Assessment of shear bond strength of glass ionomer cement reinforced by different amounts of Hydroxyapatite

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Summary:

Background: This study was done to assist bond strength of glass ionomer cement reinforced by different amount of Hydroxyapatite

Materials and methods: In this study a hydroxyapatite materials were added to glass ionomer cement at different ratios; 10%, 15%, 20%, 25% and 30% (by weight) and the bond strength was detected by construction a cylinders from these mixed materials, constructed on exposed dentine of human extracted premolar teeth and by Zwick's universal testing machine the bond strength were detected for these mixed materials.

Results: Results showed that the glass ionomer cement reinforced by hydroxyapatite has higher bond strength than conventional glass ionomer cement and the hydroyapatite powder to glass ionomer cement powder ratio by weight best to be 25%.

Conclusion: The addition of hydroxyapatite to conventional glass ionomer cement increased its bond strength to dentine.

Key words: Shear bond, glass ionomer, hydroxyapatite.

Fac Med Baghdad 2009; Vol. 51, No. 2
Received Sep.2008
Accepted Jan.2009

Introduction:

Continuous development of new materials provides a wide range of biomaterials appropriate to various clinical conditions in dentistry. Despite all the improvements, there is still a need for a biomaterial which possesses high biocompatibility, antimicrobial effects and good mechanical properties. (1) The glass ionomer cement considerd to be a remarkable esthetic restorative material. These materials are a hybride of polycarboxylate and silicate cements which permit the excellent properties of each of these materials. (2,3) This material can be used as filling, lining, luting or as core build up material.(4)The glass ionomer cement has a good biocompatibility and ability to adhere to both enamel and dentin, also known to inhibit demineralization and may even rematerialize adjacent tooth structure. However, it has certain demerits, mainly, a low resistance to wear, low tensile and compression strengths, and an early susceptibility to moisture contamination.(5,6) in 1977 , the first step taken in an attempt to strengthen the glass ionomer material by the addition of a metal alloy to improve the strength, fracture toughness, resistance to wear and provided radiopacity.(7) Recently glass ionomer cement reinforced by hydroxyapatite, by addition different ratios may improve the physical and mechanical properties of the glass ionomer cement. Therefore the present study has been undertaken to evaluate and assess the bond strength of glass ionomer cement reiforeced by hydroxyapatite.

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Materials and Methods:

Sample grouping:

Six groups were used in this study (15 samples for each group) as shown in Table (1):

Table (1): The control and experimental groups of the glass ionomer cement and glass ionomer cement reinforced by different amount of Hydroxyapatite

Group I (Control)	glass ionomer cement *
Group II (Experimental)	glass ionomer cement reinforced by 10% of Hydroxyapatite
GroupIII (Experimental)	glass ionomer cement reinforced by 15% of Hydroxyapatite
Group IV (Experimental)	glass ionomer cement reinforced by 20% of Hydroxyapatite
Group V (Experimental)	glass ionomer cement reinforced by 25% of Hydroxyapatite
Group VI (Experimental)	glass ionomer cement reinforced by 30% of Hydroxyapatite

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Addition of hydroxyapatite to glass ionomer cement:

The addition of hydroxyapatite to glass ionomer cement was employed in 10%, 15%,20%,25% and 30% by weight (for example: each 10 mg of hydroxyapatite was mixed with 90 mg of glass ionomer cement to get glass ionomer cement reinforced by 10% of Hydroxyapatite).The weight of elements were measured by using electronic balance and admix in period about 30 minutes to get homogenous mixtures.

Selection of the samples:

Ninety (90) sound human upper first premolar teeth recently extracted for orthodontic purpose were selected**.** The patient age range from (13-20) years of comparable size and shape.

The teeth were examined using magnifying lens (X10) and by transillumination light to identify any crack, so as if present such teeth were excluded from the samples, the teeth were cleaned from debris by using slurry of pumice in a rubber cup with low speed hand piece and then washed with distilled water.

Construction of acrylic blocks:

The roots of the teeth were notched on the proximal surfaces for anchorage using diamond bur in a high speed hand piece with distilled water spry. Then each tooth was embedded in the acrylic mould by using matrix of rubber base to get standardized blocks and then the embedded tooth was sectioned horizontally at the junction of the occlusal and middle thirds exposing dentine surface and it was wet polished with 600 grit silicon carbide abrasive papers.

Shear bond strength test to dentine:

The powder and liquid of glass ionomer cement and glass ionomer reinforced by different amount of hydroxyapatite (10%, 15%,20%,25% and 30% by weight) were mixed on the cement slab then applied on the exposed dentine at surface area with diameter of 4 mm by using clear plastic tubes that was held on exposed dentine surface vertically by using specially designed toot for standardization of application of the materials, and then the samples were stored for twenty four hours after initial setting in water bath to ensure complete setting of the materials. The shear bond strength were determined by using a Zwick universal testing machine, with across head speed of 0.5 mm/mim and astainless steel chisel-shaped rod was used. The specimen was clamped in a fixed base so that the cylinder project parallel to the horizontal floor, the long axis of the chisel-shaped rod was parallel to the flat prepared bonding site and perpendicular to the long axis of the restoration cylinder. The vertical force transferred to a knife edge, which was applied approximately at the interface producing shearing stresses. The speciemens were loaded until they fractured. The force was recorded in Newten which has been divided by the surface area of adhesion to obtain the shear bond strength calculated in Mpa , then the data of all groups were collected and statistical analysis was employed by using descriptive statistic and inferential statistic (ANOVA test and LSD test).

Results:

The result showed (Table 2 and figure 1) that the group V has the highest shear bond strength to dentine while the group I has the lowest bond strength to dentine.

Table 2: Means and standard deviations of bond strength to dentine (MP) of all groups.

Groups	Mean (MP)	± SD
I	1.777	0.176
II	1.913	0.134
III	2.123	0.126
IV	2.168	0.179
V	3.750	0.11
VI	2.408	0.219

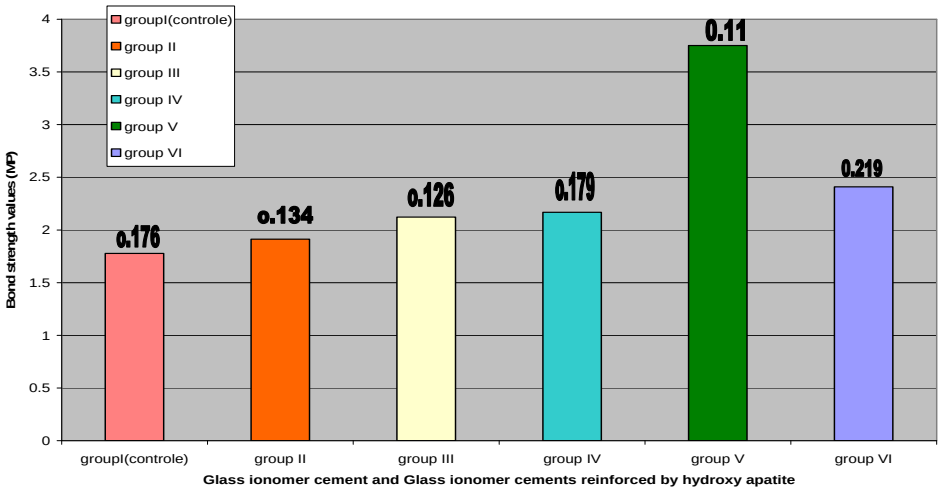

Figure 1: Bond strength (MP) of Glass ionomer cement and Glass ionomer cements reinforced by different percentages of Hydroxyapatite(10%,15%,20%,25% and 30%) to dentine.

One way ANOVA test (Table 3) showed that there was a statistically highly significant difference among all groups at the P value less than 0.01.

LSD statistical test was applied to compare between each paired groups (Table4) it showed that there was statistical significant difference between most compared paired groups except when we compare group III with group IV the result showed that there was no statistical significant difference at level P less than 0.05.

Table (3): ANOVA test of the all tested groups:

Source	S.S	df	M.S	F	P(value)
Between groups	38.512	5	7.702	295.581	P<0.01
Total	40.700	89			

d.f. = degree of freedom
P-value = probability
S.S= Sum of squre
M.S=Mean square

Table (4): LSD statistical test to compare between the groups

Statistic		
Comparison (I)group X (J)group	Correlation (I-J)	Sig.
I x II	-0.137*	0.023
I x III	-0.347*	0.000
I x IV	-0.392*	0.000
I x V	-1.974*	0.000
I x VI	-0.631*	0.000
II x III	-0.210*	0.001
II x IV	-0.255*	0.000
II x V	-1.837*	0.000
II x VI	-0.494*	0.000
III x IV	-0.045	0.445
III x V	-1.627*	0.000
III x VI	-0.285*	0.000
IV x V	-1.582*	0.000
IV x VI	-0.240*	0.000
V x VI	1.342*	0.000

* The mean difference is significant at the 0.05 level.

Discussion:

By bonding a restorative material to tooth structure, the cavity is theoretically sealed, protecting the pulp, eliminating secondary caries and preventing leakage at the margins. This also allows cavity forms to be more conservative and to some extent, reinforces the remaining tooth by integrating restorative material with the tooth.(8) One of the most characteristics of glass ionomer cement is their ability to adhere physicochemical to mineralized tissues. Glass ionomer cement are still considered the only material that self adheres to tooth tissue,its mechanism of adhesion may also be based on a combined micromechanical and chemical interaction.(9,10)but the shear bond strength is relatively low.(8,11) It was evident from the results that the addition of hydroxyapatite to glass ionomer cement caused increase in bond strength to dentine and the fractures in the glass ionomer cement reinforced by hydroxyapattite is adhesive fracture not like that of conventional glass ionomer cement in which the fracture is cohesive fracture, which was detected in this study by using stereomicroscope, this may be due to change in the mechanism of adhesion to tooth structure. In conventional glass ionomer cement the setting reaction is an acid base reaction between the acidic poly-electrdyte and aluminosilicate glass (7). When the powder and liquid are mixed to form a paste, the surface of the glass particles attacked by the acid. Calcium, aluminum, sodium and fluoride ions are leached into the aqueous medium. The poly acrylic acid chains are cross-linked by the calcium ions and form a solid mass within the next 24 hours, a new phase forms in which aluminum ions become bound within the cement matrix. Sodium and fluoride ions do not participate in the cross linking of the cement. The un reacted portion of glass particles are sheathed by silica gel that develops during removal of the cations from the surface of the particles. Thus, the set cement consists of an agglomeration of un reacted powder particles surrounded by a silica gel in an amorphous matrix of hydrate calcium and aluminum polysalts.(10) while the reaction of glass ionomer cement with hydroxyapatite of the tooth structure to get adhesion is initiated by the polyalkenoic acid. When freshly mixed material contacts the tooth surface. Phosphate ions are displaced from hydroxyapatite by carboxyl group, each phosphate ion taking a calcium ion with it to retain electrical neutrality. Therefore, it appears that chemical bonding is achieved by a calcium phosphate-polyalkenoate crystalline structure acting as an interface between dentine and a set material. (7,8,9,10,12) but with the glass ionomer cement reinforced by hydroxyapattite the chemical bonding is may be achieved by a calcium phosphate-polyalkenoate crystalline structure acting within glass ionomer cement and between hydroxyapatite of dentine and glass ionomer cement. Thus, the reaction between glass ionomer cement and added hydroxyapatite may be the same chemical reactions happen within glass ionomer cement and with hydroxyapatite of the tooth structure.

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