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Bond Strength of Aluminum Oxide Surface Treatment on Sandwich Restoration

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الخلاصة

ألاهداف: لتقييم تأثير أوكسيد الالمنيوم كعلاج للسطح على قوة السندات لل (GIC) المعامل وغير المعامل بحامض الفسفوريك للحصول على حشوة ساندويتش مع أنواع مختلفة من الحشوات البيض ولتقييم نوع الفشل. **المواد وطرائق العمل:** أعد ستون قالب تفلون (٥ملم قطر وارتفاع ٤مام) منGIC ذاتي التفاعل . وقد قمست هذه القوالب إلى مجموعتين رئيستين الاولى بدون معامله(قياسيه) والمجموعه الثانيه عُومِلت باوكسيد الالمنيوم .ثم قسمت كلتا المجموعتين الرئسيه الى مجموعتين فرعيتين الاولى بدون معامله(قياسيه) والمجموعه الثانيه عُومِلت ب ٣٧٪ من حامض الفوسفوريك . ثم وضعت المادة اللاصقه على السطح المعامل لجميع المجاميع. ووضع الجزء الثاني من قالبِ تفلون (٣ملم قطرها وارتفاع ٤مام) فوق القالب الاول و قسمت كلتا الجموعتين الفرعيتين الاولى والثانيه إلى ثلاثة مج اميع جديدة : الاولى مُلأَت بمادة ال (tg microhybrid)، الثانيه مُلأَت بمادة ال (tg fine glass)، والثالثه مُلأَت بمادة ال (Ceram X) . اختبرت العينات بماكنة الاختبار العالميه و فَحصَ نمط الفشلِ باستخدام ال stereomicroscope **النتائج:** اختلافات كبيرة للغاية بالنسبة لجميع المتغيرات عند المستوى ١٪ من الاختلاف باستثناء حامض الفوسفوريك. اما أوكسيد الالمنيوم كعلاج للسطح فقد اظهر تفوق لقوه الربط (٢,٣٤٢MPa) ومادتي ال (tg micro hybrid) and Ceram X أظهرتا أعلى قيمه لقوه الربط . الاستنتاجات: حامض الفوسفوريك لم يظهر أي تحسينِ على قيم ه لقوه الربط في حشوة ساندويتش في حين استخدام أكسيد الألومنيوم للمعالجة السطحية ومادتي ال (tg micro hybrid and Ceram X) اعطت تح سنا على قيمه لقوه الربط في حشوة ساندويتش .الفشل بشكل رئيسي تماسكي في (GIC) باستثناء (tg fineglass) فقد اظهرت فشل تماسكي في ماده الحشوه بح د ذاتها.

ABSTRACT

Aims: The aim of this study is to evaluate the effect of aluminum oxide as a surface treatment on shear bond strength of etched and non-etched GIC for sandwich restoration with different types of tooth colored restorations .In addition, failure type was assessed. **Materials and Methods:** Sixty Teflon molds (5mm diameter and 4mm height) of a chemically cured GIC were prepared. They were divided into two main groups 1st control, 2 ed air-abraded with 50µm aluminum oxide particles. Both groups were sub divided into two subgroups 1st control, 2 ed etched with 37% phosphoric acid. Bonding material was applied to the treated surface of all groups and cured. The second split of Teflon mold (3mm diameter and 4mm height) was placed onto the prepared specimen .Each subgroups (1st control, 2 nd etched with phosphoric acid) were farther subdivided into three subgroups which entrain filled as fallow: 1st split filled with a tg microhybrid, in 2 ed split filled with tg fine glass, and in 3 rd split filled with Ceram X. Shear bond strength was measured by using Universal Testing Machine, and mode of failure examined by a stereomicroscope. **Results:** Anova test showed that there was a highly significant difference for all variables except acid etching effect. Aluminum oxide surface treatment displays superior shear (2.280MPa). tg micro hybrid composite and Ceram X showed highest shear bond strength. **Conclusions:** Phosphoric acid etching did not improve shear value of sandwich restorations, while uses of aluminum oxide surface treatment, tg micro hybrid and Ceram X filling material gave an improvement on it. The failures were mainly cohesive within the GIC except tg fine glass was cohesive in filling material itself.

Key words: Air abrasion aluminum oxide, GIC, Composite, and Phosphoric acid.

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INTRODUCTION

The modern aesthetic and reconstructive dentistry can't be imagined without using of composite and glass-ionomer cement (GIC). Especially, materials which obturate the dentinal tubules and protect the pulp from effects of acids and oral fluids with bacteria.[1,2] Undoubtedly manufacturer of GIC restorative materials permanently improves the materials, in order to achieve similar characteristic with tooth tissue. These bioactive materials became available as a result of pioneer studies by Alan Wilson and M c Lean from the laboratory of the Government Chemist, London in late 1960. With unique characteristics, these materials have shown their quality in restorative dentistry. [3]

Adhesively, marginal connection and adaptation of cavity interface were and they still are the problem in technology during the working with materials of permanent restoration.[4, 5] The glass ionomer based use in the "sandwich technique", in dental practice, was implement by M c. L ean and authors in 1985. This technique gives significant positive results. Glass-ionomer base has several advantages: anti-cariogenic effect, volumetric reduction of composite resin, pulp protection - anti-inflammation, and relatively reliable form of adhesion to the dentine with little or no polymerization stress. [6]

The sandwich restoration may be of practical importance in conservative dentistry, because it should enable composite resins to attach to dentin with the GIC functioning as an intermediary bonding layer, minimizing some clinical problems related to microleakage and secondary caries.[7,8]The combination of GIC and composite gives excellent results of retention, and it always reduce postoperative sensitivity results at anterior and posterior composite restorations.[9]However, such combinations must have certain strength to withstand the variety of stresses developed during its clinical use. Among the factors that may affect the bond strength between a resin composite and a GIC are the tensile strength of the cement itself, the adhesive system and the composite resin employed, [6] the type of GIC,[10] and the surface treatment of the cement.[11]

The acid etching technique introduced by Buonocore,[12] induces microscopic roughness, increasing the available enamel surface area making mechanical adhesion possible. New technologies have since been introduced, providing increased comfort to the patient and professional, as well as enhancing adhesion of restorative materials to the dental structure, decreasing pain sensitivity, and preserving a greater amount of healthy dental structure. These techniques may be accomplished using various systems, such as laser therapy and the application of air abrasion with aluminum oxide, allowing the reduction of the problems of heat generation, vibration and other mechanical stimulation during cavity preparation. [13, 14] The use of air abrasion with aluminum oxide basically consists of the application of an abrasive jet with particles of different diameters and may be indicated for the removal of caries and restorative materials, repair of ceramic restorations and surface treatment of enamel and dentin, in addition to the possibility of increasing adhesion of restorative materials to tissues. [15-17] The purpose of this in vitro study was to evaluate the effect of aluminum oxide as a surface treatment on shear bond strength of etched and non-etched GIC used for sandwich restoration with adifferent types of toothed colored restorations In addition; the location of bond failure after debonding was assessed.

MATERIALS AND METHODS

The materials used in this study are listed in (Table 1). Sixty specimens of chemical cured base GIC, prepared using a mold with central hole (5mm) in diameter and (4mm) in height, each mold filled with a GIC using a plastic instrument and covered with microscopic slid to produce a smooth surface and remain intact for 15 min to enhance complete setting according to the manufacturer's instructions.

Table (1): Materials used

Material	Batch No.	Manufacturer
glass ionomer cement , meron	1086	comobirack art. germany.
attaque gel 37% ortho phoshoric acid	0434	Biodinamica spain.
one – up bond f plus a self –etching and light-cured dental adhesive	0123	tokyama dental tokyo, japan.
tg micro hybrid light cure composite	0510	technical & general ltd, london, England
tg fine glass light cure composite (compoglass)	811fga1	technical & general ltd, london, England
ceram, x duo universal nano-ceramic restorative material	78467	dentsply, detrey gm bh. konstanz, germany.

The samples were randomly distributed into 2 groups (n=30). in 1 st group (A1) GIC surface remained intact (control), while the 2ed group (A2), the cement surface was air-abrade with 50µm aluminum oxide particles using a MICROBLASTER (bio.art Rua Teotônio Vileia, 120- Jd. Tangará-CEP 13568-000- São Carios- SP- Brasil.) (Figure 1) operated at a 5mm distance and 90° to cement surface for 5s(Figure 2), washed with a distilled water and dried. Both 1 st and 2ed (A1, A2) groups farther subdivided into two groups (n =15),(B1, and B2). In (B1) groups the GIC surface had no treatment (control), while in (B2) groups the cement surface was etched for 15 seconds with 37 %phosphoric acid etching gel, washed and dried. Bonding material (one - up bond F plus) was applied on treated surface of all groups according to the manufacturer's instructions with light brushing motion, lightly air thinned and cured with visible light source (Ivoclar vivadent. LED itian) for 20 second with a standard light at 560mw/cm ^{2} assessed with a radiometer every 5 restorations. Immediately the second split of Teflon mold (3mm in diameter and 4mm in height) was placed on to the prepared specimen. Each subgroups (B1, and B2) farther subdivided into three groups (C1, C2, and C3) .The second split of Teflon mold of (C1) group filled with a tg microhybrid and cured for 40 second from the top of the specimens, in (C2) group filled with tg fine glass, and the (C3) group filled with Ceram X and cured as in (C1) group. Then, the second split mold was removed. The samples were stored in distilled water at 37°C for 24h, thermo-cycled for 300 cycles at temperature ranging from 5±2°C to 55±2°C; each cycle lasted for 45 second with a dwell time of 15 second, in each path, and 15 second intervals between paths.

Shear bond strength between GIC and tooth colored restorations measured using Universal Testing Machine (Soil Test Co. Inc., USA) (Figure 3) with a Knife edge head placed at the interface between GIC and composite at a cross head speed of 0.5mm/min. [18]The modes of failure examined by a stereomicroscope (Zeiss, MC 63A, Germany) at 20X magnification power. Data were tabulated and statistically analyzed. They were analyzed using analysis of variance (ANOVA) followed by Duncan’s Multiple Range Test at 1% level of significance to indicate if there were any statistical difference in shear bond strength of the three groups.

RESULTS

Means and standard deviations of shear bond strength (MPa) of variables are shown in Table (2).

Table (2): Means and standard deviation of shear bond strength (MPa) of variables.

Surface treatment	acid etchings	Restorative materials		
		Comps. Mean + SD	Comg. Mean + SD	Ceram. Mean + SD
Control	Control	1.032 + 0.1047	1.584 + 0.1873	2.698 + 0.2374
	PH	1.922 + 0.0855	1.862 +0.2357	2.592 + 0.1395
AL_2O_3	Control	4.072 + 0.2608	1.726 + 0.0955	1.750 + 0.0469
	PH	2.310 + 0.1466	1.358 + 0.2692	2.444 + 0.2197

Comps: tg Composite; Comg: tg Compoglass; Ceram: Ceram X; AL_2O_3: Aluminum oxide air abrasive; PH: Phosphoric acid.

Mean square analysis of level 1% listed in Table (3) which showed highly significant differences for all variables except acid etching effect which indicated no significant differences at1%.

Table (3): Mean square analysis for surface treatment, acid etching and restorative materials.

S.O.V.	d.f	M.S.
Surface treatment (AL_2O_3)	1	1.676**
acid etching	1	0.07
restorative materials	2	3.42**
Interaction Between Surface treatment and acid etchings	1	2.52**
Interaction Between Surface treatment and restorative materials	2	7.29**
Interaction Between acid etching and restorative materials	2	0.64**
Interaction Among Three Main Factors	2	3.83**
Error	48	0.034

** Significant differences at 1% level; S.O.V.: Source of variance; d.f: Degree of freedom; M.S.: Mean square.

Duncan's Multiple Range Test which listed in Table (4) to identify statistically the effect of aluminum oxide air abrasion surface treatment and acid etching on shear bond strength of GIC bonded to different colored restorative materials which indicate that, generally the GIC with aluminum oxide surface treatment displays superior shear bond strength (2.280 MPa) than GIC without aluminum oxide surface treatment (1.941 MPa). For the acid etching effect represented no significant differences with or without acid etching with 37 %phosphoric acid. While in studying the restorative materials that bonded to GIC, the result indicated that the tg micro hybrid composite and Ceram X showed highest shear bond strength(2.330 MPa),(2.362 MPa) respectively and no significant differences between them followed by tg fine glass (1.630 MPa).

The effect of aluminum oxide surface treatment on restorative materials, showed that the tg micro hybrid composite with aluminum oxide give superior shear value (3.191 MPa). But, the effect of acid etching on restorative materials, displayed that tg micro hybrid composite give superior shear bond strength (2.552 MPa) followed by other groups which showed no significant differences. And Aluminum oxide surface treatment without acid etching group had the highest shear value (2.710 MPa) followed by a group etched with phosphoric acid that showed no significant differences between its groups.

The failures were mainly cohesive within the GIC for all groups except tg fine glass group where was cohesive in filling itself material Table, (5).

able (4): Duncan's New Multiple Range Test for variables

Surface Treatment	**Restorative Material**	**Acid Etchings** Control	PH	Control	PH	**Surface Treatment**	**Means of Surface Treatment**	**Means of Restorative Materials**
Control	Comps.	1.032^{G}	1.922^{D}	2.552^{A}	2.116^{C}	1.478^{E}		2.330^{A}
	Comg	1.584^{EF}	1.862^{D}	1.655^{D}	1.610^{D}	1.723^{D}		1.630^{B}
	Ceram.	2.698^{B}	2.556^{BC}	2.224^{BC}	2.498^{AB}	2.627^{B}		2.362^{A}
AL_2O_3	Comps.	4.072^{A}	2.310^{C}			3.191^{A}		
	Comg	1.726^{DE}	1.358^{F}			1.542^{DE}		
	Ceram.	1.750^{DE}	2.444^{C}			2.095^{C}		
Control		1.771^{C}	2.110^{B}				1.941^{B}	
AL2O3		2.710^{A}	2.037^{B}				2.280^{A}	
Means of Acid Etchings		2.144^{A}	2.075^{A}					

Different letters indicate significant differences. Comps. : tg Composite; Comg : tg Compoglass; Ceram: Ceram X; AL_2O_3: Aluminum oxide air abrasive; PH: Phosphoric acid.

Table (5): Type of failure between the Surface treatment and different tooth-colored restorative materials.

Restorative Material	**GIC** **Without AL_2O_3** Control		ph		**With AL_2O_3** Control	ph
Comps	4 (B)	1 (C)	1(A)	4 (B)	5 (B)	5 (B)
Comg	1(A)	4(C)	1(A)	4 (C)	2(A) 3(B)	3(A) 2 (B)
Ceram.	4 (B)	1 (C)	1(A)	4 (B)	5 (B)	5 (B)

GIC: glass ionomer cement, Comps. :tg Composite; Comg. : tg Compoglass; Ceram: Ceram X; AL_2O_3: Aluminum oxide air abrasive; PH: Phosphoric acid. A: adhesive failure, B: cohesive failure in the GIC, C: cohesive failure in the restorative material.

DISCUSSION

In an effort to combine the esthetic superiority to the composite resin and the bonded ability of GIC which so-called glass ionomer- composite sandwich technique. The method is now known as the double laminated technique. [19,20] Within the limits of our investigation , the data showed highest shear strength obtained with aluminum oxide air abrasive surface treatment due to fact that roughening the surface by air abrasion with aluminum oxide increasing surface area for bonding and decreasing the surface tension , creating very fine roughness enhancing mechanical and chemical bonding.[21-23]

When GIC surfaces etching with 37 %phosphoric acid no improvement on shear value obtained for sandwich restorations, because acid etching of GIC surfaces allow a cleaned mildly roughened surface with high surface energy. [24, 25] The results is agreed with Zanata etal(1997) [26] there were no significant differences among the shear bond strength of the resin composite to etched and non- etched GIC. Sá et al(2005) [27] concluded that the etching of GIC surface is not necessary. Subrata and Davidson (1989) [28] reported that roughening the surface of the GIC or partial dehydration followed by application of dentine bonding agent, resulted in a composite resin bond strength value comparable to that obtained with phosphoric acid-etch technique, therefore, because of the deteriorating effect of phosphoric acid on GIC, it is used to etch the enamel margin only.

The bond strength between GIC and restorative materials is influenced by, at least, four factors: the tensile strength of GIC, which depends mostly on the powder/liquid ratio. The viscosity of the bonding agent and its ability to wet the GIC surface; the volumetric change in the composite resin during polymerization; and the difficulties in packing and adaptation of the composite resin to the glass ionomer cements without incorporation of voids.(25) Other studies (10,29) assessing the acid etching, grinding or air drying the surface of the GIC had a significant effect on the bond strength. Our investigation displayed that the tg micro hybrid composite and Ceram X give the high shear value when bonded to GIC in sandwich technique. this result come in agreement with that of Farah et al(1998) (30) which found that the filler content of resin composite (micro filled vs hybrid) did not affect the adhesive shear bond strength to both resin modified and self-cured GIC.

Most failures occurred cohesively in the GIC itself for all groups except tg fineglass group where it was cohesive in filling material itself. This seems to be a typical finding and may be because the GIC contains numerous air inclusions. These air inclusions can act as stress points, thus giving rise to the increased likelihood of cohesive failure within the cement which was seen as the most common form of failure mode. This same phenomenon can also occur in resin-based systems, but the numbers of defects within the resin are must less than GIC. (31) The previous statement could be the explanation for the cohesive failure in the tg fineglass itself rather than GIC, where the tg fineglass is probably has weaker cohesive bond than adhesive bond to GIC or cohesive bond of GIC itself.

CONCLUSION

With the limits of this in vitro study, highest shear value obtained with aluminum oxide surface treatment that creating a very fine roughness surfaces enhancing mechanical and chemical bonding. Etching GIC surfaces with 37 %phosphoric acid did not improve shear value of sandwich restorations; due to it is deteriorating effect on GIC surfaces. The tg micro hybrid and Ceram X give the high shear value when bonded to GIC because its filler content not affect the adhesive shear value of GIC. The failures were mainly cohesive within the GIC for all groups except tg fine glass group where it was cohesive in filling material itself.

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