How to Cite:
Araby, S. M. E., Moteea, M. E. S., Abbas, A. N., Eissa, A. A., Abokhlifa, Y. H., Elmansy, T. A., Refaei, M. A. A., Elsayed, H. M., Elmanakhly, A. R., & El-ghany, A. A. A. (2021). Chemicomechanical caries removal in primary molars: Evaluation of shear bond strength of modified glass ionomer restorations: An in vitro study. *International Journal of Health Sciences*, *5*(S2), 1335–1346. Retrieved from https://sciencescholar.us/journal/index.php/ijhs/article/view/14676

Chemicomechanical caries removal in primary molars: Evaluation of shear bond strength of modified glass ionomer restorations: An in vitro study

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International Journal of Health Sciences ISSN 2550-6978 E-ISSN 2550-696X © 2021.
Manuscript submitted: 27 May 2021, Manuscript revised: 09 July 2021, Accepted for publication: 18 August 2021

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***Abstract*---**The recent trend in pediatric dentistry is tending towards minimal invasive materials and techniques. Aim: To evaluate and compare shear bond strength of three modified glass ionomer restorations (GIRs) to dentin of primary molars after removal of caries via Papacarie Duo (a Chemicomechanical caries removal material CMCR). Materials and methods: 45 deciduous molars with occlusal carious cavity Samples were randomly divided into three groups, i.e., groups I , II , III and were restored with Riva silver glass ionomer , light cure (LC) Riva glass ionomer , and Riva bulk fill hybrid glass ionomer respectively. Shear bond strength was determined. Results: It was found that the shear bond strength was highest in group III treated with Papacarie restored with Riva bulk fill hybrid glass ionomer (11.32± 3.15) MPa, followed by group II treated with papacarie restored with light cured glass ionomer riva (5.53±3.33), with the lowest value (3.87±1.5) recorded in Gp I treated with papacarie restored with riva silver reinforced glass ionomer. The difference between groups was significant. Conclusion: Bulk fill hybrid glass ionomer was significantly better than Light cure GIC and silver reinforced glass ionomer GIC in terms of shear bond strength.

***Keywords*---**papacarie duo, silver modified glass ionomer, resin-modified glass ionomer cement, shear bond strength.

Introduction

One of the most common chronic oral diseases worldwide, dental caries is a condition that damages the hard tooth structure. It is often identified by cavitation of the tooth as a result of the hard tooth structure weakening. (1) The idea of "extension for prevention" in dentistry has given way over time to "minimum invasive dentistry." Laser ablation, air abrasion, sono-abrasion, and Chemomechanical caries removal (CMCR) are examples of minimally invasive caries removal techniques that are frequently used.(2) The CMCR technique selectively removes caries-infected tissue while leaving intact caries-affected tissue.(3)

The Papacarie enzyme-based CMCR gel is one of the most widely used types. Compared to the traditional surgical approach, it is less invasive, more universally accepted, and equally effective. (2) Years have passed since the adoption of various restorative materials to retain form, function, and aesthetics while preserving missing tooth structure (4).Dental amalgam has long been used as a great and adaptable restorative material. Its numerous disadvantages include lack of aesthetics and the inevitable usage of mercury, which is thought to be detrimental to the patient's health. This prompts the hunt for better resources. (4)

A restorative material with the desired qualities was the goal behind the development of glass ionomer cement (GIC).In order to withstand different dislodging forces operating within the oral cavity, restorative materials must have a strong adherence to the dentinal surface for them to be clinically successful.(5) The three strengths that are used to quantify these forces are shear, tensile, and compressive. The ability of restorative material to move past tooth structure is known as shear bond strength. In terms of clinical relevance, it is quite significant. (6).Consequently, improved material-to-tooth bonding is implied by increased shear bond strengths. the aim of the study is to evaluate the shear bond strength of three GICs to dentin of primary teeth.

Materials and Methods

The present study was carried out in the Department of Pedodontics and Preventive Dentistry, Al Azhar university ,Cairo ,Egypt. A total of 45 extracted human primary molars that had cavity holes larger than 2 mm, occlusal caries that extended into the dentin, and were accessible with hand tools were gathered. For orthodontic or exfoliative mobility reasons, these teeth had to be excised. The teeth that were rejected were those with hypoplastic or hypomineralized teeth, teeth whose crowns broke during extraction, and teeth with any type of developmental defect.

After removing debris, an ultrasonic scaler was used to clean the teeth. According to the Occupational Safety and Health Administration's (OSHA) guidelines, all of the chosen teeth were utilized within three months of collecting and kept in saline (7) at room temperature until was used in study. Before the extraction process began, the patient's parent or guardian gave their informed consent. The Faculty of Dental Medicine for Girls at Al-Azhar University provided clearance for the research ethics committee.[P-PD-23-16]

The materials used in the study were Papacárie® Duo (Formula & Acao, Sao Paulo, Brazil)**,** Silver reinforced glass ionomer(“Riva SDI Dental Limited, Australia”)**,**Resin reinforced light cure glass ionomer(“Riva SDI Dental Limited, Australia”) Bulk fill glass hybrid restoration system(“Riva SDI Dental Limited, Australia”).

Collection of samples
Sample size calculation

An ANOVA test or a comparable non-parametric test will be used to compare the shear bond strength of three distinct modified glass ionomer restorations in primary teeth treated with papacarie. Based on a prior investigation by Maru et al. (2014)(7) and utilizing the G power statistical power Analysis software (version 3.1.9.4) to determine sample size, For the two-sided hypothesis test, a total sample size of 45 (subdivided into 15 groups) was adequate to detect a big effect size (f) = 0.48, with power (80%) and a significance level (5%).

Preparation of samples
Caries removal

Teeth were treated with Papacárie®Duo gel. Figure (1) Caries was removed using blue Papacárie® gel according to the manufacturer's directions. Papacárie® Duo.The completeness of removal of caries was judged by visual and tactile clinical criteria (smooth passage of the explorer and absence of a catch or a tug-back sensation).[6]) Figure (2)

Figure (1) Papacárie®Duo gel

Figure (2) caries removal via papacarie

Preparation of samples for shear bond strength

The 45 samples were verified to have an excavation site at least 3 mm width, being equal to the PVC (Poly vinyl catheter) tube diameter used in the bond test.[8]**.** The occlusal surface of 45 teeth was ground on a rotary grinding machine using abrasive diamond disc rotating at low speed with continuous water coolant until no remnant of enamel existed to produce a flat and smooth dentin surface. The direction of grinding was done perpendicular to the long axis of the teeth then another grinding was done using 600 then 800 grit. The specimens were washed and then dried with moist &oil free compressed air.

Mounting of teeth in acrylic blocks

The teeth were embedded vertically in cylindrical plastic syringe (2 cm height and 1.7cm internal diameter) using self cure acrylic resin After complete setting of acrylic resin, plastic syringes were removed and acrylic resin blocks 2cm height & 1.7cm width were obtained. Figure (3)

Figure (3) acrylic blocks

Restoration of samples

A PVC tube, Figure (4) (internal diameter 3mm, height 3mm was placed on dentin surface.

Sample grouping

The specimens were divided into three groups, each containing 15 teeth, based on type of restoration used.
Group I : Silver reinforced glass ionomer("Riva SDI Dental Limited, Australia"),
Group II: Resin reinforced light cure glass ionomer(" SDI Dental Limited, Australia")
Group III: Bulk fill glass hybrid restoration system("Riva SDI Dental Limited, Australia")

Grouping after caries removal by & type of restoration

Table (1) showing sample grouping

group I n=15	group II n=15	Subgroup III n=15
Caries removed by Papacárie® Duo & restored by riva silver	Caries removed by Papacárie® Duo & restored by riva light cured	Caries removed by Papacárie® Duo & restored by bulk fill hybrid

Every group is restored according to the manufacturer instructions. Finally we obtained cylinders of glass ionomer ready for shear bond strength testing. Figure(5)

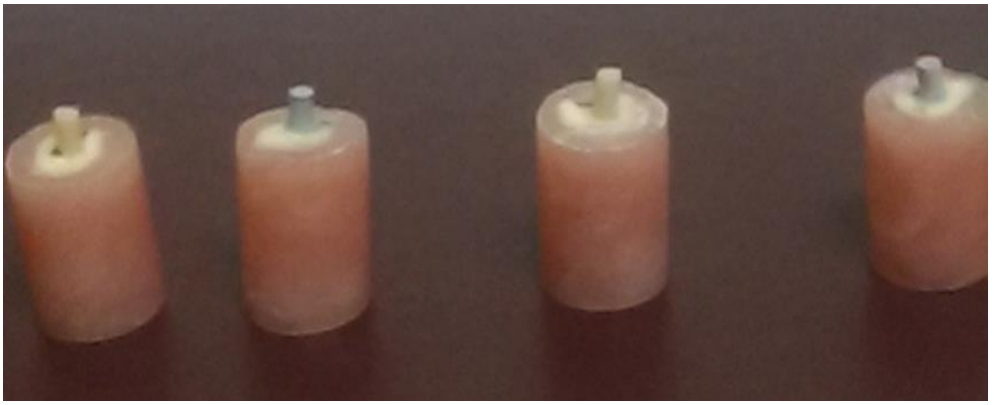

Figure (5) cylinders of glass ionomer bonded to dentin

Evaluation of shear bond strengths
Test procedure

The binding strength was assessed using a circular interface shear test. With a load-cell of 5 kN, each sample was placed separately on a computer controlled materials testing apparatus (Model 3345; Instron Industrial Products, Norwood, USA), and data were collected using computer software (Bluehill Lite; Instron Instruments). Samples were fastened using a specially made sample holder that was screwed onto the testing machine's lowest fixed compartment. A metallic rod with a beveled shape resembling a chisel attached to the upper moveable

compartment of the testing machine and moving at a cross-head speed of 0.5 mm/min was used to perform a shearing test utilizing a compressive mode of force delivered at the dentin-resin interface. Newtons were used to measure the load necessary for de-bonding.

Shear bond strength calculation

The load at failure was divided by bonding area to express the bond strength in MPa:

$$\tau = P/ \pi r^2$$

where ; τ =shear bond strength (MPa, P =load at failure(N)"
"π =3.14 and r =radius of glass ionomer disc(mm)"

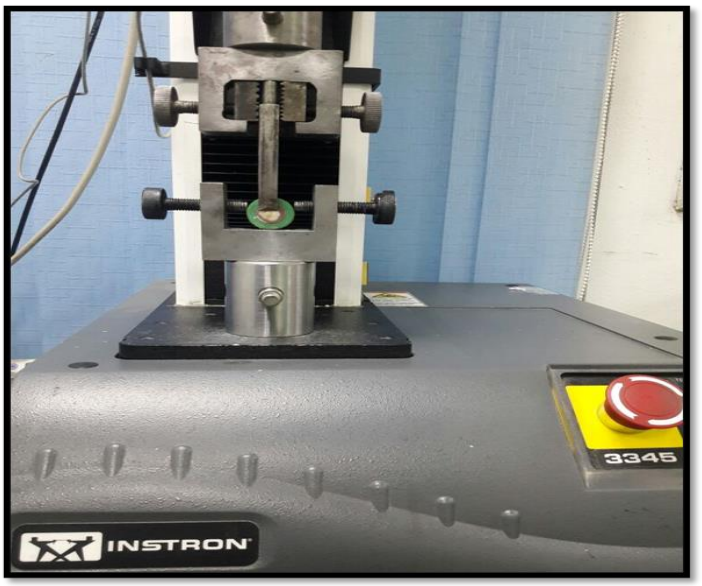

Figure (6): testing machine

Statistical Analysis

Then, using a commercially accessible software program (SPSS 20; SPSS, Chicago, IL, USA), statistical analysis was carried out.The mean, standard deviation (SD), and confidence intervals were used to display the values. The Shapiro test of normalcy and the Kolmogorov-Smirnov test were used to examine the data for normality. ANOVA was utilized to examine data that was parametric between groups, and for repeated pairwise comparisons, Bonferroni's post hoc test was employed. $P \leq 0.05$ was used as the significance threshold.

Results

The highest mean value (11.32 ±3.15) was recorded in group III treated with papacarie restored with hybrid bulk fill riva glass ionomer, followed by group II

treated with papacarie restored with resin reinforced light cured glass ionomer riva (5.53±3.33), with the lowest value (3.87±1.5) recorded in group I treated with papacarie restored with riva silver glass ionomer. The difference between groups was statistically significant (p=0.000). Post hoc test revealed no significant difference between group 1 I and group II (Table2)

Table (2) Descriptive statistics of Shear bond strength (MPa) and comparison between groups

Groups	Mean	SD	"95% Confidence Interval for Mean"		Min	Max	F	P
			Lower Bound	Upper Bound				
Gp I (riva silver glass ionomer)	3.87[b]	1.50	3.04	4.70	1.37	5.63	29.66	.000*
Gp II (resin reinforced LC glass ionomer riva)	5.53[b]	3.33	3.68	7.37	1.15	10.36		
Gp III (hybrid bulk fill riva glass ionomer)	11.32[a]	3.15	9.58	13.07	8.39	21.00		

Significance level p≤0.05, *significant level

Table (3) Detailed results of Bonferroni post hoc test for pairwise comparison of Shear bond strength (MPa) between groups

(I) Groups	(J) Groups	Mean Difference (I-J)	SD	P	95% Confidence Interval	
					Lower Bound	Upper Bound
Gp I (riva silver glass ionomer)	Gp II (resin reinforced glass ionomer riva)	-1.65900	1.02	.33	-4.19	.88
	Gp III (hybrid bulk fill riva glass ionomer)	-7.45400-*	1.02	.00	-9.99	-4.92
Gp II (resin reinforced glass ionomer riva)	Gp I (riva silver glass ionomer)	1.65900	1.02	.33	-.88	4.19
	Gp III (hybrid bulk fill riva glass ionomer)	-5.79500-*	1.02	.00	-8.33	-3.26
Gp III 3 (hybrid bulk fill riva glass ionomer)	Gp I (riva silver glass ionomer)	7.45400*	1.02	.00	4.92	9.99
	Gp II (resin reinforced glass ionomer riva)	5.79500*	1.02	.00	3.26	8.33

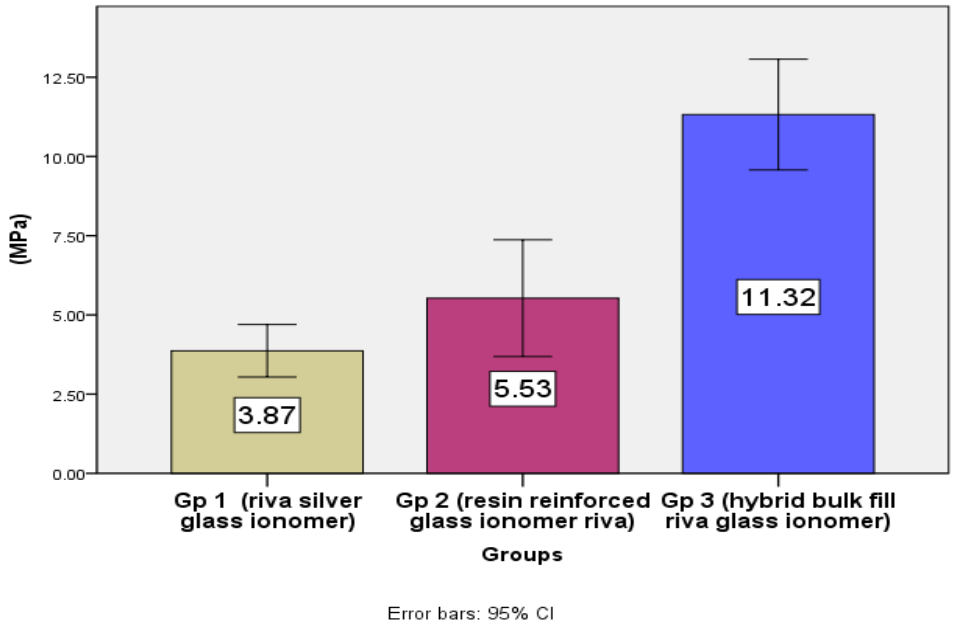

Fig. (7) Shear bond strength (MPa) in different groups

Discussion

For as long as there have been dental researchers studying pediatric dentistry, one of their main goals has been to develop new techniques for removing tooth decay. The ability of CMCR agents to distinguish between infected and affected dentin sets them apart from other advanced methods for caries removal. This makes them a minimally invasive technique that avoids needless removal of healthy tooth structure, reduces or eliminates the need for local anesthesia, is cost-effective, and requires less equipment than all other advanced methods combined. (9) (10)

Because of all these advantages, it is quite commonly used, particularly in the field of pediatric dentistry and hence it was utilized in this study. Papacarie eliminates the smear layer, as opposed to the traditional caries eradication approach that creates a smear layer that influences the bonding mechanism. In cavities treated with Papacarie, the extremely uneven surfaces or high roughness preserved in the absence of a smear layer may offer an appropriate surface for effective adhesion in strong bonding with restorative materials; consequently, greater shear bond strength was reported 11). Using a gel that both lubricates the caries removal process mechanically and has a chemical impact on the carious dentine that is diseased, a CMCR system is a modified hand excavation technique (12).

The experiment was conducted using normal clinical criteria to assess the completeness of caries eradication in everyday clinical practice situations. It's been proposed that standard tactile and optical standards are adequate to guarantee the majority of diseased dentine is removed (13) Because the use of dyes does not offer a comprehensive, objective approach for assessing caries

eradication, they were not employed. The deeply penetrating dye colors both the porosity afflicted dentin and the carious infected dentin. Due to the porosity of primary dentin, dye testing would not be appropriate for determining total removal (14).

GIC systems have become more important as dental restorative materials for children because they are easy to use, practical, leach fluoride, have superior biocompatibility, and adhere to teeth. Because GIC systems are flexible and easy to employ, they have great biocompatibility, leach fluoride, and attach to tooth structure, making them significant dental restorative materials for use in youngsters. (2016)

One may consider glass-ionomer cement (GIC) to be a basic filler; it is well-known, reasonably priced, and easy to apply. They self-cure, are typically put in large fills without the need for an adhesive, and don't require sophisticated dental tools.Thus, GIC systems were employed in this work in compliance with Verma V et al.'s 2020 utilization of Type IX glass-ionomer cement (17). A key component of modern restorative treatment is the materials' ability to adhere to tooth structure. Micro leaks and secondary cavities are avoided. The measurement of tensile and shear bond strength (SBS) is typically used to assess adhesives. Thus, the evaluation of shear bond strength (SBS) was used. (12) These materials were chosen for the study because they represent novel bioactive ion glass technology in pediatric dentistry restorative applications.

According to this study, hybrid bulk fill glass-ionomer cements are a better option for restorative materials than resin-modified LC glass-ionomers since they don't have the same issues with residual HEMA, which is the main cause of restorations made using resin-modified glass-ionomer cement.(18)

According to the findings of a prior study that supported this one, pre-etching Riva glass ionomer cement (SDI) alone with 10% polyacrylic acid for 30 s or 37% phosphoric acid for 5 s increased the material's shear strength. However, no statistically significant differences were observed when comparing the other materials tested in that study.(19).

Compared to Group I (3.87±1.5 MPa) and Group II (5.53±3.33), Group III (11.32 ±3.15 MPa) had a substantially higher shear bond strength (mean ± SD). This outcome was consistent with a 2012 research by Sabah A. Ismail and Shaymaa SH, which revealed that RMGIC (light cure) had considerably greater SBS than traditional GIC.(20) Standardizing all the sample characteristics, such as the lesions' form, consistency, depth, kind, location, and activity status, was not possible due to the use of real lesions in this investigation. Therefore, to assess these in vitro outcomes seriously, long-term clinical investigations are needed.

Conclusion

Shear bond strength of Papacarie treated teeth restored with Bulk fill glass hybrid GIC showed higher values than those restored with Silver reinforced and light cured GIC

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