Original article

Clinical Bonding Durability Assessment of Rebonded Brackets considering ARI Score

Mohammad Hossein Ahangar Atashi[1], Setareh Khosravi[2], Aziz Goshaderoo[3], Abbas Goshaderoo[4]

1. Associated Professor, Department of Orthodontics, Tabriz University of medical science, Tabriz, Iran
2. Assistant professor, Department of Orthodontics, Shahed University of medical science, Tehran, Iran
3. Assistant professor, Department of prosthodontics, Shahid Beheshti University of medical science, Tehran, Iran
4. Post graduate student of periodontics, Tabriz University of medical science, Tabriz, Iran

*correspondence: **Setare Khosravi**, Assistant professor, Department of Orthodontics, Shahed University of medical science, Tehran, Iran. Email: khosravi_setareh@yahoo.com

Abstract:

Introduction: Debonding is known as one of the main problems in orthodontics. Rebonding these brackets require clinical chair time and is a nuisance and costly process in the course of orthodontic treatment. Clinical bonding durability of new brackets in comparison with rebonded brackets with different Adhesive Remnant Index (ARI) scores has been investigated in this study.

Methods: The subjects of this study consisted of 76 debonded brackets of maxillary first and second premolars. According to ARI scoring after debonding, brackets were divided into two groups. 27 debonded brackets with composite residual value (ARI) greater than or equal to 90% were assigned to group A (ARI≥4) and 28 brackets to group B (ARI≤2) with a composite residual value less than or equal to 10%. The third group was used as a control group in which 21 new brackets were used.

Findings: Similar bonding durability time was recorded in group A (ARI≥4) and group C (new brackets) which was significantly higher than of group B (ARI≤2).

Conclusion: Debonded brackets with high ARI score (ARI≥4) and new brackets have the same performance on bonding durability. Therefore, a high ARI debonded bracket can be used instead of a new bracket for rebonding.

Keywords: Bonding Durability, ARI Score, Bracket Rebonding, Debonding

Introduction:

Orthodontics has used bonding for more than 40 years. Nowadays, the maxillary first molars are the only teeth that are not routinely bonded, and other molars are also less bonded (1). The pioneering bonding of brackets to enamel was with phosphoric acid etching done by Bonocore in 1955 (2). The first accurate assessment after direct bonding was published on a large group of patients in 1977 (3). Since then, brackets, adhesives, and technical details have progressed significant improvements. Since replacing the brackets is time-consuming and costly, reducing bond failure must be considered as a high priority goal (1). Different parameters play roles in bonding. The etching process, type of adhesive and enamel structure are among the factors have significant effects on the bonding strength. In terms of epidemiological, outbreak of bracket debonding has been reported to be 3.5-23% (4). Studies have reported that in every five brackets, one bracket will be debonded during treatment (4). Generally, three mechanisms have been mentioned for bracket debonding:

1. Fracture of the bond inside adhesive
2. Fracture of the bond between adhesive and enamel
3. Fracture of the bond between adhesive and bracket

The failure of the bond inside the adhesive layer or between the adhesive - bracket is more favorable than fracture in between the adhesive - enamel in terms of damage to the enamel (5).

In general, there are two approaches to rebonding: using a new bracket or making changes to the previous bracket and reuse it.

The overall sequence of usual rebonding process is as follows:

1. The metal bracket is removed from the archwires.
2. The remnant adhesive should be removed from the tooth surface with a tungsten carbide bur.
3. The remnant adhesive on the bracket is removed (i.e. sandblasting, laser, grinding, etc.)
4. The tooth is etched with phosphoric acid (35%) for 15 seconds.
5. After using the primer, the bracket is rebonded. The adjacent brackets and rebonded brackets are ligated respectively (1).

The strength of rebonded brackets must be sufficient to withstand the daily forces of chewing; also, it should not damage the enamel during debonding at the end of treatment (6, 7). However, in previous studies, no agreement is reached on the comparison of rebonded brackets with new brackets. Some studies have suggested a more robust bond for rebonded brackets (8), some suggest a comparable bond strength, and some have shown lower value for rebonded brackets (9, 10). This difference is due to a variety of variations such as the methods of reconditioning of brackets / enamels (11, 12), composite residual value (ARI) and the type of brackets (13).

ARI index determines the amount of remnant resin in the base of the bracket (in percent) after debonding (14). ARI score is used to evaluate the amount of remnant resin:

Score 5: No resin on the enamel (all resin on the bracket)

Score 4: Less than 10% resin on the enamel (more than 90% resin on the bracket)

Score 3: between 10% to 90% resin on the enamel

Score 2: More than 90% of resin on the enamel (less than 10% resin on the bracket)

Score 1: All resin on the enamel

In a lab analysis, in 1999, Mui et al. examined various techniques for rebonding. Their results showed that the optimum method for rebonding the debonded bracket is removing the adhesive remained on enamel with a 12 bladed tungsten carbide bur, 60 seconds of etching enamel with phosphoric acid (30%) and micro-etching of the previous bracket or using a new bracket (15).

In 2006, Tavares et al. examined the bond strength of rebonded brackets by various refreshing techniques. The authors concluded that there was no significant difference in the bond strength of sandblasted brackets, new brackets, and control group. Industrial restoration and grinding methods had less bond strength (16).

In 2006, Eminkahyagil et al. divided 40 bonded premolar brackets into four groups of ten. In order to determine the ARI, the brackets were examined after debonding by a plier under a microscope. In each of the four groups, the remnant adhesive on the base of the bracket was removed using a low-speed tungsten carbide bur. The remnant resin on enamel surface was removed by four methods: First, high-speed tungsten carbide bur, second, low-speed tungsten carbide bur, third, disk finishing and fourth method was by micro-etching. They found that, except micro-etching method, the rebond strength of other methods was significantly more than the control group (ten new brackets). The researchers concluded this could be due to the increased surface roughness of the enamel after the resin removal and mechanical reinforcement of the rebonded brackets (8).

In most of the studies done on the bracket debonding, the Adhesive Remnant Index (ARI) has been mentioned. However, no clinical research has been conducted on rebonding of debonded brackets with different ARI indexes.

Therefore, this study will compare the clinical durability of rebonded brackets, which have different adhesive indexes, with new brackets.

The present paper proposes numerical and experimental procedure of ultrasonic guided wave inspection applied on a defected plate to find its fault.

Methods:

Table 1, Table 2 and Table 3 present the abundance of 281 debonded brackets over 2 years in a private clinic, considering the type of tooth, arch side, and dental arch, respectively.

Of 281 registered debonded brackets, 95 cases were associated with the maxillary first and second premolars, the target population of which was selected based on the following criteria.

Criteria for eligible brackets:

The same bonding conditions (the same bonding materials, by an expert)

Rebonding in the first three months of patient's treatment (leveling and alignment)

Remaining debonded bracket on the wires

Criteria for ineligible brackets:

debonded by patient

Detecting the unusual (hard) nutrition (patient's own statements or patient's parents), and any occlusive factors that might cause debonding

Having oral habits like bruxism or clenching

The sequential debonding of the same bracket

Posterior cross-bite

Restoration on the buccal surface of the tooth

The least effect of chewing force factor on upper first and second premolar teeth makes them appropriate cases for the aim of the present study.

According to the mentioned criteria, of the 95 cases of debonding associated with maxillary first and second premolars, 76 cases were eligible for the study. Patients' demographic data were also categorized based on age, sex, type of malocclusion, and overbite type.

According to ARI scoring after debonding, brackets were divided into two groups. 27 debonded brackets with composite residual value (ARI) greater than or equal to 90% were assigned to group A (ARI≥4) and 28 brackets to group B (ARI≤2) with a composite residual value less than or equal to 10% (

Figure **1**). In 21 cases, new brackets were used as a control group (group C).

Research Methodology

All orthodontic patients in the treatment center were evaluated for debonding of the maxillary first and second premolar for 2 consecutive years. After encountering debonding and performing refreshing, the distribution of residual composite on the base of the standard bracket slot 18 (Equilibrium, Dentaurum Inc, Germany) was performed to visualize the ARI using a magnifying glass (

Figure **2**). The bracket at a distance from the magnifying glass (Lumagny, China) was magnified by ten times and a rectangle drawn with the same dimensions of the magnified bracket on the magnifying glass lens was divided into ten equal parts.

Rebounding Method

A very thin layer of remaining composite on the base of the bracket was removed for refreshing using a multi-blade (D & Z, CC129FX, Lemgo, Germany) bur at a speed of 30000 rpm (17) considering not to expose the metal mesh bracket. In group C (new brackets), no refreshing is required to be done on brackets. After removing the remnant adhesive on the tooth with a tungsten carbide bur, the enamel was etched with 35% phosphoric acid for 15 seconds, followed by washing and drying. Bonding materials including bonding agent and no mix adhesive resin (resilience, orthotechnology, Tampa, USA) were used.

The number of debondings occurred on rebonded brackets and their durability was recorded.

Statistical Analysis

The frequency of debonded brackets was extracted for each group and Chi-Square test was used in SPSS 17 software to compare the groups. In this study, the value of $P<0.05$ was considered statistically significant. The Log-Rank test was also used to compare the rebonding durability of groups.

To evaluate the normal distribution of bonding durability time data, Kolmogorov-Smirnov test was used in three groups and the results are presented in Table 4. Considering that the significance level was more than 0.05 and the data had a normal distribution, a parametric test was used to investigate the research objectives.

Findings:

As mentioned in previous sections, investigation of the clinical durability of rebonded brackets with different ARI scores compared with using new brackets for rebonding has been of the main goals of the present study. Therefore, a pairwise comparison of the frequency of debonded brackets in three groups is performed at the end of the study (without considering the time intervals). The results are presented in Table 5.

The durability of rebonded brackets, known as the most important criterion in orthodontics has been evaluated for each of target groups in this study and bonding durability time in three time periods is reported in Table 6.

Table 7 and Figure 3 show the results of Log-Rank test in order to compare the bonding durability time of debonded brackets in three groups. Based on the results, bonding durability time of debonded brackets was significantly different in three groups ($P<0.05$). Figure 3 shows that the slope of the diagram is similar in both groups A and C and varies with group B.

Discussion:

Reviewing the literature shows all previous studies on rebonding are in vitro studies which mostly have evaluated the shear bond strength or tensile strength of rebonded brackets. Debonding with laboratory machines is achieved by inserting shear or tensile force at much higher levels of force. Debonding force in these studies is a continuously increasing force which is not a complete representative of the forces involved in the mouth; as a result, the complex oral environment cannot be simulated in the laboratory in the same clinical precise (1). Therefore, the present clinical study has evaluated the effective factors in debonding of brackets under natural conditions.

The results of most incidences of debonding in various studies have been reported differently. In the study, done by Zachrisson, the first and second premolar teeth had the highest debondings (18).

In the present study, the highest incidence of debonding was in the maxillary second premolars (Table 1). Whilst, in the study H.R Sukhia performed, the highest level of debonding was in mandibular premolars (19). Rassol introduced maxillary premolars having the highest bond failure (20). Possible reasons for this increased incidence of debonding is the difficulty of accessing the buccal surface of the premolar teeth and subsequent contamination with moisture, as well as possible presence of prismless enamel (21).

Table 1 shows a higher bond failure in maxillary dentition than mandibular. This result is in agreement with the Rassol's study (20), in contradiction with the findings of HR Sukhia (19) and Pseiner BC (22). On the other hand, Marquezan M showed that the distribution of the debonding was equal in two arcs (23). Chewing force is of important probable reasons for increasing debonding of mandibles. In this study, the maxilla was investigated in order to reduce the effect of chewing interventional factor in rebonding.

The results of this study, using Chi-Square test, showed that the number of debonded brackets after rebonding in high ARI group (ARI≥4) was similar to the cases of using new brackets. Also, the duration of bonding durability between these two groups was not significantly different. However, a statistically significant difference in the rebonding failure was observed when the low ARI group was compared with them. Subsequently, it can be concluded that if the bonding between enamel and adhesive is broken (most of the adhesive is on the base of the bracket), this bracket will be a better candidate for rebonding purposes. On the contrary, in brackets with low ARI, in most cases debonding occurs in the bracket-adhesive interface; so it's not a good option for rebonding.

In the study of debonding of rebonded brackets in less than 6 months, 6-12 months and 18-12 months, results showed that in less than 6 months, the highest level of debonding was observed in the lower ARI group, while in the other two groups, debonding was at a time greater than 6 months. Therefore, it can be interpreted that debonding in the lower ARI group is more frequent at the earliest time and the probable reason is the low level of adhesive remaining for rebonding.

Conclusion:

The method introduced in this paper, unlike all previous studies, not only does not seek to remove the residual composite resin on the bracket but also uses the advantage of remaining composite on its base (24-26). Consequently, a high ARI debonded bracket can be used instead of a new bracket. Results indicated that in most cases the rebonded bracket could be maintained until the end of treatment.

References:

1. Zachrisson BU, Buyukyilmaz T. Bonding in orthodontics. Graber LW, Vanarsdall RV,Vig KWL Orthod Curr Princ Tech. 2012;5th ed.:727–748.
2. Buonocore MG. A Simple Method of Increasing the Adhesion of Acrylic Filling Materials to Enamel Surfaces. J Dent Res. 1955;34(6):849–853.
3. Zachrisson BU. A posttreatment evaluation of direct bonding in orthodontics. Am J Orthod. 1977;71(2):173–189.
4. Lovius BBJ, Pender N, Hewage S, O'Dowling I, Tomkins A. A Clinical Trial of a Light-Activated Bonding Material over an 18 month Period. Br J Orthod. 1987;14(1):11–20.
5. Bishara SE. Textbook of orthodontics. Saunders; 2001.
6. Akin-Nergiz N, Nergiz I, … KB-TEJ of, 1996 U. Shear bond strength of a new polycarbonate bracket—an in vitro study with 14 adhesives. academic.oup.com. 1996:295–301.
7. Keizer S, ten Cate JM, Arends J. Direct bonding of orthodontic brackets. Am J Orthod. 1976;69(3):318–327. http://linkinghub.elsevier.com/retrieve/pii/0002941676900798.
8. Eminkahyagil N, Arman A, … AÇ-TA, 2006 U. Effect of resin-removal methods on enamel and shear bond strength of rebonded brackets. angle.org. 2006:314–321.
9. Jassem HA, Retief DH, Jamison HC. Tensile and shear strengths of bonded and rebonded orthodontic attachments. Am J Orthod. 1981;79(6):661–668.
10. Bishara SE, Laffoon JF, VonWald L, Warren JJ. The effect of repeated bonding on the shear bond strength of different orthodontic adhesives. Am J Orthod Dentofac Orthop. 2002;121(5):521–525.
11. Basudan AM, Al-Emran SE. The Effects of In-office Reconditioning on the Morphology of Slots and Bases of Stainless Steel Brackets and on the Shear/Peel Bond Strength. J Orthod. 2001;28(3):231–236.
12. Chung C-H, Friedman SD, Mante FK. Shear bond strength of rebonded mechanically retentive ceramic brackets. Am J Orthod Dentofac Orthop. 2002;122(3):282–287.
13. Willems G, Carels CEL, Verbeke G. In vitro peel/shear bond strength evaluation of orthodontic bracket base design. J Dent. 1997;25(3–4):271–278.
14. Bishara SE, Ortho. D, Truiove TS. Comparisons of different debonding techniques for ceramic brackets: An in vitro study: Part I.

Background and methods. Am J Orthod Dentofac Orthop. 1990;98(2):145–153.
15. Mui B, Rossouw P, Orthodontist GK-TA, 1999 U. Optimization of a procedure for rebonding dislodged orthodontic brackets. angle.org.
16. Tavares SW, Consani S, Nouer DF, Magnani MBB de A, Nouer PRA, Martins LM. Shear bond strength of new and recycled brackets to enamel. Braz Dent J. 2006;17(1):44–48.
17. Shahamfar M, Sciences MA-RJ of M, 2014 U. In vitro Evaluation of Shear Bond Strength of New and Rebonded Brackets Reconditioned with Grinding: Effect of ARI Index. docsdrive.com.
18. Zachrisson BU. A post treatment evaluation of direct bonding in orthodontics. Am J Orthod. 1977;71(2):173–189.
19. Sukhia HR, Orth D, Sukhia RH, Mahar A. Bracket de-bonding and breakage prevalence in orthodontic patients. Pakistan Oral Dent J. 2011;31(1).
20. Gholam R. Patients, Frequency of bracket breakage and bond failure in. P Oral Dent. 2013:299–302.
21. Whittaker DK. Structural variations in the surface zone of human tooth enamel observed by scanning electron microscopy. Arch Oral Biol. 1982;27(5):383–392.
22. Pseiner BC, Freudenthaler J, Jonke E, Bantleon H-P. Shear bond strength of fluoride-releasing orthodontic bonding and composite materials. Eur J Orthod. 2010;32(3):268–273.
23. Marquezan M, Lau T. Shear bond strengths of orthodontic brackets with a new LED cluster curing light. J Orthod. 2010;37(1):37–42.
24. Hickel R, Brüshaver K, Ilie N. Repair of restorations--criteria for decision making and clinical recommendations. Dent Mater. 2013;29(1):28–50.
25. Lynch CD, Blum IR, Frazier KB, Haisch LD, Wilson NHF. Repair or replacement of defective direct resin-based composite restorations: contemporary teaching in U.S. and Canadian dental schools. J Am Dent Assoc. 2012;143(2):157–163.
26. Baur V, Ilie N. Repair of dental resin-based composites. Clin Oral Investig. 2013;17(2):601–608.

Tables and Figures:

Table 1: Number of debonded brackets of each type of tooth

Type of tooth	Number of debonded brackets
upper incisor	30 (10.6%)
lower incisor	44 (15.6%)
upper canine	26 (9.2%)
lower canine	21 (7.5%)
upper first premolar	21 (7.5%)
lower first premolar	8 (3 %)
upper second premolar	74 (26.3%)
lower second premolar	57 (20.3%)

Table 2: Number of debonded brackets of each arch side

Arch side	Number of debonded brackets
right	122 (43.4%)
left	159 (56.6%)

Table 3: Number of debonded brackets of each dental arch

Dental arch	Number of debonded brackets
upper	151 (53.7%)
lower	130 (46.3%)

Table 4: Evaluation of distribution of bonding durability time data for three groups

Group	Number of rebounded brackets	Kolmogorov-Smirnov	Significance level
A (ARI≥4)	27	0.745	0.636
B (ARI≤2)	28	0.521	0.949
C (New Brackets)	21	0.962	0.313

Table 5: Pairwise comparison of the frequency of debonded brackets at the end of the study

<table>
<tr><th rowspan="2">Pairs of groups</th><th rowspan="2">Number of brackets</th><th colspan="2">Debonded brackets</th><th rowspan="2">P value*</th></tr>
<tr><th>Number</th><th>Percent</th></tr>
<tr><td>A</td><td>27</td><td>6</td><td>22.2</td><td rowspan="2">0.527</td></tr>
<tr><td>C</td><td>21</td><td>4</td><td>19</td></tr>
<tr><td>B</td><td>28</td><td>19</td><td>67.9</td><td rowspan="2">0.002</td></tr>
<tr><td>C</td><td>21</td><td>4</td><td>19</td></tr>
<tr><td>A</td><td>27</td><td>6</td><td>22.2</td><td rowspan="2">0.009</td></tr>
<tr><td>B</td><td>28</td><td>19</td><td>67.9</td></tr>
</table>

* obtained from Chi-Square test

Table 6: The frequency of debonded brackets based on three time periods

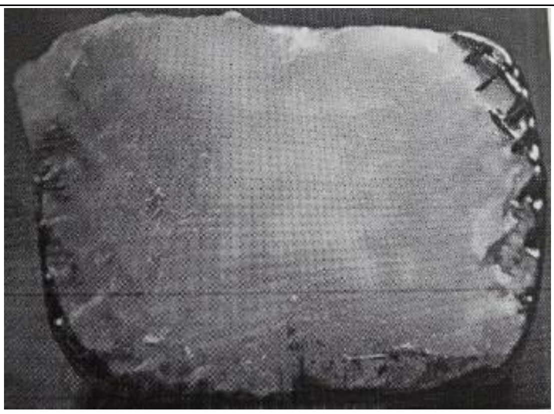
<table>
<tr><th rowspan="2">Group</th><th rowspan="2">Number of debonded brackets</th><th colspan="3">Bonding durability time (months)</th></tr>
<tr><th>0 - 6</th><th>6 - 12</th><th>12 - 18</th></tr>
<tr><td>A</td><td>6</td><td>-</td><td>5
(83.3%)</td><td>1
(16.7%)</td></tr>
</table>

B	19	11 (57.9%)	8 (42.1%)	-
C	4	-	3 (75%)	1 (25%)

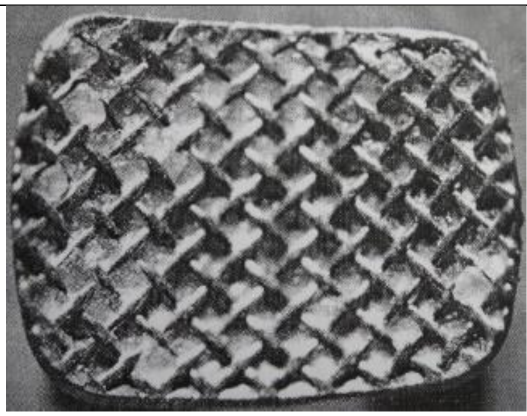
Table 7: Bonding durability time of debonded brackets during the study period

Group	Average ± standard deviation of bonding durability time (days)	95% confidence interval		P value*
		Lower limit	Upper limit	
A	217.33 ±75.16	157.193	277.474	0.045
B	133.05 ± 71.96	100.696	165.410	
C	245.75 ±91.86	155.724	335.776	

* Log Rank (Mantel-Cox)



Group A (ARI≥4)



Group B (ARI≤2)

Figure 1: Categorization of debonded brackets based on ARI

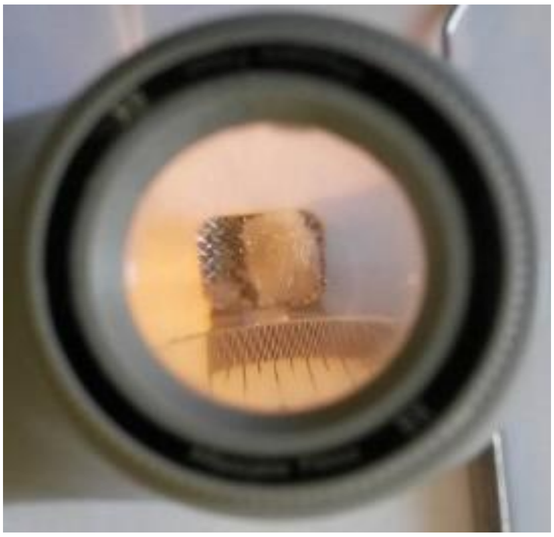


Figure 2: The magnifying glass used to visualize the ARI

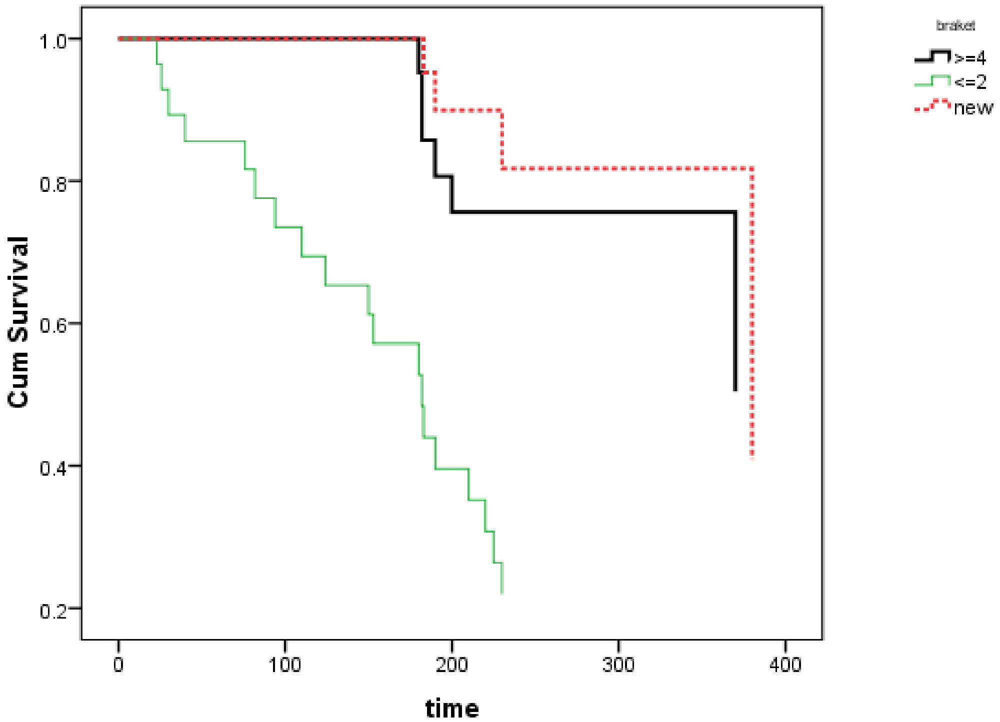


Figure 3: Bonding durability of three groups