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The Effects of Fluoride Varnish on Shear Bond Strength and Adhesive Remnant Index of Ceramic Orthodontic Brackets

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Abstract

Objectives: This research sought to assess how fluoride varnish affects the shear bond strength (SBS) and adhesive remnant index (ARI) of ceramic brackets used in orthodontics.

Methods: Forty-eight freshly extracted premolars were randomly assigned to four groups (N=12 each). Groups 1, 2, and 3 were treated with 5% sodium fluoride varnish 1, 7, and 14 days before ceramic bracket bonding, respectively. Group 4 as the control group received no pretreatment. The SBS of the brackets was measured using a Universal Testing Machine, while the adhesive remnant on the tooth surfaces was assessed based on the ARI. The SBS and ARI were analyzed statistically using one-way ANOVA and Kruskal-Wallis tests, respectively at a significance level of 0.05.

Results: Group 2 exhibited significantly lower SBS than that of group 1 (P=0.001). Group 1 displayed higher SBS than that of the control group (P=0.016). Additionally, group 3 exhibited greater SBS than group 2 (P=0.020). However, none of the groups showed an SBS lower than the standard value of 6 MPa. Regarding ARI, a significant difference was found only between Groups 1 and 2, with Group 2 showing a higher ARI than Group 1 (P=0.025).

Conclusion: The application of fluoride varnish at 1, 7, and 14 days prior to bonding ceramic brackets in orthodontics does not decrease SBS and does not significantly affect ARI compared to the control group.

Keywords: Orthodontic Bracket , Fluoride treatment , fixed orthodontic appliances, Dental debonding

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Introduction

Despite the multiple benefits provided by orthodontic treatments, tooth enamel decalcification or white spot lesions (WSL) remain common challenges in fixed orthodontic treatment[1], which can negatively impact the oral health.[2] WSLs are the earliest visible signs of enamel decay.[3] These lesions occur during fixed orthodontic treatment because of difficulties in maintaining oral hygiene and the limited self-cleansing ability of brackets, resulting in increased plaque accumulation.[4] The presence of WSLs and dental caries can affect aesthetics and patient satisfaction, and even lead to legal issues.[5,6] The prevalence of WSLs before orthodontic treatment ranges from 15.5% to 40%, while its incidence during treatment is reported to be between 30% and 70%.[7] These lesions can manifest shortly after treatment initiation or even after 4 weeks[8], highlighting the importance of preventive measures.

Fluoride varnish treatment is one of the preventive approaches used to mitigate the risk of WSLs. It forms a protective layer on the teeth, reducing enamel solubility. However, this may potentially affect the shear bond strength (SBS) of brackets by interfering with bonding mechanisms.[9] Studies on this topic have yielded contradictory results. Some studies have shown a decrease in bond strength after topical fluoride application before bracket bonding, while others have not observed significant changes or even reported improved bond strength. One study demonstrated that preventive treatment with fluoride varnish improved SBS[10], whereas another study indicated a significant decrease in bracket SBS with fluoride varnish use.[11] A separate study found no effect of fluoride varnish on bracket shear strength.[12]

Additionally, during bracket debonding, removing residual resin can lead to irreversible enamel damage, resulting in the loss of approximately 30 to 60 microns of enamel thickness.[13] Therefore, minimizing adhesive remnants on the tooth surface is desirable.[13] Achieving a lower score on the adhesive remnant index (ARI) is clinically favorable as it minimizes enamel damage during debonding.[14] However, this aspect has received less attention in studies on fluoride varnish use. Although some studies have suggested that topical fluoride application may interfere with the etching process and adhesive penetration into enamel layers, affecting bracket SBS, these studies have primarily focused on metal brackets. To date, no studies have specifically investigated the effect of fluoride varnish on ceramic brackets. Moreover, existing studies have yielded conflicting results. Therefore, this study aimed to evaluate the influence of fluoride varnish on the SBS and ARI of ceramic brackets at different time intervals before bonding.

Methods

This experimental laboratory study was conducted on self-made blocks following the approval of the ethics committee at Shahid Beheshti University of Medical Sciences (IR.SBMU.DRC.REC1399.153). Forty-eight human premolar teeth with healthy buccal surfaces, extracted for orthodontic treatment, were included in the study based on previous research and using Stata 11 for sample size estimation. Considering this sample size, the study had enough power to find this discrepancy (a=0.05. power=0.99). Calculations for the sample size were performed by means of fixed effect analysis of variance in the PASS software.

SBS and ARI scores were measured and recorded by means of a universal testing machine and a stereomicroscope, respectively. Teeth without discoloration, caries, cracks, or restorations, particularly on the buccal surface, were selected. The teeth were cleaned and kept in a normal saline solution. They were then randomly allocated into four groups, each consisting of 12 teeth: Group 1: Fluoride varnish was applied and brackets were bonded the following day. Group 2: Bonding occurred 7 days after fluoride varnish application. Group 3: Bonding occurred 14 days after fluoride varnish application. Group 4: Control group, with brackets bonded without applying fluoride varnish.

For each experimental group, a 5% sodium fluoride varnish (Ariadent) was utilized on the buccal surface of the teeth. For bracket bonding, the surface was etched with 37% phosphoric acid for 20 seconds, followed by a 40-second water rinse. The teeth were air-dried, and a thin layer of bonding agent (Eagle American Orthodontics) was applied using a micro brush after assessing the enamel surface. The bonding agent was cured for 20 seconds using a light-curing device (Woodpecker LED blue light). Resin composite (Brace paste adhesive – American orthodontics) brace paste was placed on the base of ceramic brackets (MBT, T.S.H, Iran), and the bracket positioned on the middle third of the buccal surface with constant pressure applied by a gauge in the slot area. Excess composite in each area was removed with a sharp instrument, and all teeth were light-cured for 10 seconds from the mesial, distal, gingival, and occlusal aspects using a light-curing device with a light intensity of 1000 mW / Cm^2.

Acrylic molds were used to mount the teeth in self-setting yellow acrylic (Acropars 200, Iran). The teeth were mounted using a 16 x 22-inch square wire in the bracket slots, ensuring that the vertical axis of the bracket at the base-tooth junction was perpendicular to the horizontal plane. The mounted teeth were then placed in an AGS_X Universal testing machine (Autograph, Kyoto, Japan) with the blade of the machine positioned exactly at the level of the bracket-tooth bond and the bracket grooves parallel to the horizontal plane. A separating force was exerted by the blade at a speed of 0.5 mm/min until the bracket was debonded from the tooth. SBS was calculated in MPa by dividing the maximum recorded separation force at bond failure (N) by the bracket surface area (m^2).

After removing the brackets, the amount of adhesive remaining on the enamel surface was evaluated by two clinicians independently (with 92% Inter-observer agreement) using a stereomicroscope (Olympus, Japan) at x10 magnification. The evaluation was based on the following criteria: Score 0, no composite on the surface; Score 1, less than 50% composite remaining; Score 2, more than 50% composite remaining; and Score 3, all composite remaining with the base bracket clearly visible.

Data analysis was performed using IBM SPSS version 16. Statistical analysis included one-way ANOVA to compare the SBS between groups, with mean and standard deviation reported. Homogeneity of the data was checked before conducting Tukey's post-hoc test for pairwise comparisons. Independent-samples Kruskal-Wallis test was used to compare ARI scores between groups, followed by individual pairwise comparisons. A 95% confidence interval was applied for all statistical tests.

Results

The study results revealed a significant difference in SBS among the four groups (P=0.001) (Table 1). The post-hoc test revealed that the group 2 had significantly lower SBS compared to the group 1 (P=0.001) (Table 2). However, there was no significant difference in SBS between the control group and the groups 2 and 3 (P=0.654 and P=0.249, respectively). The SBS in group 1 was higher than the control group (P=0.016). Additionally, there was a significant difference between the groups 3 and 2, with group 3 having higher SBS than group 2 (P=0.020). Importantly, none of the groups had SBS values lower than the standard value of 6 MPa.

Regarding the ARI, there was a significant difference among the groups (P=0.031) (Table 3). The two-by-two comparison indicated a significant difference between the groups 1 and 2, with the group 2 having a higher ARI than group 1 (P=0.025) (Table 4).

Table 1- The comparison of SBS mean between four groups

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Group1	12	37.39	13.34	3.85	28.91	45.87
Group2	12	17.75	5.14	1.48	14.48	21.03
Group3	12	31.69	14.52	4.19	22.46	40.92
Control	12	23.07	9.31	2.68	17.15	28.99
Total	48	27.48	13.27	1.91	23.62	31.33

*SBS= shear bond strength (MPa)

Table 2- Post-hoc (Tukey-HSD) test for pairwise comparisons of SBS between the groups.

(I) Group	(J) Group	Significance level (p-value)
Group1	Group2	0.001
	Group3	0.602
	Control	0.016
Group2	Group1	0.001
	Group3	0.020
	Control	0.654
Group3	Group1	0.602
	Group2	0.020
	Control	0.249
Control	Group1	0.016
	Group2	0.654
	Group3	0.249

* P-value was calculated using Independent-Samples Kruskal Wallis test at 95% levels of CI

Table 3- The comparison of ARI means in four groups

Group	Median	Mean	Std. Deviation	Minimum	Maximum
Group1	2.00	2.17	0.718	1	3
Group2	1.00	1.25	0.452	1	2
Group3	1.50	1.67	0.985	0	3
Control	2.00	1.92	0.793	1	3
Total	2.00	1.75	0.812	0	3

Table 4- The comparison of ARI means in two-by-two groups

Sample1-sample2	Test statistic	Std. Test Statistic	Sig.	Adj.Sig.
2.00-3.00	-7.12	-1.33	0.18	1.00
2.00-4.00	-11.08	-2.07	0.03	0.22
2.00-1.00	15.29	2.86	0.004	0.02
3.00-4.00	-3.95	-0.74	0.459	1.00
3.00-1.00	8.16	1.52	0.127	0.759
4.00-1.00	4.20	0.78	0.431	1.00

Discussion

Demineralization of tooth enamel close to orthodontic

brackets is one of the multiple clinical problems pertaining to orthodontics.[15] There are many treatments to prevent and treat tooth demineralization, the most common being topical fluoride treatment.[11] However, some studies have suggested that topical fluoride can interfere with the etching process and adhesive penetration into the enamel layers, thus affecting the SBS of the bracket.[16] Despite the presented theory, the effect of fluoride on SBS is a conflicting subject of much orthodontic research, and different results have been presented.[11,17,18] The current study intended to examine the effect of fluoride varnish on the SBS and ARI of ceramic brackets, with three different time intervals of 1 day, 1 week, and 2 weeks before bracket bonding. The findings showed that fluoride varnish did not reduce SBS; in fact, in the group where fluoride varnish was applied one day before bonding, an elevation in SBS index was observed. Regarding ARI, there was no significant difference between the control group and the other groups. However, it is important to note that these results were obtained under laboratory conditions and may vary in clinical settings.

A study by Gianguido Cossellu et al. aimed to investigate different preventive treatment methods for the SBS of orthodontic brackets and demonstrated that fluoride significantly reduced SBS. In the present study, the SBS was lower than the required clinical values only in the group that used fluoride.[11] Another study conducted by Mohammad Al-Soliman et al. assessed the effect of fluoride varnish and amorphous calcium phosphate as preventive methods on the SBS of brackets bonded with a self-etch primer and showed that the use of fluoride varnish reduced the SBS of brackets.[17] In contrast, Tatiana Kelly et al.'s study showed that using topical fluoride not only did not reduce the SBS of brackets but actually increased it.[18] Another study by Khosravani Fard et al. sought to investigate the effect of acidulated phosphate fluoride on the SBS and ARI of orthodontic brackets, and it demonstrated that adding 20 to 25% of 1.23% acidulated phosphate fluoride to phosphoric acid etchant might considerably reduce the amount of residual adhesive, without compromising the SBS.[19] In light of the contradictory results from the aforementioned studies, it is crucial to consider the use of different materials and variations in methodology as contributing factors.

In the present study, ceramic brackets were utilized, as they are increasingly being used for aesthetic purposes but have not been extensively investigated. Additionally, the impact of the time interval between fluoride varnish application and bracket bonding was examined.[20,21] A study conducted by Nhan RT et al. in 2015 [12] showed the effect of fluoride varnish applied on days 1, 8, and 15 before bracket bonding on SBS of orthodontic brackets. This study demonstrated that applying fluoride varnish before bracket bonding, irrespective of the time interval, does not reduce the SBS of the bracket, which aligns with our results. In that particular study, two different brands of fluoride varnish were used. The groups treated with Kolorz Clearshield exhibited higher SBS in all groups except for the group treated on day 8, compared to the control. On the other hand, SBS did not increase in the groups treated with the Vanish brand, although no significant difference was observed between the groups and the control group.[20] This indicates that the discrepancies in the studies can be attributed to the use of different brands. Similar to our study, the residual cement index in the mentioned study did not significantly differ between the control group and the other groups. Moreover, a study conducted by Gianguido Cossellu et al. aimed to investigate the temporal relationship between the use of fluoride varnish and the bonding of brackets, and showed that SBS returned to the ideal clinical amount when brackets were bonded 15 days after fluoride varnish application.[21] However, this result contradicts our study and the study by Nhan RT [12], as we found that fluoride varnish, regardless of the time interval, not only did not reduce SBS but also increased it in some cases. It is worth noting that the Gianguido Cossellu study utilized cow incisors, whereas our study employed human-extracted premolars.

Another study by Song-Yi Yang et al. intended to examine the time-dependent effect of fluoride on the etching process in orthodontic bracket bonding. That study was similar to the present study in terms of examining the effect of time, but it used acidulated phosphate fluoride 1.23% (APF) instead of sodium fluoride varnish.

There were several limitations in the present study, including: 1. Laboratory Setting: The study was conducted in a laboratory environment, which may not fully apply in clinical conditions. Factors present in the oral environment, such as salivary flow, oral hygiene practices, and individual patient characteristics, can influence the outcomes differently than observed in controlled laboratory setting. 2. Generalizability: Since the study was conducted in a laboratory, the findings may not be fully generalizable to actual clinical practice. The outcomes observed in a controlled setting may not accurately reflect the outcomes that would be observed in a diverse patient population with various oral conditions. 3. Limited Availability of Consumables and Brands: It was not feasible to obtain all the consumables and brands used in previous studies. The use of different materials and brands can potentially impact the results and make direct comparisons challenging. Variations in product composition and application methods can lead to differing outcomes.

These limitations should be considered when interpreting the results of the study. Further research conducted in clinical settings with larger sample sizes and a wider range of patient populations would provide more comprehensive insights into the effects of fluoride varnish on the shear bond strength of

orthodontic brackets.

Conclusion

Despite the limitations, the examination of SBS and ARI indicated that the use of fluoride varnish did not reduce SBS in any time intervals of 1, 7, and 14 days. In fact, an increase in SBS was observed in the group where fluoride varnish was applied one day before bonding. Additionally, the ARI values in all three groups did not show significant differences compared to the control group. These findings provide a reasonable basis for considering the clinical use of fluoride varnish in orthodontic practice; however, further research in clinical settings is necessary to support this recommendation.

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Data Availability Statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of Interest: No Conflict of Interest Declared ■

References

1. Proffit WR, White RP, Sarver DM. Contemporary treatment of dentofacial deformity. St Louis: C. V. Mosby; 2003. p. 681.
2. Buren JL, Staley RN, Wefel J, Qian F. Inhibition of enamel demineralization by an enamel sealant, Pro Seal: an in-vitro study. Am J Orthod Dentofacial Orthop. 2008;133(4 Suppl):S88-94.
3. Kidd EA, Fejerskov O. Dental caries: The disease and its clinical management: Blackwell Munksgaard; 2003, chapter 13, page 19-49.
4. van der Veen MH, Attin R, Schwestka-Polly R, Wiechmann D. Caries outcomes after orthodontic treatment with fixed appliances: do lingual brackets make a difference? Eur J Oral Sci. 2010;118(3):298-303.
5. Deahl ST, Salome N, Hatch JP, Rugh JD. Practice-based comparison of direct and indirect bonding. Am J Orthod Dentofacial Orthop. 2007;132(6):738-42.
6. Fricker JP. Therapeutic properties of glass-ionomer cements: Their application to orthodontic treatment. Aust Dent J. 2022;67(1):12-20.
7. Heymann GC, Grauer D. A contemporary review of white spot lesions in orthodontics. J Esthet Restor Dent. 2013;25(2):85-95.
8. Chen Q, Zheng X, Chen W, Ni Z, Zhou Y. Influence of orthodontic treatment with fixed appliances on enamel color: a systematic review. BMC Oral Health. 2015 Mar 10;15:31
9. Meng CL, Li CH, Wang WN. Bond strength with APF applied after acid etching. Am J Orthod Dentofacial Orthop. 1998;114(5):510-3.
10. Velİ I, Akin M, Baka ZM, Uysal T. Effects of different pre-treatment methods on the shear bond strength of orthodontic brackets to demineralized enamel. Acta Odontol Scand. 2016;74(1):7-13.
11. Cossellu G, Lanteri V, Butera A, Sarcina M, Farronato G. Effects of six different preventive treatments on the shear bond strength of orthodontic brackets: in vitro study. Acta Biomater Odontol Scand. 2015 ;1(1):13-17.
12. Nhan RT, Xu X, Yu Q, Ballard R, Armbruster P. The effect of topical fluoride varnish on the shear bond strength of orthodontic brackets. Aust Orthod J. 2015;31(1):14-9.
13. Devanna R, Keluskar KM. Crystal growth vs. conventional acid etching: a comparative evaluation of etch patterns, penetration depths, and bond strengths. Indian J Dent Res. 2008;19(4):309-14.
14. Montasser MA, Drummond JL. Reliability of the adhesive remnant index score system with different magnifications. Angle Orthod. 2009;79(4):773-6.
15. Sudjalim TR, Woods MG, Manton DJ, Reynolds EC. Prevention of demineralization around orthodontic brackets in vitro. Am J Orthod Dentofacial Orthop. 2007;131(6):705.e1-9.
16. Yang SY, Jeong IJ, Kim KM, Kwon JS. Time-dependent effects after enamel fluoride application on an acid etching system in orthodontic bracket bonding. Clin Oral Investig. 2021;25(2):497-505.
17. Al-Suleiman M, Silikas N, Watts D. Effects of procedures of remineralization around orthodontics bracket bonded by self-etching primer on its shear bond strength. J Orthod Sci. 2012;1(3):63-8.
18. da Silva Fidalgo TK, Pithon MM, do Santos RL, de Alencar NA, Abrahão AC, Maia LC. Influence of topical fluoride

application on mechanical properties of orthodontic bonding materials under pH cycling. Angle Orthod. 2012;82(6):1071-7.
19. Khosravanifard B, Yazdani R, Rakhshan H, Rakhshan V. The effect of acidulated phosphate fluoride incorporated phosphoric acid etchant on shear bond strength of orthodontic brackets. Dent Res J (Isfahan). 2011;8(4):183-8.
20. Al-Kawari HM, Al-Jobair AM. Effect of different preventive agents on bracket shear bond strength: in vitro study. BMC Oral Health. 2014 ;14:28.
21. Cossellu G, Lanteri V, Butera A, Laffi N, Merlini A, Farronato G. Timing considerations on the shear bond strength of orthodontic brackets after topical fluoride varnish applications. J Orthod Sci. 2017;6(1):11-15.