Glass ionomer cement surface protection

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ABSTRACT: ***Purpose:*** To evaluate the effectiveness of various surface treatments for glass ionomer cement (GIC) by determining quantity of dye uptake spectrophotometrically. ***Materials and Methods:*** Sixty specimens, 4.5 mm diameter and 2 mm thick, were made from Shofu GIC and divided into 10 groups. Positive control (A) and negative control (B) specimens were not protected while experimental specimens were protected with ARM chemically-cured bonding resin (C), Durafill Bond light-cured bonding resin (D), Bondlite light-cured bonding resin (E), Colorama nail varnish (F), Shofu varnish (G), Copalite varnish (H), Vaseline (I) or Vaseline followed by Copalite (J). The discs were immersed in 0.05% methylene blue solution 10 minutes after mixing except group B specimens which were immersed in deionized water. After 24 hours the discs were removed, washed, and individually placed in 1 ml 65% nitric acid for 36 hours. The solutions were filtered, centrifuged and the absorbance determined spectrophotometrically at 590 nm. Dye uptake was expressed in µg dye/restoration and the data analyzed by ANOVA and Tukey Kramer test. ***Results:*** The mean (SD) of dye uptake were: A:95.12 (11.28); B:0 (0); C:40.90 (5,06); D: 33.89 (3.63); E:35.73 (3.36); F: 3.29 (0.79); G: 14.87 (2.86); H: 21.99 (3.25); I: 47.21 (7.06); J: 29.74 (3.49). All the surface agents were effective in protecting setting restorative glass ionomer cement, but nail varnish provided the best results. (*Am J Dent* 1994; 7:203-206).

CLINICAL SIGNIFICANCE: Although several of the agents tested were partially effective in protecting the surface of a glass ionomer cement restoration, the low viscosity nail varnish provided the best protection.

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Introduction

Glass ionomer restorative cements undergo a prolonged setting reaction and the clinical implications of this reaction must be considered for optimum results. When set, glass ionomer cements have a high water content and in the early stages of setting will absorb further water.[1] If left exposed to air after the initial setting, the glass ionomer cement will lose water rapidly leading to shrinking and crazing. This will leave the surface of the restoration susceptible to staining as well as placing heavy stress on the newly formed ionic bonds, thus possibly leading to loss of adhesion.[2] On the other hand, exposing the setting cement to an aqueous environment too soon after placement may upset the setting process.[3] Correlations have been demonstrated between early exposure to water and reduced mechanical properties leading to poor clinical performance.[4] Lower compressive strengths and reduced degrees of hydration of the set matrix have also been reported.[5]

As water forms an important part of the cement structure,[6] affecting the vulnerability of a setting glass ionomer cement, some form of surface protection during this period is essential. It appears that there is no ideal barrier to protect glass ionomer cement restorations. Light-cured bonding agents are cited as perhaps the best solution,[12] while petroleum jellies are not suitable because they are easily removed by tongue movements.[6] It has been suggested that pretroleum jelly and varnish provide the best protection for the silicate cement.[7] A clear nail varnish has also been cited as an effective barrier for the protection of glass ionomer restorations.[6]

In spite of some studies evaluating the effect of moisture[3,8,9] and the effectiveness of surface treatments,[10,12] there are still doubts as to the most effective surface agents to be used to protect glass ionomer cement.

The purpose of this study was to evaluate spectrophotometrically the effectiveness of surface agents to protect setting restorative glass ionomer cement.

Materials and Methods

To conduct this study, a glass ionomer cement type II, Shofu Glass Ionomer[a] was used. The glass ionomer cement was mixed for 45 seconds at 23°C, in a powder/liquid ratio of 0.65 g/0.20 ml.

The cement was placed with a syringe (Centrix[b]) into plastic rings, 4.5 mm in internal diameter and 2 mm in depth, held between two glass slabs separated by mylar matrix strips, and then pressed with a 1000 g load. Seven minutes after initiation of mixing, the load, slabs and matrix strips were removed and the test specimens protected. After that, excess cement was trimmed off and the specimens protected again.

Ten surface treatments were evaluated and six test specimens were prepared for each treatment:

A = No protection - positive control.[a]
B = No protection - negative control.[a]
C = Chemically-cured bonding resin (ARM[c]).
D = Light-cured bonding resin (Durafill Bond[d]).
E = Light-cured bonding resin (Bondlite[e]).
F = Nail varnish (Colorama[f]).
G = Proprietary varnish (Shofu[a]).
H = Copal resin varnish (Copalite[g]).
I = Vaseline.[h]
J = Vaseline and Copalite.

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All the surface treatments were applied with a brush to both exposed surfaces of each specimen two times, before and after trimming. The light-cured bonding resins used on groups D and E were light-cured for 20 seconds at each of the exposed surfaces, after trimming. In group J, the interaction between two surface treatments were evaluated, Vaseline and Copalite. These test specimens were smeared with Vaseline. After trimming, the Vaseline was wiped off, leaving only a film and the specimens were covered with Copalite.

The method used to quantify the effectiveness of the surface protection was adapted from Douglas & Zakariasen[13] as described by Rigsby *et al.*[14] Following the surface treatments, each specimen was immersed separately into 1 ml of 0.05% methylene blue solution at 37°C with the exception of the specimens from group B, which were placed in 1 ml of deionized water. After 24 hours, specimens were rinsed with 50 ml of deionized water, removed from the plastic rings and immersed separately into new tubes containing 1 ml of 65% nitric acid. Standard solutions of methylene blue in 1 ml of 65% nitric acid were prepared containing from 0-30 µg dye/ml and glass ionomer cement specimens, prepared as previously described. The time necessary for glass ionomer cement dissolution was obtained from a pilot study. Specimens were completely dissolved after 36 hours at which time the standard and experimental nitric acid solutions were diluted with 2 ml of deionized water. The solutions were filtered, centrifuged and the supernatant used to determine the absorbance in a spectrophotometer. The absorbance of the standard solutions now containing from 0-10 µg/ml was determined at wave lengths ranging from 500- 660 nm, and the best results were obtained at 590 nm. Prior to determining the absorbance at 590 nm of experimental solutions, the coefficient of correlation (r) between dye concentration and absorbance of the standard solutions was calculated, an r value of 0.998 was obtained. To estimate the dye concentration on the experimental samples, a linear regression was obtained. The regression equation expressed as:

$$y = -0.1564 + 9.4435.x$$

where y is the absorbance and x is the dye concentration.

The effectiveness of the surface treatments for the glass ionomer cement was recorded as µg dye per specimen, lower values indicating better protection.

For statistical analysis, an one way analysis of variance (ANOVA) was used.[15] To identify significant differences, Tukey-Kramer's test[15] at 5% level of significance was applied, and the least significant differences (LSD) were thus obtained.

Results

The effectiveness of the surface treatments for glass ionomer cement used in this study, compared with control groups, were expressed as µg dye per specimen. The data are presented in Table 1.

The ANOVA showed highly significant differences among the treatments (F=167.56) at 1% confidence level (F critic = 2.78). A Tukey-Kramer's test identified these differences, by means of least significant differences (LSD = 9.79).

Table 1. Mean dye penetration in glass ionomer cement specimens by treatments (n=6).

Treatment	µg dye/specimen Mean (S.D.)
Positive control	95.12 (11.38)
Vaseline	47.21 (7.06)
ARM	40.90 (5.06)
Bondlite	35.73 (3.36)
Durafill	33.89 (3.63)
Vaseline/Copalite	29.74 (3.49)
Copalite	21.99 (3.25)
Shofu varnish	14.87 (2.86)
Nail varnish	3.29 (0.79)
Negative control	0.00 (0.00)

Tukey-Kramer: LSD 5% =9.7
Means are listed in decreasing order of magnitude
Means connected by vertical lines were not significantly different

Mean values of dye penetration for nail varnish and the negative control group were not significantly different but significantly lower than those of the other groups. No statistically significant differences were found between Shofu varnish and Copalite and between Copalite and the combined Vaseline/Copalite. There was a significant difference between Shofu varnish and Vaseline/Copalite groups. The three bonding resins used in this study did not differ significantly among themselves. However, data from Bondlite and Durafill were significantly lower than that of Vaseline and were not significantly different from Vaseline/Copalite, whereas there was no statistically significant difference between ARM and Vaseline. The positive control group allowed the greatest dye penetration, significantly different from all the other groups.

Discussion

The glass ionomer cements set and harden by a transfer of metal ions from the glass to the polyacrylic acid, to form a salt hydrogel that is the binding matrix.[6] The strength and resistance of these cements rely on the formation of this insoluble polyacid/cation matrix. The matrix takes time to form and the character of the ionic cross-links changes from being predominantly hydrolytically unstable calcium polyacrylate to the more stable aluminum polyacrylate, during the early life of the restoration.[16]

Initial setting, also called gelation, is regarded as the result of chain entanglement as well as weak ionic cross linking which corresponds to the viscoelastic behavior of the freshly set material. During the process of transfer the matrix-forming metal ions are in soluble form and vulnerable to attack by aqueous fluids. As the cement matures, during the first 24 hours and beyond, progressive cross linking occurs as the sensitivity to moisture decreases and the percentage of bound water and glass transition temperature increases.[6]

Protecting the glass ionomer cement from water results in a greater degree of cross linking in the final cement, the degree of cross linking increasing as the log of the time the cement is protected from water.[3] There is another reason for protecting the setting cement. Water is the reaction medium and is also an essential part of the hydrogel which is required to hydrate the metal polyalkenoate formed.[6]

An ideal surface protector must successfully control the water balance to permit sufficient maturation of the glass ionomer cement before the restoration is exposed to the oral environment. The requirement is for a surface treatment that protects a glass ionomer cement for at least 1 hour.[3,4] However, protection for 24 hours appears to render the material relative resistance to desintegration.[11] The present study evaluated the effectiveness of surface treatments 24 hours after mixing which is based on this premise.

The data obtained in this study showed that apart the low viscosity nail varnish, the other surface treatments were only partially satisfactory in protecting the glass ionomer cement during initial setting. Shofu and Copalite presented the same degree of effectiveness, which is significantly superior to the other treatments although inferior to nail varnish. The interaction between Vaseline and Copalite as used for silicate cement[7] showed similar results to Copalite alone. Clinically it would be better to cover the restoration with Vaseline immediately after removal of the matrix and after trimming the excess. The Vaseline is wiped off so that only a thin layer covers the filling and the varnish is painted on the surface of the restoration.

The bonding resins tested showed similar protection and it did not matter whether the bonding resin was light-cured or chemically-cured. However, clinically it would be better to use light-cured bonding resin because it enables the removal of excess before curing. Vaseline was the least effective of all the other agents listed above but still provide some protection.

These findings do not vary greatly from those of Earl *et al*[10,12] who quantified by liquid scintillation spectrophotometry the cumulative release of tritium from a surface treated with tritium-labeled glass ionomer cement. According to these authors, the method used which measures outflow, is simple and useful to evaluate the permeability of a cement surface because it is to be expected that water movement in one direction across a barrier is the same as water movement in the opposite direction, hydrostatic and osmotic forces being equal.

The present method of evaluating the effectiveness of surface treatments on glass ionomer cement was chosen because it quantifies dye uptake. As a 0.05% aqueous solution of methylene blue was used, the data obtained represented inflow. Since glass ionomer cement restorations are usually exposed to the oral cavity during the initial setting reaction, aqueous inflow seems to provide a better assessment of surface treatments to glass ionomer cements.

The use of a dye to investigate the surface effect on a glass ionomer cement was reported.[4,9] However, these studies evaluated the intensity or the depth of dye uptake and could not measure dye penetration to its full extent. Since glass ionomer cement specimens were completely dissolved in the present study to determine dye quantity spectrophotometrically, this methodology could be used to provides a much more detailed assessment of dye penetration.

This method to measure dye uptake which has been used for leakage evaluation,[13,14] is simple but has a critical point. If absorbance is recorded more than 48 hours after placement of the specimens in nitric acid, there will be gradual color changes in the methylene blue solution which will interfere with the estimation of dye concentration. This was observed in the pilot study. Nevertheless, such color modifications can be detected even in the very initial stage by determining the coefficient of correlation between dye concentration and absorbance in standard solutions. The coefficient of correlation obtained ($r = 0.998$) supports the reliability of our findings. It is extremely important that the absorbance of the standard and experimental methylene blue solution be determined at the same time interval.

Results of this study showed that nail varnish was the best surface agent to protect the glass ionomer cement during setting since no statistically significant difference was found between this and the negative control group. The good protection provided by nail varnish may be due to its resistance to disintegration, to its hydrophobic nature and to its low permeability. It also has a low viscosity, and may explain the different results obtained by Earl *et al,*[10] who used Cutex nail varnish, that has a greater viscosity.

The efficacy of the other surface agents in preventing dye uptake was limited, but significant. Their application afforded some degree of protection to the setting glass ionomer cement since all the surface treatments tested differed statistically from the positive control group.

No significant difference was found between Shofu and Copalite varnish, in spite of their differences in composition. Even though it was expected that bonding resin would be more effective than varnish, the three bonding resins evaluated in this study did not perform satisfactorily with no statistically significant differences among them. Probably these bonding resins form a high contact angle on the cement and the strength of the union between the resin composite and the glass ionomer cement is related, at least in part, to the contact angle that the bonding resin forms on the cement.[12,17] In spite of no statistically significant difference between chemically- and light-cured bonding resins, the results suggest a poorer performance of the chemically-cured bonding resins since ARM did not differ significantly from Vaseline.

a. Shofu Inc., Kyoto, Japan.
b. Centrix Inc., Shelton, CT, USA.,
c. Johnson & Johnson, New Brunswick, NJ, USA.
d. Kulzer, São Paulo, Brazil.
e. Kerr Mfg. Co., Romulus, MI, USA.
f. Bozzano Ceil, São Paulo, Brazil.
g. Cooley & Cooley, Houston, TX, USA.
h. Micronal, S.A., São Paulo, SP, Brazil.

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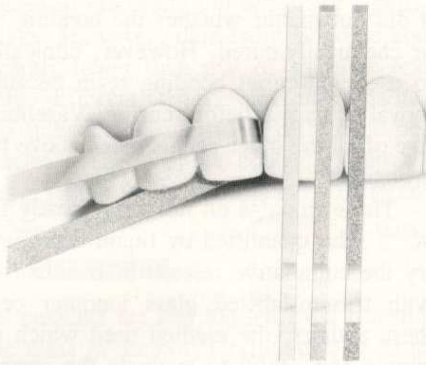

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