Original Article

Effect of Different Surface Treatment Methods on Shear Bond Strength of Orthodontic Metal Brackets to Four Provisional Restorative Materials

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Abstract

The aims of this study were to determine the effect of different surface treatment methods and provisional materials on the shear bond strength of orthodontic brackets. One hundred and sixty samples were randomly divided into 4 material groups (n=40); A: acrylic resin (Unifast™ Trad), B: bis-acryl (Protemp™ 4), C: polycarbonate crown (3M ESPE), D: denture teeth (Cosmo™ HXL). In groups A and B, 5×5×2 millimeter box-form cavities were prepared on cured resin blocks and these cavities were filled with provisional materials. After polymerization, the materials' surfaces were polished and stored in distilled water for 7 days. In group C and group D, samples were embedded in a self-curing epoxy resin within polyvinyl chloride pipes in which the labial surfaces of C and D were above the self-curing epoxy resin and stored in distilled water for 7 days. Samples of each group were randomly divided into 4 subgroups of the following surface treatments (n=10); 1: Control, 2: 600-grit sandpaper, 3: Assure™ Plus, and 4: Sandblast. Lower incisors brackets (Gemini™, 3M) were attached with Transbond™ XT adhesive. All samples were stored in distilled water for 24 hours. A thermocycling procedure was conducted for 500 cycles between 5 °C and 55 °C. Samples were stored in distilled water for 24 hours. The shear bond strength was measured with a universal testing machine. The mode of failure was examined under a stereo microscope.

The results of the surface treatment groups showed that the mean shear bond strength of sandblasting groups was significantly higher than all other surface treatment groups of all materials, except for sandblasting on the bis-acryl group (B4) ($p<0.05$). Other surface treatment methods on all materials showed no statistically significantly difference except in the polycarbonate crown with Assure™ Plus (C3), which presented the lowest mean shear bond strength ($p<0.05$). The mean shear bond strengths of custom type materials (group A and B) were significantly higher than the prefabricated type material (group C and D) ($p<0.05$).

Both types of materials and surface treatment methods influenced the shear bond strength of the brackets bonded to the provisional materials. The sandblasting technique enhanced the shear bond strength effectively in all materials except for bis-acryl that originally expressed high shear bond strength even without surface treatment. The surface treatment that uses the sandblasting technique and using bis-acryl composite which exhibited higher shear bond strength to other materials and surface treatment may offer a good option in clinical practice.

Keywords: Bracket, Provisional restoration, Shear bond strength, Surface treatment

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Introduction

Currently, orthodontic treatment is widely applied to all age groups including e adults with complex dental problems. Some of these problems are teeth loss, large carious and root canal treatment are usually followed by fixed or removable prostheses for substitution. The orthodontic treatment plan for these patients should be concerned about esthetic in the anterior region, occlusal relationships, and maintaining mesio-distal width of the teeth during orthodontic treatment. Therefore, provisional restoration plays a major role in successful permanent fixed prosthesis after the completion of orthodontic treatment. Orthodontic patients with anterior tooth loss should have bonded brackets onto denture tooth and tie them onto the main archwire. A denture tooth should be used to fill the space for esthetic improvement and to maintain the proper space. An orthodontic band can be used in posterior root canal treated teeth, whereas the provisional crown is suitable for in anterior root canal treated teeth due to esthetic concerns.[1] The bond strength between brackets to the provisional materials and denture teeth is relatively lower than brackets bonded to enamel.[2] The failure of bonded brackets on these provisional material surfaces has been studied. The detachment of brackets will prolong the treatment time, reduce efficacy of treatment, and endanger the patients in the case of using prefabricated denture teeth tied to main archwire.[2] Thus, producing higher bracket bond strength to provisional materials and denture teeth will ensure better orthodontic treatment results.

From previous studies, the shear bond strengths of orthodontic brackets to provisional materials depends on various factors such as material, surface treatment method, duration of polymerization, and bracket base designs.[2-5] However, the previous studies did not fully compare different surface treatments and universal bonding usage on custom type provisional materials (self-curing acrylic resin and bis-acryl composite resin) and prefabricated type provisional materials (polycarbonate crown and prefabricated denture teeth) including artificial aging with thermocycling. Thus, this study was designed to cover more factors that effect to shear bond strength on orthodontic metal brackets to provisional restorative materials.

The aims of this study were to determine the shear bond strength of orthodontic brackets bonded to provisional materials under the different surface treatments. The null hypothesis was material types, surface treatments could not affect the shear bond strength of orthodontic metal brackets.

Materials and Methods

The sample size was calculated from Cohen's sample size table (1988) with the power of the test = 0.80 in which the level of significance was set at 0.05, effect size = 0.80 and degree of freedom = 9. Each experimental subgroup contained 10 samples. In this study, four materials were divided into four groups. Each group contained 40 samples: Group A represented the self-curing acrylic group (Unifast™ Trad), Group B represented the bis-acryl composite group (Protemp™ 4), Group C represented the polycarbonate crowns group (3M ESPE), and Group D represented the prefabricated acrylic denture teeth (Cosmo™ HXL). The materials, the manufacturers and their compositions used in this study are presented in Table 1. The box-form cavities (size 5×5×2 mm) were created with round and fissure burs on the surfaces of the polymerized self-curing acrylic resin in polyvinyl chloride (PVC) pipes (diameter 20 mm; length 12 mm). The molds of this cavity were created by silicone putty impressions for identical specimen cavities. Samples of Groups A and B were placed in PVC pipes then filled with clear polyester resin in a silicone mold. After the polymerization of the clear polyester resin was completed, the surfaces were polished with 600-, 800- and 1200-grit sandpaper, respectively. Group A (self-curing acrylic resin group): Self-curing acrylic was mixed by using powder/liquid ratio: 1g of powder to 0.5 ml of liquid as per the manufacturer's recommendation. The powder was added to the liquid and mixed thoroughly for 10–15 seconds. The mixture reached a dough state at 20–30 seconds after mixing. All manipulation was finished within 2 minutes after mixing. The samples were kept in 37°C distilled water for 7 days until fully polymerized. Polishing was performed with 600-, 800-, and 1200-grit sandpaper and finally yellow silicone bur. Group B (bis-acryl composite group): Bis-acryl composite resin was fabricated by loading the material to fill into the box in the PVC pipes. Finishing was achieved by using 70 % alcohol wiped labial surfaces to remove air-inhibited layers at 5 minutes after the onset of mixing. Group C (polycarbonate crowns group): The labial surface of the polycarbonate crowns was embedded to clear the polyester resin in the PVC pipes. The labial surface of the samples was above the clear polyester resin. Group D (prefabricated denture teeth): The labial surface of the dentures were embedded in PVC pipes following the same procedure as Group C. All samples were stored in 37°C distilled water for 7 days to wait until the material had reached full cross-linking polymerization.[6]

Forty samples of each material were randomly divided into four subgroups according to the surface treatment methods; Subgroup 1: The control group in which no surface treatment was applied, Subgroup 2: Surfaces that were roughened with 600-grit sandpaper with an up and down direction 10 times, Subgroup 3: Changed Transbond™ XT bonding agent to Assure™ Plus bonding agent. After etching with 37 % phosphoric acid for 15 seconds, one coat of liquid was applied to the surfaces by bonding the surfaces with a micro brush, and air dried with a chairside triple syringe for 5 seconds then bonded with Transbond™ XT adhesive. Subgroup 4: The surfaces were sandblasted by a Micro-abrasive sandblaster, (Parkell™ Inc, New York, USA), blowing 50µm aluminum oxide particles with 2 bars of pressure in 2 seconds. The distance was 5 mm perpendicular to the surface of an object. After the surface treatment preparation, samples in Groups 1, 2, and 4 were rinsed and air dried with a chairside triple syringe. Mandibular incisors orthodontic brackets (Gemini™ metal bracket, Unitek™, 3M with network micro-etched 80-gauge base design) were attached to provisional materials with the light curing adhesive system (Transbond™ XT, Unitek™, 3M) by a manufactory manual. The surface of the provisional material was etched with 37 % phosphoric acid for 15 seconds and then rinsed with running water for 10 seconds and air dried with a chairside triple syringe for 5 seconds. A thin layer of adhesive was applied to the testing surface except for Group 3. A small amount of Transbond™ XT was applied to the bracket bases and pushed to the center position of each specimen. The excess orthodontic adhesive was removed by explorer. Then, light-cured with a light emitting diode (LED) light curing unit 2 mm from the bracket bases, 10 seconds at the mesial and distal of the bracket bases. All samples were stored in 37°C distilled water for 24 hours. Then 500 cycles of thermocycling (TC 301, MERL™, Bangkok, Thailand) were conducted between temperatures of 5°C and 55°C with exposure to each bath at 20 seconds (the transfer time between baths was 7 seconds) and then the specimens were stored in 37°C distilled water for 24 hours (ISO/TS 11405:2015). The shear bond strength was tested by a universal testing machine

Table 1 *Composition of experimental materials*

Brand Name	Manufacturer	Preparation	Major ingredients	Curing system
Protemp™4	3M™ ESPE, St Paul, Minn	Automixing cartridge	-Bis-acrylic resin composite -Base paste: Bisphenol A polyethylene glycol diether dimethacrylate (Bis-EMA) and Bisphenol A glycidylmethacrylate (Bis-GMA) 50-60 % -Silane-treated amorphous silica 20-30 % -Polyurethane methacrylate 10-20 % -Catalyst paste: Ethanol 70-80 %, -Silane-treated silica10 % -Benzyl-phenyl-barbituric acid 10 %	Self-cure
Unifast™ Trad	GC™America	Powder (100 g) Liquid (104 ml)	Poly (methyl methacrylate (PMMA) Powder: Methyl methacrylate and ethyl methacrylate copolymer Liquid: Methyl methacrylate monomer, dimethyl-p-toluidine	Self-cure
Denture teeth	Cosmo™HXL	Preform	Interpenetrating polymer network acrylic resin	
Polycarbonate crown	3M ESPE, St Paul	Preform	Polycarbonate resin with microglass fibers	
Assure™Plus	Reliance orthodontic™ products, Illinois, USA	Liquid	-Bisphenol A glycidylmethacrylate (Bis-GMA) 20-50 %, -2-Hydroxyethyl Methacrylate (HEMA) 5-25 % -Ethanol 30-50 % -10-MDP 5-25 %	
Transbond™ XT	3M ESPE, St Paul	Single syringe paste (4 g)	-Bisphenol glycidyl methacrylate (Bis-GMA) 10-20 % - Bisphenol A polyethylene glycol diether dimethacrylate (Bis-EMA) 9 % -2-hydroxyethylether 5-10 % -Silane-treated quartz 70-80 % -Silanetreated silica <2 % -Diphenyliodonium hexafluorophosphaten<0.2 % Primer: Triethylene glycol dimethacrylate (TEGDMA) 45-55 %, -Bisphenol A diglycidyl ether dimethacrylate (Bis-GMA) 45-55 % -Triphenylantimony <1 %, -4-(dimethylamino)-benzeneethanol <0.5 %, -Camphoroquinone <0.3 % -Hydroquinone <0.03	Light-cure

(Instron™ 8872, Instron™ – Euro Headquarters, Coronation Road, High Wycombe, Bucks, UK) with the cross-head speed of 1 mm per minute.[7,8] Shear forces were applied perpendicular to the specimens between the bracket bases and bond surfaces until the brackets were detached. The forces in the Newton units were measured. The shear bond strengths were calculated by the force/surface area (N/mm^2, MPa). All the measurements were performed by one technician.

All detached brackets and bond surfaces of each material subgroup were observed as modes of failures by the zoom stereo (20x) (Olympus™ SZX16, Hatagaya, Shibuya-ku, Tokyo, Japan).[9] The modes of failure were characterized following the site of failures; Type 1: Mixed failure, Type 2: Adhesive failure, Type 3: Cohesive failure in materials, and Type 4: Cohesive failure in resin. The results of the shear bond strength test calculated the mean and standard deviation by SPSS program version 17.0. A two-way analysis of variance (two-way ANOVA) was conducted to analyze the combined effect of surface treatment methods and provisional materials. Tukey HSD was used for post-hoc analysis. All tests set statistical significance at p-value = 0.05.

Results

The descriptive statistics of shear bond strengths for four surface treatment methods in four provisional restorative materials are shown in Table 2. A two-way ANOVA showed significant interaction between the materials and surface treatment methods and revealed the statistical difference within each material and surface treatment usage ($p<0.05$). One-way ANOVA compared interaction of each provisional material within the same surface treatment method on shear bond strengths and interaction of each surface treatment within the same provisional material on shear bond strengths showed the statistical difference (except for bis-acryl provisional material) ($p<0.05$). The samples with mean shear bond strengths over 15 MPa were categorized to the high shear bond strength group. The high shear bond strength group was used to find the combination of surface treatment and/or provisional material that created the highest shear bond strength. The details of all post-hoc tests are described below.

Effect of different surface treatment methods on shear bond strengths of each provisional material.

Self-curing acrylic resin group: The subgroup A4 exhibited the highest mean shear bond strength and the mean shear bond strengths of subgroup A1 to subgroup A3 showed no statistically significantly difference.

Bis-acryl group: There were no statistically significantly difference among different surface treatments within the material group.

Polycarbonate crown: The mean shear bond strength of subgroup C4 was the highest. In contrast, the mean shear bond strength of subgroup C3 was significantly lower than subgroup C1, subgroup C2 and subgroup C4. While subgroup C1 and subgroup C2 showed no statistically significantly different mean shear bond strength.

Denture teeth: The subgroup D4 presented the highest mean shear bond strengths. However, the mean shear bond strengths of D1, D2 and D3 showed no statistically significantly difference.

Effect of different provisional materials on shear bond strengths of each surface treatment method.

Control group: The mean shear bond strengths of subgroup A1 and subgroup B1 were statistically significantly higher than C1 and D1, while the mean shear bond strengths between subgroup A1 and subgroup B1, and also subgroup C1 and subgroup D1 were not statistically significantly different.

Sandpaper group: The subgroup B2 revealed the highest mean shear bond strength, while subgroup A2 was statistically significantly different from subgroup B2 and subgroup C2. The mean shear bond strengths between subgroup C2 and subgroup D2 were not statistically significantly different.

Assure™ Plus group: The subgroup B3 showed the highest mean shear bond strength, while the mean shear bond strength of subgroup C3 was the lowest. The mean shear bond strengths between subgroup A3 and subgroup D3 were not statistically significantly different.

Sandblast group: The mean shear bond strengths of subgroup A4 and subgroup B4 were statistically significantly higher than subgroup C4 and subgroup D4. There were no statistically significantly difference between subgroup A4 and subgroup B4, and also between subgroup C4 and subgroup D4.

Effect of both different surface treatment methods and provisional materials on shear bond strengths.

The interaction between the surface treatments and provisional materials was defined by the high shear bond strength group. The high shear bond strength group including subgroups A4, B1, B2, B3, B4, C4 and D4, presented no statistically significantly difference among these subgroups ($p<0.05$)

The sandblasting method on all materials created the significantly higher shear bond strength than other surface treatment methods. However, bis-acryl material treated by sandblasting (B4) showed no statistically significantly difference from the bis-acryl without surface treatment (B1).

The mode of failure of all the specimens is presented in Table 3. The mode of failure of A1, A2 and A3 groups was type 2 (adhesive failure) in which the fracture occurred between the adhesive resin and material surfaces. In the A4 group, fifty percent of specimen exhibited type 1 (mixed failure) which occurred as both adhesive failure (between adhesive resin and provisional materials) and cohesive failure (within adhesive resin), and type 2 (adhesive failure). In group B, the mode of failure was mostly type 1 (mixed failure) which occurred in both adhesive failure (between adhesive resin and provisional materials) and cohesive failure (within bis-acryl material). In group C, the mode of failure was type 2 (adhesive failure). The mode of failure of subgroup D1, D2, D3 and most of D4 was type 2 (adhesive failure).

Table 2 *Shear bond strengths for four surface treatment methods in four provisional restorative materials*

Surface treatments	Provisional materials			
	Self-curing acrylic resin (A)	Bis-acryl composite resin (B)	Polycarbonate crown (C)	Prefabricated denture teeth (D)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Control (1)	$19.13 \pm 2.98^{a,b}$	$24.1 \pm 4.46^{a,b}$	$10.22 \pm 5.12^{c,d}$	$9.37 \pm 3.23^{c,d}$
Sandpaper (2)	$14.30 \pm 5.65^{a,d}$	24.51 ± 5.49^{b}	$7.02 \pm 4.26^{c,d}$	$12.00 \pm 3.38^{a,c,d}$
Assure™ Plus (3)	$14.22 \pm 5.87^{a,d}$	26.43 ± 5.15	2.26 ± 0.76*	$9.70 \pm 4.90^{a,d}$
Sandblasting (4)	$26.27 \pm 3.82^{*a,b}$	$24.50 \pm 3.85^{a,b}$	$17.96 \pm 3.32^{*c,d}$	$21.00 \pm 4.21^{*c,d}$

** statistically significantly different of each provisional material at p<0.05*
a, b, c, d the same letter means no statistically significantly different in each surface treatment method

Table 3 *Number of specimens per mode of failure*

Groups (n=10)	Mode of failure			
	Type 1	Type 2	Type 3	Type 4
A1	0	10	0	0
A2	0	10	0	0
A3	0	10	0	0
A4	5	5	0	0
B1	8	2	0	0
B2	7	3	0	0
B3	8	2	0	0
B4	9	1	0	0
C1	0	10	0	0
C2	0	10	0	0
C3	0	10	0	0
C4	0	10	0	0
D1	0	10	0	0
D2	0	10	0	0
D3	0	10	0	0
D4	1	9	0	0

Discussion

The type of material, surface treatment method and the combination of material and surface treatment method played important roles regarding the shear bond strength. From the results, the material types and surface treatments affect the shear bond strength. Thus, the null hypothesis is rejected.

Roughening the surface with 600-grit sandpaper that simulated clinical grinding with burs to provide surface roughness and improve mechanical retention.[11] This method is the most common surface treatment as no additional instrumentation is required and easy to perform. However, no significant differences were recorded for shear bond strength between the sandpaper surface treatment group and the control group in this study. This result was similar to Al Jabbari *et al.*, Blakey R. and Mah J. and Chay *et al.*[1-3] which may be explained by the forming of microcracks after surface grinding by sandpaper.[12] The microcracks are caused by the limited ability of a strongly crosslinked polymer matrix its limited plastic deformation to deform plastically during grinding.[13] On the contrary, the surface and subsurface microcracks increase the contact area between the adhesive system and the surface of the provisional materials, but they may also act as stress concentrators, initiating fractures of the adhesive joints.[13] Thus, when performing surface grinding to create surface roughness that enhances the shear bond strength, force should be applied lightly to prevent microcrack formation.

The Assure™ Plus adhesive contains 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) with a ethanol solvent (Table 1). This product is a new universal adhesive system that claims to improve bond strength on various surfaces including normal, atypical, wet or dry enamel, dentin and defective enamel, gold, amalgam, stainless steel, plastic and composite restorations, porcelains and even zirconia. The 10-MDP is a versatile amphiphilic monomer with a hydrophobic methacrylate group on one end (capable of chemical bonding to methacrylate-based restoratives and adhesive resin) and a hydrophilic polar phosphate group on the other (capable of chemical bonding to tooth tissues, metals, and zirconia).[14] The dihydrogen phosphate group from 10-MDP monomer is responsible for etching and chemical bonding, while its long carbonyl chain provides the hydrophobic properties and hydrolytic stability to this acidic monomer.[14] In this study, Assure™ Plus did not increase shear bond strengths significantly in self-curing acrylic resin, bis-acryl composite and prefabricated denture teeth. In addition, this bonding agent reduced shear bond strengths in polycarbonate crown material. The reason for this phenomenon may be the lack of bonding sites in polycarbonate crown material that can be attached to both ends of the 10-MDP monomer, since polycarbonate crown material contains bis-GMA and polycarbonate monomers with micro-glass fibers without reactive methacrylate groups like acrylic resin and bis-acryl; therefore, the methacrylate group of the 10-MDP functional monomer cannot bond to the polycarbonate structure. When there are no bonding sites available, the unreacted Assure™ Plus bonding agent creates separation between the orthodontic adhesive and the polycarbonate surface which results in a reduction of the shear bond strength. In our study, Assure™ Plus groups were not subjected to surface grinding according to the manufacturer's instructions to eliminate confounding factors from the additional surface treatments.

Sandblasting was the most effective way to produce the highest shear bond strengths in all materials (except bis-acryl composite). This method created a randomized roughened surface with deep pockets, leading to increased micromechanical retention and shear bond strength.[1-4] The chemical bonding of bi-functional methacrylate groups within the bis-acryl composite material to orthodontic adhesive was originally significantly high.[2,3,16] Thus, the micromechanical retention created from sandblasting did not synergistically increase in the bis-acryl composite material shear bond strengths.

The shear bond strength of custom provisional material is higher than prefabricated type, due to the proportion of unreacted methacrylate monomers is greater than in prefabricated types. Our results revealed that the shear bond strength of bis-acryl composite material was the highest, similar to other studies.[2,3,16] Since, the major components of bis-acryl composite materials are bis-GMA and bi-functional acrylate groups[2], and the high level cross-linked polymers are formed by free-radical polymerization from dimethacrylates of bis-GMA and two reactive groups. Thus, this material provided higher bond strength compared with the others because of greater cross-linked density.[16] Self-curing acrylic resin also showed high shear bond strength, especially when the surfaces were sandblasted. There is only one reactive group; as a result, in self-curing acrylic resin, the material exhibited lower shear bond strength than bis-acryl composite materials.

The mean shear bond strengths of prefabricated provisional materials were lower than custom types, caused by cross-linking and a high degree of conversion impeded the reaction of methacrylate monomers with functional groups of the adhesive resin. Sandblasting was an effective method to improve shear bond strengths in these materials. Our results were similar to Blakey R, Mah J and Maryanchik I, *et al.,*[1,16]

The lowest shear bond strengths was showed in polycarbonate crown group. As described above, composite resins do not bond to polycarbonate crowns, thus surface treatment is necessary.[12] Polycarbonate is able to be dissolved by MMA, eugenol, and phosphoric acid causing surface softening and swelling of the polycarbonate crown surface, and enhancing infiltration of the adhesives.[17] Yilmaz, A. found that surface treatment by applying MMA for 180 seconds before bracket bonding created macro and micro-mechanical retention areas and resulted in higher mean shear bond strengths as the adhesive agents penetrated and interlocked within the surface irregularities.[17]

Denture teeth are fabricated under high pressure and temperature[18], thus the material has greater density and fewer potential bonding sites, resulting in low shear bond strength.[16] However, denture teeth are the easiest option when pontic teeth are required in anterior areas. Unfortunately, the shear bond strength of this material is relatively low as mentioned above. However, the force transfer in anterior teeth is lower than in posterior teeth. Thus, the shear bond strength with/without surface treatment may be sufficient for bracket bonded anterior denture teeth. Using denture teeth in anterior region without surface treatment may be possible, but sandblasting is a better recommendation.

The higher shear bond strengths resulted in a greater number of type 1 mode of failure specimens, especially for bis-acryl composite material and sandblasting surface treatment on self-curing acrylic resin. A type 1 mixed failure with adhesive failure between adhesive resin and provisional material and cohesive failure within provisional material was shown by the bis-acryl composite material only. This result indicated the superior shear bond strength of the bis-acryl composite material which tightly bonded with Transbond™ XT adhesive. In contrast, when the bracket was debonded or detached this may partially damage the bonded surface. Fortunately, the damaged surface can be easily repaired with flowable light curing composite resin, because of the similar composition of bis-acryl composite resin and restorative composite resin.[19]

In the oral cavity, thermal changes in cycle from high and low temperatures normally occur when eating, drinking, and breathing. The change of oral temperature may affect the shear bond strength of orthodontic brackets bond to tooth or non-tooth surfaces.[3] The difference of coefficient of thermal expansion between orthodontic adhesives, brackets, and dental material surfaces created weakness in molecular bond. Repeated expansion and shrinkage will produce internal stress that reduces the shear bond strength.[20] Thus, the change of temperature is an important factor to consider. In this study, artificial aging was included by the use of thermocycling machine. This method is a minimal mimicking the oral environment to simulate the usage of bonding bracket in oral cavity. After being exposed to 500 cycles of thermocycling, there was no detached bracket found in our study.

Reynolds IR.[21] noted that the minimum recommended shear bond strength for orthodontic treatment was 6-8 MPa. The results indicated that most of provisional materials had sufficient shear bond strengths, except polycarbonate crowns with Assure™ Plus bonding agent. Theoretically, all materials could directly bond with metal brackets without additional surface treatment as they all exhibited higher values than the minimum shear bond strength recommendation. However, in clinical practice, several forces are applied from diverse directions in both anterior and posterior teeth. Hence, it is necessary to ensure high bond strength to maintain brackets attachment on provisional or pontic material surfaces until the orthodontic treatment is complete.

From this study, surface treatment with sandblasting technique and the use of bis-acryl composite material exhibited the highest shear bond strength. This may offer a good option in many orthodontic cases.

For clinical practice application, Al Jabbari, S. *et al.*[2] suggested that provisional crowns fabricated from bis-acryl composite material are acceptable for provisional restorations required in posterior teeth for a minimized chance of bracket detachment. If substitution teeth are required for patients with anterior deep bite or high load forces such as edge to edge bite, then sandblasting should be performed on the denture tooth. However, many dental practices do not have a sandblaster. Consequently, the fabrication of pontic teeth from custom provisional restorative materials becomes an alternative choice.[16] Although the shear bond strength for custom provisional materials are high, more chair time is required to fabricate provisional restorations than prefabricated types. It is suggested that custom provisional restorations should be fabricated before appointments to gain higher shear bond strength and to reduce chair time.

Cost is another important factor for the clinician to consider which material or surface treatment to use in provisional restoration. Bis-acryl composite materials provide the highest shear bond strength and are esthetic and easy to use, however, it is the most expensive when compared to other materials. Self-curing acrylic materials are the cheapest per restoration unit, but it offers inferior esthetic qualities and patients are required to spend a long time in the chair in order to do the fabrication. Polycarbonate crowns showed the lowest mean shear bond strength with a high cost per unit, but they have good esthetic properties and are easy to use. Prefabricated denture teeth are the easiest material to manipulate for pontics of anterior teeth. The residual prefabricated denture teeth from prosthodontic treatments can be used for this purpose with no cost if the shade and size both match.

Conclusion

Both type of materials and surface treatment methods affected the shear bond strength of brackets bonded to provisional materials. The sandblasting technique enhanced the shear bond strength effectively in all materials except for bis-acryl that originally expressed high shear bond strength even without surface treatment. The shear bond strengths of custom type materials were significantly higher than prefabricated type materials The polycarbonate crown exhibited the lowest shear bond strength; moreover, Assure™ Plus has significantly reduced the shear bond strength of the polycarbonate crown in this study.

Reference

1. Blakey R, Mah J. Effects of surface conditioning on the shear bond strength of orthodontic brackets bonded to temporary polycarbonate crowns. ***Am J Orthod Dentofacial Orthop*** 2010;138:72-8.
2. Al Jabbari YS, Al Taweel SM, Al Rifaiy M, Alqahtani MQ, Koutsoukis T, Zinelis S. Effects of surface treatment and artificial aging on the shear bond strength of orthodontic brackets bonded to four different provisional restorations. ***Angle Orthod*** 2014;84:649-55.
3. Chay SH, Wong SL, Mohamed N, Chia A, Jin Yap AU. Effects of surface treatment and aging on the bond strength of orthodontic brackets to provisional materials. ***Am J Orthod Dentofacial Orthop*** 2007;132:577.e7-.e11.
4. Almeida JXd, Deprá MB, Marquezan M, Retamoso LB, Tanaka O. Effects of surface treatment of provisional crowns on the shear bond strength of brackets. ***Dental Press J Orthod*** 2013;18:29-34.
5. Rambhia S, Heshmati R, Dhuru V, Iacopino A. Shear bond strength of orthodontic brackets bonded to provisional crown materials utilizing two different adhesives. ***Angle Orthod*** 2009;79:784-9.
6. Chen HL, Lai YL, Chou IC, Hu CJ, Lee SY. Shear bond strength of provisional restoration materials repaired with light-cured resins. ***Oper Dent*** 2008;33:508-15.
7. Klocke A, Kahl-Nieke B. Influence of cross-head speed in orthodontic bond strength testing. ***Dent Mater*** 2005;21:139-44.
8. Algera TJ. A better understanding of orthodontic bracket bonding. Amsterdam: University of Amsterdam; 2009.
9. Montasser MA, Drummond JL. Reliability of the adhesive remnant index score system with different magnifications. ***Angle Orthod*** 2009;79:773-6.
10. Öz AA, Yazicioğlu S, Arici N, Akdeniz BS, Murat N, Arıcı S. Assessment of the confidence of the adhesive remnant index score with different methods. ***Turk J Orthod*** 2013;26:149-53.
11. Brauer GM, Burns FR. Sulfinic acid derivatives as accelerators in the polymerization of methyl methacrylate. ***J Polym Sci*** 1956;19:311-21.
12. Yuzugullu B, Acar O, Cetinsahin C, Celik C. Effect of different denture cleansers on surface roughness and microhardness of artificial denture teeth. ***J Adv Prosthodont*** 2016;8,333-338.
13. Comba L, Bradna P. The effect of surface treatment and adhesive system on the durability of composite repairs. ***Dentistry*** 2015;05.
14. Alex G. Universal Adhesives: The next evolution in adhesive dentistry? ***Compend Contin Educ Dent*** 2015;36:15-26.
15. Nitkin DA, Rosenberg HM, Yaari AM. An improved technique for the retention of polycarbonate crowns. ***ASDC J Dent Child*** 1977;44:108-10.
16. Maryanchik I, Brendlinger EJ, Fallis DW, Vandewalle KS. Shear bond strength of orthodontic brackets bonded to various esthetic pontic materials. ***Am J Orthod Dentofacial Orthop*** 2010;137:684-9.
17. Yilmaz A. A compairison of two different methods and materials used to repaired polycarbonate crowns. ***J Contemp Dent Pract*** 2007;8:105-12.
18. Sakaguchi RL, Powers JM, Craig RG. Craig's restorative dental materials. 13th ed. ed. Sakaguchi RLe, Powers JMe, Craig RG, editors. Philadelphia, Pa.: Elsevier/Mosby; 2012. xvi, 400 p.
19. Bohnenkamp DM, Garcia LT. Repair of bis-acryl provisional restorations using flowable composite resin. ***J Prosthet Dent*** 2004;92:500-2.
20. Harraa SM. The effect of thermocycling and debonding time on the shear bond strength of different orthodontic brackets bonded with light-emitting diode adhesive (In vitro study). ***J Bagh College Dentistry*** 2013;25,139-145.
21. Reynolds IR. A review of direct orthodontic bonding. ***Br J Orthod*** 1975;2:171-8.