New Criteria for Evaluating Shear Adhesion of Newly Developed Ceramic Brackets to Different Basic Designs

Youn Soo Shim, Sang Bae Lee, So Young Park, Jong Bin Kim, JiSun Shin, Seung Woo Shin, Jong Soo Kim, So Youn An

***Abstract**: This study is designed to provide a new evaluation criterion for the evaluation of shear adhesion of newly developed ceramic brackets to different base designs.*

***Methods/Statistical analysis**: The parentheses are selected for testing. Bracket was evaluated for a variety of design characteristics. The brackets used in the tests are W1 (World Bio Tech Co., Ltd., Korea), Clarity ADVANCED (3M Unitek, USA), and Crystaline (TOMY Inc., Japan) respectively. SEM (TM-3000, Hitachi) with lateral and surface area considering surface roughness using optical contactless surface shape measuring devices (ContourGT, Braker, USA)*

***Findings**: Our study shows that the base shape of the bracket affects shear adhesion. In the three brackets that conducted the experiment, the shear adhesion(kg/base) ranked 3m, tomy and W1. Lateral area and surface area of 3M is lower than Tomy, but the bond strength of 3M is higher than Tomy.*

***Improvements/Applications**: The size and basic design of brackets can influence the adhesion. It was assumed that the larger the bracket base size, the greater the adhesion, the different results were actually. This shows the error of the existing evaluation method, which evaluates adhesion by only a simple horizontal area. In this study, ceramic brackets from other manufacturers have significantly different underlying surface area. Therefore, the assessment of true adhesion must reflect this new criterion, the surface area, not the simple base size.*

***Keywords**: Base designs, Ceramic brackets, Debonding, Mechanical retention, Shear bond strength*

I. INTRODUCTION

Dental materials are an area in which new products are constantly being developed to meet the needs of various patients. Dental treatments are changing from cure in the past to prevention and aesthetics. Demand for orthodontic treatment has increased worldwide, especially orthodontic treatment for middle-aged patients. Ceramic brackets were developed in 1987 for the purpose of promoting aesthetic needs of patients during orthodontic treatment. All currently available ceramic calibration teeth brackets consist of many advantages of aluminum oxide, including biocompatibility and excellent binding strength over the stainless steel bracket. However, clinical trials may include: brackets or ties - blade break, enamel damage in de-fabrication and enamel wear in opposite teeth [1-5]. After this increase in aesthetic qualities and supplementation of ceramic brackets, the additional concern is the proper adhesion during the treatment process. Various factors influence the bond strength. Attachments should be capable of transmitting orthodontic and creative force and should be aesthetically and easily removed of the final treatment [6]. Thus, Many orthodontic material companies continue to try to develop new designs to suit the specific bracket brand. A product was developed that increased binding force with resin cement by adding chemical treatment to the base. Therefore, the first method of improving chemical binding power was the shattering technique [7]. However, the adhesive strength was so strong that when the bracket was removed, the tooth surface was damaged [8]. An alternative method of adhesion has been proposed, with the bracket base forming teeth shapes and gaps to provide mechanical retention [9]. This indentation allows mechanical engagement with the adhesive. Additional methods of increasing binding force were polymer processing techniques. This formed a layer of calibration resin cement in the polymer layer, reducing the brittle damage to enamel during de-bonding [10].

Although aesthetic brackets have improved the design of various types of brackets to achieve optimum adhesion, so far, papers comparing the adhesion of brackets have not only been able to compare these surface forces (the actual surface area is not considered). In other words, there are two types of brackets, which have the same adhesion of 100 N. Therefore, in this study, three typical types of ceramic brackets were selected and evaluated in order to measure the joint strength and impact of different bracket base designs on joint walls. This study is designed to provide a new evaluation criterion for the evaluation of shear adhesion of newly developed ceramic brackets to different base designs.

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II. MATERIALS AND METHODS

2.1. *Materials*

In the Korean orthodontic dental market, three direct-adhesized ceramic brackets are selected for testing. Bracket was evaluated for a variety of design characteristics. The brackets used in the tests are W1 (World Bio Tech Co., Korea), Clarity ADVANCED (3M Unitek, USA), and Crystaline (TOMY Inc., Japan). Lateral area and Surface area considering surface roughness were measured using Optical non-contact surface profilometer (ContourGT, Braker, USA) and the shape of surface were observed using SEM (TM-3000, Hitachi, Co., Japan).

2.2. Methods

2.2.1. 3D Optical Profiler Analysis

The bracket bases were examined with Optical non-contact surface profilemeter (ContourGT, Braker, USA).

2.2.2. SEM Analysis

The bracket bases were examined with a scanning electron microscope (SEM) (TM-3000, Hitachi, Co., Japan).

2.2.3. Shear bond strength

A total 60 of bovine anterior teeth within 1 week after extraction were collected. Wipe the buccal surface of bovine tooth with non-cointained oil or fluoride permissor for 10 seconds, and then dry it after washing. 30% Phosphoric acid was applied to the enamel paving. for 15 seconds. Two types of orthodontic resin cement (Transbond XT (3M Unitek, USA) and Lightbond (Reliance orthodontic products, Inc, USA)) were bonded and photosynthetic using FREELIGHT II (3M ESPE, Germany). For the experiment, the specimen was stored in a 37° water tank for 24 hours and the joint strength was measured at 2mm/min with Instron universal Testing machine (Instron 3300, Instron Co., USA) [Figure 1].

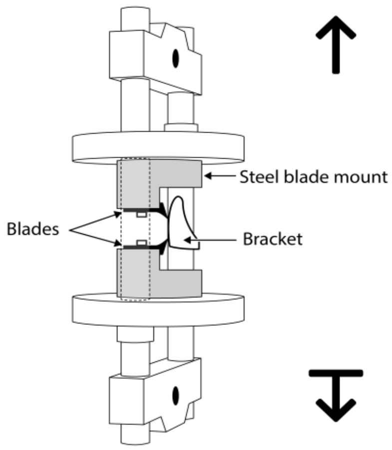

Figure 1. Diagrammatic illustration of test apparatus

III. RESULTS AND DISCUSSION

3.1.1. 3D Optical Profiler Analysis

The largest lateral area was Crystaline (TOMY Inc. Japan) that was 14.9mm2, and the smallest one was W1 that was 7.6mm2. Surface area of ceramic bracket was measured by optical non-contact surface profilometer [Table 1]. Figure 2 shows a three-dimensional surface image of each bracket base.

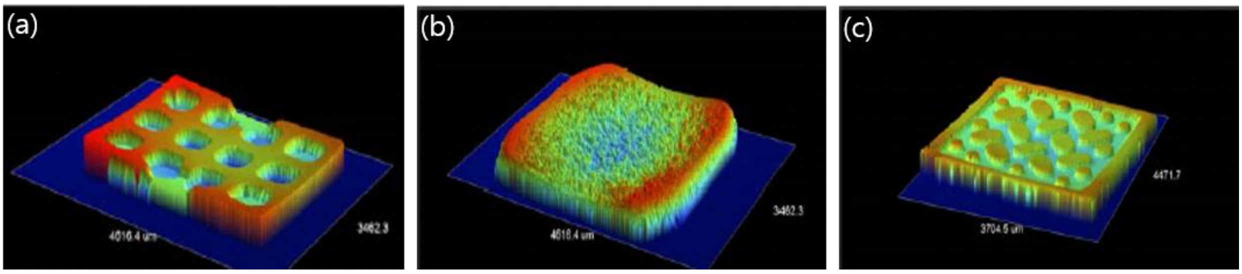

Figure 2. The 3D interferograms of (a) W1, World bio Tech co. Ltd, Korea, (b) Clarity ADVANCED, 3M Unitek, USA , (c) Crystaline , TOMY Inc. Japan

Table 1. Surface area measurement

Spec	Ra	Sa	Rz	Sz	Rt	Sdr	Lateral Area	Surface Area
Unit	μm	μm	μm	μm	μm	%	mm^2	mm^2
W1	95.3	99.7	495.1	526.8	535.5	1.1	7.6	12.4
Clarity	50.5	50.1	293.6	328.3	331.2	60.2	14.1	21.6
Crystaline	81	81.1	584.7	720.1	719.9	29.6	14.9	26.1

3.1.2. SEM images

Figure 3 shows the results of the base design of the three different brackets that were tested using SEM. Each one has its own unique shape.

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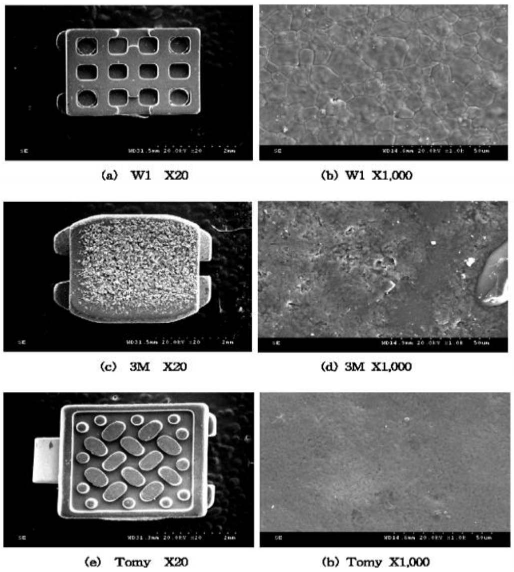

Figure 3. The SEM image of (a) W1, World bio Tech co. Ltd, Korea, (b) Clarity ADVANCED, 3M Unitek, USA , (c) Crystaline MB , TOMY Inc. Japan

3.1.3. Shear bond strength

In the three brackets that conducted the experiment, the shear adhesion(kg/base) ranked 3m, tomy and W1. Lateral area and surface area of 3M is lower than Tomy, but the bond strength of 3M is higher than Tomy [Table 2].

Table 2. Shear Bond Strength of Compositional Analysis of Ceramic Bracket

Spec	Load (Transbond)	Load (Lightbond)	Strength to LA (Transbond XT)	Strength to SA (Transbond XT)	Strength to LA (Lightbond)	Strength to SA (Lightbond)
Unit	N	N	MPa	MPa	MPa	MPa
W1	56.1±15.4	55.9±11.4	7.4±2.0	4.5±102	7.4±1.5	4.5±0.9
Clarity	180.7±32.3	187.6±28.8	16.3±2.9	12.7±2.3	16.8±2.7	13.2±2.0
Crystaline	156.2±26.5	165.6±24.2	14.8±2.5	10.0±1.7	15.7±2.3	10.6±1.6

Two ways to increase the adhesion of ceramic brackets, the first is the shape, undercut or groove, of the base to increase mechanical adhesion. The second is to improve adhesion through chemical shattering on a flat base [2]. One end of the scylla molecule is a different telomeres combination of silanol groups and acrylic resins that can be strongly coupled to silica. The resulting chemical bond is extremely strong and can be applied to the enamel adhesive layer in the event of a dental bond or a sudden clasmic collision that causes irreversible damage to the teeth. In particular, it is difficult to remove adhesive residue without damaging the enamel if there is only a break in the ceramic bracket and the base of the bracket remains on the surface of the tooth when the correction is completed [11]. Ceramic brackets and the hard and fragile conditions of enamel underneath are not good [2]. If the adhesion of the enamel is greater than that of the paulter itself, it may cause damage to the poultry part when removing the bracket. Recently, many calibration material companies have developed a product that makes the base size of the calibration bracket smaller but increases the contact area by giving it a mechanical shape. The surface area is increased so that the bracket and resin are mechanically engaged [1].

According to a recent study, the shear adhesion of ceramic brackets was significantly influenced by the design of the base but not significantly by the ceramic bracket bonding method. The basic design of the irregular shape combines tiny fused glass particles in the polycrystal alumina to increase the surface area for proper adhesion. However, these glass particles may have a mechanical holding force that is not adequately bonded to the enamel or to penetrate a rough surface of the entry. Similarly, a large round-foot base design with a diameter of approximately 1 mm within a bracket surrounded by a flat surface did not have any undercut shape. This result was confirmed by type 1 misconnection (adhesive - non-uniform). Thus, the shear strength of the irregular, large round hole-based design was not significantly different. Conversely, the bead surface has a circular monocrystal of about 50mm, which is completely distributed on the base surface.

Glass beads can enhance statistically significant adhesion among all groups of both ceramics mechanical interlocking of adhesive resin. In this experiment, the brackets were attached while uniform pressure was applied to the surface of the right wing to exclude various interference factors, and the thinnest possible resin bonding was formed. In this experiment, there was no breakage in the frame of the bracket or the bovine tooth’s enamel layer when removing the bracket. Depending on the bracket base, the hardness may change during the penetration of the resin cement or during polymerization[9]. The bead has an undercut for mechanical engagement of adhesive resin, indicating the highest shear binding strength statistically among all groups of all mechanical interconnections of adhesive resin. However, the thickness of the resin and a unique defect or defect in the bracket or device affect the strength of the coupling. In this study, there were attempts to control these factors. Each specimen are bonded by applying the best pressure to the bovine tooth surface and minimize the thickness of the adhesive layer, resulting in large amounts of variability and fractures. No fracture of the teeth of the bracket or bovine tooth surface was found in this study. Therefore, the embedded defect does not affect the shear adhesion. Depending on the bracket base design, it can affect the fastening thickness and the photosynthesis depth of the resin for calibration [12]. The air gap in the mesh shape of the bracket base also affects the depth of the photo-grinding and the adhesion of the resin for calibration [13]. We concluded that the size and basic design of brackets can influence the adhesion. The Crystaline was a round, concave base design with a higher joint strength than W1, but less than Clarity. Therefore, the method of evaluating adhesion by comparing the size of a simple base cannot produce accurate comparison results. A sharpness with a side and surface area smaller than a Crystaline. It indicates a greater binding strength Clarity than a Crystaline and W1. Several factors influence the bond's adhesion. Finally, in the case of this experiment, the limit is that the actual oral state could not be reproduced. Within the oral cavity, there may be a variety of factors, such as saliva or blood, other than just surface area and calibration resin cement and bonding products. Therefore, it would be better for later experiments to reproduce these factors to create a laboratory environment in a form similar to a clinical setting.

The size and basic design of brackets can influence the adhesion. It was assumed that the larger the bracket base size, the greater the adhesion, the different results were actually. This shows the error of the existing evaluation method, which evaluates adhesion by only a simple horizontal area. In this study, ceramic brackets from other manufacturers have significantly different underlying surface area. Therefore, the assessment of true adhesion must reflect this new criterion, the surface area, not the simple base size.

IV. CONCLUSION

In this study, ceramic brackets from other manufacturers have significantly different underlying surface area. The shear adhesion of the Clarity is less lateral and surface area than the Crystaline. The size and basic design of brackets can influence the adhesion. However, in this in vitro study, it is not possible to reproduce the environment in the mouth such as water, protein, minerals, pH and temperature, which may affect the binding strength of the teeth surfaces of ceramic brackets.

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