Original Articles

THE EFFECT OF DIFFERENT PROTECTIVE COATINGS ON THE SURFACE HARDNESS OF GLASS IONOMER CEMENTS

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الاسمنت الزجاجي عرضة لامتصاص الرطوبة والجفاف أثناء تصلبه البدئي . إن استعمال الراتنج المتصلب بالضوء كطبقة واقية لسطح حشوات الاسمنت الزجاجي يمنع انتقال الماء عبر سطح الاسمنت الزجاجي .

في هذه الدراسة تم اختبار تأثير خمسة مواد مغطية على صلابة سطح حشوات الاسمنت الزجاجي (كيتاك فيل) .

وهذه المواد المغطية هي : زبدة الكاكاو، فرنيش الكيتاك ، المانيكور الشفاف ، فرنيش الكوبالايت ، راتنج متصلب بالضوء .

وتم اختبار صلابة سطح حشوات الاسمنت الزجاجي في المجموعات الخمسة بعد ساعة وبعد ٢٤ ساعة وبعد أسبوع . وتم مقارنتها بمجموعة من حشوات الاسمنت الزجاجي لم يتم حماية سطحها بهذه المواد.

وقد تبين من هذه الدراسة بأن جميع هذه المواد المستعملة للتغطية لم تحافظ على القساوة الأصلية لسطح حشوات الاسمنت الزجاجي . وإن زبدة الكاكاو وفرنيش الحشوات الزجاجية ، والمانيكور الشفاف كانوا أقل ضررا على قساوة سطح الحشوات الزجاجية من فرنيش الكوبالايت والراتنج الضوئي .

لقد تم إيجاد اسمنت الحشوات الزجاجية عام ١٩٧٢م من قبل ويلسون وكنت. واليوم لهذه الحشوات تطبيقات واسعة في طب الأسنان . كحشوات لحفر الصنف الثالث والخامس ، واسمنت لاصق للترميمات المصبوبة . ولترميم حفر الأسنان المؤقتة ، ومواد مبطنة ، ولبناء الأسنان ، وحشوات للحفر الصغيرة .

هذا النوع من الحشوات يجمع الخواص المفضلة من حشوات السيليكات . واسمنت البوليكاربوكسيلات ولها خاصية الشفوفية مثل الخزف وخاصية طرح مادة الفلور على مدى طويل من الزمن ويلتصق بمادة السن وكذلك يلتصق بالمعادن الرخيصة. وإن التفاعل بين السائل والمسحوق هو تفاعل حامضي. وعلى الرغم من تطوير هذه المادة فإنها لاتزال تعاني من تأثير الرطوبة عليها أثناء تصلبها . وإن تماسها المبكر مع الماء يؤدي إلى حشوات ضعيفة وسطح خشن وطليل . في حين تجفافها يؤدي إلى فقدها للماء، وبالتالي تقلصها مع تشقق سطحها، لذلك يجب حماية هذه الحشوات من التماس المبكر مع الماء أو تجفافها.

Class ionomer cements are liable to hydration and dehydration during their initial set. The use of a light-activated bonding resin is advocated as a protective method of limiting water movement across the surface. This study tested the effect of five coating materials on the surface hardness of Ketac-Fil restorative glass ionomer. Cocoa butter (CB), Ketac varnish (KV), clear finger nail polish (NP), copalite varnish (CV), and a light-cured unfilled resin (UFR) were evaluated. The surface hardness of each group was determined at 1 hour, 24 hours and 1 week, and compared to that of unprotected surface as a control (C). The results showed none of the tested coatings was able to maintain the original surface hardness of the unprotected cement. CB, KV and NP were less effective in reducing the surface hardness of Ketac-Fil than CV and UFR.

Received 15/12/92; revised 09/02/93; accepted 03/03/93

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Introduction

The glass ionomer cement (GIC) was introduced to the dental profession by Wilson and Kent in 1972.[1] Today the GICs have a wide range of clinical applications.[2] They may be used as restorative materials for class III and class V cavities, fissure sealants, luting agents for cast restorations, restoration of deciduous teeth, lining materials, core build up, restoring minimal cavity preparations such as tunnel preparation, and dentin substitute in laminate restorations. These types of cements combine certain favorable characteristics of the silicate and the polycarboxylate cements.[3,4] Glass ionomer cements have porcelain-like translucency,[5] release fluorides over a period of time[6'7] and adhere to tooth structure and base metals.[8,9] In recent years, GICs have shown a promise as bone cements since they are bioactive and promote bone growth.[5]

The glass ionomer cement is composed of fluoride containing acid decomposable, calcium-alumino-silicate glass powder, and polyacrylic acid or alkenoic acid. The reaction between the powder and the liquid is an acid-base reaction. On mixing, the glass powder reacts with the acid; calcium and aluminum ions are displaced from the glass in the form of Ca^{2+} and Al^{3+} along with the fluoride ion F^{-}. The Ca^{2+} ions react rapidly in the liquid forming a salt bridge between the negatively charged carboxylic groups. The polycarboxylate chains become cross-linked by this process and soon form a gel which marks the initial setting of the cement. The Al^{3+} ions react more slowly largely because they are trivalent and have more difficulty in forming the salt bridge. However, they slowly increase the cross-linking and produce further hardening until the final setting is achieved.[10]

Despite all improvements of the new glass ionomer cements over the early ones, they still suffer from the effect of moisture contamination and desiccation during the reaction stages. After setting and before the cement is completely hardened, the calcium and aluminum salts are in the soluble form and can be permanently lost if they come in contact with water, resulting in a weak cement with a rough and opaque surface.[11-12] Desiccation, on the other hand, retards the reaction due to the loss of water. In such a case, the material undergoes shrinkage with crazing of the surface.[13] The susceptibility to desiccation decreases as the cement matures but continues from one to thirty days depending on the brand of cement. Accordingly, the cement must be protected against moisture gain or desiccation 10—30 minutes after insertion.[14] The ideal protective film against these two extremes is yet to be developed. Some manufacturers provide the profession with special coating varnishes.[15] It has been found that GIC liners and bases showed a significant reduction in surface hardness when a cavity varnish was applied.[16] It was also found that Ketac Fil showed a significantly rapid development of surface hardness than did some other brands.[17]

The purpose of this study was to compare the effect of different protective coatings on the surface microhardness of Ketac-Fil glass ionomer cement.

Materials and Methods

The materials used for this study were Ketac-Fil* glass ionomer restorative and five coating materials. Eighteen fillings were prepared in resin blocks. Cylindrical blocks of self-curing acrylic resin** were prepared using copper molds 15 mm long and 12 mm in diameter. Each cylinder was placed on a glass slab, filled with the resin and covered with a glass slide to obtain a smooth and flat surface when the resin is hardened. On the top surface of each block, a cavity was prepared. The cavities were 5 mm in diameter and about 3 mm deep as shown in Fig. 1. The cavities were filled with the glass ionomer cement using the manufacturer's recommended technique. Immediately after insertion of the filling, the surface of the restoration was covered by a Mylar matrix and pressed with a microscope slide to obtain a smooth and flat surface. Five minutes later, the glass slide and matrix were removed and the surface was immediately covered by the protective coating.

The eighteen blocks were divided into six groups, each consisting of the three specimens; five treatment groups, based on the material used as a protective coating, and one control group. In the control group, the surface was not coated.

Each of the five experimental groups were coated with either cocoa butter (CB), Ketac

*ESPE - Premier Dental Products, Norrisfown, PA USA.
**DeTrey Division Dentsply, Waybridge,

varnish* (KV), clear finger nail polish (NP), copalite varnish** (CV), or light-cured unfilled resin*** (UFR). The specimens were then stored in an environmental chamber at 37°C and 80% relative humidity until they were ready for testing.

The surface hardness (average of three measurements) for each specimen was measured after one hour, 24 hours, and one week using a Viker's microhardness tester.**** All indentations were made at a load of 100 g for 5 seconds.

Statistical Analysis

The experiment has been performed like a split plot design[18] where the groups were considered as the whole unit treatment and the time as the sub-unit treatment. Analysis of variance (ANOVA) has been used to compare the time factors as well as the treatments. To test the validity of the repetition of the same sample, repetition factor was also included in the ANOVA. The least significant difference (LSD) was calculated to compare group means, time means, time means within the same group, and group means within the same and/or different times.

• ESPE-Premier Dental Products, Norristpwn, PA, USA.
**Teledyne Cetz, Elf Grove Village, IL, USA.
***Prisma Universal Bond, Caulk/Dentsply, Milford, DE, USA.
****Buehler Micrometer II, Lake Bluff, IL, USA.

Results

The mean values of the surface hardness obtained with different coating materials and time intervals are presented in Fig. 2 and tabulated in Table 1. Analysis of variance (ANOVA) is presented in Table 2. The LSD for all treatments at all times is presented in Table 3.

The general pattern was the increase in surface hardness with time for all surface treatments as well as for the control (Table 1). Coating the surface with unfilled resin resulted in a great reduction in surface hardness at all times. The surface hardness with the unfilled resin was at least 50% less than that with the rest of coatings except with Copalite varnish at 24 hours. The control group, on the other hand, gave the highest value of surface hardness. Analysis of variance (Table 2) revealed that there was at least one coating material that is significantly different (P < .001) from the other four, at least one time interval was significantly different (P < .001) from

Table 1. Mean surface hardness and standard deviation of all groups vs, time.

	1 Hour			24 Hours			1 Week		
	n	Mean	S.D.	n	Mean	S.D.	*n*	Mean	S.D.
1. Control	9	57.43	(5.91)	9	76.81	(9.01)	9	83.09	(7.02)
2. CB	9	44.48	(2.31)	9	61.64	(6.04)	9	70.97	(7.90)
3. KV	9	41.84	(5.33)	9	53.29	(9.31)	9	67.70	(9.49)
4. NP	9	42.87	(6.40)	9	62.41	(16.26)	9	66.26	(9.95)
5. CV	9	36.52	(3.18)	9	38.80	(9.87)	9	54.12	(4.96)
6. UFR	9	17.87	(3.69)	9	25.89	(5.45)	9	26.83	(5.80)

Table 2. Analysis of variance (ANOVA) for group treatment and time.

Source of variation (SOV)	Degree of treatment (DF)	Sum of squares (SS)	Mean squares (MS)	F-Test
Croup treatment	5	37,458.500	7,491.700	97.106***
Error (A)	48	3,947.074	82.231	
Time	2	12,471.445	6,235.722	104.328**
Treatment time	10	1,936.698	193.670	3.240*
Error(B)	96	5,737.943	59.770	
Total	161	60,572.660		

* p<.05 **p<.01 ***p < .001

Mean surface hardness of all groups versus time

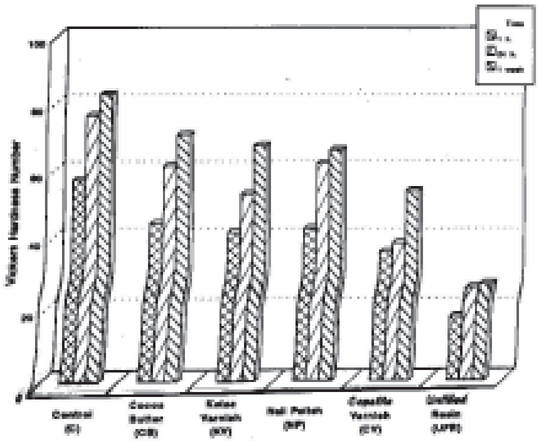

Figure 1. Schematic illustration of the prepared cavity in an acrylic block.

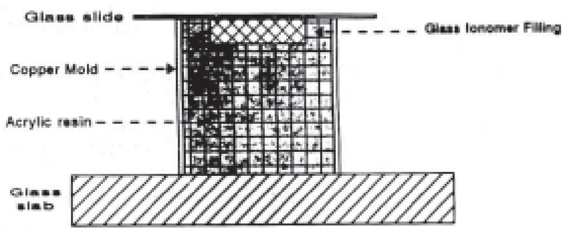

Figure 2. Mean surface hardness of all groups vs. time intervals.

the other two, and at least one coating material showed a significant difference ($P < 0.05$) at each time interval. The least significant difference (Table 3) showed the differences in surface hardness among groups as a whole and at different time intervals.

Specimens treated with cocoa butter, Ketac varnish and nail polish were comparable since they showed no significant difference in surface hardness at the one hour and one week periods. However, hardness of specimens treated with KV was about 16% lower than these two treatments after 24 hours. Values obtained with Copalite varnish, although much higher than those obtained with the unfilled resin, were significantly lower than those obtained with other surface treatments, especially after 24 hours.

Discussion

The surface hardness may be defined as the resistance of a material surface to abrasion.[9] This definition makes the surface hardness an important parameter in evaluating dental materials, especially restorative materials. Considering glass ionomer cements and similar materials commonly used in class V restorations, they are susceptible to abrasion caused, at least, by everyday use of the toothbrush. It has always been recommended that glass ionomer cements must be covered immediately after setting with a water-proof coating. It was demonstrated by O'Hara[16] that glass ionomer liner and base may suffer a reduced surface hardness if put against cavity varnish. Although not substantiated by a scientific explanation, the finding was a warning that other coating materials may behave similarly. Earl *et al*[20] have shown that immediate covering of immature glass ionomer cement with a light-cured bonding resin is the most effective method of limiting water movement across the surface. Hotta *et al*[21] have studied the effect of different coating materials on the color stability of glass ionomer cement. They came up with the conclusion that coating with light-cured resin is the best in this regard. However, the effect of these recommended coating materials on the surface hardness of the restorative glass ionomer cement has not been reported in the literature. It was surprising that in the present study, all protective coatings used have resulted in a reduction of the surface hardness of the cement when compared with the control. It was also interesting that the light-cured unfilled resin caused the maximum drop in surface hardness. The Copalite varnish was better than the resin in this respect, yet it gave a low value of surface hardness at the 1 hour and 24 hours compared to one week hardness. After one week, the surface hardness of the resin coated cement was less than the one hour hardness of all other coating materials. Cocoa

Table 3. The least significant difference (LSD) for the treat-ments.

1 Hour		24 Hour		1 Week		Total (all times)	
	653421		653241		654321		653421
5	*	3	*	5	*	5	*
3	*	2	**	4	*	3	*
4	*	4	**	3	**	4	**
2	**	1	***	2	**	2	**
1	*****			1	****	1	*****

* Significantly different

butter, Ketac varnish and nail polish were all comparable in reducing surface hardness and their effect was less than that of the Copalite varnish and the unfilled resin.

Conclusion

None of the protective coatings used in this study was able to maintain the original surface hardness of the unprotected glass ionomer restorative. Cocoa butter, Ketac varnish and nail polish were the least effective in reducing the surface hardness of Ketac-Fil compared to Copalite varnish and unfilled light-cured resin.

Acknowledgment

The authors are grateful to Dr. Nazeer Khan, Biostatistician, Research Center, College of Dentistry at King Saud University, for his valuable work in the statistical analysis of data and to Professor H. Mohammed-Al Tahawr, Chairman of the Department of Prosthetic Dental Sciences, College of Dentistry, King Saud University for his advice and encouragement relative to the experiment.

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