Original Article

Microleakage of Different Adhesive Systems in Primary Molars Prepared by Er: YAG Laser or bur

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Abstract

Background and aim: This study aimed to examine the microleakage of class V cavities of primary molars prepared by either a conventional dental bur or Er:YAG laser and one of two different adhesive systems. **Methods:** A total of 50 tooth samples from primary molars were used in this study. They were randomly assigned into five experimental groups of 10 samples each, according to the cavity preparation technique and the type of adhesive system applied to the cavities. Following cavity preparation, etching, bonding, and filling steps, samples were dyed using basic fuchsine and were sectioned longitudinally in buccolingual direction. Percentages of dye penetration at gingival and occlusal margins were calculated for each group. **Results:** Overall, microleakage scores of gingival margins were significantly higher than those of occlusal margins ($P < 0.001$). The group that underwent laser preparation, laser etch, and self-etch bonding procedures had worse microleakage scores for gingival margins. However, all groups had similar occlusal scores ($P > 0.05$). **Conclusion:** Self-etch bonding systems and cavity preparation with Er:YAG laser may be an alternative to conventional restoration of primary molars with compomers. Further studies are warranted to fully elucidate the effect of laser-based etching techniques in cavities prepared by laser.

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Introduction

Microleakage induced by polymerization shrinkage continues to be a major concern for the clinical durability of resin-based dental restorations.[1] Microleakage is related to the bonding quality and polymerization shrinkage of adhesives.[2] Although improved adhesive systems have been developed, they do not completely prevent microleakage at enamel and dentin margins. Also, instruments utilized during cavity preparation have an impact on the occurrence of microleakage.[3]

With the use of conventional diamond burs, the cavity surface may be covered by debris consisting of organic and nonorganic material that is termed as the "smear layer," and may predispose resin-based restorations to microleakage.[3] Although the increasingly used laser techniques are not associated with smear layer formation, they may lead to structural changes on the enamel and dentin with a subsequent risk of microleakage.[4,5]

Adhesive systems have "etch-and-rinse" or "self-etch" features, defined on the basis of their respective application procedures and adhesion mechanisms.[1] Self-etching adhesive systems have no separate acid etching step and contain acidic monomers which can etch both enamel and dentin surfaces like the primer does, thus penetrating the tooth surface for resin infiltration into demineralized dentin.[1] The self-etch systems have been classified as two-step and one-step (all-in-one) adhesives. Recently introduced one-step self-etch

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systems (all-in-one) incorporate all the components of an adhesive system (etchant, primer, and bonding resin) into a single solution and combine all the three bonding steps into a single application.[6] Generally, self-etching adhesives are preferred materials because they eliminate the washing and drying steps, save chairside time, which is very important for pediatric dentistry, and reduce procedural errors.[1]

The widespread use of adhesive dentistry in pediatric patients and an increasing use of laser technology in dental practice are paralleled by a trend that prompts a growing interest in the interaction between adhesive systems and lased primary dentin substrates.[1] On the contrary, since primary and permanent teeth exhibit many structural and morphological differences, the results from studies on permanent teeth cannot be extrapolated to primary teeth in most occasions. Also, studies evaluating the use of laser systems in primary teeth for cavity preparation prior to adhesive use are scarce.[7]

The aim of this *in vitro* study was to evaluate the microleakage of class V cavities of primary molars prepared by either a conventional dental bur or Er:YAG (erbium, chromium: yttrium aluminum garnet) laser and two different adhesive systems.

Materials and Methods

Sample Preparation and Study Groups

A total of 25 freshly extracted restoration- and caries-free primary molar teeth were selected randomly for the study. The teeth were cleaned of calculus, soft tissue, and debris with hand instrumentation and placed in a 0.5% chloramine T solution for disinfection for 24 hours. The teeth were stored in distilled water for a maximum duration of 6 months until the time of analysis, as recommended by the International Organization for Standardization (ISO, Guidance on Testing of Adhesion to Tooth Structure. International Organization for Standardization, TR 11405,1-4, Geneva, Switzerland, 1994). To prevent bacterial growth, water was renewed weekly. The collection procedure for the extracted teeth was approved by all patients and by the relevant ethics committee.

The teeth were mounted in a cold-curing acrylic resin and kept in cold water until the resin was completely cured, in order to avoid the thermal effects generated by the resin curing process and were subsequently divided in half in a mesiodistal direction using a diamond blade (15.2 cm × 0.5, 6'' Dia. X 0.20'' Buehler, USA). The pulp chambers of the tooth were sealed with glass ionomer restorative material (Fuji II LC, GC Corporation, Tokyo, Japan) and a total of 50 tooth samples were obtained. Then, they were randomly assigned into five experimental groups of 10 samples each, according to the cavity preparation technique and the type of adhesive system applied to the cavities according to manufacturer's instructions, as outlined below. Study groups were: Group 1, bur preparation, nonrinse etch, standard bonding (control group); Group 2, bur preparation and self-etch bonding; Group 3, laser preparation, nonrinse etch, standard bonding; Group 4, laser preparation, laser etch, self-etch bonding; Group 5, laser preparation, no etching, self-etch bonding.

Cavity Preparation by Bur or Laser

Standardized class V cavities (1.5-mm deep, 3-mm long, and 2-mm wide, with the occlusal margin in enamel and the cervical margin extending 0.5 mm below the cemento-enamel junction) were prepared at the cemento-enamel junction of each primary molar sample using metal templates. All cavity preparations were done by a single dentist using burs at a high-speed handpiece under water cooling or an Er:YAG laser system (Fotona Medical Lasers, Fidelis PLUS Er:YAG and Nd:YAG Dental Laser, Ljubljana, Slovenia). For the laser procedure, the following specifications were used for cavity preparation: 4-6 W(330mJ,20Hz). A new bur was used for every five preparations in bur-prepared cavities. Finally, the cavity size was checked using a periodontal probe.

Etching, Bonding, and Filling

The same laser instrument was used for laser etching with following specifications: 0.80 W (80mJ, 10 Hz). For nonrinse etching, a nonrinse conditioner/NRC was used. For self-etch bonding, GC Unifill bond was used. For standard bonding, Prime & Bond/NT was used. Chemical composition and application procedures of the adhesive systems used in this study are shown in Table 1. Cavities were restored with compomer resin Dyract Extra, De Trey Gmb H, Konstanz (Germany) according to manufacturers' instructions.

After short-term storage in distilled water, parts of the teeth outside of cavity region were coated twice with nail varnish to prevent dying of normal teeth. Then, samples were immersed in 0.5% basic fuchsin and were sectioned longitudinally in buccolingual direction into three sections. Multiple sections were evaluated for dye preparation in each tooth. Digital images were examined and worst scores for both occlusal and gingival margins were used for data analysis. The depth of the cavity walls and dye penetration along occlusal and cervical margins toward the axial wall were determined, and the percentage of dye penetration was calculated. The means of percentage of dye penetration for both interfaces were calculated for each group.

Statistical Analysis

Statistical Package for Social Sciences version 23 was used for the analysis of data. For intergroup comparisons of data, Kruskal-Wallis test was used and built-in pairwise comparison test for Kruskall-Wallis test was used for *post hoc* analysis. For intragroup comparisons, Wilcoxon signed-rank test was used. *P* value smaller than 0.05 was used as an indication of statistical significance.

Results

Microleakage scores (percentages) for all five groups at the occlusal and gingival margins are depicted in Table 2. Example images are shown in Figure 1.

Microleakage scores of gingival margins were higher than those of occlusal margins for all study samples. The difference was statistically significant ($P < 0.001$).

Occlusal groups had similar microleakage scores with no statistically significant difference between the groups ($P = 0.989$). There were, however, significant differences between groups in terms of gingival microleakage scores ($P = 0.002$). Group 4 had significantly higher scores

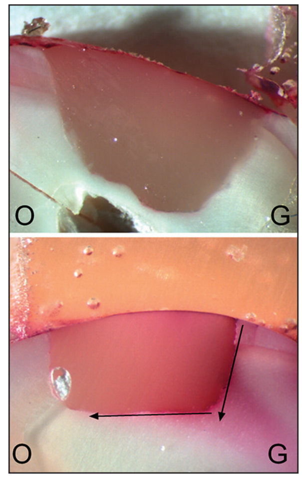

Figure 1: Two example images showing the scoring of microleakage. Upper image, no microleakage at occlusal or gingival side. Lower image, 64% microleakage at gingival side, whereas no leakage at occlusal site. O, occlusal; G, gingival. Arrows indicate the path of microleakage at gingival side.

Table 1: Chemical composition and application procedures of adhesive systems

Adhesive system	Composition	Application procedure
Prime&BondNT/Dentsply DeTrey GmbH, Konstanz/Germany (standard bonding)	Di-and trimethacrylate resins, functionalised amorphous silica, PENTA (Dipentaerythritol pentaacrylate phosphate), photoiniators, stabilisers, cetylamine hydrofluoride, acetone	Bond applied to the entire cavity wall with a disposable brush tip and left for 20 s. Volatile ingredients evaporate with a mild oil-free air stream. Using a gentle oil-free air flow, a uniform bond film created. Light-cured for 10 s with a dental curing light.
NonRinseConditioner/Dentsply DeTrey GmbH, Konstanz/Germany (non-rinse etch)	Itaconic acid, maleic acid, water, solvent	Sufficient amount applied to enamel and dentine using an applicator tip or disposable brush and left undisturbed 20 s. Not rinsed. Excess removed by blowing gently with an air syringe or blot dry using a cotton pellet. Dentine structure not desiccated
GC Unifil Bond GC Corp, Tokyo, Japan (self-etch bonding)	Methacryloxyethyl trimellitic acid, ethanol, distilled water, HEMA, initiator	Applied to the dentine and enamel surfaces and left undisturbed for 20 s. Then gently dried with an air syringe for 5 seconds. Not rinsed with water. Light-cured for 10 s.

Table 2: Gingival and occlusal microleakage scores of the groups

Groups	Occlusal scores	Gingival scores
Group 1 (control group)	7.9 ± 7.2	29.3 ± 26.1
(bur preparation, nonrinse etch, standard bonding)	7.0 (0--21)	25.5 (0--68)*
Group 2	8.8 ± 6.6	27.7 ± 21.0
(bur preparation, self-etch bonding)	7.5 (0--22)	30.0 (1--62)†
Group 3	7.9 ± 6.2	21.1 ± 16.4
(laser preparation, nonrinse etch, standard bonding)	7.5 (0--18)	16.0 (0--48)‡
Group 4	16.7 ± 24.7	63.9 ± 23.5
(laser preparation, laser etch, self-etch bonding)	8.0 (0--80)	69.0 (20--94)
Group 5	10.7 ± 12.1	43.4 ± 16.5
(laser preparation, no-etching, self-etch bonding)	9.0 (0--38)	47.0 (11--63)
P for overall difference	0.989	0.002

Data presented as mean ± standard deviation and median (range). *versus group 4, $P = 0.049$; †versus group 4, $P = 0.031$; ‡versus group 4, $P = 0.003$

when compared with group 1 (P = 0.049), group 2 (P = 0.031), and group 3 (P = 0.003).

Discussion

In this *in vitro* study comparing five different cavity preparation/etching methods with regard to microleakage in Black V cavities of primary teeth, no significant differences in gingival or occlusal locations were found between the majorities of the methods tested; however, a more marked microleakage was observed in cavities in the laser preparation and etching group. Our study represents one of the few studies comparing multiple methods in the setting of primary teeth.[1,5,7-9]

Self-etch adhesives are commonly preferred due to their ability to eliminate the washing and drying steps, save procedure time, and reduce procedural errors.[10] Therefore, laser and self-etch adhesives were included in the current comparison based on their widespread popularity in modern dentistry. A particular reason for inclusion of the primary teeth in our study was the potential difference in the outcome of restorative procedures between permanent and primary teeth due to differences in morphology and mineral content.[8]

A major issue in adhesive restorations is represented by the lack of proper adhesion to the tooth structure and microleakage between the tooth and filling material. Class V cavities are located in both dentin/cementum and enamel. Studies involving the restoration of cervical lesions using composite resins, glass ionomer cements, or compomers have shown more severe marginal leakage at the gingival margin than occlusal margin.[1,11] The structural dissimilarity between enamel and dentin has an impact on the adhesion of the filling material to the dental tissues and is one of the determinants of the risk of microleakage. While occlusal surfaces contain higher proportion of enamel with a smoother surface, organic material content of the dentin is higher giving rise to higher susceptibility to potentially adverse effects of dental applications and also leading to differential clinical outcomes as compared with the enamel.[1,8,11] This is likely to explain the more severe marginal leakage at the gingival margin located in cementum or dentin than that observed at the occlusal margin located in enamel.[1,11,12] In the study by Sidhu and McCabe[13] comparing the marginal adaptation of compomers in cervical cavities applied with different bonding agents, greater microleakage along the gingival margin was found than along the occlusal margin,[13] consistent with our observations. Also, presence of adequate enamel tissue was reported to reduce the risk of microleakage in etching procedures.[14]

There has been a recent and growing interest in the use of lasers for routine cavity preparation and for conditioning enamel and dentin surfaces, the latter being used as an alternative to conventional bur and acid-etch methods.[11,15] Pain, dissonance, and vibration associated with the use of conventional rotary instruments such as diamond burs are generally associated with a significant discomfort in pediatric patients, necessitating the use of anesthesia in many cases.[8] In this regard, laser-based procedures offer certain advantages such as low vibration and low noise during cavity preparation and little or no need for local anesthesia compared to conventional handpiece.[7,9] Furthermore, as compared to laser-based cavity preparation procedures, conventional rotary instruments such as diamond burs lead to the formation of a smear layer that covers the cavity surface, impacting unfavorably the bonding strength.[1] The current trend in the development of adhesive systems is toward simplification of bonding steps in order to achieve a more user-friendly therapeutic experience. Additionally, reduced number of procedural steps in adhesive systems offers the extra advantage of shortened therapy duration in pediatric procedures.[16] The two-step self-etch primers or single-step self-etching adhesives produce simultaneous conditioning and priming effects on dental substrates.[11] These systems do not remove the smear layer, instead modify it and penetrate the subjacent enamel and dentin, creating a thin hybrid layer dependent on pH, composition, and concentration of polymerizable acids.[11] Casagrande *et al*.[17] evaluated the cervical microleakage of Scotchbond Multi-Purpose (etch and rinse) and Clearfil SE Bond (self-etch) in occlusoproximal composite restorations of primary molar teeth prepared by bur. They reported that neither of the adhesive systems prevented cervical microleakage. Similarly Baygin *et al*.[1] reported that none of the adhesive systems tested, i.e., Adper Single Bond2, Scotchbond Multi-Purpose Plus, Xeno III, Clearfil Protect Bond, and Prime&Bond NT, eliminated microleakage completely, with higher microleakage along the gingival margin than along the occlusal margin. In our study, however, there were no significant microleakage differences between different adhesive systems examined (i.e. group 1 vs. group 2 or group 3 vs. group 5).

While similar results in terms of microleakage have been obtained in some previous studies comparing cavity preparation by laser or conventional bur techniques,[18,19] others reported worse outcomes for the laser-based procedures.[12,20] Moldes *et al*. found significantly lower microleakage in Er:YAG ve Er,Cr;YSGG laser and self-etch groups as compared with etch and rinse adhesive systems.[21] Again Kohara *et al*. reported less marked marginal leakage in cavities prepared with Er:YAG laser in primary teeth versus those cavities prepared with a conventional high-speed air turbine.[22] Hossain *et al*. reported that enamel and dentin surfaces treated with

Er:YAG laser irradiation were capable of decreasing the microleakage of composite resin restorations.[19] In a study by Ghandehari *et al*.[9] involving primary teeth, no significant difference in microleakage was found between glass ionomer restoration in Black V cavities prepared by Er:YAG laser or bur techniques.[9] In the current study, similar results were obtained in groups involving the use of different cavity preparation techniques (group 1 vs. group 3).

However, in this study, use of laser for both cavity preparation and etching resulted in a more unfavorable outcome in terms of microleakage at gingival surface. Laser-induced changes in the surface texture of enamel and dentin have been reported to potentially influence the microleakage in adhesive restorative materials,[4,23,24] and this influence may vary according to the type, dose, duration, and even angulation of the laser beam. Laser-based applications on dentin tissue cause dentin ablation that fuses collagen fibrils and decreases interfibrillary space; this causes a reduction in resin diffusion into intertubular spaces, with a consequent decrease in intertubular retention leading to microleakage.[5,25] This may explain the higher occurrence of microleakage in teeth where laser-based cavity preparation and etching was performed in this study.

Certainly, due to the complex nature of the oral cavity, this *in vitro* result may not accurately reflect *in vivo* conditions. Another limitation of our study is the inclusion of a small sample size.

The results of this preliminary study suggest that self-etch bonding systems and cavity preparation with Er:YAG laser may be used as an alternative to conventional restoration of primary molars with compomers. However, further studies are warranted to fully elucidate the effect of laser-based etching techniques in cavities prepared by laser.

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Conflicts of interest

There are no conflicts of interest.

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