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Original Research

Comparison of Shear Bond Strength of New Self-etching Primer with Conventional Self-etching Primers: An *In-vitro* Study

Abhinay Sorake[1], Rohan Rai[2], Gautham Hegde[1], Ridhima Suneja[3], Naveena Kumar[4], Jibin Skaria[5]

Contributors:

[1]Reader, Department of Orthodontics and Dentofacial Orthopaedics, A.J. Institute of Dental Sciences, Mangalore, Karnataka, India; [2]Professor & Head, Department of Orthodontics and Dentofacial Orthopaedics, A.J. Institute of Dental Sciences, Mangalore, Karnataka, India; [3]Lecturer, Department of Conservative Dentistry and Endodontics, Gulf Medical University, Ajman, UAE; [4]Assistant Professor, Department of Orthodontics and Dentofacial Orthopaedics, A.J. Institute of Dental Sciences, Mangalore, Karnataka, India; [5]Post-graduate Student, Department of Orthodontics and Dentofacial Orthopaedics, A.J. Institute of Dental Sciences, Mangalore, Karnataka, India.

Correspondence:

Skaria J. Department of Orthodontics, A.J Institute of Dental Sciences, Mangalore, Karnataka, India. Phone: +91-9972988949. Email: drjibinskaria@gmail.com

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Abstract:

Background: In the past few years, there has been a major research drive to increase bond strength between dental materials and dental hard tissue and to reduce the associated demineralization around fixed orthodontic appliances. Thus, a recent approach is to incorporate an antibacterial agent into the primer to reduce the demineralization and enhance bond strength. The objective of this study was: (1) To evaluate the shear bond strength of orthodontic preadjusted edgewise appliance brackets bonded to extracted premolar teeth with antimicrobial self-etch primer (Reliance self-etching primer, Clearfil Protect Bond) and self-etching primer without antimicrobial agent (Clearfil SE bond). (2) To compare the mean shear bond strength values of the tested materials to conventional self-etching primer Transbond Plus.

Materials and Methods: A total of 125 extracted human premolar teeth were randomly divided into five groups of 25 teeth each. Each sample was embedded in an acrylic block of polymethyl meth acrylate resin till coronal portion. Instron testing machine model LR LOYD 50 K was used for testing the shear bond strength of individual samples.

Results: The results of the study showed that all five groups had adequate clinically acceptable bond strength. In intergroup comparison, there was statistically significant difference in bond strength of Reliance self-etching primer, Promt L pop, Clearfil Protect Bond, clearfil SE bond and Transbond Plus.

Conclusion: Reliance self-etching primer showed highest bond strength, followed by Clearfil Protect Bond, clearfil SE bond, and Transbond Plus. Clearfil Protect Bond primer containing methacryloxy dodecyl pyridium bromide have been demonstrated to kill *Streptococcus mutans* within a short time of contact and also exhibits an inhibitory effect on the growth of bacteria on its surface.

Key Words: Methacryloxy dodecyl pyridium bromide, self-etching primer, shear bond strength, tooth demineralization

Introduction

Over the past 50 years, the bonding of various adhesives to enamel and dentine has developed a niche in nearly all areas of dentistry, including orthodontics. The direct bonding of orthodontic attachments has become a routine clinical procedure. It was Buonocore in 1955, who initially demonstrated the adhesions of acrylic filling materials to enamel, following acid etching with phosphoric acid. Newman in 1965 suggested that the technique might be used for orthodontic bonding. Since then, many attempts have been made using various different methods and materials for the enamel surface pre-treatment, as an important ingredient in the bonding protocol.[1] Recently, several bonding systems have been developed and proposed as the sixth generation of adhesive materials. These materials are known as one-step bonding systems. The sixth-generation systems are composed of an acidic solution that cannot be kept in place, must be refreshed continuously and have a pH that is not enough to properly etch enamel. Many researchers have studied adhesion to enamel. Although different modalities have been tested, at present, phosphoric acid etching seems to be the most frequently used method of enamel surface preparation. One of the potential disadvantages of etching with phosphoric acid is that the acid causes demineralization of the most superficial layer.[2]

Conventional adhesive systems use three different agents (an enamel conditioner, a primer solution, and an adhesive resin) in the process of bonding orthodontic brackets to enamel. Combining conditioning and priming into a single treatment step results in improvement in both time and cost effectiveness to the clinicians and indirectly to the patient. Contemporary self-etching primers, which were introduced in 1990's, and the recently introduced, all in one adhesives are attractive additions to the clinician's bonding armamentarium. They are user-friendly, in that the number of steps required in the bonding protocol is reduced. As the smear plugs are not removed prior to the application of these adhesives, the potential for post-operative sensitivity that is caused by incomplete resin

infiltration of patent dentinal tubules can be substantially reduced.[3]

In self-etching primer, the active ingredient is a methacrylate phosphoric acid ester. The phosphoric acid and the methacrylate group are combined into a molecule that etches and primes at the same time. Etching and monomer penetration to the exposed enamel rods is simultaneous. In this manner, the depth of the etch is identical to that of the primer penetration. Because there seems to be only 1 recent self-etching adhesive product (Transbond plus 3M Unitek, Monrovia, California) designed, especially for orthodontic purpose, most of the previous orthodontic bond strength studies tested various self-etching adhesives used in restorative dentistry. Despite some encouraging findings, variations in results or methodologies used necessitate further *in-vitro* studies before routine use of self-etching adhesives for orthodontic bonding purposes can be advocated.[4] Decalcification around orthodontic bracket is a common problem and a potential risk of orthodontic treatment. There is a significant increase in salivary and plaque levels of *Streptococcus mutans* in patients undergoing fixed appliance treatment. The creation of new retentive areas favors the local growth of *S. mutans*, which in turn increases the general infection level of this organism. Decalcification marks can be seen as early as 4 weeks after the band or bracket placement. Clinically, these appear as white spot lesions around the brackets and represent the early forms of enamel caries. Aiming to prevent caries, some investigators reported attempts to inhibit plaque accumulation on the surfaces of teeth and restoration by antibacterial varnishes or resin materials containing antibacterial agents. However, not much is known about the use of antimicrobial agents containing orthodontic bonding adhesives. Fluorides have been incorporated into orthodontic resins, the most common class of orthodontic adhesive; unfortunately, it has limited antimicrobial activity and a short term of release. In the literature various methods have been suggested to prevent enamel demineralization e.g., applying a light cured unfilled resin to the labial surface of teeth with previously placed orthodontic appliances, fluoride varnish, chlorhexidine coating varnish, polymeric coating fluoride added to composite, or fluoride releasing glass isonomer cement. Methods such as antibacterial ozone gas therapy and tooth conserving adhesives, are becoming more important in dentistry.

To prevent harmful effects caused by oral bacteria, an adhesive system with antibacterial properties is available. This is provided by a newly developed monomer methacryloxy dodecyl pyridium bromide (MDPB) added to the primer of an adhesive system. Several *in-vitro* studies investigated the preventive effect of MDPB, demonstrating substantial antibacterial effects on infected human dentin.

Thus, a recent approach is to reduce demineralization area on the enamel surface during fixed appliance therapy by incorporating an antibacterial agent into the bonding system. This methodology was based on the hypothesis that, if the antibacterial agent MDPB has a preventive effect on enamel, this would be reflected in lower decalcification incidence and also in better gingival status *in-vivo*. Clearfil protect bond contains MDPB, which is reported to decrease decalcification. These innovative products have promised to decrease decalcification or increase efficiency of the bonding process or both; however, their bond strengths for bonding orthodontic brackets has not been evaluated.[5]

Hence, this study was undertaken to compare shear bond strength of orthodontic brackets bonded to human enamel conditioned by self-etch primer with MDPB as antimicrobial agent (Clearfil Protect Bond) and self-etch primer without antimicrobial agents (clearfil SE bond) by Kuraray, Prompt L pop (3M) and control group as Transbond Plus (SEP) and all groups were bonded with Transbond XT adhesive. A new self-etch primer Reliance self-etch primer was used in the study to compare its properties with all other groups.

Aims and objectives

Objectives of this study were:

1. To evaluate the shear bond strength of orthodontic preadjusted edgewise appliance (PEA) bracket bonded to extracted premolar teeth with self-etch primer Reliance self-etching primer, Clearfil Protect Bond, clearfil SE bond and Promt L pop
2. To compare the mean shear bond strength values of the tested materials to conventional self-etch primer Transbond Plus.

Materials and Methods

Totally 125 freshly extracted human premolars were collected and stored in a solution of 0.1% (weight/volume). Thymol solution for a period of 15 days to prevent dehydration and bacterial growth.

Inclusion criteria

1. Intact buccal enamel
2. No caries
3. No visible cracks.

The teeth were fixed in acrylic self-cure blocks such that the roots were completely embedded in acrylic up to cementoenamel junction.

Distribution of the sample

Teeth were divided into five groups of 25 teeth each
Group I (TP): Transbond Plus (Fifth generation)
Group II (SE): Clearfil SE bond (Fifth generation)
Group III (CP): Clearfil Protect Bond (Sixth generation)
Group IV (PP): Prompt L pop (Sixth generation)
Group V (RSEP): Reliance self-etching primer (Sixth generation) (Figure 1).

Brackets
Bondable stainless steel 0.022" slot PEA (Roth prescription) upper and lower first premolar brackets, (American Orthodontics, USA) were included in the study. The average bracket base surface area was determined to be 8.686 mm^2 (as prescribed by the manufacturer).

Light curing unit
3M curing light 2500 (3M dental products) with an intensity of 480 nm was used for polymerization for 20 s. Each bracket was cured for 4 s from gingival, 4 s from occlusal, 4 s from mesial, 4 s from distal and 4 s inter proximally.

Adhesive
Transbond XT was used for bonding all five groups.

Primer
1. Transbond plus self-etching primer (3M, Unitek, Monrovia, Calif)
2. Clearfil SE bond (Kuraray, Osaka, Japan)
3. Clearfil Protect Bond (Kuraray, Osaka, Japan)
4. Prompt L pop (3M ESPEE)
5. Reliance self-etching primer (Reliance orthodontics).

Incubation
- The samples were stored in deiodized water at 37°C for 24 h before debonding
- The Instron universal testing machine (model no. LR LOYD 50 K - UK) was used to carry out the test for shear bond strength.

Bonding procedures
Bonding samples in Group I and II
The buccal surface of all teeth in the group were pumiced and thoroughly rinsed with distilled water. The tooth surfaces were dried and isolated to avoid contamination of the treatment area.

The primer was applied through the applicator tip, which had three compartments, the first compartment contains methacrylated phosphoric acid esters, initiators and stabilizers, the second compartment contain water, fluoride complex and stabilizers.

Bonding samples in Group III, IV, and V
The buccal surface of all teeth in the group were pumiced and thoroughly rinsed with distilled water. The tooth surfaces were dried and isolated to avoid contamination of the treatment area.

Primer liquid was dispensed into the mixing dish, immediately before application and was applied gently and dried with mild airflow. Required amount of the bond was dispensed into a mixing dish and applied to the primed area. After applying bond, a uniform bond film was created using a gentle oil-free airflow; it was light-cured for 10 s with curing light. Bracket with adhesive was placed on the tooth surface and firmly pressed in place and was light-cured for 20 s with visible light curing unit.

Figure 1: Reliance self etching primer

Bond strength testing
The shear bond strength of bonded specimens were tested after 24 h of bonding in an instron testing machine model LP50K with a crosshead speed of 0.5 mm/min (Figure 2).

The acrylic block mounted with specimen was secured to the lower grip of the machine (fixed head) and a custom made grip was placed in the upper grip (movable head) connected to the load level, the blade was positioned in such a way that it touched the bracket.

The crosshead speed was adjusted to 0.5 mm/min, and the force at which the bracket debonded was recorded. The bond strength was calculated in mega Pascals by using the following formula.

Force in Newton

Bond strength in Mpa = Surface area of bracket in mm^2

Materials used
1. Transbond Plus
2. Clearfil SE bond
3. Clearfil Protect Bond
4. Prompt L pop
5. Reliance self-etching primer
6. Transbond XT adhesive
7. PEA stainless steel premolar bracket
8. Thymol solution for storage of extracted premolar teeth.
   - Group I (TP)
   - Group II (SE)
   - Group III (CP)

Figure 2: Instron testing machine

- Group IV (PP)
- Group V (RSEP).

Results (Table 1)

Reliance self eching primer showed superior shear bond strength among tested samples.

Statistical analysis (Tables 2 and 3, Graph 1)

The mean bond strength among four groups was found to be very highly significant. Maximum mean was found in Reliance self-etching primer and minimum in Transbond Plus.

Discussion

Advances in material sciences over the years have led to the progressive improvisations of the materials in turn making the direct bonding procedure more precise, comfortable and time effective.

Table 1: Comparision of shear bond strength in MPa.

PP	Transbond	SE	CP	RSEP
9.37	9.37	10.36	11.54	9.74
9.64	9.82	11.38	9.64	10.48
11.7	7.61	8.96	12.56	9.36
9.25	8.95	6.96	14.57	12.86
10.5	10.25	12.9	7.39	13.26
12.25	10.3	10.25	8.56	15.42
11.7	8.82	11.9	14.26	16.38
10.48	9.91	12.36	11.7	14.89
11.37	9.18	9.96	15.57	13.19
10.96	10.48	8.36	12.36	14.69
10.71	9.95	11.78	7.98	12.39
13.1	11.37	9.2	14.69	11.64
11.52	7.85	10.25	15.52	10.34
12.69	11.63	9.8	12.36	11.44
6.49	10.96	6.23	9.25	10.63
9.18	7.52	8.12	9.78	12.39
8.96	6.49	7.89	14.25	13.33
12.36	10.71	9.39	9.36	12.12
10.56	9.95	13.1	7.93	10.21
7.98	9.18	9.7	10.5	9.39
9.39	11.18	9.37	12.69	9.89
11.18	10.16	9.57	16.49	10.23
6.23	10.16	7.26	14.2	15.13
7.8	8.3	8.96	10.36	11.94
8.9	11.52	9.99	14.99	14.90

PP: Prompt L pop, SE: Clearfill SE bond, CP: Clearfil protect bond, RSEP: Reliance self-etching primer

Table 2: Statistical analysis.

Value	N	Mean	Standard deviation	Minimum	Maximum
PP	25	10.171	1.828	6.23	13.10
Transbond	25	9.665	1.343	6.49	11.63
SF	25	9.760	1.787	6.23	13.10
CP*	25	11.940	2.740	7.39	16.49
RSFP*	25	12.250	2.102	9.36	16.38

*In the intergroup comparison of Tukey test showed that there is significant difference between groups tested. Reliance self etching primer and Clearfil SE bond strength showed high significance with $P<0.001$. Intergroup comparison was found to be significant between RSEP, CP, Prompt L P, & Transbond. There was no significant difference between other groups. PP: Prompt L pop, SE: Clearfill SE bond, CP: Clearfil protect bond, RSEP: Reliance self-etching primer

The results of the present study showed that:

Self-etching primer containing antimicrobial MPDB monomer Clearfil Protect Bond exhibited superior bond strength compared to other tested self-etching primers (clearfil SE bond and Transbond Plus).

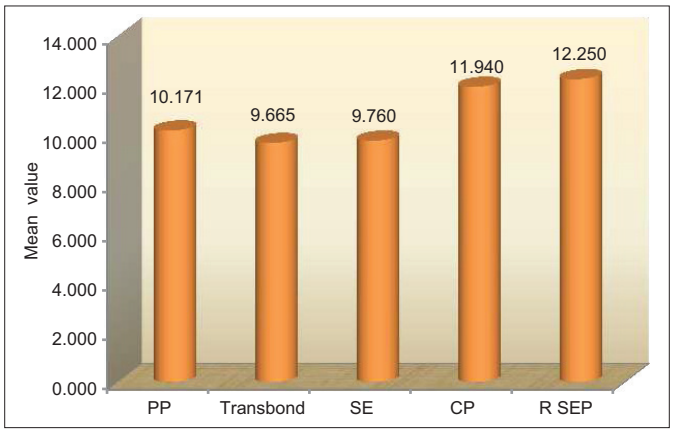
a. Among the self-etching primers without antimicrobial monomer, clearfil SE bond showed better shear bond strength values compared with conventional self-etching primer Transbond Plus
b. MDPB containing primer showed slightly higher shear bond strength than in the control, with no statistical significance
c. MDPB containing primer has been demonstrated to kill *S. mutans* within a short period of contact and also exhibit an inhibitory effect on growth of bacteria on its surface. Thus in the new era of innovations, self-etching primers with antimicrobial MDPB will be the material of choice, since the resultant bond strength and antibacterial effect is quite enough for orthodontic purposes which has been proved in *in-vitro* conditions
d. Reliance self-etching primer showed superior properties among the tested materials and was very economical.

Table 3: Multiple comparisons.

Dependent variable: Value
Tukey HSD

(I) Group	(J) Group	Mean difference (I-J)	P
PP	Transbond	0.5060	0.901
	SE	0.4108	0.951
	CP	−1.7692	0.02 sig
	RSEP	−2.0788	0.004 hs
Transbond	SE	−0.0952	1.000
	CP	−2.2752	<0.001 vhs
	RSEP	−2.5848	<0.001 vhs
SE	CP	−2.1800	0.002 hs
	RSEP	−2.4896	<0.001 vhs
CP	RSEP	−0.3096	0.983

PP: Prompt L pop, SE: Clearfill SE bond, CP: Clearfil protect bond, RSEP: Reliance self-etching primer, hs: Highly significant, vhs: Very highly significant



Graph 1: Comparison of shear bond strength of prompt L pop, clearfill SE bond, clearfil protect bond, reliance self etching primer.

Conclusion

Reliance self etching primer showed highest bond strength followed by Clearfil Protect bond, Clearfil SE bond, Tran bond Plus. Clearfil Protect Bond primer containing MDPB have been demonstrated to kill streptococcus mutans within a short time of contact and exhibits an inhibitory effect on growth of bacteria on its surface.

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