■ *Original Article*

SEM evaluation of gap at the resin dentin interface in Class II composite resin restoration: an in vitro study

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Abstract

Introduction: Composite resins have become one of the most commonly used direct restorative materials for anterior and posterior teeth.[1] **Objectives**: To observe and analyze the gap at the resin dentin interface in class II cavities restored with light cure composite resin in four experimental groups employing 37% phosphoric acid or self etching monomers and restored with /without light cure flowable composite resin. **Methods:** 40 sound maxillary first premolars, extracted due to orthodontic reasons was taken, distoproximal cavities were prepared and divided into 4 groups. Teeth of Group 1 was etched by 37% Phosphoric acid and light cure flowable composite resin was used, in group 2 ,two coats of self etching acidic monomer were applied and light cure flowable composite resin was used. Teeth of group 3 was etched with 37% phosphoric acid and restored without light cure flowable composite resin and in group 4, two coats of self etching acidic monomer were applied and restored without using light cure flowable composite resin material. Thermocycling was done after finishing and polishing and viewed under scanning electron microscope to observe and analyze the gap between tooth and the restoration. **Result:** Gap was observed at dentin-composite resin interface in all 4 groups. Results were evaluated by F-test and Manwhitney U test. No statistically significant difference was found. **Conclusion:** Use of flowable composite resin liner and the etching technique do not have any influence on the gap.

Keywords: gap, flowable composite resin**,** scanning electron microscopy.

Introduction

Composite resins have become one of the most commonly used direct restorative materials for anterior and posterior teeth.[1] But one of the inevitable drawbacks of dental composites is shrinkage during free radical polymerization, which may be as high as 3% by volume causing microleakage, secondary caries and postoperative sensitivity. The reduction of the gap formation was always a challenge to the researchers and as a result newer methods and materials were introduced.[2]

Before the introduction of acid etching, bonding system was able to resist only 2-3 MPa of stress while approximately 17 MPa are necessary to resist the contraction stresses at resin dentin interface to prevent debonding. With the introduction of acid etching (1979) upto 22 MPa stress could be resisted. Adhesion of dental resins to enamel and dentin has progressed dramatically in the 40 years since Buonocore introduced the technique of etching enamel with phosphoric acid to improve the adhesion of resin filling materials.[3] Different generations of bonding agents from first to seventh were introduced

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to increase the adhesion of composite resin material to the tooth structure simultaneously reducing the gap formation. The sixth and seventh generation dental adhesive (Self-etch adhesives), composed of aqueous mixture of acidic functional monomers that are generally phosphoric acid esters, do not require a separate acid-etch component and subsequent rinsing procedures.[4]

Also it is generally accepted that the use of materials with a low modulus of elasticity like flowable composite resin, reduces the formation of cervical gaps and marginal leakage. Because these materials may exhibit a stress-reduction-by-flow property.[1]

The aim of this study was to evaluate in vitro the interfacial adaptation of class II resin composite restorations with and without a flowable resin composite liner and using 37% Phosphoric acid or self etching monomer through a quantitative scanning electron microscopic marginal analysis technique.

Methods

40 sound human maxillary 1st premolar recently extracted for orthodontic reason were taken as specimen. They were collected periodically and stored in normal saline at room temperature.

Disto proximal cavities were prepared in each tooth with a standard dimension of 5×3×1.5 mm^3 with a cylindrical diamond abrasive (DIA-BURS;SF-31, MANI, UTSUNOMIYA, TOCHIGI, JAPAN). Each was used to prepare 10 cavities in a high-speed hand piece using copious water cooling. No bevels were prepared and all margins were placed in enamel.

Teeth were randomly divided into 4 experimental groups (n=10) to be treated with etchants/acidic monomers and subsequently restored prior to put to experimentation.

Group 1 –Teeth were etched by 37% Phosphoric acid (Total etch etching gel, IVOCLAR VIVADENT Tetric N-Ceram. LIECHTENSTEIN) for 15 seconds, washed and dried for 10 seconds. Bonding agent (5th generation, Tetric N-Bond Total etch dental adhesive, IVOCLAR VIVADENT, LIECHTENSTEIN) was applied on the cavity and cured for 10 second. All the walls (buccal, lingual, axial and gingival) of the proximal cavity were lined with a thin layer of light cure flowable composite resin (Tetric N Flow, IVOCLAR VIVADENT, LIECHTENSTEIN) and light cured for 20 seconds. Cavity was restored using light cure composite resin material (IVOCLAR VIVADENT, Tetric N Ceram.LIECHTENSTEIN), applied using oblique three increment technique and all increments were light cured for 40 seconds **(Fig 1).**

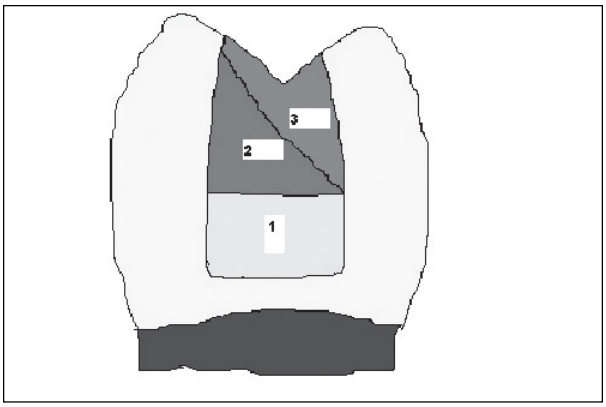

Fig 1: Oblique three increment technique.

Group 2 –Two layers of self etching acidic monomer (7th generation single component self etching gel, Tetric N Bond Self Etch, IVOCLAR VIVADENT, LIECHTENSTEIN) were applied on the cavity with a disposable brush. The first layer was applied for 30 seconds, surface was slightly air dried and light cured for 10 seconds. A second coat was applied; air dried and light cured for another 10 seconds. All the walls (buccal, lingual, axial and gingival) of the proximal cavity was then lined by a thin layer of flowable composite resin (Tetric N Flow, IVOCLAR VIVADENT, LIECHTENSTEIN) and light cured for 20 seconds. The cavity was restored using light cure composite resin material (IVOCLAR VIVADENT, Tetric N Ceram. LIECHTENSTEIN) applied using oblique three increment technique and all increments were light cured for 40 seconds.

Group 3 –Teeth were etched using 37% Phosphoric acid (Total etch etching gel, IVOCLAR VIVADENT, Tetric N-Ceram. LIECHTENSTEIN)for 15 seconds, washed and dried for 10 seconds. Bonding agent (5th generation, Tetric N-Bond Total etch dental adhesive, IVOCLAR VIVADENT, LIECHTENSTEIN) was applied and

cured for 10 seconds. Cavity was restored using light cure composite resin material (IVOCLAR VIVADENT, Tetric N-Ceram. LIECHTENSTEIN) which was applied using oblique three increment technique and all increments were light cured for 40 seconds.

Group 4 – Two layers of Self etching acidic monomer (7th generation single component self etching gel, Tetric N Bond Self Etch, IVOCLAR VIVADENT, LIECHTENSTEIN) were applied on the cavity with a disposable brush. The first layer was applied for 30 seconds, the surface was slightly air dried to remove the excess solvent and light cured for 10 seconds. A second coat was applied; air dried and light cured for another 10 seconds. Restoration was done using light cure composite resin material (IVOCLAR VIVADENT, Tetric N-Ceram. LIECHTENSTEIN) which was applied using oblique three increment technique and all increments were light cured for 40 seconds.

All the restorations were done strictly following the manufacturer's instructions. Satelec LED Light cure lamp (MINILED AUTOFOCUS STD CEE: Model No. F02900, FRANCE) with 6 second pulse were used for curing. The restorations were finished with fine diamond abrasives (CT 11EF, MANI, UTSUNOMIYA, TOCHIGI, JAPAN), polished with rubber points and cups(SHOFU Composite Polishing Kit,KYOTO, JAPAN) after 24 hours of curing and stored in normal saline for 7 days at room temperature.

After the 500 cycles of thermocycling (500 cycles, 5° to 55°C, 5 seconds dwell time and a 3-seconds interval between each bath), the teeth were sectioned in a mesio-distal direction through the middle of the restorations with a low-speed diamond disc (LM Pianotti, S.R.L, ITALY) in a hand piece with copious water spray . The sections were then planed with medium and fine Sof-Lex disks (3M ESPE, 4931M and 4931F, U.S.A) under continuous water spray to minimize smear layer formation (Fig 2 & 3). After desiccation with 100% alcohol, acetone and alcohol acetone mixture for three consecutive days, the sections were mounted on stub with 26 mm holder, gold coated and viewed under Field Emission Scanning Electron Microscope (FEI, Model no. Quanta 200) in 800X zoom to evaluate the resin tooth interface for gaps (Fig 4 & 5).

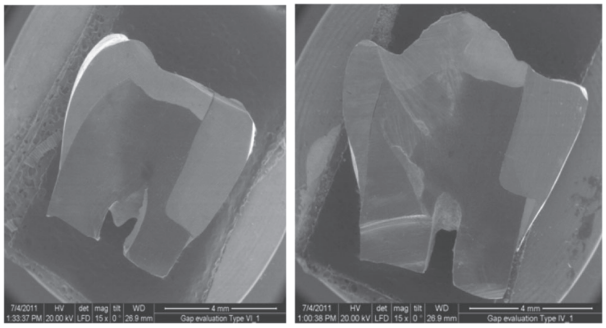

Fig 2 and 3: Specimen tooth

Fig 4: Specimens placed within the vacuum chamber,

Fig 5: FEI, Quanta 200 Scanning Electron microscope.

Results

In present study, excellent marginal adaptation was found between enamel and
composite resin but there was definite gap between the dentin and the restoration in all four groups, (**Fig 6 - 9.**)

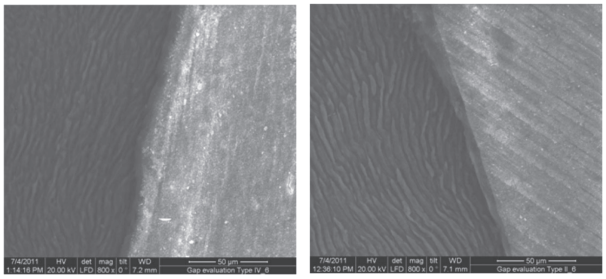

Fig 6 and 7: Excellent interfacial adaptation between enamel and composite resin.

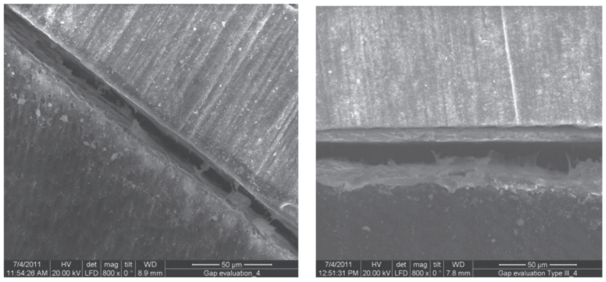

Fig 8 and 9: Gap found between dentin and composite resin material.

Table 1: Gap measured in micrometer (µm).

Group 1	Group 2	Group 3	Group 4
35.14	27.95	22.59	19.64
22.64	28.71	21.22	23.84
18.61	24.06	19.37	17.03
20.80	13.33	17.74	22.80
22.01	18.96	20.81	19.07
25.29	16.56	24.66	22.86
32.79	23.58	17.23	21.74
25.97	22.83	24.76	19.66
27.13	28.34	22.10	23.84
23.10	19.51	23.46	25.83

Statistical Test: Statistical analysis was done using MATLAB software. F test was done for equality of variance of all four categories with different treatment protocol.(Ho- There is no difference between the variance of two test categories , Ha- There is significant difference exist between the variance of the test categories).

Table 2: Test outcomes between categories

(Groups)	P value	95% CI	F-stat	(at 5% cut off) Inference
1-2	0.9889	0.2460 to3.9878	0.9905	Ho accepted
1-3	0.0569	0.9584 to15.5344	3.8585	Do
1-4	0.0639	0.922 to14.9437	3.7118	Do
2-3	0.0553	0.9676 to15.6832	3.8955	Do
2-4	0.0621	0.9308 to15.0868	3.7474	Do
3-4	0.9549	0.2389 to 3.8729	0.962	Do

So the overall inference- All possible study category pairs are homoscedastic, though the p- values for 1-3, 1-4, 2-3 and 2-4 tests are showing marginal values.
1-2 and 3-4 are comparable under parametric assumption (testing difference between the means)

Table 3: Inference for both the tests

Test categories (Groups)	P value	95% CI	t-stat	df	(at 5% cut off) Inference
1-2	0.2206	-1.9433 to7.8733	1.2691	18	No significant difference exists
3-4	0.8454	-2.7543 to 2.2803	0.1978	18	Do

Table 4: T-test under considering marginal p-value dependent homoscedasticity

Test categories (Groups)	P value	95% CI	t-stat	df	(at 5% cut off) Inference
1-3	0.0465	-0.0687to7.8393	2.1381	18	Significanly different (marginally)
2-3	0.6007	-2.9110to4.8890	0.5321	18	no significant difference
3-4	0.6914	-3.1637to 4.6677	0.4035	18	do
1-4	0.0606	-0.1841 to 7.6181	2.0018	18	do

Though apparently only 1-3 test is statistically significant, but following multiple correction (Bonferroni correction) the corrected p value cut off goes down to 0.05/6=0.008. So at this corrected level no test outcomes are significantly different.

Alternatively (considering 1-3, 2-3, 3-4, 1-4 test pairs under non parametric assumptions) Manwhitney U test were performed and the respective p- values are 0.8454, 0.0757,0.1211, 0.5708. These are not significant even before any multiple corrections. So evidently the entire null hypothesis are accepted.

Table 5: Mean and variance

	Group 1	Group 2	Group 3	Group 4
Mean	25.34	22.383	21.3940	21.631
± variance	5.2116	5.2365	2.6531	2.7051

So the statistical inference is: There are no difference exists between different treatment groups.

Note: Although eye balling over the data implies that the variance of the treatment categories are greater where flowable is used for treatment. Since sample size is just 10 in each category may be its actual effect is bypassing the statistical test. May be different response group exists to flowable treatment. In future such study with very large sample size may infer its actual role.

Discussion

The demand for esthetic restoration was from the ancient time but up to the first half of 20th century, silicates were the only tooth colored material for cavity restoration. But they become eroded within few years so they were replaced by tooth colored acrylic resin only during late 1940's and early 1950's. But they also have relatively poor wear resistance and they shrink severely during curing causing leakage. These problems were reduced somewhat by the addition of quartz fillers with the resin to form a composite structure but were not very successful because the fillers were not bonded (coupled) with the resin causing defects to develop around fillers and resin resulting in leakage, staining and poor wear resistence.[5]

A major advance was made when Dr. Ray. L. Bowen in the year 1962 developed a new type of composite material containing bisphenol A glycidyl methacrylate (bis-GMA), a dimethacrylate resin and an organic silane coupling agent to form a bond between the filler particle and the resin material.[5]

But the problem of marginal gap between tooth and resin is still a challenge to the dentist and the researchers.[6]

The most common tests to study interfacial adaptation is by dye penetration, stereomicroscopic evaluation, scanning electron microscopic evaluation and environmental scanning electron microscopic evaluation.

In SEM analysis, the gap was considered loss of interfacial adhesion due to polymerization shrinkage. SEM is a widely used method to evaluate interfacial adaptation.[1,2] It has the following advantages,[6,7]

1. Allows distinguishing marginal gaps from marginal irregularities or tooth fractures.
2. Analysis is conducted in very high magnification (from 15x/ to 800x/).
3. Doubtful areas can be evaluated in higher magnification.

All the previous studies examining the interfacial gap by SEM showed varied results. In his study, Ernst et al showed that the use of a flowable composite resin seems to have a clinical benefit.[8] These results were supported by Peutzfeldt and Asmussen.[9] Yonca et al found clinical improvement of marginal adaptataion with flowable composite resin liner.[10]

But, Lindberg et al found no improvement in interfacial adaptation of class II restorations with the use of flowable liner in class II enamel-bordered resin composite restorations when viewed under SEM.[1] which was supported by the study of Ziskind et al and Roberta et al.[11,12] Andreia et al found no clinical improvement with the use of flowable composite resin liner.[12] Prabha et al found no difference in microleakage with the use of flowable composite resin material.[13] John et al found no clinical improvement with the use of flowable composite resin material under the restoration in a 3 year evaluation.[14] The present study also showed the same result.

Generally the application of etchant to the enamel removes the interprismatic substance: at the level of the dentin, the etchant opens the dentinal tubules and demineralizes the dentinal surface, thus exposing the collagen fibers for a depth of 3 to 10 µm, concentration, and time of application of the selected acid[5]. But the result of different etching material used during composite resin restoration also showed varied result in the previous studies.

Claus-Peter et al found superiority of using 37% Phosphoric acid upon the self etch adhesive system. Same result was found by Siegward et al [8,15] Koliniotou et al and Claus-Peter et al.[16,17]

On the other hand, Simon et al found no statistically significant difference in microleakage with total etch and self etch technique.[18] Fábio et al found no difference among the total etch and self etch technique to reduce the gap when viewed under SEM.[19] The result of the present study are in agreement with these studies.

Conclusion

The present study showed no statistically significant difference in gap between tooth and the restoration using two different etching technique with 37% phosphoric acid self etching monomer and restoration done with and without flowable composite resin liner beneath the conventional composite resin restoration. So, it can be concluded that there is no significant beneficial effect of using light cure flowable composite resin beneath the conventional composite resin restoration and also no effect of using total etch technique by 37% phosphoric acid as etchant over self etch technique using self cure acidic monomer.

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