

A New Technique With Sodium Hypochlorite to Increase Bracket Shear Bond Strength of Fluoride-releasing Resin-modified Glass Ionomer Cements: Comparing Shear Bond Strength of Two Adhesive Systems With Enamel Surface Deproteinization Before Etching

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By eliminating the organic substances from the enamel surface before etching (deproteinization), orthodontic bond strength can theoretically be increased because the resulting etch-pattern is predominantly type 1 and 2, instead of type 3. Fluoride-releasing resin-modified glass ionomer cements (RMGIs) might then routinely be used to bond brackets, instead of composite resins. Reducing the incidence of white spot lesions, a major current iatrogenic effect of orthodontic treatment, is a worthy cause which might be achieved due to the fluoride-releasing properties of RMGIs. The objective of this study was to determine whether deproteinization of human dental enamel surfaces, with 5.25% sodium hypochlorite (NaOCl) before etching, increases orthodontic bracket shear bond strength (SBS) of 2 adhesive systems: a composite resin and a RMGI.

Seventy six extracted human premolar teeth were cleaned, and randomly divided into four groups (2 experimental and 2 control), with 19 premolars in each group. In group 1 (experimental) and group 2 (control), brackets were bonded to the teeth using Transbond XT (3M Unitek Orthodontic Products, Monrovia, CA) and in group 3 (experimental) and group 4 (control), Fuji Ortho LC (GC America, Inc., Alsip, IL) was used. The buccal surfaces of the premolars in experimental groups 1 and 3 were deproteinized with 5.25% NaOCl for 1 minute followed by rinsing, drying and acid etching for 30 seconds. Subsequently, the acid was rinsed off, the enamel was dried (and remoistened in the Fuji Ortho LC groups), and orthodontic brackets were bonded, either with primer and composite resin, or with RMGI. The same protocol was used in the 2 control groups (2 and 4), except that NaOCl was not used. The teeth were then stored in distilled water at room temperature for a maximum of 24 hours, thermo-cycled 500 times, between 5°C and 55°C, placed in a controlled Water Bath, at 37°C for 24 hours, mounted on acrylic rings, and debonded using a universal testing machine. The enamel surfaces were examined at 10X magnification to determine the amount of residual adhesive remaining on the tooth. An analysis of variance was used to determine whether there was a significant difference in SBSs between the 4

test groups, together with a post hoc test to determine possible significant differences among the pair of means; a χ^2 test was used to compare the adhesive remnant index (ARI) scores. There were no significant differences in the SBS ($P = 0.05$) between the Transbond XT groups. There were significant differences in the SBS ($P = 0.05$) between the Fuji Ortho LC groups. The mean SBS for Transbond XT with NaOCl was 9.41 ± 4.46 megapascals (MPa); for Transbond XT without NaOCl, 8.12 ± 3.10 MPa; for Fuji Ortho LC with NaOCl, 9.64 ± 5.01 MPa; and for Fuji Ortho LC without NaOCl, 5.71 ± 3.87 MPa. The comparisons of the adhesive remnant index scores between the 2 Transbond groups ($\chi^2 = 6.41$) indicated that bracket failure mode was not significantly different ($P < 0.05$), and for the Fuji Ortho LC groups ($\chi^2 = 24.08$) indicated that bracket failure mode was significantly different ($P < 0.05$), with more adhesive remaining on the enamel bonded using Fuji Ortho LC with NaOCl. SBS was significantly increased from 5.7 to 9.6 MPa using NaOCl in the Fuji Ortho LC group (compared with 9.4 MPa in the Transbond XT group with NaOCl). The FUJI Ortho LC experimental group, in which NaOCl was used, had a significantly greater amount of adhesive remaining on the enamel than the control group. It was concluded from this in vitro study that with NaOCl use, bracket bond strength with Fuji Ortho LC is similar to Transbond XT, so that fluoride-releasing RMGIs may possibly be used to bond brackets to reduce the incidence of white spot lesions. (Semin Orthod 2010; 16:66-75). © 2010 Elsevier Inc. All rights reserved.

Orthodontists have been reluctant to use resin-modified glass ionomer (RMGI) as a routine bracket adhesive because of shear bond strength (SBS) issues.¹⁻⁴ The perception is that composite resins provide greater bracket bond strength than RMGIs, despite the many studies that demonstrate comparable SBS.²⁻⁹ Toledano et al⁹ concluded that SBSs of RMGIs were acceptable only when phosphoric acid is used as an etchant. An in vivo study¹ showed no significant differences in bracket failure rates between the RMGIs and composite resin adhesives. An ex vivo study⁸ showed an increase in SBS with RMGI when the enamel surface was moistened with artificial saliva before bonding the bracket to the tooth (following 37% phosphoric acid etching, rinsing and drying). This result was probably due to the hydrophilic properties of RMGIs.

Clinicians are aware that enamel white spot lesions (WSLs) frequently occur in patients undergoing orthodontic treatment^{10, 11}, and that they are caused by the accumulation of plaque around the brackets. Using advanced detection techniques, Boersma et al¹² observed that 97% of all subjects receiving fixed orthodontic treatment were affected with WSLs. Many orthodontic patients do not adequately comply with oral hygiene protocols, which may include fluoridated mouth rinses. In addition, orthodontic patients may not keep their regularly scheduled dental appointments during their orthodontic treatment. Geiger et al,¹³ showed that less than 15% of orthodontic patients used daily fluoride rinses, as instructed. Monthly in-office applications of highly concentrated fluoride varnish does result in a 44.3% reduction in enamel demineralization.^{14, 15} However, there is a limitation on the frequency of exposures that the patient will receive due to the costs to the patient and the clinician's chair time; also temporary discoloration of

teeth and gingival tissues occur using most available fluoride varnishes. Application of fluoride-containing sealants has also not been successful because the concentration of fluoride ions released significantly decreased with time, to the point of having barely detectable levels a few weeks after initial bonding.¹⁶ Thus, orthodontists might very well be putting patients at risk of developing WSLs by using nonfluoride-releasing composite resins to bond brackets, rather than using fluoride-releasing RMGIs.

Orthodontists are aware that RMGIs provide a sustained fluoride release following bonding (for as long as the bracket is maintained on the enamel), that glass ionomer acts as a continuous fluoride pump, and that fluoride does protect enamel from developing WSLs.¹⁷⁻²⁵ If RMGIs were routinely used to bond brackets, the incidence of WSLs might dramatically decrease. Schmit et al²⁶ studied the effect of a fluoride varnish on ex vivo human enamel demineralization, adjacent to brackets bonded with RMGI cement. They concluded that the RMGI reduced enamel demineralization as effectively as the varnish. In vitro data suggest that RMGIs are more effective at inhibiting enamel demineralization adjacent to orthodontic brackets, than fluoride-releasing resins.²⁷

The objective of the present research was to investigate whether deproteinization of the enamel surface would increase SBS when using Fuji Ortho LC, a fluoride-releasing RMGI. A composite resin adhesive, Transbond XT, was used as a control.

Espinosa et al²⁸ showed that wetting and/or conditioning the enamel surface with 5.25% sodium hypochlorite (NaOCl) for 1 minute, before acid etching, increased the quality of the etching pattern because NaOCl eliminated the organic matter from the enamel surface (deproteinization). The authors demonstrated that it is this outer organic layer that prevents conventional 37% phosphoric acid from effectively etching the surface, resulting in inconsistent etch-patterns and an unreliable enamel surface for orthodontic bonding. Type 1 and 2 etching patterns resulted when NaOCl was used, whereas type 3 etching pattern predominated when NaOCl was not used.

From the above mentioned description, it can be speculated that increased SBS might be achieved by deproteinizing the enamel surface with 5.25% NaOCl, before etching with 37% phosphoric acid. If SBS can be increased with NaOCl, then RMGIs could be routinely used to bond brackets, instead of composite resin, thereby possibly reducing the incidence of white spot lesions (WSLs) due to the fluoride-releasing property of RMGIs.

Up to the writing of this article, no research has been published evaluating whether deproteinization of human dental enamel surfaces, with 5.25% NaOCl before etching, increases orthodontic bracket SBS. Thus, it was suggested that such an investigation was appropriate and meaningful to further study this potential benefit to patients.

Materials and Methods

Teeth

Seventy six, freshly extracted, human premolars were collected, cleaned and stored in distilled water at room temperature, a maximum of 6 months and a minimum of 3 days. To meet the criteria for use in the study, the teeth were selected only if they had intact buccal enamel, had not been pretreated with chemical agents (eg, H₂O₂), had no surface cracks from extraction forceps, and were caries-free. The premolars were randomly divided into 4 groups, (2 experimental and 2 control), with 19 premolars in each group. In group 1 (experimental) and group 2 (control), brackets were bonded to the teeth using Transbond XT (primer plus composite resin), and in group 3 (experimental) and group 4 (control), Fuji Ortho LC (a RMGI cement) was used for bonding.

Brackets

Standard orthodontic premolar .018" metal brackets (Gemini, 3M Unitek, Monrovia, CA), with a 100-gauge mesh, were used in this study. The average surface area of the bracket base was $7.9 \pm 0.3 \text{ mm}^2$. This was determined by the following laboratory procedures. A thin sheet of aluminum foil was used to make 10 imprints of the bracket mesh of a bracket selected at random from this study. The 10 imprints were cut around the mesh periphery with fine scissors. Gloves were used throughout the procedure to prevent skin contamination of the aluminum. Each aluminum imprint was then held with pliers and cleaned with an alcohol-impregnated cotton roll. The 10 imprints were then weighed using a microscale. The mesh surface area was determined by applying a mathematical formula to each of the recorded weights.

Groups Tested

Group 1 (Experimental), Premolars Bonded with Transbond XT resin, Using NaOCl

The buccal surfaces of the premolars were cleaned with a nonfluoridated prophylaxis paste and rubber prophylactic cups for 10 seconds, rinsed, dried and deproteinized with 5.25% NaOCl (Clorox, The Clorox Co, Oakland, CA; pH = 12.5) for 1 minute using a micro-brush (Fig. 1), followed by rinsing, drying and acid etching with 37% phosphoric acid for 30 seconds. Subsequently, the acid was rinsed off, the enamel was dried, a thin layer of primer was applied with a micro-brush, and light cured for 20 seconds. The composite resin was then placed on the bracket mesh covering the entire base of the bracket, without bubbles or voids, and

the bracket was then applied to the tooth using sufficient force to produce a “flash” of excess adhesive around the bracket to ensure a uniform thickness of adhesive. This procedure ensured similar conditions as encountered in the actual clinical environment. Excess adhesive was removed with a sharp scaler, and the bracket was light cured with a halogen light for 40 seconds (10 s on each side).



Figure 1. Clinical example of enamel deproteinization with 5.25% NaOCl for 1 minute (applied with a microbrush) to increase bracket shear bond strength. (Color version of figure is available online).

Group 2 (Control), Premolars Bonded with Transbond XT resin, Without Using NaOCl

The same protocol was used in this control group, except that NaOCl was not used.

Group 3 (Experimental), Premolars Bonded with Fuji Ortho LC, Using NaOCl

The buccal surfaces of the premolars were cleaned with a nonfluoridated prophylaxis paste and rubber prophylactic cups for 10 seconds, deproteinized with 5.25% NaOCl for 1 minute using a micro-brush, followed by rinsing, drying and acid etching with 37% phosphoric acid for 30 seconds. Subsequently, the acid was rinsed off, the enamel was dried, and then remoistened with artificial saliva (Viarden Co, México) applied with a micro-brush. This step ensured that the bonding surface was not desiccated. Fuji Ortho LC (an RMGI) was mixed according to the manufacturer’s instructions, and placed on the bracket mesh covering the entire base of the bracket, without bubbles or voids. The bracket was then applied to the tooth using sufficient force to produce a “flash” of excess

adhesive around the bracket to ensure a uniform thickness of adhesive. This procedure ensured similar conditions as encountered in the actual clinical environment. Excess adhesive was removed with a sharp scaler, and the bracket was light cured with a halogen light for 40 seconds (10 s on each side).

Group 4 (Control), Premolars Bonded with Fuji Ortho LC, Without Using NaOCl

The same protocol as in group 3 was used in this control group, except that NaOCl was not used.

Storing and Thermo-cycling

Test specimens were prepared at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and stored in distilled water at room temperature for 24 hours. They were then thermocycled between 5°C and 55°C for 500 cycles. The exposure to each bath was 25 seconds. The 2 transfer times between the 5°C and 55°C baths were 5 seconds each. Following thermocycling, the premolars were placed in distilled water in a controlled water bath (incubator), at 37°C , for 24 hours. This was done to discriminate between those materials that can and those that cannot withstand a wet environment. A rectangular wire, measuring 0.017" x 0.025", was ligature tied to each premolar bracket. This wire acted as a mounting jig while the premolars were embedded in acrylic placed in aluminum rings to be able to test them with the Universal Testing Machine (Instron Testing Machine # 5567, Norwood, MA). The wire aligned the facial surfaces of the teeth parallel to the bottom of the mold. This kept the buccal surface of the tooth parallel to the applied force during the shear test. Following mounting, the premolars were debonded using a universal testing machine.

Debonding Procedure

A wire, attached to the crosshead of an Instron testing machine 5567, was looped around the bracket. The wire applied a gingivo-occlusal load to the bracket, producing a shear force at the bracket-tooth interface until the bracket was detached. The results of each test were recorded by a computer that was electronically connected to the testing machine. The machine recorded the results from each test in megapascals (MPa,) at a crosshead speed of 1.0 mm/min.

Adhesive Remnant Index

Once the brackets were debonded, the enamel surface of each tooth was examined at 10X magnification in a stereomicroscope to determine the amounts of residual adhesive remaining on each tooth. A modified adhesive remnant index

(ARI) was used to quantify the amount of remaining adhesive, using the following scale: 1 = all the adhesive remained on the tooth, with the imprints of the bracket base; 2 = more than 90% of the adhesive remained on the tooth; 3 = 10% to 90% of the adhesive remained on the tooth; 4 = less than 10% of the adhesive remained on the tooth, and 5 = no adhesive remained on the tooth.^{4,7}

Statistical Analysis

A Fisher test was used to determine whether there was a statistically significant difference in SBSs between the 4 test groups. If it was determined that there was a statistically significant difference, then a Tukey test was applied to detect in which of the groups the difference occurred. The χ^2 test was used to compare the bond failure mode (ARI scores) between the groups. Significance for all statistical tests was predetermined at $P \leq 0.05$.

Scanning Electron Microscope Pilot Study of Enamel Morphology

A qualitative study was carried out to observe with Scanning Electron Microscope (SEM) the type of etch pattern with, and without, the use of NaOCl before etching. Ten extracted, intact, human premolars were cleaned, and randomly divided into 2 groups (control and experimental), with 5 premolars in each group. The buccal surfaces of the premolars in the experimental group were deproteinized with 5.25% NaOCl for 1 minute followed by rinsing, drying and acid etching for 30 seconds. Subsequently, the acid was rinsed off, the enamel was dried, and observed with SEM to determine etch pattern. The same protocol was used in the control group, except that NaOCl was not used. The teeth were prepared for observation at 1,200X magnification with SEM.

Results

Shear Bond Strength

The descriptive statistics, including mean, standard deviation, and minimum and maximum values for the 4 adhesive systems, are presented in Table 1.

Table 1. Descriptive Statistics (in MPa) of the Transbond XT and the Fuji Ortho LC Adhesive Systems

Group #	n	\bar{X}	SD	Range
1. Transbond XT with NaOCl	19	9.41	4.46	1.70 – 15.67
2. Transbond XT without NaOCl	19	8.12	3.10	1.59 – 13.14
3. Fuji Ortho LC with NaOCl	19	9.64	5.01	2.95 – 27.02
4. Fuji Ortho LC without NaOCl	19	5.71	3.87	1.16 – 15.44

n, sample size; \bar{X} , mean; SD, standard deviation.

The mean SBS for the brackets bonded using Transbond XT, with enamel deproteinization, was 9.41 ± 4.46 MPa, and the mean SBS for the brackets bonded using Transbond XT in the control group (without enamel deproteinization) was 8.12 ± 3.10 MPa.

The mean SBS for the brackets bonded using Fuji Ortho LC, with enamel deproteinization, was 9.64 ± 5.01 MPa, and the mean SBS for the brackets bonded using Fuji Ortho LC in the control group (without enamel deproteinization) was 5.71 ± 3.87 MPa.

To determine statistical significance an analysis of variance F ratio (Fisher test) was used. This test detected that a statistical significant difference existed between the 4 groups as the F experimental value was higher (3.56) than the F critical value (2.74) ($P = 0.05$). To determine which of the groups had significant differences, a Tukey test was used. The result indicated that the Transbond groups had no statistical difference, as the experimental T value was 1.29 while the critical T value was 3.56 ($P = 0.05$). The Fuji groups did have statistical difference because the experimental T value was 3.93, which is higher than the critical T value (3.56, $P = 0.05$).

Adhesive Remnant Index

The failure modes of the 2 types of adhesives are presented in Table 2.

Table 2. Frequency Distributions of the Modified ARI Scores of the Four Groups

Group #	n	Modified ARI score*				
		1	2	3	4	5
1. Transbond XT with NaOCl	19	6	1	4	4	4
2. Transbond XT without NaOCl	19	7	2	8	2	0
3. Fuji Ortho LC with NaOCl	19	0	5	11	2	1
4. Fuji Ortho LC without NaOCl	19	0	0	1	11	7

$\chi^2 = 6.41$ for the Transbond groups; $P = 0.05$; $\chi^2 = 24.08$ for the Fuji groups; $P = 0.05$; ARI, adhesive remnant index; n, sample size

*1, all adhesive remained on the tooth with the imprints of the bracket base; 2, >90% of the adhesive remained on the tooth; 3, 10% to 90% of the adhesive remained on the tooth; 4, <10% of the adhesive remained on the tooth; 5, no adhesive remained on the tooth.

The χ^2 comparisons of the ARI scores between the 2 Transbond XT groups was $\chi^2 = 6.41$. This value was lower than the χ^2 critical value of 9.49, indicating that they did not differ significantly ($P = 0.05$) from each other.

The χ^2 comparisons of the ARI scores between the 2 Fuji Ortho LC groups was $\chi^2 = 24.08$. This value was greater than the χ^2 critical value of 9.49, indicating that they differed significantly ($P = 0.05$) from each other. The experimental group, in which NaOCL was used, had a significantly greater amount of adhesive remaining on the enamel than the control group.

Pilot SEM Study

Comparison of the enamel surfaces of the experimental and control groups (5 premolars in each group) shows that the enamel conditioned with NaOCl produced a qualitatively rougher enamel surface (Fig. 2) than the enamel in which NaOCl was not used (Fig. 3). The SEM images from the experimental group (using NaOCL) show a better etch pattern (types 1 and 2) than the images of the control group, in which NaOCl was not used (type 3 etch pattern).

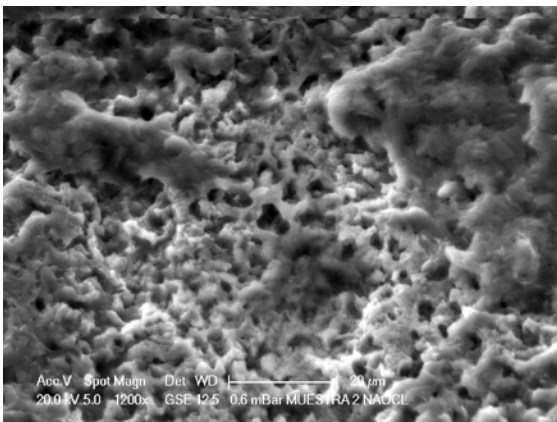


Figure 2. A SEM of enamel wetted with 5.25% NaOCl for 1 minute, and conditioned with 37% phosphoric acid for 30 seconds. Observe types 1 and 2 etching patterns.

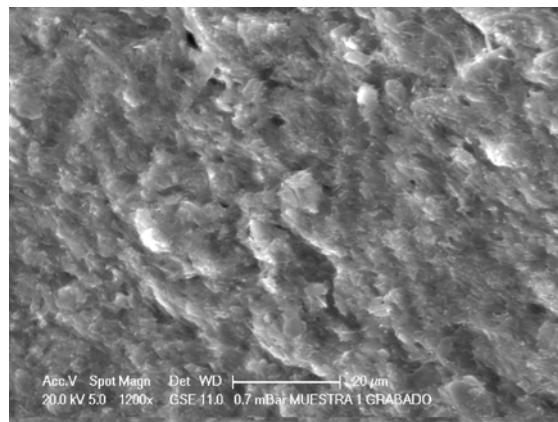


Figure 3. A SEM of enamel conditioned with 37% phosphoric acid for 30 seconds (no NaOCl was used). Observe type 3 etching pattern.

Discussion

The present study evaluated 2 contemporary adhesive systems marketed for use to bond orthodontic brackets—a RMGI, Fuji Ortho LC, and a primer and/or composite resin system, Transbond XT. The main objective of the study was to determine whether NaOCl, applied for 1 minute before etching, increases bracket SBS.

By conditioning the enamel with 5.25% NaOCl followed by a 30-second etching with 37% phosphoric acid, the present findings indicated that the mean SBS of brackets bonded using Fuji Ortho LC was 9.64 ± 5.01 MPa, which exceeds the clinical recommendation by Reynolds,²⁹ which is a minimum tensile bond strength of 5.9-7.8 MPa. In contrast, the Fuji group in which NaOCl was not used had a much lower mean SBS (5.71 ± 3.87 MPa). Thus, if the clinician wishes to use RMGI to prevent white spot lesions, it is recommended, based on the findings of the present study, to deproteinize the enamel surface with 5.25% NaOCl for 1 minute before acid-etching as there was a statistically significant difference between the 2 Fuji Ortho LC groups.

The SBS increased 3.9 MPa in the Fuji experimental group (with NaOCl), while increasing only 1 MPa in the Transbond XT experimental group. The authors believe that the small increase in the experimental Transbond XT group is because a primer is used in this system. Even though the etching pattern is probably type 3 when no NaOCl is applied, the primer penetrates the microporosities created during the acid-etching process on the enamel surface. This allows for the incorporation of small resin "tags" into the enamel, thereby creating microscopic mechanical interlocks between the enamel and resin providing as a result adequate SBS. In contrast the Fuji material does not use a fluid primer. Thus, if RMGIs are to be used, it is imperative that the enamel etching pattern be of type 1 or 2 (to increase SBS), and not of type 3. The authors consider that the application of NaOCl to achieve a better etching pattern is important for RMGIs to be clinically useful. Enamel deproteinization is a prudent step in the overall bracket bonding procedure, whether RMGIs or resin composites are used. An improved marginal seal of the bracket base to the enamel is obtained because of types 1 and 2 acid-etching patterns produced with the aid of the NaOCl application. WSL formation might be minimized due to this improved seal.

As the test specimens in the present study were stored in distilled water, the organic elements on the enamel surfaces might have been partially lost. Thus, the authors believe that the in vivo application of NaOCl might result in greater SBS than demonstrated in this ex vivo study.

The ARI scores indicated that the brackets bonded using Fuji Ortho LC without NaOCl failed in a different mode than those bonded using the Transbond XT adhesive system and the Fuji with NaOCl. In general, bond failure for brackets bonded using Fuji Ortho LC without NaOCl occurred at the enamel-adhesive interface, whereas brackets bonded using NaOCl failed more often at the bracket-adhesive interface. These results were significant. The important result was that the ARI scores for the Fuji Ortho LC group (with NaOCl), and the Transbond XT groups were similar.

Bracket failure at each of the 2 interfaces has its own advantages and disadvantages.⁷ Bracket failure at the bracket-adhesive interface is advantageous as it indicates good adhesion to the enamel. However, considerable chair time is needed to remove the residual adhesive, with the added possibility of damaging the enamel surface during the cleaning process. In contrast, when brackets fail at the enamel-adhesive interface, less residual adhesive remains on the enamel but then bracket failure probably occurs more often during treatment, disrupting chair time and prolonging the duration of orthodontic treatment.

The SEM results showed that the enamel surface, conditioned first with NaOCl and followed with phosphoric acid, was qualitatively rougher than when no NaOCl was used. Etching patterns of type 1 and 2 were observed on enamel surfaces of premolars conditioned with NaOCl followed by acid-etching (Fig 2). Etching patterns of type 3 were observed in premolars where no NaOCl was used (Fig 3). These results are similar to the ones reported by Espinosa et al²⁸ in 2008. Etching of enamel with 37% phosphoric acid after eliminating the organic elements from the enamel surface probably produces longer adhesive tags that penetrate the enamel. The longer tags greatly increase the mechanical retention of adhesives to the enamel, particularly of RMGIs, as demonstrated in the present study.

RMGIs provide the advantages of sustained fluoride release and the ability to bond brackets in a moist environment (due to their hydrophilic properties). The latter advantage is particularly useful for bonding attachments to second molars. These molars are not being routinely banded, probably due to the difficulty/pain involved. This occurs due to the tissue impingement of bands distal to these molars. If these molars are bonded with resin composite, the bonds frequently fail due to saliva contamination of the enamel surface during the bonding procedure. The American Board of Orthodontics has determined that many of the finishing problems in the clinical cases presented for certification arise in second molars.³⁰ By bonding attachments on second molars with RMGIs, the American Board of Orthodontics candidates could improve their chances of passing American Board of Orthodontics' clinical examination. Bonding second molars with RMGIs has a greater chance of success than bonding with resin composites because it has been documented that the presence of humidity on the enamel surface, during the bonding procedure with RMGIs, increases bond strength. However, RMGIs do have some disadvantages. Wetting the enamel surfaces with NaOCl for 1 minute (to increase SBS) and mixing Fuji Ortho LC powder and liquid, takes additional chair time. This adhesive requires a longer time to set than composite resin, and it has a lower SBS in the first half hour after bonding, although it increases 20-fold within the first 24 hours.⁴ Thus, clinicians need to consider the properties of RMGIs to be able to use them successfully. It is hoped that manufacturers in the future will develop RMGIs with better initial bond strength. Because of the recent improvements in the fluoride-releasing capabilities and the SBS of RMGIs, it has been suggested that these adhesives should play a greater role (ie, be more widely used) in bonding orthodontic brackets in the future.³¹

Clinical Recommendations

Once Fuji Ortho LC liquid/powder has been mixed, the operator has less than a minute or two (depending on room temperature) to position the brackets before the adhesive begins to harden. This probably occurs due to the ambient light (as it is light-cured). It is therefore recommended to prepare adhesive for only 2 teeth at a time. NaOCl should also be applied to 2 teeth at a time. The saliva suction tip should be positioned in such a fashion as to suction away all NaOCl excess. As RMGIs take a longer time to set (24 h) than composite resins, the authors

recommend tying a very light wire (0.010" SS) or a NiTi wire, as the initial wire to avoid accidental dislodging of brackets immediately after full bonding due to the low initial bond strength of RMGIs. When tying in the initial arch-wire, full bracket engagement should be avoided in severely malaligned teeth. When bonding brackets, care should be taken to avoid maxillary teeth from biting against lower arch brackets, preventing accidental dislodgement.

The authors agree with Forsberg et al³¹ who demonstrated that the labial enamel of teeth ligated with an elastomeric ring may exhibit a significantly higher number of microorganisms in the plaque than incisors ligated with steel wire. It is then understandable that WSLs occur so frequently, both due to the widespread use of elastomeric rings, or chains, to tie arch-wires, and to the use of nonfluoride releasing bonding adhesives.

Using a systematic review Benson et al³³ concluded that there is some evidence that the use of daily NaF mouth rinse, or a glass ionomer cement, for bonding brackets might reduce the occurrence and severity of WSLs during orthodontic treatment.

This article is being published in the hope that it will create awareness among clinicians that they might diminish the incidence of WSLs by using NaOCl in combination with fluoride-releasing RMGIs.

Conclusions

- Significantly greater bracket SBS can be obtained with Fuji Ortho LC if the enamel surface is wetted for 1 minute with 5.25% NaOCl, before etching.
- When 5.25% NaOCl is used to deproteinize the enamel surface, brackets bonded with Fuji Ortho LC have comparable SBS to brackets bonded with Transbond XT.
- With 5.25% NaOCl use, the ARI scores are similar when either Transbond XT or Fuji Ortho LC is used to bond brackets.
- Applying 5.25% NaOCl to the enamel surface eliminates the organic elements. This effect allows the acid etchant to penetrate more effectively into the enamel, creating type 1 and 2 etching patterns. The increased bonding strength allows the orthodontist to use fluoride-releasing RMGIs as bonding adhesives to be able to possibly protect enamel from developing WSLs, which is a major iatrogenic effect of orthodontic treatment. Combining clinical aims and experience with the best available evidence should be an important goal of every clinician.
- Additional research is needed to determine the real clinical benefits of fluoride-releasing RMGIs. In vivo testing of the effectiveness of RMGIs to prevent WSLs would be a worthwhile endeavor.

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