Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

ISSN NO. 2320-5407

Article DOI:10.21474/IJAR01/19007
DOI URL: http://dx.doi.org/10.21474/IJAR01/19007

RESEARCH ARTICLE

TO COMPARE THE SHEAR BOND STRENGTH OF RESIN MODIFIED GLASS IONOMER CEMENT TO COMPOSITE RESIN USING FOUR DIFFERENT ADHESIVE SYSTEMS: AN IN VITRO STUDY

Dr. Nima Wangziom Mosobi[1], Dr. Ajay Kumar Nagpal[2], Dr. Snehil Singh[3] and Dr. Aditya Kumar[4]

1. Post Graduate Student, Department of Conservative Dentistry and Endodontics, Kanti Devi Dental College and Hospital, Uttar Pradesh, India.
2. Head of the Department, Department of Conservative Dentistry and Endodontics, Kanti Devi Dental College and Hospital, Uttar Pradesh, India.
3. Post Graduate Student, Department of Conservative Dentistry and Endodontics, Kanti Devi Dental College and Hospital, Uttar Pradesh, India.
4. Post Graduate Student, Department of Conservative Dentistry and Endodontics, Kanti Devi Dental College and Hospital, Uttar Pradesh, India.

……………………………………………………………………………………………………....

Manuscript Info

……………………….

Manuscript History
Received: 30 April 2024
Final Accepted: 31 May 2024
Published: June 2024

Key words:-
Resin-Modified Glass Ionomer Cement, Composite Resin, Shear Bond Strength, Bonding Agent

Abstract

………………………………………………………………………

Aim: To evaluate and compare shear bond strength of resin modified glass ionomer cement to composite resin using different adhesive systems.

Materials and Methods: 60 acrylic blocks were prepared by drilling holes to retain resin modified glass ionomer cement (GC Gold Label 2 LC Light Cured Universal Restorative-GIC). Samples were then divided into five groups (n=12) based on the generation of bonding agent used. Group I- Fifth Generation Bonding agent – 3M ESPE Adper single bond 2 adhesive, Group II- Sixth Generation Bonding Agent – Shofu FL Bond II Primer Self Etching Agent, Group III- Seventh Generation Bonding Agent – GC Solare Universal, Group IV- Eighth Generation Bonding Agent – IvoclarTetric N-Bond Universal and Group V- Control group. All the 60 specimens were filled with composite resin - Nano-Hybrid Composite (IvoclarVivadentTetric N-Ceram) over resin-modified glass ionomer cement and light cured. Shear bond strength was determined using the Universal testing Machine and directing the shearing force on the composite andresin modified glass ionomer cement interface. Amount of force required for bond failure was recorded in Newton. The data was analysed using one-way ANOVA and Post hoc Tukey test for statistical analysis.

Result: Group IV showed higher bond strength followed by Group III, Group II, Group I & Group V.

Conclusion: Bond strength of composite to resin modified glass ionomer cement was significantly higher for eighth generation bonding agent when compared to others.

……………………………………………………………………………………………………....

Corresponding Author:- Dr. Nima Wangziom Mosobi
Address**:-** Department of Conservative Dentistry and Endodontics, Kanti Devi Dental College and Hospital, Uttar Pradesh, India, 281001.

Introduction:-

The field of adhesive dentistry is one that is fast developing. The dentistry community has been working to improve composite's adherence to tooth substrate for a long time because stable bonding should result in decreased microleakage and restorative durability [1]. The evolution of dentin adhesives has led to their availability in three-step, two-step, and single-step systems, based on completion of essential stages such as etching, priming & bonding to the tooth surfaces [2].

Adhesives that are self-etch have been reported to offer a number of benefits over etch-&-rinse adhesives. Firstly, because the etch-&-rinse step is skipped with self-etching adhesives, the process is less technique-sensitive. However, this might lead to the collapse of the delicate demineralized network of collagen following acid etching [3]. Second of all, an appropriately infiltrated hybrid layer should result from the simultaneous demineralization and resin penetration [4]. Thirdly, mild self-etch adhesives are thought to result in reduced post-operative discomfort because they employ smear layer as a bonding material and leave behind residue of smear plugs that reduced the flow of dentinal fluid [5]. Finally, gentle self-etching adhesives allow functional monomers to chemically attach to calcium, potentially improving surface stability while leaving hydroxyapatite crystals free.

In an effort to minimize working time by reducing clinical procedures, fifth generation bonding agent tried to modernize the fourth generation adhesion process in the 1990s and the present decade. It mixed the adhesive and primer into the same solution that was employed to the tooth surface, along with 35–37% phosphoric acid, for 15 - 20 seconds [6].

"Self-etching primers," or sixth generation bonding adhesive, which were marked a substantial technological advancement when they were initially made available between the closure of the 1990s and the beginning of the 2000s. The purpose of sixth generation bonding agent was to either do away with the etching phase entirely or involve it chemically into another process: i.e self-etching adhesive. Acidic primer and adhesive are included in two bottles or a unit dosage [5].

The bonding methods of the seventh generation were unveiled in late 1999 and early 2005. With these methods, a single bottle contains adhesive, primer, and acid etching component [7].Inthe newer generation i.e eighth generation bonding agent, the incorporation of nano-fillers, averaging 12 nm in size, enhances both resin monomer infiltration and thickness of hybrid layer, leading to improved mechanical characteristics of the bonding technologies. Nano-bonding agents are solutions containing nano-fillers that result in enhanced stress absorption, extended shelf life, and stronger enamel and dentin bonds [8].

The postoperative sensitivity linked to the traditional procedure has significantly decreased since the sandwich technique was introduced. This technique approach integrates the outstanding visual advantages of the composite restoration with the therapeutically beneficial characteristics of GIC, such as a greater capacity to bind to the tooth surface and continuous release of fluoride [9]. This method can also be utilized using RMGIC, which has better flexural, tensile strength & less moisture sensitivity than GIC [10].

The link between GIC and composite is critical component of sandwich restorations, contributing to the restoration's longevity, sealing, and retention. The primary causes of such restorative failures are cavities and an inadequate connection between GIC and composite resin [11]. Research has indicated that bonding agents exhibiting high wettability, low viscosity, and low contact angle resulted in a superior interaction between the composite and GIC. The bonding strength between composite resin and teeth has been strengthened by a variety of alterations made to more recent adhesive agents, including additions of nanofillers, alterations to primers, and viscosity changes [12].

Hence the present investigation has been taken to assess the shear bond strength of resin modified glass ionomer cement to composite resin utilizing different generation adhesive technique.

Material and Methods:-

60 specimens made of acrylic blocks were prepared using cuboidal aluminiummould of 15x20 mm in dimensions and in each block. In each block,cavities of 8 mm diameter and 2.5 mm depth were prepared as seen in Figure 1.

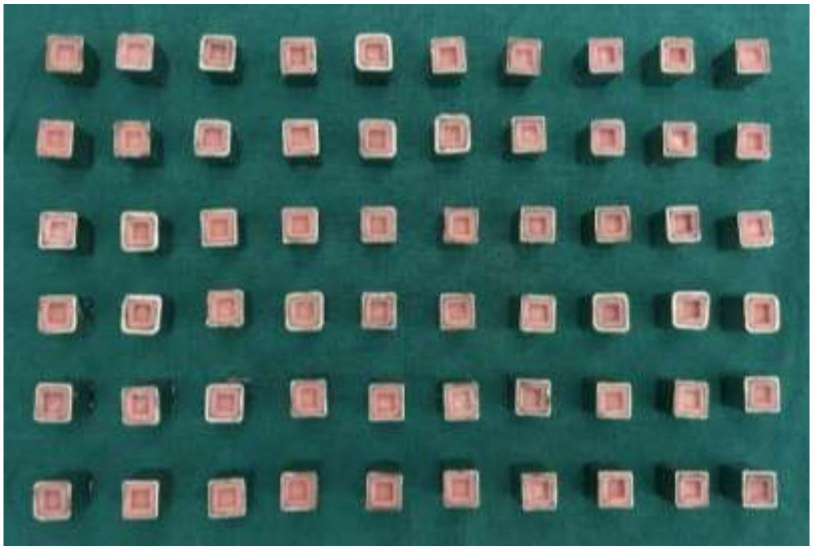


Figure 1:- Samples after cavity preparation

The cavities were filled with RMGIC (GC gold label light cured universal restorative, GC corporation, Tokyo, Japan) and cured with LED curing light (Guilin Woodpecker Medical Instrument, Guilin, Guangxi, China), according to the manufacturer's instruction, to produce a final set as seen in Figure 2.

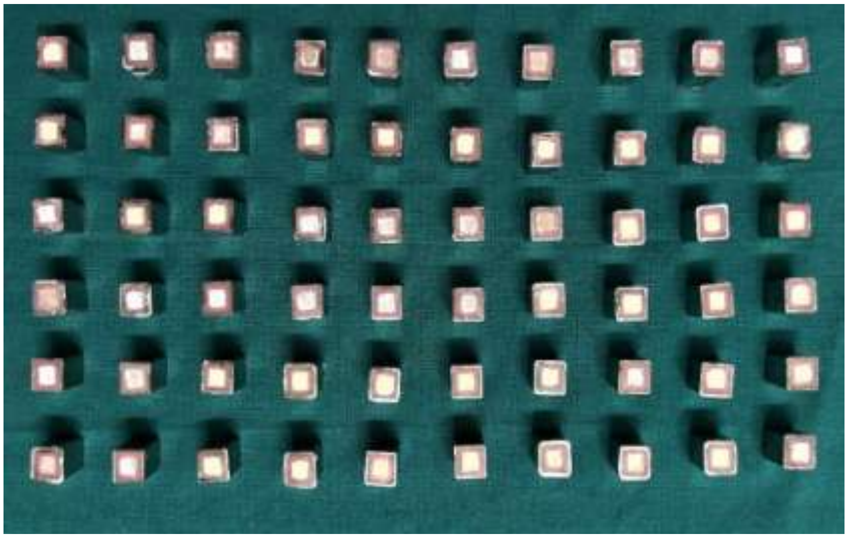


Figure 2:- Cavity filled with Resin-Modified Glass Ionomer Cement

After curing, all samples were split into five groups (n=12) based on the generation of bonding agent usage.
Group I: Fifth generation bonding agent – Adper Single Bond 2 Adhesive(3M/ESPE Brasil, Sumare, SP, Brazil). The surface of RMGIC was etched for 15 seconds, followed by a thorough rinse for 10 seconds. After blotting, two consecutive coating of bonding agent was applied and air dried, ensuring a contact time of 15 seconds and light cured for 10 seconds.
Group II: Sixth generation bonding Agent – Shofu FL Bond II Primer Self Etching Primer & Bonding Agent(Shofu Dental, Kyoto, Japan). The primer was applied to the RMGIC surface. Following this, thorough drying with air for five seconds was performed. Subsequently, the bonding agent was applied with a light-curing duration of 15 seconds.
Group III: Seventh generation Bonding Agent – GC Solare Universal Bond Adhesive(GC, Toriimatsu-cho, Kasugai, Aichi, Japan). Application of bonding agent to the RMGIC surface, allowing it to remain undisturbed for 10 seconds. Air drying was done for five seconds and the final step of a 10-second light-curing process was performed.
Group IV: Eighth generation Bonding Agent – IvoclarTetric N-Bond Universal(IvoclarVivadent, Lichenstein). The

adhesive was applied to the resin modified glass ionomer cement surface followed by a thorough air drying for five seconds and the final step of a 10-second light-curing process was performed.
Group V: No adhesives agents was applied (Control group). Composite resin and RMGIC were bonded without using any adhesive system.

All of the 60 specimens were filled with composite resin over RMGIC using a plastic ring of 4 mm height and 5 mm internal diameter in increments of 2 mm each and each layer was light cured for 40 secs as seen in Figure 3.

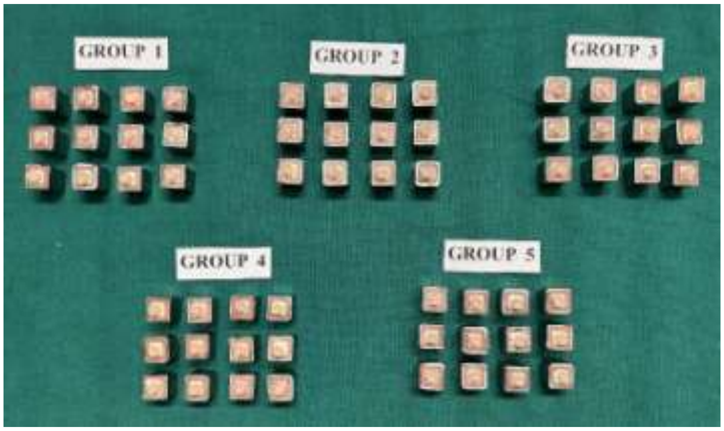


Figure 3:- Grouping of samples

To mimic oral environment, the samples were submerged in distilled water at 37°C for 24 hours prior to SBS test. After that, each sample was placed horizontally in a UTM(Shambhu Nath & Sons, India) and exposed to a shearing force. At the interface, a knife-edge blade was attached to the UTM's moveable crosshead. Each specimen was then loaded to a gradually increasing vertical force at crosshead speed of 0.5 mm/min until debonding occurred as seen in Figure 4. Amount of force necessary for bond failure was noted in Newton.

Figure 4:- Fracture of specimen.

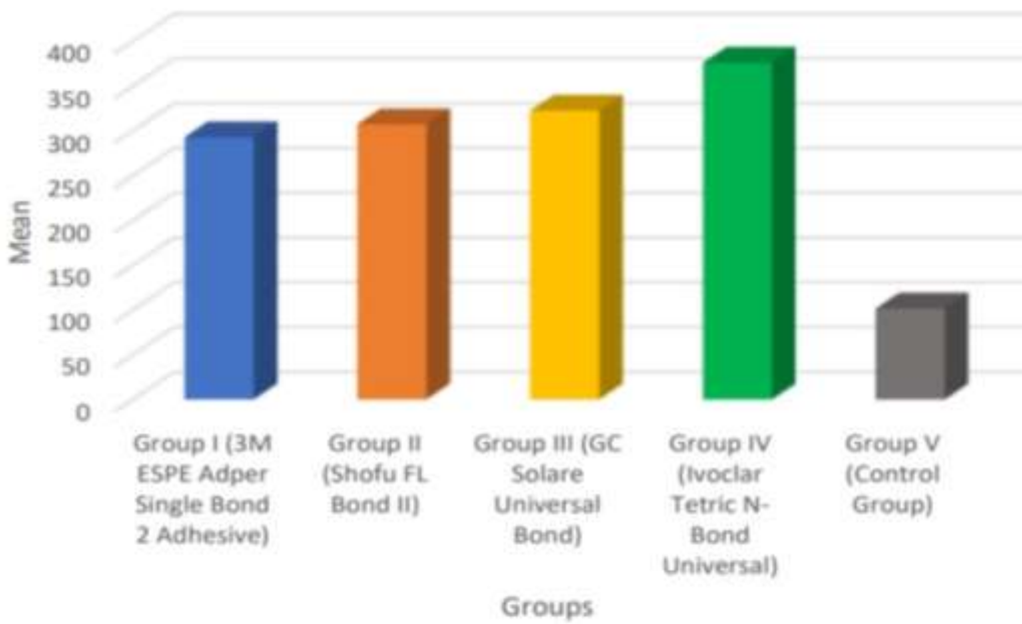
Result:-

The data were analyzed utilizing statistical package for social sciences version (SPSS) 22.0. The level of statistical significance was set at 95% (P=0.05). P-value > 0.05 was non-significant and P value < 0.05 was significant. The data was analysed using ANOVA for comparison of mean resistance in various groups, and Post hoc Tukey were used for pairwise comparison of mean resistance observed in various groups.

According to the results: Table 1 and Graph 1 represents: Maximum mean value of shear bond strength was obtained in Group IV – eighth generation bonding agent (IvoclarTetric N-Bond Universal) i.e., 376.08 N with minimum value of 345 N and maximum value of 403 N and standard deviation of 19.62. It was followed by Group III – seventh generation bonding agent (GC Solare Universal Bond) with mean value of 322.58 N with standard deviation of 16.01 followed by Group II – Sixth generation bonding agent (Shofu FL Bond II) with mean of 307.42 N. Amongst the experimental groups, Group I – Fifth generation bonding agent (Adper Single Bond 2 Adhesive) had lowest SBS value of 293 N. The SBS of Group V - Control group was lowest with mean value of 101.58 N with standard deviation of 11.45.

Groups	Minimum	Maximum	Mean	Std. Deviation
Group I (3M ESPE Adper Single Bond 2 Adhesive)	274.0	333.0	293.00	16.27
Group II (Shofu FL Bond II)	278.0	332.0	307.42	17.18
Group III (GC Solare Universal Bond)	298.0	344.0	322.58	16.01
Group IV (Ivoclar Tetric N-Bond Universal)	345.0	403.0	376.08	19.62
Group V (Control Group)	77.0	117.0	101.58	11.45

Table 1:- Descriptive statistics of shear bond strength observed in samples of various groups



Graph 1:- Mean shear bond strength observed in samples of various groups

Table 2 represents: On comparison between the groups, the values were statistically significant. However, on comparison within the groups there was no statistically significant values found.

	Sum of Squares	df	Mean Square	F	p value
Between Groups	525581.27	4	131395.32	493.170	<0.001*
Within Groups	14653.67	55	266.430		
Total	540234.93	59			

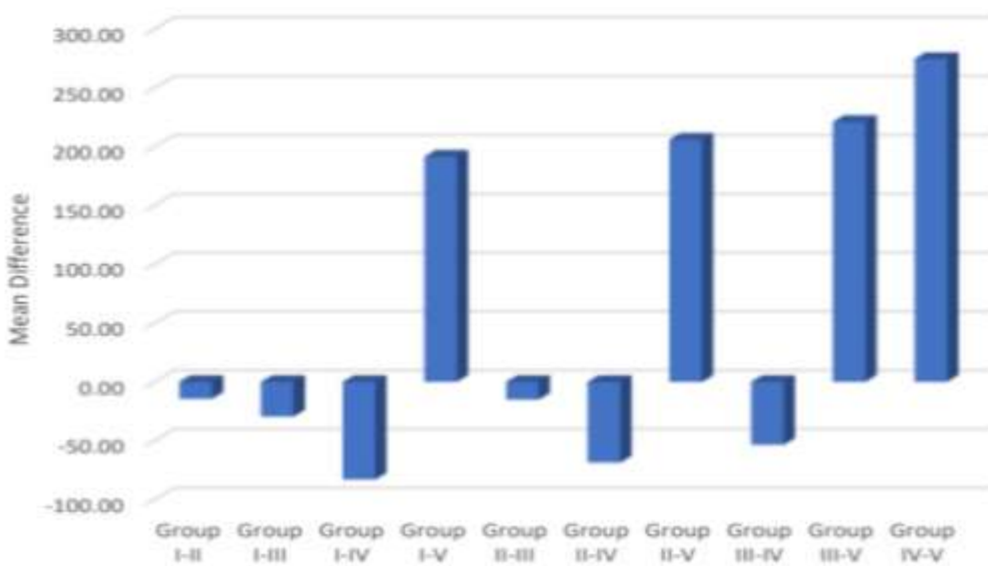
Table 2:- Comparison of mean shear bond strength observed in samples of various groups using one way ANOVA

Table 3 and Graph 2 represents: On comparison of Group IV with other groups, statistically significant difference was observed with p value < 0.01. In pairwise comparison with Group I all the groups had statistically significant difference except with Group II with p value of 0.21 and mean difference of 14.42. In comparison with Group II and III, no statistically significant difference was noticed with p value of 0.17 and mean difference of 15.17. Comparison of the control group i.e., Group V also showed statistically significant difference with all other groups.

Groups		Mean Difference	p value	95% Confidence Interval	
				Lower Bound	Upper Bound
Group I	**Group II**	-14.42	0.21	-33.21	4.38
	Group III	-29.5833*	<0.01*	-48.38	-10.79
	Group IV	-83.0833*	<0.01*	-101.88	-64.29
	Group V	191.4167*	<0.01*	172.62	210.21
Group II	**Group I**	14.42	0.21	-4.38	33.21
	Group III	-15.17	0.17	-33.96	3.63
	Group IV	-68.6667*	<0.01*	-87.46	-49.87
	Group V	205.8333*	<0.01*	187.04	224.63
Group III	**Group I**	29.5833*	<0.01*	10.79	48.38
	Group II	15.17	0.17	-3.63	33.96
	Group IV	-53.5000*	<0.01*	-72.29	-34.71
	Group V	221.0000*	<0.01*	202.21	239.79
Group IV	**Group I**	83.0833*	<0.01*	64.29	101.88
	Group II	68.6667*	<0.01*	49.87	87.46
	Group III	53.5000*	<0.01*	34.71	72.29
	Group V	274.5000*	<0.01*	255.71	293.29
Group V	**Group I**	-191.4167*	<0.01*	-210.21	-172.62
	Group II	-205.8333*	<0.01*	-224.63	-187.04
	Group III	-221.0000*	<0.01*	-239.79	-202.21
	Group IV	-274.5000*	<0.01*	-293.29	-255.71

*Stastically Significant

Table 3:- Pairwise comparison of mean shear bond strength observed in samples of various groups using post hoc tukey test



Graph 2:- Mean difference of shear bond strength observed in samples of various groups.

Discussion:-

GICs possess unique characteristics, such as the ability to chemically bond with moist tooth structure, long-term release of fluoride, a low coefficient of thermal expansion, optimal biocompatibility, hydrophilicity, and the ability to combat tooth decay. However, the use of GICs is associated with certain drawbacks, including inferior mechanical properties, low resistance to wear, sensitivity to moisture at an early stage, poor polishability, porous surface, and low strength [13].

In contrast, composite was employed for both anterior and posterior restorations due to their aesthetically pleasing nature. Nonetheless, composite resins have their own set of disadvantages, including polymerization shrinkage, microleakage and irritation to the dental pulp. The shrinkage of composite resins during the polymerization process can result in gap formation between the restoration and tooth structure. These gaps can ultimately cause tooth hypersensitivity and potentially damage to dental pulp [14].

To mitigate microleakage, GIC is utilized as a base underneath the composite. The approach, known as the "laminate restoration" or "sandwich technique," was introduced by McLean in 1985 to seal cavities and minimize microleakage. The sandwich technique involves the application of two restorative materials to create a single, durable restoration. The clinical advantages of this technique include protection of the dental pulp, the anticariogenic effect of fluoride release, reduction in the amount of composite used, and consequently reduction in polymerization shrinkage [15].

Numerous research has demonstrated that RMGIC exhibits significantly greater mechanical properties and SBS compared to conventional GIC. The mechanical interlocking between the composite and RMGIC, an air-inhibited layer that forms on the surface increases the count of unreacted carbon double bonds. This may contribute to a stronger chemical bond with the composite. The inclusion of resin within RMGICs restricts their initial water uptake, leading to enhanced mechanical properties. This translates to greater cohesive strength and lower modulus of elasticity in contrast to conventional GICs. Based on the research of Pamir et al., it was observed that the bonding of composite to conventional GIC was considerably weaker than that observed with RMGIC [16].

Considering the aforementioned reasons, the present study aimed to analyse the shear bond strength of RMGIC to composite.

In the present study acrylic blocks were utilized to avoid the variations present in teeth which could affect the result. Also to standardize the samples, the blocks were measured and cavities of equal depth and length was prepared. The connection of RMGIC and composite for application of mechanical loading was presented better in acrylic blocks.

The utilization of bonding agents has been shown to strengthen the ability of RMGIC to bond to composite, thereby encouraging a robust shear bond strength. This enhancement in bonding can be credited to the similar chemical composition of RMGICs and composite, which allows for a strong bond. Both RMGICs and composite undergo a curing process facilitated by a free radical initiator system, which creates the potential for chemical bonding between these materials [17].

Dental adhesives play a crucial role in improving the bond by creating rough surface where glass particles protrude above the matrix. This rough surface allows the resin to integrate into the micropores between the particles, resulting in mechanical interlocking. Additionally, dental adhesives provide retention to the composite resin, enabling it to withstand mechanical forces. It is also important for a good adhesive to eliminate leakage at the edges of a restoration, as inadequate sealing can lead to restoration failure [15].

The sixth, seventh and eighth generation bonding agents, which are self-etch adhesives, have demonstrated superior shear bond strength in comparison to the fifth generation, which is a total-etch adhesive. According to this study, the shear bond strength of fifth generation bonding agent was least when compared to other groups. This can be accountable to the fact that the application of self-etch adhesive systems can improve the SBS between the composite and RMGIC. In contrast, total-etch adhesive systems require etching before application, and the etching and rinsing procedure may remove calcium and aluminum from the GIC, thereby reducing its cohesive strength. Acid-etching of RMGIC surfaces can also lead to decrease in SBS as it may partially remove the hydroxyethyl methacrylate and reduces the quantity of oxygen-inhibited functional methacrylate groups, which contribute to the adhesion to composite. Furthermore, it was shown that acid-etching of RMGIC surfaces lengthens the clinical application period and may improve method sensitivity, but does not increase sandwich restorations capacity to seal [17].

In recent times, manufacturers have developed a combination of etchant, primer, and bonding agents in a single bottle known as self-etch bonding agents. These agents exhibit a low contact angle on rough surfaces and better wettability due to their acidic pH and the presence of carboxylic monomers. This ultimately leads to improved bonding between restorations. Previous articles have reported that bonding agents with lower viscosity can result in stronger bond strength. On the other hand, the etch and rinse technique, which involves a rinsing step, might result in reducing the shear bond strength by partially eliminating hydroxyethyl methacrylate present in RMGIC. Arora V et al. [18], and Chandak MG et al. [19], have shown that the application of self-etch adhesives results in greater SBS between RMGIC and composite compared to total etch adhesives or no adhesive agent [21].

Dentin bonding agents of the seventh and eighth generations share similar components, but in various ratios: solvent, activators, cross-linking monomers, functional monomers, and inhibitors. In the current investigation, eighth generation bonding agent, achieved the greatest SBS. The majority of mechanical strength is derived from cross-linking monomers; eighth generation bonding agents feature micro-sized cross-linking functional monomers, which may result in a greater bond strength than seventh generation. According to Joseph et al. [21], and Kamble et al. [22], eighth generation bonding agent seemed to be more beneficial than other generations bonding agent [23].

The study's findings indicate that the eighth generation bonding agent has the strongest shear bond. Due to its highly functionalized silicon dioxide nano particles, it helps to promote the cross-linking of the resin's constituent parts. Adhesive infused with nanoparticles creates a more robust layer of adhesive and a more pliable interface, perhaps mitigating the stress caused by the composite's shrinkage during polymerization. Dentin bonding agents become more viscous and have better mechanical characteristics when nanoparticles are added. It also displays a high tolerance to moisture and exhibits excellent longevity in terms of marginal integrity. The utilization of the one-cure technique, one-step self-etch adhesives, or all-in-one adhesives, renowned for their convenient and rapid application, represents the most convenient technique presently accessible in the marketplace. The application process involves a solitary step, which integrates etching, priming, and bonding. The reduction in application process should consequently result to a decrease in manipulation time and a mitigation of technique sensitivity, thus resulting in an enhancement of bonding effectiveness [24].

Mithiborwala S et al. [25], have also expressed that the preference for decrease in technique sensitivity of any bonding system is paramount. In light of the aforementioned advantages, a proclivity towards the selection of self-etching adhesive systems is evident at this point in time.

In order to compare two self-etch systems, namely the sixth and seventh generation bonding agent, Kasraie S et al. [26], undertook the research. The pH levels of these two systems are 2 for sixth generation and 2.7 for seventh generation bonding agent, and it is possible to suggest that the sixth generation primer could potentially lead to a deeper or more comprehensive etching of the surface when compared to seventh generation, because of its greater pH. This, in turn, could lead to a greater bond strength. Bond strength can be influenced by various characteristics, one of which being the adhesive's viscosity.

The use of bonding systems leads to a rise in the SBS between RMGIC and composite resin. Findings of this investigation determined that the eighth generation bonding agent demonstrated the maximum level of bond strength. Single-bottle system not only saves a significant amount of time but also necessitates fewer armamentarium and exhibits lower technique sensitivity, all while offering improved mechanical properties in the bonding system.

Conclusion:-

Within the limitations of this study, it can be concluded that assessing the outcome, it was evaluated that application of eighth generation bonding agent between the composite and RMGIC results in higher SBS when compared to fifth, sixth and seventh generation system. Utilizing a bonding agent leads to a rise in SBS between RMGIC and composite in comparison to no bonding agent being used.

Moreover, the self-etch adhesive system increases the SBS between composite and RMGIC more significantly than total-etch adhesive system. The strongest SBS between RMGIC and composite was attained using a one bottle adhesive system.

References:-

1. McLean, J.W. (1991): The clinical use of glass-ionomer cements- Future and current developments. Clin. Mater., 7:283-288.
2. Mathis, R.S., and Ferracane, J.L. (1989): Properties of a glass-ionomer/resin-composite hybrid material. Dent. Mater., 5:355-358.
3. McLean, J.W., and Wilson, A.D. (1977): The clinical development of the glass-ionomer cements. I. Formulations and properties. Aust. Dent. J. 22:31-36.
4. Li, J., Liu, Y., Liu, Y., Söremark, R., and Sundström, F. (1996): Flexure strength of resin-modified glass ionomer cements and their bond strength to dental composites. Acta.Odontol. Scand., 54:55-58.
5. Sofan, E., Sofan, A., Palaia, G., Tenore, G., Romeo, U., Migliau, G. (2017): Classification review of dental adhesive systems: from the IV generation to the universal type. Ann.Stomatol. (Roma)., 8:1-17.
6. Farah, C.S., Orton, V.G., Collard, S.M. (1998): Shear bond strength of chemical and light-cured glass ionomer cements bonded to resin composites. Aust. Dent. J., 43:81-86.
7. Tay, F.R., Pashley, D.H., Suh, B.I., Carvalho, R.M., Itthagarun, A. (2002): Single-step adhesives are permeable membranes. J. Dent., 30:371-382.
8. Navyasri, K., Alla, R.K., Vineeth, G., Sajjan, S.M.C. (2019): An overview of dentin bonding agents. Int. J. Dent. Mater., 1:60–67.
9. Carvalho, R.M., Chersoni, S., Frankenberger, R., Pashley, D.H., Prati, C., Tay, F.R. (2005): A challenge to the conventional wisdom that simultaneous etching and resin infiltration always occurs in self-etch adhesives. Biomater., 26:1035-1042.
10. Yoshida, Y., Nagakane, K., Fukuda, R., Nakayama, Y., Okazaki, M., Shintani, H., et al.(2004): Comparative study on adhesive performance of functional monomers. J. Dent. Res., 83:454-458.
11. Rodrigues, S.A., Pin, L.F., Machado, G., Della, B.Á, Demarco, F.F. (2010): Influence of different restorative techniques on marginal seal of class II composite restorations. J. Appl. Oral. Sci.,18:37-43.
12. Erickson, R.L., Glasspoole, E.A. (1994): Bonding to tooth structure: A comparison of glass-ionomer and composite-resin systems. J.Esthet.Restor. Dent., 6:227-244.
13. Lohbauer, U. (2009): Dental glass ionomer cements as permanent filling materials? Properties, limitations future trends. Materials. (Basel)., 3:76-96.
14. Rathi, S.D., Nikhade, P., Chandak, M., Motwani, N., Rathi, C., Chandak, M. (2020): Microleakage in composite resin restoration-a review article. J.Evol. Med. Dent. Sci., 9:1006-1011.

15. Pandey, S.A., Lokhande, M.T., Gulve, M.N., Kolhe, S.J., Aher, G.B. (2019): Shear bond strength of composite resin to resin-modified glass ionomer cement using 2-hydroxyethyl methacrylate-based and 2-hydroxyethyl methacrylate-free adhesive system. J. Conserv. Dent., 22:292-295.
16. Pamir, T., Sen, B.H., Evcin, O. (2012): Effects of etching and adhesive applications on the bond strength between composite resin and glass-ionomer cements. **J. Appl. Oral. Sci.**, 20:636-642.
17. Sadeghi, M., Atafat, M., Abbasi, M. (2015): Shear bond strength evaluation of resin composite to resin-modified glass-ionomer cement using three different resin adhesives vs. glass-ionomer based adhesive. J. Dent. Mater. Tech., 4:153-160.
18. Arora, V., Kundabala, M., Parolia, A., Thomas, M.S., Pai, V. (2010): Comparison of the shear bond strength of RMGIC to a resin composite using different adhesive systems: An in-vitro study. J.Conserv. Dent., 13:80-83.
19. Chandak, M.G., Pattanaik, N., Das, A. (2012): Comparative study to evaluate shear bond strength of RMGIC to composite resin using different adhesive systems. Contemp. Clin. Dent., 3:252-255.
20. Sam, V., Singh, V.P., Varughese, A., Muddappa, S.C. (2023): The impact of dental adhesives on the shear bond strength between restorations in sandwich technique: A systematic review and meta-analysis. Cons. Dent.Endod. J, 7:11-22.
21. Paul, J., Chakravarthy, Y., Kumar, S., Raju, R. (2013): Comparative evaluation of the bonding efficacy of sixth, seventh and eighth generation bonding agents: An in-vitro study. Int. Res.J. Pharm., 4:143-147.
22. Kamble, S.S., Kandasamy, B., Thillaigovindan, R., Goyal, N.K., Talukdar, P., Seal, M. (2015): An in-vitro comparative evaluation of tensile bond strength of 6th, 7th and 8th generation dentin bonding agents.J. Int. Oral. Health.,7:41-43.
23. Ganesh, A.S. (2020): Comparative evaluation of shear bond strength between fifth, sixth, seventh, and eighth generation bonding agents: An in-vitro study. Indian. J. Dent. Res., 31:752-757.
24. Sachdeva, B., Dua, P., Mangla, R., Kaur, H., Rana, S., Butail, A. (2018): Bonding efficacy of 5th, 6th, 7th & 8th generation bonding agents on primary teeth. IOSR. J. Dent. Med. Sci., 17:61-66.
25. Mithiborwala, S.H., Chaugule, V., Munshi, A., Patil, V. (2011): Comparative evaluation of the adhesive properties of two generations of dentin bonding agents by checking the microleakage in the primary teeth: An in-vitro study.Int. J. Clin. Pediatr. Dent., 4:195-202.
26. Kasraie, S., Shokripour, M., Safari, M. (2013): Evaluation of micro-shear bond strength of resin modified glass-ionomer to composite resins using various bonding systems. J.Conserv. Dent., 16:550-554.