2008

Alternative Orthodontic Bonding Protocol Using Self Etching Primer

Rush-Baker Gaines Caldwell
Virginia Commonwealth University

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

By

Rush-Baker G. Caldwell, DMD
B.S., Wofford College, 2002
D.M.D., Medical University of South Carolina, 2006

Thesis Director: ESER TÜFEKÇİ, D.D.S., MS. Ph.D
ASSOCIATE PROFESSOR, DEPARTMENT OF ORTHODONTICS

Virginia Commonwealth University
Richmond, Virginia
May 5, 2008

Acknowledgments

The list of acknowledgments is long and distinguished. First, I would like to thank Dr. Eser Tüfekçi for being so persistent with her encouragement and gracious with her time. Dr. Peter Moon deserves special recognition for his guidance and instruction during this study. I am also thankful to Jon Rucker for his selflessness in helping me to complete this project. The biggest acknowledgement goes to my lovely wife for helping and encouraging me to finish strong and to complete a meaningful project. Lastly, I would like to thank 3M Unitek for providing the necessary materials to complete this study.

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Abstract

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Thesis Director: Eser Tüfekçi, D.D.S., MS, Ph. D.
Associate Professor, Department of Orthodontics

The purpose of the current study was to develop a bonding method that can achieve clinically acceptable bond strength values while leaving a minimum amount of adhesive on the tooth surface during the debonding process. One hundred teeth were randomly assigned into groups. Five different enamel surface preparation protocols were tested (N = 20, each): Conventional acid etch, standard SEP, SEP applied with a light brush stroke (altered SEP 1), SEP applied directly to the composite of pre-coated bracket (altered SEP 2), and Primer Only groups. Brackets were debonded using an Instron universal testing machine (Instron, Canton, MA) in shear mode and the mean shear bond strength values were calculated. In addition, enamel surfaces were examined under light microscope to determine the location of failure using ARI. The Primer Only group had significantly lower mean shear strength (0.14 MPa, $P<0.05$) than the conventional acid etch (13.81 MPa), standard SEP (12.10 MPa), altered SEP 1 (10.80 MPa), and altered SEP 2 (11.48 MPa) groups. The conventional acid etch, standard SEP, altered SEP 1 and altered SEP 2 groups were not significantly different from each other ($p>0.05$). With

respect to ARI values, there was a significant difference among these four groups. 85% of samples in the altered SEP 2 group had 10% or less composite resin left on their surfaces. This group had also a mean shear bond strength value of 11.43 MPa, significantly above the minimal strength needed for orthodontic attachment bonding, and the lowest ARI values overall. Therefore, application of SEP directly to the composite resin of the pre-coated brackets may be an ideal bonding method by providing adequate bond strength and leaving a minimum amount of composite resin on the tooth surface during debonding. It should be kept in mind that future *in-vivo* studies would be needed to confirm the findings obtained from the current *in-vitro* study.

Introduction

The practice of orthodontics consists of meticulous patient evaluation and treatment planning followed by the execution of the plan utilizing a well thought-out series of mechanics. Once archwires are engaged into orthodontic attachments, tooth movement is initiated by forces generated by the bracket/archwire system. Currently, orthodontic brackets are directly bonded onto tooth surfaces with orthodontic bonding agents. The continuous developments in dental materials resulted in a wide range of commercially available bonding systems.

Direct bonding using the enamel acid etch technique was first introduced into dentistry in 1955 by Buonocore.[1] A decade later the concept of direct bonding of orthodontic brackets using epoxy resin pioneered by Newman[2] and the invention of bis-GMA resins by Bowen[3] paved the way for the direct placement of brackets onto tooth enamel in orthodontics. Since the introduction of this new concept, the art and science of orthodontic attachment placement has spurred much research and debate that led to the development of contemporary orthodontic resins.

Nowadays, chemical- and light- cured adhesives are universally used for routine bonding of orthodontic attachments. Direct bonding of orthodontic appliances offers many advantages including increased patient comfort by eliminating the need to band teeth, improved esthetics, and increased ability in maintaining better oral hygiene.[4,5]

Currently in orthodontics, two methods of direct bonding to enamel are widely used. The "conventional" method involves a two-step process using a 37% phosphoric acid to etch the enamel surface, followed by a priming agent, and finally adhesive resin. A one-step method, on the other hand, using self etch primer (SEP) combines the acid etch and primer steps into a single procedure, resulting in decreased chair time for the clinician.[6]

Regardless of which bonding method is used, orthodontic brackets should exhibit adequate bond strength capable of withstanding intraoral and orthodontic forces. It has been reported that shear bond strength values of 6-8MPa are ideal for clinical orthodontic needs and the safe removal of brackets without causing damage to enamel during debonding procedures at the end of treatment.[7]

The question of how SEPs and the conventional bonding technique compare was evaluated by Bishara et al in 2001.[8] Brackets bonded with SEP were found to have a significantly lower mean shear bond strength compared to those bonded with a conventional two-step acid etch system. However, mean shear bond strength values for the SEP group (7.1 ± 4.4 MPa) were within the clinically acceptable range of 6-8 MPa. Lill et al[9] also reported a significantly lower and clinically acceptable bond failure rate with SEP and suggested the need for pumice prophylaxis when using SEP for orthodontic bonding. Nevertheless, SEP is adequate for clinical orthodontic applications since clinically acceptable bond strength values may be achieved when manufacturer's recommendations are followed during the bonding process. In addition, SEP is found to leave significantly less adhesive on the tooth surface than the conventional acid-etch technique making the debonding and adhesive removal process very efficient.[10-12]

Debonding of brackets consists of physical removal of appliances using pliers followed by an adhesive "cleanup" protocol. Bracket and adhesive removal at the end of active treatment has the greatest potential for enamel damage.[11,13] In orthodontics, the ideal debonding and resin removal technique should leave the tooth surface with a natural finish without removing an excessive amount of tooth structure.[8,14]

The concern over enamel damage post-debonding stems from the importance of the layer of enamel that is affected during the removal of composite resin. The uppermost layer is the hardest, with a higher mineral and fluoride content than the deeper zones of enamel.[15] When there is a loss of surface enamel, enamel prism endings are exposed to the oral cavity. This may lead to a decreased resistance to the acids associated with dental plaque, which in turn may increase the likelihood of decalcification in patients with poor oral hygiene.[15]

In orthodontics, there are many techniques suggested for the removal of orthodontic resin. Many of these procedures have been studied for finishing of the tooth surface, enamel loss and time efficiency for bracket and resin removal. How safely and effectively to remove orthodontic appliances and adhesive remnants without producing excessive enamel damage has been widely investigated in order to develop a removal protocol that would leave the tooth surface in its original status.[11,14,16-22] Less enamel loss has been reported with the use of slow speed removal techniques by many investigators.[11,16,17,21,22] However, the use of a high-speed handpiece for resin removal was found to be less damaging by other authors.[14,18] Amidst the confusion, some investigators have even come up with new removal methods.[19,20]

The earliest study on composite removal by Newman and Facq[23] concluded that bracket and adhesive removal followed by pumicing could return the tooth surface to its original appearance. In contrast to most studies, there was no information on how the bracket and adhesive was removed in this study. In 1977, Gwinnett and Gorelick[24] reported that use of a green rubber wheel followed by pumice or composite finishing paste was satisfactory in restoring the enamel to its natural surface. In 1995, Campbell[14] described in detail a technique to return the enamel to its original architecture. He proposed using a high-speed number 30 fluted tungsten carbide bur with a "brush" stroke followed by Enhance points and cups (Dentsply, Milford, DE) to polish gross scarring. Subsequently, the use of water slurry of fine pumice followed by brown and green cups was suggested to bring the enamel surface to a high gloss.

In 1979, Retief and Denys[25] expressed concern on this issue by stating: "with modifications of the acid etch technique and improvements of the physical and mechanical properties of the resin systems, the removal of directly bonded attachments and the finishing of the underlying enamel have become an acute clinical problem". In their study, the use of a 12-fluted carbide bur at high speed followed by progressive polishing was employed to return the tooth surface close to its original architecture.

In 2002, Alexander[20] proposed the use of a YAG laser for removal without enamel damage. Despite offering a tooth surface with no enamel damage, this technique is not considered clinically practical due to the excessive amount of time needed for removal. In a study by Radlanski,[19] the use of a bur with an altered wedge angle resulted in a decreased overall cutting capacity on the enamel while the removal efficiency within the adhesive resin was not affected. Perhaps the most accurate finding in the current literature is that there is no ideal clean-up method available for removal of orthodontic adhesive.[26]

Eliades et al.[27] stated that, "in spite of the substantial increase in the means available for the removal of adhesive resin post-debonding, the methods utilized to investigate the effects of various resin grinding protocols have not followed the same pace", drawing attention to the qualitative nature of the methods used. In fact, only a few studies have directly measured the actual enamel loss associated with debonding and adhesive removal. Therefore, because of lack of a quantitative approach, these studies were considered not to provide a reliable comparative assessment of enamel surfaces.[27]

In recent years, there has been a paradigm shift toward conducting studies that included a quantitive approach to investigate enamel damage following debonding. In 2004, Tüfekçi et al[21] compared enamel loss from human teeth with and without white spot lesions (WSL), using low-speed finishing burs or disks. Debonded surfaces were analyzed with a contact stylus profilometer, and digitized data were compared to baseline readings using software. There were no significant differences in enamel loss between the bur and disk groups in teeth without WSL. However, in teeth with WSL, burs removed less enamel compared to disks. Nevertheless, differences between the groups were so small that they may not be clinically significant.[21]

In another study,[27] profilometery was used to quantitatively assess surface roughness following two different debonding techniques. Resin removal with a diamond bur at high-speed was shown to result in a significantly rougher surface when compared to traditional carbide bur removal at high-speed. These results suggested that the use of a carbide bur at high-speed causes less enamel damage than a diamond one.[27]

Hosein et al.[11] also conducted studies of a quantitative nature by employing the use of planar surfometry. A net loss of 2.76 μm of enamel loss was reported with pumicing and conventional acid etch, as opposed to only 0.27 μm with a self-etching primer. The Adhesive Remnant Index (ARI) was also used to determine the location of bond failure between the orthodontic resin and the bracket. At debonding, there were significant differences in the adhesive remnant index scores between the acid etch and SEP groups. There was significantly more adhesive left on the enamel surface treated with the conventional acid etch technique, compared to those treated with SEP.[11] These findings were in agreement with those reported by Larmour et al in 2003.[12] These authors also found that SEP application for orthodontic attachment application provides adequate bond strength values while having significantly less adhesive remnants on tooth surfaces than the corresponding conventional acid etch group.[12]

In 1999, Urabe et al[13] investigated if shear bond strength was affected by variations in the concentrations of acid etch. It was shown that the acid concentration did not have a direct effect on the bond strength values. However, there were statistically significant differences in the ARI scores among the groups that were treated with different acid etch concentrations. The groups that received lower concentrations of acid etch had ARI values indicating less adhesive remaining on the tooth. These results suggest that decreasing traditional acid concentrations can provide comparable bond strengths while leaving a minimum amount of adhesive on the enamel surface upon debonding.[13] While bond failure location at the bracket/ orthodontic adhesive interface is desirable due to decreased likelihood of enamel fracture,[6,8] increased amount of resin remnants may predispose the enamel to even more damage during the composite removal procedure in light of the abrasive nature of removal techniques.[11,13] In fact, it has been shown that as much as 55 μm of enamel structure can be removed during the adhesive removal process at the end of debonding.[28]

In analyzing the body of work related to enamel damage produced by placement and removal of orthodontic appliances, there is a consensus among authors that considerable change in the surface enamel characteristics is inevitable upon removal of orthodontic appliances. Therefore, the goal of orthodontists should be to employ a protocol of bonding/debonding that aims to minimize enamel damage and to bring the enamel surface to its original status. The purpose of the current study was to develop a bonding method that can achieve clinically acceptable bond strength values while leaving a minimum amount of adhesive on the tooth surface at debonding.

Materials and Methods

One hundred and five extracted human premolars were collected and stored in 0.1% (wt/vol) thymol (Alfa Aesar, Ward Hill, MA) from the time of collection until bracket placement. Only healthy teeth with no apparent defects were included in the study. Each tooth was mounted in phenolic rings (Buehler, Lake Bluff, Illinois) using cold cure acrylic resin. Twenty teeth were randomly assigned to each one of the following five groups: Acid etch group, standard SEP group, Altered SEP 1 group, Altered SEP 2 group, and Primer Only group. The remaining five samples were set aside for the calibration of the testing machine (Instron, Canton, MA) prior to the testing of the actual samples.

All five groups were bonded with APC II Victory Series maxillary premolar brackets (3M Unitek, Monrovia, CA) with a base area of 0.096129 cm^2 as reported by the manufacturer. A single operator performed all of the bonding procedures. Initially, tooth surfaces were cleaned using non-fluoridated pumice for 5 seconds, rinsed for 10 seconds and then air dried with oil-free compressed air. Subsequently, teeth in each group were subjected to different protocols as follows:

Acid Etch Group (N=20): Teeth were etched with 35% phosphoric acid (Transbond XT Etching Gel, 3M Unitek, Monrovia, CA) for 15 seconds, rinsed with copious amounts of water and then dried with oil free compressed air until there was a frosty white appearance, primed for 3 seconds with Transbond Moisture Insensitive Primer (MIP) (3M Unitek, Monrovia, CA), and then air dispersed for two seconds.

Standard SEP Group (N=20): Teeth were prepared by vigorously rubbing Transbond™ Plus self etch primer (3M Unitek, Monrovia, CA) with provided microbrush for five seconds, and then air dispersed for two seconds.

Altered SEP 1 Group (N=20): Teeth were prepared by lightly painting Transbond™ Plus self etch primer with provided microbrush for five seconds, and then air dispersed for two seconds.

Altered SEP 2 Group (N=20): Transbond™ Plus self etch primer was applied directly to the composite on the APC II Victory Series bracket. The APC bracket with SEP application was then partially seated on the tooth surface to allow the composite/SEP to be expressed around the margins of the bracket base. After an initial seating of approximately 5 seconds, the bracket was firmly placed.

Primer Only Group (N=20): Teeth were primed for 3 seconds with Transbond Moisture Insensitive Primer with provided microbrush, and then air dispersed for two seconds.

Following bracket placement in each of the five groups, flash adhesive was removed from the borders of the bracket. The bracket was then cured for 3 seconds on the mesial and distal surfaces using a plasma arc visible light-curing unit (Ortholite, 3M Unitek, Monrovia, CA).

During bonding procedures, samples were prepared in random order on five separate occasions to eliminate operational errors that could otherwise affect the results. Once prepared, each sample was given a corresponding group letter (A-E) and number (1-20) based on the group to which they belonged. Samples were then kept in distilled water from the time of bonding until the bond strength test was to be performed. At the end of a

24 hour waiting period, mechanical testing was performed using an Instron universal testing machine (Instron Corp., Norwood, MA). Samples were seated on a custom holder that could be positioned at different angulations. The sample holder was tilted until the bracket slot was parallel to the upper member of the Instron machine to ensure parallelism between the bracket surface and the testing machine. Samples were debonded in shear mode using a cross-head speed of 0.2mm/min. The force required to debond the bracket was recorded. The shear strength was calculated by dividing the force by the bracket base area (0.096129 cm^2). The values were then converted into megapascals (MPa).

Following debonding, enamel surfaces were examined under a microscope at 10X magnification to determine the location of the bond failure using the modified adhesive remnant index. Each tooth was given a score of 1 through 5 based on the amount of composite left on the tooth as follows:

1= all the composite remained on the tooth

2= more than 90% of the composite remained on the tooth

3= between 10-90% of the composite remained on the tooth

4= less than 10% of the composite remained on the tooth

5= no composite remained on the tooth

Statistical Analyses

The mean shear bond strength values for each test group were analyzed using a one-way analysis of variance (ANOVA). Since shear bond strength data were not normally distributed, the analysis was performed on the Log transformed value. The average force necessary to debond 5% of the brackets was estimated using Weibull survival analysis with a 95% confidence interval. ARI values were compared using a Chi-square test. In addition, a subset of ARI values consisting of scores of 4 and 5 among the five groups was also analyzed and compared using a Chi-square test.

Results

The mean shear strength values of the five groups tested are given in Table I and Figure 1. Since the shear strength values were skewed, the log-transformed (LT) mean results were analyzed where a zero strength value was set as 0.01 MPa. The results of ANOVA indicated that the five groups were significantly different (P<0.0001). Tukey's HSD indicated that the Primer Only group had significantly lower shear strength than the other groups (P<0.05). Acid etch, standard SEP, altered SEP 1, and altered SEP 2 were not significantly different from each other.

Table I: Mean shear strength (MPa) of the five groups

Group (N=20)	LTMean	Lower 95% CI* of Mean (MPa)	Higher 95% CI* of Mean (MPa)
Acid etch	13.87	8.91	21.57
Standard SEP	12.10	7.78	18.83
Altered SEP 1	10.80	6.94	16.79
Altered SEP 2	11.43	7.35	17.78
Primer Only	0.14**	0.09	0.22

* Confidence Interval
** Significantly lower than other 4 groups (P<0.05)

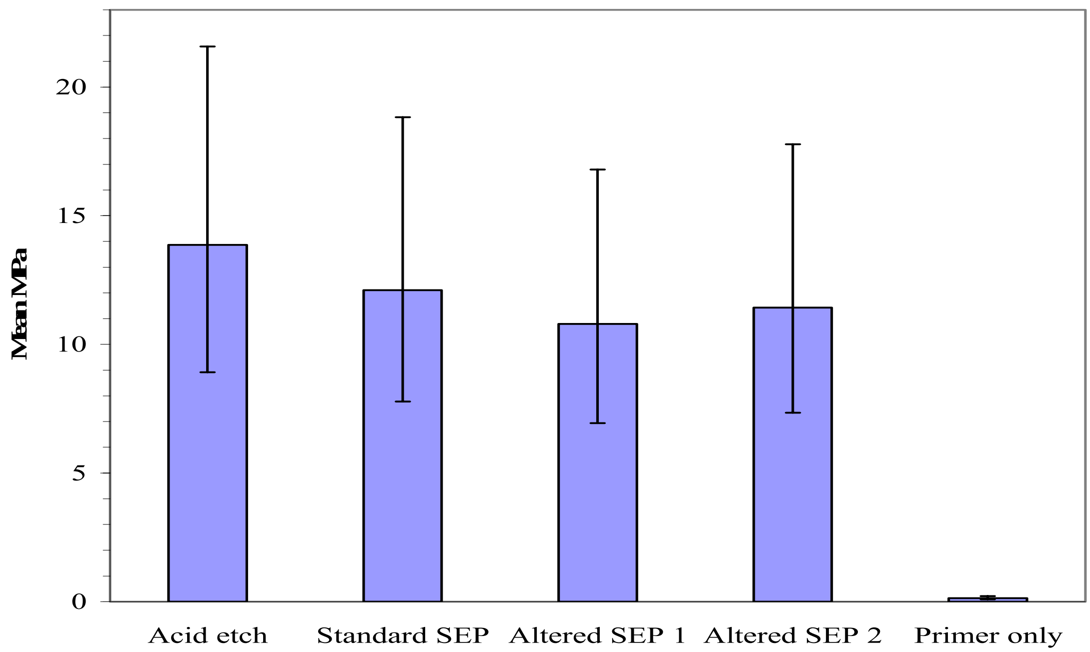

Figure 1: Mean shear strength (MPa) of the five groups

The force necessary to debond 5% of the brackets (representing a 5% bond failure rate, or the force level at which 95% of the brackets remained on the teeth) was estimated using a Weibull survival analysis. These estimates are shown in Table II and Figure 2.

Table II: Force necessary to debond 5% of all brackets

Group (N=20)	MPa	Lower 95% CI* in MPa	Higher 95% CI* in (MPa)
Acid etch	6.67	5.40	8.23
Standard SEP	5.58	4.48	6.96
Altered SEP 1	5.20	4.23	6.40
Altered SEP 2	6.49	5.21	8.09
Primer only	0.00**	0.00	0.01

*Confidence Interval
** Significantly lower than other 4 groups ($P<0.05$)

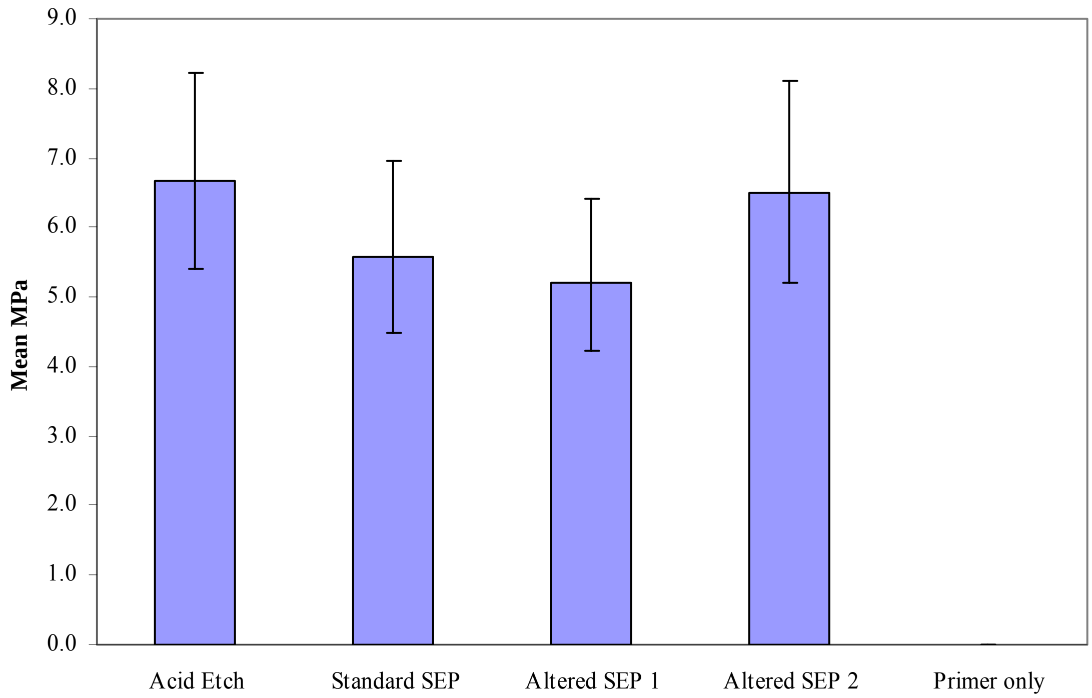

Figure 2: Force necessary to debond 5% of the brackets

The ARI results for each group are shown in Table III. The acid etch, standard SEP, altered SEP 1, altered SEP 2 groups were found to be statistically different than the Primer Only group ($P<0.0001$) but not from each other ($p = 0.22$). Figure III shows the percentage of teeth with less than 10% or no adhesive remaining on the tooth surfaces with ARI scores 4 or 5. There were statistically significant differences among these four groups when only ARI scores of 4 and 5 were taken into consideration ($p = 0.0124$). In both the acid etch and standard SEP groups, 45% of the samples had ARI scores of either 4 or 5. In contrast, 75% of the samples in the altered SEP 1 and 85% of the samples in the altered SEP 2 groups had ARI scores of 4 or 5 indicating that experimental groups had less adhesive remnants compared to those control groups (self etch and standard SEP).

Table III: ARI values for each of the five groups

Group	ARI Values					Total
	1	2	3	4	5	
Acid Etch	2	3	6	7	2	20
Standard SEP	1	3	7	6	3	20
Altered SEP 1	0	0	5	10	5	20
Altered SEP 2	0	1	2	10	7	20
Primer Only	0	0	0	2	18	20
Total	3	7	20	35	35	100

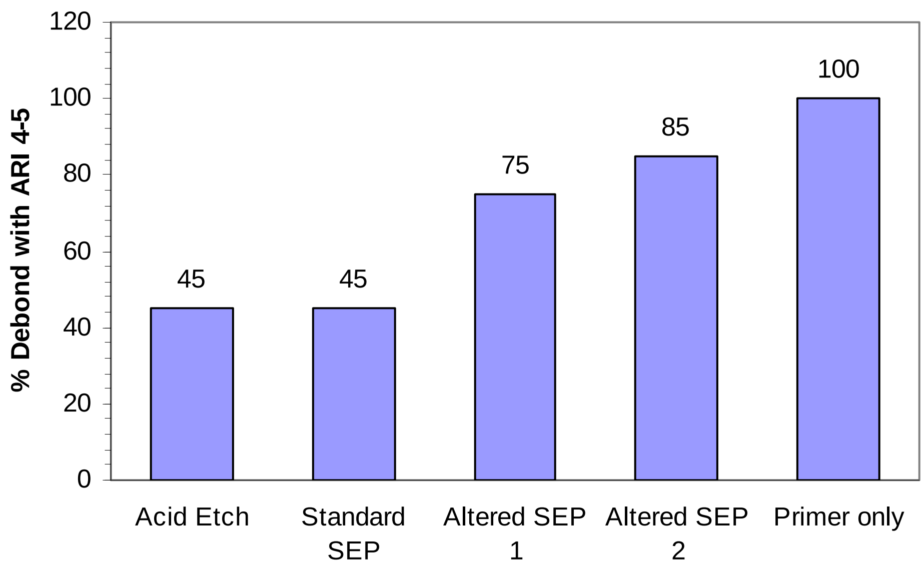

Figure 3: Percentages of teeth with ARI values of 4 or 5 (10% or less adhesive remaining)

Discussion

The purpose of the present study was to determine if altering current self-etching primer application protocols could create a composite/enamel interface capable of withstanding orthodontic forces while leaving minimal amounts of adhesive upon debonding compared to conventional bonding techniques. There were 5 bonding protocols evaluated: 2 conventional (self etch and standard SEP, as controls) and 2 experimental (altered SEP 1, altered SEP 2) and one as a negative control (Primer Only).

The findings of the current study indicate that with the exception of the Primer Only group, all remaining groups exhibited clinically acceptable mean shear bond strength values. In addition, the Weibull survival analyses showed that the bond strength required to debond 5% of the brackets was below the minimum clinically acceptable level of 6 MPa in the standard SEP and altered SEP 1 groups. The acid etch and altered SEP 2 groups had clinically acceptable 5% bond failure rates at shear bond strengths of 6.67 MPa and 6.49 MPa respectively.

Since 85% of samples in the altered SEP 2 group had 10% or less (ARI scores of 4 and 5) composite left on the tooth surface upon debonding while exhibiting sufficient enough bond strength, it may be concluded that there is less potential for enamel damage to occur during removing brackets bonded using this method. In addition, decreased bonding time because of one-step surface preparation, and decreased etched enamel surface are the other advantages of using the altered SEP 2 method. Etching less enamel surface would prevent the unnecessary removal of enamel structure during the etching process. Studies that investigated the repair procedures on etched enamel surfaces not covered by adhesive suggest that the remineralization process takes place to some degree; however, the enamel surface is not restored completely to its normal status.[29-31]

The results of this study were similar to those of Vicente et al.[32] In analyzing bond strengths of two self etch primers versus traditional acid etch, there were no statistically significant differences among the groups. In addition, analysis of ARI values indicated that the SEP groups had statistically less adhesive remnants compared to the acid etch group.[32] These findings are also in agreement with those by Hosien[11], Larmour[12], and Cal-Neto et al.[10] Although the current study did not find a statistical difference in overall ARI values among the SEP and acid etch groups, differences were noted when comparing the number of samples in each group with less than 10% or no adhesive left on the enamel surface corresponding to the ARI scores of 4 and 5, respectively.

The potential damage to enamel during bracket removal procedures has also been investigated. Brosh et al[33] compared the effects of bracket removal pliers engaged at the base and the wings of the brackets. It was shown that the force needed to remove the bracket at its base was 1.5 times greater than removing it at its wings. This greater force to debond could lead to greater enamel damage upon debonding.

In summary, in light of these studies, it may be concluded that independent of the technique used, each time a bracket is removed and composite resin clean-up is carried out there is some damage to enamel and that there is no ideal clean-up method available. The current study aims to take what is known about enamel damage during bonding and debonding procedures and apply that knowledge in seeking a new bonding method. Cleaning remaining adhesive upon bracket removal is the most damaging portion of the bonding/debonding procedure.[11,13] Therefore, it is desirable to use a combination of bonding agent and technique that would provide an acceptable bond strength while leaving a minimum amount of adhesive on the tooth surface during debonding and resin removal procedures.

It should be kept in mind that different bonding systems/techniques with statistically significant differences in mean bond strengths may have no statistically significant differences in clinic failure rates. Even though Weibull analysis offers clinical failure predictions based on *in-vitro* data, it would be more accurate to conduct clinical studies to evaluate the actual *in-vivo* behavior of these systems.

Conclusion

The altered SEP groups performed similarly to the standard acid etch and SEP groups when bond strengths were compared. The Primer Only group performed inadequately in bond strength tests as anticipated. It was concluded that all groups except the Primer Only group could be used in bonding orthodontic attachments with the goal of achieving clinically acceptable bond strengths (6-8MPa). Since 85% of the "altered SEP 2" samples had ARI scores of 4 or 5, it may be concluded that this group was able to meet the goals of this study the best. In other words, samples in the "altered SEP 2" group produced acceptable bond strengths while leaving less adhesive on the enamel post-debonding. Therefore, SEP application directly to the composite resin on the APC brackets may provide adequate bond strength with a minimum amount of enamel loss during orthodontic treatment. Future clinical studies are needed to confirm the findings of the current study.

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Appendix (Raw Data)

Tooth #	Debonding Force (lbs)	Debond Force (MPa)	ARI
Acid Etch			
1	35.7	16.51	3
2	9.7	4.48	4
3	33.3	15.40	2
4	35.7	16.51	4
5	43.2	19.99	2
6	38.7	17.90	2
7	32.2	14.90	3
8	32.5	15.03	3
9	42.2	19.52	3
10	26.2	12.12	4
11	26.2	12.12	4
12	50.5	23.36	3
13	36.5	16.88	4
14	34.5	15.96	1
15	27.5	12.72	1
16	25.4	11.75	5
17	28.5	13.18	4
18	27.8	12.86	4
19	13.6	6.29	5
20	20	15.82	3
Standard SEP			
1	15.8	7.31	4
2	28.2	13.04	2
3	33.7	15.59	5
4	49.7	22.99	2
5	14.5	6.70	3
6	27.7	12.81	3
7	33	15.27	4
8	49.2	22.76	2
9	42	19.43	4
10	9.4	4.34	1
11	17.5	8.09	4
12	13.6	6.29	5
13	33.6	15.54	3
14	18	8.32	5
15	42.8	19.80	3
16	32	14.80	3
17	35.5	16.42	3
18	25.6	11.84	4
19	32.7	15.13	4
20	20	9.25	3

Altered SEP 1			
1	22.9	10.59	4
2	31.5	14.57	3
3	41.1	19.01	4
4	32.4	14.99	3
5	19.7	9.11	5
6	22	10.18	4
7	25.4	11.75	4
8	20.6	9.53	4
9	19.4	8.97	4
10	26	12.03	4
11	13.9	6.43	4
12	16.6	7.68	5
13	32.5	15.03	5
14	8.8	4.07	4
15	23.9	11.05	3
16	45.5	21.05	3
17	37.5	17.35	3
18	12.5	5.78	5
19	24.7	11.42	5
20	25	11.56	4
Altered SEP 2			
1	25.2	11.66	4
2	31.4	14.52	3
3	20.8	9.62	5
4	30	13.88	5
5	34.9	16.14	2
6	27.2	12.58	5
7	33.7	15.59	4
8	32.3	14.94	3
9	18.5	8.56	4
10	14.5	6.70	4
11	18	8.32	5
12	33	15.27	5
13	23.5	10.87	4
14	23.9	11.05	4
15	19.4	8.97	4
16	24	11.10	5
17	21.4	9.90	4
18	21.5	9.94	5
19	24.5	11.33	4
20	29.8	13.78	4
Primer Only			
1	0.1	0.04	5
2	5.27	2.43	4

3	0	0	5
4	17	7.86	4
5	11.2	5.18	5
6	0.2	0.09	5
7	0.19	0.08	5
8	0	0	5
9	2.08	0.96	5
10	0.3	0.13	5
11	0.04	0.01	5
12	0.1	0.04	5
13	0.04	0.01	5
14	0	0	5
15	0.2	0.09	5
16	0.2	0.09	5
17	3.2	1.48	5
18	0.1	0.04	5
19	1.58	0.73	5
20	0.42	0.19	5

Vita

Rush-Baker G. Caldwell was born in Greenville, South Carolina on February 19, 1980. He attended James L. Mann High school until 1998. He proceeded to Wofford College in Spartanburg, South Carolina and graduated Magna Cum Laude with a Bachelor of Science degree in Biology. In May of 2006, he graduated top of his dental school class at the Medical University of South Carolina. He is currently a postgraduate resident in the Orthodontics program at Virginia Commonwealth University and will receive a certificate in Orthodontics along with a Master of Science degree in Dentistry.