Received: 21st September 2014 Accepted: 27th December 2014 Conflicts of Interest: None

Source of Support: Nil

Original Research

Comparative *in vitro* evaluation of internal adaptation of resin-modified glass ionomer, flowable composite and bonding agent applied as a liner under composite restoration: A scanning electron microscope study

M Soubhagya[1], K Mallikarjun Goud[2], B S Deepak[2], Sophia Thakur[2], T N Nandini[3], J Arun[4]

Contributors:
[1]Reader, Department of Conservative Dentistry and Endodontics, Anil Neerukonda Institute of Dental Sciences, Sangivalasa, Visakhapatnam, Andra pradesh; [2]Professor, Department of Conservative Dentistry & Endodontics, Bapuji Dental College, Davangere, Karnataka, India; [3]Reader, Department of Conservative Dentistry & Endodontics, Bapuji Dental College, Davangere, Karnataka, India; [4]Senior Lecturer, Department of Conservative Dentistry & Endodontics, Bapuji Dental College, Davangere, Karnataka, India.

Correspondence:
Goud KM. Department of Conservative Dentistry & Endodontics, Bapuji Dental College & Hospital, Davangere - 577 002, Karnataka, India. Phone: +91-9844256942. Email: malligoudk@yahoo.co.in

How to cite the article:
Soubhagya M, Goud KM, Deepak BS, Thakur S, Nandini TN, Arun J. Comparative *in vitro* evaluation of internal adaptation of resin-modified glass ionomer, flowable composite and bonding agent applied as a liner under composite restoration: An scanning electron microscope study. J Int Oral Health 2015;7(4):27-31.

Abstract:
Background: The use of resin-modified glass Ionomer cement in sandwich technique is widely practiced with the advent of various newer generation of composites the bond between resin-modified glass Ionomer and these resins should be validated. This study is done to evaluate the interfacial microgaps between different types of liners and dentin, liners and composite (Filtek p60 [FLp60]) using scanning electron microscope (SEM).

Materials and Methods: Standardized Class V preparations were performed in buccal/lingual surfaces of 30 caries, crack and defect-free extracted human third molars. The prepared teeth were divided into three groups. Group I: Single bond (SB), Group II: SB + synergy flow, Group III: SB + vitrebond. They were restored with composite resin FLp60, according to the manufacturer instructions. The SB + vitrebond, cross-sectioned through the canter of the restoration. The specimens were fixed, dehydrated, polished, and processed for SEM. The internal adaptation of the materials to the axial wall was analyzed under SEM with ×1000 magnification.

Results: The data obtained were analyzed with nonparametric tests (Kruskal–Wallis, $P < 0.05$). flowable composite or resin-modified glass ionomer applied in conjunction with adhesive resulted in statistically wider microgaps than occurred when the dentin was only hybridized prior to the restoration.

Conclusion: Hybridization of dentin only provides superior sealing of the dentin-restoration interface than does flowable resin or resin-modified glass ionomer.

Key Words: Composite resin, liner, flowable resin, interfacial gaps, internal adaptation, microleakage, resin-modified glass ionomer, scanning electron microscope

Introduction

One of the most popular tooth colored restoratives is composites. An unavoidable characteristic of dental composite is shrinkage. Clinical effects of the shrinkage stress may include postoperative sensitivity, cuspal strain or microcracks in enamel or dentin, marginal gap formation, and microleakage.[1] Microleakage has been identified as a significant problem because of interfacial gap formation, which can result in tooth discoloration, recurrent caries possible pulpal involvement, and restoration replacement.[2] Internal adaptation means adaptation to the internal dimensions of the cavity form.[3] A correlation exists between internal adaptation and the presence of total voids.

There were improvements in all aspects of solutions that reduce interfacial gaps under composite restoration. The use of low-modulus lining materials such as resin-modified glass ionomers, resinous liners like flowable composite or new-generation bonding agents have been proposed. Liners are relatively thin layers of materials used primarily to provide a barrier to protect the dentin from residual reactants diffusing out of the restoration or oral fluids that may penetrate leaky restoration interface.[4]

Resin-modified glass ionomer cement (Vitrebond [VT]) placement using a sandwich technique can provide reliable chemical adhesion to dentin, micromechanical bond to the overlying resin, pulp protection, and anti-cariogenicity from fluoride release and reduction in volume of resin used, thereby reducing the degree of shrinkage stress in composite resin.[5]

Flowable resin composites (Synergy flow [SY]) are less viscous materials when used as a liner which result in less leakage and also help in relieving stresses during polymerization shrinkage of the restorative resin.[6]

Modern dentin adhesives (SB) are currently believed to bond to dentin by a micromechanical hybridization process. So these new dentinal bonding systems initiate formation of a hybrid layer, increase the stability and durability of adhesion, thus reducing interfacial gaps and marginal leakage.[7]

Hence, the present study was conducted to evaluate the interfacial microgaps between different types of liners and dentin, liners and composite (Filtek p60 [FLp60]) using scanning electron microscope (SEM). Hypothesis of the study is dentin hybridization provides superior sealing of the dentin-restoration interface than does flowable composite or resin-modified glass ionomer.

Materials and Methods

Thirty freshly extracted crack, defects, caries free, human third molars were selected and stored in a solution of 0.5% chloramine at 4°C. All the polished 30 third molars were randomly divided into three groups each containing 10 teeth.
Group I: Included teeth that were lined with SB, FLp60.
Group II:Included teeth that were lined with SB, SY, and FLp60.
Group III: Included teeth that were lined with SB, VT, and FLp60.

Preparation of the tooth surface (Common for all the groups)

Class V cavities were prepared on the buccal/lingual surfaces with the gingival margins located 1.0 mm below the cement enamel junction. Cavity dimensions were standardized (6.0 mm diameter, 3.0 mm depth) using marked 245 carbide bur.[8] Depth of cavity initially limited to 2 mm later deepens 0.5 mm with acrylic stop on bur tip to stimulate differences in depth of cavity (Figure 1).

Liner application was carried out using the material corresponding to the appropriate study group and according to the manufacturer's instructions using the following steps:

SB

Cavities were etched for 15 s with 35% phosphoric acid gel (Scotch bond Etchant, 3M ESPE) and rinsed with water for 30 s and air dried. Two coats of SB (3M ESPE) were applied and cured for 10 s.

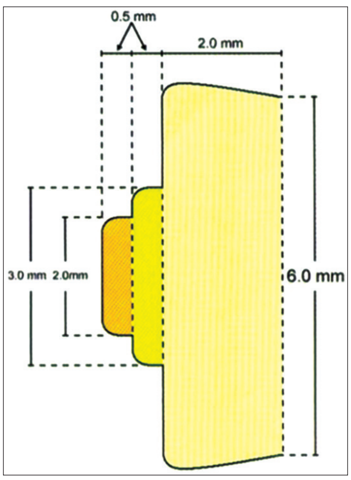

Figure 1: Cavity design.

SY

0.5 mm thick SY was inserted into the preparation with a ball burnisher instrument and light-cured for 20 s.

VT

One scoop of powder was mixed with one drop of liquid on a mixing pad for 10-15 s. The VT was inserted into the preparation with a ball burnisher instrument and light-cured for 20 s.

Restoration

Depending on group, the two deepest levels were filled with lining materials or uniform layer of FLp60 composite resin. The remaining cavities were restored using horizontal incremental technique with each increment being 2 mm. Each increment was cured for 30 s from cervical to occlusal thirds using halogen visible light curing device with intensity 900-1200 mW/cm^2 (Coltolux, 3M, ESPE).

The restored teeth were finished with sequential abrasive disks and stored in distilled water at 37°C for 24 h later thermocycling done. Teeth were sectioned longitudinally through the center of the restoration to achieve a sample thickness of 2 mm.[8] The sections were fixed in glutaraldehyde and 0.1 M and 0.2 M sodium cacodylate, later immersed in 25%, 50%, 75%, 95%, and 100% alcohols followed by immersion in Hexamethyldisilazane for drying the specimens. The specimens mounted in epoxy resin and polished for 10 s each. After polishing, the specimens were ultrasonicated in absolute ethanol for 10 min, etched with 10% of phosphoric acid for 5 s. The specimens were mounted on aluminum stubs, sputter coated with gold and palladium, and examined under SEM. Under SEM samples were photographed using magnification of ×1000 and ×120 and gaps were measured using image analyzer software.[8]

Results

Interfacial gaps between dentin and liner were subjected to statistical analysis through Kruskal-Wallis test. Comparison between the groups done by Dunn's nonparametric test. The mean interfacial gap values of Group III were the highest and were statistically significant, with Group I and II. Group II showed slightly higher values than Group I. Group I showed least value among the groups tested. The mean interfacial gaps and standard deviation values are presented in Tables 1 and 2. Pairwise comparison of groups' values is presented in Tables 3 and 4.

Discussion

To minimize the effects of resin shrinkage, the Class V preparations, which exhibited a high configuration factor,

Table 1: Interfacial gaps in each group between dentin and liner Kruskal–Wallis test.

Groups	Interfaces	Mean	Median	Standard deviation	*H* value	Significance
Group I	Dentin-SB	0.012	0	0.0379	20.84	*P*<0.001 highly significant
Group II	SB+Dentin-SY	0.038	0	0.0807		
Group III	SB+Dentin-VT	2.497	2.73	2.0509		

SB: Single bond (Bonding agent), SY: Synergy flow (Flowable composite), VT: Vitrebond (Resin-modified glass ionomer)

Table 2: Interfacial gaps in each group between liner and composite Kruskal–Wallis test.

Interfaces	Mean	Median	Standard deviation	*H** value	Significance
SB-FLp60	0	0	0	21.52	*P*<0.001 highly significant
SB+SY-FLp60	0.0610	0.0350	0.0700		
SB+VT-FLp60	1.0040	1.1050	0.7795		

FLp60: Filtek P60 (Composite), SB: Single bond (Bonding agent), SY: Synergy flow (Flowable composite), VT: Vitrebond (Resin-modified glass ionomer)

Table 3: Pair-wise comparison of study groups between dentin and liner (Dunn's-test).

Study groups	Dentin-SB	SB+Dentin-SY	SB+Dentin-VT
Group I	-	NS	*P*<0.05
Group II	-	-	*P*<0.05
Group III	-	-	0

SB: Single bond (Bonding agent), SY: Synergy flow (Flowable composite), VT: Vitrebond (Resin-modified glass ionomer)

Table 4: Pairwise comparison of study groups liner and composite (Dunn's test).

Study groups	SB- FLp60	SB+SY-FLp60	SB+VT-FLp60
Group I	-	NS	*P*<0.05
Group II	-	-	*P*<0.05
Group III	-	-	-

FLp60: Filtek P60 (Composite), SB: Single bond (Bonding agent), SY: Synergy flow (Flowable composite), VT: Vitrebond (Resin-modified glass ionomer)

were filled using 2.0 mm thick three horizontal layers of resin.[9,10] FLp60 composite was used in this study since, photo polymerizing hybrid composite resins develop higher polymerization shrinkage stresses than microfilled composite resins.

In Group I (SB+ FL P60), only one of 10 specimens had gap between SB and dentin. But excellent internal adaptation found between SB and FLp60 (Figure 2a-c).

Acid etching of dentin (1) removes the smear layer (2) opens and widens the orifices of dentinal tubules (3) demineralize the intratubular dentin up to a depth of 7 µm (4) exposes the collagen fibers of demineralized dentin.[11] The exposed collagen may provide reactive groups that can chemically interact with bonding primers. The ethanol solvent of SB, due to its high vapor pressure facilitates the diffusion and polymerization of the monomer into the exposed collagen network.[12] This serves as a framework for mechanical interlocking with etched dentin by means of resin tags, adhesive lateral branches and resin dentin interdiffusion zone or hybrid layer.[13,11] This ultrastructure could probably account for the higher bond strength for SB between 17 mpa and 30 mpa.[14] According to studies, shear bond strength between 17 mpa and 21 mpa is required to resist contraction forces of composite resin and prevent gap formation at dentin–restoration interface.[15] SB is polyalkenoic acid based adhesive so (a) assist bond strength to dentin (b) associated with moisture resistance (c) might be intrinsic stress relaxation capacity by ca-polyalkenoic acid complexes.[16,17]

In Group II (SB+SY+ FL p60), all specimens have shown proper internal adaptation between dentin and flowable composite (Figure 2d-g). The idea behind is flowable composite materials have low elastic modulus and increased elasticity.[18,19] Therefore, they act as a cushion and absorb the stress of polymerization shrinkage. The wetting effect of the flowable composite and or a relatively low surface tension when applied to the tooth surface helps in proper adaptation to dentin.[20] Internal adaptation between FLp60 and flowable composite (Figure 2d-g) 70% of samples showed gaps which were smaller in dimensions compared to Group III. It may be because flowable composite lining achieved intimate cavity adaptation but resulted in no evident improvement in adaptation to FLp60 probably because of its higher resin matrix content.[21] Contraction stress from hybrid composite might be concentrated on the interface between flowable and FLp60 composite thus forming the gap.[22] The results of current study are consistent with studies carried out by Miguez *et al.* and Eitetsu *et al.* both researchers investigated their effect on dentin bonding whereby voids were found at the interface between flowable and condensable composite.[23,22] The presence of such gap may degrade the mechanical integrity of the restoration.

According to some studies, the application of bonding agents improves the wettability of glass ionomer cement to adhere to composite resin thus promoting a strong shear bond between RMGIC and the resin composite.[24,25] Hence, the present study was conducted to evaluate internal adaptation of VT to hybridized dentin and to composite resin. In Group III, 8 specimens showed gaps at the interface between SB treated dentin and VT liner (Figure 2i and j). The gaps size should be considered because they were up to 5 µm in width which was larger compared to other groups. The reasons probably: (1) Increase bond strength between SB and dentin. (2) VT showed

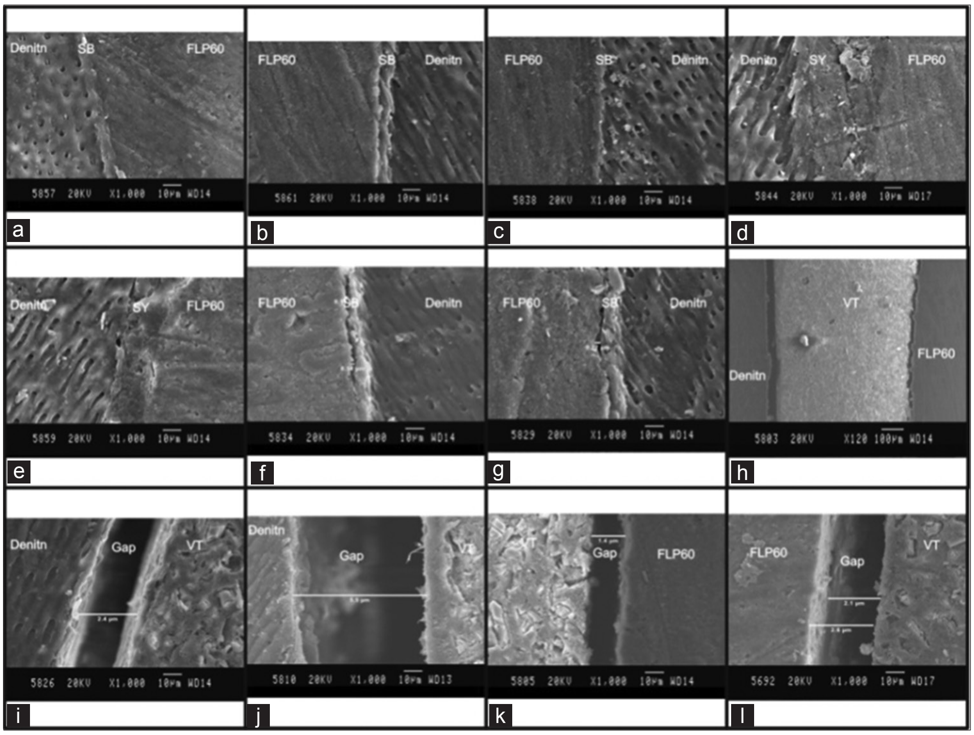

Figure 2: Scanning electron microscope images at 1000 magnification (a). (b and c) Group I specimens (interface between single bond [SB] treated dentin and FLp60) showing excellent adaptation. (d-g) Group II specimens (interfaces between SB treated dentin – synergy flow [SY], SY-FLp60) showing good adaptation between SB treated dentin and SY but gap between SY and FLp60. (h) Interface in Group III at 120 magnification showing gaps between SB treated dentin – vitrebond (VT) and VT-FLp60. (i and j) Interface between SB treated dentin – VT showing larger gap. (k and l) Interface between VT-FLp60 showing larger gap.

cohesive failure. (3) Polymerization and dehydration shrinkage of the VT.[26] This confirms no adhesion between VT and SB treated dentin. Gap formation was observed in all specimens between VT and FLp60 interface (Figure 2k and l). The reason could be VT tended to adhere more to adhesive resin than to composite during the composite polymerization and also because of the physicochemical adhesiveness of the glass ionomer to tooth structure further researches are needed.[27] Further studies are required to better understand the bonding mechanism of RMGICs with adhesive system applied to the dentinal substrate.

Cavity lining materials which are used as pulp protective measures must provide effective dentinal tubule sealing and be the inherent buffer to compensate for polymerization contraction stress of the composite restoration. The results obtained in this study demonstrate that the lining materials used did not contribute to a reduction of internal gap formation. Thus, results require rejection of the null hypothesis that the use of VT or flowable composite liner does not result in larger gaps than those seen using adhesive resins as liners.

Bonding agents are capable of coating the dentin by hybrid layer and thereby can minimize gap formation. However, the efficacy of these materials, durability of composite dentin bond, and risk of adverse biocompatibility on deep dentin usage should be evaluated further with *in vivo* studies before drawing definite conclusions.[28]

Conclusion

The following can be concluded from the results of this study:

- Resin hybridization provides superior sealing of the dentin-restoration interface than does flowable composite or resin-modified glass ionomer.
- Larger microgaps were found at the hybridized dentin-restoration interface when resin-modified glass ionomer was used as a liner.
- Use of flowable composite resin as a liner showed good internal adaptation to hybridized dentin but smaller microgaps at the restoration interface when compared to resin-modified glass ionomer groups.

References

1. Andersson-Wenckert IE, van Dijken JW, Hörstedt P. Modified Class II open sandwich restorations: Evaluation of interfacial adaptation and influence of different restorative techniques. Eur J Oral Sci 2002;110(3):270-5.
2. Chandra PV, Harikumar V, Ramkiran D, Krishna MJ, Gouda MV. Microleakage of class V resin composites using various self-etching adhesives: An *in vitro* study. J Contemp Dent Pract 2013;14(1):51-5.
3. Taylor MJ, Lynch E. Marginal adaptation. J Dent 1993;21(5):265-73.
4. Hilton TJ. Cavity sealers, liners, and bases: Current

philosophies and indications for use. Oper Dent 1996;21(4):134-46.
5. Tanumiharja M, Burrow MF, Cimmino A, Tyas MJ. The evaluation of four conditioners for glass ionomer cements using field-emission scanning electron microscopy. J Dent 2001;29(2):131-8.
6. Duingshan L, Jepsen S, Albers HK, Eberhard J. Flowable materials as an intermediate layer could improve the marginal and internal adaptation of composite restorations in class-V cavities. Dent Mater 2005;20:1-8.
7. Johnson GH, Powell LV, Gordon GE. Dentin bonding systems: A review of current products and techniques. J Am Dent Assoc 1991;122(7):34-41.
8. Peliz MI, Duarte S Jr, Dinelli W. Scanning electron microscope analysis of internal adaptation of materials used for pulp protection under composite resin restorations. J Esthet Restor Dent 2005;17(2):118-28.
9. Carvalho RM, Pereira JC, Yoshiyama M, Pashley DH. A review of polymerization contraction: The influence of stress development versus stress relief. Oper Dent 1996;21(1):17-24.
10. Alomari QD, Reinhardt JW, Boyer DB. Effect of liners on cusp deflection and gap formation in composite restorations. Oper Dent 2001;26(4):406-11.
11. Tay FR, Gwinnett AJ, Pang KM, Wei SH. Structural evidence of a sealed tissue interface with a total-etch wet-bonding technique *in vivo*. J Dent Res 1994;73(3):629-36.
12. Neelima L, Sathish ES, Kandaswamy D, Bupesh. Evaluation of microtensile bond strength of total-etch, self-etch, and glass ionomer adhesive to human dentin: An *in vitro* study. Indian J Dent Res 2008;19(2):129-33.
13. Gupta N, Kathuria N, Gulati M, Metha LK. Bonding foundation of Dentistry. J Innov Dent 2011;1:60-5.
14. Swift EJ Jr, Bayne SC. Shear bond strength of a new one-bottle dentin adhesive. Am J Dent 1997;10(4):184-8.
15. Retief DH, Mandras RS, Russell CM. Shear bond strength required to prevent microleakage of the dentin/restoration interface. Am J Dent 1994;7(1):44-6.
16. Perdigão J, May KN Jr, Wilder AD Jr, Lopes M. The effect of depth of dentin demineralization on bond strengths and morphology of the hybrid layer. Oper Dent 2000;25(3):186-94.
17. Majety KK, Pujar M. *In vitro* evaluation of microleakage of class II packable composite resin restorations using flowable composite and resin modified glass ionomers as intermediate layers. J Conserv Dent 2011;14(4):414-7.
18. Olmez A, Oztas N, Bodur H. The effect of flowable resin composite on microleakage and internal voids in class II composite restorations. Oper Dent 2004;29(6):713-9.
19. Basavanna R, Garg A, Kapur R. Evaluation of gingival microleakage of class II resin composite restorations with fiber inserts: An *in vitro* study. J Conserv Dent 2012;15(5):166-9.
20. Estafan D, Estafan A, Leinfelder KF. Cavity wall adaptation of resin-based composites lined with flowable composites. Am J Dent 2000;13(4):192-4.
21. Attar N, Turgut MD, Güngör HC. The effect of flowable resin composites as gingival increments on the microleakage of posterior resin composites. Oper Dent 2004;29(2):162-7.
22. Cho E, Chikawa H, Kishikawa R, Inai N, Otsuki M, Foxton RM, *et al*. Influence of elasticity on gap formation in a lining technique with flowable composite. Dent Mater J 2006;25(3):538-44.
23. Miguez PA, Pereira PN, Foxton RM, Walter R, Nunes MF, Swift EJ Jr. Effects of flowable resin on bond strength and gap formation in Class I restorations. Dent Mater 2004;20(9):839-45.
24. Kasraie S, Shokripour M, Safari M. Evaluation of micro-shear bond strength of resin modified glass-ionomer to composite resins using various bonding systems. J Conserv Dent 2013;16(6):550-4.
25. Arora V, Kundabala M, Parolia A, Thomas MS, Pai V. Comparison of the shear bond strength of RMGIC to a resin composite using different adhesive systems: An *in vitro* study. J Conserv Dent 2010;13(2):80-3.
26. Welbury RR, Murray JJ. A clinical trial of the glass-ionomer cement-composite resin "sandwich" technique in Class II cavities in permanent premolar and molar teeth. Quintessence Int 1990;21(6):507-12.
27. Eliades G, Palaghias G. *In vitro* characterization of visible light-cured glass ionomer liners. Dent Mater 1993;9(3):198-203.
28. Hebling J, Giro EM, Costa CA. Human pulp response after an adhesive system application in deep cavities. J Dent 1999;27(8):557-64.