ABSTRACT

Aims and Objectives: To use antibacterial agents with two conventional bonding systems and evaluate the shear bond strength (SBS) of bracket to enamel.

Materials and Methods: Overall, 120 human-extracted first premolars were used. The specimens were equally divided into six sub-groups of 20 samples. Control groups were bonded with Transbond XT™ light cure (Group I, after etching with 37% phosphoric acid, 3M Unitek™) and Unite™ self-cure adhesive (Group II, after etching with 37% phosphoric acid, 3M Unitek™). Experimental groups included teeth surface first coated with Clearfil Protect Bond™ (Kuraray, Osaka, Japan) (and then bonded with Transbond XT™ [Group III] or Unite™ [Group IV]) or bonded with Uni-Etch™ antibacterial self-etchant (and then bonded with Transbond XT™ [Group V] or Unite™ [Group VI]). The third generation MBT bracket bonding system with 0.022 slots was used for bonding. All specimens were tested on Instron machine 5567 (SIES Institute of packaging, Nerul, Navi Mumbai, India) to evaluate the SBS. The sheared surfaces were also investigated with a stereomicroscope to assess adhesive remnants index (ARI scores) on the specimen surfaces.

Results: Mean SBS in Group I–Group VI was 10.53 (2.91), 9.12 (2.56), 9.86 (1.98), 6.96 (2.92), 9.57 (2.02), and 7.65 (2.34) megapascals, respectively. Significant differences were only seen between Group III and IV and between Group II and IV. With respect to ARI scores, significant differences were seen only for comparison between Groups II, IV, and VI.

Conclusion: Newly developed antibacterial agent could be used with conventional bonding systems effectively to decrease white spots; when used with Transbond XT™ light cure, the original SBS did not get affected, but when used with Unite™ self-cure bonding system, it led to reduced SBS significantly.

Key words: Clearfil Protect Bond™, shear bond strength, Transbond XT™ light cure bonding system, Uni-Etch™ antibacterial etchant, Unite™ self-cure bonding system

A fixed orthodontic therapy is preferred and it is the best option for the treatment of malocclusion. However, it has been observed that use of fixed appliance is a challenge not only for patient, but also for orthodontist for maintaining good oral hygiene. A high incidence of white spot lesion is generally reported in patients treated with fixed orthodontic therapy compared to those who were not treated with orthodontic therapy. This white spot lesion develops during/after orthodontic treatment.

It is difficult to eliminate white spots which create very unesthetic appearance in smile, although patient had a beautiful well-aligned arch. Decalcification or white spot lesion creates new retention areas for micro-organism.

Bacterial plaque which is the main etiological factor in caries development accumulates around the bracket and
excess resin flash. Metabolites of plaque are responsible for white spot, demineralization, and periodontal disease during treatment.

Hence, various methods were suggested to prevent enamel de-mineralization. One of the recently introduced methods is the use of antibacterial Clearfil Protect Bond™ that is used along with conventional bonding agents in light cure and self-cure bonding technique.

In this study, self-etching primer,[1] Clearfil Protect Bond™ (Kuraray, Osaka, Japan), has been used as an antibacterial agent containing primer/adhesive along with conventional bonding agents such as 3M Transbond XT™ and 3M Unite™ using light cure and self-cure bonding system, respectively. Clearfil Protect Bond™ consists of newly developed monomer methacryloyloxy-dodecylpyridinium bromide (MDPB) that is added to the primer of an adhesive system. This MDPB consists of quaternary ammonium and methacycloxy group.[2]

Another recently introduced method to prevent enamel demineralization during orthodontic treatment is the use of Uni-Etch™ which is a thixotropic silica-free semi-gel etchant with benzalkonium chloride (BAC), a proven anti-microbial. Uni-Etch™ leaves no silica debris and imparts a residual microbial action.

The objective of this study was to use antibacterial agent with two direct bonding systems and evaluate the extent of postorthodontic demineralization and hence the shear bond strength (SBS) of bracket to enamel.

Objectives
To measure and compare SBS using:
- Light cure Transbond XT™ and Self-cure Unite™
- Clearfil Protect Bond™ with conventional bonding system (Transbond XT™ and Unite™)
- Uni-Etch™ for etching and conventional bonding system (Transbond XT™ and Unite™).

MATERIALS AND METHODS

Overall, 120 freshly extracted premolars were used in this study. All the premolars were sound in structure without any fracture or restorations [Figure 1].

Criteria for tooth selection included undamaged buccal enamel, no caries, no restoration, and no pretreatment with any chemicals such as acid, alcohol, or derivative of peroxide. After extraction, the residue was removed and washed away with tap water. The teeth were stored in normal saline at room temperature before use.[3]

Before start of the study, ethical approval was obtained from Institutional Ethical Committee at Y. M. T. Dental College and Hospital under MUHS. The third generation MBT bracket system was used for bonding techniques. The study design was such that there were two control groups and four experimental groups. Control group I and II consisted of Transbond XT™ and Unite™, respectively. In experimental groups, we used Clearfil Protect Bond™ with Transbond XT™ light cure bonding system (Group III) and with Unite™ self-cure bonding system (Group IV); Uni-Etch™ antibacterial self-etchant (Bisco™) with Transbond XT™ light cure bonding system (Group V); and Uni-Etch™ antibacterial self-etchant (Bisco™) with Unite™ self-cure bonding system (Group VI).

Bonding procedure
In control group the buccal surfaces of premolars were etched with 37% phosphoric acid and standard bonding procedure were followed. For experimental group, they had self-etching primers and hence standard bonding procedure was followed except etching with 37% phosphoric acid [Figures 2–8]. This was followed by SBS on Instron machine 5567 conducted at SIES Institute of packaging, Nerul Navi, Mumbai, India. The results, thus, obtained were subjected to statistical analysis, which mainly included ANOVA test (SBS) and Chi-square test (adhesive remnant index [ARI]) using the IBM-SPSS software version 20.

In this comparative study, the SBS of two conventional bonding systems (Transbond XT™ and Unite™), when used along with antibacterial agents (Clear Protect Bond™ and Uni-Etch™), was evaluated using Instron 5567 testing machine[4] [Figure 9]. The specimens’ brackets were debonded after 24 h. A jig was prepared using 0.019” × 0.025” rectangular steel wire. Each specimen was mounted on machine such that root of tooth was held firmly between the lower jaws of the machine. The jig was tightened around the bracket wings with long free end that was mounted in upper mobile part of Instron testing machine, ensuring the load constant and parallel to the tooth surface. This part of the machine exerted an occluso-gingival load to the surface of bracket in occlusal direction.[6] The shear force at a crosshead speed of 1 mm/min was transmitted to the bracket.[5] A computer electronically connected with testing machine recorded the result of each test. As the force that debonds the bracket is measured in kilograms, these values were later converted to megapascals (MPa) using the following formula:

\[
\text{Value in MPa} = \frac{\text{Values in kilograms} \times 9.8}{\text{Bracket base area} \times 10.852 \text{ mm}^2}
\]

Data obtained were subjected to statistical analysis using Student’s unpaired t-test, two-ways ANOVA, and Chi-square test. Level of significance was set at \( P < 0.05 \), i.e., 95% confidence interval.

Assessment of adhesive remnant index
The sheared surfaces were further investigated with a
stereomicroscope (Olympus, SZX9, Tokyo, Japan) under ×40 magnification to assess adhesive remnants on the specimen surfaces.\textsuperscript{[3]} The ARI as described by Artun and Bergland.\textsuperscript{[7]} The ARI score of individual groups was obtained after debonding by using ×40 magnification glass. The ARI was scored at 0–3 as follows:

- 0 - Less adhesive on the tooth
- 1 - Less than half of the adhesive left on the tooth
- 2 - More than half of the adhesive left on the tooth
- 3 - All the adhesive left on the tooth with mesh pattern visible.

**RESULTS**

The mean SBS in Group I–VI were 10.53 ± 2.91, 9.12 ± 2.56, 9.86 ± 1.98, 6.96 ± 2.92, 9.57 ± 2.02, and 7.65 ± 2.34 MPa, respectively [Tables 1–3].

Group I when compared with Group III; Group I versus Group V; Group III versus Group V; Group IV versus Group VI; Group II versus Group VI; Group V versus Group VI showed no statistically/clinically significant difference [Tables 1–3].

Group II when compared with Group IV; Group III versus Group IV showed statistically/clinically significant difference among all sub-groups [Tables 1–3].

With respect to ARI scores, “P” value was significant only for comparison between Groups II, IV, and VI. For rest of all the group comparisons, it was statistically nonsignificant.

**DISCUSSION**

A major problem associated with fixed appliance orthodontic treatment is decalcification around the periphery of
bracket and bands. The earliest clinical evidence of enamel demineralization is an opaque white spot. The use of antibacterial adhesive for bracket bonding will be better alternative to reduce enamel damage during fixed orthodontic treatment in future.\(^8\)

This study assessed the effect on SBS of conventional bonding system in combination with antibacterial agent.

Incorporation of MDPB in bonding system has caries prevention potential.\(^2\) MDPB is a contact-active disinfectant; it consists of quaternary ammonium. Being an immobilized
agent, it does not leach out from the surfaces. Leaching of antimicrobials has several disadvantages, such as decreased mechanical properties of the carrier substance over time, short lived effect, and possible toxicity to subjects under treatment.

The antibacterial effect of quaternary ammonium compound is due to cationic binding to cell wall component, which disturbs membrane function and subsequently induces leakage of cytoplasmic material, causing lysis of bacterial cells. MDPB on the surface of a resin-based material has a bacteriostatic effect and an anti-adhesion property against oral streptococci.

Uni-Etch™ is a 32% H₃PO₄ with BAC. Uni-Etch™ uses polymer filler to create thixotropic property, thereby enhancing handling characteristics leaving no silica debris on etched surface which impede flow of primer and of resin over the surface into the dentinal tubules and composite resin showing antibacterial properties. Leendert Boksman confirmed the development of residual bacterial inhibition zones of up to 7 mm, when challenged with Streptococcus mutans and Actinomyces viscosus.

Transbond XT™ is a light cure adhesive resin. It contains acrylate monomer and can be used with ceramic and metal brackets. Transbond XT™ contains 14% bis-GMA, 9% bis-EMA, and 77% fillers (silylated quartz and submicron silica). Transbond XT™ primers do not discolor the enamel.

Unite™ is a chemically cured no-mix resin adhesive used for bracket bonding.

Comparison of the present findings and the previous studies would be challenging. This is due to the different retaining devices that were used (human/bovine teeth or plastic cylinders), or different study sample sizes, bracket types (different brands, new, recycled), bracket base sizes, recycling methods (thermal, chemical, or sandblasting), or methods of bond strength assessment (shear or tensile) that were used.

Bulut et al. compared SBS of three bonding systems: Unite (no-mix chemically cured), Concise (two paste chemically cured), and Transbond XT (light cured), combined with an antibacterial adhesive component (Clearfil Protect Bond, Kuraray, Osaka, Japan, lots 020306 and 020311). They studied 120 samples which were divided into six groups of 20 each (three experimental groups and their respective control groups). In all experimental groups, an antibacterial bonding system (Clearfil Protect Bond, Kuraray, Osaka, Japan, lots 020306 and 020311), consisting of a self-etch primer and a light-curing fluoride releasing resin, was first applied to the enamel and then bonded with the bracket.

Table 1: Descriptive statistics for shear bond strength measurement (megapascals) in the studied groups

| Main group | Sub-group | n  | Mean (SD)      | Range      | SE  |
|------------|-----------|----|---------------|------------|-----|
| Control    | I         | 20 | 10.53±2.91    | 5.61-16.58 | 0.65|
|            | II        | 20 | 9.12±2.56     | 4.83-14.35 | 0.57|
| Experimental| III       | 20 | 9.86±1.98     | 6.97-13.60 | 0.44|
|            | IV        | 20 | 7.65±2.34     | 4.33-11.23 | 0.52|
|            | V         | 20 | 9.57±2.02     | 7.32-15.20 | 0.45|
|            | VI        | 20 | 6.96±2.32     | 2.82-11.15 | 0.51|

SE=Standard error, SD=Standard deviation

Table 2: Two-way ANOVA analysis (dependent variable: Bond strength and two factors)

| Factor         | F   | P       | Significance |
|----------------|-----|---------|--------------|
| Group          | 6.835 | 0.010   | Significant  |
| Sub group      | 7.494 | <0.0001 | Highly significant |

One is main group and second factor is sub-group

Table 3: Multiple comparison tests for shearing bond strength between and within group

| Comparison   | Mean difference | P   |
|--------------|-----------------|-----|
| Group I versus Group III | 0.673 | 1.000 |
| Group I versus Group V  | 0.957 | 1.000 |
| Group II versus Group IV | 2.116 | 0.089 |
| Group II versus Group VI | 1.477 | 0.790 |
| Group III versus Group IV | 2.846 | 0.004 |
| Group III versus Group V  | 0.284 | 1.000 |
| Group IV versus Group VI | 0.639 | 1.000 |
| Group V versus Group VI  | 1.923 | 0.182 |

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bonding systems. They found that the mean SBS for brackets bonded with Unite and Concise combined with Clearfil Protect bond was significantly reduced than that of their respective control groups. However, there was no statistically significant difference in bond strength found in samples bonded with Transbond XT combined with Clearfil Protect bond and its control group.

The different findings in these studies could be due to the small sample sizes\(^{[11,12]}\) that were not able to detect the differences between groups and dissimilar specimen types (molars\(^{[13]}\) vs. premolars\(^{[12]}\)). Alternatively, different etching times (30 s\(^{[13,14]}\) or 60 s\(^{[15]}\)) or curing times, differences in the time gap between bonding and debonding (½ h after bonding\(^{[13]}\) vs. 24 h\(^{[12]}\)), and dissimilar used bonding materials could explain the contradictory findings.

In Unite™ bonding, an oxygen inhibition layer is formed on the surface of light-cured adhesive that weaken the bond. Another reason is that coefficient of types of resin are different, thus having weaker bond or it can be due to partial destruction of etching pattern,\(^{[8,14]}\) and also weaker retentive enamel morphology.\(^{[13]}\)

Vicente and Bravo\(^{[16]}\) compared Group I (Transbond XT™ light cure bonding system) and Group V (Uni-Etch™ antibacterial self-etchant (Bisco™) with Transbond XT™ light cure bonding system) and showed no statistically significant difference.

Sehgal and Shetty\(^{[17]}\) had shown that there was no significant difference in mean SBS of Group II (Unite™ (3M Unitek) self-cure bonding system) and Group VI (Uni-Etch™ antibacterial self-etchant (Bisco™) with Unite™ self-cure bonding system).

The most recent method of anti-microbial and anti-caries application in orthodontics includes the use of nanoparticles (NPs).\(^{[18]}\) NPs are insoluble particles smaller than 100 nm in size. To prevent microbial adhesion or enamel demineralization in orthodontic therapy, two broad strategies have been used. These are incorporating certain NPs into orthodontic adhesives/cements or acrylic resins (nanofillers, silver, TiO\(_2\), SiO\(_2\), hydroxyapatite, fluorapatite, and fluorohydroxyapatite) and coating surfaces of orthodontic appliances with NPs (i.e., coating bracket surfaces with a thin film of nitrogen-doped TiO\(_2\)). Although the use of NPs in orthodontics can offer new possibilities, previous studies investigated the antimicrobial or physical characteristic over a short time span, i.e., 24 h to a few weeks, and the limitations of in vitro studies should be recognized. Information on the long-term performance of orthodontic material using nanotechnology is lacking and necessitates further investigation and so do possible safety issues (toxicity), which can be related to the NP sizes.\(^{[18]}\)

A limitation of the study was the lack of information on the mechanism for the reduced adhesion as no scanning electron microscopy of the enamel or bracket surfaces was performed. The present study used a common method (ARI)\(^{[8]}\) to assess the amount of adhesive left on the enamel surface. When compared the ARI score for Group II and IV, an apparent decrease was observed of ARI score for Group IV, indicating extremely weak bond. When compared the ARI score of Group I with Group III, no significant difference was observed. The ARI score of Group V and VI showed no significant difference (Table 4).

The limitations of in vitro studies should be considered\(^{[5]}\) when interpreting the findings of the present study. The average in vivo bond strengths are approximately 40% < those measured in the in vitro studies.\(^{[19,20]}\) Therefore, most measured in vivo bond strengths may not be as high as those measured using the in vitro models. The gradual decrease in bond strength of composites may also be due to aging, complex oral environment, and storage of material in saliva is another factor that should be considered before making clinical recommendations.\(^{[21‑24]}\)

**CONCLUSION**

- The combination of light cure adhesive and Clearfil Protect Bond™ showed minimal difference in mean SBS when compared with control group
- When Clearfil Protect Bond™ was used with chemically cured adhesive (Unite™), it showed decrease in mean SBS than as compared with light cure adhesive
- Antibacterial etchant (Uni-Etch™) when used with light cure or chemically cured adhesive did not show any significant difference in mean SBS
- Uni-Etch™ combined with light cure adhesive gives better mean SBS than combined with chemically cured adhesive
- The weak bond was with Group IV (Unite™ + Clearfil Protect Bond™) and strong bond was with Group III (Transbond XT™ + Clearfil Protect Bond™)
- Clearfil Protect Bond™ when used with Transbond XT™ has better bond strength and better anti-decalcification effect than compared to Uni-Etch™ combined with Transbond XT™, but Uni-Etch™ is more cost-economical and easily available

### Table 4: Descriptive statistics for adhesive remnant index

| Group | ARI | Total | \(\chi^2\), P |
|-------|-----|-------|---------------|
| I     | 0   | 3     | 5             | 20   |
| II    | 0   | 6     | 5             | 9    | 20   |
| III   | 0   | 2     | 8             | 10   | 20   |
| IV    | 4   | 6     | 10            | 0    | 20   |
| V     | 0   | 7     | 3             | 10   | 20   |
| VI    | 1   | 7     | 6             | 6    | 20   |

ARI=Adhesive remnant index
Because there is no statistically/clinically significant difference between the above two groups, it is left to the choice of the practitioner to choose wisely based on the clinical requirements of the particular case.

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Conflicts of interest
There are no conflicts of interest.

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