Original Article

Effect of Primer before Resin Cement on Bracket Base and the Influence of Storage Time on Shear Bond Strength

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Abstract

Background: The elapsed time after bracket bonding and sandblasting the base could influence the shear bond strength (SBS) to enamel. **Aim:** This study evaluated the effect of primer application on the bracket base before application of resin and its interaction with storage time and sandblasting factors on SBS. **Materials and Methods:** Brackets were bonded on the enamel surface of 160 bovine incisors divided into eight groups (n = 20) with mesh bases, with and without sandblasting, with different storage times (immediately and 24 h), and with two different techniques (with and without primer on the base before resin). **Results:** SBS mean in conventional and primer groups ranged from 23 ± 7.76 MPa to 48 ± 11.34 MPa, respectively. After 24 h period, SBS increased when the primer was applied before resin on the bracket bases ($P < 0.001$). The effect of each isolated factor (storage time and primer application) was statistically significant ($P < 0.001$). Primer application versus time factors was statistically significant ($P < 0.001$). Sandblasted bases were not influential on SBS separately or by any of the interaction factors ($P = 0.628$). Adhesive interface failures were significant when the adhesive remnant index was evaluated regarding storage time without primer ($P = 0.022$); however, primer application did not show significance when the time was evaluated ($P = 0.686$). **Conclusion:** Primer increases the SBS after a 24 h period. Most of the failures occurred at the enamel/adhesive interface. Sandblasting treatment of bracket bases did not influence the SBS.

Keywords: *Composite resins, orthodontic brackets, resin cements, shear strength*

Received: 13 September 2023
Revised: 14 November 2023
Accepted: 23 November 2023
Published: 29 April 2024

Clinical Relevance to Interdisciplinary Dentistry

- Applying primer on bracket base improves the shear bond strength. This implies that greater orthodontic forces can be applied on bracket.

Introduction

The use of adhesive primer system is widely employed in bracket bonding procedures, and its application has the purpose of increasing bond strength between the enamel/resin interface.[1] Technique modifications of conventional bracket bonding methods have been proposed to reduce the vulnerability of brackets to adhesive failures due to the intrinsic factors of the intraoral environment.[2-5] The use of adhesive promoters has been investigated to improve mechanical retention in bracket bonding techniques to increase the shear by bond strength (SBS) at different biomaterial surfaces.[2,3,5] In addition, literature has shown that late polymerization of resin adhesives increases the SBS due to complete polymerization of the resin.[6,7]

Tension introduced after bracket bonding procedures during archwire activation and occlusal trauma could

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Access this article online

Quick Response Code:

Website: www.jidonline.com

DOI: 10.4103/jid.jid_52_23

How to cite this article: Moreira FC, Jacob HB. Effect of primer before resin cement on bracket base and the influence of storage time on shear bond strength. J Interdiscip Dentistry 2024;14:32-40.

lead to bonding failure.[8] When bracket bond failure occurs, rebonding procedures can lead to enamel loss.[4,9,10] Thus, bracket base design is also an important variable for the retention of orthodontic brackets on the tooth enamel.[1,6,11-14] Additional retention can be obtained by modifying bracket base design, thus improving the microinterlocking mechanism at the bracket/adhesive interface.[1,9] Sandblasting with aluminum oxide particles creates microroughness and microporosity improving the mechanical interlocking between the adhesive layer and the surface of the treated metal base.[15] However, the use of sandblasting alone may not be sufficient to obtain additional retention.[1] In addition, laser treatment is also a method that increases specific surface area enhancing wettability and surface energy.[4] It has been shown that Yb:YAG laser irradiation of the orthodontic brackets base surface increases shear bond strength to enamel when primer was applied on the treated base surface.[4] It is unclear whether the application of primer influenced only bases modified by a laser beam or whether there is also some influence on conventional. This evidence does not establish any consistent conclusion on whether the application of primer from the same adhesive system is useful to improve adhesive bond strength.

Currently, there is no study evaluating SBS when different bracket base designs are bonded with an adhesive primer on the bracket base before resin cement application at two different storage times. The aim of this study was to evaluate the shear bond strength of bracket bases bonded to enamel using primer of the same adhesive system applied on the base surface before resin cement. Two additional factors were assessed, including storage time and sandblasted bases. The bracket/adhesive/enamel interfaces obtained after the bonding procedure were evaluated to verify site failure between the biomaterial and enamel surface. The null hypothesis was that there is no difference in SBS between the conventional and modified bracket bonding technique (primer application on bases before resin) with and without sandblasting under the influence of the storage time factor.

Materials and Methods

The sample consisted of 160 bovine incisors with intact labial surfaces and no defects on the enamel surface. The teeth were cleaned with a periodontal curette, washed with distilled water, and stored in 0.9% saline solution in a refrigerator at approximately 4°C. The roots were sectioned 1 cm from the crown/root and the teeth were placed in cylindrical PVC tubes (Tigre®, Joinville, Santa Catarina, Brazil) filled with self-curing acrylic resin (VIPIFlash, VIPI industry, Pirassununga, São Paulo, Brazil). A customized positioner device was used for the correct positioning of the crown to allow the dental surface to be perpendicular to the plane and parallel to the shear forces. After inclusion, the specimens were stored in distilled water at 37°C until the time of the bonding procedures.

Eight groups (n = 20) were created as follows bracket bonding technique (no primer on the base and primer on the base), storage time (immediate and 24-h period), and type of mesh base with or without sandblasted base [Figure 1].

The two *in vitro* direct bracket bonding procedures were carried out:

1. Addition layer of primer before resinous adhesive on the bracket base surface (same as conventional but a layer of primer was applied on the bracket base)
2. Resin cement of the same adhesive system applied directly on the bracket base according to the manufacturer's instructions (conventional technique).

In addition, the effect of the three interaction factors on SBS (type of base design with and without sandblasting, storage time-immediate and 24-h period, and primer application on the base) were evaluated for the two direct bonding techniques.

Bonding procedures

Orthodontic self-ligating brackets manufactured by the metal injection molding method (Easyclip Plus™, Aditek Orthodontics, Cravinhos, São Paulo, Brazil) were bonded on labial surfaces of bovine enamel. The type of bracket used was for the upper right central incisor with an 80G mesh base with an area of 10.90 mm^2. Metallic bracket bases presented two different mechanical mesh retention designs: with sandblasting and without sandblast treatment. First, all teeth were cleaned using a rubber cup and pumice paste and water for 15 s for debris removal. After cleaning, all samples were rinsed with air–water spray and dried for 10 s. The adhesive system used for bonding of all brackets was Transbond XT™ Light Cure Adhesive Kit (3M Unitek, Monrovia, California, USA). The treatment of enamel surfaces of all specimens was accomplished by conditioning with 37% phosphoric acid-Condac 37 (FGM, Joinville, Santa Catarina, Brazil) for 30 s, rinsed for 10 s with oil-free air–water spray, followed by air jet to dry the prepared surface.

A modified technique with a layer of primer added on the base (primer on the base group, n = 80) and a conventional technique (no primer on the base group, n = 80) was employed to directly bond the brackets on the conditioned enamel according to the manufacturer's directions [Figure 1]. Transbond XT Adhesive Primer (3M Unitek, Monrovia-California, USA) was applied on the

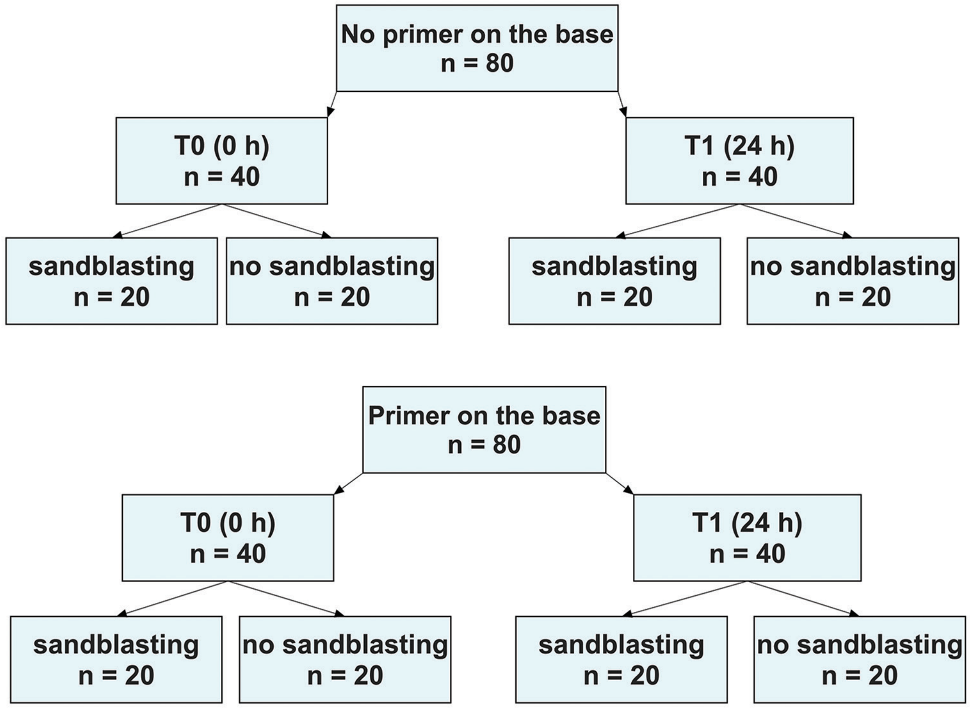

Figure 1: Flowchart demonstrating groups according to bracket bonding technique, storage time, and type of mechanism of the base retention

conditioned enamel on all samples (both Primer and No Primer group) and on the metallic bracket base (only for primer on the base group). Then, a light jet of air was applied and a uniform thin layer of adhesive on the surface of the base of the brackets. A Bluephase Led light-curing unit (Ivoclar Vivadent, Liechtenstein, Austria) with a light intensity of about 1200 mW/cm^2 along with a light probe with a diameter of 10 mm was used for adhesive photopolymerization on the enamel. Transbond XT Light Cure resinous adhesive was applied on the bracket base and pressed with the aid of an orthodontic tensiometer (Morelli, Sorocaba, São Paulo, Brazil) with a force of 300 gf to standardize the bonding procedure. The resin excess was removed from the margin of the bracket with a dental probe before setting. Photopolymerization was accomplished by curing for 20 s on each bracket face (mesial, distal, cervical, and incisal).

Shear bond test

Shear bond strength tests were carried out on all specimens according to the specifications of ISO 11405: 2003 (E). After bracket bonding, both two immediate subgroups T0 (both primer and no primer on the base groups, $n = 20$) were directly tested, and the other two remaining 24-h groups T1 (both primer and no primer on the base groups, $n = 20$) were incubated in a 37°C water bath for 24 h waiting for the complete polymerization of the resin [Figure 1]. A Universal Testing Machine EMIC DL1000 (Instron, São José dos Pinhais, Paraná, Brazil) carried out the shear bond tests. To avoid any bias, all specimens were fixed in an adjustable device so that the buccal surface and bracket were parallel to the shear forces. An occlusal-gingival force was applied on the bracket/resin/enamel interface using a shear blade (6.0 mm × 0.4 mm) at a speed of 0.5 mm/min with a 100 N load cell. A computer coupled to the shear test machine recorded all the results using Tesc 2.0 software (Instron, São José dos Pinhais, Paraná, Brazil).

A Stereomicroscope Leica M50 (Leica M80, Leica Microsystems, Wetzlar, Germany) was used to inspect each sample at a magnification of 20 times to verify the condition of the enamel and to study the location of adhesive failure. The Adhesive Remnant Index (ARI) was used to quantify the remaining amount of composite on the enamel surface after shear tests.[16] The scores were quantified as 0, no bonding resin left on the tooth; 1, less than half of the bonding resin left on the tooth; 2, more than half of the bonding resin left on the tooth; and 3, all bonding resin left on the enamel surface. Micrographs were obtained from each group before and after the shear tests using a scanning electron microscopy (SEM) (JSM-6610 LV, JEOL Ltd, Tokyo, Japan) to achieve surface characterization, analyze the bonding interfaces, and evaluate failure sites.

Statistical analysis

The data were performed using GraphPad Prism version 9.5 for Windows (GraphPad Software, La Jolla, California, USA). The homogeneity of variance and normality of the residues were confirmed by Levene and

Shapiro–Wilk tests, respectively. Descriptive statistics were used to explore SBS means and standard deviation of the variables. Shear bond strength analysis and the three interaction factors were performed by a three-way analysis of variance: sandblasting the base or not, effect of the storage time (immediate and 24 h period), and bond technique (with and without primer). A *post hoc* Tukey's test was carried out for multiple comparisons among all eight groups. Frequencies and Chi-square analysis were used to determine significant differences in ARI scores among all groups. Statistical significance level was determined at $P < 0.05$. The simple linear regression model was used to estimate the SBS variation between the three different variables (primer on the base and sandblasting factor) as a function of storage time (0 h and 24 h).

Results

Shear bond strength

The SBS mean ranged from 23 ± 7.76 MPa to 48 ± 11.01 MPa [Table 1]. Shear bond strength increased significantly after the 24 h period after primer application on the bracket base before direct bonding [48 MPa, Table 1] compared with no primer on the base (independent of time) mean approximately of 28 MPa. At 24 h, the bracket bases that were sandblasted and not sandblasted presented SBS as high as 48 ± 11.01 MPa and 45 ± 10 MPa, respectively [Table 1].

A between-subjects factorial ANOVA was calculated comparing the shear bond strength for time, primer application, and bracket base design [Table 2]. The main effect for storage time factor independent of primer and base type was significant [$P < 0.001$, Table 2] with means of 27 versus 38 MPa between both time 0 h and 24 h, respectively. The effect for primer factor independent of the base and time was also significant [$P < 0.001$, Table 2] with means of 29 versus 35 MPa between both no primer and primer factor, respectively. The interaction between storage time and primer factor independent of bracket base design also was significant with means of 29 versus 46 MPa between both no primer and primer factor after 24 h period, respectively [$P < 0.001$, Table 2]. The estimate effect of sandblasting factor on SBS is reported in Table 2 and Figure 2. The main effect for base type with primer and time factor interaction was not significant ($P > 0.377$), with means of 31 versus 33 MPa between sandblasted (yes or not) and primer factor and sandblasted (yes or not) and time factor.

The difference between the slopes of the lines (deviation from zero) was significant [$P < 0.001$, Figure 3]. The

Table 1: Descriptive analysis for shear bond strength (MPa) according to primer, sandblasting, and storage time factor

Groups	Storage time (h)	Sandblasting (no)		Sandblasting (yes)	
		Mean±SD	Minimum–maximum	Mean±SD	Minimum–maximum
Primer on the base	0	23.04±7.76	9.30–39.60	24.10±9.39	13.50–54.40
	24	45.66±10.69	23.00–65.70	48.06±11.01	30.70–65.70
No primer on the base	0	29.87±10.52	11.90–52.80	30.00±10.37	15.80–46.20
	24	28.52±7.95	13.50–43.30	28.77±10.25	12.80–49.20

SD=Standard deviation

Table 2: Statistical analysis, three-way ANOVA means of the shear bond strength (MPa), and interactions results among three different factors

	Primer	No primer	Mean
Nonsandblasted	34.35	29.45	31.90
Sandblasted	37.10	29.63	33.37
Mean	35.72	29.54	32.63

	0 h	24 h	Mean
Nonsandblasted	26.45	37.34	31.90
Sandblasted	28.07	38.66	33.37
Mean	27.26	38.00	32.63

	Primer	No primer	Mean
0 h	24.59	29.94	27.26
24 h	46.86	29.14	38.00
Mean	35.72	29.54	32.63

Three-way ANOVA	
Factors	P
Primer	***<0.001***
Sandblasting	0.377
Time	***<0.001***
Sandblasting × primer	0.441
Sandblasting × time	0.929
Primer × time	***<0.001***
Sandblasting × primer × time	0.901

Bold italic: Statistical significance (P<0.05) results obtained in the simple regression analysis were similar and significant and ranged from R^2 = 0.553 to R^2 = 0.606 [P < 0.001, Table 3], except for no primer group (R^2 = 0.004) that was not significant [P = 0.553, Table 3].

Adhesive remnant index

ARI scores were evaluated according to primer application technique and storage time [Table 4]. Brackets without primer showed a significant difference when ARI was evaluated with regard to storage time (P = 0.022). When primer was added, the metallic bracket base did not show significant differences in ARI scores when storage time was evaluated (P = 0.686). Regarding the sites where the failures occurred, 50% (ARI score 0) were adhesive failures and occurred at the interface of the adhesive/enamel junction, whereas 37% (ARI score 1 and 2) occurred at the bracket/adhesive/enamel interface internally within the resin mass (cohesive type). Only 13% (ARI score 3) of the fractures occurred at the bracket/adhesive interface, meaning that all the resin adhered to the surface of the dental enamel.

Regarding technique (primer application or not) independent of the storage time, the results showed that there was no statistical significance [P = 0.534, Table 4]. The results were performed and grouped according to primer and storage time factors to evaluate the resin adherence onto both surface of the bracket base and enamel [Figure 4]. Regarding the storage time factor, interactions did not differ significantly between the immediate and 24 h period (P > 0.067). In general, the ARI scores of 0 were higher overall with a mean of 50% of the total in all analyzed specimens, followed by ARI score 1, 2, and 3 (19%, 18%, and 13%, respectively).

Scanning electron microscopy

Using SEM for comparative surface analysis among the studied bracket bases before and after shear bond tests, it is clear that 50% of all specimens tested retained most of the applied composite on the bracket base and the others varied [Figure 5]. Under stereomicroscopy, using a magnification of 20 times, no enamel fracture was noted.

Table 3: Simple linear regression analysis of the shear bond strength (MPa) according to the two different factors and interaction with storage time

Factors	Regression coefficient (β); SE	95% CI	R^2	Slops
Primer	0.938; 0.090	0.748–1.128	0.553	***P<0.001***
No primer	−0.053; 0.095	−0.233–0.126	0.004	*P*=0.553
Sandblasted	0.998; 0.134	0.725–1.27	0.590	***P<0.001***
Nonsandblasted	0.942; 0.123	0.693–1.192	0.606	***P<0.001***

Bold italic: Statistical significance (P<0.05). CI=Confidence interval, SE=Standard error, R^2=Coefficient of determination

Discussion

Adhesive primer application on the bracket base increases the bond strength between the metallic base and the dental enamel. The present study showed that

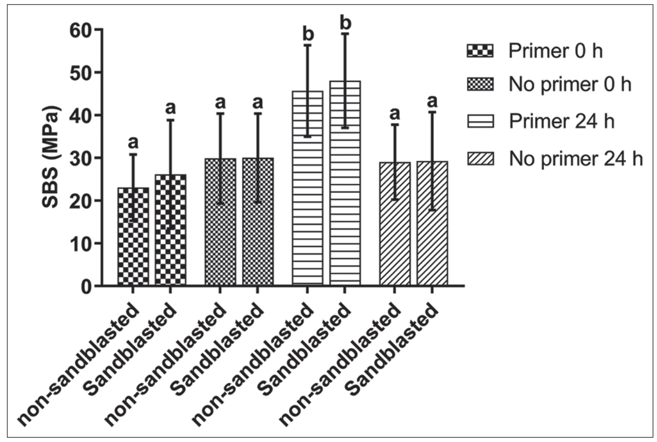

Figure 2: Statistical comparisons for SBS (MPa) among groups according to primer application, type of bracket base, and storage time factor. SBS = Shear bond strength

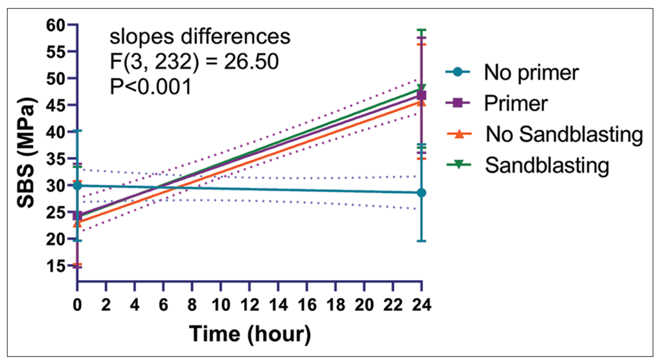

Figure 3: Simple linear regression analysis of the SBS (MPa) according to bonding technique and bracket base retention and the interaction with storage time. SBS = Shear bond strength

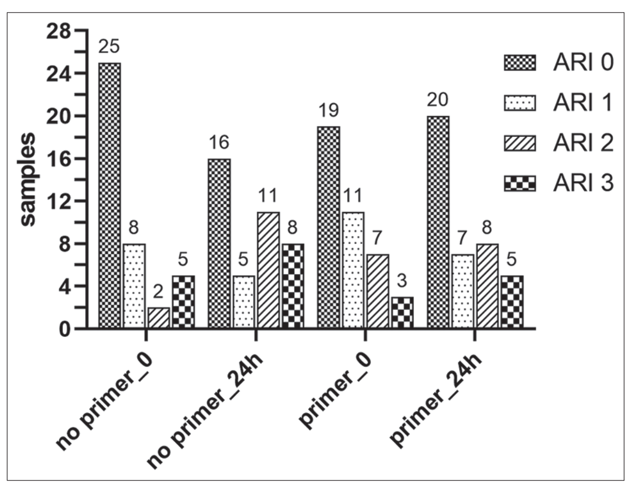

Figure 4: Adhesive remnant index scores distribution grouped according to bonding technique and time factors. ARI = Adhesive remnant index

Table 4: Distribution frequency, percentages of adhesive remnant index scores, and statistical comparison among groups according to primer, storage time and sandblasting factor

ARI	Primer 1		No primer 2		Primer independent of time 3		Time 4		Sandblasting 5		Total, *n* (%)	*P* (χ^2)
	0 h, *n* (%)	24 h, *n* (%)	0 h, *n* (%)	24 h, *n* (%)	Primer, *n* (%)	No primer, *n* (%)	0 h, *n* (%)	24 h, *n* (%)	Yes, *n* (%)	No, *n* (%)		
0	19 (48)	20 (50)	25 (63)	16 (40)	39 (49)	41 (51)	44 (55)	36 (45)	52 (33)	28 (18)	80 (50)	(1) *P*=0.686
1	11 (28)	7 (18)	8 (20)	5 (13)	18 (23)	13 (16)	19 (24)	12 (15)	15 (9)	16 (10)	31 (19)	***(2) P=0.022***
2	7 (18)	8 (20)	2 (5)	11 (28)	15 (19)	13 (16)	9 (11)	19 (24)	9 (6)	19 (12)	28 (18)	(3) *P*=0.534
3	3 (8)	5 (13)	5 (13)	8 (20)	8 (10)	13 (16)	8 (10)	13 (16)	4 (3)	17 (11)	21 (13)	(4) *P*=0.067
												(5) P=0.003

P (χ^2)=Probability (Chi-square test). Bold italic: Statistical significance (P<0.05). ARI=Adhesive remnant index

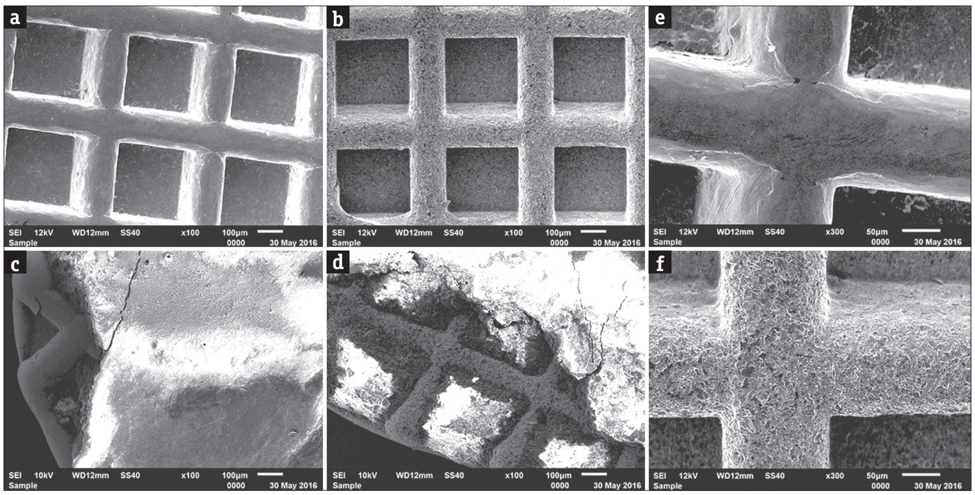

Figure 5: Scanning electron microscope analysis of brackets easyclip Plus™ (SEM, x50, x300) – without sandblasting (a, c, e) and sandblasted base (b, d, f).

the application of adhesive primer on the bracket base increased the SBS in 40.13% after a 24 h-period of the storage, which is more than clinically acceptable for orthodontic treatment.[4,6,9,15,17] It has been shown that the application of adhesive booster promoters on the bracket bases increase the SBS up to 22%.[5] On the other hand, other studies showed that the application of adhesive promoters did not increase SBS.[2] None of the previous studies applied the booster directly to the metallic bracket base. Some authors used adhesive applied to the enamel, whereas others employed the biomaterial on the bracket pad, that is a cured composite bracket pad added to the metallic bracket base.[17] Comparisons between previous studies and the present study are problematic due to different methodologies. Previous studies applied Plastic Bracket Primer (PBP) on different types of bracket bases to evaluate the improvement of the low bond strength of the plastic brackets.[18] Although the primers used in previous studies are different from this research, some chemical components of the adhesive are similar (Transbond XT is composed by 90% BISGMA and TEGDMA). The authors showed an increase of 58% on bonding strength when PBP was applied on plastic bracket bases (5.53 to 8.75 MPa), but a decrease of 6% when it was applied on metallic bases (9.44 to 8.44 MPa). Kilponen *et al.*[19] combined different types of brackets and primers to have the ability to modify the bonding characteristics of metal, ceramic, and polycarbolixate brackets to enamel. Interestingly, only the combination of silane and ceramic brackets was significantly higher (26.45 MPa, $P < 0.005$) than others. Primer application on metal bracket bases showed a decrease of adhesive resistance (8.14 to 7.44 MPa) in opposition to this study that obtained a significant SBS value of 48 MPa after the 24 h period [$P < 0.001$, Table 1]. A plausible explanation could be related to the primer used among the groups, as none of the authors used the bonding agent provided with the adhesive system kit.

The present study relies on the simplicity and ease of application of Transbond XT Adhesive Primer and Transbond XT Light Cure Adhesive on the bracket base, compared to others that made an additional preparation to create customized brackets followed by a surface treatment.[17] Another important factor that makes it difficult to compare the studies is the period (immediately or delayed) of evaluation of the specimens regarding SBS.

It was found that time increases shear bond strength. Specimens that were storage over a 24-h period showed approximately 30% higher values of SBS. The literature has shown inconsistences when the SBS was evaluate at different time points.[20] Previous studies[20] showed increases (≈30%) of SBS over a 24 h period, and a significant decrease (≈20%) after 6 months and after 12 months (40%). On the other hand, another study did not show significant differences in bond strength when SBS was evaluated after a 24 h period storage time.[21] Interestingly, the authors also compared *in vitro* and *in vivo* showing the SBS was lower on *in vivo* specimens.[21] A systematic review suggested that the inconsistencies in the literature are mainly related to two variables: bracket base design and curing time of the resin.[22] In addition, polymerization time influences the SBS; an additional 20 s increment is able to increase the shear bond strength approximately 9 MPa.[22] An explanation for the increase of the SBS could be attributed to the degree of conversion (DC) or monomer units that convert in the polymer chain.[23]

The DC modifies the physical and mechanical properties of the adhesive.[24] Previous studies demonstrated that SBS of orthodontic brackets is influenced by various factors[1,4,6,11-14] including the DC of the composite resin in different polymerizations protocols.[24-26] The physical–chemical properties of resin cement are directly related to the DC of the resinous cement. Considering less bisphenol A released from the resin after polymerization, the greater the DC and strength of the polymeric material.[26] The present study used only one type of adhesive system and variables such as light source, thickness of the resin layer, curing time, and distance of the light tip were all standardized, thus simplifying the process of drawing conclusions. Although the literature has shown no significant influence of time for the DC, comparisons need to be carefully made due to differences in methodology.[24] Previous studies established the interaction of orthodontic composites and storage time using different adhesive systems showing a significant role in the DC ($P < 0.05$).[24] It is important to notice the immediate groups (with and without primer) did not show statistical difference among them ($P > 0.01$) when compared to the 24-h period with the primer base application group [Figure 2]. According to another study, the higher SBS after the 24-h storage time period is possibly due to the progress of the polymerization reaction to its maximum by light activation.[23,25,26]

Although primer and time individually increase shear bond strength, it is clear the interaction of both factors increases outcome even more [Table 2]. The present study showed an increase of approximately 100% in SBS when adhesive primer was applied on bracket bases and evaluated after 24-h storage time compared with those immediately debonded [Figure 2]. A reasonable explanation could be the interaction among base design/primer/resin and tooth enamel surfaces (higher energy surface and surface tension).[4] Therefore, the reactive surface allows the adhesive resin to flow through the base wetted by the primer, thereby flowing into the microretention lock-ins in the base mechanisms. In addition, the linear regression analysis showed that only no primer application group had no time influence on bonding strength of metal brackets [$P = 0.553$, Table 3]. When primer was applied on bracket bases after the 24 h storage time, there was more resistance on shear forces compared to the other groups [Table 3 and Figure 3].

Sandblasted bracket bases with or without primer application did not increase SBS [Figure 2]. This study showed the interaction of primer application and time increased the SBS and sandblasting had no influence. Manufacturers have been employing sandblasting on bracket bases since the 70s,[27] and the literature has been controversial. Although SBS increased 18% when different bracket designs (with and without sandblasting) were compared, the difference was not statically significant.[27] Using the same bracket design, another study showed increasing of the SBS when brackets with and without sandblasted bases (60G, foil-mesh base) were evaluated, but the authors used different system adhesives.[3] The majority of the literature evaluating the influence of sandblasted bracket bases on SBS is related to recycled brackets showing similar values of SBS when compared to brand-new brackets of the same type.[2,6,28-31] The differences in SBS related to both studies could be explained by differences in the characteristics of the brackets bases. Apparently, the use of sandblasting has no effect on SBS.

Primer application on bracket bases did not change interface failure during debonding. Bonding failures occurred the vast majority of the times at the enamel/adhesive interface independently of the storage time, and the remaining failure interfaces were evenly distributed [Table 4]. The equivalent distribution of failure interfaces among the specimens that presented remaining composite on tooth and bracket simultaneously suggest a cohesive failure of the resin due to higher bonding strength among base/resin/enamel interfaces.[32] These findings provide information regarding enamel damage possibilities during debonding and help the clinician to understand the behavior of the adhesiveness among different materials. ARI score is dependent on several factors, including the adhesive and bracket base design.[9,14,33] In addition, mathematical models have reported that the interface failure is initiated when a stress component exceeds the cohesive adhesive limit.[32,34] Comparisons are problematic due to ARI scores being subjective and the results of the studies should be interpreted with caution.[14] Furthermore, different types of base design and amount of the adhesive might result in different ARIs, which could damage the enamel surface during bracket debonding.[4]

The application of Transbond XT primer adhesive on enamel has an effect on SBS, and it has been used in several studies as a gold standard resin cement.[4] The present study showed that the application of the adhesive primer on bracket base provides a great benefit to clinicians in terms of increasing SBS, regardless of whether the base was sandblasted or not. Despite the SBS values obtained in this study was more than sufficient to withstand orthodontic forces,[4] no damage to the enamel surface was reported. The results achieved in this *in vitro* study suggest that the high level of force aforementioned could compensate for the clinical conditions to which brackets are exposed *in vivo* conditions. In addition, applying primer before the resin could be an effective method of increasing the bond strength of the bracket base on the enamel in fluorosed teeth. The simple application of the primer on the bracket base represents a minimal time loss associated with larger SBS gain. In this sense, the use of this practice during bonding procedures can be useful in cases where an increase in bond strength is required. Therefore, waiting for 24 h before applying orthodontic forces to the bracket could be advantageous. Finally, we suggest further comparative studies using other types of adhesive systems, fluorosed teeth, and self-etching primer systems, as we believe that decreasing the clinical steps in the bracket bonding procedure can be an advantage in orthodontic practice.

Conclusion

Based on the results, we can draw three conclusions:

1. Adhesive primer application on bracket bases increases the shear bond strength between metallic bracket bases to dental enamel only after a 24 h period
2. Primer application on bracket bases before adhesive does not change interface failure during debonding and the most failures occurred at the enamel/adhesive interface
3. Sandblasting treatment on metallic bracket bases does not influence the shear bond strength.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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