

Evaluation of Shear Bond Strength Orthodontic Bracket and Adhesive Remaining Materials on the Enamel Surface Using ARI (Adhesive Remnant Index)

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Abstract

Background: The bracket attachment on the teeth uses a variety of adhesive materials, one of those materials is a resin composite. Composite resin polymerization can be done chemically and by irradiation or light cured. Along with the advancement of technology has been widely used light cured with a high intensity to shorten the operator work time. During orthodontic treatment, the shear strength is the force that mostly works on the bracket. After orthodontic treatment will remain adhesive on the enamel surface, the primary concern is to restore the enamel surface like its original condition.

Objective: To determine differences in shear strength of the orthodontic bracket towards differences in the residual of adhesive material on the enamel surface.

Materials and Methods: 5 premolars teeth of mandible were applied etchant materials, bonded and resin composite material was applied on the bracket base. Furthermore, the irradiation was done by using the LED with intensity of 2700 mW/cm² and the exposure time was 10 seconds. Then it was immersed in artificial saliva on the incubator with temperature 37°C for 24 hours. The shear strength test was done by using the universal testing machine to determine the strength of bracket attachment from tooth surface. Furthermore, the residual of adhesive material on the tooth surfaces were observed by using stereo microscope and determined ARI scores (*Adhesive Remnant Index*).

Results and Conclusions: There was low shear strength of 4.9 MPa and obtained residual adhesive with low scores.

Keywords: ARI; Shear Strength; Resin Composite

Abbreviations

ARI: Adhesive Remnant Index; LED: Light Emitting Diode; F: Force; kgf: Kilogram-Force; N: Newtons; MPa: Mega Pascals; nm: Nano-Meter; SEM: Scanning Electron Microscope

Introduction

Attachment of orthodontic brackets by direct and indirect is already started to be used in orthodontics using enamel acid etching technique since 1955 by Bounocore [1]. Bracket attachment on the teeth using variety of bracket adhesives that are commercial and one of them is composite resin. Composite resin polymerization can be performed by acid-base reaction that occurs chemically and polymerization carried out by irradiation or light cured [2].

It has been widely used light cured with high intensity. The use of high-intensity light cured has several advantages than lower light intensity, such as working time is short, the operator work is more efficient, and greater light intensity of visible light that used in light cured, so that the accessible areas of light are wider. Light cured with high light intensity can optimize the polymerization process and bracket attachment to the tooth surface is getting stronger [1,3]. The losses obtained on the use of high intensity is high intensity of light can produce heat temperature to intra-pulp with 5.7°C, so that it can increase the risk of injury to the intra-pulp [4,5].

The factors that influence at the time of polymerization composite ray are the distance between the ray source to the material surface, long of irradiation and ray intensity [2]. Long exposures of irradiation and ray intensity inversely, theory suggests the decline of irradiation duration can be compensated by increasing the ray intensity and also vice versa [6].

The measurement of shear bond strength is a measure most commonly used in the laboratory to evaluate orthodontic bonding system, because the shear strength is the strength of most widely work on orthodontic brackets during treatment [14]. Achievement of proper bonding strength between the bracket and the tooth surface in orthodontic treatment is important to minimize the release bracket which can increase costs and delay the treatment process [6].

After the use of fixed orthodontic appliance, the main concern is to restore the enamel surface like its original condition. At the release of orthodontic bracket, there are two conditions that can occur. First, the failure of adhesions between the adhesive-email, and second the failure of the adhesive-bracket attachment. In both cases, there will be remnants of adhesive left on the enamel surface, which require special handling such as scraping with a scaler or adhesive remover plier, or remove the tungsten carbide burs. If the rest of the removed adhesive material is not really clean, the tooth surface will be rough. This can cause discoloration of non-aesthetic and increase plaque retention [7]. To be used in orthodontic treatment, the bracket attachment system must be able to withstand pressure between 5.9 to 7.8 MPa [8]. The strength of the attachment bracket should not exceed 13 MPa so it does not to cause damage to the email at the time of bracket release [9]. Email fractures can occur at the time of bracket release [10].

ARI (Adhesive Remnant Index) is the method used to determine the failure location of the bracket attachment [11]. Index score of ARI is 0 score that is no adhesive left on the teeth; 1 score is less than half of the adhesive left on the teeth; 2 score is more than half of the adhesive left on the teeth; and 3 score is all adhesive left on the teeth with the mark that is different from the nets bracket [21]. There are low domination scores between the groups, showed little or no amount of resin bound email [12]. The strength of bracket attachment with LED light in shorter exposure time (5 or 10 seconds) seems to be a good alternative for reducing working time in orthodontic practice every day, but further studies are still needed if the technique will be recommended [20].

The benefits of this research are to determine the difference in shear strength of orthodontic bracket and the rest of the adhesive material on the enamel surface, so that the working time is more efficient. Based on the description above, authors wanted to know the differences in shear strength of orthodontic bracket and the rest of the adhesive material on the enamel surface using ARI (Adhesive Remnant Index).

Materials and Methods

This study was a laboratory experimental research conducted at the Histology Laboratory and Microbiology Laboratory of Biomedical Section Faculty of Dentistry, University of Jember and Basic Laboratory Joint to Faculty of Pharmacy, University of Airlangga. Samples were 5 premolar teeth mandible that were extracted and coded to samples 1 - 5.

This implementation began with sample preparation was premolar teeth of mandible were cleaned using pumice and cryth then bracket was set. The bracket inserted phase was begun by smearing of etching materials 37%, the application of total-etch bonding materials and adhesive materials. All teeth was rayed using visible light intensity Light Emitting Diode (LED) 2700 mW/cm² with the same distance and irradiating time, that was instrument attached to the bracket surface for 10 seconds. Each of these samples was stored in

artificial saliva pH 7 in incubator with temperature of 37°C for 24 hours. Furthermore, at the fixation, teeth root cutting was done by using separating disc. PVC pipe was cut at 1.5 cm and punched the side to be inserted with threaded spikes. Each sample was inserted and fixed in the PVC pipes using self-cured acrylic with buccal surface facing upwards.

The phase of shear strength test using equipment test of Torsee’s Digital Universal Testing Machine with pooling tools of ligature wire 0.02 inches. Modified ligature wire and connected it with the bracket as a shear tool and shear strength tested the tool in a straight line drawn upwards at speed of 1 mm/min until the bracket apart. Results of Torsee’s Digital System Universal Testing Machine that came out of force (F) in units of kilogram-force (kgf) were then converted to Newtons (N). To obtain shear strength (P) in Mega Pascals (MPa), force (F) divided by the surface area of the bracket (A) in units of mm². The rest of the adhesive material in the samples tested by using stereo microscope to count the number of scores ARI (Adhesive Remnant Index).

Result

The results obtained by the average value of the shear strength were 4.9 MPa and average residual adhesive by 1.00. Data of shear strength using universal testing machine and score of observation residual adhesive material using stereo microscope on the research could be seen in table 1 and figure 1.

Sample Code	ARI Score	Shear Strength Test (Mpa)
1	1	3,9 Mpa
2	1	4,8 Mpa
3	1	4,8 Mpa
4	1	5,7 Mpa
5	1	5,3 Mpa

Table 1: Test Results and Scores Slide Time Adhesive Material.

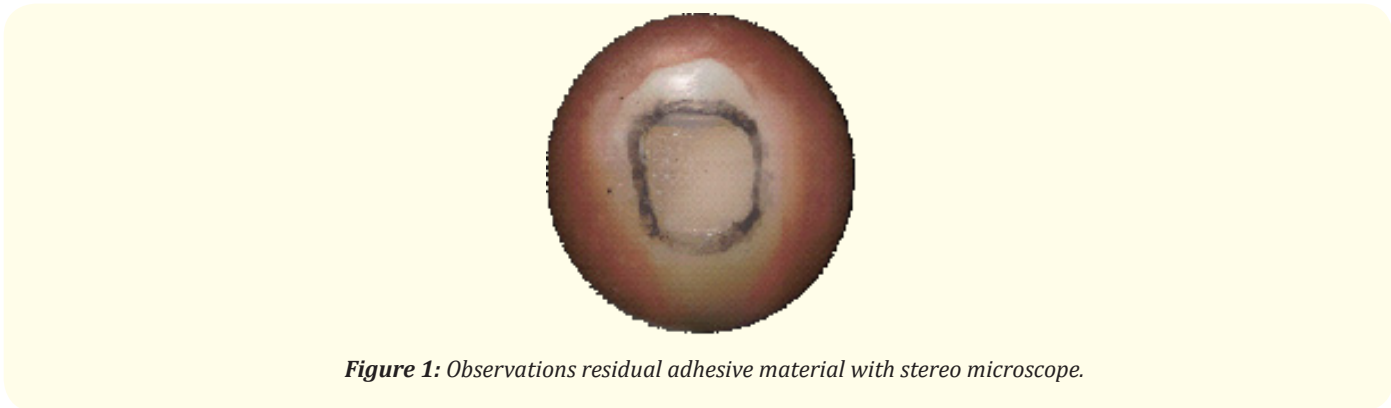


Figure 1: Observations residual adhesive material with stereo microscope.

Discussion

In orthodontic well researched is adhesion force measurements between the bracket and the tooth surface. The adhesion strength is usually measured by attaching the bracket to the tooth surface that has been extracted and then given the pressure that may lead to failure of attachment. Measurement of adhesion strength is divided into two, namely the shear and tensile strength [13]. In this study, it was measured the attachment strength with the shear strength test.

Composite resin that gets their energy from the Light Curing Unit will undergo polymerization process. Polymerization process occurs in three stages, namely the initiation stage where large molecule decomposes due to heat process into free radicals. The release process

uses visible light that starts with wavelength of 460-485 nm. The second stage is propagation, at this stage the activated monomer will be linked to each other in order to achieve a polymer with certain amount of monomer. The final stage is termination where the chains create the stable molecules [14].

The reaction of initial stage produces free radicals which can be obtained from the activation of free radical-producing molecules, one with visible light in this study using a blue ray of Light Emitting diode has wavelength between 460-490 nm wavelengths that approaches to photo initiator camphorquinone that is used in composite resin that is activated optimally on wavelength of 470 nm. Photo initiator contained in the composite is camphorquinone and accelerator diethyl-amino-ethyl methacrylate (amine) will absorb blue light from Light Emitting Diode, so that monomer in the molecular structure out into the active phase and then changed to the polymer [15].

The changes of monomers into polymers can be denoted in the conversion degree [16]. The degree of conversion (DC) is the percentage of the carbon-carbon double bonds (-C = C-), which turns into a single bond (-C-C-) during the hardening process for forming the polymer resin. The increasing value of conversion degree of, it can increase strength, endurance use, and other important properties [3].

From the research data showed that the shear strength differences between samples. The results of shear test using a universal testing machine was obtained on the sample 1 was 3.9 MPa, the sample 2 at 4.8 MPa, 3 samples of 4.8, 4 samples of 5.7 MPa, and 5 samples of 5.3 Mpa. The average value of the shear strength was 4.9 MPa. To be used in orthodontic treatment, the bracket attachment system must be able to withstand pressure between 5.9 to 7.8 MPa [8]. The strength of the attachment bracket should not exceed 13 MPa, so as not to cause damage to the email at the time of releasing bracket [9]. Email fractures can occur at the time of releasing bracket [10].

The results of evaluation data residual adhesive material on orthodontic bracket conducted in this study, low score meant there was less amount of resin remaining in the email. According to previous research, there was dominance of low scores between groups, showed little or no amount of resin bound email [12]. It can be influenced by several factors at the time of bracket application, including the drying stage is less or excessive with water spray dental unit. The less drying affects the increased bonding layer/primer at the same thickness at the interface between the composite material with enamel. Conversely, if carried excessive drying can lead the oxygen trapped in the resin that will interfere the polymer formation with the binding chains of free radicals that can inhibit polymerization.

The process of acidification on the enamel surface will leave the surface of microscopic irregular or rough, etching materials will form the valleys and peaks in the email, thus allowing the resin locked mechanically at such irregular surfaces [17]. The smaller of phosphorus acid etching concentration, the shallower well-formed resin tags and this affects the adhesion strength, especially the shear strength of the bracket to the tooth surface, where it will be leaving the resin on the enamel surface.

The shear strength is the ability of objects to survive while receiving style parallel to the object surface. The tensile strength is ability of the current object survives, receives force perpendicular to the object surface [18]. The pressure distribution in the shear strength test is uneven and complex because there are concentrations of pressure on certain areas. Tensile strength tests allow distribution pressure evenly across the surface so it is more accurate in assessing the characteristics of adhesive attachment [19]. In this study, it was obtained the rest of the adhesive material which is dominated on one side opposite to the shear force. The rest of the adhesive material on this study, was gotten the different number and on the left side of the work area.

There are two conditions that can occur in the release of orthodontic bracket. First, the failure of adhesions between the adhesive-mail and second, the failure of the adhesive-bracket attachment [7]. From the results, the residual adhesive on the enamel surface was little and it could be concluded that there was failure of adhesion that occurred between the adhesive-emails.

Conclusions and Recommendations

The conclusion in this study was that there was low shear strength of 4.9 MPa and obtained residual adhesive with low scores which meant less residual adhesive material on the enamel surface then acted to restore the enamel surface was lower.

The suggestions from this study is that from the data obtained sufficient shear strength can be used for anterior teeth have a light load of mastication, but need to do more research on exposure time 15 or 20 seconds for posterior teeth that have big load of mastication. In addition, it is necessary to conduct further research using bonding materials with different brands and it is necessary to analyze the teeth surface by using SEM (Scanning Electron Microscope).

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