The effect of pre-etching with 37% orthophosphoric acid on the shear bond strength of orthodontic brackets bonded using self-etching primer-adhesive system

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ABSTRACT

Objectives: The purpose of this study was to compare the effect of pre-etching with 37% orthophosphoric acid on the shear bond strength (SBS) of orthodontic brackets bonded using self-etching primer (SEP).

Materials and Methods: Two hundred freshly extracted human premolars were divided randomly into two groups based on pre-etching with 37% orthophosphoric acid: Group 1 (control, n = 50) without pre-etching and Group 2 (experimental, n = 150) with pre-etching. Group 2 was further divided into three sub groups 2a, 2b, and 2c with 50 teeth each and was first pre-etched with 37% orthophosphoric acid for 10, 30, and 60 s, respectively. Brackets were bonded on the teeth in both the groups using SEP and light cure adhesive. The SBS were determined using universal testing machine. The comparison of SBS was done using one-way analysis of variance and Tukey’s honest significant difference test.

Results: The SBS of experimental Group 2 was significantly higher than the control Group 1 (p < 0.0001). Further, the SBS of Group 2a was highest, followed by Group 2b and 2c (p < 0.0001).

Conclusion: It was found that pre-etching for 10 s prior to application of SEP-adhesive system increases the SBS of orthodontic brackets.

Key words: Pre-etching, self-etching primer, shear bond strength

Bonding of the orthodontic attachments on the teeth is crucial for the success of the fixed orthodontic treatment and the orthodontist uses the acid-etched bonding technique as a primary means of attaching brackets to the enamel surface. The conventional bonding system is a multi-step process requiring etching, washing thoroughly, drying, and applying primer and adhesive, placing the bracket and light curing, which is time consuming. Self-etch primer adhesive system is now available that allows etching and priming of enamel in one step. These primers have simplified the bonding procedure, reduced loss of enamel, prevention of saliva contamination, and less chairside time.

A key to successful bonding is the removal of the salivary pellicle. It has been recommended that pumicing the bonding surface beforehand to remove the salivary pellicle results in increased bond strengths and decreased clinical failures. The increase in the clinical chairside time and the possible mechanical injury to the gingiva has raised concern regarding this procedure. An alternative to pumicing for the removal of the pellicle would be to reintroduce an etching step. In vitro studies have shown consistently greater bond strengths when enamel was pretreated with orthophosphoric acid before bonding with self-etching primer (SEP).

Fitzgerald et al. compared the shear bond strengths (SBS) of orthodontic brackets bonded with SEP using different

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enamel surface preparation - pumicing and pre-etching and found out that pre-etching the bonding surface for 5 s resulted in greater SBS. However, the authors said that this may not be practical if bonding more than a few teeth with this technique as by the time etchant is removed from the first tooth more than 5 s may have elapsed.

Therefore, this study was undertaken to evaluate this effect of varying pre-etching time - 10, 30, and 60 s on the SBS of orthodontic brackets bonded using SEP-adhesive system.

MATERIALS AND METHODS

Teeth
Two hundred freshly extracted human premolars were collected from the Department of Oral and Maxillofacial Surgery, Rungta College of Dental Sciences and Research, Bhilai, and stored in normal saline at 37°C. Teeth with intact buccal surface not subjected to any pretreatment and without any decays, gross irregularities, cracks, fractures, and hypoplasia were selected. An ethical clearance was obtained from the Institutional Ethics Committee of this institution.

Bonding procedure
The test samples were divided randomly into two groups based on pre-etching with 37% orthophosphoric acid as illustrated in Flow chart 1: Group 1 (control group, \(n = 50\)) without pre-etching and Group 2 (experimental group, \(n = 150\)) with pre-etching. Group 2 was further divided into three subgroups 2a, 2b, and 2c based on different pre-etching timings of 10, 30, and 60 s, respectively. Each tooth was mounted using split square aluminum box (18 mm × 18 mm × 18 mm). It was stabilized and embedded in self-curing acrylic resin (RR cold cure, DPI, Mumbai, India) such that the long axis of the tooth was parallel to the long axis of the acrylic block and the buccal surfaces were accessible for surface treatment and adhesive bonding. The acrylic blocks in each of these groups were color coded and numbered for easy identification and data recording. The teeth were cleansed and polished with pumice and rubber prophylactic cup for 10 s.

In Group 1, the teeth were treated directly with SEP (Transbond Plus, 3M Unitek, Minnesota, USA) and orthodontic premolar brackets (Master Series, American Orthodontics, Sheboygan, Wisconsin, USA) were coated with light cure orthodontic adhesive (Transbond XT, 3M Unitek, California, USA). The excess of adhesive was removed with explorer and light curing was done for 20 s using halogen curing light (Elipar 2500, 3M ESPE, Minnesota, USA). Group 2a, 2b, and 2c were first pre-etched etched with 37% orthophosphoric acid for 10, 30, and 60 s, respectively followed by the application of the SEP and bonding adhesive [Figure 1a-d].

Shear bond strength testing
A universal testing machine (Instron Corp., Massachusetts, USA) was used for determining the SBS of the test sample.

For testing, the prepared tooth mounted acrylic block was fixed to the metal framework with a central circular opening of 1.5 inches diameter with the long axis of tooth and bracket base parallel to the direction of shear force applied. The specimens were stressed in an occluso-gingival direction with uniform crosshead speed of 0.5 mm/min. The maximum force necessary to debond or initiate bracket fracture was measured in Newton and then converted into megapascal (MPa) as a ratio of Newton to surface area of the bracket. The mean area of the bracket base surface was 12 mm².

Statistical analysis
The data were collected and analyzed using SPSS software (Version 19, IBM Corp., Illinois, USA). The range, mean and standard deviation of the SBS were calculated for the different groups. The one-way analysis of variance and Tukey’s honest significant difference (HSD) test was used to determine significant differences between the mean SBS of the different groups. The level of significance was set at \(P < 0.05\).

RESULTS

The SBS of control and experimental groups are presented in Table 1. The mean SBS of Group 2a (10.35 MPa) was highest followed by Group 2b (9.33 MPa) and Group 2c (7.85 MPa) and was least for Group 1 (4.86 MPa). The one way analysis of variance (\(F = 236.697\)) showed significant differences existed among the mean bond strengths of the different groups (\(P < 0.0001\)). Table 2 depicts the multiple comparisons of the SBS using Tukey’s HSD test, which showed that the SBS of the four groups were statistically different (\(P < 0.001\)).

DISCUSSION

Advances in adhesive technology lead orthodontists to use new adhesives and bonding techniques in their clinical practices. SEP combines acid etching and priming of the
enamel surface. It reduces clinical chair side time, minimizes technique sensitivity, and procedural errors.

The SEPs have been a great addition to orthodontic bonding, but the SBS of SEPs has been a matter of concern due to shallower etching pattern and reduced micromechanical retention.\(^8\)\(^{-13}\) In the conventional bonding system, the salivary pellicle covering the teeth is removed by application of 37% phosphoric acid. The need for initial pumicing/pre-etching is reintroduced when using SEPs to remove this pellicle. A 5 s pre-etch with 37% phosphoric acid gives significantly greater bond strengths compared with pumicing when bonding with SEPs.\(^7\)

It was not possible to etch more than a couple of teeth in 5 s. Therefore, the enamel surface was pre-etched with 37% orthophosphoric acid for varying time period of 10, 30, and 60 s along with the use of SEP. Less than 10 s of etching time does not produce enough tagged areas on the enamel, and etching times of 60 s or more than 60 s impair the integrity of honeycombed prismatic structures on the enamel, which negatively affects bond strength.\(^14\) In the present study, it was observed that etching time of 10 s with SEP was enough to have higher bond strength as compared to increased etching time periods of 30 and 60 s.

In the present study, enamel surface was pre-etched with 37% orthophosphoric acid for varying etching time period along with the use of SEP. It showed that pre-etching with minimum time that is for 10 s gives maximum SBS, which can be helpful in the premolar region where moisture contamination is more and is difficult to control.

Paskowsky.\(^{13}\) in an in vivo test evaluated the SBS of SEP (Transbond Plus [3M Unitek, Monrovia, Calif]) and conventional bonding methods (Transbond XT) by comparing the bond failure rates between systems in orthodontic patients. The findings showed no significant difference between the groups. Brackets bonded with SEP had SBS of 8.43 ± 2.81 MPa. Brackets bonded with conventional method had SBS of 8.71 ± 2.10 MPa. In the present study, SBS obtained by pre-etching the enamel surface for 10 s prior to treatment with SEP was higher (13.3 MPa) as compared to values obtained by Paskowsky et al. The reason for reduced values of bond strength of SEP was due to lesser depth of microtags formed. Pre-etching prior to application of SEP increased the depth of tagged areas formed, thereby increasing the value of SBS as seen in results of the present study.

Romano et al.\(^8\) found lower SBS for the brackets bonded to enamel using SEP compared to the conventional technique. They found mean SBS of bracket bonded using Transbond SEP and Transbond XT adhesive paste of 4.61 MPa, which is similar to the mean SBS (4.87 MPa) of Group 1 of our study.

Considering that pre-etching was done for longer duration before bonding with the SEP, it could have been expected to have the greatest bond strengths. However, this was not confirmed by the results of this study. A possibility is that pre-etching for longer time period, and etching from the SEP may “over prepare” the enamel surface, similar in concept to studies done by Wang and Lu\(^{14}\) and Reisner et al.\(^{16}\) that showed beyond an optimal conventional etching time, bond strengths remain the same, or may actually decrease.

The values of high SBS have an impact on breaking point at the adhesive-enamel conjunction during debonding process. A greater proximity to the enamel border has the advantage of a fast polishing procedure afterward but bears the risk of enamel fractures at the same time. The high SBS values have an advantage of leaving less adhesive on the teeth, thereby reduced polishing time, the disadvantage is an increased risk for enamel fractures during debonding explaining the need for an optimal value of SBS which is neither less nor too high.\(^{15}\)

Anecdotal accounts mention that some clinicians are adding pre-etching step during their SEP bonding protocol. Little evidence exists in literature examining the effectiveness of this practice. The results obtained in this study suggest that pre-etching enamel for 10 s prior to SEP application allows absolute exposure of the enamel to the SEP, fully removing the salivary pellicle,
maximizing primer penetration of the enamel, and therefore maximizing bond strength. Clinical studies examining debond and enamel fracture rates are needed before fully endorsing this procedure.

CONCLUSION

There were significant differences in mean SBS of orthodontic brackets bonded with and without pre-etching with 37% orthophosphoric acid and SEP-adhesive system ($p < 0.0001$). The orthodontic brackets pre-etched with 37% orthophosphoric acid for 10 s showed highest SBS. The minimum pre-etching prior to application of SEP gives maximum clinically acceptable SBS.

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Conflicts of interest

There are no conflicts of interest.

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