Comparison of the Shear bonding Strength of ION-Z GIC to a Resin Composite Using Different Adhesive Systems: RCT Study

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Research article

Keywords: ION-Z GIC, Shear bonding strength, Resin Composite, Self-etching bond, Total-etching bond

Posted Date: May 3rd, 2021

DOI: https://doi.org/10.21203/rs.3.rs-31621/v2

Abstract

Background:

In restorative dentistry we usually use Sandwich Technique for posterior restorations where GIC is placed below and a resin composite is placed over it. The bonding strength between these two materials are low. We are looking for the best adhesive system to put it in between. We think that the self-etching bond will give the best bonding strength between them whereas total etch will give lower bonding strength than self-etching system.

Methods:

ION-Z GIC was bonded to resin composite by using two different bonding agents. The thirty specimens used were prepared by using acrylic blocks with holes in each hole to retain the ION-Z GIC. The specimens were randomly divided into three groups:

Group I: Control group.

Group II: Total-etch adhesive was applied and cured over ION-Z GIC.

Group III: Self-etch adhesive was applied and cured.

The composite resin placed over the ION-Z GIC and cured.

The shear bond strength was measured by shearing of the bonded specimens on Universal Testing Machine (Model 114) using speed of 0.1mm / minute.

The reading was tabulated and subjected to statistical analysis using ANOVA and Tukey's test.

Results:

The test showed statistically significant difference between Group III and Group I and between Group III and Group II. Group III had the highest shear bonding strength.

Conclusion:

Self-etch adhesive agent produces have better shear bond strength to ION-Z than total-etch adhesive and to the group without any bonding agent.

Background

In modern dental practice, because of the advances in adhesive techniques, an increased focus on the aesthetic qualities of dental restorations and adoption of a minimally invasive dentistry approach, have a great influence on the treatment plan in the posterior and anterior regions.[1,2]

Because of posterior composites advantages such as single visit and short application time, aesthetics, ability to protect dental tissues during preparation, and is cheaper when compared to indirect methods, it has been generally preferred for back tooth restorations. [3] A lot of negative results are generally based on polymerization shrinkage stress such as poor marginal adaptation, marginal discoloration, white line formation around the restoration, tubercle fractures, microleakage, secondary caries, and postoperative sensitivity in composite resin restorations;[4–5] thus, various attempts have been made to achieve low polymerization shrinkage in restorative materials.[6]

Furthermore, glass ionomer cement (GIC) can be used instead of composite resins in the conservative restoration of caries lesions in the posterior region. The advantages of GIC are having a similar thermal expansion coefficient to natural tooth tissue, physicochemical adhesion to tooth tissues, fluoride release, biocompatibility, low shrinkage, low marginal leakage, anti-caries properties on the restoration edges, and increased remineralization in adjacent proximal caries.[7,8] However, conventional GIC has disadvantages such as low fracture and abrasion resistance, inadequate color stability, moisture sensitivity, and poor aesthetic properties. These disadvantages restrict its use in areas exposed to intensive chewing forces and weaken the physical properties of the restoration.[9]

ION-Z GIC is a glass ionomer-based radiopaque self-curing material with bactericidal and dentinogenic active ingredients, with induction of dentinal new formation, for the control of caries.It is indicated for the ART technique mainly due to its bactericidal power, but all the other features work together in leading to this indication: release of fluoride ions, fast-acting, excellent viscosity, high mechanical strength.It is reinforced with zinc has lower shrinkage during curing and excellent hygroscopic expansion: leading to a perfect marginal seal and it frees fluoride ions and acts as a rechargeable reservoir of this ion. In addition, it has high mechanical strength and chemical adhesion to enamel and dentin and high smoothness of the surface: providing greater comfort to the patient and favorable aesthetics.

By developing of adhesive systems, this disadvantage might by reduced, as they do not require etching and rinse procedure [10]. Self-etching systems combine the functions of adhesive components and primer and don’t need an etch and rinse phase, which decreases clinical application time and reduces technique sensitivity.[11] In addition, the infiltration of the resin occurs simultaneously with the self-etching process, which reduces the risk of a discrepancy between both processes.[11] The self-etch effect should be ascribed to non-rinsing, polymerizable monomers to which one or more carboxylic or phosphate acid groups are grafted[10].

There is limited literature on the bond strength of ION-Z to composite resin with adhesive agents in between. Newer adhesive agents have undergone various modifications to improve the bond strength between the tooth and composite resin. However, there are very few studies conducted to compare the bond strength between ION-Z GIC and the composite, with different adhesive agents applied on the ION-Z GIC. Hence, the present study was conducted to evaluate and compare the shear bond strength of ION-Z GIC to composite resin, using different generations of bonding systems applied on ION-Z GIC.

Methods

ION-Z GIC was bonded to a resin composite by using two different bonding agents, a Total-etch adhesive and a Self-Etch adhesive.

Preparation of the specimens:

The thirty specimens (sample size) used in this investigation were prepared by using acrylic blocks. A total number of 30 acrylic blocks was prepared using a cuboidal plastic mold. In each block, four wells of 6 mm diameter and 2 mm depth were prepared by drilling holes in each block, to retain the ION-Z GIC (FGM, Joinville, Brazil). With the aid of disposable micro applicators, one drop of the liquid on the walls of the hole was applied for 10 seconds, then the holes were washed (according to the manufacturer's instructions). The holes were then filled with self-cure ION-Z GIC by mixing it according to the manufacturer’s instructions (one scoop of powder mixed with one drop of liquid) and covering the holes with glass plates to produce a smooth surface. The glass plate was carefully removed to ensure that the glass ionomer surface was smooth and not pitted. The specimens were randomly divided into three groups of 10 specimens each. The groups were:

Group I: Acts as a control group, no adhesive agent was applied between the ION-Z GIC and resin composite.

Group II: ION-Z GIC with a thin layer of total-etch adhesive (Dentkist, South Korea, Korea) was applied according to the manufacturer’s instructions and cured, and then a cylinder of composite resin was added and cured over the specimen.

Group III: Same as group II, but a thin layer of self-etch adhesive (Dentkist, South Korea, Korea) was applied and cured over ION-Z GIC.

Immediately following this procedure, a transparent plastic ring, 4 mm in height, with a 5 mm internal diameter, was centered over the ION-Z GIC. The composite resin (FGM, Joinville, Brasil) was condensed into a transparent plastic ring, using an incremental curing technique, above the ION-Z GIC substrate, and all sides of the specimen were cured to ensure complete curing of the material. Following the curing, the plastic ring was removed. All the procedures were conducted at room temperature. The specimens weren't stored in any solution before testing.

Permission was taken from the faculty of Dentistry to use the shearing measure machine at the Faculty of Mechanical and Electrical Engineering. The shear bond strength was measured by shearing of the bonded specimens on Universal Testing Machine (Model 114) (TesT GmbH, Erkrath, Germany) which was located in the strength materials lab, using the speed of 0.1mm / minute. The shearing apparatus was constructed to grip the acrylic block, and a wedge blade system was designed to apply a shear force on the adhesive interface.

The reading was tabulated and subjected to statistical analysis using ANOVA and Tukey's test on SPSS 24. Mean and standard deviation were calculated for each group by using the ANOVA test and intergroup comparison was done by the multiple comparison test – Tukey's test, which revealed a statistical significance among the groups ($P<0.05$).

Results

The mean shear bond strengths were calculated for each group. In group I: the minimum value 5 MPa and maximum value 7.92 MPa. In group II: the minimum value 5.37 MPa and the maximum value 9.32 MPa. In group III: the minimum value 8 MPa and the maximum value 11.47 MPa (Table 1).

The maximum shear bond strength values were recorded for Group III, where the self-etch adhesive was used, with a mean value of 9.151 MPa and a standard deviation of 1.26. On the other hand, group I recorded minimum shear bond strength, with a mean of 6.158 MPa and a standard deviation of 0.912. Group II with total-etch adhesive recorded a mean shear bond strength of 6.966Mpa and a standard deviation of 0.976. (Table 2).

The shear bond strengths (MPa) for the groups: (Table 1)

Group I	Group II	Group III
7.92	9.32	10.48
5.24	6.8	11.47
5.74	5.37	10
5	6.47	8
5.84	6.43	8.08
6.36	6.4	8
6.52	7.66	8.2
7.52	7.16	8.04
6.14	7.17	10.14
5.3	6.88	9.1

Table 1

ANOVA					
strength bonding					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	47.925	2	23.963	19.823	.000
Within Groups	32.638	27	1.209		
Total	80.563	29			

Table 2

Intergroup comparison was conducted by using the multiple comparison test (Tukey's test), which revealed a statistically significant difference among the groups. (Table3)

Multiple Comparisons							
Dependent Variable: strength bonding							
	(I) bonding system	(J) bonding system	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	no bonding	total etching	-.80700-	.49170	.246	-2.0261-	.4121
		self-etching	-2.99200-*	.49170	.000	-4.2111-	-1.7729-
	total etching	no bonding	.80700	.49170	.246	-.4121-	2.0261
		self-etching	-2.18500-*	.49170	.000	-3.4041-	-.9659-
	self-etching	no bonding	2.99200*	.49170	.000	1.7729	4.2111
		total etching	2.18500*	.49170	.000	.9659	3.4041
LSD	no bonding	total etching	-.80700-	.49170	.112	-1.8159-	.2019
		self-etching	-2.99200-*	.49170	.000	-4.0009-	-1.9831-
	total etching	no bonding	.80700	.49170	.112	-.2019-	1.8159
		self-etching	-2.18500-*	.49170	.000	-3.1939-	-1.1761-
	self-etching	no bonding	2.99200*	.49170	.000	1.9831	4.0009
		total etching	2.18500*	.49170	.000	1.1761	3.1939

Table 3

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

The test showed a statistically significant difference between Group III and Group I.

On the other hand, there is no difference between Group II and Group I.

Discussion

Glass Ionomer Cement has been used as a liner restoration in the posterior teeth due to its chemical bonding with the teeth. Nevertheless, because of its weak resistance toward the occlusal force, resin composite was used as a final restoration because of its cosmetical and physical properties.

On the other hand, we still have to find a way to get the best bonding strength between those two materials. Thus, we did this RCT study.

Thirty specimens were prepared with ION-Z and resin composite which was bonded by using two different kinds of bonding agents and the bond strength was measured.

The result of the study has concluded that a self-etch adhesive agent produces better shear bond strength to ION-Z, which is highly significant as compared to a total-etch adhesive and to the group without any bonding agent.

In the literature, there are no clear guidelines about shear force limits, but in fact, adhesives should allow good bonding performance in order to sustain masticatory forces (5-10 MPa). On the other hand, adhesion forces should not be too strong in order to avoid enamel and dentin loss in case of injury (40-50 MPa). Therefore, the ideal biomaterial should have bonding forces included in the interval of 5-50 MPa, even if these limits are mostly theoretical.[12]

Thus, the proper bond strength between resin composite and ION-Z is necessary for the success of the restoration. Applying self-etch adhesive over ION-Z creates a stronger bond of composite resin to ION-Z compared with total-etch adhesive.

Our study showed that self-etch adhesive has a higher shear bond strength between the ION-Z and composite. Similar results were achieved by Kandaswamy et al. who reported that the mild self-etch bonding provided higher shear bond strength.[13] Some previous studies showed that using self-etch adhesive with a lower pH (1-0.8) created lower shear bond strength.[13,14]

Stronger acid neutralizes more cations, resulting in salt crumps formation. Therefore, the structure of the GIC is weakened and fragile, thus consequently the bond will be weakened.[13,15]

This research also found that self-etch adhesives improved the bond between the composite and ION-Z GIC compared with the total-etch adhesive.

A similar result was achieved by Arora et al. who reported that the self-etch adhesive caused a stronger shear bond between the composite and RMGIC.[16] Similar result was achieved in a study conducted by Chandak et al. on the same issue.[17] Another study also showed that using self-etch adhesive on the surface of RMGIC had the potential of creating a better bond strength with the resin composite.[18] This might be due to the acidic pH of self-etch adhesive. Etching the surface of GIC with 37% phosphoric acid leads to the dissolution of the lower layers of the GIC matrix and therefore, would decrease the cohesive strength of the GIC which subsequently can affect the bond strength of the composite and GIC adversely.[18,19]

From the results of the present study, it can be concluded that the application of self-etch bond agents improves the wettability of ION-Z to adhere to composite resin, thus promoting a strong shear bond

between ION-Z and the resin composite.

Declarations

Funding:

No funding was received. The authors confirm the independence of this research completely from any governmental or non-governmental authorities or local /international organizations and the research is self-funded by Sana Lala.

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Contributions:

SL: Did the research, wrote the background, methods, results, discussion, and conclusion section, designed the chart. TL: participated as the research supervisor, completed the statistical analysis, edited and checked up the research manuscript. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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Abbreviations: GIC: Glass Ionomer Cement. RCT: Randomized Controlled Trial. RMGIC: Resin Mortified Glass Ionomer Cement

Ethical Declarations:

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors. The research ethical approval was obtained from the scientific committee at the faculty of Dentistry.

Consent to publication: Not applicable.

Competing interests: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Availability of data and materials:

All necessary data are presented within the manuscript. All other materials and data are available upon request. For any more details regarding the data of this research please contact the corresponded author

– Dr. Sana Lala.

Acknowledgments: This research could not be completed without the help of the Faculty of Mechanical and Electrical Engineering, Damascus University.

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