Assessment of diametral tensile strength and microhardness of Glass ionomer reinforced by different amounts of Hydroxyapatite

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ABSTRACT

Back ground: Glass ionomer materials lack resistance to wear and pressure and are susceptible to moisture during the initial stages of setting and dehydration. So this study was done to assess diametral tensile strength and microhardness of glass ionomer reinforced by different amounts of hydroxyapatite.

Materials and methods: In this study a hydroxyapatite material was added to glass monomer cement at different ratios: 10%, 15%, 20%, 25% and 30% (by weight). The diametral tensile strength test described by the British standard specification for zinc polycarboxylate cement was used in this study and the microhardness test was performed using Vickers microhardness testing machine and the microhardness values were calculated and statistical comparison was performed on the tested groups.

Results: The group of glass ionomer cement that contains 20% hydroxyapatite has higher diametral tensile strength and microhardness values than other groups of this study. Also the results showed that the group of glass ionomer cement without hydroxyapatite has the lowest values of diametral tensile strength and microhardness than other groups. The groups of glass ionomer cement with 10%, 15%, 25% and 30% hydroxyapatites also showed increasing in diametral tensile strength and microhardness values in comparison with group of glass ionomer cement without hydroxyapatite.

Conclusion: The addition of hydroxyapatite to conventional glass ionomer cement will increase its diametral tensile strength and microhardness.

Key words: Diametral tensile, microhardness, glass ionomer, hydroxyapatite. **(J Bagh Coll Dentistry 2006; 18(3)17-20)**

INTRODUCTION

Glass ionomer cements were developed by Wilson and Kent 1972 [1], since then applications in operative dentistry have steadily increased, however; there are some limitations in their applications due to low early mechanical strength and short working time [2]. Mechanical strength is an important factor that has to be analyzed for clinical success of dental restorations. The diametral tensile test provides a simple method for measurement of the tensile strength of brittle materials like glass monomer cement [3]. The microhardness of the material is defined as the resistance of the material to plastic deformation. In this study microhardness measurements were made with Vickers hardness Tester (VHT). There have been recent modifications that replace part or most of the original formulations with alternative filler particles and/or matrix setting reaction [4]. Therefore, hydroxyapatite materials were added to improve the microhardness of Glass ionomer cement. It is well known that Hydroxyapatite shows high stability, strength and low irritation to tissue but it does not set itself by any chemical reaction, Hydroxyapatite is similar to the host bone crystallity [5, 6]. Glass ionomer reinforced by hydroxyapatite have been newly introduced to undergo some laboratory testing. This study was conducted to investigate the diametral tensile and microhrdness of a new glass ionomer reinforced by hydroxyapatite cement material.

MATERIALS AND METHODS

Preparation of hydroxyapatite

In this study a synthetic hydroxyapatite was prepared by using 250 ml of 0.02 moles of $Ca(AC)_2$ added drop by drop to 150 ml of boiling solution of 0.1 moles of Na_2HPO_4, the PH should be 9 through out the procedure [7, 8].

The prepared hydroxyapatite was added to the powder of glass monomer cement at different weight percentage (10%, 15%, 20%, 25% and 30%) and the mixed powders were shacked for half to one hour to get homogenous powders.

Sample grouping

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

Table 1: The experimental and control groups of the base materials.

Group I (Experimental)	**Glass ionomer without hydroxyapatite**
Group II (Experimental)	**Glass ionomer with 10% hydroxyapatite**
Group III (Experimental)	**Glass ionomer with 15% hydroxyapatite**
Group IV (Experimental)	**Glass ionomer with 20% hydroxyapatite**
Group V (Experimental)	**Glass ionomer with 25% hydroxyapatite**
Group VI (Experimental)	**Glass ionomer with 30% hydroxyapatite**

Diametral tensile strength test

Specimens of glass ionomer cement and glass monomer cement reinforced by hydroxyapatite were prepared as cylinders of 4mm in diameter and 6mm in length which were prepared by using a stainless steel mold and kept in water bath at 37±1 ^{0}C and 90-100% relative humidity for one day. The diametral tensile strength was determined by using compressive strength testing machine at speed of 1mm/minutes. The load was applied in the short axis of the specimens. The diametral tensile strength was measured for each specimen by detecting the force that caused early signs of fracture of the specimens [(9)].

Microhardness test

Six acrylic blocks were prepared with 2.5cm width, 5cm in length and 0.5cm in high, with 15 holes of 4mm in diameter and 2mm in depth (one block for each group), then the glass monomer cement and glass monomer cement reinforced by hydroxyapatite were loaded in holes of acrylic block after mixing and kept in the ambient at 37 ^{0}C for 24 hours. The Vickers microhardness testing machine was used to measure the microhardness values of the experimental and control groups [(8)].

RESULTS

Diametral tensile test

The results of the diametral tensile test are presented in Figure (1) showing that group IV has the highest values of the diametral tensile test while group I have the lowest values. The results of other groups II, III, V and VI also showed increasing in the diametral tensile strength with different levels.

One way ANOVA test for the all tested groups showed that there was statistically significant difference among the groups (Table 2), while LSD statistical test to compare between each paired tested groups (Table 3) showed that there was statistical significant difference between most compared paired groups except when we compare the group I with group II showed there was no statistical significant difference at P value less than 0.05.

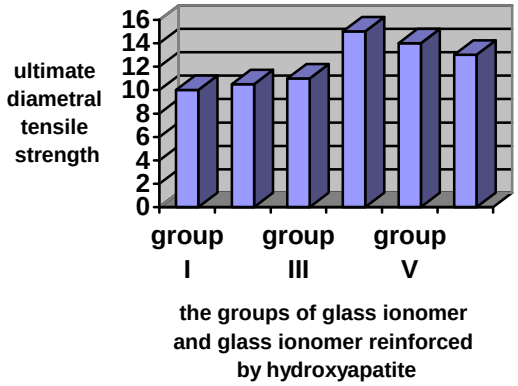

Figure 1: Diametral tensile strength of all tested groups.

Table 2: ANOVA test of the diametral tensile strengths of the tested groups.

Source	Sumof square	df	Mean square	F	Sig.
Between groups	**420.297**	**5**	**84.059**	**153.174**	**P< 0.01**
Within groups	**46.098**	**84**	**0.549**		
Total	**466.395**	**89**			

DF = degree of freedom , P-value = probability

Table 3: LSD statistical test to compare between the tested groups.

Comparison groups (I) group X (J) group	Mean difference (I-J)	Sig.
I X II	-0.515	0.06
I X III	-1.558 *	0.00
I X IV	- 6.067 *	0.00
I X V	- 4.477 *	0.00
I X VI	- 3.131 *	0.00
II X III	- 1.043 *	0.00
II X IV	- 5.553 *	0.00
II X V	- 3.963 *	0.00
II X VI	- 2.617 *	0.00
III X IV	- 4.509 *	0.00
III X V	- 2.919 *	0.00
III X VI	- 1.573 *	0.00
IV X V	1.590 *	0.00
IV X VI	2.936 *	0.00
V X VI	- 1.346 *	0.00

*** The mean difference is significant at the 0.05 level**

Microhardness test

The results are presented in Figure 2 showing that the group IV and group V have the highest values of the microhardness test while the group I has the lowest mean values for microhardness test.

One-way ANOVA test (Table 4) showed that there was statistically significant difference among all tested groups while LSD statistical test to compare between each paired groups (Table 5) showed that there was statistical significant difference between most compared paired groups except when we compare the group II with group VI and group IV with group V showed that there was no statistical significant difference at the level P less than 0.05.

DISCUSSION

Glass ionomer cements have some limitations in their applications due to low early mechanical strength and short working time, glass ionomer cements have also shown moisture sensitivity especially during the initial stages of the setting reaction [10]. To overcome these problem, hydroxyapatite in different amounts were added to the powder of the conventional glass ionomer to improve these properties.

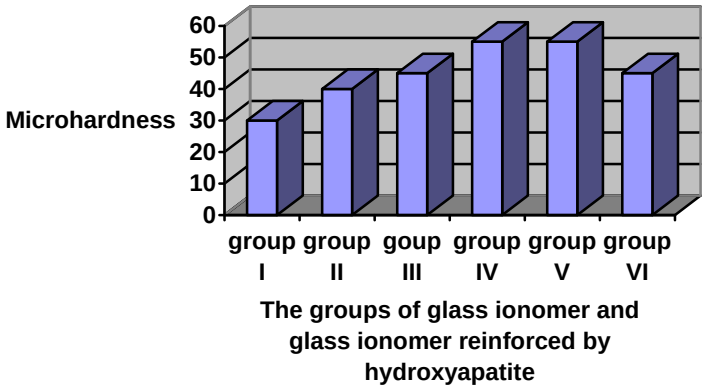

Figure 2: The difference between the mean values of microhardness (HV Kg/ mm^2) of the base materials.

Table 4: ANOVA test of the microhardness (HV) of the all tested groups.

Source	Sum of square	Df	Mean square	F	Sig.
Between groups	5493.898	5	1098.780	45.066	P< 0.01
Within groups	2048.029	84	24.381		
Total	7541.927	89			

\DF = degree of freedom , P-value = probability

Table 5: LSD statistical test to compare between the groups.

Comparison groups (I)X (J)	Mean difference (I-J)	Sig.
I X II	-10.11 *	0.000
I X III	-14.98 *	0.000
I X IV	-22.37 *	0.000
I X V	- 22.37 *	0.000
I X VI	- 9.87 *	0.000
II X III	- 4.87 *	0.008
II X IV	- 12.26 *	0.000
II X V	- 12.26 *	0.000
II X VI	- 0.237 *	0.896
III X IV	- 7.40 *	0.000
III X V	- 7.40 *	0.000
III X VI	- 5.10 *	0.006
IV X V	000 *	1.000
IV X VI	12.50 *	0.000
V X VI	12.50 *	0.000

*** The mean difference is significant at the 0.05 level.**

According to diametral tensile strength

The diametral tensile test provides a simple method for measurement of the tensile strength of brittle material like glass monomer [(11)]. All the tested groups presented an increase in diametral tensile strength except the group I (glass ionomer without hydroxyapatite); this increase can be explained by setting reaction of glass ionomer. Calcium polyacryla2GFte may be formed in the first 5-7 minutes after mixing. The diametral tensile strength in the group IV has the highest values but in the group I the results showed the lowest values. These results might be due to admix of hydroxyapatite to the glass monomer leading to formation of chemical reaction between polycarboxylic acid and hydroxyapatite forming strong chemical bonds.

According to microhardness

Within the limits of this investigation, the data showed that the highest values of microhardness in group IV while the lowest value in group I without hydroxyapatite. The other groups II, III, V and VI also showed increase in microhardness but with different levels in comparison to group IV. This might be due to powder /liquid ratio differences and also particle size of the powder. According to Kent and Wilson [(1)], fine grained glasses produce stronger cement. It is claimed that finer the powder particle, shorter the working time and faster setting time. This may be responsible for better surface finish and hardness.

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