ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

Evaluation of polyacid modified composite compared to hybrid composite and resin modified glass ionomer cement *(An in vitro study)*

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Abstract

Background: Dental caries is one of the most significant problems in world health care. Restoring carious primary teeth is one of the major treatment goals for Children, and the light activated resin restoration materials like composite, resin-modified glass ionomer and polyacid-modified which was introduced in dentistry in 1970 , widely used in clinical dentistry but its application increased dramatically in recent years because of its biocompatibility , color mathching , good adhesive properities of its ressemblence in physical and mechanical aspects to tooth.

The aim of this study: To evaluate the Degree of Conversion (DOC) and Vickers Surface hardness of Polyacid-Modified Composite Compared to Flowable Hybrid Composite and Resin-Modified Resin composite(PMCM).

Materials and methods: A total of 60 PVC readymade (DENTSPLY) molds of 2mm depth were used for disc preparation to prepare a sixty(60) samples. Using flowable composite (3M, Z350), Resin-modified glass Ionomer RMGI (Riva LC) and Compomer (Polyacid-modified composite Resin (PMCR) (Dyract). The samples will be divided into three groups according to type of restorative material used and light cured for with a light cure device (ivoclar vivodent Bluephace) , after complete curing the sample will be removed from the mold and then measure the degree of conversion by FTIR (Fourier tranceform infrared spectroscopy) and micro-hardness by Vickers hardness test.

Results: The RMGI (Riva LC) showed the statistically significantly highest mean micro-hardness. Compomer (Dyract). showed statistically significantly lower mean value. Flowable Composite (Z350) showed the statistically significantly lowest mean micro-hardness. There was no statistically significant difference between Degree of Conversion values in the three groups

Conclusion*:* The RMGI (Riva LC) is better in term of micro-hardness than Compomer (Dyract) and Flowable Composite (Z350) due to a correlation between the surface microhardness and filler mass fraction. but the Degree of Conversion of the the three groups is better in Composite (Z350) and RMGI (Riva LC) than Compomer (Dyract) but statistically no significant difference among them

Key words: Degree of Conversion, micro-hardness, FTIR, Vickers hardness test, resin materials.

INTRODUCTION

Restoring carious primary teeth is one of the major treatment goals for Children. Amalgam was the material of choice worldwide. A declining acceptance of amalgam in pediatric dentistry is due to small thickness of enamel wall in primary molars compared to permenant teeth and fear of potential mercury toxicity especially for children. Amalgam restoration have been reported to be less durable in primary molars than in permenant teeth (1).

The light activated composite resin restoration which was introduced in dentistry in 1970 , widely used in clinical dentistry but its application increased dramatically in recent years because of its biocompatibility , color matching , good adhesive properties of its resemblance in physical and mechanical aspects to tooth (2).

Although, the composite materials have some limitations and disadvantages that restrict their use as microleakage , sensitivity , recurrent carries ,polymerization shrinkage , wear in stress bearing area which may decrease the success of these restorations(3).

Glass ionomer cement systems have become important dental restorative materials for use in children. It have several advantages like biocompatibility , its fluoride release and uptake from dentifrice mouthwash and topically applied solution regarded as reservoir and chemical bonding to tooth structure (4).

However Glass ionomer cement has disadvantages like marginal defect , chipping, color changes, sensitive technique due to mixing requirement , low mechanical properties and its solubility in oral cavity fluids so need for moisture protection to prevent surface degradation (5).

A new generation of glass ionomer now available are resin reinforced glass ionomer (poly acid modified composite resin) called compomer which is a mixture of composite resin and glass ionomer. It reflect the combination of both component properties of the two materials. They possess advantages superior to Glass ionomer cement or composite like biocompatibility , dual cure polymerization chemical adhesion to dentin without etching it , Fluoride release continuously after placement , insolubility in oral fluorides, low coefficient of thermal expansion, less polymerize shrinkage and its condensable material (6).

The Degree of conversion and surface hardness of Resin restorations material considered a critical factor for the durable success of these material . An insufficient curing degree affect the properties of resin composite such as wear resistance ,surface hardness and strength as well as irritant and toxic component for the material. Many factors such as the size of filler particles and light exposure source can influence the degree of conversion and there by influence their mechanical properties (7).

This in vitro study is intended to compare between poly acid modified composite resin, Glass Ionomer Cement and hybrid composite for restoring the primary teeth.

MATERIAL AND METHODS:

Materials:

Materials	Manufacture
Flowable Composite	3M (Z350) dental product St. paul Mn. USA
Resin modified glass Ionomer	Riva LC (SDI Australia)
Polyacid modified Resin composite	Dyract (Dentsply (rock) USA)
single bond adhesive	3M dental product St. paul Mn. USA
Etchan (35% phosphoric acid)	(Dentsply)

Specimens' preparation:

A total of 60 PVC molds were used for disc preparation. The use of PVC material prevents the attachment of filling material to the wall of the mold after curing and easily removed without damage. The molds were fabricated by the manufacture (Dentsply) with 4 holes of 4 mm diameter each at varying depths (2, 4, 6, 8 mm). Only the 2 mm hole were used in this study (Fig. 1). The material was injected into the mold using a compule gun or the tip of material's tube according to type of materials. The tip of the compule or tube was placed in a centralized position at the very bottom of the hole and the material was injected until the mold is slightly overfilled to avoid the void formation. For light curing, a fully-charged LED curing light was used (Ivoclar polywave). The light intensity (1200 mW/cm2) was tested by using a built-in tester incorporated in the charging base.

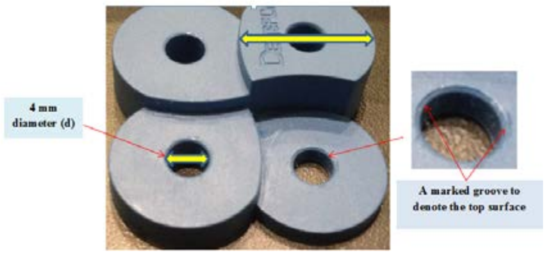

Figure (1): The mold with a marked groove on the top surface

Grouping of the specimens:

Three type of materials were used which are hybrid composite Z350 flowable restoration composite (Group 1), resin modified glass ionomer cement (Group 2) and polyacid modified glass ionomer (Group 3). A total of (120) specimens were prepared at 2 mm depth divided into three groups, (40) specimens for each group. Furthermore, each group were subdivided into two subgroup, (20) specimens for each subgroup for measuring the Vickers hardness test while the other half (20) specimens were made for measuring the degree of conversion test. After grouping, the specimens were placed in a dry bottle and kept at 37 °C, for 24 hours for complete polymerization of the specimens before testing.

Evaluation of the Degree of conversion (DOC):

The degree of conversion was evaluated using FTIR, which measure the degree of conversion of polymers in solid state (9). The calculation of DOC was based on the measurement of the net peak absorbance area of the C=C bonds and the aromatic C-C bonds as reference. The net absorbance peak area ratio of cured to uncured material was provided as percentage of converting double bonds. These methods were reported to generate highly reliable results. A metal grinder was used manually to grind a sample from the bottom surface of the specimen in order to have 1 mg of the ground material. This was done using laboratory electronic weighting scale.

The ground material was mixed with 100 mg of pre-dried and desiccated solid potassium bromide (KBr). This small amount of the mixture was enough to obtain a clear and transparent pellet at which the beam of the spectrometer can be transmitted The mixture was finely ground using mortar and pestle. It was done under an IR lamp to exclude any water vapors, until the specimen was well dispersed and the mixture had the consistency of fine flour. The die was assembled, by placing the bottom anvil flat on the table and sliding the die over the bottom anvil column (Fig. 2).

The ground mixture was transferred into the cylinder specimen well and the top anvil was positioned on top of the die and pushed gently

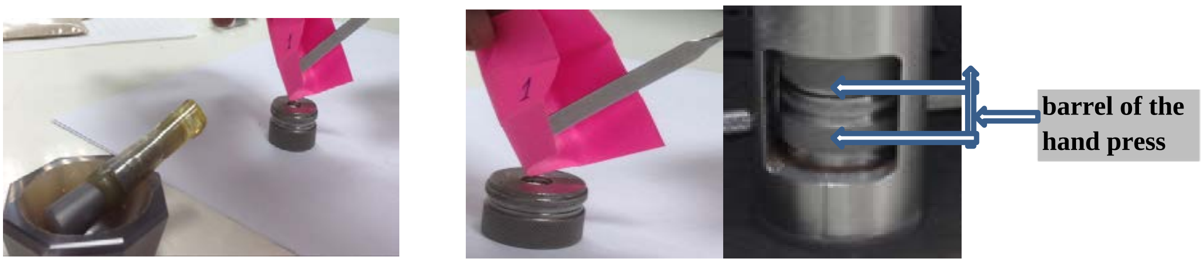

Figure (2): Placement of mixture in the die

Figure (3): FTIR spectrometer and spectrometer's spectrum (JASCO FT/IR-6300)

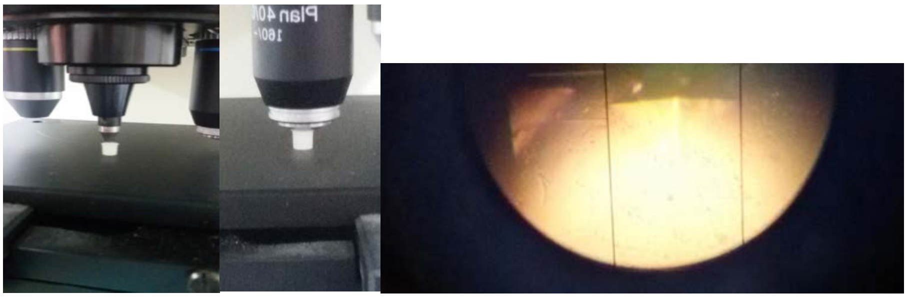

Figure (4): Vickers hardness indenter while indent is being Adjustment of the tube at 40 X

Table (1): Descriptive statistics and results of one-way ANOVA test for comparison between micro-hardness values (VHN) in the three groups

	Composite	**Compomer**	**RMGI**	***P*-value**
Mean (SD)	34.5 (4.5) ^{C}	40.3 (4.4) ^{B}	52.2 (5.2) ^{A}	<0.001*
95% CI	32 – 37	36.3 – 44.4	48.2 – 56.3	

*: Significant at P ≤ 0.05, Different superscripts are statistically significantly different

Table (2): Descriptive statistics and results of one-way ANOVA test for comparison between Degree of Conversion values in the three groups:-

	Composite	**Compomer**	**GIC**	***P*-value**
Mean (SD)	1740.1 (322.1)	1610.5 (89.8)	1719.6 (360.1)	0.413
95% CI	1561.7 – 1918.5	1560.7 – 1660.3	1520.2 – 1919	

**: Significant at P ≤ 0.05*

The die set was placed in the barrel of the hand press, and then the handle was squeezed gently all the way down and paused for 15 sec. The pressure was released and the die set was removed from the press. The resulting KBr disc was removed from the die set (the disk was checked for translucency and homogeneity) and positioned into the path of the IR radiation of FTIR spectrometer using a special holder. The spectrum was recorded. The recorded spectrum was based on the wave number that result from the measurement the reduction in the intensity of the stretching band of carbon-to-carbon aliphatic double bonds (C=C) of methacrylate (Fig. 3).

Evaluation of the surface microhardness:

The Vickers hardness tester was adjusted to a load of 200 g with the Vickers indenter placed in a centralized position. Thus, the microscope was placed in a position that makes the indenter above the specimen disc (10). The stage micrometer scale was adjusted to 0.1mm using 40 X magnification. The indent was adjusted to lie between a vertical line of the fixed scale and the other vertical line of adjustable scale of the filar eyepiece (Fig. 4) (11).

RESULTS:

Micro-hardness

There was a statistically significant difference between micro-hardness values in the three groups (*P*-value <0.001). Pair-wise comparisons between the three groups revealed that RMGI showed the statistically significantly highest mean micro-hardness. Compomer showed statistically significantly lower mean value. Composite showed the statistically significantly lowest mean micro-hardness.

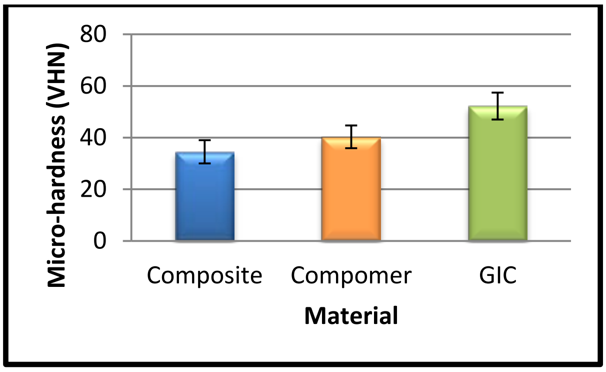

Figure (5): Bar chart representing mean and standard deviation values for micro-hardness in the three groups

Degree of Conversion

There was no statistically significant difference between Degree of Conversion values in the three groups (*P*-value = 0.413).

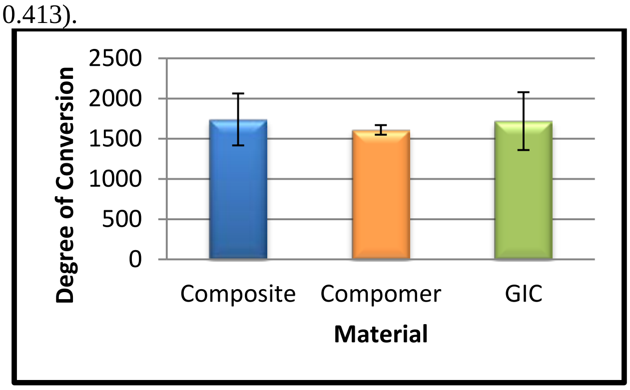

Figure (6): Bar chart representing mean and standard deviation values for Degree of Conversion in the three groups

DISCUSSION:

In order to standardize the specimens, ready-made molds fabricated by the manufacturer, were used for specimen fabrication. The molds had hole of 2 mm depth, a marked groove on their top surface to allow application of the light cure tip at the center of the mold. LED curing light was used with spectral output between 400 to 500 nm, which intended to be ideal to activate CQ. Additionally, LED supposed to avoid significant degradation by heat produced from halogen light curing.

The DOC was measured by Fourier transformed infrared spectroscopy (FTIR), while the MH was measured using Vickers hardness tester. The calculation of DOC was based on the measurement of the net peak absorbance area of the C=C bonds and the aromatic C-C bonds as reference. The net absorbance peak area ratio of cured to uncured material was provided as percentage of converting double bonds. These methods were reported to generate highly reliable results (Marco et.al, 2012; Poggio et.al, 2012; Czasch and Ilie, 2013). Additionally, some researchers found a correlation between MH and DOC (12, 13).

In this investigation, the microhardness results of the three groups Polyacid Modified Composite Compared to Hybrid Composite and Resin Modified Glassionomer in these properties (P-value <0.001). Comparisons between the three groups revealed that RMGI showed the statistically significantly highest mean micro-hardness. Compomer showed statistically significantly lower mean value. Composite showed the statistically significantly lowest mean micro-hardness. Moreover, the morphology of the filler, filler mass fraction, filler size and volume and the refractive index may permit adequate light transmission and allow the material to reach adequate hardness. This was supported by other investigators who stated that the type and composition of the resin matrix may influence material microhardness. With increasing the filler volume, the flexural strength and modulus hardness could be improved (Czasch and Ilie, 2013; Son et.al, 2014). Furthermore, a correlation between the surface microhardness and filler mass fraction have been previously reported (14,15).

In agreement with our results, (Effat et,al. 2015); found that the lower level of compomer's (Ionosit) microhardness than resin modified glass ionomer cement (Ionoseal) might also be caused by its formulation and particle size variety. Comparing composite and compomer with RMGIs, PMCs and resin flowable composite require an acid-etch technique plus a bonding agent and have polymerization shrinkage due to their resin composite nature that leads to a broken marginal seal in the dentin substrate with an increasing risk of secondary caries. Moreover, their fluoride release level is lower than those of RMGI materials.

The result of this study in disagreement with those of previous studies of (Taha et,al. 2015); found that the hardness of resin composites is highest than GIC, this is due to the porosity in GIC material during manipulation which affect on the hardness and other mechanical properties. So, Lower porosity and more integration as in our study can improve the surface hardness of glass ionomer materials.

The extent to which the monomers can be transformed into a polymer is called the "degree of conversion." In this study, the DOC was measured to evaluate the photopolymerization efficiency that infer the quantity of the remaining double bond using FTIR. Unlike indirect techniques which rely on measuring changes in the mechanical performance of the material to assess relative DOC, FTIR spectroscopy allows the direct detection of the amount of unreacted C=C in the resin matrix.

For current dental polymers, the degree of conversion is on the order of 50% to 70% which is considered clinically acceptable. In this study, all the DOC mean values were more than 50% for all used materials, yet, There was no statistically significant difference between Degree of Conversion values in the three groups (P-value = 0.413).

The DOC is influenced by the material composition as filler particle size and loading, polymerization initiator concentration, monomer type and amount, the shade and trancluceny of the material, intensity and wave length of the light source, as well as irradiation time (18).

Since the light source, the distance, the intensity and the material thickness were standardized, and since the material type is the only significant variable, one of explanation to the decreased DOC could be related to the attenuation of light as it reaches the deeper layer. The irradiated photons reached the subsurface and initiated polymerization by crosslinking the monomer molecules three-dimensionally from the top to bottom. The intensity of these photons, however, could be decreased with depth, indicating that less photoinitiator molecules are activated and the polymerisation process in the gel phase becomes slower as the layer thickness is increasing (19).

Additionally, the DOC was nearly equivalent at both the top surface and the bottom surface, confirming consistant DOC within the same group. It is worth noting that this study was performed in an ideal laboratory setting with the light-curing unit very close to the material. That is unlikely to occur clinically, which may result in different DOC. Yet, the irradiation time stated by the manufacturer may be considered suboptimal cure and may influence the DOC. Probably increasing the irradiation time may optimize the conversion rate at 2 mm depth (20, 21). This was also confirmed by a very recent study by Zorzin et.al, (2015) who speculated that enhanced curing time improved the polymerization properties of material.

CONCLUSION:

The RMGI (Riva LC) is better in term of micro-hardness than Compomer (Dyract) and Flowable Composite (Z350) due to a correlation between the surface microhardness and filler mass fraction. but the Degree of Conversion of the three groups is better in Composite (Z350) and RMGI (Riva LC) than Compomer (Dyract) but statistically no significant difference among them

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