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Original Research

Invitro analysis of adhesive remnant index (ARI) of different metal brackets after shear bond testing

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ABSTRACT:

Introduction: All the present methods used to measure bond strength evaluate the cohesive strength of the cement and the strength of the bracket-cement and cement-enamel interfaces. That is they record only the weakest elements of this system. The plane of failure is commonly determined by adhesive remnant measurements (Artun and Bergland 1984). The aim of this study was to analyse the mode of adhesive failure after debonding under shear 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**: Chi-square test was used to compare the pattern of ARI scores between the groups. This test showed that, there was statistically significant difference between the groups with respect to ARI scores. ($\chi 2=24.06$, $p=0.004$). Chi-squared comparisons of the ARI indicated a highest frequency of ARI score of 1 (less than half of the adhesive has remained on the substrate and been removed from the bracket) in Group A1 (7 (46.7%)), C1 (6 (40%)), and D1 (9 (60%)). **Conclusions**: Polymer coated and laser structured base showed no fracture at bracket-adhesive interface proving the high retention of these bracket bases

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

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INTRODUCTION

Bond failure is common to be seen in daily practice. And it is of clinical importance. When the fracture occurs mainly at the resin enamel interface, it helps in easy removal of excess resin. This is favorable from the orthodontist's point of view, as the optimum bonding system is one that will allow easy bracket removal and remaining resin from tooth surface at debonding time and also has a sufficient bond strength to retain the bracket till the completion of treatment.[1] All the present methods used to measure bond strength evaluate the cohesive strength of the cement and the strength of the bracket-cement and cement-enamel interfaces. That is they record only the weakest elements of this system. The plane of failure is commonly determined by adhesive remnant measurements (Artun and Bergland 1984) [2]

Artun and Bergland [3] devised an Adhesive Remnant Index (ARI) system to evaluate the amount of adhesive left on the tooth after debracketing. This system was developed by conducting a study on 20 extracted teeth and the criteria were as follows: score 0 was given when there was no adhesive remained on the tooth surface; score 1 was given when less than half of the adhesive remained on the tooth surface; score 2 was given when more than half of the adhesive remained on the tooth surface; and score 3 was given when all the adhesive remained on the tooth surface with an impression of the bracket mesh. Over last two decades, ARI scores have gained much importance in studies on orthodontic adhesives. However, this approach may suffer from being a subjective one so many attempts have been made to modify the original system to more accurately assess the adhesive remnant. Most studies on the bond strength of orthodontic brackets have examined teeth and brackets under 10× magnification to score the adhesive remnant,[4-7] and various laboratory studies have used methods such as scanning electron

microscope, 3-dimensional profilometry and finite element analysis.[8-10]

AIMS AND OBJECTIVES

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

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

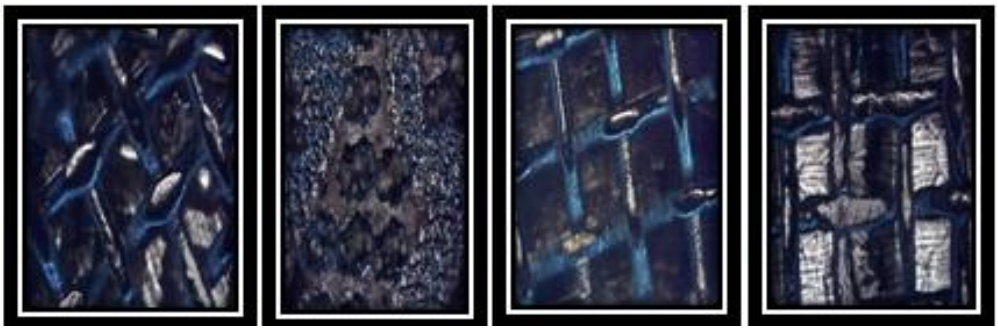
MATERIALS AND METHODS

This study was 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 premolars were obtained from a group of patients who had undergone therapeutic orthodontic extraction and were aged between 14-24 years. This study was cleared by the Ethical Committee of the institute. 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.

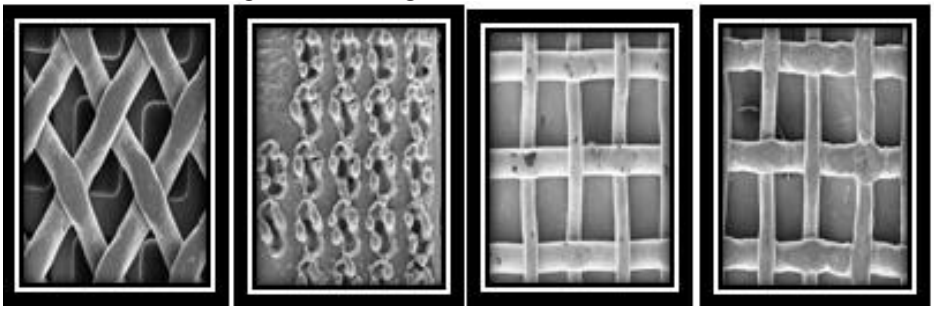
1. Fifteen Minimaster brackets with **photochemically etched** base (Fig 1A and Fig 2A)
2. Fifteen Discovery brackets with **laser structured** base (Fig 1B and Fig 2B)
3. Fifteen Mini-Diagonali brackets with **sintered foil mesh** pads (Fig 1C and Fig 2C)
4. Fifteen Nu-Edge brackets with **polymer coated**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



A B C D

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 225X magnification for the different bracket bases, in the ‘‘as received’’ condition, are presented in Fig 2.



A B C D

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:

Gouping of sample: A1) Polymer coated base B1) Sintered foil mesh pad base C1) Photochemically etched base D1) Laser structured base **.** To help in easy identification, the sample groups were color coded with different colors. The acrylic blocks belonging to group A1, B1, C1 and D1 were color coded with green, yellow ,red and brown respectively..

ARI SCORING

After shear bond testing, samples were assembled in a tray and each sample was given a number to help in easy identifying.

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.

Score 0 **Score 1**

Score 2 **Score 3**

RESULTS AND DISCUSSION

ARI is a useful tool to interpret bracket bond findings regarding the benefits of high versus low bond strength and the need for post-debonding procedures to clean the bonded surface. The adhesive remnant index (ARI) scores were calculated after shear bond test under naked eye. In addition, the samples were analysed under 10X magnification using an optical microscope to evaluate the type of bond failure at the bracket-adhesive interface in each test group and to visualize the adhesive remnant after the removal of the brackets.

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

Chi-square test was used to compare the pattern of ARI scores between the groups. This test showed that, there was statistically significant difference between the groups with respect to ARI scores. ($\chi 2=24.06$, p=0.004). Chi-squared comparisons of the ARI indicated a highest frequency of ARI score of 1 (less than half of the adhesive has remained on the substrate and been removed from the bracket) in Group A1 (7 (46.7%)), C1 (6 (40%)), and D1 (9 (60%)). 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.

Group B1 showed the highest frequency of ARI score 2 (more than half of the adhesive has remained on the substrate and been removed from the bracket) (8(53.3%)).

In group A1, ARI scores were in following order 1 (46.7%) > 0 (33.33%) > 2 (20%) > 3 (0%).

In group B1, ARI scores were in following order 2 (53.3%) > 3 (33.33%) > 1 (13.3%) > 0 (0%).

In group C1, ARI scores were in following order 1 (40%) = 2 (40%) > 3 (13.3%) > 0 (6.7%).

In group D1, ARI scores were in following order 1 (60%) > 2 (20%) = 0 (20%) > 3 (0%).

Table 1A: ARI-SBS under naked eye in various groups

ARI Score	A1		B1		C1		D1	
	No.	%age	No.	%age	No.	%age	No.	%age
0	5	33.3	0	0.0	2	6.7	3	20.0
1	7	46.7	2	13.3	6	40.0	9	60.0
2	3	20.0	8	53.3	5	40.0	3	20.0
3	0	0.0	5	33.3	2	13.3	0	0.0
Total	15	100	15	100	15	100	15	100
Chi-square=24.06; P-value=0.004 (Statistically Significant)								

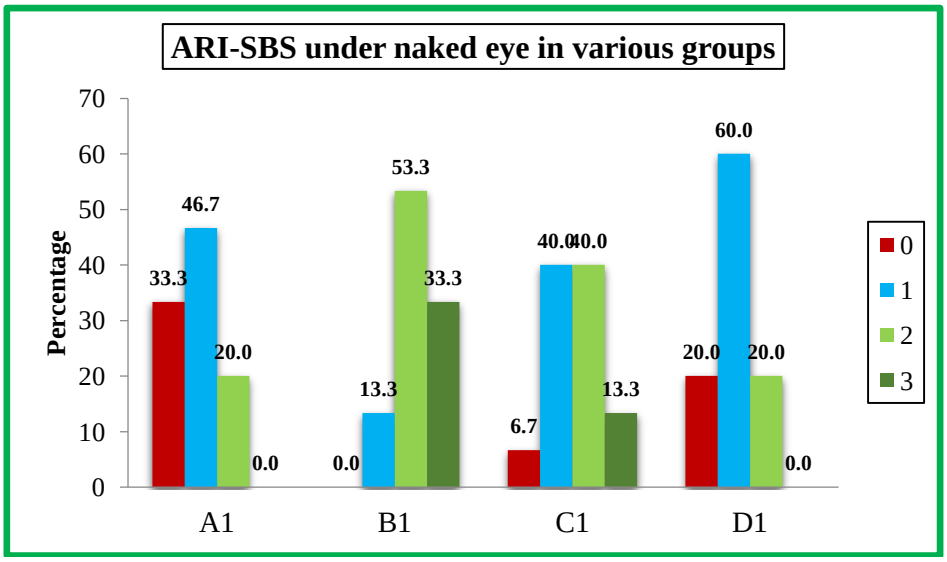


Fig. 3: ARI-SBS under naked eye in various groups

ARI scores after shear bond strength under 10X magnification were listed in **Table 1B and Fig 4..**
Chi-squared comparisons of the ARI indicated a highest frequency of ARI score of 1 in Group A1 (8 (53.3%)), score 2 in Group B1 (8 (53.3%)) and C1 (7 (46.7%)). In Group D1, there was equal frequency of score 1 and 2 (7 (46.7%).

In group A1, ARI scores were in following order 1 (53.3%) > 2 (33.3%) > 0 (13.3%) > 3 (0.0%).
In group B1, ARI scores were in following order 2 (53.3%) > 3 (46.7%) > 1 (0.0%) = 0 (0.0%).
In group C1, ARI scores were in following order 2 (46.7%) > 1 (26.7%) > 3 (20.0%) > 0 (6.7%).
In group D1, ARI scores were in following order 2 (46.7%) = 1 (46.7%) > 0 (6.7%) > 3 (0%).

Table 1B: ARI-SBS under 10X magnification in various groups

ARI Score	A1		B1		C1		D1	
	No.	%age	No.	%age	No.	%age	No.	%age
0	2	13.3	0	0.0	1	6.7	1	6.7
1	8	53.3	0	0.0	4	26.7	7	46.7
2	5	33.3	8	53.3	7	46.7	7	46.7
3	0	0.0	7	46.7	3	20.0	0	0.0
Total	15	100	15	100	15	100	15	100
Chi-square=24.06; P-value=0.004 (Statistically significant)								

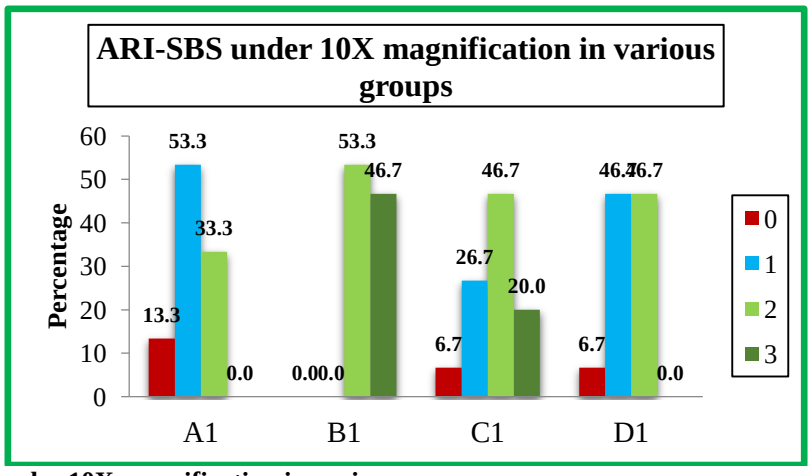


Fig. 4: ARI-SBS under 10X magnification in various groups

TYPE OF ADHESIVE FAILURE
After debracketing, the enamel surface of each tooth was examined to have the fracture pattern assessed and the Adhesive Remnant Index (ARI) was determined with both naked eye and an optical microscope under 10X magnification. All teeth were analyzed by the same observer. The ARI, as proposed by Artun and Bergland,[3] was used to classify the

enamel surface after debonding, according to the following scores: score 0, no composite resin left on the tooth; score 1, less than half of composite resin left on the tooth; score 2, more than half of composite resin left on the tooth; score 3, all composite resin left on the tooth with distinct impression of the bracket base. The bracket/adhesive interface can be considered as the most favorable site of failure for safe debonding as it leaves most of the adhesive on the enamel surface,[11,12] as seen in scores 2 and 3. This interface can be considered safe as there is less chance of fracture of enamel. The low ARI scores (0 and 1) have been considered favorable by some authors, [4,13] since there is less adhesive to remove from the tooth surface and, thus, less risk of iatrogenic damage during enamel polishing. In the current study, when ARI scores were calculated after shear bond strength testing, it was found that there were statistically significant differences between various bracket groups. In brackets with polymer coated base and laser structured base none of the sample fractured at the level of bracket-adhesive interface. These findings are in line with what was expected for the Primekote polymer, since this polymer is intended to improve the adhesion of the resin to the bracket base.[14] Most of the fractures seen were of mixed type having ARI score of 1 and 2. It was noted that debonding occurred within the adhesive (cohesive type) therefore, the bond-failure patterns when composite was used were potentially favorable for enamel preservation. Jaffer et al.[15] found that most of the composite resin was left on the bracket when brackets were debonded, meaning that the bond failure occurred purely or primarily at the adhesive enamel interface. While as in brackets with foil mesh pads, no fractures were seen at the level of enamel-adhesive interface. Almost all of the debonding was seen to occur at the level of bracket-adhesive interface with ARI scores 2 and 3. In brackets with photochemically etched base, fractures seen were of mixed type. As reported in the literature, the problem with the mesh based bracket was the presence of voids beneath the weld spots which resulted in the exposure of this area to marginal leakage and hence bond failure. Brazing was then introduced to overcome this. But improper brazing resulted in poor joining of mesh. Cozza et al.[16] while evaluating the conventional mesh found 50% of cases of bond failure took place at the enamel-adhesive interface and that the remaining 50% were mixed fractures.

CONCLUSION

The ARI-SBS index score values showed a large variability. Polymer coated and laser structured base showed no fracture at bracket-adhesive interface proving the high retention of these bracket bases while as foil mesh pad brackets showed no fracture at enamel-adhesive interface proving the enamel friendly nature of this bracket base.

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