Bond Strength of Light Activated Glass Ionomer With Different Conditioners on Human Dentin.

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Abstract- Light cured glass ionomer cements offer improved handling characteristics. Photocuring within the cavity preparation may assist in decreasing the moisture contamination and dehydration difficulties associated with the early stage of setting reaction. The success of restoration depends on good adhesion between glass ionomer cement and the tooth structure. Various dentin conditioners have been advised to increase the bond strength of glass ionomer cement to dentin. The purpose of this in-vitro study was to evaluate the influence of three dentin conditioners on shear strength of light activated glass ionomer cement.

Keyword : Shear bond strength, Light activated glass ionomer,10% polyacrylic acid, 10% maleic acid, 5.25% NaOCl, Smear layer, Dentin

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INTRODUCTION

Bonded restorations have a significant importance in present day restorative dentistry. Since they are claimed to be truly adhesive to the tooth structure, they considerably reduce removal of tooth structure and also eliminate micro leakage thus minimizing discolorations, post-operative sensitivity and risk of secondary caries formation. Complete bonding of a restorative material to tooth structure is therefore of the greatest significance which directly influences the clinical success. Shear bond strength assumes much importance for restorative materials clinically, because of the fact that the major dislodging forces at the tooth restoration interface have the shearing effect. Hence high shear bond strength of a restorative material implies better bonding of that material to the tooth. The advantages of hybrid material or light activated or resin modified glass ionomer over conventional glass ionomer cements are controlled working time, less sensitivity to moisture, higher fracture resistance and fatigue resistance, lower solubility and better esthetics. [1] Resin modified glass ionomer cements are water hardening cements, where resin components are added to the conventional glass ionomer cements and part of the water component is replaced by a water/hydroxyethyl methacrylate (HEMA) mixture. Its structure is that of a methacrylate, but it contains a hydroxyl group that makes it water soluble. These formulations are suitable water soluble initiators/activators for the polymerization of HEMA.

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Two types of setting reactions take place in a light cured glass ionomer: (a) The acid-base reaction between the fluoroaluminosilicate glass and the polycarboxylic acid i.e. Calcium aluminosilicate glass (base) + poly (acrylic acid) = calcium and aluminium polysalt hydrogel as in a conventional glass ionomer cement. (b) A light–activated free radical polymerization of methacrylate 4 groups of the polymer and HEMA (2-Hydroxyethylmethacrlate) i.e. HEMA + photo-chemical initiator/activator =polyHEMA matrix. [2] It is presumed that the ionic reaction of resin-modified glass ionomer cement with the tooth surface is inferior as compared to conventional glass ionomer cement. However, it can be markedly improved by treating the tooth surface with an acid conditioner [3]. McLean and Wilson first used the term surface conditioning for pretreatment in order to differentiate it from acid etching. Surface conditioning is done to eliminate the wide variation found in the structures of the tooth surfaces following cutting. The need for surface treatment, however, is still controversial.

Whenever a tooth is prepared with a bur or other instrument, residual organic and inorganic components form a smear layer of debris on the surface. [4] The smear layer has been defined as "any debris, calcific in nature produced by manipulation of dentin, enamel or cementum". [5] The smear layer fills the orifices of dentin tubules forming smear plugs and decreases dentin permeability by up to 86%. The composition of smear layer is basically hydroxyapatite and altered denatured collagen. The approximate thickness of the smear layer varies from 0.5 to 5 micron. Smear layer are usually contaminated with microorganisms and should be removed before resin bonding.[6] Bonding to the smear layer can only facilitate bond strength to tooth structure that depends on the attachment of the smear layer to the solid dentin and by the smear plugs pressed into the dentinal tubules. This approach of bonding to dentin by using the smear layer as a substrate resulted in low bond strength values.[7] Therefore to improve the contact between dentin and restorative material, the smear layer has to be at least partly dissolved and incorporated into adhesive layer or has to be removed totally. Both approaches can be achieved by using weak mineral etchants and milder organic acids such as Nitric acid (2.5 %), Citric acid (10%), Maleic acid (10%), Pyruvic acid (10%), Polyacrylic acid (20%), Ferric chloride, Aluminum chloride and Oxalic acid (1.5 to 3.5%) have been suggested. However, there is no compelling clinical evidence to verify that dentinal pretreatment enhances the adhesion, and improves shear bond strength of light activated glass ionomer cement. The current in vitro study evaluated the influence of three dentin conditioners on shear bond strength of

light activated glass ionomer cement·

METHODOLOGY

Sixty single rooted, non-carious, human mandibular premolar teeth were collected for this in vitro study. The teeth were extracted for orthodontic reasons with the approval of the Institutional Review Board of The Oxford Dental College, Hospital & Research Centre (Rajiv Gandhi University Of Health Sciences). The teeth were thoroughly cleaned for debris and were stored in distilled water containing thymol crystals as a disinfectant, until used. The teeth were removed from the thymol solution and stored in distilled water for at least 24 hours before use. The resin modified glass ionomer cement used for the study was Vitremer (3M ESPE). During the whole experimentation the glass ionomer cements were light cured with a LED unit, Ortholux (3M Unitek, India). The cordless unit was maintained at full charge at all times before use. The teeth were mounted in phenolic rings of 1 inch diameter with cold cure acrylic resin and the occlusal surfaces were ground flat using a diamond disc at low speed to expose the dentin. The specimens were randomly divided into four groups of fifteen specimens each. Each group then received a different surface treatment as follows.

Group A: Untreated dentin.
Group B: 10 % of Polyacrylic acid.
Group C: 10 % of Maleic acid.
Group D: 5.25 % of Sodium hypochlorite.

Except for group A, the surface conditioners for all different groups were applied with a disposable micro brush on the cut dentin surfaces and left undisturbed for a period of 20 seconds. The surface conditioners were then rinsed with distilled water for a period of 30 seconds using a three way syringe. The excess water was removed by blotting a tissue paper, leaving the tooth surface visibly moist. Vitremer primer was applied with a disposable micro brush to the unconditioned and conditioned dentin surfaces of all the groups for a period of 30 seconds. The surfaces were then dried for 15 seconds with compressed air and light cured for 20 seconds. Vitremer shade A3 was mixed according to manufacture's instructions and loaded into a centrix syringe. The material was injected and condensed into a plastic cylinder of 4mm internal diameter and 3mm height. The cylinder was applied to dentin and a mylar strip was placed on top of the mold. A glass slide was pressed against the mylar strip on top to remove the excess cement and to form a flat surface. The material was then light cured for a period of 40 seconds vertically and also cured for 10 seconds horizontally at 90^0 angles to ensure complete polymerization of the material. For all the specimens, the curing tip was placed as closely as possible to the glass ionomer and dentin surface.
All the specimens were stored in distilled water at 37^oC for a period of seven days in an incubator (Bod).The testing assemblies were then mounted in a test jig for determination of shear bond strength using an Instron Universal Testing Machine, (Model 1011 3M Corporation). An orthodontic edge wire loop of 18 gauges was used to deliver the shearing force. The use of jig enabled a load to be applied parallel to the dentin surface at the restorative-dentin interface. The bonded glass ionomer cylinders were placed under continuous loading at a crosshead speed of 1mm/min at a load cell of 500 kg until it fractured. The fracture loads (1N) were converted to shear bond strength (Mpa) based on the internal cross-sectional area of the hollow cylinders.

Calculation:
1Mpa=1N/mm^2, 1N – Fracture load.
mm^2 - πr^2 (22/7x2x2) = 12.57 mm^2
The data so obtained were analyzed using the statistical software program and significance determined.

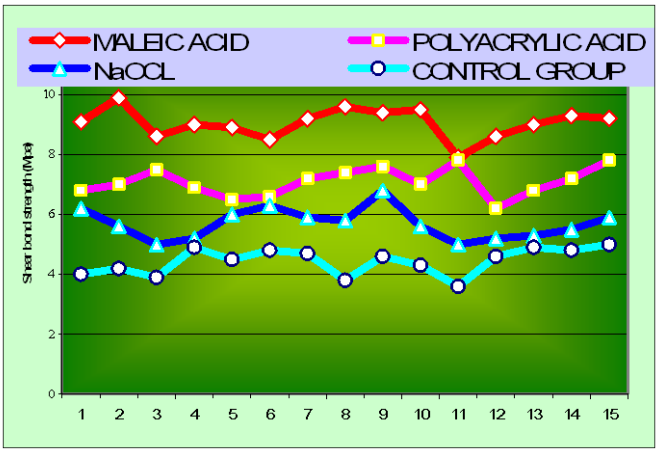
RESULTS

The location of failure for all the specimens was at glass ionomer/dentin interface. Mean and standard deviations of shear bond strength for each Group is shown in table 1 and Graph 1.

Groups	Shear bond strength (Mpa)		
	Range	Mean ± SD	95%CI
Group A (N=15)	3.60-5.00	4.44 ± 0.45^d	4.19-4.69
Group B (N=15)	6.20-7.80	7.09 ± 0.47^b	6.82-7.35
Group C (N=15)	7.90-9.90	9.05 ± 0.50^a	8.77-9.32
Group D (N=15)	5.00-6.80	5.69 ± 0.51^c	5.40-5.97
Significance	F=249.166, P<0.001		

Table 1
Comparison of three dentin conditioners with control for shear bond strength

Non-identical superscripts are significant at 5% level of significance



Graph 1
Graph showing the line plot of individual samples

The highest mean shear bond strength was in group C, followed by Group B, Group D, and Group A. There was statistically significant difference in the bond strength shown between all the groups.

DISCUSSION

The bonding of the restorative materials to the tooth structure is of great significance and is often the most important factor in controlling clinical success. A good marginal adaptation of the restorative materials to the prepared or lost tooth structure is essential to prevent microleakage with recurrent caries. The various acid conditioners used on the cavity walls aim to improve the interaction between the dentin and the restorative material, thus minimizing microleakage and increasing the bond strength of the light cured glass ionomer to the tooth surface. Preparation of the dentin surface with a strong acid such as phosphoric acid weakens the surface adhesives; therefore polyacrylic acid, citric acid and tannic acid are used for this propose. The bond strength of a resin-modified glass-ionomer cement increases because its tensile strength improves with the treatment.[3] The bonding of resin to smear layer yielded low bond strengths because the bonding between the smear layer and the underlying dentin was weak.[8] The use of different treatments on dentin surfaces causes different effects on smear layer, from total removal to partial removal. These effects help the physicochemical interaction between some adhesive systems and the tooth, providing satisfactory restorative material and tooth interaction. Since the purpose of the study was to evaluate only the effect of various surface treatments on the dentin surface, 10% polyacrylic acid, 10% maleic acid, and 5.25% of NaOCl solutions were applied on to the dentin before the primer was used. It was found that the surface pretreatment with maleic acid when compared to other conditioners showed improved bond strength between the resin modified glass ionomer and the dentin surface. In the Vitremer tri-cure glass ionomer system the acidic, low viscosity polymer of the primer modifies and wets the tooth structure so as to provide a constant surface which is ideally receptive to the glass ionomer mix. The primer has strong inherent attraction for dentin and enamel surfaces. Photocuring the primer cross links the methacrylate groups of the polymer. Once the Vitremer mix is placed on the primer, the polyacid of the primer reacts with fluoroaluminosilicate glass of the ionomer mix. The primer thus becomes a part of the overall glass ionomer restoration. [9]

GROUP A: (CONTROL GROUP).

As shown from the table 1, the mean shear bond strength of this group is 4.44 ± 0.45 where the dentin is unconditioned and showed significantly lower value when compared to conditioned group. This suggests that the removal of the dentinal smear layer prior to the placement of resin modified glass ionomer material enhances the shear bond strength of the material to dentin.

GROUP B: (10% POLYACRYLIC ACID).

The mean bond strength value obtained for this group is 7.09 ± 0.47, which is statistically significant as compared to control group and group D. Study by Friedl showed that dentin pretreatment with polyacrylic acid removes the smear layer, demineralizes the dentin and makes HEMA penetrate the exposed collagen network.[10] Satoshi Inoue and colleagues have shown that polyacrylic acid significantly improved the shear bond strength. This indicates that removal of smear layer on intertubular dentin resulted in effective hybridization, [11] thus improving the bond strength. On the other hand, the shear bond was less when compared to group C, since polyacrylic acid removes the smear layer and reveals the cut dentinal tubules without opening the tubules.

GROUP C (10% MALEIC ACID)

The mean bond strength values of this group is 9.05 ± 0.50, which showed superior bond strength when compared to all other groups. Bertolotti (1992) and Gwinnett (1994) showed that maleic acid removed the smear layer, but not smear plugs and the acid did not demineralize dentin in its depth. Adding maleic acid can provide an alteration of the tissue of approximately 1mm when applied for 15seconds. [12], [13].
Although maleic acid is quite acidic (pH-1.47 in 0.1M solution) it does not decalcify deeper dentin leaving a thin hybrid layer. Watson demonstrated improved adaptation of glass ionomer to dentin when conditioned with maleic acid. The increased bond strength using maleic acid could be due to the modification of smear layer without completely eliminating the smear layer. [14]

GROUP D (5.25% of NaOCl).

The mean shear bond strength value of this group was 5.69 ± 0.51, which showed decreased bond strength when compared to group B and group C. Study by Prati C and colleagues have shown that NaOCl applied on the dentin smear layer did not significantly modify their SEM morphology.[15] Oxygen released by NaOCl molecules inhibit adhesive polymerization and hence compromise the mechanical performance of the obtained bonding interfaces [16]. This results in poor bond strength values as compared to group B and group C. Since smear layer contains organic material, NaOCl a well-known proteolytic agent has a capacity to dissolve organic material. This would have resulted in partial dissolution of the smear layer, resulting in slight increase in bond strength when compared to the control group. Powis and colleagues reported that the most effective surface conditioners to improve the adhesion of glass ionomer cement were high molecular weight substances containing a multiplicity of functional groups capable of hydrogen bonding, such as polyacrylic acid and reported that low molecular weight chelating agent, such as citric acid that dissolve calciferous material and dramatically alter the surface were less effective. [17]

CONCLUSION

The advantages of light activated glass ionomer cement over conventional glass ionomer are good esthetics, good working time with a command over set, rapid early development of strength, and resistance to aqueous attack. Dentin conditioning with 10% maleic acid for a period of 20 seconds prior to the application of adhesive resin increased the shear bond strength at the dentin – restorative interface.

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