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Microleakage of Resin-Modified Glass Ionomer Restorations With Selective Enamel Etching

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Clinical Relevance

In situations where enamel bonding is crucial and saliva contamination is inevitable, selective enamel etching can improve the bond quality of a resin-modified glass ionomer. However, selective enamel etching may lower the quality of the dentin bond.

SUMMARY

Aim: Bonding of resin-modified glass ionomers to enamel is an important quality, especially when saliva contamination is inevitable. This study evaluated if microleakage of a resin-modified glass ionomer improves with selective enamel etching, with or without saliva contamination.

Methods: Class V cavities with the occlusal margin in enamel and the gingival margin on the root were prepared in extracted human permanent teeth and filled with a resin-modified glass ionomer using an acidic primer according to the manufacturer's recommendation or with an additional selective enamel etching step. Preparations were contaminated with saliva before primer application or before restoration placement (n=10). Restored teeth were thermocycled between 5°C and 55°C for 1000 cycles, stained with basic fuchsin, and sectioned. Microleakage distance was measured and analyzed with analysis of variance followed by Duncan *post hoc* test at a significance level of 0.05.

Results: Enamel microleakage was highest when saliva contamination occurred before the placement of resin-modified glass ionomer. Microleakage distances were significantly reduced in the selective etching groups regardless of saliva contamination. However, selective etching of enamel increased microleakage in cementum. The increase in cementum leakage was significantly higher when saliva contamination occurred before restoration placement.

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Conclusion: Selective etching reduces enamel microleakage of a resin-modified glass ionomer even with saliva contamination, but it may increase microleakage at the cementum. The severity of microleakage is affected by the timing of saliva contamination.

INTRODUCTION

The increasing demand for esthetic restorations in all aspects of dentistry continues to revolutionize tooth-colored materials at the clinician's disposal. Resin-based composites are esthetically pleasing with adequate mechanical properties, whereas acid-base glass ionomer cements do not possess comparable strength, esthetic, and preferred setting characteristics but do maintain their special place in clinical applications.[1] Resin-modified glass ionomers have emerged as a hybrid material that combines benefits from both resin-based composites and glass ionomer cements by adding methacrylate functional groups to polyacrylic acids.[2] Recently, a new resin-modified glass ionomer has been introduced with bonded nanofiller technology for improved polish and esthetics (Ketac Nano, 3M ESPE, St Paul, MN, USA).[3]

One crucial factor determining the longevity of tooth-colored restorations is the quality of the bonded interface between the restorative materials and tooth structures. The bonded interface of resin-based composites is easily compromised by contamination from oral fluids.[4] Previous research showed that glass ionomer materials, in particular a conventional glass ionomer, is more tolerant to saliva contamination than composite or the recently introduced resin-modified glass ionomer, which comes with a no-rinse acidic primer.[5] In bonded restorations, by omitting the separate etching and rinsing steps, self-etch adhesives are less technique sensitive than etch-and-rinse systems and thus provide reliable clinical performance in adhesive restorations.[6,7] Self-etch adhesives are also more tolerant to saliva contamination, especially on dentin.[8-10] However, they generally do not etch enamel sufficiently, which results in lower bond strength to enamel than etch-and-rinse adhesives.[11-13] Therefore, a selective etching technique has been proposed to incorporate the advantage of the etch-and-rinse system on enamel with the self-etch system on dentin.[14]

Resin-modified glass ionomers can be a material of choice in compromised patients due to their anticariogenic property. However, when bonding to enamel is important, it would be advantageous if the bonding could be improved by an additional etching step. No studies to date have evaluated the concept of selective enamel etching with and without the presence of saliva contamination on a resin-modified glass ionomer system with its no-rinse acidic primer. The objective of this study was therefore to evaluate if the bond quality of a resin-modified glass ionomer could be improved with selective enamel etching with or without saliva contamination at different stages of the restorative procedure. The assessment of the bonding was carried out with microleakage tests.

METHODS AND MATERIALS

Tooth Preparation and Sample Distribution

Extracted human permanent premolars and molars were collected and kept in normal saline solution (Institutional Review Board exempt category study number 11-01212-XM). After cleaning with pumice slurry, a cylindrical cavity (3-mm diameter, 1.5-mm depth) was prepared at the cementoenamel junction area of the buccal surface using a high-speed handpiece with #245 carbide bur under a copious amount of water coolant. The prepared teeth were randomly divided into six groups, all to be restored with resin-modified glass ionomer Ketac Nano (3M ESPE). In group 1, the prepared teeth were restored following the manufacturer's instructions with the application of an acidic primer (Ketac Nano Primer, 3M ESPE) for 15 seconds, air-dried for 10 seconds, and light cured for 10 seconds before placement of the resin-modified glass ionomer and then light cured for 20 seconds. In groups 2 and 3, the cavities were contaminated with saliva before the primer application and before the glass ionomer placement, respectively. The saliva was applied to the preparation with a saliva-saturated cotton swab (Q-tips) for 5 seconds and dried with compressed air. The saliva was collected on the day of the test and pooled from four individuals. The data for groups 1-3, published previously,[5] were used for comparison. Group 4 had an additional step of selective etching by applying phosphoric acid gel only on the enamel for 20 seconds, followed by rinsing with water and Ketac Nano Primer application as previously described. Groups 5 and 6 had an additional selective enamel etching step whereby saliva contamination happened before the primer application or before the glass ionomer placement, respectively. The restorations were wet polished with an Esthetic Polishing System (EP 200, Brassler USA, Savannah, GA, USA). The experimental groups and steps with saliva contamination are summarized in Figure 1. The sample size was 10 per group.

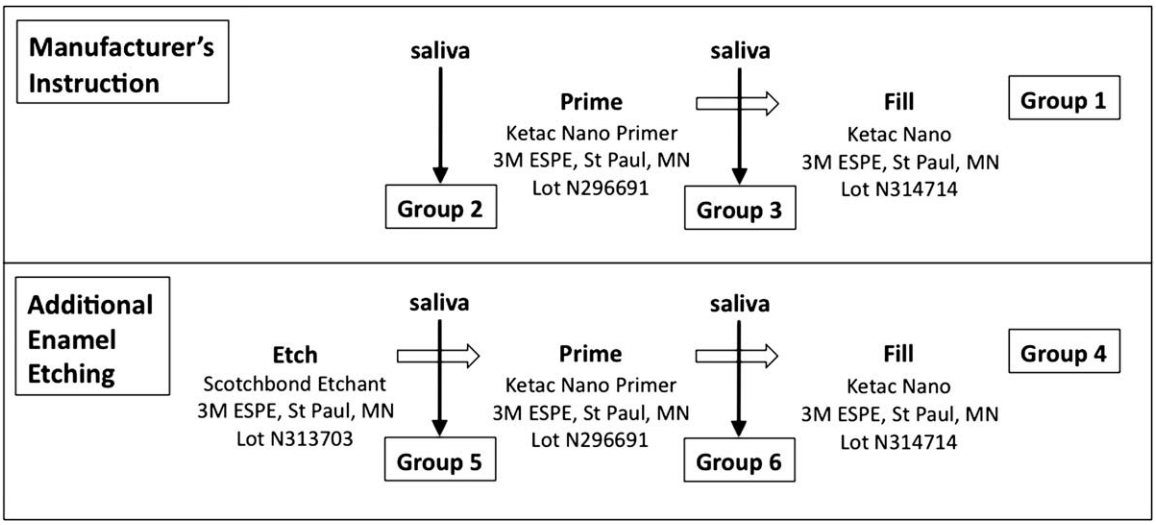

Figure 1. *Diagram summarizing the experimental groups and stages of saliva contamination. The resin-modified glass ionomer was restored according to the manufacturer's instructions in group 1, with saliva contamination before the primer application in group 2 and before the restoration placement in group 3. Group 4 had an additional selective enamel etching step. Groups 5 and 6 also had the selective enamel etching step with saliva contamination before the primer application and before the restoration placement, respectively.*

Microleakage and Statistical Analysis

Root apices were obstructed with utility wax, and the roots were painted with nail polish before the samples were subjected to a thermocycling process, consisting of 1000 cycles alternating between hot water (55°C) and cold water (5°C) with a 30-second immersion time.[14] After thermocycling, the teeth were immersed in 0.5 wt% basic fuchsin solution for 16 hours and sectioned buccolingually through the center of the restoration using a low-speed diamond saw (Isomet, Buehler, Lake Bluff, IL, USA). Both sections from each tooth were imaged using a stereomicroscope with a CCD camera (SZX16 and UC30, Olympus, Tokyo, Japan). The microleakage distances at the occlusal (enamel) and gingival (cementum) margins were measured using imaging software (Stream Basic, Olympus Soft Imaging Solution GmbH, Münster, Germany), as shown in Figure 2. Two independent evaluators who were blinded to the group of each tooth performed the measurements. The final microleakage distance was determined as the average of the two evaluators. If a measurement differed more than 10%, the image was reviewed with both evaluators present to determine a consensus distance. For each tooth, the microleakage distances from both sections were averaged into a single number for the enamel or the cementum margin. Microleakage distances were subjected to one-way analysis of variance (ANOVA) followed by the Duncan new multiple range test at a significance level of 0.05. Two-way ANOVA was used to test the effect of the timing of saliva contamination, the effect of selective etching, and their interaction.

RESULTS

Selective etching significantly affected the microleakage of both enamel and cementum regardless of timing of saliva contamination (two-way ANOVA; $p<0.05$). If etching status (etched or not etched) was disregarded, timing of saliva contamination significantly affected the enamel microleakage ($p=0.0001$) but not the cementum microleakage ($p=0.072$). No statistical interaction was shown between the two effects for either enamel ($p=0.4657$) or cementum microleakage ($p=0.4145$).

Microleakage distances at the enamel and cementum margins are shown in Figure 3. The additional step of selective enamel acid etching significantly reduced microleakage distance at the enamel margin but increased microleakage at the cementum margin. Enamel microleakage was highest when saliva contamination occurred before the restoration placement (group 3) but was reduced significantly by the selective etching step (group 6; $p<0.05$). When saliva contamination occurred before the primer application, enamel microleakage was also reduced by selective etching, although the values were not significantly different (group 2 vs group 5).

Microleakage at the cementum margin of the resin-modified glass ionomer restored according to

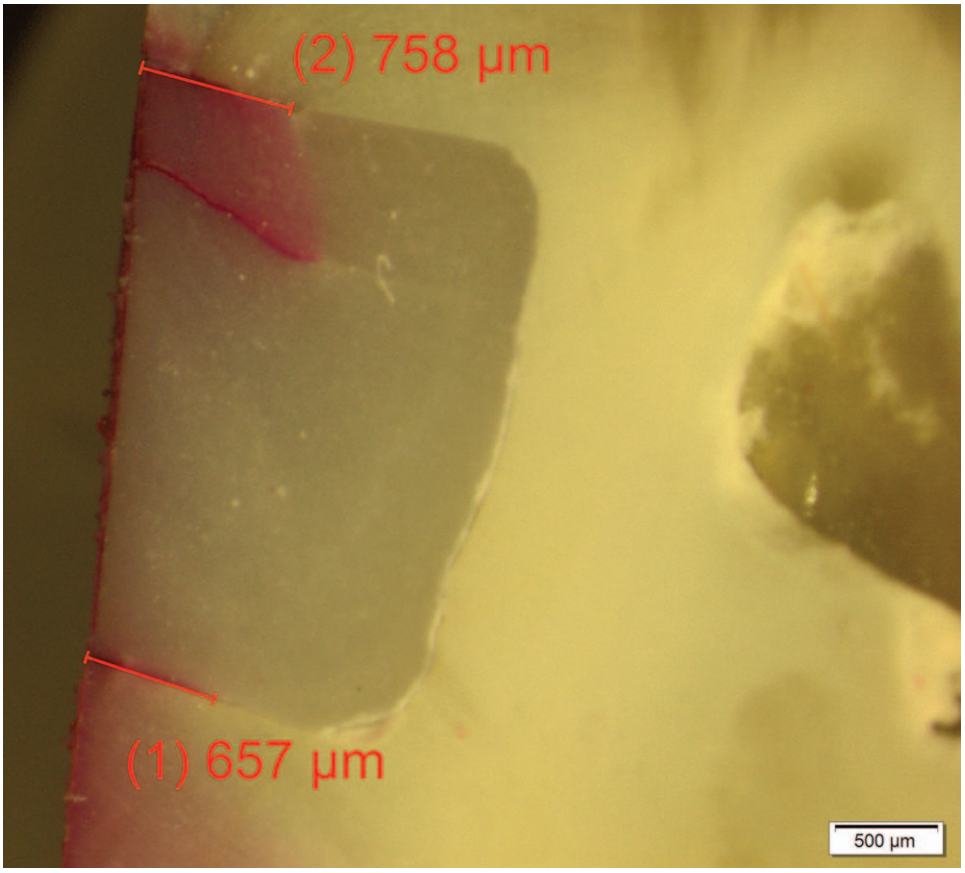

Figure 2. *Using imaging software to measure microleakage distances at the occlusal and gingival margins of the restoration.*

the manufacturer's instructions did not significantly increase with saliva contamination (groups 1-3). The additional selective etching step increased microleakage at the cementum margin (groups 4-6) and became significantly different when saliva contamination occurred before restoration placement (group 6). Group 6 also had the highest microleakage distance.

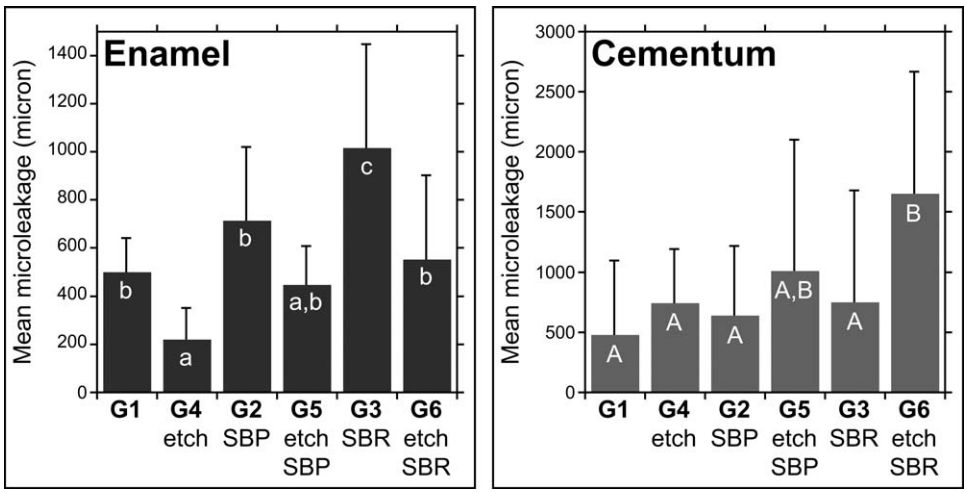

Figure 3. *Microleakage distances (mean and standard deviation) at the enamel and cementum margins. The reference groups (1-3) had no selective enamel etching step.*[5] *Same letters indicate mean values that are not significantly different (analysis of variance followed by Duncan* post hoc *test, significance level = 0.05). SBR, saliva contamination before restoration; SBP, saliva contamination before application of primer.*

DISCUSSION

Enamel Microleakage

Unlike other glass ionomers that use polyacrylic acid to condition the cavity surfaces, the resin-modified glass ionomer in this study used a no-rinse acidic primer for bonding. The results showed that selective etching reduced microleakage of the resin-modified glass ionomer at the enamel margin. Selective enamel etching is an additional step using phosphoric acid to etch only the enamel margin of a cavity, followed by rinsing, prior to the application of an acidic primer. Etching of enamel with phosphoric acid increases the surface area available for bonding and improves the wettability of the enamel surface.[16] The increase in enamel bond quality in this study is mirrored in other studies that tested self-etch adhesive with composites.[12,14,17] Resin-modified glass ionomer and composites thus behaved similarly in terms of qualitative bonding performance to etched enamel, likely because Ketac Nano also uses a resin-based primer that forms a bonding layer on the tooth surface. Since Ketac Nano restorations have shown significant enamel marginal staining in 1 year in a clinical study,[18] the proposed selective enamel etching may help to improve the marginal quality and reduce such staining.

Cementum Microleakage

Although the selective etching step was applied only on the enamel, our results showed that it also affected microleakage at the cementum margin. The cementum leakage increased in all groups after selective enamel etching and was statistically significant higher when saliva contamination occurred before restoration placement (see group 6 in Figure 3). An improved enamel bond for the restoration could have caused a higher failure rate at the cementum margin during polymerization shrinkage or thermocycling because if the enamel bond strength improves, the stress on the cementum margin will increase. Moreover, during rinsing, phosphoric acid may have contacted the dentin surface and depleted hydroxyapatite. A resin-modified glass ionomer forms an ionic bond between its carboxyl groups and calcium in hydroxyapatite and provides micromechanical retention at the interface.[19] Depleted hydroxyapatite from an etched dentin surface was suggested to reduce bonding effectiveness over time,[14] although no significant difference was found in bond strengths of glass ionomer bonded to dentin treated with phosphoric or polyalkenoic acid.[20] Note that Ketac Nano is not applied directly onto the tooth surface. Its primer is comprised of methacrylate-modified polyalkenoic acid (Vitrebond copolymer), 2-hydroxyethyl methacrylate, which is similar to the liquid component of the Ketac Nano restorative material.

The acidic nature of the Ketac Nano primer that was applied to both the enamel and the dentin facilitates adhesion by modifying the smear layer and wetting the tooth surface.[3] If the phosphoric acid used in the selective enamel etching had come into contact with dentin during rinsing, it may also have removed the smear layer and thus affected the bond quality of the cementum margin. Some studies that applied selective enamel etching in combination with a self-etch adhesive reported reduced bond strength on etched dentinal surfaces.[12,17]

Saliva Contamination

There is no consensus in the dental literature about the effect of saliva contamination on the quality of the bond of glass ionomer restorations. Results reported range from no effect of saliva contamination on enamel and dentin bond strength[21,22] to some effect on marginal integrity[23] to substantial bond strength reduction that cannot be recovered with rinsing or etching.[24] Saliva contamination, independent of timing, reportedly did not significantly affect dentin bond strength when a self-etch adhesive (instead of an acid primer) was used with a resin-modified glass ionomer.[25] In the present study, which used the acid primer, we found that saliva contamination increased microleakage distance in both enamel and cementum margins, although the effect was not always statistically significant (Figure 3). Saliva contamination after the application of the acidic primer had higher microleakage than when the contamination occurred before primer application, especially at the enamel margin, where the difference was statistically significant. The current results therefore show that the time of contamination was important for the acidic primer and resin-modified glass ionomer used in this study.

CONCLUSIONS

The results of our study show that a selective enamel etching improved the bond quality of a resin-modified glass ionomer to enamel, also in cases of saliva contamination. On the other hand, microleakage at contaminated cementum margins increased with the selective enamel etching. When enamel bonding becomes crucial, selective etching is an option to be considered when using a resin-modified glass ionomer.

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Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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