Available online at https://www.mmpubl.com/

**International Journal of Orthodontic Rehabilitation**

# COMPARATIVE EVALUATION OF BOND FAILURE RATE OF ORTHODONTIC BRACKETS BONDED WITH RESIN MODIFIED GLASS IONOMER CEMENT AND COMPOSITE -A RANDOMIZED CONTROLLED TRIAL

*Savani Sawant[1], Nitin Gulve[2], Amit Nehete[3], Shivpriya Aher[4]*

*[1]Post graduate, [2]HOD and Professor, [3]Professor, [4]Reader, MGV's KBH Dental College and Hospital, Nashik, Maharashtra.*

***How To Cite This Article**: Comparative evaluation of bond failure rate of orthodontic brackets bonded with resin modified glass ionomer cement and composite -A randomized controlled trial. Int J Orthod Rehabil 2023; 14 (3) 30-39.*

*Doi: 10.56501/intjorthodrehabil.v14i3.882.*

*Received: 05-07-2023* *Accepted: 22-09-2023* *Web Published: 07-10-2023*

## ABSTRACT

**Introduction-** Successful orthodontic treatment depends on the adhesive used for bonding orthodontic brackets and patient cooperation. Resin based adhesives are conventionally used but have drawbacks like white spot lesions and technique sensitivity. To overcome these problems, Resin modified glass ionomer cements (RMGIC) were introduced to utilise the fluoride releasing characteristic of GIC.

**Aim-** To compare and evaluate bond failure rate and type of bond failure between brackets bonded with RMGIC and composite.

**Materials and methods-** 25 patients undergoing orthodontic treatment were included and evaluated for 6 months. Bonding was done with RMGIC and composite. Patients were recalled every month and bond failure rate and type of bond failure was evaluated.

**Results-** A total of 526 teeth were bonded out of which 263 were bonded with RMGIC and 263 with composite. Statistical analysis was done with Chi-square test ($p>0.05$). Maximum debonding was seen in RMGIC group (6.46%) compared to composite (3.42%). Maximum debonding was seen in 1$^{st}$ molars bonded with RMGIC (35.3%). Majority bond failure type observed was Adhesive enamel failure in brackets bonded with RMGIC.

**Conclusion-** From the study, it can be concluded that bond failure was commonly seen in RMGIC group in comparison with composite group. Adhesive enamel failure was the most commonly seen bracket failure type. RMGIC had majority bracket failure but within acceptable range and hence can be used as a substitute adhesive for bonding.

**Keywords-** Resin modified glass ionomer cement, Composite, Brackets, Bonding.

***Address for Correspondence:***

*Dr Savani Sawant*
*Post graduate Student*
*Department of Orthodontics, MGV's KBH Dental College and Hospital.*
*Nashik, Maharashtra.*
*Email id: drsavanisawant@gmail.com*

***© 2023 Published by MM Publishers***

## INTRODUCTION

Successful fixed orthodontic treatment depends on a number of variables, including the bond strength between the tooth's enamel and the orthodontic bracket, as well as other crucial variables like the type of enamel conditioner, acid concentration, etching time, adhesive composition, bracket design, bracket material, oral environment, and the clinician's bonding skills.[1]

Using a resin-based adhesive method for bracket bonding has many disadvantages, some of which include the development of white spot lesions and loss of enamel surface due to etching and during adhesive removal after bracket de-bonding. [2] A frequent side effect of treatment with fixed orthodontic appliances is enamel demineralized lesions. [3] Fluoride has been proven to lower the occurrence of demineralization, mostly by encouraging remineralization, in addition to maintaining good dental hygiene and reducing the intake of fermentable carbohydrates. [4]

Glass ionomer cements can be advantageous as they are less damaging to enamel as they have low solubility, fluoride releasing capability.[5] Resin particles were then added to their formulation in glass ionomer cement to create resin modified glass ionomers. These adhesives release fluoride like conventional glass ionomer cements and can be successfully used to bond orthodontic brackets because of their relatively higher bond strengths. Light-activated RMGIC were formulated to overcome the problems of moisture sensitivity of composites and low early mechanical strength of glass ionomers while maintaining the clinical advantages of conventional glass ionomers. RMGIC were introduced to solve the moisture sensitivity issue during bonding.[6] GIC that have been modified or reinforced with resin have grown in acceptance as resin cement substitutes through time and with extensive investigation.[7]

Studies conducted in-vitro have certain limitations, including patient variables and the difficulty of determining bond failure of orthodontic brackets in oral environment, role of masticatory forces, brushing forces, different food substances consumed by the patient. This study was a comparative evaluation of brackets bonded with RMGIC and composite and evaluation of bond failure rate of these brackets. An in-vivo investigation will aid in determining the bond failure rate with consideration of patient characteristics as well.

### Aim

To compare and evaluate the bond failure rate of orthodontic brackets bonded with RMGIC and composite and type of bond failure rate.

## MATERIALS AND METHODS

From the Department of Orthodontics and Dentofacial Orthopaedics at our Institute, 25 patients undergoing fixed orthodontic treatment were informed and chosen for this study and evaluated for a time period of 6 months. The study was conducted abiding by all human ethical principles as per World Medical Association- Declaration of Helsinki and the guidelines of good clinical practice by Indian Council of Medical Research were followed.

Selection Criteria-

Inclusion criteria- Patients starting fixed mechanotherapy treatment at our institute, completely erupted permanent teeth (incisors, canines, premolars, 1st molar).

Exclusion criteria- Patients having enamel defects, pre-existing white spot lesions, patients having crowns or veneers, patients having moderate to severe skeletal discrepancies, patients with multiple carious lesions.

Four quadrants in the patient's oral cavity were considered as sites. One site was represented by each quadrant.

Sample Size-Fifty sites each will be studied for the bracket failure rate of two adhesives i.e. composite and RMGIC. Level of significance = 5%, Power = 80%, Type of test = two-sided Formula of calculating sample size is Sample size for clinical trial (outcome variable on nominal scale) and testing null hypothesis: P1=P2 (Proportion of Two Intervention Groups).

$$n= \frac{\{z1\sqrt{[2P(1-P)]}) \quad +z2(\sqrt{[P1(1-P1)+P2(1-P2)]}\}^2}{(P1-P2)^2}$$

| | | |
|---|---|---|
| P1 | Estimated Probability of outcome (bond failure) in Test Group-1 (intervention) | 0.029 |
| P2 | Estimated Probability of outcome (bond failure) in Test Group-2 (RMGIC) Intervention | 0.018 |
| P | Arithmetic average of P1 & P2 | 0.105 |
| 1-α | Set Level of confidence | 0.95 |
| 1-β | Set level of power of test | 0.8 |
| Z1 | Z value associated with alpha | 1.959 |
| Z2 | Z value associated with beta | 0.841 |
| n1 | Minimum sample size | 50 |

Assuming all the factors, our sample size comes around fifty sites per group / twenty five subjects (n1). Total Sample size estimates to hundred sites accounting for two groups. Since, it is a split mouth study, twenty five subjects are required in which total hundred sites will be undertaken for study.

For this study split mouth technique was used. Fifty sites each were studied for the bracket failure rate of two adhesives i.e., Composite and RMGIC (Figure 1).

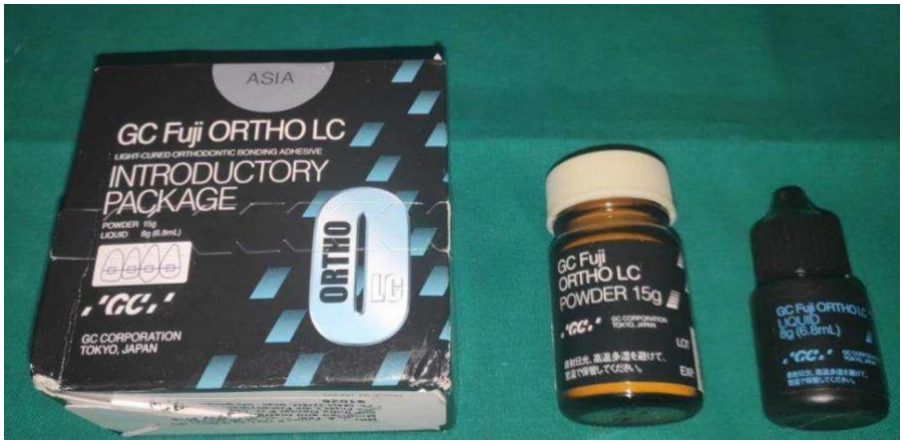


*Figure 1- Resin Modified Glass Ionomer Cement*

**Methods of measurements:**

Patients were given chits to randomly select the adhesives used in a specific pair of sites. Sequentially numbered, opaque sealed envelopes containing the chits were given to the patients to maintain allocation concealment.

Pair of sites according to the quadrants used are:

1) Group A- Upper Right (RMGIC), Upper left (Composite), Lower Right (Composite), and Lower Left (RMGIC).

2) Group B- Upper Right (Composite), Upper Left (RMGIC), Lower Right (RMGIC), and Lower Left (Composite).

Initially the tooth surface was cleaned with pumice for 5 seconds. 37% phosphoric acid was used for etching of the tooth surface for 30 seconds. Teeth surfaces were cleaned with water and dried till frosty white appearance was achieved on enamel.

For the **RMGIC** group the etched tooth surface was moistened with a cotton roll. The adhesive cement was mixed and manipulated as directed by the manufacturer. Bracket holding tweezers was used to hold the stainless steel bracket. RMGIC was equally distributed on the meshed surface base and it was verified that there was no space between bracket base and adhesive. The bracket was then positioned on the tooth surface.

For **Composite** group the enamel surface was dried thoroughly. After drying of the enamel surface, a thin layer of bonding agent was applied and cured for 20 seconds. Bracket holding tweezers was used to hold the stainless-steel bracket and composite was applied on the bracket base. The bracket was then positioned on the tooth surface. The placement of bracket on the teeth was made considering the correct occlusogingival, mesiodistal angulation. MacLaughlin, Bennet, and Trevisi group guidelines were followed for bonding of the bracket. After evaluating the final position of the bracket, it was pressed against the tooth surface taking care if remnants of the adhesive was present around the bracket, it was removed carefully with the help of a explorer. After the placement of the bracket on desired place it was cured with the help of curing light for 30 seconds. To achieve optimal strength and to allow the adhesives to set properly, 10 minutes time gap was kept between further procedure (Figure 2).

Since using RMGIC as an adhesive involved mixing of the powder and liquid components of the cement. So, in order to prevent patient discomfort and elongated appointment time, bonding with RMGIC was done first followed with composite bonding which also allowed the RMGIC to achieve sufficient strength for clinical use.

*Figure 2- Armamentarium for Bonding*

Data management- Every patient was recalled every month for their follow up appointment and presence of missing or loose brackets at each appointment were checked and failures were noted. The patients were requested to note down when the bracket failed and to report the failure at the subsequent appointment. Dates obtained from the patient were used to record the bracket failure. Each failed bracket was replaced with new brackets with the same slot dimension and further bonding was done with conventional method (Figure 3).

Bracket debonding was recorded for a period of 6 months.

*Figure 3- Intra-oral photograph after bonding with RMGIC and Composite*

**RESULTS**

The goal of the current study was to measure and compare the bond failure of brackets bonded with composite and RMGIC. During the course of six months, 25 patients were evaluated for bond failure with each adhesive; each patient was called back for a check-up each month.

A total of 526 teeth were bonded out of these 263 teeth were bonded with composite and 263 were bonded with RMGIC. (Table 1)

Total number of teeth with debonding occurrence was higher in RMGIC group i.e., 17 (6.46%) teeth as compared to composite Group i.e., 9 (3.42%) teeth. (Table 1) On application of Chi square test, it was observed that the difference between both groups was not found to be of statistical significance ($p>0.05$). (Table 1)

Maximum debonding in RMGIC group was seen in molars (35.3%) followed by first premolars (23.5%), second premolars and canines (17.6%) and a lateral incisor (5.8%). Whereas in composite group out maximum debonding were seen in canines and molars (33.3%) followed by first premolars (22.2%), lateral incisor (11.1 %). On comparative statistics of type of teeth debonded in both groups using Chi square test, it was observed that there

exists no statistically significant difference (p>0.05) between both groups in relation to tooth type distribution for debonding occurrence. (Table 2)

Majority bond failure type observed was Adhesive enamel failure in brackets bonded with RMGIC (64.7%) while in composite group it was (44.4%). Similarly Cohesive type of bracket failure was seen more (35.3%) in RMGIC group while in composite group it was observed to be less (44.4%). Adhesive Bracket Failure was observed in a single composite sample (11.2%). On using Chi square test, there was found to be no statistical significant difference (p>0.05) between both groups in relation to bracket failure type. (Table 3)

**Table 1- Descriptive statistics of bond failure**

| | RMGIC | Composite |
|---|---|---|
| Total Number of Sites Bonded | 50 | 50 |
| Total Number of Teeth Bonded | 263 | 263 |
| Total number of Teeth Debonded | 17/263 (6.46%)<br>(n%) | 9/263 (3.42%)<br>(n%) |
| | Chi square test value = 2.590<br>p = 0.108 (No statistically significant difference) | |

***RMGIC- Resin Modified Glass Ionomer Cement**

**Table 2-Comparative statistics of type of teeth debonded in both study groups**

| Teeth Debonded | RMGIC<br>n (%) | Composite<br>n (%) |
|---|---|---|
| Central Incisor | 0/17 (0%) | 0/9 (0%) |
| Lateral Incisor | 1/17 (5.8%) | 1/9 (11.1%) |
| Canine | 3/17 (17.6%) | 3/9 (33.3%) |
| First Premolar | 4/17 (23.5%) | 2/9 (22.2%) |
| Second Premolar | 3/17 (17.6%) | 0/9 (0%) |
| First Molar | 6/17 (35.3%) | 3/9 (33.3%) |
| | Chi square test value = 1.29<br>p = 0.481 (No statistically significant difference) | |

**Table 3- Comparative statistics of type of bracket failure between both study groups**

| Type of Bracket Failure | RMIGIC | Composite |
|---|---|---|
| Cohesive | 6/17 (35.3%) | 4/9 (44.4%) |
| Adhesive -Enamel Failure | 11/17 (64.7%) | 4/9 (44.4%) |
| Adhesive -Bracket Failure | 0/17 (0%) | 1/9 (11.2%) |
| | Chi square test value = 2.436<br>p = 0.296 (No statistically significant difference) | |

**DISCUSSION**

Adhesive properties of various bonding materials like bond between the bracket base and adhesives at different interphase are some of the factors determining the shear bond strength. Various interphases such as composite to bracket, tooth to composite interphase and polymerization of bonding materials are crucial in determining shear bond strength. An ideal bonding system has a few key characteristics, such as shear bond strength, biocompatibility, handling properties, fluoride releasing properties, hygiene maintenance, and adequate working time.[8] Since the dawn of time, composite resin-based adhesives have been utilised commercially. Composite resins are favoured because they are simple to work with and have great shear bond strength. This makes it possible to set brackets precisely. However, the drawbacks of composite resin include biocompatibility, plaque build-up, and moisture sensitivity. One of the issues following debonding is accurate adhesive remnant removal.[9]

RMGIC was developed by Antonucci et al in 1988 to improve the binding strength of regular GIC.[10] GICs' acid-base reaction causes them to automatically set.[11] It combines the benefits of traditional GIC with the capacity to form chemical bonds with enamel, dentin, metal, and a significant amount of fluoride release to prevent white spot lesions and decalcification. They have diffusion-based adhesion between the cement and tooth surface. Finally, their best quality is their ability to adhere even in wet conditions.[12] To address the issues of moisture sensitivity of composites and low early mechanical strength of glass ionomers while preserving the clinical benefits of traditional glass ionomers, light activated RMGICs were developed.[2] Traditional GIC has a small amount of resin and a photo initiator added to it. The Fuji Ortho LC bonding system is a light-cured, resin-reinforced GIC adhesive. It features an aluminofluorosilicate matrix that releases fluoride at first and can reabsorb more fluoride ions from the patient's dental paste or mouthwash.[1]

The introduction of light activated RMGIC in dentistry was to prevail over issues like moisture sensitivity of composite and reduced early mechanical strength of GIC while maintaining the clinical benefits of conventional glass ionomers. A small of resin in addition to a photo initiator was added to conventional glass ionomer cement.[4,9] Fuji Ortho LC bonding system is a light-cured resin-reinforced GIC adhesive. It has an aluminofluorosilicate matrix that initially releases fluoride and can reacquire additional fluoride ions from tooth

pastes or oral rinses used by the patient.[12] The RMGIC's manufacturers recommends using 10% polyacrylic acid enamel conditioner and allowing 40 seconds for light curing.[13] To prepare the enamel and improve cement retention of the enamel before bonding with RMGIC.[14] The polyacrylic acid in RMGIC itself might not be at a sufficiently high concentration to facilitate cleaning and wetting the tooth surface. Hence the use of phosphoric acid was recommended for additional retention and preparation.[7]

Shear bond strength and tensile bond strength of RMGIC were believed to be significantly improved by enamel surface etching, according to Xiao-Chuan Fan and Li Chen.[6] A moist environment could speed up both shear bond strength and tensile bond strength, but not the final bonding strength.[15] The optimum processing technique was etching of the enamel followed by moistening the surface with a wet cotton pellet for resin modified glass ionomer cement. The bonding surface should be wet and loading time delayed when using RMGIC cement over unetched enamel. Tensile bond strength appeared to be more reasonable and objective when assessing the mechanical qualities of the adhesive materials than shear bond strength. Therefore, in this investigation, moistening the etched enamel surface was beneficial for increasing bond strength.

As per studies conducted in the past modern RMGIC have shown reduced bond strength as compared to resin composite system, however studies conducted in vitro studies have concluded that these cements have sufficient strength to be used for bonding orthodontic brackets.[16] The failure rate of the brackets in this study was insignificant when RMGIC was compared to the composite resin adhesives. Even yet, 10% is thought to be within the clinically acceptable range for debonding during orthodontic therapy.[2] When compared to prior studies that rely on in vitro results to determine bond strengths necessary for clinical effectiveness, the findings from the present study offer a more accurate account of in vivo bond strength. This study design is thought to be more useful for calculating bond strength values after a predetermined amount of time in an oral environment.

In this study, a total of 263 teeth bonded with RMGIC were observed and only 17 teeth debonded during the study indicating that RMGIC has sufficient bond strength and can be used as an adhesive. Maximum debonding in brackets bonded with RMGIC was observed in molars followed by first premolar. Molar debonding is most commonly observed in all orthodontic cases as they provide anchorage and maximum forces are applied by elastomeric chains and elastics on molars. Most common bracket failure type observed in our study was Adhesive enamel failure, leaving very less adhesive on the enamel after debonding. This was advantageous as the process of residual adhesive removal procedure with airotor was skipped.[8]

This study was conducted for a period of 6 months, but the orthodontic treatment generally requires an average of 18 months' time duration. So further long-term clinical trial is required.

In this study the RMGIC is hand mixed and during the hand mixing process, air may become incorporated into the mixture forming voids which may potentially reduce the cohesive and tensile strengths of the cement. Not only the film thickness is important but also the uniformity of the film. Variations in the film thickness can lead to the development of areas of stress concentration from which crack initiation and propagation can arise. Increasing the film thickness can also lead to the formation of higher internal stress due to greater polymerization shrinkage. Long term research on RMGIC as an adhesive can also help in finding out more information about demineralizing lesions post orthodontic treatment. Operator reliability stats were not measured.

The search for an efficient and effective adhesive prevails to overcome the drawbacks and technique sensitivity involved with composite. RMGIC has its advantages such as increased bond strength in presence of moisture

making it easier for the orthodontist to bond molars and other teeth where isolation is difficult. RMGIC can also be used in cases of cleft palate and impactions where isolation is difficult for bonding. RMGIC can be used in difficult situations where isolation is difficult to maintain such as partially erupted premolars [16]. In this study the RMGIC is hand mixed, LC capsules can also be used for further research.

## CONCLUSION

From the study it was found that bond failure was commonly seen in RMGIC group in comparison with composite group. Adhesive enamel failure was the most commonly seen bracket failure type. Although RMGIC had a greater debonding rate the bracket failure rate was within acceptable range and hence can be used as a substitute adhesive for bonding.

## CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

## SOURCE OF FUNDING

No external sources of funding.

## REFERENCES

1. Bishara SE, VonWald L, Olsen ME, Laffoon JF. Effect of time on the shear bond strength of glass ionomer and composite orthodontic brackets. Am J Orthod Dentofacial Orthop. 1999;16:616-620.

2. Tahir A, Ulfat B, Khan HA. Comparison of bracket retention of a resin modified glass ionomer cement and a resin based adhesive. Pak Orthod J. 2018; 10:82-86.

3. Zimmer, Bernd & Rottwinkel, Yvonne. Assessing patient-specific decalcification risk in fixed orthodontic treatment and its impact on prophylactic procedures. Am J Orthod Dentofacial Orthop.2004; 126. 318-24.

4. Benson PE, Alexander JA, Cotter S, Dyer F, Fenesha F, Patel A, Campbell C, Crowley N, and Millett TD. Resin-modified glass ionomer cement vs composite for orthodontic bonding: A multicentre, single-blind, randomized controlled trial. Am J Orthod Dentofacial Orthop 2019;155:10-8.)

5. Komori A, Ishikawa H. The effect of delayed light exposure on bond strength: light cured resin reinforced glass ionomer cement vs light cured resin. Am J Orthod Dentofacial Orthop 1999;P134-145.

6. Fan XC & Chen L. Effects of enamel surface preparation on bonding strength of resin modified glass ionomer cement: an in vitro study. J Adhesion Sci Tech. 2017;31:2017-2017.

7. Valente MR, Rijk GW, Drummond LJ and Evans AC. Etching conditions for resin modified glass ionomer cement for orthodontic brackets. Am J Orthod Dentofacial Orthop. 2002;121:516-520.

8. Shaik JA, Reddy RK, Bhagyalakshmi K, Shah MJ, Madhavi O, Ramesh SV. In vitro Evaluation of Shear Bond Strength of Orthodontic Brackets Bonded with Different Adhesives. Contemp Clin Dent. 2018;9:289-292.

9. Cheng YH, Chen HC, Chuan LL, Tsai HH, Chou HT and Wang NW. Bond strength of orthodontic light cured resin modified glass ionomer cement. Eur J Orthod. 2011;33:180-184.

10. Antonucci JM, McKinney JE, Stansbury JW. Resin-modified glass ionomer cement. US patent application.1988;856:117-160.

11. Hassan ZM, Bjorn G, Morten S. An in vitro comparison of the shear bond strength of resin reinforced glass ionomer cement and a composite adhesive for bonding orthodontic brackets. Eur J Orthod. 2005;27:477-83.

12. Rix D, Foley TF, Mamandras A. Comparison of bond strength of three. adhesives: composite resin, hybrid GIC, and glass-filled GIC. Am J Orthod Dentofacial Orthop. 2001;119:36-42.

13. Bishara SE, Vonwald L, Olsen ME, Laffoon JF, Jakobsen JR. Effect of light curing time on the initial shear bond strength of a glass ionomer adhesive. Am J Orthod Dentofacial Orthop. 2000;117:164-168.

14. Zhang L, Tang T, Zhang Z, Liang B, Wang X, Fu B. Improvement of enamel bond strengths for conventional and resin modified glass ionomers: acid etching vs. conditioning. J Zhejiang Univ Sci B. 2013;14:1013-1024.

15. Reicheneder, C.A, Gedrange T, Lange A, Baumert U & Proff P. Shear and tensile bond strength comparison of various contemporary orthodontic adhesive systems: An in-vitro study. Am J Orthod Dentofacial Orthop. 2009;135. 422.e1-422.e6.

16. Decalcification and bond failure rate in resin modified glass ionomer cement versus conventional composite for orthodontic bonding: A systematic review & meta-analysis. Khan AR, Fida M, Gul M. Int Orthod. 2020;18:32-40.

Published by MM Publishers

https://www.mmpubl.com/ijorthrehab

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial 4.0 International License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given, andthe new creations are licensed under the identical terms.

To view a copy of this license, visit http://creativecommons.org/licenses/by-nc/4.0/ or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.

*Copyright © 2023, Savani Sawant, Nitin Gulve, Amit Nehete, Shivpriya Aher*