FILLINGS OF RESIN COMPOSITES AND GLASS-IONOMERS: REDUCED MARGINAL GAPS

RESTAURAÇÕES DE RESINA COMPOSTA E CIMENTO IONOMÉRICO: REDUÇÃO DAS FENDAS MARGINAIS

Vera Aun PENTEADO
Erik ASMUSSEN
Department of Dental Materials, School of Dentistry,
Faculty of Health Sciences, University of Copenhagen, Denmark

Marginal gaps associated with restorations of resin composite or glass-ionomer may have unfavorable consequences such as penetration of bacteria, marginal discoloration, risk of secondary caries, and demage to the pulp. The purpose of this in vitro study was to evaluate the effect of various pretreatments on the formation of marginal gaps at fillings of glass-ionomer and/or resin composite. The investigation was carried out using cavities prepared in dentin. The cavities were treated with 10% phosphoric acid and Gluma 3 before being lined with light-curing glass-ionomer cement and filled with resin composite. The control groups were resin composite alone and glass-ionomer alone, used with or without pretreatment of the cavities. After setting of the fillings, marginal gaps were measured in the microscope. It was found thar some combinations of pretreatment, glass-ionomer and resin composite gave rise to an excellent marginal seal.

Uniterms: Dental material, adaptation; Adhesion; Operative dentistry.

INTRODUCTION

Several problems may arise when a cavity surrounded totally or partially by dentin is restored with a resin composite[8,10,17]. The problems are associated with the fact that wide gaps are liable to form at the interface between composite and cavity wall[1,4,19]. Therefore, the capability of establishing a strong and permanent bond to dentin is a highly desirable property of a resin composite[3]. However, no commercial dentin-bonding agent can as yet completely prevent the formation of a contraction gap[2].

Resin composite is recognized as being superior to glass-ionomer cement from an esthetic point of view, but the glass-ionomer cements have been suggested as cavity liners, because of the several advantageous properties this material has. These properties include biocompatibility with pulpal tissue[18], slow release of fluoride[6,16], and ability to bond to enamel and dentin[14]. As regards the bond, however, gap formation may be reduced but is not eliminated[12]. Glass-ionomer cements are available in light-curing versions. Because of the resin component of these materials, it is conceivable that the bond to tooth structure may be enhanced by acid etching of enamel and by use of a dentin-bonding agent.

The aim of the present investigation was to evaluate the marginal gaps of fillings in dentin cavities which were acid etched and treated with a dentin-bonding agent before being filled with resin composite, glass-ionomer, or a combination of the two materials.

MATERIAL AND METHODS

The material used in this stugy are presented in Table 1.

The investigation was conducted on extracted human molar teeth form the permanent dentition which had been kept in 1% aqueous chloramine solution until use.

The surface of the teeth was ground flat on wet carborundum paper #80 and #220 until a plane surface of dentin was exposed. Cylindrical butt-joint cavities were prepared (diameter 3.0 mm, height 1.0 - 1.5 mm) in the ground dentin surface by means of a carbide bur under water spray; low speed was used to perform the final cutting of the cavities.

42 cavities were prepared and divided into 7 groups (each with 6 teeth), which were treated and filled as follows:

Group A - Pekafill
Group B - Fuji II LC
Group C - 10% phosphoric acid, gluma 3, 4, Pekafill
Group D - 10% phosphoric acid, Fuji II LC
Group E - 10% phosphoric acid, Gluma 3, Fuji II LC
Group F - 10% phosphoric acid, Gluma 3, 4, Fuji II LC
Group G - 10% phosphoric acid, Gluma 3, Photac-Bond Aplicap, Pekafill

In the following, the groups are described in more detail.

The groups A and B served as control. In these groups the cavities were dried with a blast of air only, while cavities of the other 5 groups were subjected to conditioning with 10% phosphoric acid for 30 s by means of a sponge. After the etching, the cavities were rinsed with deionized water for 20 s and dried with air, and care was taken not to desiccate the dentin. The cavities of group C, E, F, and G were then treated with the dentin primer Gluma 3. Gluma 3 was applied with a sponge for 30 s and dried eith air for 10 s. The low-viscous resin Gluma 4 used in groups C and F was applied with a sponge and cured with a visible-light curing-unit. When used with Pekafill (group C), the resin was polymerized together with Pekafill. When used with glass-ionomer (group F), the resin was polymerized for 20 s before application of the glass-ionomer.

In groups B, D, E, and F, the cavities were filled with Fuji II LC. Fuji II LC was mixed in accordance with the manufacturer's instrucrions for 30 s, and the cement was squeezed into the cavities and immediately covered with a matrix (3M, USA). The glass-ionomer was then irradiated for 20 s with the visible-light curing-unit, with close contact maintained between the exit window of the lamp and the matrix.

In group G, Photac-Bond Aplicap was used as liner. The Photac-Bond Aplicap capsule was activated and mixed in accordance with the manufacturer's instructions. The material was mixed by use of a Silamat for 10 s, applied with a sponge, and polymerized for 20 s.

In group A and G, the filling material was Pekafill. Pekafill was applied with a centrix syringe, covered with a matrix (3M, USA), and polymerized for 20 s.

After setting, the fillings of groups A, B, C, D, E and F were stored in tap water for 20 min, whereas in group G the fillings were stored in water for 24 h. The longer storage time in water of group G was chosen to examine the effect of hygroscopic expansion of the filling material. The teeth surfaces were then ground on carborundun paper #1000 and polished gently with carborundum powder (0,3 μm).

The maximum width of gaps was measured in a light-microscope (Leitz, Wetzlar, Germany) with a measuring ocular at a nominal magnification of 80 x 0.8 x 8.

The data were analyzed statistically by nonparametric statistics: The Mann-Whitney U test and the Kruskal-Wallis one-way analysis of variance.

Table I - List of materials used in the investigation

Materials	Batch No.	Manufacturer
Pekafill	1994 K	Bayer
Gluma Bonding System 3 & 4	7395 T	Bayer
Fuji II LC	Liquid: 070631 powder: 100931	GC
Photac-Bond Aplicap	0009-W1114	ESPE

RESULTS

The maximum contraction gaps of the seven groups of the study are recorded in Table 2. The control groups A and B involving resin composite and glass-ionomer alone showed the largest gap widths, with mean values of 18 um and 8.3 um, respectively. Pretreatment with phosphoric acid and, in the case of Pekafill, use of Gluma 3 and 4, reduced the marginal gaps, which measured 2.3 um and 6 um in groups C and D. In groups E, F, and G, combining conditioning, dentin-bonding agent, light-curing glass-ionomer, and, in the case of group G, resin composite, the smallest gaps were observed, with a mean value of 0.2 um in all 3 groups.

The statistical analysis showed significant differences between groups A-G ($p<0.001$) and between groups A-D ($p<0.001$). Likewise, significant differences were found between groups A and C, between groups B and E, and between groups D and E ($p<0.001$). The differences between groups C and F and between groups C and G were significant at the level $p = 0.06$.

Table II - Contraction gaps (μm)

Groups	Range	Mean values and SD
A	14 - 22	18.0 ± 3.5
B	2 - 10	8.3 ± 3.2
C	0 - 6	2.3 ± 2.6
D	3 - 10	6.0 ± 3.3
E	0 - 1	0.2 ± 0.4
F	0 - 1	0.2 ± 0.4
G	0 - 1	0.2 ± 0.4

DISCUSSION

The main reason for pulpar damage observed in teeth restored with fillings of resin composite or glass-ionomer may not be chemical irritation from the material, but irritation from infection caused from bacteria growing in the space between the filling and cavity wall[5]. Therefore, prevention of bacterial ingress and growth is vitally important to pulpar health[19]. However, even the most effective dentin-bonding systems do not prevent the formation of marginal gaps, when a resin composite polymerizes in a cavity surrounded - totally or partially - by dentin.

Glass-ionomer liners have been recommended because this material has several advantageous properties, such as fluoride release and biocompatibility with pulpal tissue, but it has been found that gap formation always occurs to a greater or lesser extent, depending on the technique used[12].

In the present study we tested various combinations of pretreatment, dentin-bonding agent, and filling material in an attempt to minimize the formation of marginal gaps. A complete investigation of all possible combinations of pretreatments, materials, and filling techniques would involve a very large number of groups. However, we only wanted to explore such combinations which we considered promising from a gap-reducing point of view.

Phosphoric acid was used as conditioner, because this acid will give a strong bond to enamel with composite and presumably with light-curing glass-ionomer[7]. The values of groups A and B are in agreement with other studies, in which contraction gaps of resin composites and glass-ionomer were measured without pretreatment of the cavities[9,15]. The reduction as compared to group A observed with group C, in which a dentin-bonding agent was used, is also in agreement with numerous earlier studies[e.g.9].

In group D, the reduction in gap width as compared to group B was not statistically significant. In the present study 10% phosphoric acid was used as conditioner. Other studies have investigated the effect of acidic conditioners on the bond between dentin and glass-ionomer. In some studies a positive effect has been observed, but in other studies no effect or an adverse effect was found[13]. It is conceivable that thesse conflictling results may be due to different techniques, and as a consequence to the balance between removal of the dentinal smear layer on the one hand, and a superficial removal of the bonding Ca^{++} -ions on the other hand[14]. In groups E and F, a dentin-bonding agent was used, and in comparison with group B and D a significant reduction in gap width was found. The explanation is probably linked to the resin component of the light-curing glass-ionomer. As with other resinous materials, the use of a dentin-bonding agent has a positive effect on marginal gaps[10]. Comparing groups C and F, the smaller gaps observed with the light-curing glass-ionomer may be explained by the greater flexibility of the glass-ionomer, as suggested by KEMP-SCHOLTE; DAVIDSON[11].

The use of an intermediary, noncomposite resin did not reduce the marginal gaps in a measurable degree (groups E and F). This is at variance with HANSEN; ASMUSSEN[9] who found a (small) reduction in marginal gap when a noncomposite resin was used. In group G, a glass-ionomer was used as liner, and the polishing of the fillings was postponed for 24 h. The use of glass-ionomer as liner earlier been found to reduce marginal gaps[12]. Likewise, postponing the polishing of filling of resin composite has been shown to have a positive effect on marginal adaptation. In the present study the gaps were small, but not eliminated.

It may be concluded that some combinations of pretreatment, dentin-bonding agent and filling material resulted in fillings in dentin cavities having very small or no marginal gaps.

RESUMO

A ocorrência de fendas marginais em restaurações de resinas compostas de cimentos ionoméricos pode ter consequências disfavoráveis tais como penetração de bactérias, descoloração marginal, risco de ocorrência de cáries secundárias e lesões na polpa dental. A finalidade deste estudo "in vitro" foi avaliar os efeitos de vários pré-tratamentos na formação de fendas marginais em restaurações de cimentos ionoméricos e/ou resinas compostas. A investigação foi feita utilizando-se cavidades preparadas em dentina que eram tratadas com solução de ácido fosfórico a 10% e Gluma 3 antes de serem forradas com cimento ionomérico e restaurados com resina composta. Os grupos de controle foram só a resina composta ou só o cimento ionomérico com e sem o pré-tratamento das cavidades após a presa dos materiais restauradores, as fendas foram medidas num microscópio. Observou-se que algumas combinações de pré-tratamento, cimento ionomérico e resina composta promoveram um ótimo selamento marginal.

UNITERMOS: Material dentário, adaptação; Adesão; Destística operatória.

REFERENCES

1.ARAUJO, P.A.; ASMUSSEN, E. Effect of dentin adhesives on contraction of restorative resin in cavities surrounded by acid-etched enamel. **Acta odont. scand.**, v.48, p.333-6, 1990.

2.ASMUSSEN, E.; HANSEN, E.K. Dentine bonding systems. In: VANHERLE, G.; DEGRANGE, M.; WILLEMS, G. eds. **State of the Art on Direct Posterior Filling Materials and Dentine Bonding**. Proceedings of the International Symposium Euro Disney, Paris, 1993. p.33-47.

3.ASMUSSEN, E.; MUNKSGAARD, E.C. Adhesion of restorative resin to dentinal tissue. In: VANHERLE, G.; SMITH, D.C., eds. **Posterior Composite Resin Dental Restorative Materials**. Minnesota Mining & Manufacturing Co., 1985. p.217-30.

4.ASMUSSEN, E.; MUNKSGAARD, E.C. Bonding of restorative resin to dentin: status of dentine adhesives and impact on cavity design and filling techniques. **Int. dent. J.**, v.38, p.97-104, 1988.

5.BRÄNNSTRÖM, M.; VOJINOVIC, O. Response of the dental pulp to invasion of bacteria around three filling materials. **J. Dent. Child.**, v.43, p.83-9, 1976.

6.CRANFIELD, M.; KUHN, A.T.; WINTER, G.B. Factors relating to rate of fluoride-ions release from glass-ionomer cement. **J. Dent.**, v.10, p.333-41, 1982.

7.CORTES, O.; GARCIA-GODOY, F.; BOJ, J.R. Bond strength of resin-reinforced glass-ionomer cements after enamel etching. **Amer. J. Dent.**, v.6, p.299-301, 1993.

8.EHRNFORD, L.; DERAND, T. Cervical gap formation in Class II composite resin restorations. **Swed dent. J.**, v.8, p.15-9, 1984.

9.HANSEN, E.K.; ASMUSSEN, E. Comparative study of dentin adhesives. **Scand. J. dent. Res.**, v.93, p.280-7, 1985.

10.HANSEN, E.K.; ASMUSSEN, E. Marginal adaptation of posterior resin: Effect of dentin-bonding agent and hygroscopic expansion. **Dent. Mat.**, v.5, p.122-6, 1989.

11.KEMP-SCHOLTE, C.M.; DAVIDSON, C.L. Complete marginal seal of class V resin composite restorations effected by increased flexibility. **J. dent.Res.**, v.69, p.1240-3, 1990.

12.PEUTZFELDT, A.; ASMUSSEN, E. Bonding and gap formation of glass-ionomer cement used in conjuction with composite resin. **Acta odont. scand.**, v.47, p.141-8, 1989.

13.PRATI, C.; NUCCI, C. MONTANARI, G. Effects of acid and cleaning agents on shear bond strength and marginal microleakage of glass-ionomer cements. **Dent. Mat.**, v.5, p.260-5, 1989.

14.SHALABI, H.B.; ASMUSSEN, E.; JORGENSEN, K.D. Increased bonding of a glass-ionomer cement to dentin by means of $FeCl_3$. **Scand. J. dent. Res.**, v.89, p.348-53, 1981.

15.SIDHU, S.K. Marginal contraction gap formation of light-cured glass-ionomers. **Amer. J. Dent.**, v.7, p.115-8, 1994.

16.SWIFT, E.J. Effects of glass-ionomers on recurrent caries. **Oper.Dent.**, v.14, p.40-3, 1989.

17.SWIFT, E.J. Pulpal effects of composite resin restorations. **Oper. Dent.**, v.14, p.20-7, 1989.

18.TOBIAS, R.S.; BROWNE, R.M.; PLANT, C.G.; INGRAM, D.V. Pulpal response to a glass ionomer cement. **Brit. Dent. J.**, v.144, p.345-50, 1978.

19.TORSTENSON, B.; BRÄNNSTRÖM, M. Composite resin contraction gaps measured with a fluorescent resin technique. **Dent. Mat.**, v.4, p.238-42, 1988

Address of corresponding author:
Erik Asmussen
Department of Dental Materials, School of Dentistry, Faculty of Health Sciences, University of Copenhagen, 20 Nörre Allé, DK-2200 Copenhagen N, Denmark