an ARI score of 3). Hence, the removal of excess resin after debonding was increased with these type of brackets. Sorel et al.¹¹ also found the similar values in case of simple foil mesh pad brackets but the findings of current study regarding laser structured base were in contradiction with their study. They found higher ARI scores with this type of base.

In comparison to the other bracket groups, polymer coated and laser structured bases showed more bond failures at enamel-adhesive interface which confirms the high retention of these bracket bases but at the same time they pose higher chances of enamel damage. It needs to be emphasized that the test conditions of this in-vitro study have not been subjected to the rigors of the oral environment. The retention of the bonded orthodontic attachments in the patient's mouth is governed partly not only by factors related to the operating orthodontist but also by factors related to the patient. A careful clinical technique, adequate moisture control, choice of appliance fitted, and instructions to the patient are all controlled by the operating orthodontist. The age and sex of the patient, malocclusion type, and appliance care are not controlled by the operator, but also influence clinical success.¹² The diet in general and trauma are important factors in bonding failure.^{13,14} These indicate the reasons that in vivo bond strengths are lower than in vitro bond strengths.^{14,15}

ARI scores indicated that there was a combined frequency of bond failure at the bracket-adhesive interface and at the adhesive-bracket interface. These results were in accordance with other reported findings. The bracket – adhesive interface is more resistant to compressive than to tensile stress. Fractures at the bracket-adhesive interface resulted in lot of resin remnants on the tooth surface after debracketing while as no resin remnants and a clean enamel surface was seen in fractures that occurred at enamel-adhesive interface. It has been stated that at times it is desirable to have resin remnants on the enamel surface after debracketing to prevent enamel fracturing¹⁶. This idea was also supported by Northrup et al.¹⁷, who stated that a higher ARI score indicates failure between the bracket and the adhesive, with less risk for enamel fracture during debracketing. The ARI is dependent not only on the adhesive type¹⁸ but also on the type of bracket base used¹⁹ ARI oversimplifies the complex issues of bond-failure analysis, but it allows for statistical analysis and cross-study comparisons. However, ARI results should be interpreted with caution because they are subjective²⁰ Conventional ARI testing involves two major deficiencies: 1) that the scores are derived through a subjective assessment, which involves

the visual inspection of the tooth surface; and 2) disproportional scales are used. Even with the modified ARI, with a five-point scale instead of four, there is no proportionality among the scales.

CONCLUSION

The ARI-TBS index score values showed a large variability. Polymer coated ,sintered meshpads and photochemically etched base showed most of the fracture at bracket-adhesive interface proving the low retention of these bracket bases on applying tensile forces while as laser structured base showed no fracture at bracket-adhesive interface proving the high tensile strength of this bracket base.

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