MICROLEAKAGE UNDER LINGUAL RETAINER COMPOSITE BONDED WITH AN ANTIBACTERIAL MONOMER-CONTAINING ADHESIVE SYSTEM

Objective: To determine and compare the microleakage of a conventional acid-etched, light-cured lingual retainer adhesive system with a recently developed antibacterial monomer-containing adhesive with and without etching. Methods: Sixty human mandibular incisors were separated into three groups of 20 teeth each, which received the following treatments: group 1 (control) = Transbond LR (3M Unitek), conventional lingual retainer bonding; group 2 = Clearfil Protect Bond (Kuraray Medical) with acid-etching; and group 3 = Clearfil Protect Bond without acid-etching. The wire in each was 0.0215-inch multi-stranded PentaOne (Masel Orthodontics). Samples were sealed with nail varnish, stained with 0.5% basic fuchsin, and sectioned. Transverse sections were evaluated under a stereomicroscope and scored for microleakage in millimeters at the composite-enamel interface. Statistical analysis was performed by Kruskal-Wallis and Mann-Whitney tests with Bonferroni correction. Results: Group 2 had less microleakage (0.11 ± 0.19 mm) than group 1 (0.26 ± 0.30 mm) or group 3 (0.24 ± 0.27 mm). However, the difference in the microleakage of the composite-enamel interface among all investigated groups was not significant (P > .05). Conclusion: The findings of this study do not speak against using an antibacterial monomer-containing self-etching adhesive to bond lingual retainers. World J Orthod 2009;10:196–201.

Key words: antibacterial, microleakage, self-etching
retainers and concluded that regardless of the type of wire involved, there is a tendency for plaque and calculus accumulation along the wire, which seems to increase with time. Further, Artun and Brobakken\(^5\) indicated that plaque accumulation with subsequent acid production often leads to decalcification concomitant with an alteration in the appearance of the enamel surface.

Gaps between the bonding material and enamel surface are likely caused by polymerization shrinkage of the adhesive.\(^6\) These gaps may promote seeping of fluids and bacteria, thus facilitating the formation of white-spot lesions.\(^7\) The microleakage beneath the composite is particularly important for lingual retainers, as they are exposed to the oral cavity for a long time.

Because recently developed bioactive adhesive systems possess an antibacterial effect and intensive remineralization ability, they are considered to offer a superior clinical performance.\(^8\) Øgaard et al\(^9\) found that the use of a fluoride varnish with or without chlorhexidine reduced the incidence of white-spot lesions significantly, particularly in the maxillary incisors. In the present study, a new antibacterial and fluoride-releasing self-etching adhesive is tested. This system consists of a primer that contains an antibacterial monomer (12-methacryloyloxydodecyl pyridinium bromide [MDPB]) and a bonding agent that contains sodium fluoride.\(^10\)

Obviously, so far, the microleakage under bonded lingual retainers was not investigated. Therefore, the aim of this study was to determine and compare the microleakage of a conventional acid-etched, light-curing adhesive system to the new system with and without etching. The null hypothesis assumed that there were no significant differences in microleakage between the two bonding systems in lingual retainers.

### MATERIALS AND METHODS

#### Sample preparation

Sixty freshly extracted human mandibular incisors were stored in distilled water. Immediately before bonding, all teeth were cleaned with a scaler and pumice to remove soft tissue remnants, plaque, and calculus. These teeth were divided into three groups of 20 each.

The wire used in all groups was 0.0215-inch multistranded PentaOne (Masel Orthodontics). The wire was cut into sections of 10 mm to ensure standardization. All sections were bent to fit the lingual curvature of the respective incisors. Detailed information about the products used in this study is shown in Table 1.

To ensure stability during placement and contouring of the composite, all teeth were placed in silicone putty compound. The free ends of all wires were

### Table 1: Study materials and their chemical composition

<table>
<thead>
<tr>
<th>Material</th>
<th>Manufacturer</th>
<th>Component</th>
<th>Chemical composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS White</td>
<td>SS White Group</td>
<td>Etching gel</td>
<td>37% phosphoric acid</td>
</tr>
<tr>
<td>Transbond XT</td>
<td>3M Unitek</td>
<td>Primer</td>
<td>Triethylene glycol dimethacrylate, bisphenol A diglycidyl ether dimethacrylate</td>
</tr>
<tr>
<td>Clearfil Protect Bond</td>
<td>Kuraray Medical</td>
<td>Primer</td>
<td>MDP, MDPB, HEMA, hydrophilic dimethacrylate, water, initiators</td>
</tr>
<tr>
<td>Clearfil Protect Bond</td>
<td>Kuraray Medical</td>
<td>Bond</td>
<td>MDP, HEMA, Bis-GMA, hydrophobic dimethacrylate, dl-camphorquinone, N,N-diethanol-p-toluidine, silanated colloidal silica, surface-treated sodium fluoride</td>
</tr>
<tr>
<td>Transbond LR</td>
<td>3M Unitek</td>
<td>Paste</td>
<td>Bisphenol a diglycidyl ether dimethacrylate, triethylene glycol dimethacrylate, dichlorodimethylsilane reaction product with silica</td>
</tr>
</tbody>
</table>

MDP = 10-methacryloyloxydecyldihydrogen phosphate, MDPB = methacryloyloxydodecyl-pyridinium bromide, HEMA = 2-hydroxyethylmethacrylate, Bis = A diglycidylmethacrylate.
also secured with silicone putty to provide an optimal fit with the individual tooth surface. For standardization, care was taken to shape the bulk of the composite 4 mm in diameter and 1 mm in thickness around the wire.

The sample preparation in the three groups was as follows:

**Group 1 (control).** All samples were etched for 15 seconds with 37% orthophosphoric acid (3M Dental Products), rinsed with water from a three-in-one syringe for 15 seconds, and dried with an oil-free source for 15 seconds. Before composite placement, a thin uniform coat of Transbond XT primer (3M Unitek) was applied to the etched surfaces. The primer was not cured according to the manufacturer's instructions. With an adhesive dispenser, Transbond LR (3M Unitek) was placed and cured by a light-emitting diode (Elipar Free Light 2, 3M ESPE Dental Products) for 5 seconds according to the manufacturer's instructions.

**Group 2 (Clearfil Protect Bond with acid-etching).** Etching, rinsing, and drying occurred as in group 1, followed by application of the self-etching primer containing an antibacterial monomer (Clearfil Protect Bond, Kuraray Medical). This primer rested for 20 seconds before it was dried with a mild air stream to evaporate the solvent. Then, Clearfil Protect Bond was applied, gently air-flowed, and light-cured for 10 seconds. Thereafter, Transbond LR composite was applied as described before.

**Group 3 (Clearfil Protect Bond without acid-etching).** Self-etching Clearfil Protect Bond primer was applied as suggested by the manufacturer. The enamel was wiped with this primer for 20 seconds and then dried with a gentle air flow. The following steps were identical as those in groups 1 and 2.

**Microleakage evaluation**

Prior to dye penetration, all apices were sealed with sticky wax and the teeth were rinsed in tap water. They were air dried, and nail varnish was applied to the entire tooth surface except for approximately 1 mm around the composite bulk. To minimize dehydration, the samples were placed in water immediately after the nail polish had dried. Subsequently, all teeth were immersed in a 0.5% solution of basic fuchsin for 24 hours at room temperature. After removal from this solution, the teeth were again rinsed in tap water, the superficial dye was carefully removed with a brush, and all teeth were dried. Each specimen was sectioned just above and parallel to the retainer wire with a water-cooled diamond bur at low speed. All sections were evaluated under a stereomicroscope (20× magnification) (SZ 40, Olympus) for dye penetration along the composite-enamel interface at both the mesial and distal border. Microleakage was determined by direct measurement using an electronic digital caliper and recording the data to the nearest 0.5 mm.

**Statistical analysis**

The overall microleakage score for the composite-enamel interface was obtained by calculating the mesial and distal microleakage scores. The total scores for all groups were obtained by calculating the mean of all individual microleakage scores. Intergroup differences were tested using the Kruskal-Wallis and Mann-Whitney tests with Bonferroni correction. The intra- and interexaminer method error was evaluated by Kappa test. The level of significance was set at \( P < .05 \).

**RESULTS**

The intra- and interexaminer Kappa scores were high with values > 0.85 (Table 2). The descriptive statistics are shown in Table 3.

The results of this study demonstrate that group 2 had less microleakage (\( m = 0.11 \pm 0.19 \) mm) than group 1 (\( m = 0.26 \pm 0.30 \) mm) and Group 3 (\( m = 0.24 \pm 0.27 \) mm) (Table 4). However, no significant differences were found among all investigated groups (\( P > .05 \)). Thus, the null hypothesis of this study had to be accepted.
DISCUSSION

Ideally, enamel etching with phosphoric acid creates an etching pattern characterized by deep and uniform demineralization. The demineralized areas are infiltrated by the adhesive resin, producing tags which penetrate into the enamel. Compared with phosphoric acid, self-etching primers produce a more conservative etching pattern. When problems arise during bonding, it can lead to seeping of fluids and bacteria into the composite-enamel interface. This process can cause white-spot lesions.

Celiberti and Lussi indicated that etching with phosphoric acid showed significantly better (longer) tag formation and lower microleakage when compared to self-etching. Van Landuyt et al investigated the bond strength of a self-etching adhesive with and without prior acid-etching. They concluded that the bonding effect of the self-etching adhesive system could be significantly improved by pre-etching with phosphoric acid. They interpreted this increase in bond strength as a consequence of increased enamel porosity, resulting in an increased micro-mechanical retention.

Several techniques exist to assess microleakage around dental restorations. The easiest and most commonly used method is to expose the samples to a dye solution and examine cross sections under a light microscope. To realize the relevance of leakage, the size of oral bacteria must be considered. Because this size varies, methylene blue and fuchsin are dyes that are used to reveal clinically relevant gaps. Dye penetration was chosen for this study because it is simple and relatively cheap and allows a quantitative evaluation.

### Table 2: Intra- and interexaminer Kappa scores for assessment of microleakage

<table>
<thead>
<tr>
<th></th>
<th>Mesial side</th>
<th></th>
<th>Distal side</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 3</td>
<td>Group 1</td>
</tr>
<tr>
<td>Intraexaminer</td>
<td>0.88</td>
<td>0.87</td>
<td>0.88</td>
<td>0.86</td>
</tr>
<tr>
<td>Interexaminer</td>
<td>0.85</td>
<td>0.93</td>
<td>0.91</td>
<td>0.83</td>
</tr>
</tbody>
</table>

### Table 3: Mesial and distal microleakage scores between enamel-composite interface (mm)

<table>
<thead>
<tr>
<th>Group/side</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.175</td>
<td>0.294</td>
<td>0.000</td>
<td>1.000</td>
<td>.318</td>
</tr>
<tr>
<td>2</td>
<td>0.075</td>
<td>0.183</td>
<td>0.000</td>
<td>0.500</td>
<td>.457</td>
</tr>
<tr>
<td>3</td>
<td>0.150</td>
<td>0.286</td>
<td>0.000</td>
<td>1.000</td>
<td>.156</td>
</tr>
</tbody>
</table>

### Table 4: Microleakage between composite-enamel interface (mm) of three groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.26</td>
<td>0.30</td>
<td>0</td>
<td>1.0</td>
<td>.154</td>
</tr>
<tr>
<td>2</td>
<td>0.11</td>
<td>0.19</td>
<td>0</td>
<td>0.5</td>
<td>.154</td>
</tr>
<tr>
<td>3</td>
<td>0.24</td>
<td>0.27</td>
<td>0</td>
<td>1.0</td>
<td>.154</td>
</tr>
</tbody>
</table>

SD = standard deviation.
Microleakage occurs due to shrinkage of the adhesive or to the difference in the linear thermal expansion coefficients of the tooth hard substances and the adhesive. Thermocycling is widely used to simulate temperature changes in the mouth, generating successive thermal stresses at the tooth-adhesive interface. Kubo et al. investigated the microleakage of fillings applied with a self-etching primer after thermal and flexural load cycling. They found that the marginal integrity of these fillings did not deteriorate even after a maximum of 10,000 thermal cycles and flexural loads. Similarly, other researchers indicated that an increase in the number of thermal cycles was not related to an increase in microleakage of restorations.

Therefore, thermocycling was not performed in this study.

In orthodontic treatment with fixed appliances, undue shrinkage and gap formation between the adhesive covering the bracket base and enamel surface is not a concern for mainly two reasons: (1) the adhesive layer under the bracket is normally extremely thin, and (2) excess adhesive at the bracket edges absorbs some of the shrinkage.

Various attempts were made to minimize white-spot lesion formation during orthodontic treatment, including the use of adhesive systems containing fluoride or antibacterial agents. Clearfil Protect Bond is a recently developed self-etching antibacterial adhesive system containing MDPB, which is an antibacterial monomer. Imazato reported that this antibacterial agent does not leach from the carrier material but acts as a contact inhibitor against bacteria that attach around a restoration. In vitro antibacterial activity, bonding ability, cytotoxicity, and pulpal response of MDPB-containing self-etching primers and adhesives have been published in the restorative dentistry literature. However, in orthodontics, this protective material has not been investigated thoroughly to date.

Descriptive statistics showed small but insignificant differences of microleakage at the mesial and distal composite-enamel interfaces of the three groups. However, the fact that all groups exhibited some microleakage emphasizes this aspect in relation to lingual retainers.

According to the study of Celiberti and Lussi, the use of self-etching adhesives on intact enamel is not advocated because of a significantly lower bond strength due to the insufficient etching pattern and greater microleakage. This could not be confirmed by two other studies nor the present one.

Bishara et al emphasized that the use of an antibacterial fluoride-releasing adhesive requires an additional step during the bonding procedure. However, the increased chair time is compensated by avoiding additional measures to decrease the incidence of white spot formation.

CONCLUSION

The following conclusions were drawn:

- All groups exhibited some amount of microleakage under their lingual retainer bonds regardless of the enamel preparation technique. Thus, microleakage under retainer composites should be seriously considered.
- The findings of this study support the use of an antibacterial monomer-containing self-etching adhesive to routinely bond lingual retainers in the orthodontic practice.
- The advantage of this protective antibacterial system requires an additional step during bonding.

REFERENCES


