Shear bond strengths of Chinese and American brackets used in Indonesia

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Abstract

The aim of this study was to evaluate the shear bond strengths of three types of metal brackets used in Indonesia. Forty human maxillary premolars, extracted for orthodontic purposes, were fixated in PVC cylinders using acrylic resins. The specimens were divided into four groups (n = 10) based on the type of bracket and adhesive used. The bond strengths of two types of Chinese metal brackets (Hangzhou 3B™ and Zhejiang Protect™) bonded with Transbond XT™ (3M, Unitek) and an American metal bracket (Mini Dyna Lock™) bonded with Transbond XT™ and Enlight™ (Ormco) were determined. Statistical analysis was conducted using independent samples *t*-test ($p < 0.05$). The mean shear bond strengths of the 3B™ and Protect™ brackets were 6.09 ± 0.53 and 7.9 ± 0.61 MPa, respectively ($p < 0.05$), and those of the Mini Dyna Lock™ brackets using Transbond XT™ and Enlight™ were 12.46 ± 0.35 and 9.69 ± 0.53 MPa, respectively ($p < 0.05$). These results suggested that the shear bond strengths of the Chinese metal brackets were within the acceptable range for orthodontic use. In addition, the American bracket bonded with Transbond XT™ had a higher shear bond strength when compared with that bonded with Enlight™.

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Introduction

The demand for orthodontic treatment is increasing owing to improvements in the health and expectations of the population. Orthodontic treatment is no longer intended for children alone; adults are also keen on this treatment for both health and aesthetic reasons.[1] Moreover, patients have easier access to health services such as hospitals, dental clinics, and community health clinics that provide fixed and removable orthodontic treatments. One of the components of a fixed orthodontic appliance is the bracket, which is a small device bonded to the tooth in order to hold the wire firmly in place.[2] Brackets can be made of three types of materials: ceramics, polymers, and metals with metal being the most commonly used.

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During the treatment procedure, the bracket is bonded to the enamel structure with an adhesive material, forming two interfaces: one between the enamel and the adhesive material and the other between the adhesive material and the bracket. The bond between the enamel and the adhesive material is achieved by a mechanical interlock through the penetration of the adhesive resin into the enamel, whereas the bond between the bracket base and the adhesive material is obtained by various means, but most commonly with retentive elements required for mechanical retention.[3,4]

Replacing a loose bracket is inefficient and both time- and cost-consuming. Therefore, the shear bond strength property of a bracket is of paramount importance.[3,5]

Shear bond strength is the ability of a material to persist when accepting a shear force before bonding failures occur.[3]

The minimum shear bond strength value acceptable for orthodontic clinical use is 6–8 MPa,[6] and bonding failure tends to occur if the shear bond strength value is below this number.

The currently available stainless steel brackets are designed and manufactured by various countries such as the United States of America, Japan, Germany, and China. The brackets are distributed domestically with varying specifications and prices. Chinese stainless steel brackets are sold at a very cheap price when compared with the American varieties. A variety of Chinese dental brackets are available for sale by dental suppliers in Jakarta indicating that they are commonly used for orthodontic treatment in Indonesia. Specifications about the composition and properties are not provided along with the packaging of these products, resulting in the sale of products of questionable quality.

Several studies have been conducted to compare the shear bond strength of a bracket with the tooth using various types of light cured resin cements. Studies on the shear bond strength of brackets bonded with Transbond XT™ have resulted in various values ranging from 4.5 to 24.6 MPa.[7-9] Variations in shear bond strength value are highly affected by the width, shape, application method, and design of mesh at the base of the bracket.

Universitas Indonesia Dental Hospital uses standard American brackets accompanied by clear specifications and instruction manuals. Thus, in the present study, we aimed to determine the shear bond strengths of metal brackets from Hangzhou 3B™ and Zhejiang Protect™ sold by a dental supplier in Jakarta and an American bracket (Mini Dyna Lock™) bonded to the teeth using Transbond XT™ and Enlight™ adhesive materials.

Materials and methods

Chinese metal brackets

Twenty human maxillary right and left premolars, extracted for orthodontic treatment, were immersed in saline solution for less than 3 months. Non-carious teeth with no evidence of cracks or history of etching or other treatments were included in this study.

The teeth were planted in decorative acrylic using PVC cylinders (height, 20 mm; diameter, 20 mm) up to a distance of 1 mm below the cervical line, with the long axis perpendicular to the floor.[8,10] The buccal surfaces were cleaned with non-fluoride pumice and water using a rotary brush and a low-speed hand piece (NSK EX-203) for 10 s. The teeth were subsequently rinsed with running water (10 s) and dried with air for another 10 s.[8,11] Prior to the application, the area of the base of the bracket was measured by multiplying the length by the width using a digital caliper.[12]

Metal brackets were obtained from Hangzou 3B™ (MBT, no hook, slot 0.022”) and Zhejiang Protect™ (Edgewise, 3W/hook, slot 0.022”). Ultra-Etch (37% phosphoric acid; Ultradent Products, Inc., USA) and Transbond XT™ (Unitek 3M) were used for adhesion.

The 3B™ metal brackets were placed on the surfaces of the teeth using adhesive materials according to the manufacturer's instructions.[13] The enamel surfaces were etched with 37% phosphoric acid for 10 s, rinsed with running water for 10 s, and dried with air until a *frosty* appearance was noted on the surface.[5] A thin layer of primer was applied to the etched enamel surface using a brush.[13] The adhesive material (weight, 0.015 g using an analytical balance) was applied to the base of the bracket,[13] which was then placed and positioned on to the center of the tooth surface, using a bracket holder. After placement, the brackets were pressed in order to attach to the tooth surface and excess adhesive material was removed with a probe. Light curing was performed for 10 s in the interproximal areas (5 s each on the mesial and distal sides) using an LED Light Curing Unit (LCU-LED; Elipar S10, 3M) with an irradiance of 850 mW/cm^2 (measured by a radiometer). The same procedures were repeated for the Protect™ metal brackets. Subsequently, the specimens were stored in a vessel containing aquades and incubated at 37 °C for 24 h.[8]

Shear bond strength test was performed using the Shimadzu Universal Testing Machine (AG-5000) with a crosshead speed of 0.5 mm/min and a maximum load of 50 kgf; pressure was applied until the bracket was detached from the tooth surface.[11] The shear bond strength (MPa) was obtained by dividing the force (Newton) with the surface area of the bracket (mm^2).[8]

American metal brackets

Twenty maxillary right or left human premolars were prepared as described earlier. The Mini Dyna Lock™ bracket (3M; lock slot 0.22; *n* = 20) and two types of adhesive materials, Transbond XT™ (Unitek 3M) and Enlight™ (Ormco) were used in this study. Prior to bracket application, the area of the base of the bracket was

measured by multiplying the length with the width using a digital caliper.[12] The adhesive materials were used to bond the brackets to the teeth. In the case of the Transbond XT™ adhesive materials, the enamel was etched as described for the Chinese brackets, whereas for brackets bonded with Enlight™, the etching period was 30 s. Polymerization, storage, and the shear bond strength tests were performed as described for the Chinese brackets.
Statistical analysis was conducted using. Independent samples *t*-test was used to compare the shear bond strength values between the Chinese and American brackets with the corresponding adhesive materials.

Results

Chinese brackets

The average surface area of the base of the 3B™ and Protect™ brackets were 14,83 ± 0,09 mm^2 and 12,76 ± 0,07 mm^2. The results of the average de-bonding forces and shear bond strengths are shown in Table 1.

Table 1. Results of shear bond strength test.

Bracket type	Average de-bonding force N ± SD	Average shear bond strength MPa ± SD
3B™	90,34 ± 7,69	6,09 ± 0,53
Protect™	100,98 ± 8,04	7,91 ± 0,61

Debonding force attained using 3B bracket is N, newton; SD, standard deviation; MPa, megapascal

The average de-bonding force and shear bond strength of the Protect™ bracket was higher than that of the 3B™ bracket; the difference in shear bond strength values between the two types of brackets was statistically significant ($p < 0,05$).

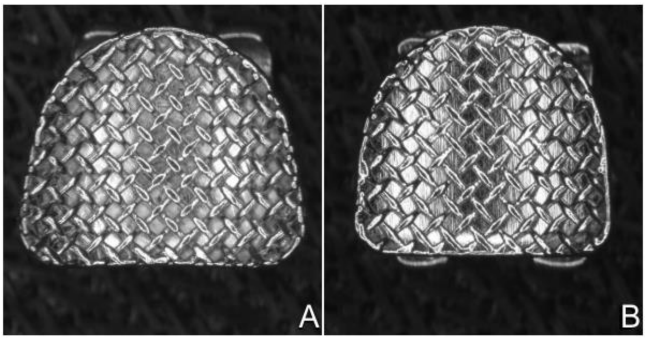

Figure 1. Surface of bracket base viewed under a stereomicroscope.

As seen in Figure 1, both types of brackets presented with the same base design, although the Protect bracket was smaller in size.

American brackets

The average surface area of the bracket bases was 10,08 ± 0,08 mm^2. Figure 2 shows the image of the Mini Dyna Lock™ bracket with a horizontal undercut as observed using a stereomicroscope.

Figure 2. Surface of the Mini Dyna Lock™ bracket base seen with a stereomicroscope (magnification, 10×).

Table 2. Shear bond strength values of Transbond XT™ resin cement and Enlight™.

Resin cement	De-bonding force (N)	Shear bond strength (MPa)
Transbond XT™	125,09 ± 3,53	12,46 ± 0,35
Enlight™	98,04 ± 5,24	9,69 ± 0,53

The shear bond strength values of the Mini Dyna Lock™ brackets bonded with Transbond XT™ and Enlight™ resin cement are shown in Table 2. A statistically significant difference in shear bond strength was noted between the brackets bonded with Transbond XT™ and Enlight™.

Discussion

In the present study, we evaluated and compared the shear bond strengths of two types of Chinese orthodontic brackets (3B™ and Protect™) and one American bracket (Mini Dyna Lock™) commonly used at our hospital.
The average areas of the bases of the Chinese brackets were 14,83 ± 0,09 mm^2 for the 3B™ bracket and 12,76 ± 0,07 mm^2 for the Protect™ bracket. A more accurate measurement of the base may be attained by using a micro computed

tomography (micro-CT) scan.[14] Shear bond strength is measured by dividing the force (N) by the surface area (mm^2); therefore, accurate measurements of the bracket base area is important.

The minimum shear bond strength accepted clinically for orthodontic use is 6–8 MPa[6] and is considered adequate to handle masticatory as well as orthodontic force. The average shear bond strength values for the 3B™ and Protect™ brackets in the current study were 6,09 and 7,91 MPa, respectively, which were within the acceptable range for clinical orthodontic use. The shear bond strength of the 3B™ bracket was significantly lower than that of the Protect™ bracket. The three factors that affect shear bond strength are the tooth, adhesive material, and bracket. The teeth used to test the two types of brackets were the maxillary premolars. The same adhesive materials were used for both brackets, so the difference may have been caused because of differences in the two types of brackets. The bracket (3B™ and Protect™) were different in terms of size and surface area of the base. The surface area of the base affects the bonding area.[15] A broader base can decrease the adaptation between the bracket and an irregular tooth enamel surface.[16]

The polymerization of Transbond XT™ was performed using LCU-LED with an irradiance of 850 mW/cm^2 and a curing duration of 10 s. Irradiance and duration time may affect the polymerization of composite resin materials; LCU-LED with a lower irradiance requires a longer activation period to produce the same effect as that of a curing unit with a higher irradiance.[17] Higher shear bond strength can be achieved by curing the material for a longer curing duration using LCU-LED.[18]

This study was conducted using a conventional bonding system, wherein adequate adhesive shear strength can be obtained if the enamel surface is kept dry and free of contaminants. Conventional bonding systems have a hydrophobic property; hence, the moist surface can decrease the shear strength value. In the oral cavity, saliva, biofilm, and organic debris are always present on the surface of the enamel and can decrease the surface energy of the substrate thereby decreasing its wettability leading to a decrease in the bond strength.[19] The presence of blood and salivary contaminations under clinical conditions may decrease the bonding strength by up to 50%.[20,21] Thus, the shear strengths of the Chinese brackets did not satisfy the minimal shear bond strength (6–7 MPa) required for orthodontic use because a 50% decrease in adhesive strength implies that the shear bond strengths of 3B™ and Protect™ brackets were 3.05 and 3.85 MPa, respectively.

The Mini Dyna Lock™ bracket is an American metal bracket used in orthodontic treatment at our dental hospital. It is smaller and is different in shape from the Chinese bracket (Fig. 2). The smaller surface area of the base (10.03 ± 0.08 mm^2) and the different forms of retention result in greater shear bond strength when compared with the Chinese bracket, irrespective of the adhesive material used (Transbond XT™, 12.46 ± 0.35 MPa; Enlight™, 9.69 ± 0.53 MPa).

The bond strength between the bracket and the tooth must meet two requirements. First, the strength of the binding should be strong enough to withstand the force applied during orthodontic treatment, and second, the strength of the binding must not be too strong in order to avoid injury to the surface of the enamel during the de-bonding procedure.[22] The bond strength of the Mini Dyna Lock™ bracket attached with Transbond XT™ might reduce by 50% to a value of 6.23 MPa if contaminated, yet it would remain within the ideal range required for orthodontic use (6–8 MPa).

The shear bond strength of the bracket with Enlight™ was 9,69 ± 0,53; however, salivary contamination could decrease the strength to 4.84 MPa, which is not within the ideal range required for orthodontic purposes. Therefore, it is important to minimize contamination when Enlight™ adhesive cement resins are used.

The differences in shear bond strength values between the Transbond XT™ and Enlight™ adhered Mini Dyna Lock™ brackets may be due to differences in the composition of the primer solution and adhesive paste. The organic matrix in the Transbond XT™ primer solution contains BISGMA (bisphenol A-glycidyl methacrylate; high hydrophobic and viscosity properties) and TEGDMA (triethylene glycol dimethacrylate; high hydrophilic property and low viscosity), whereas the Ortho Solo primer in Enlight contains hydroxyethyl methacrylate (HEMA), which is hydrophilic.[19] BISGMA organic matrix can improve the stiffness of the bonding material, whereas a hydrophilic organic matrix such as HEMA demonstrates good permeability in the enamel and dentine; nevertheless, it can weaken the bonding layer because of its low molecular weight.[23]

The adhesive pastes in both resin cement groups are highly filled (>60% fillers) on the basis of product descriptions. The shear bond strength of a metal bracket attached to a tooth using highly filled composite resins is 13.0 MPa.[24] In the current study, the shear bond strength value of Transbond XT™ resin cement was approximately 13 MPa, whereas that of the Enlight™ resin cement was less than 10 MPa. This may be due to the difference in the amount of fillers contained in the two adhesive pastes. The higher the filler content in the adhesive cement, the higher the shear bond strength.[25]

The results of the present study indicate that although both Chinese and American brackets were adhered to the tooth surface using Transbond XT™, the Chinese products could not match the American products in terms of the shear bond strength. The size as well as the surface area and retention form of the base of the bracket influence the shear bond strengths of the brackets. Furthermore, the shear bond strength of the American brackets adhered with Transbond XT™ were higher than those bonded with Enlight™.

On the basis of the results of a survey, the Chinese bracket seems to be used by some government-mandated community health clinics in Jakarta.[26] The results of the present study may prove useful for those who use Chinese brackets by providing them additional information about the shear bond strength of the products.

Conclusion

The shear bond strength of Chinese brackets (3B™ and Protect™) bonded with Transbond XT™ may be acceptable for clinical orthodontic use. However, contamination during the procedure should be avoided. The shear bond strength of the American bracket (Mini Dyna Lock™) bonded with Transbond XT™ is better that that bonded with Enlight™.

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