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Assessment of shear bond strength of Polycarboxylate cement reinforced by different amounts of Hydroxyapatite

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Abstract

This study was done to assess bond strength of Polycarboxylate cement reinforced by different amount of Hydroxyapatite. In this study a hydroxyapatite materials were added to Polycarboxylate 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 showed that the Polycarboxylate reinforced by hydroxyapatite has higher bond strength than conventional Polycarboxylate cement and the hydroxyapatite powder to Polycarboxylate cement powder ratio by weight best to be 20%. The addition of hydroxyapatite to conventional Polycarboxylate cement increased its bond strength to dentine.

Key words: Shear bond, Polycarboxylate, hydroxyapatite.

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 practical development of an adhesive system as a dental cement was outlined only as recently as 1968 by Dr. Smith of the Turner Dental School, Manchester. This new cement was claimed to feature the compressive strength of the zinc phosphate materials. A claim was made for adhesion both to enamel and dentine, with the suggestion of reduced marginal leakage, and the material was also envisaged as a cavity sealing agent and as an anti-cariogenic coating for enamel, additionally, it was clear that the material adhered to metals or alloys which featured a stable oxide layer on the surface (e.g. stainless steel). (2,3) The bonding of polyacrylates with tooth material is mainly with the inorganic components, i.e. the calcium substrates and presumably with hydroxyapatite $Ca_5(PO_4)_3OH$ as an important contributor.(4)

A difficulty with this systems was the tendency for the cement liquid to set on standing, and particularly at low temperature which made incorporation of the powder difficult, if not impossible. This has been overcome by the copolymerization of other carboxylic acid monomers (particularly itaconic acid) with the

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acrylic acid to yield a satirically more irregular polymer, or by the freeze-drying of such solutions to yield a solid which is incorporated into the cement powder. These latter materials may be termed hydraulic cements which set through the addition of distilled water or a salt solution.[4,5] Recently Polycarboxylate cement reinforced by hydroxyapatite, by addition different ratios may improve the physical and mechanical properties of the Polycarboxylate cement. Therefore the present study has been undertaken to evaluate and assess the bond strength of Polycarboxylate cement reinforced by hydroxyapatite.

Materials and Methods

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 cleaned from debris by using slurry of pumice in a rubber cup with low speed hand piece and then washed with distilled water. 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,

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 paper .

Addition of hydroxyapatite to Polycarboxylate cement:

The addition of hydroxyapatite to Polycarboxylate 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 Polycarboxylate cement to get Polycarboxylate cement reinforced by 10% of Hydroxyapatite).The weight of elements were measured by using electronic balance and admix in period 30 minutes to get homogenous mixtures.

Sample grouping:

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

Shear bond strength test to dentine:

The powder and liquid of Polycarboxylate cement and Polycarboxylate 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 with 2mm in length 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/min and a stainless 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 specimens were loaded until they fractured. in this study the fracture site was examined to see the type of fracture whether adhesive or cohesive fracture by using stereomicroscope, The force was recorded in Newton 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 IV has the highest shear bond strength to dentine while the group I has the lowest bond strength 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 (Table 4) it showed that there was statistical significant difference between most compared paired groups except when we compare group I with group III, group III with group IV and group V with group VI their result showed that there was no statistical significant difference at level P less than 0.05.

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.[6] One of the most characteristics of Polycarboxylate cement is their ability to adhere physicochemically to mineralized tissues. The Polycarboxylate cement based on an acid-base reaction between ZnO (with admixed MgO) and an aqueous solution of polyacrylic acid (PAA). The monomer acrylic acid is polymerized in aqueous solution, with subsequent vacuum distillation, to yield the desired concentration of polymer (about 30-40%). The setting mechanism may be viewed as an acid base reaction to give some what elastomeric matrix of zinc polyacrylate binding together with the unreacted ZnO.[5]

Polyacrylic acid strongly bonds to hydroxypatite thus suggesting a bond with enamel and dentine. It was evident from the results that the addition of hydroxyapatite to Polycarboxylate cement caused increase in bond strength to dentine and the fractures in Polycarboxylate cement reinforced by hydroxyapattite is adhesive fracture not like that of conventional Polycarboxylate 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 and may be related to chemical adhesion of the zinc polycarboxylate to dentine by carboxyl groups to form a complex with calcium ions of the dentine. [7] This is in agreement with the finding of Christensen 1993[8] who found that both zinc polycarboxylate cement and glass ionomer have chemical bond to the tooth surface through the hydroxyl group and also coincide with the results of Kocadereli et al. 1995[9] they

showed that the zinc polycarboxylate and the glass ionomer cements have ability to bond to enamel ,dentine and stainless steel. [9]

References

1- Lasfargues N, Goldberg M : In vitro study of the pulp reaction to Fuji IX, a glass ionomer cement; J of Dent 2000;28;413-422.

2- Diaz-Arnold A.M.,Vargas M.A.,Haselton D.R.: Current status of luting agent for fixed prostho- dontic. :J.P.Dent. 1999:81;135-141.

3- Smith D.C. :Development of glass-ionomer cement systems biomater.J.Prosth.Dent.1998: 19;467-478.

4- Ray N.,:Dental material science:Text.book. ;2000; 18.

5- Graig R.G. , O'brien W.J., Powers J . M. : Dentalmaterials :properties and manipulation: Sixth ed. Mosby Co.St louis USA.chapter 1,2,3 and 7 ;1996.

6- Mount A.M, Hume W : Preservation and restoration of tooth structure.;1998;Mosby. International Ltd chapter 8,P69.

7- Parkl S.W.,LeeY.K.,Kim2 Y.U., Kim M.C., Kim2 K.N.Cchoil B.J. ,Cchoi H.J,:The effect of hydroxyapatite on the remineralization of dental fissure sealant;Bioceramic17;Key Engineering materials.USA;2004:Volume284-286.

8- Christensen G.J.: Glass – Ionomer resin : A maturing concept ;Journal of the American Dental Association : ;1993 124 (7) ;248-249.

9- Kocadereli., Ciger S.:Retention of orthodontic bands with three different cements.;Journal of clinical Pediatric Dentistry :19(2):127-130;1995.

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

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

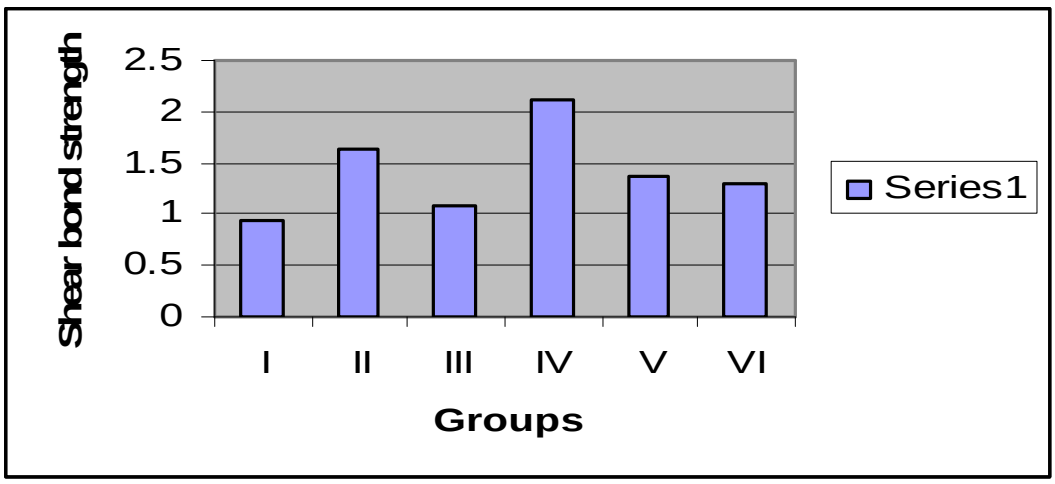

Figure 1 : Bond strength (MPa)of Polycarboxylate cement and Polycarboxylate cements reinforced by different percentages of Hydroxyapatite (10%,15%,20%,25% and 30%) to dentine.

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

Groups	Mean (MP)	± SD
I	0.93	0.257
II	1.64	0.288
III	1.09	0.561
IV	2.11	0.148
V	1.38	0.191
VI	1.29	0.521

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

Source	S.S	df	M.S	F	P(value)
Between groups	13.296	5	2.559	20.479	0.000
Total	24.204	89			

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

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

Statistic		
Comparison (I)group X (J)group	Correlation (I-J)	Sig.
I x II	-0.709*	0.000
I x III	-0.162	0.221
I x IV	-1.178*	0.00
I x V	-0.446*	0.001
I x VI	-0.359*	0.008
II x III	0.547*	0.000
II x IV	-0.469*	0.001
II x V	0.263*	0.049
II x VI	0.35*	0.009
III x IV	-1.016*	0.000
III x V	-0.284*	0.034
III x VI	-0.196	0.139
IV x V	0.732*	0.000
IV x VI	0.82*	0.000
V x VI	0.88	0.508

* The mean difference is significant at the 0.05 level.