OSR
ORAL SCIENCES REPORTS

Original Article

Comparison of the Shear Bond Strength of Compomer Bonding on Different Enamel Surface Preparations

Chadamat Gesama[1], Wikanda Khemaleelakul[2], Supassara Sirabanchongkran[2]

[1]Master Student, Master of Science Program in Dentistry, Division of Orthodontics, Department of Orthodontics and Pediatric Dentistry, Faculty of Dentistry, Chiang Mai University, Thailand
[2]Department of Orthodontics and Pediatric Dentistry, Faculty of Dentistry, Chiang Mai University, Thailand

Editor:
Awiruth Klaisiri,
Thammasat University, Thailand

Received: January 26, 2024
Revised: February 29, 2024
Accepted: March 13, 2024

Corresponding Author:
Assistant Professor Wikanda Khemaleelakul, Department of Orthodontics and Pediatric Dentistry, Faculty of Dentistry, Chiang Mai University, Chiang Mai 50200, Thailand.
E-mail: wikanda.k@cmu.ac.th

Abstract

Objectives: To compare the effects of etching time and bonding agent application on the shear bond strength of compomer bonding in orthodontic bite raising.

Methods: Seventy-five sectioned crown of maxillary premolar teeth were embedded in acrylic rings. The samples were divided into 5 groups according to enamel surface preparation before applying Ultra Band-Lok® (Reliance Orthodontic Products). Group 1: without surface preparation, Group 2: etched with 37% phosphoric acid (Kerr Gel Etchant, Kerr®) for 15 seconds, Group 3: etched with 37% phosphoric acid for 15 seconds, then apply bonding (OptiBond™ FL), Group 4: etched with 37% phosphoric acid for 30 seconds and Group 5: etched with 37% phosphoric acid for 30 seconds, then apply bonding. All samples were put through the thermocycling procedure and then shear bond strength was tested using the Universal Testing Machine. The mean and standard deviation of shear bond strength were statistically analyzed with two-way ANOVA and the enamel surface was observed by scanning electron microscope at 10,000x magnifications.

Result: In Group 1, all Ultra Band-Lok® dislodged from the enamel surface during the thermocycling process. Consequently, shear bond strength testing could not be conducted for Group 1. The mean shear bond strength of Groups 2-5 were 19.80±7.06, 18.97±4.60, 18.04±5.09 and 16.80±5.47 MPa respectively. The mean shear bond strength of each group was not statistically significant difference (p=0.887).

Conclusions: Varying enamel etching times (15 and 30 seconds) did not affect the compomer shear bond strength. Furthermore, the application of a bonding agent during tooth surface preparation did not significantly improve the bond strength between the compomer and the tooth surface.

Keywords: bite raising, compomer, shear bond strength, surface preparation

Introduction

In the field of orthodontics, bite raising is commonly practiced to correct deep bite, open bite, scissor bite, and crossbite. The bite-raising technique involves using a temporary instrument or material to create an artificial surface, facilitating contact between the teeth of opposing arches for occlusion. Full closure of the jaws is prevented either anteriorly or posteriorly. Bite planes are primarily categorized into removable and fixed bite planes, which can be placed in either the anterior or posterior section of the mouth.(1)

Initially, the removable plates of the bite plane were crafted to fit the patient's palate fully. Over time, designs have become more compact and practical, allowing for easy attachment to the teeth. This development ensured patient comfort and encouraged compliance.(2) The benefits of removable bite planes include ease of cleaning and removal, vertical and horizontal anchorage due to palatal coverage, effective reduction of overbite in growing children, and the ability to transfer forces to the blocks of teeth.(3) Removable bite planes depend greatly on patient cooperation and must be adjusted frequently to accommodate orthodontic tooth movements. They are easily lost or broken, and there is a risk that the patient may swallow them.(4) This appliance may also promote plaque accumulation, leading to poor oral hygiene and an increased risk of dental caries and *Candida* infection. Additionally, they may affect speech, and their fabrication requires more time in the laboratory and expense.(5,6)

The metal bite turbo, a fixed anterior bite plane, was first introduced by Joe Mayes in 1994 as an alternative to removable acrylic bite plates; it uses a simple lingual bracket modification.(7) Fixed metal bite turbos demonstrated greater muscle deprogramming qualities than acrylic biting planes and gained widespread use due to their simplicity, hygiene, solidity, and compatibility with oral hygiene procedures.(7,8) However, the difficulty of application stemming from anatomical differences in the palatal surfaces of the teeth was a significant drawback of these devices.(7)

Advances in restorative materials and the drawbacks of fixed metal bite turbos have led to the exploration of fixed bite planes made from various non-metal restorative materials, including acrylic gel, resin composite, flowable resin composite, glass ionomer cement and compomer.(4) Ultra Band-Lok®, a compomer or polyacid modified resin composite adhesive, is one of the most popular materials. Compomer materials combine the advantages of glass ionomer cement and resin composite, featuring physical properties that closely resemble those of resin composite.(9) Several studies found that compomer exhibits high bond strength, compressive strength, flexural strength, and fracture hardness.(9-12) However, Ultra Band-Lok® is subject to a clinical issue: If it slips out of the tooth, there can be negative consequences for the treatment, such as breaking bonded brackets, which can slow the teeth-moving process.(1)

The bond strength between the enamel and compomer must withstand the stresses occurring in the oral environment. The compomer must be removable without leaving any residue or harming the enamel. Typically, tooth surface preparation, whether physical or chemical, influences the strength of the material's bond to the tooth surface. Mechanical methods, such as acid etching and sandblasting, as well as chemical techniques involving bonding agents, contribute to creating a strong bond between the tooth and the restorative material. A previous study evaluated the microtensile bond strength between human dentin and the compomer base material.(13) Nevertheless, research on the shear bond strength of Ultra Band-Lok® bonded to human enamel surface preparations, whether chemical or physical, has not been reported. The aim of this study was to compare the effects of etching time and bonding agent application on the shear bond strength of compomer, with specific attention given to Ultra Band-Lok®.

Materials and Methods

This experimental study compared the shear bond strength of compomer attachment to enamel surfaces with different preparation techniques. The study received ethical approval from the Human Experimentation Committee of the Faculty of Dentistry, Chiang Mai University, Thailand (No. 38/2022).

Teeth preparation

The sample size was determined from a previous study.(13) The G*power program was used to calculate the sample size based on an effect size of 1.46. Using the 2-tailed test, α error = 0.05 and power = 80.0%, the total calculated sample size was 9 for each group.(14,15) In this study, the sample size was 15 per group. Seventy-five extracted upper premolar teeth were selected with the criteria that the teeth did not have the following defect conditions: caries, enamel hypoplasia, fluorosis, enamel cracks, and history of bracket bonding and restorations. All teeth were stored in a 0.1% aqueous solution of thymol for no longer than 6 months. Tooth specimens were prepared by sectioning with carborundum discs 3 mm apical to the cemento-enamel junction (Figure 1A). Each tooth sample was embedded in a molded acrylic block (made from self-curing acrylic resin and cylindrical polyvinylchloride rings with a 15 mm diameter and a height of 10 mm, exposing the buccal side of the crown to the superficial surface (Figure 1B, 1C). For controlled curvature of the tooth surface, the buccal surface of each crown was flattened and polished using a specimen grinding machine (MoPao 160E Metallographic, Jinan Hensgrand Instrument, Jinan, China) with wet sandpaper under water cooling for 20 seconds for each grit from 200 to 600 grit. The prepared tooth surface of each sample is 4 mm in diameter and was localized on the enamel surface only. Each tooth surface was observed by stereomicroscope (SZX7 & SZ2-ILST LED illuminator stand & E-330, Olympus, Tokyo, Japan) with a magnification of 20× to confirm that the prepared area was enamel without dentin.

Bonding Process

The ground enamel surfaces of each sample were polished with superfine pumice and water for 10 seconds, rinsed with water spray, and dried by an air jet for 10 seconds. The samples were randomly divided into 5 groups of 15 samples. Each group underwent different bonding methods on the prepared tooth surface, as follows. Group 1: Apply Ultra Band-Lok® (Reliance Orthodontic Products, Inc. West Thorndale Ave, IL, USA) directly to tooth surface; Group 2: Prepare tooth surface by etching with 37% phosphoric acid (Kerr Gel Etchant, Kerr®, Kloten, Switzerland) for 15 seconds, then rinsing with water spray and drying by air jet for 10 seconds before applying Ultra Band-Lok®; up 3: Prepare the surface as for Group 2, then apply the bonding agent (OptiBond™ FL adhesive, Kerr®, Kloten, Switzerland) with a microbrush, and light cure for 10 seconds before applying Ultra Band-Lok®; Group 4: Prepare tooth surface by etching with 37% phosphoric acid for 30 seconds then rinsing with water spray and drying by air jet for 10 seconds before applying Ultra Band-Lok®; and Group 5: Prepare the surface as in Group 4, then apply the bonding agent (OptiBond™ FL) with a microbrush, and light cure for 10 seconds before applying Ultra Band-Lok®.

For each Ultra Band-Lok® application, a tubelike thermoplastic template with a diameter of 3 mm and a height of 3 mm was used to transfer and control the amount of Ultra Band-Lok® material applied to the tooth surface. All samples were light-cured for 5 seconds on each of the four sides of the sample surface using a high-power light-emitting diode curing unit (Mini LEDTM, Satelec® Acteon Group, Merignac, France) with a light intensity of 1,250 mW/cm^2. The distance between the Ultra Band-Lok® and the light tip is 4 mm, perpendicular to the Ultra Band-Lok® surfaces.

Thermocycling Process

All samples were incubated in distilled water for 24 hours at 37°C in a water bath (Model WNB-14, Mem-

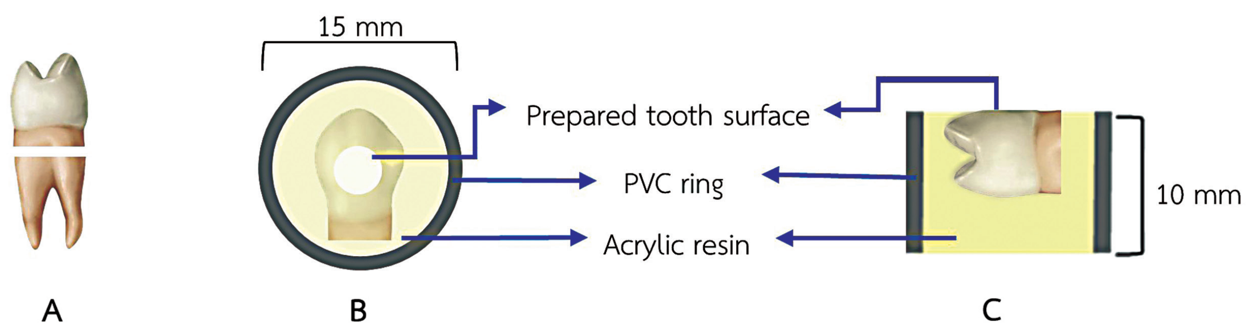

Figure 1: (A) Sectioning of tooth specimen 3 mm apical to the cemento-enamel junction
(B) Tooth embedded in polyvinylchloride ring and self-curing acrylic resin
(C) Buccal side of crown exposed to the superficial surface

mert Corporation, Germany). A thermocycling procedure with a thermocycling machine (Model TC 301 with cold and hot water baths, models CWB332R and HWB332R, Medical and Environment Equipment Research Laboratory, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand) was used to perform 5,000 cycles at 5°C and 55°C for 30 seconds per bath with a transfer time of 10 seconds.

Shear bond strength testing

Using a holder, each sample was clamped onto a universal testing machine (Instron® Model 5566, Instron Universal Testing Machine Calibration Laboratory, Norwood, Massachusetts, USA). Subsequently, a load cell of 1 kilo-Newton with the knife edge head was pressed to the junction between the compomer and enamel surface (Figure 2) with a speed of 0.5 mm/min until the Ultra Band-Lok® broke away from the enamel tooth surface. The data were analyzed with Bluehill software, CAT No. 2603-080 (Bluehill Software Company, Whitstable, Kent, UK). The load needed for debonding the Ultra Band-Lok® cylinders was expressed in Newton/millimeter^2 (N/mm^2). This value was converted to megapascal (MPa), and then descriptive statistics were calculated.

Assessment of the adhesive remnant on enamel surface after shear bond strength testing

The tested specimens were examined under a stereomicroscope at 20× magnification to determine the amount of residual adhesive on the enamel surface. The adhesive remnant index (ARI) scores modified from Artun and Bergland[16] were recorded with the following scores: 1, Cohesive failure in enamel; 2, Mixed failure: Adhesive failure and cohesive failure in enamel; 3, Adhesive failure between compomer and enamel; 4, Cohesive failure in compomer with all of compomer remaining on the enamel; 5, Mixed failure, adhesive failure and cohesive failure in compomer with more than half of the compomer remaining on the enamel; 6, Mixed failure, adhesive failure and cohesive failure in compomer with less than half of the compomer remaining on the enamel; and 7, Mixed failure, a combination of adhesive and cohesive failures in enamel and compomer.

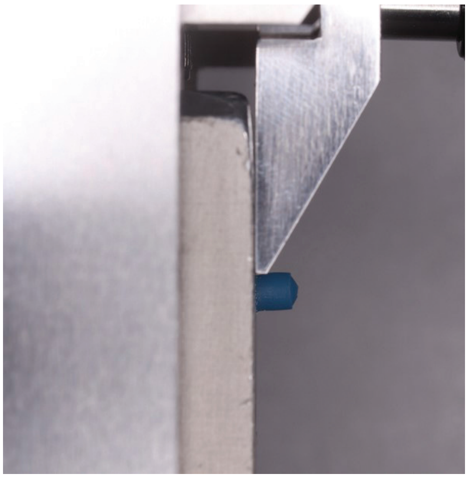

Figure 2: Knife edge head of universal testing machine pressing on the junction between the compomer and the enamel surface

Selected surfaces of each group were also examined under a scanning electron microscope (TESCAN, VEGA3, Czech Republic) at 10,000× magnification to observe the enamel surface after shear bond strength testing.

Results

In Group 1, the Ultra Band-Lok® dislodged from the enamel surface during the thermocycling process in every sample. Therefore, shear bond strength testing could not be performed on any of the samples in Group 1. The mean shear bond strength values for the other experimental groups are as follows: Group 2: 19.80±7.06 MPa, Group 3: 18.97±4.60 MPa, Group 4: 18.04±5.09 MPa and Group 5: 16.80±5.47 MPa (Table 1). The statistical analyses of the mean shear bond strength of each method of surface preparation using two-way ANOVA analysis revealed no significant differences between the mean shear bond strengths of these groups (p=0.887).

The results of the mode of failure are presented in Table 2. In Group 1, all specimens exhibited adhesive failure. As for Groups 2, 3, 4, and 5, all specimens demonstrated mixed failures, comprising adhesive and cohesive failures in the compomer, with over half of the compomer remaining on the enamel.

SEM observations

Scanning electron micrographs of the enamel surface before shear bond strength testing are shown in Figure 3. The enamel surface etched with 37% phosphoric acid for 15 seconds shows dissolved enamel prisms. The demineralized enamel presents significant honeycomb appearance on the surface (Figure 3A). Whereas the enamel surface

Table 1: The mean and standard deviations (SD) of shear bond strengths of each experimental group

Group	Enamel surface preparation	N	Shear bond strength (MPa)			*p*-value
			Mean ± SD	Min	Max	
1	No etching and no bonding	15	N/A	N/A	N/A	N/A
2	Etching 15 s.	15	19.80±7.06	8.31	32.93	0.887
3	Etching 15 s. + bonding	15	18.97±4.60	12.74	26.94	
4	Etching 30 s.	15	18.04±5.09	10.64	24.84	
5	Etching 30 s. + bonding	15	16.80±5.47	8.83	28.19	

N/A: Not applicable.

Table 2: The ARI score of specimens in each group

Group	Enamel surface preparation	ARI						
		1	2	3	4	5	6	7
1	No etching and bonding			15				
2	Etching 15 s.					15		
3	Etching 15 s. + bonding					15		
4	Etching 30 s.					15		
5	Etching 30 s. + bonding					15		

etched with 37% phosphoric acid for 30 seconds shows more dissolved enamel prism cores and peripheries. The demineralized enamel presents more significant honeycomb appearance on the surface (Figure 3B).

Scanning electron micrographs of enamel surface after shear bond strength testing are shown in Figure 4. In Groups 2 and 4, most of the enamel surfaces are covered by the Ultra Band-Lok®. Group 2 shows the enamel surface generally covered with Ultra Band-Lok® (Figure 4A). In Group 4, Ultra Band-Lok® covers the enamel surface and shows a honeycomb appearance (Figure 4C). Whereas Groups 3 and 5, which used a bonding agent, the enamel surface is covered by bonding filler and Ultra Band-Lok®. In Group 3, Ultra Band-Lok® and bonding filler cover the surface in generalized pattern (Figure 4B). While in Group 5, Ultra Band-Lok® and bonding filler cover the enamel surface, which also shows a honeycomb appearance (Figure 4D).

Discussions

This study evaluated the shear bond strength of compomers, specifically Ultra Band-Lok®, when applied to different enamel surface preparations. It examined the effects of various etching times and bonding methods on the bond strength of the compomer materials.

A compomer, or polyacid-modified resin composite, contains some of the same components as resin composite and glass ionomers cement.(17) Several studies found that compomers have significantly lower flexural modulus of elasticity, compressive strength, flexural strength, fracture toughness, and hardness than resin composite.(18-20) Compared to glass ionomers, compomers have higher bond strength, compressive strength, flexural strength, and fracture hardness, but lower wear rates and fluoride release levels.(20-23) Compomer is effective in a wide range of applications, including Class I, Class II, and Class V restorations, as well as fissure sealants.(24) Overall, clinical findings indicate that compomers work well and are well-suited for their recommended applications in dental repair.

In orthodontics, compomer is used for orthodontic band cement as well as to fabricate bite turbos.(24) These two applications require different preparation methods for the tooth surface. The procedure for band cementation using Ultra Band-Lok® involves prophylaxis of the tooth to be banded. Then, a bead of Ultra Band-Lok® is applied to the inner surface of the band. The band is placed on the tooth and seated into its ideal position, followed by a 30-second light cure. An etching procedure is only required in cases involving cementing high-stress banded appliances. For occlusal build-ups, the tooth is prophy-

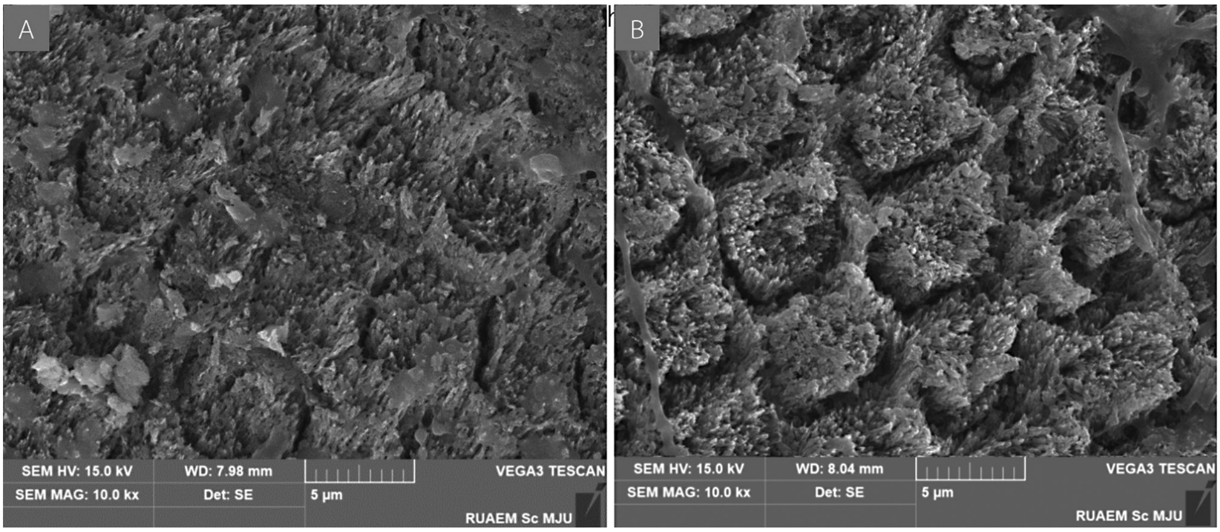

Figure 3: SEM images of enamel surface etched with 37% phosphoric acid for (A) 15 seconds and (B) 30 seconds at magnifications of 10,000×

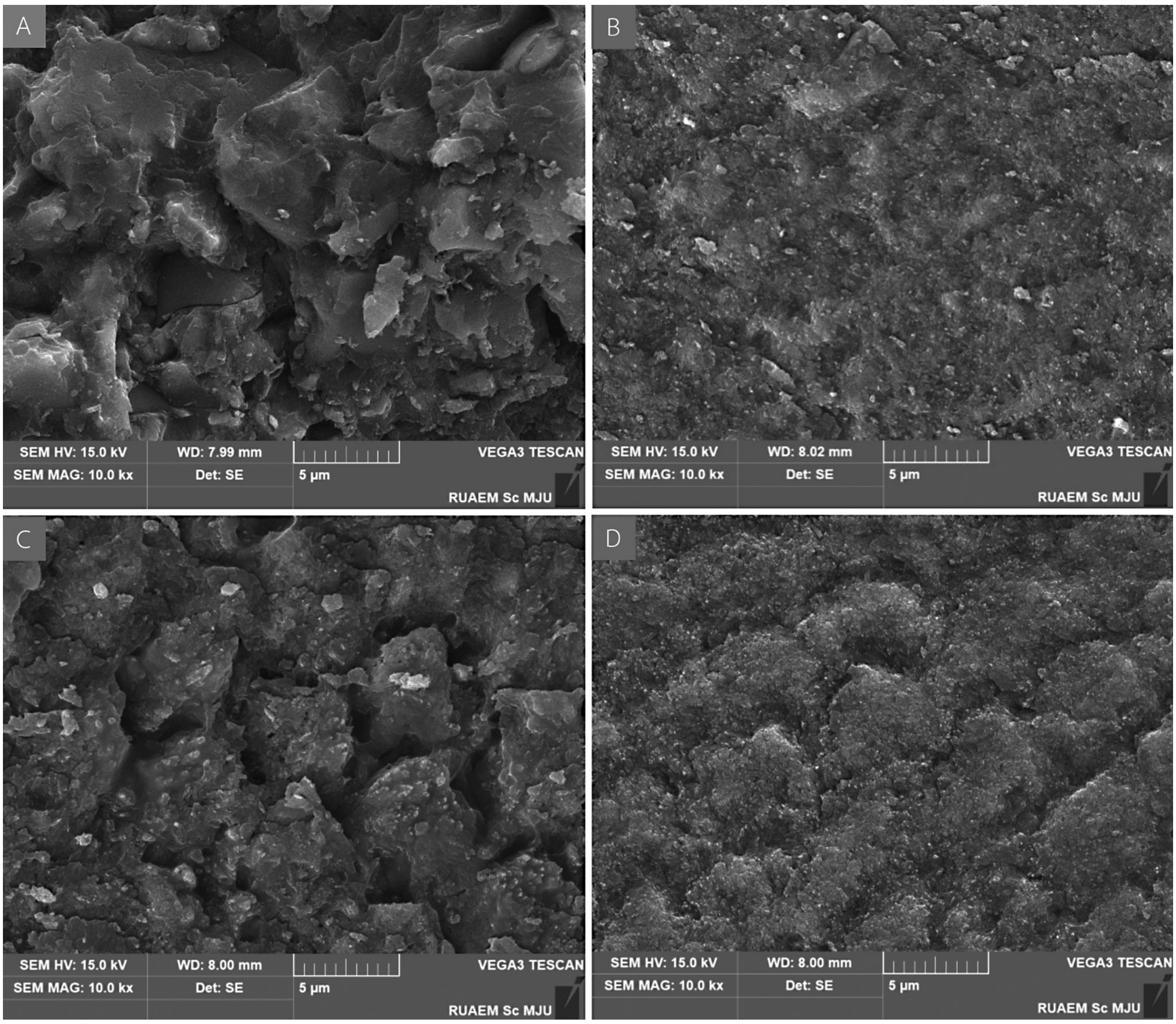

Figure 4: SEM images of debonded enamel surface at magnification of 10,000×: (A) Group 2 (15 s. etching): the enamel surface covered by Ultra Band-Lok® in a generalized pattern, (B) Group 3 (15 s. etching + bonding): the enamel surface covered by bonding filler and Ultra Band-Lok® in a generalized pattern, (C) Group 4 (30 s. etching): the enamel surface covered by Ultra Band-Lok® in a honeycomb appearance, and (D) Group 5 (30 s. etching + bonding): the enamel surface covered by bonding filler and Ultra Band-Lok® in a honeycomb appearance

laxed with pumice, rinsed, and the surface is dried. The occlusal surface is etched for 30 seconds, rinsed with water, and dried. Ultra Band-Lok® is applied to the occlusal surface in the required amount and shape, and finally, a 20-second light cure is administered.(25)

Enamel etching is the crucial step for attachment of the compomer material. The effects of enamel etching include removing debris from enamel, creating an intricate, three-dimensional microtopography on the surface of the enamel, increasing the enamel surface area available for bonding, creating micropores where there is mechanical interlocking of the resin, and increasing the surface wettability by exposing more reactive surface layer.(26, 27) Furthermore, etching time is a critical factor of the bonding process, affecting both the quality of the bond between the dental materials and the enamel, as well as the surface condition of the enamel. When enamel is properly etched, a micro-rough surface is created that promotes the adhesion of dental materials.(27)

Etch-and-rinse adhesive solutions have been successfully used on enamel and shown to be a long-lasting clinical method for adhesive restorative dentistry.(28) However, the etch-and-rinse adhesives that use 37% phosphoric acid cause enamel mineral loss of around 5 to 50 μm.(26) The amount of mineral loss depends on the concentration of phosphoric acid and the duration of the application.(27) Some research has recommended an optimal etching time of 15-30 seconds for reliable bonding for resin composite, ensuring the desired surface roughness.(29) The etching time directly influences the bond strength, with some scientific studies recommending a minimum of 15 seconds of 37% phosphoric acid etching for strong bonding with resin composite.(26,30-32) Over-etching has been shown to cause enamel loss and weaken the tooth structure.(33) Some investigations on enamel pretreatment methods have demonstrated that the acid etching procedure achieves the strongest bond strength of compomer to human enamel while also significantly reducing the frequency of adhesive fractures, variability, and microleakage.(19-21) In restorative work, etching for 15 seconds is sufficient for effectively bonding compomer to the enamel surface.(34) The manufacturer's instructions for using Ultra Band-Lok® for occlusal build-ups recommend etching the occlusal surface with an etchant for 30 seconds.(25) However, in this study, varied etching times of 15 and 30 seconds did not yield significantly different shear bond strengths.

From this study, all of the Ultra Band-Lok® in Group 1 were dislodged from the enamel surface during the thermocycling process. The compomer cannot bond directly to the enamel surface when it does not have micromechanical surface interlocking from the etching process. Consequently, during the thermocycling process, all specimens experienced dislodgment due to the insufficient bond strength of the material. Thermocycling is a laboratory-based aging process for restorative materials that mimics the intraoral temperature. Rapid and frequent temperature changes during thermocycling can induce thermal stress in dental materials, potentially leading to bond degradation over time.(35) In a previous study, compomers were found to absorb water, significantly changing their mechanical properties when exposed to aqueous solutions. It has been observed that the mechanical characteristics of compomers are particularly sensitive to water storage.(36, 37) This susceptibility may arise from the higher organic matrix content of compomers, making them more prone to water absorption and subsequent surface disintegration in an aqueous environment.(38) Water may function as a plasticizer, weakening the covalent bonds, degrading components, and ultimately decreasing the strength of the material.(39)

According to previous studies, compomer cannot sufficiently adhere to enamel and dentine, necessitating an additional bonding system.(40-42) The use of bonding agents has been recommended to strengthen the bond of the compomer to the tooth.(43) The manufacturer advises using a bonding agent in conjunction with the compomer when it is used as a restorative material.(44) Because of the low viscosity property of the bonding agent, it rapidly wets and penetrates the microspaces in the dried, cleaned enamel, forming resin tags. Macrotags are the resin tags that develop in the spaces between enamel prisms. Microtags comprise the finer network of smaller tags that form across the end of each rod when individual hydroxyapatite crystals are dissolved. The fundamental process of enamel–resin adhesion is the development of resin micro- and macrotags within the enamel surface, which enhances the bond strength of the material.(45)

However, the current study shows that the shear bond strength in the bonding groups (Groups 3 and 5), with mean shear bond strengths of 18.97±4.60 and 16.80±5.47 MPa, respectively, was not significantly different from the group that did not use a bonding agent. Unlike the study by Prasansuttiporn in 2016, there was a considerable increase in the microtensile bond strength of the compomer base materials to human dentin in the groups restored with adhesive systems compared to those restored without adhesive systems.(13) Due to the presence of a hybrid layer that formed from the interdiffusion of the low-viscosity monomers into the exposed collagen network and the intertubular dentin to form a micromechanical bond with dentin, the bond strength between the compomer and tooth surface increased. However, the previous research focused on the dentin surface, while the current study investigates the enamel surface.

When bonding an orthodontic bracket, the bond strength must be strong enough to endure the strains placed on it by the arch wires and the forces of mastication. Bond strength varies in each study. Reynolds has stated that for orthodontics attachment, a minimum resistance of 5.9-7.8 MPa is sufficient to withstand masticatory forces.(46) In contrast, Brantley and Eliades have surveyed orthodontic adhesive systems and found that shear bond strength can vary between 8 and 30 MPa.(47) The mean shear bond strengths for Groups 2, 3, 4, and 5 in this investigation were 19.80±7.06, 18.97±4.60, 18.04±5.09, and 16.80±5.47 MPa, respectively, which fall within the range that can withstand the masticatory force. Therefore, the various surface preparation techniques used in this study can all be applied clinically for the bite-raising technique.

The ARI is widely employed as a method for evaluating the quality of the adhesion between the composite material and the tooth, as well as between the composite and the base of the bracket.(48,49) In this study, Group 1 had ARI scores of 3 (adhesive failure between compomer and enamel), indicating that no adhesive remained on tooth surfaces. The ARI score of 5 (mixed failures with over half of the compomer remaining on the enamel) was the most prevalent in Groups 2-5. This could be clinically advantageous, as failures at the enamel–adhesive interface during a raised bite are less traumatic to the enamel surface. However, cleaning the teeth will probably be more difficult because some material remnants may still be attached to the enamel surface.(50,51)

SEM images of the enamel etched with 37% phosphoric acid for 15 and 30 seconds showed a consistent honeycomb appearance; however, the groups that were etched for 30 seconds had greater height and deeper prisms in the interrod and central regions than the groups that were etched for 15 seconds. On the microstructural level, enamel comprises enamel rods, which are tightly packed masses of organized hydroxyapatite crystallites.(52) The interfacial area between these rods with a width of approximately 1 μm, known as the interrod enamel, is rich in protein and results from the incoherence of combining crystals with different orientations.(53) Acidic etching of enamel, such as with phosphoric acid, selectively dissolves hydroxyapatite crystallites within each enamel rod and interrod.(54) In the interrod, where the organic matrix and water are primarily found, more corrosion occurs than in the rod area.(52)

Following the shear bond strength testing, the surface of the groups etched for 30 seconds (Groups 4 and 5) exhibited a more honeycomb appearance than those etched for 15 seconds (Groups 2 and 3). Furthermore, the groups without a bonding agent (Groups 2 and 4) demonstrated Ultra Band-Lok® coverage on the enamel surface, while those with a bonding agent (Groups 3 and 5) exhibited coverage with bonding filler and Ultra Band-Lok®. In particular, the group in which the surface was etched for 30 seconds and used a bonding agent exhibited shallow interrod characteristics due to the low viscosity of the bonding agent, enabling it to penetrate the interrod space.(55) Whereas the viscosity of Ultra Band-Lok®, with an average filler particle size ranging from 0.8 to 5.0 μm,(56) may not thoroughly infiltrate the etched enamel structure, preventing the creation of stronger microlocking structures. Moreover, the degradation of the compomer due to water absorption during the thermocycling process further impacts its shear bond strength. Therefore, although SEM images of the groups etched for 15 and 30 seconds with and without using a bonding agent revealed different surface morphologies, shear bond strength values, and ARI showed no significant difference.

The factors for selecting the raise bite material are as follows: it must be hygienic, simple to apply, lessen interference with speech, biocompatible, be placed or removed quickly and painlessly without needing specific tools, and be accepted by the patient.(57) According to the results of this study, alternative approaches and materials to achieve enough bond strength between the tooth surface and compomer when used as a raised bite plane in orthodontic treatment procedures must be considered. The findings from this study indicate that varying etching times of 15 and 30 seconds with and without a bonding agent on the enamel tooth surface did not result in significantly different shear bond strengths. Therefore, etching with 37% phosphoric acid for only 15 seconds without bonding achieves sufficient bond strength for clinical practice and facilitates the convenient fabrication of orthodontic bite raising.

Conclusions

The results obtained from this study indicate that varying the etching times of 15 and 30 seconds on the enamel surface did not yield significantly different shear bond strengths for the compomer material. Applying a bonding agent to the enamel surface does not substantially improve the bond strength between the compomer and the enamel surface.

Acknowledgments

This work was supported by the Research Fund for Postgraduate Students of the Faculty of Dentistry, Chiang Mai University, Chiang Mai, Thailand. The authors also would like to thank Asst. Prof. Dr. Surasak Kuimalee, Science and Technology Service Centre, Faculty of Science, Maejo University, Chiang Mai, Thailand. Special appreciation is given to Dr. Nopawong Luevitoonvechakij and Dr. Thanapat Sastraruji from the Faculty of Dentistry, Chiang Mai University, Thailand, for their assistance in preparing the manuscript.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Singh G, Gupta H, Rathi A, Bisht D, Goyal V, Singh R, Dhawan S. The use of bite raisers in orthodontic treatment -a review of literature. Acta Sci Dent Sci. 2021;5(4):219-28.
2. Philippe J. Treatment of deep bite with bonded biteplanes. J Clin Orthod. 1996;30(7):396-400.
3. Tait A, Mandall N, Lewis D, Littlewood S. The role of removable appliances in contemporary orthodontics. Br Dent J. 2001;191:304-10.
4. Kravitz ND, Jorgensen G, Frey S, Cope J. Resin bite turbos. J Clin Orthod. 2018;52(9):456-61.
5. Batoni G, Pardini M, Giannotti A, Ota F, Giuca MR, Gabriele M, *et al*. Effect of removable orthodontic appliances on oral colonisation by mutans streptococci in children. Eur J Oral Sci. 2001;109(6):388-92.
6. Kılınç DD, Sayar G. Comparison of shear bond strength of three different adhesives used as temporary bite raiser in daily orthodontic practice. Int Orthod. 2018;16(3):440-9.
7. Mayes JH. New levels of bite-opening acceleration. Clin Impress. 1997;6:15-7.
8. Roy AS, Singh GK, Tandon P, De N. An interim bite raiser. Int J Orthod Milwaukee. 2013;24(2):63-4.
9. Attin T, Vataschki M, Hellwig E. Properties of resin-modified glass-ionomer restorative materials and two polyacid-modified resin composite materials. Quintessence Int. 1996;27(3):203-9.
10. Xie H, Zhang F, Wu Y, Chen C, Liu W. Dentine bond strength and microleakage of flowable composite, compomer and glass ionomer cement. Aust Dent J. 2008;53(4):325-31.
11. Welbury RR, Shaw AJ, Murray JJ, Gordon PH, McCabe JF. Clinical evaluation of paired compomer and glass ionomer restorations in primary molars: final results after 42 months. Br Dent J. 2000;189(2):93-7.
12. Triana R, Prado C, Garro J, García-Godoy F. Dentin bond strength of fluoride-releasing materials. Am J Dent. 1994;7(5):252-4.
13. Prasansuttiporn T, Promchaiwattana P, Thanatvarakorn O, Krongbaramee T, Jittidecharaks S. Adhesive systems on bond strength between dentin and compomer base materials. CM Dent J. 2016;37(2):91-100.
14. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007;39(2):175-91.
15. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. Behav Res Methods. 2009;41(4):1149-60.
16. Artun J, Bergland S. Clinical trials with crystal growth conditioning as an alternative to acid-etch enamel pretreatment. Am J Orthod. 1984;85(4):333-40.
17. McLean JW, Nicholson JW, Wilson AD. Proposed nomenclature for glass-ionomer dental cements and related materials. Quintessence Int. 1994;25(9):587-9.
18. Meyer JM, Cattani-Lorente MA, Dupuis V. Compomers: between glass-ionomer cements and composites. Biomaterials. 1998;19(6):529-39.
19. Peutzfeldt A, Garcia-Godoy F, Asmussen E. Surface hardness and wear of glass ionomers and compomers. Am J Dent. 1997;10(1):15-7.
20. Yap AU, Chung SM, Chow WS, Tsai KT, Lim CT. Fracture resistance of compomer and composite restoratives. Oper Dent. 2004;29(1):29-34.
21. Nicholson JW, Millar BJ, Czarnecka B, Limanowska-Shaw H. Storage of polyacid-modified resin composites ("compomers") in lactic acid solution. Dent Mater. 1999;15(6): 413-6.

22. Nicholson J, Czarnecka B, Limanowska-Shaw H. A preliminary study of the effect of glass-ionomer and related dental cements on the pH of lactic acid storage solutions. Biomaterials. 1999;20:155-8.
23. Qvist V, Laurberg L, Poulsen A, Teglers P. Class II restorations in primary teeth: 7-year study on three resin-modified glass ionomer cements and a compomer. Eur J Oral Sci. 2004;112:188-96.
24. Andersson-Wenckert IE, Folkesson UH, van Dijken JW. Durability of a polyacid-modified composite resin (compomer) in primary molars. a multicenter study. Acta Odontol Scand. 1997;55(4):255-60.
25. Products RO. Ultra Band-Lok - Light Cure Compomer Band Cement 2022 [updated 2022 Mar 21; cited 2022 May 22. Available from: https://www.relianceorthodontics.com/Ultra-Band-Lok.
26. Lopes G, Thys D, Klaus P, Oliveira G, Widmer N. Enamel acid etching: a review. Compend Contin Educ Dent. 2007;28:18-24.
27. Al-Suleiman M, Baba F, Sawan M, Suliman A. Mechanical evaluation of the effect of reducing phosphoric acid concentrations and etching duration on the bond strength of orthodontic brackets. J Dent Oral Disord Ther. 2014;2(2):1-5.
28. Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P, *et al*. Buonocore memorial lecture. Adhesion to enamel and dentin: current status and future challenges. Oper Dent. 2003;28(3):215-35.
29. Erickson R, Barkmeier W, Latta M. The role of etching in bonding to enamel: a comparison of self-etching and etch-and-rinse adhesive systems. Dent Mater. 2009;25:1459-67.
30. Barkmeier WW, Shaffer SE, Gwinnett AJ. Effects of 15 vs 60 second enamel acid conditioning on adhesion and morphology. Oper Dent. 1986;11(3):111-6.
31. Wang WN, Lu TC. Bond strength with various etching times on young permanent teeth. Am J Orthod Dentofacial Orthop. 1991;100(1):72-9.
32. Wang WN, Yeh CL, Fang BD, Sun KT, Arvystas MG. Effect of H_3PO_4 concentration on bond strength. Angle Orthod. 1994;64(5):377-82.
33. Ravichandran NK, Tumkur Lakshmikantha H, Park HS, Jeon M, Kim J. Analysis of enamel loss by prophylaxis and etching treatment in human tooth using optical coherence tomography: an *in vitro* study. J Healthc Eng. 2019;2019:1-9.
34. Kim SK, Jeong TS, Kim S. A study on the microleakage of compomer restorations in cervical cavities of primary molars according to the length of etching time. J Korean Acad Pediatr Dent. 2000;27(2):229-36.
35. Morresi AL, D'Amario M, Capogreco M, Gatto R, Marzo G, D'Arcangelo C, Monaco A. Thermal cycling for restorative materials: does a standardized protocol exist in laboratory testing? a literature review. J Mech Behav Biomed Mater. 2014;29:295-308.
36. Fujishima A, Miyazaki T, Suzuki E, Miyazaki T. Tensile strength of posterior composite resins after water immersion. Japan J Cons Dent. 1990;33:1242-50.
37. Hammouda IM, Al-Wakeel EE. Effect of water storage on fluoride release and mechanical properties of a polyacid-modified composite resin (compomer). J Biomed Res. 2011;25(4):254-8.
38. Milleding P, Ahlgren F, Wennerberg A, Ortengren U, Karlsson S. Microhardness and surface topography of a composite resin cement after water storage. Int J Prosthodont. 1998;11(1):21-6.
39. Nicholson JW, Alsarheed M. Changes on storage of polyacid-modified composite resins. J Oral Rehabil. 1998;25(8):616-20.
40. Attaie AB, Ouatik N. 19 - Esthetics and pediatric dentistry. In: Aschheim KW, editor. Esthetic dentistry. 3rd ed. St. Louis: Mosby; 2015. p. 423-39.
41. Restoration of teeth (simple restorations) and preventative dentistry. In: Walmsley AD, Walsh TF, Lumley PJ, Burke FJT, Shortall ACC, Hayes-Hall R, Pretty IA, editors. Restorative dentistry. 2nd ed. Edinburgh: Churchill Livingstone; 2007. p. 73-87.
42. Donly KJ, Sasa IS. 21 - Dental Materials. In: Nowak AJ, Christensen JR, Mabry TR, Townsend JA, Wells MH, editors. Pediatric dentistry. 6th ed. Philadelphia: Elsevier; 2019. p. 293-303.
43. Nicholson JW, Singh G. The use of organic compounds of phosphorus in clinical dentistry. Biomaterials. 1996;17(21):2023-30.
44. Anusavice KJ. Phillips' Science of Dental Materials. 11th ed. London: Elsevier Health Sciences; 2003.
45. Chandra SP, Chandra S, Chandra G. Textbook of operative dentistry (with MCQs). New Delhi: Jaypee Brothers Medical Publishers Ltd.; 2007.
46. Reynolds I. A review of direct orthodontic bonding. Br J Orthod. 1975;2(3):171-8.
47. Brantley WA, Eliades T. Orthodontic materials: scientific and clinical aspects. Am J Orthod Dentofacial Orthop. 2001;119(6):672-3.
48. Eslamian L, Borzabadi-Farahani A, Mousavi N, Ghasemi A. The effects of various surface treatments on the shear bond strengths of stainless steel brackets to artificially-aged composite restorations. Aust Orthod J. 2011;27(1):28-32.
49. Eslamian L, Borzabadi-Farahani A, Mousavi N, Ghasemi A. A comparative study of shear bond strength between metal and ceramic brackets and artificially aged composite restorations using different surface treatments. Eur J Orthod. 2012;34(5):610-7.

50. Al Shamsi A, Cunningham JL, Lamey PJ, Lynch E. Shear bond strength and residual adhesive after orthodontic bracket debonding. Angle Orthod. 2006;76(4):694-9.
51. Bishara SE, Ostby AW, Laffoon JF, Warren J. 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):337-41.
52. Zheng J, Huang Y, Qian LM, Zhou ZR. Nanomechanical properties and microtribological behaviours of human tooth enamel. Proc IMechE Part J J Eng Tribol. 2009;224:577-87.
53. He LH, Swain MV. Understanding the mechanical behaviour of human enamel from its structural and compositional characteristics. J Mech Behav Biomed Mater. 2008;1(1): 18-29.
54. The Oral Environment. In: Sakaguchi RL, Powers JM, editors. Craig's restorative dental materials. 13th ed. Saint Louis: Mosby; 2012. p. 5-23.
55. Garg N, Garg A. Textbook of Operative Dentistry: Jaypee Brothers Medical Publishers Pvt. Limited; 2015.
56. Restorative Materials—Composites and Polymers. In: Sakaguchi RL, Powers JM, editors. Craig's restorative dental materials. 13th ed. Saint Louis: Mosby; 2012. p. 161-98.
57. Raisan N, Nahidh M. Bite raisers in orthodontics: a review. Mustansiria Dent J. 2023;18:318-36.