Original Article

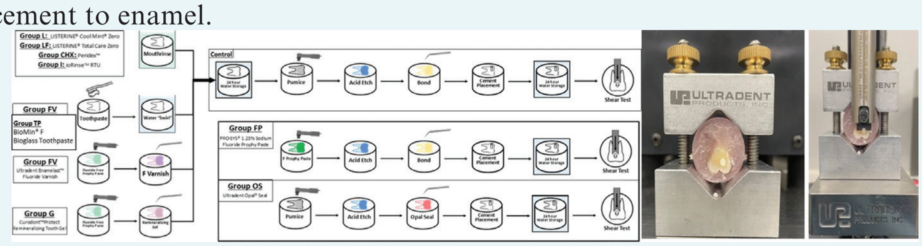
Effect of Preventive Dental Products on Bonding Force: An *in vitro* Study

Jamie Crowley[1], Nader Abdulhameed[2], Rand Al-Obaidi[3], Hind Hussein[2]

[1]Lake Eire College of Osteopathic Medicine, Bradenton, Florida, [2]Restorative Dental Sciences, College of Dentistry, University of Florida, USA, [3]Department of Pedodontic, Orthodontic and Preventive Dentistry, College of Dentistry, Mustansiriyah University, Iraq

Abstract

Aim: Testing the effect of Fluoride, chlorhexidine, and molecular iodine applications on the mean micro-shear bond strength (SBS) of enamel in an attempt to preserve enamel integrity during the bonding process. **Materials and Methods:** The study was an observational case–control one in which 150 human teeth were classified into 10 groups according to the product kind and the prescribed treatment. Each group consisted of 15 teeth. Group C was the control group. Groups FP, FV, and OS utilized products that could be utilized in a professional dental setting. Group FP was treated with 1.23% NaF prophy paste, Group FV was treated with 5% NaF varnish, and Group OS was treated with Opal® Seal Fluoride releasing primer and sealant. Groups L, LF, CHX, and I were treated with mouth rinses. Group L was treated with Listerine Zero Fluoride-Free Mouthwash, Group LF with Listerine Zero 0.02% NaF Mouth Rinse, Group CHX with 0.12% chlorhexidine gluconate, and Group I with ioRinse RTU 100 ppm molecular iodine rinse. Groups TP and G utilized alternative remineralization products. Group TP was treated with Fluoro Calcium Phosphosilicate bioglass containing toothpaste, and Group G was treated with Curodont Protect remineralizing tooth gel. One-way ANOVA test was utilized to perform all statistical analysis in this study. **Results:** For mean micro-SBS, no significant difference ($P > 0.05$) between any of the experimental groups was observed when compared to the control group. There was a significant difference ($P < 0.05$) between Opal Seal versus Listerine Total, Opal Seal versus Peridex, Listerine versus Listerine Total, and Listerine versus Peridex. All other experimental group comparisons revealed a nonsignificant difference ($P > 0.05$). **Conclusions:** As the null hypothesis (H0) assumes that changes observed in an experiment are due to chance, hence, the outcomes of this study are coherent with (H0) since the aforementioned application methods did not significantly impact the SBS of orthodontic resin cement to enamel.



Keywords: *Bonding, chlorhexidine, fluoride, remineralization*

Received : 12-Dec-2023
Revised : 14-Mar-2024
Accepted : 20-Mar-2024
Published : 27-Jun-2024

Address for correspondence: Dr. Rand Al-Obaidi, Department of Pedodontic, Orthodontic and Preventive Dentistry, College of Dentistry, Mustansiriyah University, St, 60091 Baghdad, IraqE-mail: drrandsalh@uomustansiriyah.edu.iq; rand.salih.mh@gmail.com

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jpcd

DOI: 10.4103/jispcd.jispcd_201_23

How to cite this article: Crowley J, Abdulhameed N, Al-Obaidi R, Hussein H. Effect of preventive dental products on bonding force: An *in vitro* study. J Int Soc Prevent Communit Dent 2024;14:243-51.

Introduction and Background

The resin was used to bond orthodontic brackets to enamel for the first time in 1964. For more than 30 years, the acid-etch technique has been used to attach orthodontic brackets to enamel directly.[1,2]

Proven observations have shown that decalcification can occur in bare areas of etched enamel around the direct-bonded brackets or fixed metal bands, particularly in patients who are unable to maintain good oral hygiene.[3–5] White spot lesions (WSL) can emerge fast around orthodontic braces as early as one month after placement as a result of sustained plaque accumulation on the affected surface due to poor oral hygiene.[6,7]

Physicians have been looking for ways to protect enamel morphology without affecting bond strength. Methods differ from decreasing etching times and acid concentrations[8,9] to utilizing prophylaxis agents containing fluoride.[10–12] Many available materials can be utilized to prevent enamel demineralization, including toothpaste, mouth rinses, gels, and varnishes. In the dental literature from 1942, Fluoride has been described as an effective preventive agent against tooth decay and can help in enamel remineralization.[13] Fluoride ions induce calcium Fluoride and fluorapatite crystal creation which will enhance etched enamel remineralization, rendering it less affected by demineralization. Fluoride has been incorporated into etching gel prior to orthodontic braces attachment to detect its uptake by enamel and its effect on the bond force. Many studies indicated that Fluoride varnish application prior to or at the time of bracket positioning didn't modify the bracket-enamel bond force.[14,15]

There are a wide variety of dental products that claim to strengthen enamel and prevent tooth decay. Products available to patients include conventional fluoridated toothpastes and mouthwashes, and also more novel remineralization pastes and gels.[16] Mouthwashes such as Peridex or ioRinse, while not containing Fluoride, can act to decrease the microbial load in the oral cavity. In addition, dental health providers can utilize many Fluoride-containing products during bonding as well. It can be said that the use of fluoridated dental care products can benefit a patient's general oral health. However, if they were to decrease the orthodontic bond force below clinically acceptable levels, it may decrease the effectiveness of the orthodontic treatment.

The purpose of this work is to investigate the impact of different products that clinicians or patients may use prior to or during the orthodontic bonding process on the micro-SBS of orthodontic resin cement on the enamel. We assume that the applied materials would not significantly impact the micro-SBS of orthodontic resin cement on enamel.

Materials and Methods

Study design AND sampling criteria

150 sound human teeth with no restoration on either buccal or lingual surfaces were utilized in this *in vitro* study. The teeth were collected from routine dental extractions in the school of dental medicine college's clinic, Florida, USA, after receiving protocol No. 26-161 Institutional Review Board (IRB) waivers for the project. The teeth were extracted as a normal part of the patient's care and did not include any patient's identifiers. All extracted teeth were placed in a solution of 1:10 sodium hypochlorite to water at 25°C to maintain hydration until use.

The samples were prepared based on the methods, molds, and jigs provided by Ultradent (Ultradent Products, Inc., South Jordan, UT). The samples were mounted with the enamel surface exposed. All samples were polished to a flat enamel surface by grit sandpapers #400 and #600 using a polishing machine (Pace technology, Nano-2000T, AZ, USA). The samples were kept in distilled water (dH_2O) at 25°C prior to the group assignments and following treatment before preparations for micro-shear testing. The BiostaTGV site [iPLESP, 2000] was used to calculate the number of teeth needed in this observational case-control study. Taking into account the results of our primary pilot study, we have calculated a minimum measurable odds ratio of 20, and the least number of teeth to be used in this study is 14. In doing so, we've set up 15 teeth in each of the study groups, and the samples were distributed into groups according to product kind and assigned treatment as shown in Table 1. The whole study has lasted eight months.

Dental products used to treat the experimental groups prior to micro-shear test

A. **Preventive products that could be utilized in a professional dental setting:**

PRO-SYS Prophy Paste (1.23% sodium Fluoride prophy paste, medium grit) (Benco Dental, Pittston, PA, USA) was used to treat Group FP, while Group FV was treated with Ultradent Enamelast (5% Sodium Fluoride varnish, 22,600 ppm), and Group OS was treated with Ultradent Opal® Seal (a Fluoride releasing primer and sealant used during preparation for shear testing).

B. **Oral care products (mouth rinses):**

Listerine Total Care Zero-Alcohol Cool Mint Zero-Alcohol (Fluoride-free mouthwash) (Johnson & Johnson Consumer Health, Skillman, NJ, USA) was used to treat Group L. Group LF was treated

Table 1: Experimental groups' assignments (*n* = 15)

Group *n* = 15	Treatment
C	Control group receives no treatment
Professional dental care products	
FP	PRO-SYS Prophy Paste (1.23% sodium fluoride prophy paste, medium grit)
FV	Ultradent Enamelast (fluoride varnish)
OS	Ultradent Opal Seal (fluoride releasing primer and sealant)
Oral care products (Mouth rinses)	
L	Listerine Cool Mint Zero-Alcohol Mouthwash (fluoride free)
LF	Listerine total care zero-alcohol anticavity (sodium fluoride 0.02%)
CHX	Peridex (Chlorhexidine Gluconate 0.12%)
I	ioRinse RTU (Molecular Iodine 100 ppm)
Alternative remineralization products	
TP	BioMin F (Bioglass Toothpaste, Fluoro Calcium Phosphosilicate)
G	Curodont Protect remineralizing tooth gel, self-assembling peptide P11-4 and sodium monofluorophosphate 900 ppm

with Listerine Total Care Zero-Alcohol Fluoride mouthwash (Sodium Fluoride 0.02%) (Johnson & Johnson Consumer Health, Skillman, NJ), Group CHX with Peridex (chlorhexidine gluconate 0.12% oral rinse) (3M, St. Paul, MN), and Group I with ioRinse RTU (molecular iodine rinse 100 ppm) (Io Tech International, Boca Raton, FL).

C. **Alternative remineralization products (paste and gel):**

BioMin® F (Fluoro Calcium Phosphosilicate bioglass containing Toothpaste, available Fluoride content <600 ppm when packed) (BioMin Technologies Limited, Stroke-on-Trent, UK) was used to treat Group TP, and Group G was treated with Curodont Protect (remineralizing tooth gel, Self-assembling Peptide P11-4 and Sodium Monofluorophosphate 900 ppm) (Credentials, Windisch, Switzerland).

Methodology

Preparation of experimental groups and treatment with the selected dental product:

A. **Group C: Control Group**

Group C served as the control, and the samples did not receive any treatment with Fluoride products prior to the preparation for micro-shear testing. The samples were placed in dH_2O at 25°C for one day prior to preparation for micro-shear testing.

B. **Group FP- PRO-SYS Prophy Paste (1.23% Sodium Fluoride prophy paste, medium grit)**

Group FP received no treatment prior to preparation for shear testing. However, Fluoride containing prophy paste was utilized during the preparation for shear testing in lieu of dental pumice, as described below in the micro-shear test method. The samples were polished for 5 s with PRO-SYS® Prophy Paste using Benco Dental PRO-SYS Ultra Disposable Prophy Angle (Benco Dental, Pittston, PA, USA) and Kavo PROPHYwiz 181 P handpiece (Kavo, Biberach an der Riss, Germany) at 100 RPM. Using an air and water syringe, the samples were washed thoroughly under running water for 5 s and desiccated with air for 5 s.

Group FV- Ultradent Enamelast

Teeth were polished for 5 s using Crosstex Sparkle FREE Prophy Paste (medium grit) (Crosstex International Inc., Hauppauge, NY, USA) and Benco Dental PRO-SYS Ultra Disposable Prophy Angle with a Kavo PROPHYwiz 181 P handpiece at 100 RPM. The samples were washed and desiccated for 5 s. A thin, smooth coating of varnish was placed on the enamel surface of each sample using a painting motion and left to dry for 2 min before being stored in dH_2O at 25°C for 1 day. The samples were then prepared for micro-shear testing as described below.

C. **Group OS- Ultradent Opal Seal (Fluoride releasing primer and sealant)**

Teeth were polished for 5 s using dental pumice and Benco Dental PRO-SYS Ultra Disposable Prophy Angle with a Kavo PROPHYwiz 181 P handpiece (Kavo, Biberach an der Riss, Germany) at 100 RPM. The samples were washed and desiccated for 5 s. The enamel surface of the samples was etched with Ultra-Etch (35% phosphoric acid), which was applied for 20 s then washed with water and air dried to leave a slightly damp surface. A thin layer of Opal Seal was applied to the enamel surface using the brush tip. The samples were gently air desiccated for 2 s. The samples were then tack-cured for 5 s using SDI Radii-cal LED curing light intensity (1200 mW/cm^2) (SDI Limited, Victoria, Australia). The hole in the top of the Ultradent holder was used to inject the Ultradent Opal Bond MV into the pretreated surface. The samples were light cured for 30 s. using SDI Radii-cal LED curing light intensity (1200 mW/cm^2). The samples were then placed in dH_2O at 25°C for one day before testing.

D. **Mouth rinses**

Samples were placed in a container with an enamel surface completely covered with a mouth rinse. The container was agitated using a vibrating plate to simulate the "swishing" of the product in a patient's mouth for the amount of time prescribed in the manufacturer's instructions. Group L was treated with Listerine Total Care Zero-Alcohol Cool Mint

Zero-Alcohol Mouthwash for 30 s, Group LF was treated with Listerine Total Care Zero-Alcohol Total Care Zero-Alcohol Anticavity Fluoride mouthwash (NaF 0.02%) for 60 s; Group CHX with Peridex (chlorhexidine gluconate 0.12% oral rinse) for 30 s and Group I with ioRinse RTU (molecular iodine rinse 100 ppm) for 30 s. The teeth were placed in dH_2O at 25°C for one day following treatment and then were prepared for shear testing as described below.

E. **Group TP- BioMin F Toothpaste**

A 1 cm-long bead of BioMin F Toothpaste was applied to a wetted Oral-B Advantage 3D White soft-bristled toothbrush (The Procter & Gamble Company, Cincinnati, OH). The tooth surface was brushed with short/gentle brush strokes for 2 min. Samples were placed in a container, covered with water, and agitated using a vibrating plate for 30 s to simulate the "swirling" of the product in a patient's mouth. The water was changed, and the container was rinsed between samples. Teeth were placed in dH_2O for one day at 25°C prior to preparation for shear testing.

F. **Group G- Curodont Protect remineralizing tooth gel**

Teeth were polished for 5 s using Crosstex Sparkle FREE Prophy Paste (medium grit) and Benco Dental PRO-SYS® Ultra Disposable Prophy Angle with a Kavo PROPHYwiz 181 P handpiece (Kavo, Biberach an der Riss, Germany) at 100 RPM. The samples were washed and desiccated for 5 s. Curodont Protect was put on the enamel surface using a microbrush applicator. The product was allowed to dry for 2 min and then the samples were placed in dH_2O at 25°C for one day prior to preparations for shear testing.

Micro-shear test method

The testing was done following the manufacturer's instructions and tested under standardized conditions with one shear bond testing device. The procedure for preparing and testing the micro-SBS was based on the methods and jigs provided by Ultradent Products Inc. Following the assigned treatment and one day in (dH_2O) at 25°C, the samples were prepared for micro-shear strength testing. The samples were polished for 5 s with dental pumice using the Benco Dental PRO-SYS Ultra Disposable Prophy Angle and Kavo PROPHYwiz 181 P handpiece at 100 RPM. The samples were washed and air desiccated for 5 s. The enamel surface of the samples was etched with Ultra-Etch (35% phosphoric acid), which was applied for 20 s, washed, and dried to leave a slightly damp surface. A puddle coat of Ultradent Peak Universal Bond was placed on the enamel surface using the Inspiral brush tip and agitated for 10 s. The samples were air desiccated for 10 s. The samples were then cured for 10 s using SDI Radii-cal LED curing light intensity (1200 mW/cm^2).

The hole in the top of the Ultradent holder was used to inject the Ultradent Opal Bond MV to the pretreated surface. The samples were light cured for 30 s using SDI Radii-cal LED curing light intensity (1200 mW/cm^2). The samples were stored in dH2O at 25°C for one day prior to testing.

Each sample was tested using an Ultradent Ultra Tester with a cross head speed of 0.5 mm/s [Figure 1]. The samples were subjected to a downward force until the cylinder failed and the peak pressure reading was recorded.

Results

Statistical analysis was done with a one-way ANOVA test in Prism-GraphPad software, Inc. All statistical tests were made at an overall significant level of P = 0.05. The mean micro-shear bond strength values (MPa), standard deviations, and statistical results of the materials are given in Table 2. The statistical difference was nonsignificant ($P > 0.05$) for mean micro-SBS between any of the experimental groups in comparison to the control group. Table 3 showed that there was a significant difference ($P < 0.05$) between Opal Seal versus. Listerine Total, Opal Seal versus Peridex, Listerine versus Listerine Total, and Listerine versus Peridex. All other experimental group comparisons showed no significant difference ($P > 0.05$). A bar graph that summarizes the results of the micro-shear bond strength (MPa) of the tested groups is depicted in Figure 2.

Discussion

WSL development close to orthodontic brackets is a prominent esthetic and clinical problem. The lesions arise due to decalcification of the enamel adjacent to the brackets stemming from the buildup of plaque bacteria from lack of adequate oral hygiene.[6] With this knowledge, three key areas of lesion prevention emerge: Strengthening the enamel, promoting excellent oral hygiene, and limiting the plaque bacteria and its cariogenic potential.

Inconsistent previous research could lead practitioners to avoid using products containing Fluoride prior to bracket placement due to fear of decreased bracket-enamel bond force.[17–20]

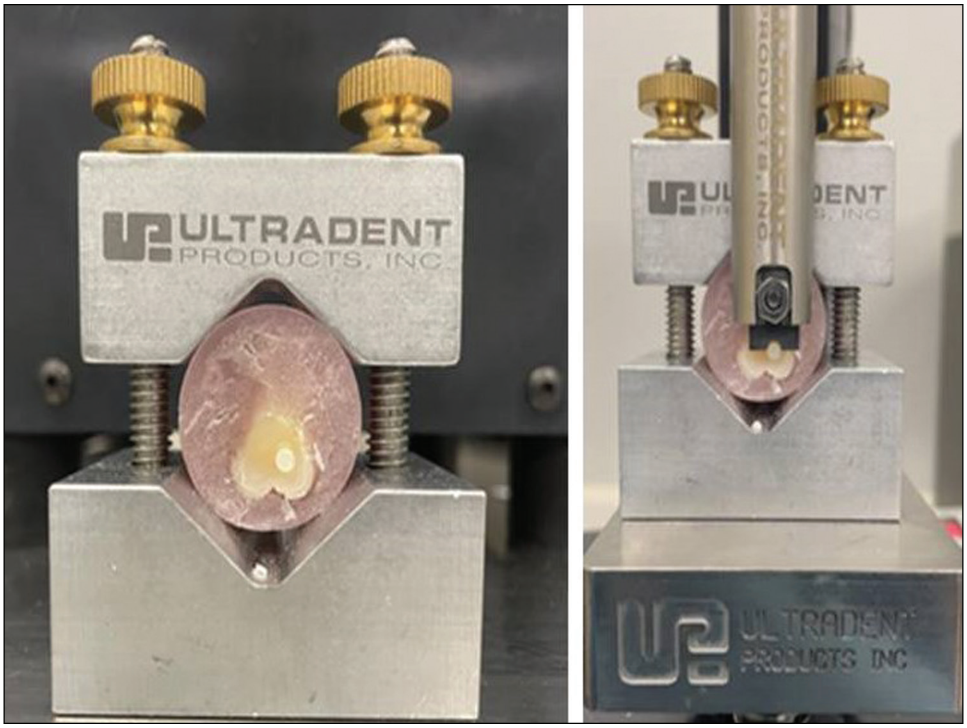


Figure 1: Examination of the samples with an Ultradent Ultra Tester with a cross-head speed of 0.5 mm/s

Table 2: Shows the micro-SBS results. No significant difference (NS) (*P* > 0.05) in mean micro-SBS between any of the experimental groups when compared to the control group

Group *n* = 15	Treatment	Micro-SBS (mean ± STD, MPa)	Mean Difference vs. Control (MPa)
C	Control, no treatment	25.58 ± 3.21	
Professional dental care products			
FP	PRO-SYS® Prophy Paste 1.23% sodium Fluoride prophy paste, medium grit	22.98 ± 7.00	2.61 (NS)
FV	Ultradent Enamelast Fluoride Varnish	24.00 ± 3.27	1.58 (NS)
OS	Ultradent Opal Seal Fluoride releasing primer and sealant	31.93 ± 8.95	−6.34 (NS)
Mouth rinses			
L	Listerine Cool Mint Zero-Alcohol Mouthwash Fluoride Free	31.82 ± 7.72	−6.24 (NS)
LF	Listerine Total Care Zero-Alcohol Anticavity Sodium Fluoride 0.02%	20.17 ± 4.72	5.41 (NS)
CHX	Peridex Chlorhexidine Gluconate 0.12%	19.81 ± 9.35	5.77 (NS)
I	ioRinse RTU Molecular Iodine 100 ppm	25.35 ± 4.84	0.23 (NS)
Alternative remineralization product			
TP	BioMin F Bioglass Toothpaste, Fluoro Calcium Phosphosilicate	27.95 ± 3.52	−2.37 (NS)
G	Curodont Protect remineralizing tooth gel, Self-assembling Peptide P11-4 and Sodium Monofluorophosphate 900 ppm	28.14 ± 5.34	−2.56 (NS)

Although many contemporary studies have shown no significant difference in micro-SBS when the enamel surface is treated with Fluoride-containing varnish or bond prior to bracket placement, studies examining additional methodology and specific products are necessary. Practitioners should seek out research on products they are interested in implementing in their practice to ensure they meet their standards with regard to orthodontic bond force.

It has been shown that the use of Fluoride containing products does not significantly reduce orthodontic micro-SBS.[21–23]

Additionally, further research is being conducted to determine whether the use of fluoridated prophylactic paste during bracket placement significantly impacts micro-SBS. Several studies indicated that SBS is not significantly affected after treatment of enamel surfaces

Table 3: Shows the micro-SBS results obtained after comparing different experimental groups treated with the selected dental products. Power of performed test with alpha (α) = 0.05

Treatment	Mean difference (MPa)	*P* value
Opal Seal vs. Listerine Total	2.91	0.0042*
Opal Seal vs. Peridex	2.79	0.0008*
Listerine vs. Listerine Total	3.08	0.01*
Listerine vs. Peridex	2.88	0.0027*
F prophy paste vs. Enamelast	2.9	>0.9999 (NS)
F prophy paste vs. Opal Seal	2.79	0.0554 (NS)
F prophy paste vs. Listerine	2.97	0.1003 (NS)
F prophy paste vs. Listerine Total	3.17	0.9966 (NS)
F prophy paste vs. CHX	2.97	0.9869 (NS)
F prophy paste vs. ioRinse	2.9	0.9981 (NS)
F prophy paste vs. BioMin	2.79	0.7446 (NS)
F prophy paste vs. Curodont Protect	2.79	0.7014 (NS)
Enamelast vs. Opal Seal	2.62	0.0887 (NS)
Enamelast vs. Listerine	2.81	0.1579 (NS)
Enamelast vs. Listerine Total	3.01	0.9577 (NS)
Enamelast vs. CHX	2.81	0.8925 (NS)
Enamelast vs. ioRinse	2.74	>0.9999 (NS)
Enamelast vs. BioMin	2.62	0.8855 (NS)
Enamelast vs. Curodont Protect	2.62	0.8536 (NS)
Opal Seal vs. Listerine	2.7	>0.9999 (NS)
Opal Seal vs. ioRinse	2.62	0.2771 (NS)
Opal Seal vs. BioMin	2.5	0.8487 (NS)
Opal Seal vs. Curodont Protect	2.5	0.8827 (NS)
Listerine vs. ioRinse	2.81	0.3973 (NS)
Listerine vs. BioMin	2.7	0.9126 (NS)
Listerine vs. Curodont Protect	2.7	0.9347 (NS)
Listerine Total vs. CHX	3.08	>0.9999 (NS)
Listerine Total vs. ioRinse	3.01	0.7824 (NS)
Listerine Total vs. BioMin	2.91	0.2002 (NS)
Listerine Total vs. Curodont Protect	2.91	0.1739 (NS)
CHX vs. ioRinse	2.81	0.6212 (NS)
CHX vs. BioMin	2.7	0.0906 (NS)
CHX vs. Curodont Protect	2.7	0.0756 (NS)
ioRinse vs. BioMin	2.62	0.992 (NS)
ioRinse vs. Curodont Protect	2.62	0.9868 (NS)
BioMin vs. Curodont Protect	2.5	>0.9999 (NS)

*Significant relation, (NS) Non-significant

with fluoridated prophylactic pastes, and the depletion in SBS value that could occur due to the incorporation of Fluoride was clinically acceptable.[11,24,25]

Gwinnett *et al.*[17,18] observed that certain topical Fluorides could highly decrease bond force through perturbing enamel tag formation.[19,20] However, the research findings in practice found that remineralization product application (toothpaste and tooth gel) has no influence on micro-SBS which is in accordance with the results stated by other studies.[26–28] In fact, Fluoride at low concentrations has been proven to promote remineralization across orthodontic brackets with an unimportant effect on SBS.[29,30]

Fluoride varnish application prior to orthodontic bracket placement should be considered in at-risk patients. Todd *et al.*[21] declared that bracket-enamel bond strength wasn't altered by the use of Fluoride varnish prior to or at the time of bracket placement. Similarly, no obvious differences in the bond force between tooth surfaces whether treated with Fluoride varnish or not, have been noticed in different studies.[22,23]

Opal® Seal Fluoride releasing primer used in this study didn't considerably impact the micro-SBS of orthodontic resin cement on enamel. Malkoc *et al.*[31] used a variety of primers with antibacterial chemicals on the etched enamel surface to determine that Seal & Protect™, which contains triclosan, had no adverse effect on the SBS of the cement. While employment of Gluma Desensitizer and Micro Prime had an excessively lessened bond force, which could be due to the closure of enamel tags producing an enamel surface not fully penetrated by resin and thereby reducing the bond force. Therefore, the reduction in SBS might be related to the composition of the antibacterial agent incorporated in the dental product.

Another area that has been explored is whether the use of bactericidal products such as molecular iodine rinse has any impact on bond force.

According to many studies, povidone-iodine has an enhanced virucidal potency compared to some of the most common antiseptic agents.[32] In a new investigation performed by an independent laboratory in Bozeman, supported by TRAC Research, molecular iodine 0.01% was nearly twice the virus lessening as 0.2% povidone-iodine with or without fresh human whole saliva defy.[33]

Demir *et al.*[34] have explained that the use of chlorhexidine and povidone-iodine prior to acid etching had no effect on bond force. The study suggested that the use of these agents under orthodontic composite resin is advisable for their antibacterial effect and to reduce the danger of bacteremia.

Moreover, Singh *et al.*[35] have examined the effect of alcohol-containing oral rinses (Listerine), nonalcoholic herbal, and CHX oral rinses on SBS and found that alcohol-containing mouth rinses shouldn't be used during fixed orthodontic treatment because they adversely affect the bond force compared to nonalcoholic herbal or CHX mouth rinses which have a minor impact on SBS compared to the control group.[36]

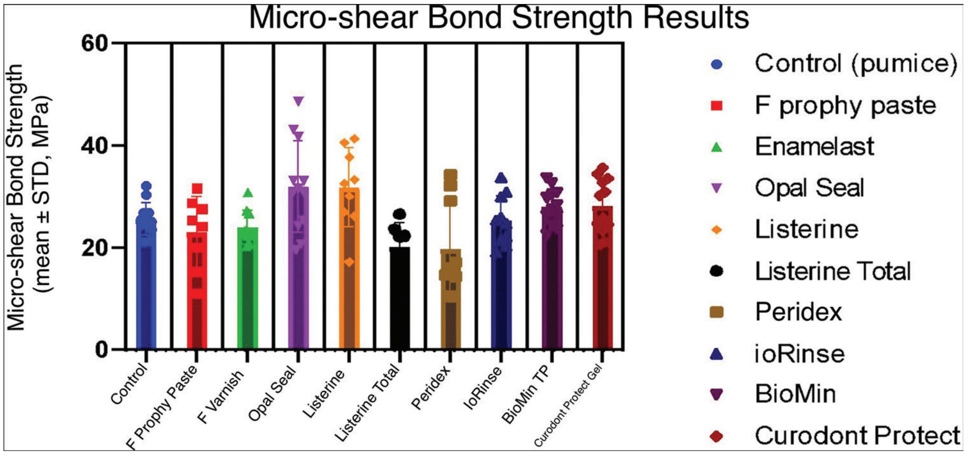


Figure 2: A bar graph shows the results of the micro-shear bond strength assessment

According to a 2021 integrated review, the clinically acceptable range of SBS for bonding of orthodontic brackets is 7.53 to 20.57 MPa.[37,38] The products included in this study exceed the necessary SBS levels. This could potentially be an issue because, ideally, the bond force is great enough not only to ensure the bracket remains in place for the duration of the treatment but also to allow damage-free removal following treatment completion. However, in this case, the SBS did not exceed 40–50 MPa, the established force that can lead to enamel loss during the removal process.[39]

This study was designed to investigate products that either strengthen enamel or serve to reduce plaque bacteria in an attempt to provide practitioners with practical knowledge regarding the use of products (prior to or during the orthodontic bonding process) that can minimize the occurrence of enamel WSL around orthodontic brackets without affecting the micro-SBS of orthodontic resin cement to the enamel. The study focused on the immediate impact of Fluoride application on bond strength in an environment with no potential oral cavity contamination challenges. Therefore, planning a longitudinal study to investigate the long term impacts of different preventive dental products on bond force with artificial saliva incorporation to mimic the intra-oral conditions and overcome the limitations of the presented study is indispensable. As new products are developed, we need to continually evaluate their impact on micro-SBS related to orthodontic treatment. Both clinicians and patients need to be made aware of any products that can be safely utilized or avoided during the course of their treatment.

Conclusion

As the null hypothesis indicates, changes observed in an experiment are not caused by any change to the variables of the experiment but rather due to chance. Thus, the current findings don't reject H0 as the preventive dental products did not significantly impact the micro-SBS of orthodontic resin cement on enamel. The use of protective dental products prior to or during the orthodontic bonding process won't affect the micro-SBS of the orthodontic bracket to the enamel and can be safely considered to be used during the duration of orthodontic treatment.

Patient declaration of consent (if *in vivo* study/case report)

N/A

Acknowledgement

The authors are pleased to acknowledge UltraDent and 3M Company for supporting the project with all materials that aided in the completion of this project. Special thanks to the College of Dentistry at Mustansiriyah University, Baghdad, Iraq, for their help.

Financial support and sponsorship

Nil.

Conflicts of interest

The authors do not have any conflicts of interest to declare.

Author contributions

Crowley J. participated in the study of concept and design, data acquisition, and analysis. Al-Obaidi R. participated in the explanation of the data, prepared tables and figures, and drafted the manuscript. Abdulhameed N. and Hussein H. participated in the study concept and design, data analysis, and prepared figures. All authors reviewed the manuscript and gave their ultimate agreement.

Ethical policy and Institutional Review Board statement

One hundred and fifty sound-extracted human teeth from various dental procedures were utilized in this study. The teeth were collected from routine dental extractions in the college's clinic after receiving (Protocol No. 26-161—IRB) waivers for the project.

Data availability statement

The records that support the results of this study are available on demand from the corresponding author.

List of Abbreviations

C: Control
CHX: Chlorhexidine gluconate
dH2O: Distilled water
FP: Fluoride prophy paste
FV: Fluoride varnish
G: Tooth gel
I: ioRinse
L: Listerine
LF: Listerine with fluoride
Mean micro-SBS: Mean micro-shear bond strength
MPa: MegaPascal
NaF: Sodium fluoride
OS: Opal seal
PPM: Parts per million
RPM: Revolutions per minute
TP: Toothpaste
WSL: White spot lesions

References

1. Newman GV. Adhesion and orthodontic plastic attachments. Am J Orthodont 1969;56:573-88.
2. Newman GV. Epoxy adhesives for orthodontic attachments: Progress report. Am J Orthodont 1965;51:901-12.
3. Zachrisson BU. A posttreatment evaluation of direct bonding in orthodontics. Am J Orthodont 1977;71:173-89.
4. Gorelick L, Geiger AM, Gwinnett AJ. Incidence of white spot formation after bonding and banding. Am J Orthodont 1982;81:93-8.
5. Meng CL, Li CH, Wang WN. Bond strength with APF applied after acid etching. Am J Orthodont and Dentofacial Orthoped 1998;114:510-3.
6. Sudjalim T, Woods M, Manton D. Prevention of white spot lesions in orthodontic practice: A contemporary review. Aust Dent J 2006;51:284-9.
7. Øgaard B, Rølla G, Arends J. Orthodontic appliances and enamel demineralization: Part 1. Lesion development. Am J Orthodont and Dentofacial Orthoped 1988;94:68-73.
8. Legler L, Retief D, Bradley E, Denys F, Sadowsky P. Effects of phosphoric acid concentration and etch duration on the shear bond strength of an orthodontic bonding resin to enamel: An in vitro study. Am J Orthod Dentofacial Orthop 1989;96:485-92.
9. Hosoya Y, Goto G. Effects of cleaning, polishing pretreatments and acid etching times on unground primary enamel. J Pedodont 1990;14:84-92.
10. Hirce JD, Sather AH, Chao EY. The effect of topical fluorides, after acid etching of enamel, on the bond strength of directly bonded orthodontic brackets. Am J Orthodont 1980;78:444-52.
11. Garcia-Godoy F, Perez R, Hubbard G. Effect of prophylaxis pastes on shear bond strength. J Clin Orthod 1991;25:571-3.
12. Taha AAH. Development of a novel bioactive glass propelled via air-abrasion to remove orthodontic bonding materials and promote remineralisation of white spot lesions. Doctoral dissertation, Queen Mary University of London. 2018.
13. Bibby B. Preliminary report on the use of sodium fluoride applications in caries prophylaxis. J Dent Res 1942;21:314.
14. Thornton J, Retief D, Bradley E Jr, Denys F. The effect of fluoride in phosphoric acid on enamel fluoride uptake and the tensile bond strength of an orthodontic bonding resin. Am J Orthod Dentofacial Orthop 1986;90:91-101.
15. Garcia-Godoy F, Hubbard GW, Storey AT. Effect of a fluoridated etching gel on enamel morphology and shear bond strength of orthodontic brackets. Am J Orthodont Dentofacial Orthoped 1991;100:163-70.
16. Taha AA, Patel MP, Hill RG, Fleming PS. The effect of bioactive glasses on enamel remineralization: A systematic review. J Dent 2017;67:9-17.
17. Gwinnett A, Buonocore M, Sheykholeslam Z. Effect of fluoride on etched human and bovine tooth enamel surfaces as demonstrated by scanning electron microscopy. Arch Oral Biol 1972;17:271-IN9.
18. Sheykholeslam Z, Buonocore M, Gwinnett A. Effect of fluorides on the bonding of resins to phosphoric acid-etched bovine enamel. Arch Oral Biol 1972;17:1037-45.
19. Richardson B. Fixation of topically applied fluoride in enamel. J Dent Res 1967;46:87-91.
20. Larsen MJ, Fejerskov O. Structural studies on calcium fluoride formation and uptake of fluoride in surface enamel in vitro. Scandinavian J Dent Res 1978;86:337-45.
21. Todd MA, Staley RN, Kanellis MJ, Donly KJ, Wefel JS. Effect of a fluoride varnish on demineralization adjacent to orthodontic brackets. Am J Orthodont Dentofacial Orthoped 1999;116:159-67.
22. Bryant S, Retief D, BradleyEJr, Denys F. The effect of topical fluoride treatment on enamel fluoride uptake and the tensile bond strength of an orthodontic bonding resin. Am J Orthodont 1985;87:294-302.
23. Brännström M, Nordenvall K, Malmgren O. The effect of various pretreatment methods of the enamel in bonding procedures. Am J Orthodont 1978;74:522-30.
24. Damon PL, Bishara SE, Olsen ME, Jakobsen JR. Effects of fluoride application on shear bond strength of orthodontic brackets. Angle Orthod 1996;66:61-4.
25. Aboush Y, Tareen A, Elderton R. Resin-to-enamel bonds: Effect of cleaning the enamel surface with prophylaxis pastes containing fluoride or oil. Br Dent J 1991;171:207-9.
26. Muntean A, Dârgău C-M, Pacurar M, Neagoe S, Delean AG. Effect of remineralizing agents on shear bond strength of orthodontic brackets—in vitro study. Children (Basel, Switzerland) 2023;10:268.
27. Mishra S. Comparative evaluation of shear bond strength of orthodontic brackets on pretreatment with CPPACP, fluor protector and phosflur: An in-vitro study. J Clin Diag Res: JCDR 2014;8:ZC01.
28. Althagafi NM. Impact of fluoride-releasing orthodontic adhesives on the shear bond strength of orthodontic brackets to eroded enamel following different surface treatment protocols. J Orthodont Sci 2022;11:3.
29. Naidu E, Stawarczyk B, Tawakoli PN, Attin R, Attin T, Wiegand A. Shear bond strength of orthodontic resins after caries infiltrant preconditioning. Angle Orthod 2013;83:306-12.
30. Lara-Carrillo E, Millán-Hernández XA, Salmerón-Valdéz EN, Scougall-Vilchis RJ, Medina-Solís CE, Toral-Rizo VH.

Fluoride releasing dental materials used in orthodontics: Literature review. J Oral Health Oral Epidemiol 2018;7:52-8.
31. Malkoc S, Demir A, Sengun A, Ozer F. The effect on shear bond strength of different antimicrobial agents after acid etching. Eur J Orthod 2005;27:484-8.
32. Bidra AS, Pelletier JS, Westover JB, Frank S, Brown SM, Tessema B. Comparison of in vitro inactivation of SARS CoV-2 with hydrogen peroxide and povidone-iodine oral antiseptic rinses. J Prosthodont 2020;29:599-603.
33. Watterson DG. The evidence on preoperative mouthwash efficacy. RDH Magazine 2021;13:2107.
34. Demir A, Malkoc S, Sengun A, Koyuturk AE, Sener Y. Effects of chlorhexidine and povidone-iodine mouth rinses on the bond strength of an orthodontic composite. Angle Orthod 2005;75:392-6.
35. Singh J, Joshi A, Manjooran T, Raghav S, Gautam A, Patel JH. An in vitro evaluation of shear bond strength of orthodontic brackets after mouth rinse. J Contemp Dent Pract 2018;19:862-6.
36. Jamilian A, Saghiri MA, Ghasemi M, Ghasemian A, Borna N, Kamali Z. The effects of two mouth rinses on shear bond strength of orthodontic brackets-An In-vitro study. Virtual J Orthodont 2011;1:1-7.
37. Cruz IDS, Tomaz AFG, Moreno MC, de Araújo RM, de Medeiros Alves AC, Pereira HSG, *et al*. Clinically acceptable values of shear bond strength of orthodontic brackets bonded on enamel: An integrative review. Res Society Develop 2021;10:e11110413927.
38. Hussain M, Wang Y. Influence of prolonged light-curing time on the shear bonding strength of resin to bleached enamel. Oper Dent 2010;35:672-81.
39. Giannini M, Soares CJ, de Carvalho RM. Ultimate tensile strength of tooth structures. Dent Materials 2004;20:322-9.