ORIGINAL RESEARCH

Impact of Surface Treatment Methods on Bond Strength of Orthodontic Brackets to Indirect Composite Provisional Restorations

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Abstract

Aim: To assess the impact of different surface treatment protocols on the shear bond strength (SBS) of metal orthodontic brackets (MOBs) and ceramic orthodontic brackets (CBOs) bonded to provisional crowns via the SBS test.

Materials and methods: A total of 120 provisional indirect composite crowns (SR Nexco; Ivoclar Vivadent) for maxillary first premolars were fabricated and evenly allocated into two groups: MOBs and CBOs. According to the surface treatment protocol, each group was divided into three subgroups: group CO, no treatment; group HF, the surface was etched with 10% hydrofluoric acid; and group SA, the surface was sandblasted followed by silanization. After bracket bonding, the samples were subjected to 3,000 thermocycles between 5°C and 55°C. SBS was evaluated using a universal testing machine at a crosshead speed of 1 mm/minute and the adhesive remnant index (ARI) was identified. For statistical analysis, ANOVA and Tukey HSD post hoc tests were performed.

Results: Mean bond strength values for CBOs cemented to control, HF-, and SA-treated subgroups before and after thermocycling were (9.6 – 1.4, 6.2 – 1.1), (17.8 – 2.1, 13.8 – 1.3), and (17.2 – 1.4, 12.1 – 1.8) MPa, respectively. For the metallic brackets, the results were (7.7 – 2.3, 3.9 – 1.4), (15.5 – 1.6, 12.8 – 1.2), and (15 – 1.2, 11.2 – 1.6) MPa, respectively. There was a significant difference ($p = 0.000$) between ceramic and metallic bracket groups.

Conclusion:Conditioning of indirect composite provisional crowns either with HF or SA was significantly affecting the adhesion to both bracket types.

Clinical significance: Increasing the bond strength between provisional crowns and orthodontic brackets (OBs) may improve the treatment standard provided to patients.

Keywords: Adhesion, Indirect composite, Orthodontic brackets, Provisional crowns, Surface conditioning.

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Introduction

Orthodontics is oftentimes an intermediate stage to oral rehabilitation.[1] Thus, abutment teeth often have provisional crowns during orthodontic treatment until the teeth have been moved into more favorable positions to receive the definitive crowns.[2] Treatment with provisional restorations must provide positional stability for abutment teeth, esthetics, reestablish masticatory and occlusal functions, adequate marginal adaptation, and maintain periodontal health.[2–5]

Although chemically activated resins are preferred by many clinicians for provisional crowns fabrication to provide adequate short-term interim prostheses, the use of visible light polymerized indirect processed composite restorations is often recommended as a long-term provisional restoration until the final treatment is indicated.[1,6–9]

Many researchers reported that the conventional bonding protocol could not provide sufficient adhesion to provisional restorations to withstand orthodontic forces, and orthodontists are often challenged with bonding attachments to these provisional restorations.[7] Several approaches attempted to improve the surface roughness and the bonding surface area.[1,2,7,10–12] The approaches suggested can be classified into two groups: mechanical or chemical. Mechanical methods involve sandblasting and surface grinding with a silica carbide paper or a diamond bur.[13–15] The chemical method is achieved by hydrofluoric acid etching and a silane primer application.[16,17]

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The bond between provisional materials and OBs is affected by different factors, including the type of adhesive material, the provisional material, the storage time after bonding, and materials aging.[1,2,15,18,19] The strength of this bond should prevent the failure caused by the orthodontic forces, mastication, and other oral functions. During the treatment period, the techniques and materials used in bonding should maintain the brackets bonded and keep the crown's surface intact during debonding. The aim of this study was to investigate the impact of various surface treatment protocols and thermocycling on the SBS of MOBs and COBs to indirect composites provisional crowns in vitro. It was hypothesized that SBS values would differ significantly among the different conditioning techniques.

Materials and Methods

Samples Preparation

This experimental study was approved by the Research Ethical Committee of the College of Dentistry, Taibah University, Madinah, Kingdom of Saudi Arabia (approval # TUCDREC/20190406/SSBorzangy). The study included 120 human permanent maxillary sound first premolars freshly extracted for clinical reasons. The obtained teeth were cleaned and stored for 6 months after extraction in 0.5% chloramine solution at 4°C. Chemically polymerized acrylic resin (Sampl Kwick, Buehler, Lake Bluff, IL, USA) was used to encircle the root of these teeth. Standardized tooth preparations for all the teeth were done using a lathe cut machine to stimulate the preparation for all-ceramic crowns. Impressions were made using the vinylpolysiloxane addition-cured silicone impression material (Elite HD, Zhermack Spa, Via Bovazecchino, Italy) for each prepared tooth and poured with dental stone type IV consistent with manufacturer's recommendations.

An indirect composite material (SR Nexco, Ivoclar Vivadent AG, Bendererstrasse 2, FL-9494 Schaan) was used in this study for the fabrication of provisional crowns. The manufacturer's instructions were followed to mix the materials and inject them into a silicone index simulating the full form of the premolar tooth mold. It was held under compression and then polymerized by a visible light cure system for 90 seconds. The provisional crowns were finished by using rubber polishers and silicone polishing wheels followed by polishing with a universal polishing past and goat hairbrush following manufacturer's recommendations. Each provisional crown was cemented to its corresponding tooth using non-eugenol temporary cement (Temp Bond NE, Kerr Corp, Orange, CA, USA), for 5 minutes under 5 kg static load.

Group Classification

Grounding of the bonded area of composite surfaces was done with a 600-grit silicon carbide (SiC) paper under running water for 30 seconds to expose filler particles except for the control group.[10] The samples were allocated into two groups (n = 60) according to the type of OBs used: group MOBs and group COBs. These groups were further subdivided into three subgroups (n = 20) according to the surface treatment protocol used on the indirect composite provisional crown. Group CO: was without any surface treatment. Group HF: 10% hydrofluoric acid (Dentsply Caulk, Milford, DE, USA) was used for etching for 30 seconds and then samples were washed under running water and ultrasonically cleaned in distilled water for 5 minutes. The silane primer (Porcelain Prep-Kit, Pulpdent, Watertown, MA, USA) was applied to the composite samples, left to evaporate for 3 minutes, and then air-dried for 30 seconds following manufacturer's instructions. Group SA: sandblasting with 50 µm aluminum oxide particles (Danville Eng. Inc., San Ramon, CA, USA) was done at a pressure of 2.8 bar for about 10 seconds from a distance nearly 10 mm; the residues of sand particles were removed gently with air and silane solution was then applied as described before.

Bracket Bonding

Sixty maxillary premolar COBs (Victory series 3M Unitek, Monrovia, CA, USA) with 0° angulations, 7° torque, and 0.022-inch archwire slots were used. A digital caliper was used to determine the bracket base surface areas as 11.9 mm^2 and 10.6 mm^2 for the COBs and MOBs (Clarity, Victory series, 3M Unitek, Monrovia, CA, USA), respectively.

After surface treatment of the bracket base, the adhesive resin paste (Transbond XT, 3M ESPE Dental Products, CA, USA) was applied and the bracket seated on the surface of the buccal surface of the provisional crown by a clinician. The excess adhesive resin was eliminated with a tip of explorer prior polymerization with a light cure (Ultralux, DabiAtlante, São Paulo, Brazil) from proximal directions for 20 seconds; each direction for each bracket. Then, a distilled water bath was used to store the samples at 37°C. After 24 hours, the samples were exposed to thermocycling process for three cycles between 5°C and 55°C with a 20-second dwell time and a 5-second transit time.

Shear Bond Strength Test

A universal testing device with a 5 kN load cell (Lloyd Instruments Plc, Fareham, Hampshire, UK) was used to perform the SBS test (Fig. 1). A crosshead speed of 1 mm/minute was used to stress the samples in an occluso-gingival direction.[10] The maximum load required to debond was reported in Newtons and later converted to megapascals (MPa). To evaluate the bond failure interface, the debonded bracket bases were inspected under an optical microscope at 16×magnification (Fig. 2). After debonding, the ARI was used to record the residual adhesive on the bracket base as follows: 0 = no adhesive left on the bracket, 1 = less than 50% of adhesive left on the bracket, 2 = more than 50% of adhesive left on the bracket, and 3 = 100% of adhesive left on the bracket.[20] When adhesive failure occurred at the cement–provisional material interface, it is scored as 0 or 1 according to this index. However, cohesive failure of the cement or bracket base–cement interface was scored as 2 or 3.

Statistical Analysis

The SPSS 11.0 software for Windows (SPSS Inc., Chicago, IL, USA) was used to perform the statistics. The two-way ANOVA was used to analyze the SBS data (MPa) while multiple comparisons were done via Tukey HSD post hoc tests. p values <0.05 were considered statistically significant.

Fig. 1: Experimental set-up for the shear bond strength test with the tooth in position and the load applied through the universal testing machine

Figs 2A to C: Residual adhesive on the bracket. Adhesive remnant index scores represented as: (A) Score 1; (B) Score 2; (C) Score 3

Table 1: Shear bond strength mean values (MPa)– standard deviations of different experimental groups. Identical superscript letters in the same column indicate no significant difference (Tukey's test, $\alpha = 0.05$)

Groups	Thermocycling	Ceramic bracket	Metal bracket
Group CO	No	9.6 – 1.4^{a}	7.7 – 2.3^{A}
	Yes	6.2 – 1.1^{b}	3.9 – 1.4^{B}
Group HF	No	17.8 – 2.1^{c}	15.5 – 1.6^{C}
	Yes	13.8 – 1.3^{d}	12.8 – 1.2^{D}
Group SA	No	17.2 – 1.4^{c}	15 – 1.2^{C}
	Yes	12.1 – 1.8^{e}	11.2 – 1.6^{E}

Table 2: Percentage scores for the adhesive remnant index of all groups (n = 10)

		Ceramic brackets				Metal brackets			
Groups	Thermocycling	Score 0	Score 1	Score 2	Score 3	Score 0	Score 1	Score 2	Score 3
Group CO	No	0	10	20	70	10	30	10	50
	Yes	0	20	10	70	10	30	50	10
Group HF	No	0	40	40	20	10	50	40	0
	Yes	0	40	50	10	0	50	50	0
Group SA	No	0	40	40	20	10	40	50	0
	Yes	0	50	40	10	0	50	40	10

Results

Descriptive statistics for all subgroups are shown in Table 1. Regarding the effect of thermocycling on SBS of the tested specimens, the two-way ANOVA showed significant differences among the subgroups of each bracket types. Within the COBs subgroups, the highest SBS value (17.8 – 2.1, 13.8 – 1.3 MPa) was obtained from the HF-treated group, and the lowest value (9.6 – 1.4, 6.2 – 1.1 MPa) was obtained from the CO group while the SA-treated group showed no significant difference ($p < 0.05$) from the HF-treated group (17.2 – 1.4, 13.3 – 1.2 MPa). For the MOBs, the values were (7.7 – 2.3, 3.9 – 1.4 MPa) for the CO group, (15.5 – 1.6, 12.8 – 1.2 MPa) for the HF group, and (15 – 1.2, 11.2 – 1.6 MPa) for the SA group.

Irrespective to the type of surface treatment used for indirect composite provisional restoration, bond strength values of metal brackets showed statically significant difference compared to ceramic bracket bonding ($p < 0.05$). The modes of failure for bracket types are shown in Table 2. There were more failures at the bracket–adhesive interface in the MOBs group compared to the COBs group.

Discussion

The success of orthodontic treatment with fixed appliances depends, within other factors, on an accurate bracket positioning and long-term retention of these parts. The time spent during the bracket bonding is an important factor in the treatment cost and the necessity of rebonding brackets can retard the progress of treatment. The current research aimed to improve the bonding procedure to long-term provisional restorations by minimizing the time needed during bonding and debonding without endangering the ability to maintain a clinically useful bond strength.

Indirect composite material is recommended as a provisional crown in cases requires long-term prosthetic and orthodontic treatments, based on its superior mechanical strength compared with other provisional restorative materials.[2] Their strength and stability are critical as fractures may occur during the treatment. Ideally, the bond strength between the brackets and the provisional material should be strong to avoid bracket debonding during the treatment; however, the bracket should be easily removed by the end of the treatment.

During the treatment, it is hard to define the magnitude of the bond strength required to withstand active orthodontic forces

Am J Orthod Dentofacial Orthop 2010;137(5):684–689. DOI: 10.1016/j.ajodo.2008.06.031.

18. Vicente A, Bravo LA, Romero M, et al. A comparison of the shear bond strength of a resin cement and two orthodontic resin adhesive systems. Angle Orthod 2005;75:109–113. DOI: 10.1043/0003-3219(2005)075<0109:ACOTSB>2.0.CO;2.
19. Bishara SE, Ostby AW, Laffoon JF, et al. Shear bond strength comparison of two adhesive systems following thermocycling. A new self-etch primer and a resin-modified glass ionomer. Angle Orthod 2007;77(2):337–341. DOI: 10.2319/0003-3219(2007)077[0337:SBSCOT]2.0.CO;2.
20. Ozcan M, Finnema K, Ybema A. Evaluation of failure characteristics and bond strength after ceramic and polycarbonate bracket debonding: effect of bracket base silanization. Eur J Orthod 2008;30(2):176–182. DOI: 10.1093/ejo/cjm100.
21. Turner PJ. Successful bonding in orthodontics: 1. Dent Update 1996;23(9):366–370.
22. Lopez JI. Retentive shear strengths of various bonding attachment bases. Am J Orthod 1980;77(6):669–678. DOI: 10.1016/0002-9416(80)90158-X.
23. Al-Saleh M, El-Mowafy O. Bond strength of orthodontic brackets with new self-adhesive resin cements. Am J Orthod Dentofacial Orthop 2010;137(4):528–533. DOI: 10.1016/j.ajodo.2008.04.027.
24. Reynolds IR. A review of direct orthodontic bonding. British Journal of Orthodontics 1975;2(3):171–178. DOI: 10.1080/0301228X.1975.11743666.
25. Kinami H, Sugimura M, Sakuda M, et al. New type metal bracket for suppression of resin remaining in debonding. Dent Mater J 1990;9(1):25–35. DOI: 10.4012/dmj.9.25.
26. Swartz ML, Phillips RW, Rhodes B. Visible light-activated resins-depth of cure. J Am Dent Assoc 1983;106(5):634–637. DOI: 10.14219/jada.archive.1983.0140.
27. Thurmond JW, Barkmeier WW, Wilwerding TM. Effect of porcelain surface treatments on bond strengths of composite resin bonded to porcelain. J Prosthet Dent 1994;72(4):355–359. DOI: 10.1016/0022-3913(94)90553-3.