Effect of Incorporation of Hydroxyapatite on Hardness of Resin Modified Glass Ionomer Cement

Hafiz Mahmood Azam[1], Zahid Iqbal[2]

ABSTRACT

OBJECTIVE: To determine the effect of incorporation of Hydroxyappatite on hardness of resin modified glass ionomer cement
STUDY DESIGN: In vitro comparative study
PLACE AND DURATION: Department of Science of Dental Materials Isra University Hyderabad and Pakistan Council of Scientific and Industrial Research laboratories (PCSIR) from 1st July 2013 to 31st January 2014.
METHODOLOGY: Resin Modified Glassionomer (Vitremer) 3M™ ESPE™ was used as control group and Hydroxyappatite (sigma Alderich) material was incorporated to Resin modified glass ionomer cement at different ratios: 3%, 5%, 7%, 8% and 9% (by weight) and were used as test group. Samples for hardness was made in disc shaped stainless steel molds with uniform size of 3 mm diameter and 6 mm in length. All samples were polymerized using LED light source for 25 seconds. The micro hardness values were measured by using the Vickers micro hardness testing machine.
RESULTS: The hardness of 3% hydroxyapatite + RMGIC was found to be 40.20 ± 0.22 VHN, 5% hydroxyapatite + RMGIC 41.31 ± 0.52 VHN, 7% hydroxyapatite + RMGIC 42.32 ± 0.34 VHN, 8% hydroxyapatite + RMGIC 28.11 ± 0.24 VHN and 9% hydroxyapatite + RMGIC 44.13 ± 0.50 VHN. By two way ANOVA a significant main effect of independent variable test groups [cement material comprising of hydroxyapatite and Resin Modified Glass Ionomer cement (RMGIC)] (3%, 5%, 7%, 8% and 9% of hydroxyapatite + RMGIC) and the control group resin modified glass ionomer cement (RMGIC) on dependent variable hardness of control group was found, F (80.38 with 0 and 4 degrees of freedom.
CONCLUSION: There is statistically significant difference of hardness between resin modified glassionomer and resin modified glassionomer incorporated with hydroxyapatite with different percentages.

KEY WORDS: Resin modified glassionomer, Hydroxyappatite, Hardness, Vickers micro hardness test

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INTRODUCTION

Various filling materials have been used in dentistry in order to treat cavity and to repair broken and cracked teeth. Usually teeth are filled with silver amalgam, gold, porcelain and plastic materials.[1] However, today glass materials, composite resin fillings, are also widely used in dental fillings, which is due to their effective and quick results.[2]

The use of dental filling materials can be traced back to the 18th century, when lead was first used as filling material. As lead is soft material, it soon became unpopular in the 19th century. At that time lead poisoning was not understood in dentistry. Moreover, aluminum, gold, tin, platinum and silver was later used for the purpose of dental filling. As the field of dentistry evolved, new dental restoration materials were introduced to the field.[3] Therefore, glassionomer cements emerge as that advancement in the field, which has many clinical advantages. Such advantages include fluoride release, similarity of the coefficient of thermal expansion, elastic modulus similar to that of tooth structure; ability of chemical bonding to calcified enamel and dentin, biocompatibility and easing of handling.[4] However glass ionomer cement has several disadvantages such as brittleness and moisture sensitivity.[5]

A number of approach have been investigated to improve physical properties of Glassionomer cement, in this aspect resin modified glassionomer cement were developed to replace conventional Glassionomer cement .According to researcher [6] these materials generally have dominant acid-base reaction and additional photo polymerization during chemical setting of resin modified glassionomer. Resin modified glassionomer cement are polymerized immediately after visible light irradiation due to addition of hydrophilic resin monomers (2-hydroxyethylmethacrylate (HEMA)), about 4.5 wt. %, and a photo-initiator.[4] Resin modified glassionomer cement have a longer working time, a rapid set, improved esthetic appearance and translucency, and higher early strength.[7] Due to the resin

1. Assistant Professor of Dental Material
Bhitai Dental College Mirpurkhas, Pakistan
2. Associate Professor of Operative Dentistry
Institute of Dentistry, Isra University Hyderabad, Pakistan

Correspondence to:
Zahid Iqbal
Associate Professor of Operative Dentistry
Institute of Dentistry, Isra University Hyderabad, Pakistan
Email: zahidig@hotmail.com

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cross linking during photo polymerization, compressive strength of Resin modified glassionomer cement is two to three times higher as compared to conventional glassionomer cement in the initial fragile setting stage of the first 24 h.[8] However, some properties of Resin modified glassionomer cement is similar to conventional glassionomer cement. Resin modified glassionomer cement is susceptible to dehydration problems and additional resin monomer and supplementary photo polymerization have not overcome this problem significantly.[9] Similarly, Resin modified glassionomer cement are reported to be more prone to abrasive wear due to a weak filler-matrix coupling.[10]

The requirement to strength resin modified glassionomer cement has led to large number of research efforts for reinforcement. Many previous approaches dealt with incorporation of micro and nano hydroxyapatite in Resin modified glassionomer cement and surface coatings of restored teeth with Resin modified glassionomer cement were investigated.

To date there are few studies that have been done internationally to determine the effect of incorporation of Hydroxyappatite on hardness of Resin modified glassionomer cement.[11,12] We did not find any local published study that determines the effect of hydroxyappatite on hardness of resin modified glassionomer cement. Therefore the purpose of this study was to determine the effect of hydroxyappatite on hardness of resin modified glassionomer cement in our local lab setting.

METHODOLOGY

This in vitro comparative study was carried out at Department of Science of Dental Materials Isra University Hyderabad and Pakistan Council of Scientific and industrial Research laboratories (PCSIR) from 1st July 2013 to 31st January. The objective was to determine the effect of incorporation of Hydroxyappatite on hardness of resin modified glass ionomer cement. Materials for sample preparation (Vitremer) were taken from 3M/ESPE dental supply and Hydroxyapatite from Sigma Alderich United States. Hydroxyapatite (Sigma Alderich) material was incorporated into Resin modified glassionomer (Vitremer) Cement at different ratios: 3%, 5%, 7%, 8% and 9% (by weight). Six groups were made in this study (five samples for each group) Group I Control Resin modified glassionomer without Hydroxyapatite Group II (Experimental) Resin modified Glassionomer with 3% Hydroxyapatite Group III (Experimental) Resin modified Glassionomer with 5% Hydroxyapatite Group IV (Experimental) Resin modified Glassionomer with 7% Hydroxyapatite Group V (Experimental) Resin modified Glassionomer with 8% Hydroxyapatite Group VI (Experimental) Resin modified Glassionomer with 9% Hydroxyapatite.

Specimens for hardness of Resin Modified glassionomer cement and Resin Modified glassionomer cement incorporated with Hydroxyapatite was prepared in stainless steel mold. Mold dimension was 3 mm in diameter and 6mm in length which were prepared by the help of wire cut machine. All specimens were kept in water bath at 37±1 0C and 90-100% relative humidity for one day. The micro hardness values (VHN) of the experimental and control groups were measured by the Vickers micro hardness testing machine (High precision 50Hz / 60Hz AC 220V Micro Vickers hardness tester HV1000 with LED display) (Kratosequipment, saoPaulo, Brazil)(Indentec ZHV Micro vicker) Statistical package for social sciences (SPSS version 17) was used to analyze the data. Relevant descriptive statistic mean and stander deviation were computed for quantitative variables. Mean and standard deviation Values of Hardness of Resin Modified Glassionomer and Resin Modified Glassionomer incorporated with Hydroxyapatite were calculated. Two way ANOVA for the appropriate analysis of variance was used to assess the mean difference of Hardness between Resin Modified Glassionomer and Resin Modified Glassionomer incorporated with Hydroxyapatite with 95 % confidence of interval and 0.05% level of significance.

RESULTS

The descriptive statistics for total 30 samples (n=30) of control and five test groups are presented in table I. The hardness of 3% hydroxyapatite + RMGIC was found to be 40.20 ± 0.22 VHN, 5% hydroxyapatite + RMGIC was found to be 41.31 ± 0.52 VHN, 7% hydroxyapatite + RMGIC was found to be 42.32 ± 0.34 VHN, 8% hydroxyapatite + RMGIC was found to be 28.11 ± 0.24 VHN and 9% hydroxyapatite + RMGIC was found to be 44.13 ± 0.50 VHN

A two way ANOVA of independent variable test groups [cement material comprising of hydroxyapatite and Resin Modified Glass Ionomer cement (RMGIC)] (3%, 5%, 7%, 8% and 9% of hydroxyapatite + RMGIC) on dependent variable hardness of test group was conducted .A 5 x 2 between test groups ANOVA was conducted on hardness as factors. A significant main effect of independent variable test groups [cement material comprising of hydroxyapatite and Resin Modified Glass Ionomer cement (RMGIC)] (3%, 5%, 7%, 8% and 9% of hydroxyapatite + RMGIC) and the control group comprising only resin modified glass ionomer cement (RMGIC) on dependent variable hardness of control group was found, F (80.38 with 0 and 4 degrees of freedom. *P*-value = Sig= 0.001as shown in table II. Since *P*-value = 0.001< 0.05 = α

Since differences were found in the number of observations so Tukey HSD of Post Hoc Test was performed for multiple comparison analysis to determine the best observation as shown in table III &IV (Figure 1).Thus we are 95% confident that five different test groups of yield a different mean values of hardness.

TABLE - I: DESCRIPTIVE STATISTICS MEAN AND STANDARD DEVIATION FOR HARDNESS OF CONTROL AND TEST GROUPS (N=30)

	N	Minimum	Maximum	Mean	Std. Deviation
Hardness Control group	5	38.50	39.97	39.25	.618
Hardness with 3% HA	5	40.03	40.60	40.2200	.22417
Hardness with 5% HA	5	40.57	41.92	41.3160	.52070
Hardness with 7% HA	5	41.98	42.80	42.3240	.34399
Hardness with 8% HA	5	42.90	43.41	43.1780	.18939
Hardness with 9% HA	5	43.41	44.77	44.1340	.50590

N=5 in each group (Total 30)

TABLE - II: TWO WAY ANNOVA DEPENDENT VARIABLES HARDNESS OF CONTROL AND TEST GROUPS (N=30)

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Normal Parameter	Observed Power[b]
Corrected Model	47.041[a]	4	11.760	80.383	.001	.941	321.532	1.000
Intercept	44593.614	1	44593.614	304805.222	.001	1.000	304805.222	1.000
Control group	.000	0	.	.	.	.000	.000	.
Test groups	47.041	4	11.760	80.383	.001	.941	321.532	1.000
Control group * test groups	.000	0	.	.	.	.000	.000	.
Error	2.926	20	.146					
Total	44643.580	25						
Corrected Total	49.967	24						

Post Hoc Test

TABLE - III MULTIPLE COMPARISONS HARDNESS OF GROUPS TUKEY HSD (N=30)

(I) test groups	(J) test groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
3% Hydroxyapatite+RMGIC	5% Hydroxyapatite+RMGIC	-1.0960*	.24191	.002	-1.8199	-.3721
	7% Hydroxyapatite+RMGIC	-2.1040*	.24191	.000	-2.8279	-1.3801
	8% Hydroxyapatite+RMGIC	-2.9580*	.24191	.000	-3.6819	-2.2341
	9% Hydroxyapatite+RMGIC	-3.9140*	.24191	.000	-4.6379	-3.1901
5% Hydroxyapatite+RMGIC	3% Hydroxyapatite+RMGIC	1.0960*	.24191	.002	.3721	1.8199
	7% Hydroxyapatite+RMGIC	-1.0080*	.24191	.004	-1.7319	-.2841
	8% Hydroxyapatite+RMGIC	-1.8620*	.24191	.000	-2.5859	-1.1381
	9% Hydroxyapatite+RMGIC	-2.8180*	.24191	.000	-3.5419	-2.0941
7% Hydroxyapatite+RMGIC	3% Hydroxyapatite+RMGIC	2.1040*	.24191	.000	1.3801	2.8279
	5% Hydroxyapatite+RMGIC	1.0080*	.24191	.004	.2841	1.7319
	8% Hydroxyapatite+RMGIC	-.8540*	.24191	.016	-1.5779	-.1301
	9% Hydroxyapatite+RMGIC	-1.8100*	.24191	.000	-2.5339	-1.0861
8% Hydroxyapatite+RMGIC	3% Hydroxyapatite+RMGIC	2.9580*	.24191	.000	2.2341	3.6819
	5% Hydroxyapatite+RMGIC	1.8620*	.24191	.000	1.1381	2.5859
	7% Hydroxyapatite+RMGIC	.8540*	.24191	.016	.1301	1.5779
	9% Hydroxyapatite+RMGIC	-.9560*	.24191	.006	-1.6799	-.2321
9% Hydroxyapatite+RMGIC	3% Hydroxyapatite+RMGIC	3.9140*	.24191	.000	3.1901	4.6379
	5% Hydroxyapatite+RMGIC	2.8180*	.24191	.000	2.0941	3.5419
	7% Hydroxyapatite+RMGIC	1.8100*	.24191	.000	1.0861	2.5339
	8% Hydroxyapatite+RMGIC	.9560*	.24191	.006	.2321	1.6799

Homogeneous Subsets (n=30)

TABLE – IV: HARDNESS OF GROUPS TUKEY HSD[a,b]

Test groups	N	Subset				
		1	2	3	4	5
3% Hydroxyapatite+RMGIC	5	40.2200				
5% Hydroxyapatite+RMGIC	5		41.3160			
7% Hydroxyapatite+RMGIC	5			42.3240		

8% Hydroxyapatite+RMGIC	5				43.1780	
9% Hydroxyapatite+RMGIC	5					44.1340
Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .146
a. Uses Harmonic Mean Sample Size = 5.000.
b. Alpha = .05.

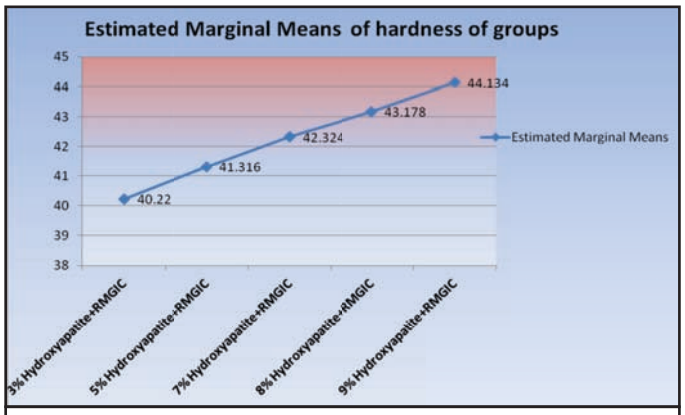

FIGURE 1: PROFILE PLOTS OF ESTIMATED MARGINAL MEANS OF HARDNESS OF GROUPS

DISCUSSION

The present study showed the significance difference of Hardness between Resin modified glassionomer cement and Resin modified glassionomer cement incorporated with Hydroxyapatite. Resin modified Glassionomer cements have some shortcomings in their applications because this material have low mechanical strength (brittleness) and moisture sensitivity during setting reactions of material.[13] Resin modified Glassionomer cements initially set through resin polymerization from exposure to visible light, followed by additional hardening through an acid–base reaction. To avoid these limitations, different amounts of Hydroxyapatite was incorporated to the powder of the Resin modified Glassionomer cements to improve these properties.[13] The hardness of Resin modified glassionomer cement incorporated with different percentage of Hydroxyapatite has higher than the Resin modified glassionomer cement. [14]The addition/ incorporation of Hydroxyapatite in Resin modified glassionomer cement does not negatively affect the other properties of the Resin modified glassionomer cement for example fluoride release microleakage, and setting time.[13] The Hydroxyapatite material has added to improve the micro hardness of Resin modified glassionomer cement. It is documented that Hydroxyapatite shows higher stability, strength, and low irritation to tissue which does not set itself by any chemical reaction, Hydroxyapatite is similar to the host bone crystallite.[14]

From the statistical results obtained, it was showed that the hardness of test group 3%, 5%, 7%, 8% and 9% Hydroxyapatite incorporated with resin modified glassionomer (test) was greater than resin modified glassionomer. Thus we are 95% confident that five different test groups of yield a different mean values of hardness.

Comparisons of the results of present study with the previous study have shown similar results. In comparison with previous study reported by researcher Vickers hardness shows a small but significant increase from 70.1 HV2 to 76.3 HV2 with 0.5 wt. % Hydroxyapatite addition.[14]

In one another previous study different ratios 10%, 15%, 20%, 25% and 30% (by weight) of Hydroxyapatite material was added to glassionomer cement. The micro hardness tests were performed by using Vickers micro hardness testing machine. The values were obtained and comparison was performed on the tested groups. The micro hardness of the base materials mean square between groups is 1098.780 and within group is 24.381(HV Kg/ mm2). The statistical significant difference was found between both values and P value was less than 0.05.[15]

It is recommended that the resin modified glassionomer incorporated with Hydroxyapatite is more efficient in terms of hardness in comparison with only resin modified glassionomer. Since Hydroxyapatite is a bioactive compound itself, [16] it can be more tightly bound to the resin modified glassionomer which is already in practice. By incorporating this active compound the more efficacious material can be developed for the dental industry. This can bring a drastic change in the dental clinical practice across the board. However the cost effectiveness is not so attractive but in coming future similar compound can be prepared or some polymers can be synthesized for the better cost effectiveness and efficiency.

Different mixing method will be required to produce a working cement with significant improvements in mechanical properties, It is documented that finer powder particle have short working time and faster setting time. This may be responsible better surface finish and hardness is also depending on mixing method. More researches are required for this idea to be approved, such as shear bond strength tests and SEM evaluations should be conducted

CONCLUSION

The findings of this study demonstrate the statistically significant difference of hardness between resin modified glassionomer and resin modified glassionomer incorporated with Hydroxyapatite. It was concluded that hardness is found to be more in resin modified glassionomer incorporated with Hydroxyapatite with different percentages.

Contribution of authors:

Iqbal Z: Conceived Idea, Designed Methodology, Manuscript Writing.

Azam HM: Data Collection, Literature Review, Data Analysis. Critical analysis

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