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Comparative evaluation of microleakage and microhardness of newer restorative materials - An in vitro study

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Abstract

To evaluate the microleakage and microhardness of various restorative materials. Class II cavities were prepared on the buccal surface of 40 human premolars. The premolars were randomly and equally divided in four groups and class II cavities were restored with LC GIC Type II, Filtek Z250, Beautifill II and Beautifill II LS. Samples were immersed in 0.2% methylene blue dye and after 48hrs dye penetration was recorded using stereomicroscopic analysis. For microhardness evaluation, 40 moulds were prepared and randomly divided into four groups and restored with LC GIC Type II, Filtek Z250, Beautifill II and Beautifill II LS restorative materials. Microhardness was evaluated using vicker's microhardness testing machine. Statistical significance revealed that the marginal intrigity was found to be best in Beautifill II LS, while microhardness was highest in Beautifill II with statistically significant difference when comparing with Beautifill II LS. Beautifill II LS was found to be most efficient restorative material in terms of both incresesed microhardness as well as low polymerisation shrinkage.

Keywords: Microhardness, microleakage, Giomer, Nanohybrid composite resin, GIC.

Introduction

Dental caries is one of the most common chronic diseases of childhood. Various steps in prevention of dental caries have been taken since ages but none of them was able to completely eradicate the caries process. Therefore, once caries occurs it has to be restored for proper functioning of dentition and prevention of further loss of the tooth structure.

The goal of research and development in restorative materials is to develop an ideal restorative material, which would be biomimetic in strength, adherence, and appearance to tooth structure. One of the oldest of restorative material is Glass Ionomer Cement which has been widely used in the restoration of deciduous dentition because of its innumerable advantages. But due to its disadvantage of being not able to provide an adequate strength, attempts were made to improve this conventional GIC. Many changes to the chemical composition of the restorative materials were made in order to increase their performances. But again due to early moisture contamination, the restoration would lack its durability eventually. An important step forward in improving Resin modified Glass Ionomer Cement features was thermo-curing. Although the cement was durable but not ample enough to meet the requirements of a fluoride releasing ability of conventional GIC and strength of composites[1]. Hence attempt was made in inquiring for a restorative material that has the fluoride releasing capability of Glass Ionomer Cement and durability of composites, introduced by Shofu Inc. (Kyoto,Japan 2000) known as GIOMERS[2].

Recently a newer giomer BEAUTIFILL II LS (LOW SHRINK) which has a property of sustained fluoride release and and at the same time low polymerisation shrinkage and greater strength and wear resistance has come up. Beautifill II LS exhibits shrinkage of 0.85% by volume which is currently the lowest value of any direct composite. Its novel SRS (Steric Repulsion Structured) molecule designed to minimize polymerization shrinkage through molecular steric repulsion results in a sturdy and stable restoration microstructure. The relatively long-chained, chemically optimised monomers (ML-01) which form the organic matrix of the innovative Beautifil II LS, are very long and connect by means of very short 'lateral arms' smartly minimize the shrinkage of this composite restorative material without compromising the safety and stability of polymerisation[3].

Despite the potential clinical benefit provided by the newly introduced Giomer composite resins, limited verification of the capabilities and properties in terms of long term benefits has taken place. Consequently, prior to the commencement of this study, the doubts about the possible benefits and limitations of new giomer restorative materials over conventionally used restorative materials cannot be ensured. With this in mind, this current study was designed in vitro, with the aim to evaluate and compare the marginal sealing ability and microhardness of four restorative materials i.e Light cure GIC type II, Filtek Z250 nanohybrid composite, Beautifill II and Beautifill II LS.

Materials and Methods

The present study was conducted in two phases:

Phase I: Microleakage study using stereomicroscope on 40 extracted sound human premolars restored with LC GIC Type II, Filtek Z250, Beautifill II and Beautifill II LS restorative materials.

Phase II: Surface microhardness study using Vicker's microhardness testing machine on standard 40 circular moulds prepared with LC GIC Type II, Filtek Z250, Beautifill II and Beautifill II LS restorative materials.

Phase I: Preparation of samples for microleakage study: Forty extracted non-caries human premolars were taken and teeth were scaled and cleaned. Rectangular class V cavities (3 mm wide X 2 mm high X 1.5 mm deep) 1mm above the cementoenamel junction, were prepared on the buccal surfaces of all the 40 selected samples. A round bur (No. 256) in a high speed airotor with water coolant was used for the initial punch cut, this was followed by straight fissure bur (No. 557) and the flattening of the pulpal floor was done by an inverted cone bur (No. 37). Forty teeth were divided into four equal groups and each of the groups were then restored with LC GIC Type II, Filtek Z250, Beautifill II and Beautifill II LS restorative materials respectively according to the manufacturer's recommendations (Figure 1).

After the restoration, all the samples were subjected to thermocycling to simulate oral conditions. For thermocycling temperature of one water bath was maintained at 5^{0} C and of the other water bath at 55^{0} C. The samples were dried using three-in-one-syringe and the apices of all teeth were sealed with blue sticky wax. All tooth surfaces were triple coated with finger nail varnish, with the exception of a 0.5-1.0 mm window around the restoration margins and then immersed in 0.2% methylene blue dye for 48 hours, after which they were thoroughly rinsed under running water and air dried for 5 minutes.

A diamond disc at slow speed in a micromotor straight hand piece was used to section the teeth longitudinally in a bucco-lingual direction. Continuous irrigation with distilled water through a syringe was done while sectioning the samples. Out of 80 sections obtained from 40 sampes of teeth, only 40 sections were selected which were complete and not fracture or chipped off (Figure 2).

Microleakage Evaluation

(Stereomicroscopic)

The microleakage was assessed under the stereomicroscope at a magnification of 40X following Vinay S and Shivanna V (2010). **(**Figure 3)

Phase II: Preparation of moulds for microhardness study: A plastic hollow cylindrical pipe opened at both ends of 6 mm internal diameter and 200 mm length was prepared. The pipe was cut using a BP blade at a distance of 5 mm using a vernier caliper and 40 moulds of equal height and diameter were prepared from it. All the molds were then cleaned and autoclaved before using for the study. The prepared 40 moulds were randomly divided into four groups after color coding and each of the groups were then restored with LC GIC Type II, Filtek Z250, Beautifill II and Beautifill II LS restorative materials respectively (Figure 4). The restorative pellets were then removed by cutting the plastic moulds with BP blade and then stored in saline for 24 hours in four different sterile labeled glass containers.

Microhardness Test (Vicker's microhardness testing machine)

The restorative pellets from all the groups, were subjected to microhardness determination using Vicker's microhardness Testing Machine in collaboration with Cosmo Analytical Laboratory, Noida. Each pellet was placed on the center of the platform of the vicker's microhardness machine. The diamond indenter of the machine made three indentations on each pellet with a force of 50 grams for a dwell time of 5 seconds as shown in Figure 5. The final value for each material was taken by averaging the measurements. Data was collected, tabulated and then sent for statistical analysis.

Results

The data was statistically analysed using ONE WAY-ANOVA and Bonferroni's test and the following results were obtained.

In case of microleakage, it was noted that Group D (Beautifill II LS) had the lowest mean value of 0.30, while Group A (Light cure GIC Type II) had the highest mean value of microleakage, i.e, 2.80 as shown in Table 1 & 2. While in case of microhardness, it was noted that Group A (Light cure GIC) had the lowest mean value of 40.65 while Group C (Beautifill II) had the highest mean value of microhardness, i.e, 65.69 as shown in Table 3 & 4 .

Discussion

The result from the present study revealed that t*he mean microleakage was observed to be least in (Group D) Beautifill II LS. In a recent research by **Ubaydah F, AL-Gailani and Salam D Alqaysi** in **2019**[3] in which microleakage of two composite resins (Beautifill II LS and Filtek Z250) was evaluated for class V cavity restorations, also reported that Beautifil™ II LS Giomer showed relatively better microleakage resistance than Filtek Z250 when using the layering technique. **Markus Firla** in **2018**[4] concluded that having used extensively Beautifil II LS, it is an all-round material for direct adhesive anterior restorations, and is very advantageous in clinical use due to the fact that even large cavities can be restored using only one shade because of its biomimetic properties[4].

In the present study microleakage was found to be least in Group D (Beautifill II LS) because of the fact that Beautifill II LS exhibits shrinkage of 0.85% by volume which is currently the lowest value of any direct composite. Its novel SRS (Steric Repulsion Structured) molecule designed to minimize polymerization shrinkage through molecular steric repulsion results in a sturdy and stable restoration microstructure which is in accordance with the study conducted by **Ubaydah F, AL-Gailani and Salam D. Alqaysi** in **2019**[3]**.** The relatively long-chained, chemically optimised monomers (ML-01) form the organic matrix of the innovative Beautifil II LS, are very long and connect by means of very short ‘lateral arms’. The sophisticated combination of various particle sizes and the addition of prepolymerised composite agglomerates, also used in different sizes, smartly minimize the shrinkage of this composite restorative material without compromising the safety and stability of polymerisation **(Markus Firla** in **2018)**[4]. Beautifill II LS, being a Giomer restorative material claims to set new standards for the aesthetic and physical properties and can be safely be used on paediatric patients as they do not require acid and washing stages, hence save time because of simple application.

When intergroup comparision between various groups was made, the mean microleakage of Beautifill II was found to be less than Filtek Z250 and Light cure GIC Type II. A similar study done by **KM Abdelaziz et al**[5] and**Indira Priyadarshini Bollu et al** in **2016**[6] comparing the microleakage of Giomer and nanohybrid restorative resins, reported statistically significant difference between the microleakage of Beautifill II in comparsion to Filtek Z250. Another research done by **MS Alshetili et al** in **2015**[7]on Polymerization shrinkage and elasticity of flowable composites found that the microleakage of composite resins with high filler loading and elastic modulus was least in comparision to the low filler loaded and elastic modulus of composites and GIC.

In this study, the better marginal adaptation of (Group C) Beautifill II is primarily attributed due to its high filler load of 83.3 wt% and hence increased elastic modulus of 21.3GPa in comparison to 78 wt% and 18.7GPa respectively in Filtek Z250 which is in accordance with the study conducted by **KM Abdelaziz et al**[5] and **Indira Priyadarshini Bollu et al** in **2016**[6]**.**

When mean microleakage of (Group A) Light cure GIC Type II was evaluated, it was found to be highest compared to all other groups. The similar findings were reported in a study conducted by **MuratSelim Botsali et al** in **2014**[8]in which microleakage of various GIC's formulations was evaluated in class V cavities, reported that that microleakage in LC GIC's was found to be most of all. Similar to this study, in vitro studies conducted by **MM Ebaya et al** in **2019**[9] and **T Singla et al** in **2012**[10] reported that microleakage was found to be more in LC GIC in comparision to nanohybrid composite resins. The highest microleakage of LC GIC Type II in this study could be attributed to its rapid polymerization followed by slow acid-base reaction leaving uncured HEMA within this GIC absorb moisture into the material, which is similar to the reason given by **MM Ebaya et al** in **2019**[9]and **T Singla et al** in **2012**[10]**.** Another reason could be due to more porosity that comes with the manual mixing system, hence leading to microleakage which is in accordance with the study conducted by **Taha et al** in **2012**[11]**.**

Microhardness is the another characteristic that has been evaluated in this study using Vickers microhardness testing machine. On evaluating the microhardness of various groups viz Group A (Light cure GIC), Group B (Filtek Z250), Group C (Beautifill II) and Group D (Beautifill II LS),the mean values were found to be 40.65, 52.77 , 65.69 ,and 57.61 respectivily. Which clearly shows that the values of (Group C) Beautifill II had highest microhardness followed by Group D (Beautifill II LS), Group B (Filtek Z250) and least in Group A (Light cure GIC).

In this study the microhardness was found to be highest in (Group C) Beautifill II. The similar results had been observed by a recent study done by **Prashant Babaji** in **2020**[12]on microhardness of Giomer and Compomer Restorative Material, it was reported that the highest value was given by Giomer which was significantly harder than hybrid composite which in turn was significantly harder when compared to RMGIC. In another study done by **Mukundan Vijayan** in **2018**[13] on microhardness between giomer, compomer, composite and resin-modified GIC in which all four materials showed statistically significant results with the highest value given by Giomer.

Allthough the microhardness of (Group D) Beautifill II LS was observed to be less than (Group C) Beautifill II, but the difference was statistically non significant. A positive correlation has been established between the hardness and the inorganic filler content of materials tested in this study. Both Beautifil II and Beautifill II LS Giomers being highly filled, incorporates inorganic fillers (83.3 wt%), that are derived from the complete or partial reaction of ion-leachable fluoroboroalumino silicate glasses with polyalkenoic acids in water before being interfaced with the organic matrix. In S-PRG (surface reaction type) only the surface of the glass filler is attacked by polyacrylic acid and a glass core remains, this creates a stable glass-ionomer phase on a glass suggesting that the pre-reacted glass ionomer particles in giomer are better able to resist acid degradation, thus have higher microhardness values compared to other restorative materials, which is in accordance with the previous findings (**Prashant Babaji** in **2020**[12]**, Mukundan Vijayan** in **2018**[13]**)** that micro indentation hardness of composites is directly related to the volume fraction of the inorganic filler component.

When intergroup comparision was made, it was found that the mean microhardness of Filtek Z250 was more than LC GIC Type II. In a similar study done by **Simranjeet Kaur et al** in **2015**[14]with the same methodology reported that Nanofilled composite resin had the higher resistance to erosion and/or abrasion and thus highest microhardness among all the materials tested, followed by microfilled composite and RMGIC respectively. Filtek Z250 comprises of nanoparticle size inorganic fillers (78%) with matrix composed of aromatic aliphatic UDMA which has high viscosity and hence less elastic, hence provides stiffness to the matrix and resistance to stresses generated in the oral cavity, which is in concurrent with a study done by **Simranjeet Kauret al** in **2015**[14]**.**

Microhardness of LC GIC Type II was found to be lowest when compared to all other groups. The same studies done by **Mazumdar et al** in **2012**[15] **and Simranjeet Kaur et al** in **2015**[14]comparing Nanohybrid composite resins and LC GIC have also reported the reason for less microhardness of LC GIC. In GIC when powder reacts with liquid, the matrix formed is of polyacrylic hydrogel which has less viscosity and thus is not so stiff to counteract enough stresses. The lowest microhardness can also be attributed to more porosity that comes with the manual mixing system which is in concurrent with the study done by **Taha et al in 2012**[11]**.**

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Legend Figures and Tables

Figure 1 : Flowchart of sample division into 4 groups

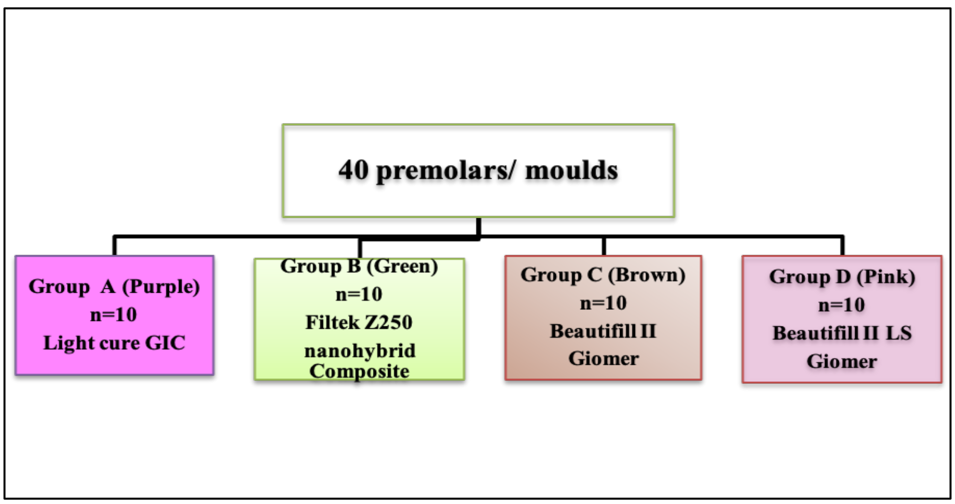

Figure 2: Color coding of all samples for microleakage evaluation.

Figure 3: Restored pellets of various groups for microhardness evaluation.

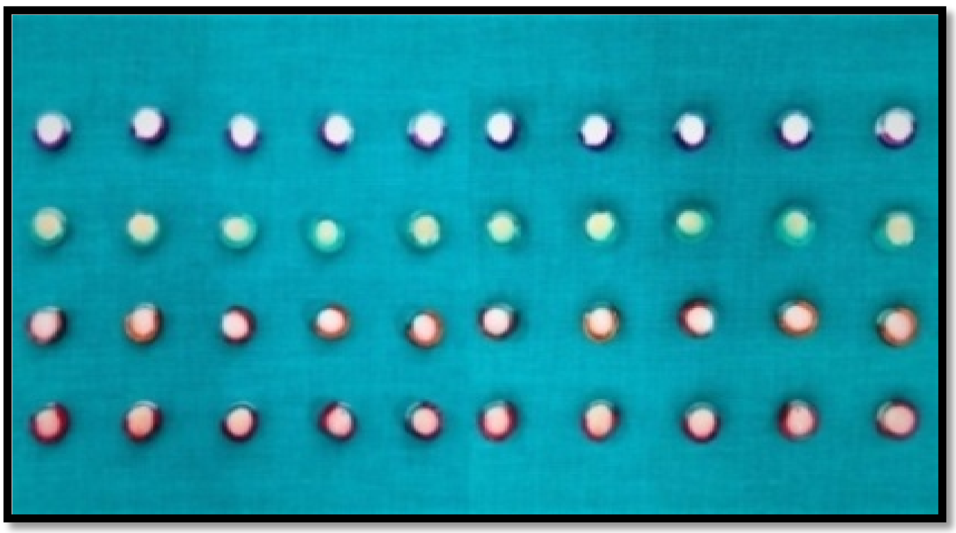

Table1: Comparison of mean values of microleakage in different groups.

GROUP	(N)	Mean	SD	Std. Error Mean	F - value	p-value
Group A : (Light cure GIC type II)	10	2.80	0.919	0.291	23.341	<0.001*
Group B: (Filtek Z250)	10	2.10	0.876	0.277		
Group C: (Beautifill II)	10	1.20	0.422	0.133		
Group D: (Beautifill II LS)	10	0.30	0.483	0.153		

Post-hoc analysis using Tukey's test

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A	B	-0.700	0.318	0.205	-0.19	1.59
	C	1.600	0.318	<0.001*	0.71	2.49

	D	2.500	0.318	<0.001*	1.61	3.39
B	C	0.900	0.318	0.04*	0.01	1.79
	D	1.800	0.318	<0.001*	0.91	2.69
C	D	0.900	0.318	0.045*	0.01	1.79

$p < 0.05$ *Significant Statistically

Table 2: Comparison of mean values of microhardness in different groups.

GROUP	N	Mean	Std. Deviation	Std. Error Mean	F - value	p-value
Group A (Light cure GIC type II)	10	40.6580	0.19309	0.06106	1.7004	<0.001*
Group B (Filtek Z250)	10	52.7730	0.22794	0.07208		
Group C (Beautifill II)	10	65.6910	0.30643	0.09690		
Group D (Beautifill II LS)	10	57.6140	0.27379	0.08658		

Post-hoc analysis using Tukey's test

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A	B	-12.11500	0.11360	<0.001*	-12.4322	-11.7978
	C	-25.03300	0.11360	<0.001*	-25.3502	-24.7158
	D	-16.95600	0.11360	<0.001*	-17.2732	-16.6388
B	C	-12.91800	0.11360	<0.001*	-13.2352	-12.6008
	D	- 4.84100	0.11360	<0.001*	-5.1582	-4.5238
C	D	8.07700	0.11360	0.06	7.7598	8.3942

$p < 0.05$ *Significant Statistically