Comparison of Microleakage in Metal Brackets Bonded using Self-etching Adhesive with and without Fluoride Release: An in vitro Study

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ABSTRACT

Objective: To evaluate and compare the extent of microleakage directly beneath the metal brackets bonded to extracted premolar teeth using self-etching-primers (SEP) with and without fluoride release and conventional acid etching using 37% phosphoric acid.

Materials and methods: Sixty extracted premolars were segregated into three groups. Forty teeth were etched with SEP, out of which 20 were etched with fluoride containing SEP (Xeno 3) and 20 with nonfluoride SEP (easy one). This two groups were compared with a control group etched with conventional 37% phosphoric acid. 3M Unitek brackets were bonded following manufacturer’s instructions and specimens were kept in distilled water and thereafter subjected to thermal cycling. The specimens were stained with 0.5% basic fuschin for 24 hours, sectioned and photographed under a microscope. Microleakage was observed in all the groups and was scored with regard to the adhesive-tooth interface in both the gingival and incisal margins. Statistical analysis was accomplished by Kruskal-Wallis test and statistical significance set at p < 0.05.

Results: Even though microleakage was observed in all the groups, the results indicate that these are not clinically significant (p < 0.132). Brackets bonded with SEP without fluoride released showed more microleakage than brackets bonded with SEP with fluoride release.

Conclusion: Addition of fluoride in the orthodontic adhesive system reduces the severity of microleakage but does not eliminate its incidence totally.

Keywords: Microleakage, Self-etching primers, Xeno 3, Easy one, Fluoride primer, White spot lesions.


INTRODUCTION

The inception of the first specialty of dentistry began with a search for a suitable ‘handle’ to transmit the therapeutic tooth moving forces to the teeth, in order to position them in an esthetic, stable and functional position. The insertion of an orthodontic appliance stimulates an environmental change, characterized by a drop in pH and an increase in concentration of carbohydrates, streptococci and lactobacilli in the plaque. (A pH of 5 is the critical decalcifying level at which calcium is leached from the enamel). Early lesions appear clinically as opaque white spots, caused by mineral loss in the surface or subsurface of the enamel. Estimate of the presence of white spot lesions per patient in the orthodontically treated population range from 2 to 96%.

The orthodontists have always been struggling with this aesthetic issue as it is discouraging to a specialty whose goal is to improve facial and dental esthetics. Since the beginning of fluoridation era in 1945, fluoride applications are used in varying forms by orthodontic practitioners. Fluoride ions encourage the formation of calcium fluoride and fluorapatite, which enhances remineralization of enamel. Several fluoride regimens with varying fluoride concentrations, pH and delivery systems (varnish, solution, gel, rinse, dentifrice, chewing sticks) have been shown to be effective in preventing demineralization and enhancing remineralization. However, compliance with using a preventive fluoride rinse program cannot be expected in 50% of patients. Moreover, investigations have proved that continuous application of a low dose of fluoride had a greater cariostatic effect than individual applications of a high dose.

A method to protect the susceptible area beneath the bonded attachments, independent of patient compliance, would be to add fluoride-releasing resin to the orthodontic adhesives. These materials exhibit locally an additional source of fluoride near the brackets. Numerous studies have investigated the efficiency of these fluoride-releasing materials on bracket.
bonding and enamel surface protection. The preventive effect of adhesives adjacent to brackets has been investigated in vitro\textsuperscript{11} and in vivo\textsuperscript{12}. Very few studies have evaluated microleakage directly beneath the brackets.

An in vitro study was designed to evaluate the extent of microleakage directly beneath the metal brackets using self-etching adhesive system with fluoride release and self-etching adhesive system without fluoride release after in vitro thermocycling and compared with conventional acid etching.

**MATERIALS AND METHODS**

**Sample Preparation**

A total of 60 premolars (maxillary or mandibular) extracted for orthodontic purpose were collected. Exclusion criteria include caries, cracks, developmental defects of enamel or restores teeth. Teeth were polished with nonfluoridated pumice flour for 10 seconds and stored in distilled water for not more than a month. The teeth were randomly separated into three equal groups of 20 teeth each (Fig. 1).

*Group 1*: Etched with a fluoride releasing two bottle self-etching adhesive system—Xeno 3 (dentsply).

*Group 2*: Etched with a nonfluoride releasing self-etching single bottle, no mix self-etching adhesive system—Easy one.

*Group 3*: Etched with conventional 37% phosphoric acid gel.

**Composition of Self-etching Primers**

**Fluoride containing SEP—Xeno 3 (Dentsply)**

*Liquid A*: 2-Hydroxyethyl methacrylate (HEMA), purified water, ethanol urethane dimethacrylate resin, butylated hydroxy toluene (BHT), highly dispersed silicon dioxide.

*Liquid B*: Phosphoric acid modified polymethacrylate resin, mono fluoro phosphazene modified methacrylate resin, urethane dimethacrylate resin, BHT, camphorquinone, ethyl-4-dimethylaminobenzoate (Fig. 2).

**Non-Fluoride SEP—Easy One (Adper\textsuperscript{TM} Easy Bond Self-etch Adhesive)**

2-Hydroxyethyl methacrylate (HEMA), Bis-GMA, methacrylated phosphoric esters, 1,6 hexanediol dimethacrylate, methacrylate functionalized polyalkenoic acid (Vitrebond\textsuperscript{TM} Copolymer), finely dispersed bonded silica filler with 7 nm primary particle size, ethanol, water, initiators based on camphorquinone and stabilizers.

**Bonding Method**

The 0.022 slot 3M Unitek metal brackets were bonded following the manufacturer’s instructions by a single operator. For Xeno 3 the two liquids were mixed in the mixing base provided by the manufacturer. The solution was applied with an applicator tip and was dried using a gentle burst of air and the brackets were bonded using Transbond XT (3M Unitek, Monrovia, California) light cure adhesive paste.

**Microleakage Evaluation**

After bonding, the specimens were stored in distilled water for 4 weeks at 37°C, after which thermal cycling in deionized water was performed at 5 ± 2°C to 55 ±2°C for 500 cycles with a dwell time of 30 seconds and a transfer time of 10 seconds (Fig. 3). Before dye penetration, the apices were sealed with sticky wax and the specimens were coated with two consecutive layers of nail varnish up to 1mm from bracket margins. Specimens were then immersed in 0.5% basic fuschin solution for 24 hours. After thorough rinsing with distilled water, the samples were air dried and embedded in epoxy resin. Parallel longitudinal sections with a low speed diamond microtome were made (Fig. 4).

All the sections were examined under a light microscope at 16× magnification (Figs 5 to 7). Each section was scored from both incisal and gingival margins to the brackets between both the bracket-adhesive interface and the adhesive-enamel interface.

**Scoring Criteria**

0 = No dye penetration between the bracket-adhesive interface.

1 = Dye penetration restricted to 1mm of the bracket-adhesive or adhesive-enamel interface.
Comparison of Microleakage in Metal Brackets Bonded using Self-etching Adhesive with and without Fluoride Release

2 = Dye penetration into the inner half (2 mm) of the bracket-adhesive, adhesive-enamel interface.
3 = Dye penetration into 3 mm of the bracket–adhesive or adhesive enamel interface.13

Statistical Analysis
Statistical evaluation of microleakage scores among the test groups was performed by Kruskal-Wallis test and Mann-Whitney U-test with Bonferroni correction with significance set at p = 0.05.

RESULTS
All the groups exhibited some amount of microleakage regardless of the adhesive and bracket type, highlighting the importance of microleakage beneath brackets. Metal brackets bonded with self-etching primer (SEP) with fluoride release (Xeno 3); (Fig. 5) and conventional phosphoric acid etch exhibited lower microleakage scores (Fig. 7; mean = 0.2) compared to those observed under metal brackets bonded with SEP without fluoride release (mean = 0.9; Fig. 6) as tabulated in Table 1. When compared with conventional 37% phosphoric group (mean = 0.3), the microleakage scores were higher in the SEP without fluoride release (Easy one). Even though microleakage was observed in all the groups, the results indicate that these are not statistically significant (p < 0.132; Table 2) (Fig. 8).
White spot formation is an undesirable complication of orthodontic fixed appliance therapy. These lesions are due to demineralization of the enamel by cariogenic bacteria that readily accumulate around the brackets. Enamel demineralization and white spot lesions occur during and remain after orthodontic treatment. O’Reilly and Featherstone have shown that visible white lesions can develop within 4 weeks of commencing fixed appliance treatment. Although orthodontists have recognized this negative complication, and must take active steps to minimize it, white spot formation and development of caries in patients who do not follow aggressive caries preventive measures during orthodontic treatment still remains a problem.

Øgaard reported that even 75% of the ‘small’ lesions had regressed during the retention period. Artun and Thylstrup in their 3-year clinical study also observed similar findings. Pancherz and Meuhlich reported that 19.1% of the patients who exhibited the lesions after treatment were free of them 3 years after treatment, whereas 56.2% showed improvement, and just 5.6% of the patients exhibited deterioration. However, it is difficult to decide for the clinician whether to wait for spontaneous regression or opt for active treatment. Moreover, better chance of regression is seen in individuals with mild lesions and good oral hygiene.

The results of the present study substantiate that the microleakage is associated with the bonding materials available but with the inclusion of fluoride it can be minimized. Fluoride therapy can reduce enamel solubility, control plaque activity through blocking bacterial enzyme systems and assist in enamel remineralization. Therefore, as a caries preventive measure, fluoride provides an unequivocal benefit to the dental health of the patient. The importance of a sustained fluoride program is well-established since fluoride is depleted from enamel during ionic exchanges with plaque. It is necessary to replenish such losses, if benefit is to be sustained. Daily administration of topical fluoride and the use of fluoridated toothpaste is one method of providing a continuous reservoir of fluoride ions necessary for enamel protection against white spot formation.

Several techniques have been introduced to assess microleakage around dental restorations. Dye penetration is a commonly used methodology in restorative dentistry and also in orthodontics because it provides a simple, relatively cheap, quantitative, and comparable method of evaluating the performance of the various techniques. This methodology involves exposure of the samples to a dye solution and then viewing cross-sections under a light microscope. To evaluate the relevance of a leakage test, the effective size of oral bacteria must be considered. Because of the range of bacteria sizes, dyes, such as methylene blue and fuchsin are realistic agents for simulation of passage of bacterial entry to cause decalcification.

**Table 1: Microleakage scores for individual teeth**

<table>
<thead>
<tr>
<th>Tooth number</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Where,

0 = No dye penetration between the bracket-adhesive interface
1 = Dye penetration restricted to 1 mm of the bracket-adhesive or adhesive-enamel interface
2 = Dye penetration into the inner half (2 mm) of the bracket-adhesive, adhesive-enamel interface
3 = Dye penetration into 3 mm of the bracket-adhesive or adhesive enamel interface

Mean = 0.2
Mean = 0.9
Mean = 0.3

**Table 2: Microleakage at the adhesive tooth interface**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number</th>
<th>Mean</th>
<th>SD</th>
<th>p-value</th>
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<tr>
<td>3</td>
<td>20</td>
<td>0.3</td>
<td>0.733</td>
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Fig. 8: Bar diagram comparing microleakage between groups

**DISCUSSION**

The present study tried to evaluate the efficacy of adding fluoride to orthodontic adhesive system using SEP in the control of microleakage directly under the metal brackets. The results of the study indicate that this method of fluoride supplement reduces the microleakage directly under the bracket but do not completely eliminate it.
Polymerization shrinkage of the adhesive will result in oral fluid leakage between the tooth and the adhesives. A path of microleakage between the adhesive and enamel leaves the potential for microbial ingress and consequent enamel demineralization. Orthodontic attachments should be bonded with materials that release fluoride. Although the fluoride-releasing effect extends around the bracket, the bacterial activity might not extend beyond the edges of the bracket; this is a possible limitation of its antibacterial action. It is known to be effective when bacteria contact the surface. This would be beneficial against demineralization under orthodontic brackets from microleakage that can occur after polymerization.\(^{25}\)

Hence, bonding should be considered as only part of a modern preventive package that also includes a strict oral hygiene program, fluoride supplementation and the use of simple yet effective appliances.

**CONCLUSION**

- All the groups in the study exhibited some amount of microleakage regardless of the adhesive and bracket type, highlighting the importance of microleakage beneath brackets. This study indicates that SEP with fluoride release (Xeno 3) is a suitable material for orthodontic bonding procedures.
- Even though microleakage was observed in all the groups, the results indicate that these are not statistically significant (p < 0.132) and the materials can be used for clinical bonding. However, further *in vivo* studies are required to evaluate the shear bond strength using these SEP.

**REFERENCES**