Original Research

A comparative study on the shear bond strength using conventional, moisture insensitive and self-etching primers in dry and wet conditions in vitro

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ABSTRACT

Moisture Insensitive primer (M.I.P) and self etching primer (SEP) are recent innovations in bonding which make bonding less time consuming and less technique sensitive. This study was conducted to compare the shear bond strengths of conventional, moisture insensitive and self etching primer in dry and wet states. Ninety Freshly extracted teeth for orthodontic purpose were used for the study. The study was conducted in dry and wet states using conventional, SEP and MIP. The results showed that conventional primer showed highest bond strength in dry condition while their bond strength in wet condition was significantly lower MIP and SEP showed satisfactory bond strength both in dry and wet conditions.

INTRODUCTION

The acid-etch technique, first suggested by Buonocore[1] in 1955, revolutionized bonding to enamel. This technique was first suggested for orthodontic use by Newman[2] and is now widely accepted. Rapid strides in material science over the years have produced progressively advanced materials making the direct bonding procedure more precise, comfortable and time-effective.

However, the stress is still on clinically adequate bond strength, which is affected by bracket base design, adhesive used and bonding protocol. Bonding is a technique-sensitive procedure, and moisture is cited as the most common cause for bond failure.[3,4]

Various steps involved in bonding are removal of enamel pellicle, acid etching, priming, application of adhesive and curing. The elimination of one or more stages without compromising clinical reliability has been the aim of recent research in the field of orthodontics. To overcome the commonly encountered problems, materials have been developed that are hydrophilic and that are believed to offer better bond strength in moisture-contaminated environment.

The advent of fifth generation bonding system, the moisture insensitive primers (M.I.P) which contains a hydrophilic primer solution dissolved in solvents such as acetone, or ethanol and tolerates the presence of moisture to a certaindegree and is recommended for use in situations where moisture control is difficult.

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Another novel concept is the sixth-generation bonding system, the self etching primer (S.E.P) where etching and priming agent are combined into a single acidic primer solution. This results in a selective preparation of the enamel with placement of the primer into the demineralized region at the same time[5,6]. In addition, the penetration involves the entire area of the previously etched enamel without requiring the traditional washing after acid application. This study was conducted to compare the shear bond strength and ARI scores of conventional, self etching and moisture insensitive primer in dry and wet conditions.

MATERIALS AND METHOD

Preparation of specimen

A total of ninety freshly extracted teeth for orthodontic purpose (maxillary and mandibular premolars) were collected. All the teeth used in this study were extracted over the course of five months. They had undamaged buccal enamel with no caries and no pre-treatment by any chemicals. Following extraction, residue on the teeth was removed and washed away with tap water. They were then stored in normal saline at room temperature to prevent dehydration and bacterial growth.

To mount the teeth in universal testing machine (Lloyd Universal testing machine-Model No.L.R 100K) they were fixed in a self cure acrylic blocks with dimension by 35mm x 9mm. The teeth were mounted on acrylic blocks such that the roots were completely embedded into the acrylic up to the cemento-enamel junction leaving the crown

exposed. The teeth were randomly divided into six groups. The blocks were colour coded for easy identification. Prior to the bonding procedure, the enamel surface were polished with oil and fluoride free fine pumice, using a brush and a slow-speed hand piece, rinsed again and dried with an air syringe. The method specified for each experimental group was then followed.

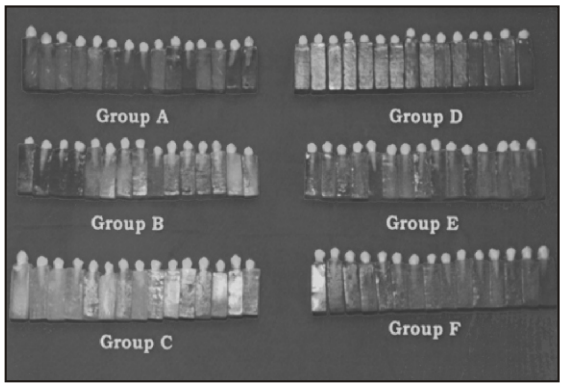


Fig-1 : *Specimen prepared for testing*

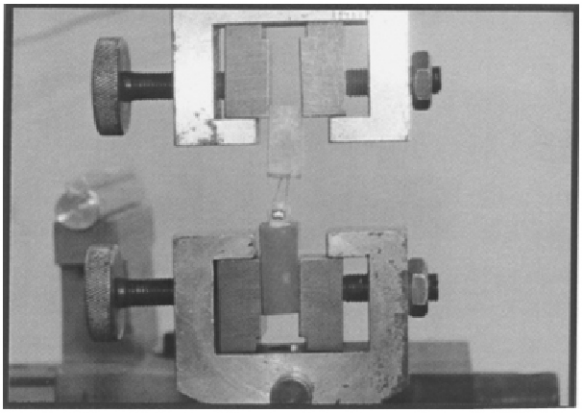


Fig-2 : *Sample mounted on Instron Machine*

BONDING SYSTEM

Enamel conditions which were studied: *Dry condition, wet condition with artificial saliva.*
Etchant used: *Phosphoric acid 37 percentage Silica free, Non-drying, Thixotropic gel. (D-TECH)*
Brackets: *Premolar metal brackets (Master series)* American Orthodontics® *with a mesh. An average base area of 10.5mm^2 was used in this study.*

Three types of primers were used:

1. Conventional Transbond adhesive primer by 3M Unitek
2. Moisture insensitive primer (M.I.P) by 3M Unitek
3. Self etching primer (S.E.P) by 3M Unitek.

Adhesive used: Transbond light cure adhesive (3M Unitek)
Light Source: A 3M ESPE, Elipar 2500-Halogen -curing unit emitting light at wavelength of 480nm was used for polymerization.

Artificial Saliva: An Aqwet (Cipla) artificial saliva solution had an electrolyte composition similar to that of human saliva. It composed of 1 g sodium carboxymethyl cellulose, 3 g Sorbitol, 0.12 g Potassium chloride, 5.2 mg Magnesium chloride, Calcium chloride 1.4 mg, 40 mg Potassium dihydrogen phosphate, 1 mg Potassium thiocyanate and 100 g distilled deionized water.

Bonding was done for all the groups as per manufacturers instructions. For bonding under wet conditions, two coats of artificial saliva was applied onto the tooth surface after etching. Excess saliva was blotted with gauze leaving the surface moist. Subsequent to bonding all the samples were stored in distilled water at room temperature for 24 hours, prior to testing.

BOND STRENGTH TESTING

Shear bond strength was measured with universal testing machine (Lloyd Universal testing machine-Model No. L.R 100K) The specimen mounted in its acrylic block was secured to the lower grip of the machine. To maintain a consistent debonding force a ligature wire embedded on to an acrylic block was fixed in the movable head. The ligature wire was positioned in such a way that it touches the bracket.

A cross-head speed of one mm/min was used. The computer recorded the force to debond the bracket in Newtons (N) and converted into megapascals as a ratio of the force to debond to the surface area of the bracket

Bond strength MPa=Force (Newton)/Surface area of bracket (mm^2)

Site of Bond Failure

The debonded specimens bond failure was assessed, and scoring was graded according to the Adhesive Remnant Index or ARI (Artun and Bergland, 1984). After debonding the teeth and bracket were examined under a 10X magnification to evaluate the amount of resin remaining on the tooth. The adhesive remnant index (ARI) was used to describe the quantity of resin remaining on the tooth surface. The A.R.I score has a range between 0 and 3 as follows:

0 No adhesive remained on the tooth.

1 Less than half of the enamel bonding site was covered with adhesive.

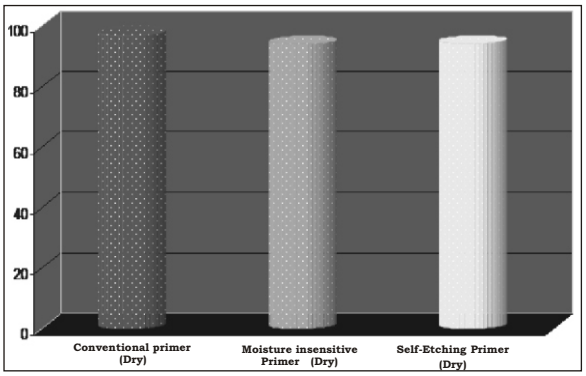
2 More than half of the enamel bonding site was covered with adhesive.

3 The enamel bonding site was covered entirely with adhesive.

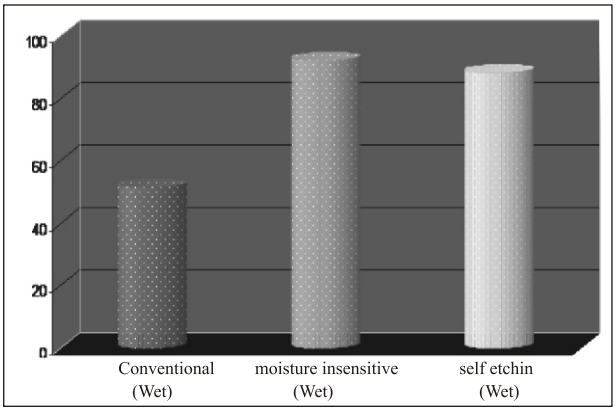
EXPERIMENTAL GROUPS		
PRIMERS	DRY CONDITION	WET CONDITION
Conventional Primer	Group A	Group D
Moisture insensitive Primer	Group B	Group E
Self-etching primer	Group C	Group F

Table 1 Experimental Group

RESULTS



Graph 1 Distribution of mean values between different study groups in dry condition



Graph 2 Distribution of mean values between different study groups in wet condition

Group	Mean ± S.D.	P-value*	Significant # Group at 5% level
A	96.89±5.51	0.15 (NS)	NIL
B	93.91±5.79		
C	93.97±1.99		

Table - 2 Comparison of mean values between different study groups in dry condition

Group	Mean ± S.D.	P-value*	Significant # Group at 5% level
D	51.45±3.37	<0.0001(sig)	E vs D, D vc F
E	92.03±5.08		
F	88.10±1.60		

Table -3 Comparison of mean values between different study groups in wet condition.

Group	Dry	Wet	P-value*
	Mean ± S.D.	Mean ± S.D.	
A	96.89 ± 5.51	51.45 ± 3.37	<0.0001(sig)
B	93.91 ± 5.79	92.03 ± 5.08	0.35 (NS)
C	93.97 ± 1.99	88.10 ± 1.60	<0.0001(sig)

Table -4 Comparison of mean values between dry and wet condition for each study group

The mean and standard deviation of shear bond strength of the three different primers under both dry and wet condition were calculated. The recorded data were statistically analysed for each group and compared among the groups.

One way ANOVA was used to compare the mean values among more than 2 independent groups. The results were tabulated.

Shear bond strength: Under dry conditions conventional primer showed a higher shear bond strength followed by self etching primer (SEP) and moisture insensitive primer (MIP)in that order. Conventional primer showed a significantly lower bond strength in wet state.

ARI scores: Kruskal- Wallis and Mann Whitney U test was done for A.R.I scoring. The results showed there was a significant difference in the distribution of ARI scores among different study groups.

In dry condition conventional primer showed a higher ARI score followed by SEP and MIP in that order. In wet condition the conventional primer showed a significantly lower ARI score , while SEP and MIP showed bond strength comparable to that in dry condition.

DISCUSSION

Bonding is a technique-sensitive procedure, and moisture is cited as the common cause for bond failure[7, 8] Contamination causes plugging of porosities caused by acid etching and a reduction in surface energy. Thus, the penetration of the resin is impaired, and the micromechanical retention is compromised.[7]

Moisture-insensitive primer (MIP) was developed based on dentin-bonding agents, which have hydrophilic components, such as hydroxyethyl methacrylate (HEMA) polyalkenote copolymer with carboxylate groups and maleic acid dissolved in acetone, that are efficient even in the presence of moisture[9]. These primers are particularly useful in conditions where moisture control is difficult like in lingual bonding or while bonding surgically exposing partially erupted or impacted ectopic tooth[10, 11] where some amount of contamination is expected.

Another unique concept in the bonding systems are the self-etching primers where etching and priming agents are combined into a single acidic primer solution[12]. Self etching primer contains Methacrylated phosphoric acid esters to perform the etching step and other constituents, which enable the diffusion of monomers and partial dissolving of hydroxyapatite simultaneously, resulting in a resin-infiltrated zone entrapped with minerals.

These self-etch primers have the advantage of having fewer steps in the bonding process which translates into fewer procedure errors, reducing technique sensitivity, besides being reliable enough for use in situations where access is difficult. Because they are hydrophilic, it is logical to presume that they may be effective in situations with moisture contamination.[13]

Maintaining the sound unblemished enamel surface after debonding orthodontic bracket is a primary concern of the clinician, As a result bond failure at the bracket- adhesive interface or within the adhesive is more desirable than failure at the adhesive / enamel interface because enamel fracture and crazing have been reported at the time of bracket debonding with excessive bond strength. Hence the mode of bond failure was also compared after using the three primers.

Analysis of the results of the study showed that the shear bond strength of all three primers under dry condition showed no significant difference, though that of conventional primer was the highest.

Under wet condition, conventional primer showed significantly less bond strength when compared to moisture insensitive and self etching primer. No significant difference was present between those of moisture insensitive primer and self etching primer. *Reynolds*[14] proposed that bond strength required to withstand normal orthodontic force to be between 6 to 8 MPa and the breaking strength of the enamel, to be about 14 MPa. In this study all the groups showed adequate bond strength with the exception of conventional primer under wet condition. This result underscores the importance of moisture control during the bonding procedure.

This study correlates with *Smith et al* [15] who found that moisture insensitive primer and light –cured composite resin resulted in a significant increase in the shear bond strength on wet enamel surface

Ireland et al [16] investigated the effect of saliva contamination on the shear bond strength of a light cured orthodontic adhesive used with Transbond Moisture insensitive primer and Transbond self etch primer. Hydrophobic Transbond XT primer was used as a control study. They found that there was a statistically significant difference between dry and contaminated groups which supports our study.

The results of this study clearly showed that the bond strength values under wet condition were good enough for clinical bonding when using moisture insensitive and self etching primers. This is supported by a study done by *Grandhi,*[17] *Cacciafesta,*[18] *Rajagopal,*[19] *Webster*[10] .

Analysis of the results of the study showed that conventional primer displayed superior bond strength when compared to moisture insensitive primer and self etching primer under dry condition but not statistically significant. In wet condition moisture insensitive primer showed higher bond strength compared to self etching primer and conventional primer. Moisture insensitive primer showed greater bond strength in dry condition than in wet conditions although both values were comparable and in excess of minimum required bond strength.

ARI scores showed Moisture insensitive primer used under dry and wet conditions had a higher frequency of adhesive failures within the adhesive enamel interface and had less adhesive left on the tooth surface.

On the other hand self etching primer showed more bond failure in the bracket adhesive interface in wet condition and less enamel adhesive interface in dry condition. They revealed no significant difference between them. This is similar to the study of *Bishara et al*[20] where self etching primer left behind less adhesive on the tooth when compared to conventional primer in dry condition.

To conclude, the results of the adhesive remnant index shows that moisture insensitive primer and self etching primer left behind less adhesive on the enamel surface than conventional primer under wet conditions. From the clinical stand point, the use of self etching primer can be desirable because they reduces the number of clinical steps, save chair side time, reduce the risk of decalcification and it would be the obvious choice in case of moisture contamination.

Moisture insensitive primer performance was found to be promising when used in moisture contaminated conditions. It can be very effective in bonding impacted tooth, lingual bonding procedures and in pediatric patients with excess salivation, leading to the conclusion that moisture insensitive primers can be a viable replacement from more traditional priming systems.

Future studies in the field of bonding using moisture insensitive and self etching primer may include increased number of samples, in-vivo studies, and multiple operators.

Summary and Conclusion

Self etching primer (SEP) and Moisture insensitive primer (MIP) provide adequate bond strength both in dry and wet fields and hence can be used for bonding in cases where moisture contamination is inevitable.

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