

EVALUATION OF SHEAR BOND STRENGTH OF COMPOSITE RESIN BONDED TO GLASS IONOMER CEMENT AND RESIN MODIFIED GLASS IONOMER CEMENT

¹BILAL ZAMAN BABAR, ²NAYAB AMIN, ³MEHREEN ZIA

ABSTRACT

The sandwich or laminate technique is recommended method for resin composite restorations. The bond between GIC or RMGIC and dental composite is main factor affecting retention, sealing and durability of the sandwich restorations.

This laboratory based experimental study compared and evaluated shear bond strength of composite resin bonded to conventional GICs and RMGICs using simple etch & rinse technique and with or without total etch adhesive.

The shear strength of conventional GICs (Fuji IX and Chemfil rock) and RMGICs (Fuji Plus and Fuji II LC) bonded to dental composite was investigated at 4 weeks. Thirty discs (10mm diameter x 2mm height) for each conventional GIC and RMGIC were fabricated by using polyvinyl siloxane (PVS) moulds. The discs of Fuji IX, Chemfil Rock and Fuji plus were self-cured (15 minutes) whereas discs of Fuji II LC were light cured (20 sec). These discs were inserted into cold cure acrylic resin in PVS moulds to form acrylic blocks. These blocks were wrapped in moist paper and put in 100 % humidified bags for 4 weeks at 37 °C. Total 120 cylinders of composites having diameter of 7mm and height of 5mm were prepared. The surfaces of GICs and RMGICs discs were initially treated with or without acid etching and acid etching plus adhesive before placement of composite cylinders. Shear bond strength of each sample was measured after 4 weeks via Instron machine (M 30 K) at 0.5mm/min speed and load of 1 KN was used to fracture the sample. Means and standard deviations were calculated and t-test was used to analyse statistical differences.

Higher shear bond strength values for RMGICs with acid etchant plus bonding agent were observed as compared to GICs whereas GICs showed higher shear bond strength values with acid etchant alone. While RMGIC (Fuji II LC) showed low value with acid etchant alone and highest with the addition of bonding agent. But Fuji Plus showed a high value than both GICs with acid etchant alone.

The conclusion was that RMGICs bonded to composite with the use of both acid etchant and bonding adhesive had greater values of shear strength than GICs. While, GICs had higher bond strength values with acid etching only than Fuji II LC.

Key words: Composite resin, glass ionomer cement, resin modified glass ionomer cement, sandwich technique

This article may be cited as: Babar BZ, Amin N, Zia M. Evaluation of Shear bond strength of Composite resin bonded to Glass ionomer cement and Resin modified glass ionomer cement. Pak Oral Dent J 2020; 40(2):92-97.

¹ **For correspondence:** Dr Bilal Zaman Babar, BDS, MSc, HOD & Assistant Professor Dental Bio-materials, Rehman College of Dentistry, Peshawar. Email: bilalbabar1@hotmail.com Postal address: Rehman College of dentistry (RMI- RCD admin block 2nd floor), phase 5, Hayatabad, Peshawar. Mobile number: 03349125240, Land line: 091-5838333- Ext-4235.

² Dr Nayab Amin, BDS, MPhil, Senior Demonstrator Dental Bio-materials, Rehman College of Dentistry, Peshawar.

³ Dr Mehreen Zia, BDS, MPhil, Assistant professor Dental Materials, Peshawar Dental College, Peshawar.

Received for Publication: Sept 19, 2019
First Revision: Nov 11, 2019
Second Revision: Nov 18, 2019
Approved: Jan 10, 2020

INTRODUCTION

The resin composite has gained popularity due to improved mechanical properties and superior esthetics.¹ The weak bond strength to dentin is thought to be a major drawback of resin composite. The use of materials having low modulus of elasticity such as glass ionomer cements (GIC) and resin modified glass ionomer cements (RMGIC) beneath composite fillings in so called sandwich or laminate or bilayered technique improves bond strength to dentin.²

In conventional sandwich restoration, presented by McLean, chemical cure conventional GIC was used. The concept was to develop interlocking mechanism between both composite and GIC.³ This bond was weak and several techniques have been reported for the enhancement of bond strength by applying coating layer of resin or phosphoric acid on unset or fully set GIC.² The bond strength was fairly enhanced but cohesive failure of GIC due to limited tensile strength was reported. Also, the absence of chemical bond between GIC and composite due to different setting mechanisms could be the reason.⁴ The increased bond strength values can be achieved by using RMGICs or etching the surface of GIC after maturation but this needs extra visit to dental clinic for completion of restoration.^{5,6}

The use of RMGIC under composite resin restorations in laminate techniques is suggested due to superior mechanical properties including greater bond strength and moisture insensitivity in setting process.⁷ The improvement can be accredited to chemical bond formation between RMGIC and composite via copolymerization of hydroxyethyl methacrylate monomer. Moreover, this possibly will be providing covalent bonding between bonding resin and polyacid chains consisting unreacted monomer in polymerized RMGIC. The quality and longevity of laminated restorations can be increased by the use of RMGIC.^{5,8} Therefore the objective of the study was to assess the shear bond strength of GICs and RMGICs bonded to dental composite using simply etch & rinse technique and total etch adhesive. The null hypothesis was that there was no difference in shear bond strength between GICs and RMGICs bonded to dental composite resin.

METHODOLOGY

Materials purchased for the study are given in table 1:

Sample preparation

Shear bond strength samples were made by using sheets of polyvinylsiloxane (PVS) impression⁹ in the metal moulds (Fig 1). The thickness of PVS sheet for all GICs & RMGICs samples was 2mm whereas it was 5mm for composite samples. The moulds of all GICs discs were prepared with a dimension of 10mm diameter x 2mm height¹⁰ and the moulds of composite cylinders were prepared with a dimension of 7mm diameter x 5mm height⁹ (Fig 2). The discs of GICs (Fuji IX, ChemFil Rock) and RMGICs (Fuji Plus) were prepared by activating capsules one at a time and placed in a roto mix as instructed by manufacturers for recommended time duration. Each capsule was positioned in an extruder after mixing and material was taken out and placed in the split mould with an excess amount. Then excess material was removed by applying finger pressure on

the metal plate and acetate strip. Finally the apparatus containing the samples of Fuji IX, ChemFil Rock and Fuji Plus was clamped and was allowed to set in an incubator at a temperature of 37°C for a period of 15 mins. The light cured RMGIC i.e Fuji II LC discs were prepared by appropriate curing all the sides using light emitting diode (LED) for a period of 20 seconds. Prior to curing of each sample, the light intensity was tested to make sure it was 1200 mW/cm² (by manufacturers recommendation) using radiometer (Demetron). A total of 10 samples of each GIC & RMGIC were fabricated.

Discs were then inserted in an acrylic resin (cold cure) to form blocks of acrylic in a PVS mould⁴. This was done by initially placing the disc inside the mould and then a mixed cold cure resin was flown into the mould till top and kept in a fridge for setting in order to prevent desiccation. Then these samples of acrylic blocks with embedded discs were kept in an incubator keeping a temperature of 37°C till not used for testing. Small plastic bags with a damp paper were utilized to maintain 100 % humidity. Before placing the composite cylinders on to the discs of GICs and RMGICs, the surface of discs were manipulated by one of 3 ways:

- Without acid etching and bonding adhesive application (used as control)
- Application of only acid etchant (37.5 % H₃PO₄)
- Application of both acid etchant and adhesive agent

The cylinders as a mould of polyvinyl siloxane were positioned at centre and on top of the discs of GIC and RMGIC. The etching gel was used for 15-30 secs (according to company's instruction). Cleaned the area, light air applied and the bonding agent application with light brushing and curing for a period of 10 secs. Incremental filling of dental composite was done and each increment was light cured. Then the siloxane mould was cut and removed, doing re-curing to ensure complete curing all over. Then the samples were kept for storage for four weeks in incubator at 37°C keeping 100 % humidified condition in a bag with damp paper¹¹.

Inclusion criteria: The samples included were free from porosities, surface defects, stored in 100 % humidity, acrylic resin blocks placed in refrigerator and jig testing at the center of the samples.

Exclusion criteria: The samples excluded were with porosities, surface chipping, cracks, unstored samples and jig not applying pressure at the center and deviated slightly.

Shear bond strength Testing: Shear bond strength evaluation was carried out using shear bond strength jig in an Instron testing machine (Model 5567 - 30KN, USA) by holding knife edge side of chisel in a special fixture at interface between GIC/RMGIC &

composite and applying 1 KN of shear load and speed of 0.5mm/min¹² (Figure 3 and 4). Load was calculated by noting the load in mega Pascal that caused fracture at the centre of the sample and ultimately shear bond strength was evaluated using equation; Bond strength = Maximum load/bonded area.

Statistical analysis

Microsoft excel 2013 was used to calculate and manage data for shear bond strength. Utilizing equation, load was noted in Newton and changed to Mega Pascal (MPa). Considering shrinkage a diameter of around 7mm was changed to the values of radius and meter. Formula for Area was πr^2 and radius was 3.5 mm, 3.25 mm and 3mm. The calculation was done to obtain means & standard deviations and histogram was designed for only acid etching and acid etchant & bonding agent. Analysis was carried out by applying t- test for comparison between the samples treated with only acid etchant, acid etchant with and without bonding agent. Analysis performed for the paired two samples for average with two tail and unequal variance. Thus the possibility for shear bond strength was found, calculated and designed. In control, there was no bonding between the bases of GICs/RMGICs to resin composite.

RESULTS

The results are shown in table 2 and 3 as follows:

The results after four weeks period (Figure 5) showed that self-cured Fuji plus (6.18 ± 2.58 MPa) had maximum values of average shear bond strength. Conventional GICs showed low values i.e. Chemfil Rock (4.61 ± 1.19 MPa) & Fuji IX (3.69 ± 1.06 MPa). Surprisingly minimum values were seen for light cured RMGIC i.e. Fuji II LC (3.04 ± 0.98 MPa). A significant statistical difference (P < 0.05) was seen for the values of only acid etching between the conventional GICs and RMGICs and between the two RMGICs. Greater values were for conventional GICs compared to RMGICs but Fuji plus achieved maximum.

Regarding acid etching and bonding agent light cured RMGIC i.e. Fuji II LC (9.98 ± 3.15 MPa) presented maximum values of average shear bond strength. Low values seen for self-cured RMGICs Fuji Plus (7.42 ± 1.65 MPa). Conventional GICs had further low values, Fuji IX (7.08 ± 3.45 MPa) and minimum values for Chemfil Rock (6.55 ± 1.57 MPa). A significant statistical difference (P < 0.05) was seen for the values of acid etching and bonding agent between the conventional GICs and RMGICs. Greater values were for acid etching and bonding agent compared to only acid etching. But, difference between the conventional GICs and RMGICs with bonding agents was not significant (P > 0.05) without Chemfil rock/Fuji II LC but significant

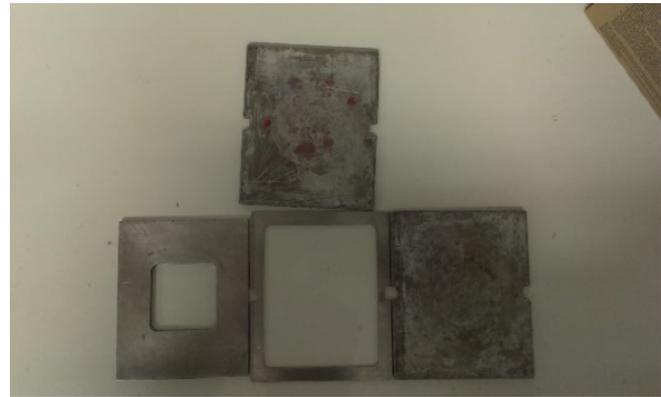


Fig 1: Metal moulds



Fig 2: PVS Sheets, disc moulds, cylinder moulds in petri dish, gun

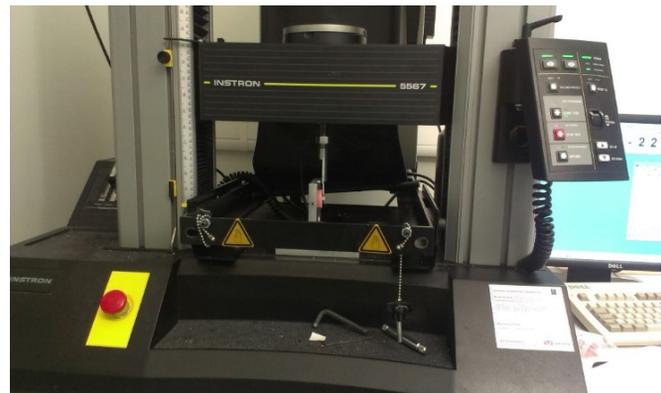


Fig 3: Instron Machine with Jig

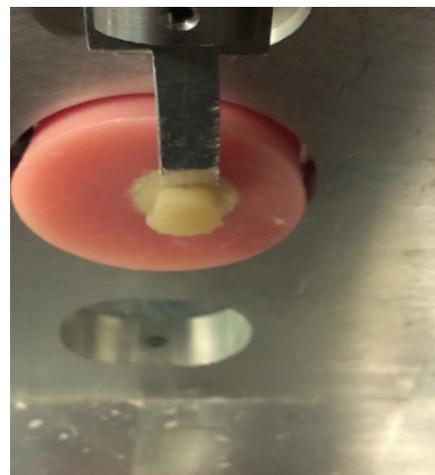


Fig4: Chisel at interface

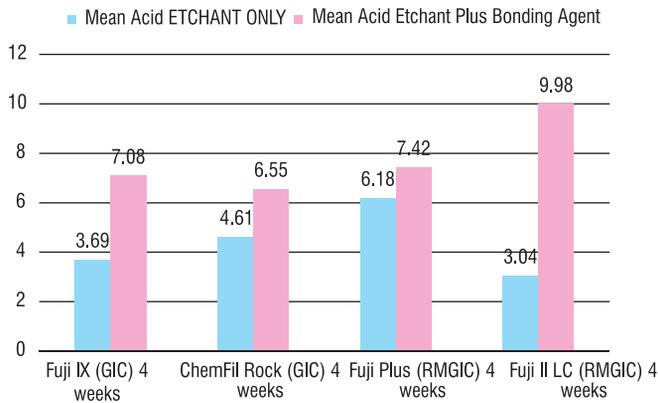


Fig 5: Shear Bond Strength of Conventional GICs & RMGICs



Fig 6: Samples containing Cohesive & Adhesive fracture

TABLE 1: MATERIALS USED IN THIS STUDY

Materials	Manufacturer
Fuji IX Capsules (Conventional GIC)	GC Corporation Tokyo Japan
ChemFil Rock Capsules (Conventional GIC)	Dentsply DeTrey GmbH Germany
Fuji II LC Capsules (Light Cured RMGIC)	GC Corporation Tokyo Japan
Fuji Plus Capsules (Self Cured RMGIC with UDMA)	GC Corporation Tokyo Japan
XRV HERCULITE ENAMEL (Dental composite material)	Kerr Italla S.r.l
Optibond Solo Plus (Total-Etch Adhesive)	Kerr Italla S.r.l

TABLE 2: SHEAR BOND STRENGTH OF GICS & RMGICS AT 4 WEEKS

Samples	No of Samples	Values	
		Average (MPa)	Standard Deviation
Fuji IX (conventional GIC) only Acid etchant	10	3.69	1.06
Acid etchant + Bonding Agent	10	7.08	3.45
Chemfil Rock (conventional GIC) Only Acid Etchant	10	4.61	1.19
Acid Etchant + Bonding Agent	10	6.55	1.57
Fuji II LC (Light cured RMGIC) Only Acid Etchant	10	3.04	1.04
Acid Etchant + Bonding Agent	10	9.98	3.15
Fuji Plus (self-cured RMGIC) Only Acid Etchant	10	6.18	2.58
Acid Etchant + Bonding Agent	10	7.42	1.65

between the two RMGICs ($P < 0.05$) that presented RMGICs with the use of acid etching and bonding agent had greater values compared to conventional GICs. All of the cohesive fractures (failures) happened in GICs and not in dental composite (Figure 6).

DISCUSSION

An adequate bond strength is important for the longevity of sandwich restorations.¹³ Conventional GIC and RMGIC is suggested beneath dental composite but

both differ in setting reaction, bonding mechanism and moisture sensitivity to materials.³ The larger dimensions were selected for GICs/RMGICs discs as compared to small composite cylinders to simulate the clinical situation. Control group presented no adhesion between the bases (GICs/RMGICs) and dental resin composite. After 4 weeks, the group for GICs and RMGICs treated with acid etching only showed less bonding values (particularly Fuji II LC) that presented with a lowest mean shear bond strength of 3.04 MPa compared to the

TABLE 3: MODE OF FRACTURE

Samples	No. of Samples	Adhesive Frac- ture	Cohesive Frac- ture	Mixed Fracture
Fuji IX (Only Acid Etchant)	10	10		
Fuji IX (Acid Etchant + Bonding agent)	10		10	
Chemfil Rock (Only Acid Etchant)	10	8	2	
Chemfil Rock (Acid Etchant + Bonding agent)	10		9	1
Fuji II LC (Only Acid Etchant)	10	9		1
Fuji II LC (Acid Etchant + Bonding agent)	10		10	
Fuji Plus (Only Acid Etchant)	10	8	1	1
Fuji Plus (Acid Etchant + Bonding agent)	10		10	

group treated with acid etching followed by bonding agent with a significant difference ($P < 0.05$). So, RMGIC showed low values of bonding, therefore, acid etchant decreased the strength and is similar to the study of Rosen et al¹⁴ suggesting that acid etchant should not be used for treating the surface of RMGIC.

The values after four weeks for the Fuji Plus treated with only acid etchant were higher than Chemfil Rock having values of 6.18 MPa and 4.61 MPa respectively. This result clarifies that Fuji Plus exhibited increased bond strength as compared to Chemfil Rock because of luting nature and comprising of urethane dimethacrylate (UDMA) as stated by manufacturer (GC Corporation, Tokyo Japan). Moreover, mean values of shear strength with acid etching & adhesive were higher for RMGIC when comparing to GICs having significant statistical difference ($P < 0.05$) that is similar to the results of Navimipour et al⁵ stating that RMGIC consists of resin portion which is precisely similar to dental composite, therefore, resulted in improved bonding. So, the results of the present study seems to be a bit close to the accuracy as was assumed before starting the experiment. The samples were saved at 37°C as this temperature mimic the oral environment and is according to the methods used by Chandak et al¹⁵ and Arora et al in their studies.¹⁶

The samples treated with only acid etchant exhibited adhesive fracture, whereas the samples that were treated with both acid etching and adhesive agent presented cohesive fracture in GICs/RMGICs surfaces at four weeks. This observation was similar to the findings of Rosen et al¹⁴ revealing that cohesive failure in RMGIC was due to bonding agent used. This cohesive failure was noticed along with an increased

bond strength values. These findings were also similar with the study done by Taher & Ateyah that observed cohesive fracture in RMGIC.¹² This explains that cohesive fracture in the current study presented better bond strength between bases and resin composite.

CONCLUSION

The shear bond strength of GICs had high values with only acid etching except for self-cured RMGIC (Fuji Plus) presenting the higher values. Both GICs and RMGICs presented higher values with the addition of bonding agent and maximum for Fuji II LC. Both GICs & RMGICs revealed lower bond strength as well as adhesive fracture with acid etchant alone and minimum values for light cured RMGICs. Bond strength improved for both GICs (Chemfil rock) and RMGICs (Fuji Plus) with the use of bonding agents and highest values for light cured RMGIC. All GICs were noted with comparatively low values of bonding strength with the use of acid etching plus adhesive agent than RMGIC.

REFERENCES

- 1 Becci AC, Benetti MD, Domingues NB, Giro EM. Bond strength of a composite resin to glass ionomer cements using different adhesive systems. *Revista de Odontologia da UNESP*. 2017; 46(4):214-19.
- 2 Boruziniat A, Gharaei S. Bond strength between composite resin and resin modified glass ionomer using different adhesive systems and curing techniques. *Journal of conservative dentistry: JCD*. 2014; 17(2):150-54.
- 3 Kandaswamy D, Rajan KJ, Venkateshbabu N, Porkodi I. Shear bond strength evaluation of resin composite bonded to glass-ionomer cement using self-etching bonding agents with different pH: In vitro study. *J Conserv Dent*. 2012; 15:27-31.
- 4 Gupta R, Mahajan S. Shear bond strength evaluation of resin composite bonded to GIC using different adhesives. *J Clin Diagn*

- Res. 2015; 9(1):27-29.
- 5 Navimipour EJ, Oskoe SS, Oskoe PA, Bahari M, Rikhtegaran S, Ghojazadeh M. Effect of acid and laser etching on shear bond strength of conventional and resin-modified glass-ionomer cements to composite resin. *Lasers Med Sci.* 2012; 27(2):305-11.
 - 6 Sadeghi M, Atafat M, Abbasi M. Shear bond strength evaluation of resin composite to resin-modified glass-ionomer cement using three different resin adhesives vs. glass-ionomer based adhesive. *J Den Mat Tech.* 2015; 4(4):153-60.
 - 7 Shirinzad M, Rezaei-Soufi L, Sabounchi SS, Shokripour M. Effect of various resin cements as liner on the microleakage of restored composite class II restoration using closed sandwich technique. *J Chem Pharm Sci.* 2016; 9(3):1354-58.
 - 8 Li J, Liu Y, Liu Y, Söremark R, Sundström F. Flexure strength of resin-modified glass ionomer cements and their bond strength to dental composites. *Acta Odontol Scand.* 1996; 54(1):55-58.
 - 9 Alrahlah A. Diametral tensile strength, flexural strength, and surface microhardness of bioactive bulk fill restorative. *J contemp dent pract.* 2018; 19(1):13-19.
 - 10 Rai R, Gupta R. In vitro evaluation of the effect of two finishing and polishing systems on four esthetic restorative materials. *J conserv dentist.* 2013; 16(6):564-67.
 - 11 Rix D, Foley TF, Mamandras A. Comparison of bond strength of three adhesives: composite resin, hybrid GIC, and glass-filled GIC. *Amer J Orthodont.* 2001; 119(1):36-42.
 - 12 Taher NM, Ateyah NZ. Shear bond strength of resin modified glass ionomer cement bonded to different tooth-colored restorative materials. *J Contemp Dent Pract.* 2007; 8(2):25-34.
 - 13 Gopikrishna V, Abarajithan M, Krithikadatta J, Kandaswamy D. Shear bond strength evaluation of resin composite bonded to GIC using three different adhesives. *J Operative dent.* 2009; 34(4):467-71.
 - 14 Rosen M, Cohen J, Becker PJ. Bond strength of glass ionomer cement to composite resin. *The Journal of the Dental Association of South Africa= Die Tydskrif van die Tandheelkundige Vereniging van Suid-Afrika.* 1991; 46(10):511-13.
 - 15 Chandak MG, Pattanaik N, Das A. Comparative study to evaluate shear bond strength of RMGIC to composite resin using different adhesive systems. *J Contem clin dentist.* 2012; 3(3):252-55.
 - 16 Arora V, Kundabala M, Parolia A, Thomas MS, Pai V. Comparison of the shear bond strength of RMGIC to a resin composite using different adhesive systems: An in vitro study. *J conserv dentist.* 2010; 13(2):80-83.

CONTRIBUTIONS BY AUTHORS

- | | |
|-----------------------------|--|
| 1 Bilal Zaman Babar: | Principal researcher, literature review and data collection. |
| 2 Nayab Amin: | Title selection and Manuscript writing. |
| 3 Mehreen Zia: | Statistical analysis and proof reading. |