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Review Article

Effect of total-etch and self-etch adhesives on the bond strength of composite to glass-ionomer cement/resin-modified glass-ionomer cement in the sandwich technique – A systematic review

Amarjot Kaur D. S. Manihani[1], Sanjyot Mulay[1], Lotika Beri[1], Rajesh Shetty[1], Shreya Gulati[1], Raj Dalsania[2]

[1]Department of Conservative Dentistry and Endodontics, Dr. D. Y. Patil Dental College, Dr. D. Y. Patil Vidyapeeth, Pune, Maharashtra, [2]Department of Pediatric and Preventive Dentistry, Pacific Dental College, Udaipur, Rajasthan, India

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Address for correspondence:
Dr. Amarjot Kaur D. S. Manihani,
Dr. D. Y. Patil Dental College and Hospital, Dr.D. Y. Patil Vidyapeeth, Sant Tukaram Nagar, Pune - 411 018, Maharashtra, India.
E-mail: amarjot.kaur04@gmail.com

ABSTRACT

The success of the sandwich technique depends on the bond strength of composite to glass-ionomer cement (GIC)/resin-modified glass-ionomer cement (RMGIC). Currently used adhesives employ the total-etch and the self-etch techniques. The total-etch system is technique sensitive, whereas the self-etch system is popular for its ease of use. The aim of this systematic review is to compare the effect of total-etch and self-etch adhesives (SEAs) on the bond strength of composite to GIC/(RMGIC) in the sandwich technique. A literature search was conducted using electronic databases (PubMed, Web of Science, Ebscohost, and Scopus) limiting the year of publications from January 1, 2000, to September 30, 2018, to identify the relevant studies. All the cross-references of the selected studies were also screened. *In vitro* studies on extracted human teeth were selected. A total of 10 articles were included in this review. A conclusion was drawn that SEAs when used in the sandwich technique resulted in greater bond strength in comparison to total-etch adhesives. Moreover, increased bond strength was achieved when the primer was employed on unset GIC as compared to set GIC. Furthermore, the application of SEAs over uncured RMGIC (co-curing technique) resulted in better bond strengths as compared to their application over cured RMGIC.

Key Words: Bond strength, composite resins, dentin-bonding agents, glass-ionomer cements

INTRODUCTION

Resin-based composites have become the most popular and commonly used tooth-colored dental materials today. With a continuous upgradation of material properties, it is envisaged that the gap between basic material science and clinical implementation would soon be bridged. Weak bond strength, especially in the gingival margin, is one of the prime concerns.[1] Hence, a material-like glass-ionomer cement (GIC) or resin-modified glass-ionomer cement (RMGIC) that has a low resistance to elastic deformation is applied under composite restorations. This is popularly known as the sandwich/laminate technique that gives increased bond strengths.[2]

GIC, known for its chemical adhesion to dentin[3] and continued fluoride release;[4,5] depicts increased bond strength over time. This is because of an ion-exchange layer present at the interface of the tooth and

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cement.[6] Nevertheless, they are highly susceptible to moisture uptake due to the slow-setting reaction.

RMGIC contains hydroxyethyl methacrylate (HEMA) and can be light cured.[7] It exhibits improved mechanical properties[8] and better resistance to moisture contamination in comparison to conventional GIC, while the fluoride release remains the same.[9,10]

Laminate restorations are popularly employed in restorative dentistry where a GIC is placed between the tooth and composite resin. Developed by McLean *et al*., in 1985, the adherent properties of glass-ionomers were utilized to seal cavities and reduce microleakage.[11] The advantage of the strong bond strengths of acid-etched enamel to composite resins and the sustained fluoride-releasing property of GICs/RMGICs make the combined use of these two materials a vital step in ensuring adequate clinical results.[12,13]

However, due to a lack of chemical bonding between the two materials, they show a limited bond strength. This is due to their different setting mechanisms.[14]

Recent trends in bonding include two concepts: the total-etch and self-etch. The former comprises a separate etching step and is technique sensitive, whereas the self-etch system is comparatively simpler and less technique sensitive.[15]

Although there has been a comprehensive description of etching of enamel and dentin prior to the use of adhesives and cements in dentistry, the pretreatment of GIC surface remains unclear.[16,17] McLean *et al*. advocated the acid etching of conventional GICs for its integration with the adhesive/composite resin. This bond can be compared to the one formed between acid-etched enamel and composite.[18,19] However, its major drawback is its sensitivity to moisture and the gradual loss in the amount of GIC which is responsible for its disintegration post etching. Due to the infusion of water in its early setting stage, the weak calcium-polyacrylate chains disintegrate, thus degrade the physical properties of the cement.

On the other hand, self-etch adhesives (SEAs) comprise either one or two steps, with the incorporation of self-etching primers that make their use less complex. Etching and resin infiltration are concomitant. Research has demonstrated that these systems produce similar enamel and dentin bond-strengths in comparison to total-etch adhesives (TEAs).[12,20] An additional advantage of self-etch bonding agents is that they can be applied over unset GIC. Elimination of the rinsing step prevents moisture contamination and drying of GIC.[21]

The success of the sandwich technique is determined by the bond strength of GIC to dentin and resin composite. Several studies have been conducted to evaluate the effects of TEAs and SEAs on the bond strength of the sandwich technique. Bonding agents of various brands and with different pH values have been used for varied different application periods. However, the clinical implications of different bonding agents are still a dilemma for many clinicians.

Hence, this systematic review aims to interpret conflicting research data and current information regarding the use of bonding agents in the sandwich technique so that a clearer understanding and in-depth knowledge enables the clinician to use these materials judiciously for a more predictable outcome.

MATERIALS AND METHODS

The review was conducted in accordance with the preferred reporting items for systematic reviews and meta-analyses statement. A PICO (Population, intervention, comparison and outcomes) question was formulated to obtain the relevant studies. The PICO question was What is the effect of total-etch and SEAs on the bond strength of composite to GIC/RMGIC in the sandwich technique?

Where, P: Freshly extracted human teeth, I: SEAs, C: TEAs, and O: Increase or Decrease in Bond Strength between Composite to GIC/RMGIC.

Electronic databases (PubMed, Web of Science, Ebscohost, and Scopus) were searched for literature using different search strategies for the aforementioned keywords and their combinations. All the cross-references of the selected studies were also screened. *In vitro* studies on extracted human teeth were selected. Finally, the review comprised ten articles. An exploratory search was conducted by two authors using the combination of the following medical subject heading terms – composite, GIC bond strength, sandwich technique, TEAs, and SEAs [Table 1].

The inclusion criteria comprised articles in the English language published between January 1, 2000, and September 30, 2018. *In vitro* studies on extracted human teeth evaluating the effect of both TEAs and SEAs on the bond strength of the sandwich technique

Table 1: The primary and secondary keywords used in this systematic review

Primary keywords	Secondary keywords
Composite	Restorative resins
GIC	GIC
Bond strength	
Sandwich technique	Laminate technique
Total-etch adhesives	Fifth-generation bonding agents, two-step bonding agents
Self-etch adhesives	Sixth-generation bonding agents, one-step bonding agents

GIC: Glass-ionomer cement

were included. Exclusion criteria comprised reviews, case reports, abstracts, letters to editors, editorials, and *in vivo* studies.

Study selection

In vitro comparative studies were selected where bond strength was evaluated between composite and GIC after using self-etch or TEAs. A total of 522 articles were identified through the database searching and one article was identified through other sources. After a thorough screening of 523 articles, 63 articles were shortlisted. Furthermore, these records were assessed for duplicates and 42 articles were removed. The abstracts of the remaining 21 articles were then screened and 6 articles were excluded. Full texts were obtained for the 15 articles and assessed for eligibility after which 5 articles were excluded. Finally, 10 articles were included in this systematic review [Figure 1].

Data collection process

Data extraction was done for one article using Microsoft Excel and further reviewed by an expert and culminated. This was followed by data extraction of all the articles for the following parameters – author and year of study, country where the study was conducted, sample size, brand of composite, brand of GIC, self-etch and TEA, outcome variable, methodology, mean bond strengths of the self-etch and TEAs, statistical tests used for data analysis, and conclusion. Only data that were relevant to this study were retained [Table 2].

RESULTS AND DISCUSSION

Several efforts have been made to achieve increased bond strengths between composite and GIC in the laminate technique. We thereby discuss the effects that both total-etch and SEAs have on the bond strength of composite to GIC/RMGIC.

Conventional glass-ionomer cement and composite

Set versus unset glass-ionomer cement

Gopikrishna *et al*.[21] studied the shear bond strength (SBS) of composite resin to GIC employing a total-etch, two-step self-etch, and GIC-based bonding system. They also evaluated the effect of the last two bonding systems over set and unset GIC. According to their study, the self-etch bonding system applied over unset GIC yielded the highest bond strength followed by the GIC-based adhesive system over set GIC. According to them, the carboxylic monomers in the SEA may have bonded to calcium in the unset GIC. The total-etch group and the group in which self-etch bonding agent was applied post the initial set of the GIC showed lower strengths.

Another study[28] evaluated the bonding of single-step SEA over unset GIC and set GIC at different intervals and compared the results to those of a TEA. It was concluded that the bond strength of the group where SEA was employed on unset GIC yielded the best results.

pH of self-etch adhesives

Zhang *et al*.[23] evaluated the microshear bond strengths (MSBS) of a TEA and four SEAs with different pH values when applied over two conventional GICs. All SEAs showed greater bond strengths than the total-etch group and no statistically significant difference was observed among the SEA groups. According to the authors, the harsh phosphoric acid etching in the total-etch group weakened the GIC surface by dissolution of the filler particles. Further, they also stated that the performance of the TEA might have been negatively influenced by insufficient solvent evaporation after its application or by the intrinsic water content of the set GIC.

Sharafeddin and Choobineh[30] evaluated the SBS using adhesives of different pH values and types where conventional GICs were used in the laminate technique. It was found that the SEAs resulted in higher SBS than TEA. Moreover, application of a mild SEA resulted in stronger bonds when compared to intermediate and strong SEA. The authors used the concepts of organic chemistry to explain that the invasion by a weak acid caused the least excitation and hence least salt crumps formation. Consequently, the unexcited cations were responsible for a strong ionic reaction with the adhesives. The results of this study were in accordance with another study[31] which

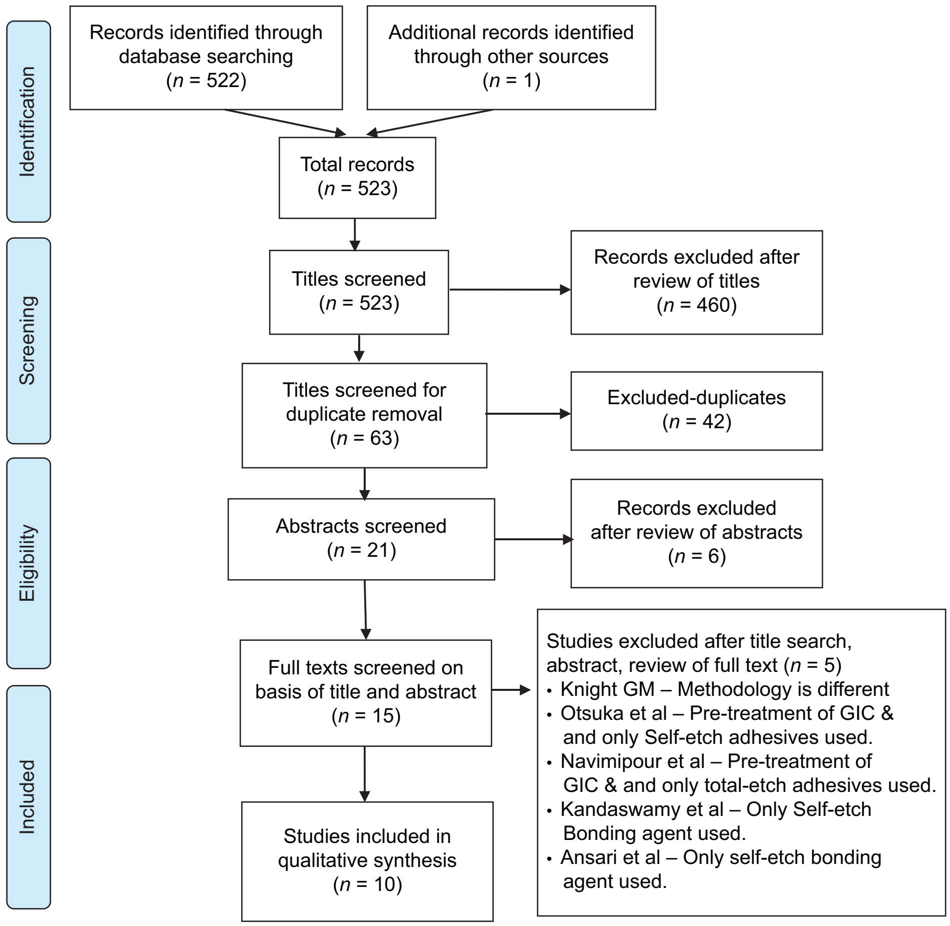

Figure 1: Preferred reporting items for systematic reviews and meta-analysis diagram illustrating the study selection process.

also stated that the application of a mild SEA on unset GIC leads to superior bond strengths.

Resin-modified glass-ionomer cement and composite

Kasraie *et al*.[26] in their study compared the MSBS of composite and RMGIC using various bonding systems. They concluded that the self-etch systems performed better than the total-etch system. Two other studies[22,24] where bond strength between RMGIC and composite was tested showed that SEAs resulted in greater bond strengths as compared to TEAs. The authors reasoned that the acidic nature of the SEA dissolves the surface of the RMGIC thereby improving the bond strength. Moreover, SEAs are less viscous, have a lesser contact angle, and hence, better wettability than TEAs.

Research[22,27,32] suggests that RMGIC can link with composites or bonding systems via a chemical bond formation of HEMA monomer by co-polymerization. This unreacted monomer is present in the air-inhibited layer of the superficial surface of the cured RMGIC. Moreover, a covalent chemical bond between bonding systems and the remaining monomer is also achieved in polyacid chains within the cured RMGIC.[33,34]

The co-curing technique suggests the simultaneous curing of two different light-cured materials.[35] Knight[36] in their study suggested that co-curing RMGIC and composite together can lower the internal stress in composite restorations and also reduce the time required for the clinical procedure. Moreover, co-curing of RMGIC with composite results in a stronger bond between the two materials.[19]

Boruziniat and Gharaei[27] assessed the bond strength of RMGIC to composite using different adhesives and various curing methods. They concluded that SEAs showed better results than the total-etch group ($P < 0.05$). Upon co-curing, increased bond strengths were observed in the groups where self-etch bonding agents were used, unlike the total-etch group that showed decreased bond strengths. The authors reasoned that the uncured HEMA on the surface of RMGIC could enhance the wetting potential of bonding agents. The appearance of distinct resin

Table 2: Characteristics of the studies included in this review

	Study (year)	Country	Sample size	Composite	GIC/RMGIC	Self-etch adhesive	Total-etch adhesive	Outcome variable
1	Gopikrishna *et al.*, 2009[21]	India	100	Solare GC Corporation, Tokyo, Japan	GIC: FUJI II GC Corporation, Tokyo, Japan	Group B and C - Unifil bond GC Corporation, Tokyo, Japan (self-etch bonding system) Group D and E - Fuji bond LC (Glass Ionomer based adhesive) GC Corporation, Tokyo, Japan	Group A - Adper Single Bond 2, 3M ESPE, St Paul, MN, USA	Shear bond strength
2	Arora *et al.*, 2010[22]	India	30	Filtek™ Z-350 3M ESPE, St Paul, MN, USA	Resin modified GIC: Vitrebond 3M ESPE, St Paul, MN, USA	Group II Adper™ Prompt™ L Pop™ 3M ESPE, St Paul, MN, USA	Group I: Adper Single Bond 2, 3M ESPE, St Paul, MN, USA	Shear bond strength
3	Zhang *et al.*, 2011[23]	Australia	100	Gradia Direct Anterior A3, GC Corporation, Tokyo, Japan	GIC: GC Fuji IX GP EXTRA, GC Corporation, Tokyo, Japan (FJ) Riva Self Cure, SDI Limited, Bayswater, Victoria, Australia (RV)	Adper Scotchbond SE, 3M ESPE (SSE) Clearfil SE Bond, Kuraray Medical Inc, Tokyo, Japan (CSE) Clearfil S3 Bond, Kuraray Medical Inc, Tokyo, Japan (CS3) One Coat 7.0, Coltene Whaledent AG, Altstätten, Switzerland (OC)	Adper Single Bond Plus 3M ESPE, St Paul, MN, USA. (SB)	Microshear bond strength
4	Chandak *et al.*, 2012[24]	India	30	Filtek™ F60 3M ESPE, St Paul, MN, USA	Resin modified GIC: Vitrebond - 3M ESPE, St Paul, MN, USA	Group A Adper™Prompt L Pop™ 3M ESPE, St Paul, MN, USA	Group B Adper™ Scotch Bond 23M ESPE, St Paul, MN, USA	Shear bond strength
5	Pamir *et al.*, 2012[25]	Turkey	150	Filtek™ Z250, 3M ESPE AG Dental Products, Seefeld, Germany	GIC: Ketac™ Molar Quick Applicap™, 3M ESPE AG Dental Product, Seefeld, Germany RM-GIC: Photac™ Fil Quick Applicap™, 3M ESPE AG Dental Product, Seefeld, Germany	All in one Adper™ Prompt™ L-Pop™ 3M ESPE Dental Products, Seefeld-Germany	Adper™ Single Bond 2 , 3M ESPE Dental Products, Seefeld Germany In the total-etch groups, etching was done at intervals of 15, 30, 60 s	Shear bond strength
6	Kasraie *et al.*, 2013[26]	Iran	16	Filtelk™ Z250 3M ESPE, St Paul, MN, USA	Resin-modified GIC: Vitrebond- 3M ESPE, St Paul, MN, USA	Group 2 - Clearfil SE Bond, Kuraray, Japan (CSE) Group 3 -Clearfil S3 Bond, Kuraray, Japan (CS3) Group 4- Control	Group 1- Single Bond, 3M ESPE, St Paul, USA	Microshear bond strength
7	Boruziniat and Gharaei 2014[27]	Iran	60	Heliomolar, Ivoclar Vivadent; Schaan, Liechtenstein	Resin-modified GIC; Fuji II LC, GC corporation Japan	Groups TS-C (Co-curing) and TS-P (Pre curing) - AdheSE , Ivoclar Vivadent; Schaan, Liechtenstein (two-step self-etch adesive) Groups OS-C (Co- curing) and OS-P (Pre curing) - AdheSE One F, Ivoclar Vivadent; Schaan, Liechtenstein (one step self-etch adhesive)	Groups T-C (Co-curing) and T-P (Pre curing): Tetric N-Bond Ivoclar Vivadent; Schaan, Liechtenstein (total-etch adhesive)	Shear bond strength

Contd...

Table 2: Contd...

	Study (year)	Country	Sample size	Composite	GIC/RMGIC	Self-etch adhesive	Total-etch adhesive	Outcome variable
8	Gupta and Mahajan 2015[28]	India	30	Filtek™ Z350 3M ESPE, St Paul, MN, USA	GIC: Fuji II, GC Corporation, Japan	Group B Self etch primer Adper™ Easy One, 3M ESPE Inc, St Paul, MN, USA (before initial set of GIC) Group C Self Etch primer Adper™ Easy One, 3M ESPE Inc, St Paul, MN, USA (after the initial set of GIC)	Group A - Adper™ Single Bond 2, 3M ESPE Inc, St Paul, MN, USA	Shear bond strength
9	Panahandeh *et al*., 2015[29]	Iran	160	Z100™ 3M ESPE, St Paul, MN, USA	GIC: Groups 1-3, 9-11: Riva Self Cure Victoria, Australia Groups 4 and 12: Riva Light Cure Victoria, Australia RMGIC: Groups 5-7, 13-15: Fuji II GC International Corp., Tokyo, Japan Groups 8 and 16: Fuji II LC International Corp., Tokyo, Japan	Groups 1-8 - Stae Self-etch bonding, SDI Victoria, Australia: Groups 1 and 5 - Bonding agent applied after working time of the GIC Groups 2 and 6 - Bonding agent applied after setting time of the GIC Groups 3 and 7 - Bonding agent applied 15 min after mixing GIC Groups 4 and 8 Bonding agent applied after curing RMGIC	Groups 9-16 - Frog Etch and rinse bonding, SDI Victoria, Australia: Groups 7 and 13 - Bonding agent applied after working time of the GIC Groups 8 and 14 - Bonding agent applied after setting time of the GIC Groups 9 and 15 - Bonding agent applied 15 min after mixing GIC Groups 10 and 16 Bonding agent applied after curing RMGIC	Shear bond strength
10	Sharafeddin and Choobineh 2016[30]	Iran	40	Filtek™ Z350 3M ESPE, St Paul, MN, USA	GIC: ChemFil Superior (Dentsply; Germany)	Group A (mild) - Clearfil SE Bond self-etch - Kuraray Medical Inc, Tokyo, Japan Group B (Intermediate) - Optibond self-etch - SDS Kerr; Orange, CA, USA Group C (Strong) - Adper™ Prompt L Pop™ - 3M ESPE, St. Paul, USA	Group D - Adper Single Bond 2, 3M ESPE St. Paul, USA	Shear bond strength

	Methodology	Mean bond strength in MPa (Self-etch adhesive)	Mean bond strength in MPa (total-etch adhesive)	Statistical analysis test	Conclusion
11	SBS was evaluated by the universal testing machine at a crosshead speed of 0.5 mm/min	Group B 4.50±0.09 Group C 3.08±0.19 Group D 3.75±0.12 Group E 4.49±0.13	Group A - 4.0010±0.12	One-way ANOVA and Tukey's test	Bond strength of composite to GIC was significantly higher for the self-etch primer group employed on unset GIC and the GIC-based adhesive group employed on the set GIC in comparison to the total-etch adhesive
12	SBS was evaluated by the universal testing machine at a crosshead speed of 0.05 mm/min	Group II: 5.8526±0.9624	Group I - 4.6380±0.8369	ANOVA, Fisher's test, and Tukey's test	Application of self-etch adhesive between RMGIC and composite resin resulted in greater bond strengths, in comparison to the total-etch adhesive

Contd...

Table 2: Contd...

	Study (year)	Country Sample size	Composite GIC/RMGIC	Self-etch adhesive	Total-etch adhesive Outcome variable
13	MSBS was evaluated by the universal testing machine at a crosshead speed of 1 mm/min	24 h 1 month 6 months SSE/RV=12.1 (2.1) 12.0 (2.6) 11.2 (2.5) SSE/FJ=12.3 (2.2) 12.2 (2.4) 11.2 (2.6)	24 h 1 month 6 months SB/RV=10.6 (2.2) 10.3 (2.8) 8.7 (1.9) SB/FJ=10.9 (2.2) 10.8 (2.8) 9.1 (2.1)	ANOVA and Tukey's test	The total-etch adhesive when applied to conventional GICs showed a lower bond strength than the self-etch adhesives when for all storage periods. It was also
	Methodology	**Mean bond strength in MPa (Self-etch adhesive)**	**Mean bond strength in MPa (total-etch adhesive)**	**Statistical analysis test**	**Conclusion**
14		CSE/RV=11.9 (2.1) 12.2 (2.6) 11.2 (2.4) CSE/FJ=12.6 (2.3) 12.6 (2.6) 11.5 (2.5) CS3/RV=11.9 (2.0) 12.1 (2.7) 11.0 (2.2) CS3/FJ=12.2 (2.2) 12.36 (2.7) 11.4 (2.4) OC/RV=12.2 (2.4) 12.2 (2.5) 11.2 (2.6) OC/FJ=12.3 (2.2) 12.3 (2.5) 11.4 (2.5)			observed that water storage for 6 months significantly reduced the MSBS for the total-etch group. However, cohesive strength of GIC was a limiting factor for the MSBS outcomes
15	SBS was evaluated by the universal testing machine at a crosshead speed of 3 mm/min	Group A - 2.74±0.03	Group B - 1.89±0.10	ANOVA and Dunnet D Test	Application of self-etch adhesive over RMGIC showed better results than total-etch adhesive
16	SBS was evaluated by the universal testing machine at a crosshead speed of 0.5 mm/min	Ketac Molar (GIC) Self-etch group=6.0±2.2 Photac Fil Quick (RMGIC) Self-etch group=12.8±2.5	GIC - Total etch groups No etch - 6.1±2.3 15 s - 5.1±1.6 30 s - 7.1±1.7 60 s - RMGIC - Total etch groups No etch 10.1±2.7 5 s - 10.0±2.3 30 s - 12.7±2.9 60 s - 12.0±2.8	Two-way ANOVA test	RMGIC showed a superior bonding to composite in comparison to GIC. No statistically significant differences were seen between the self-etching and total-etch adhesives at any etching time
17	MSBS was evaluated by the universal testing machine at a crosshead speed of 0.5 mm/min	Group 2-23.49 Group 3-16.23 Group 4-5.46	Group 1 - 14.45	One-way (ANOVA) and Tukey's test	1. Application of self-etch systems resulted in a greater increase in micro-shear bond strength between RMGIC and light-cured composite resin compared to the use of etch-and-rinse systems 2. The highest microshear bond strength between RMGIC and light-cured composite resin was achieved with the use of two-step self-etch primer system
18	SBS was evaluated by the universal testing machine at a crosshead speed of 1 mm/min	TS-C 21.43 (0.57) TS-P 18.64 (0.42) OS-C 20.33 (0.84) OS-P 18.15 (0.52)	T-C 15.84 (0.51) T-P 17.81 (0.51)	Two-way ANOVA and Tukey's test	The use of the co-curing technique and self-etch adhesive systems may improve the SBS between composite and RMGI

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Table 2: Contd...

	Study (year)	Country	Sample size	Composite	GIC/RMGIC	Self-etch adhesive	Total-etch adhesive	Outcome variable
19	SBS was evaluated by the universal testing machine at a crosshead speed of 1 mm/min	Group B 4.02±0.2530 Group C 3±0.2		Group A - 3.28±0.2044		One-way ANOVA	Application of self-etch primer over unset GIC (co curing) showed better results than the total-etch system. Self-etch primer applied after the initial set of GIC showed the least bond strength values	
20	SBS was evaluated by the universal testing machine at a crosshead speed of 1 mm/min	Group 1-12.59±0.4.48 Group 2-13.78±6.08 Group 3-9.72±4.38 Group 4-14.47±2.25 Group 5-15.35±6.50 Group 6-19.93±8.48 Group 7-16.91±3.90 Group 8-27.81±8.14		Group 9 - 16.65±3.36 Group 10 - 10.96±4.96 Group 11 - 11.69±3.20 Group 12 - 19.30±8.95 Group 13 - 18.89±7.35 Group 14 - 15.74±7.76 Group 15 - 13.61±3.05 Group 16 - 25.96±9.95		Three-way ANOVA and Tukey's Test	The type of bonding agent had no effect on the bond strength, in neither the GIC nor the RMGIC group	
21	SBS was evaluated by the universal testing machine at a crosshead speed of 1 mm/min	Mean SBS Group A 7.77±0.82 Group B 6.04±0.71 Group C 4.71±1.34		Group D - 3.45±0.78		One-way ANOVA and Tukey's test	The application of self-etch adhesive between composite and GIC showed better results than total-etch adhesive. Moreover, mild self-etch adhesives resulted in better bond strengths as compared to intermediate and strong self-etch adhesives	

ANOVA: Analysis of variance, GIC: Glass-ionomer cement, RMGIC: Resin-modified glass-ionomer cement, SBS: Shear bond strength, MSBS: Micro-SBS

tags observed in the scanning electron microscopic images of co-cured, two-step, SEA group could be attributed to their lower viscosity or the better wetting potential. The infiltration of resin into RMGICs could enhance their strength and therefore alter the failure mode. In the total-etch, co-cured group, etching was done before the development of the "resinous matrix" for its greater ingress into the resin-modified GIC. This impact of the TEA on uncured RMGIC was moderately comparable to the conventional GIC. The development of fragile salts on the surface of RMGIC,[31] elimination or reduction of calcium and aluminum ions leading to the lower tensile strength of RMGIC,[37] and a decrease in the HEMA content[32] could be the reasons for lower bond strengths in this group. Moreover, the authors concluded that the increased cohesive failures in this group were because of the weakening effect of the acid application on the uncured RMGIC structure.

Glass-ionomer cement versus resin-modified glass-ionomer cement

Pamir *et al*.[25] studied the outcome of various etching durations on the bond strength of composite to GICs and RMGICs and concluded that an etching time of 30 s was optimal for both the GIC types. They also compared the total-etch and self-etch bonding systems and concluded no statistically significant difference between the two for any time duration. RMGICs showed significantly better results than conventional GICs. The authors acknowledged the greater bond strengths between RMGIC and composite to a similarity in composition and curing mechanisms by free-radical initiator system.

Panahandeh *et al*.[29] studied the impact of time and type of adhesive application on the MSBS of composite to various GICs and RMGICs. The authors concluded that the variant (total-etch or self-etch) of adhesive had no influence on the results, but RMGICs performed better than the conventional GICs. According to them, the HEMA molecules within, along with the unreacted methacrylate groups, and the oxygen inhibition layer on the surface of RMGICs could lead to strong superior chemical covalent bonds with the adhesive resin, leading to better results.

Two articles were excluded from this systematic review as they included pretreatment of the GIC surface. Navimipour *et al*.[38] studied the effect of acid etching and Er, Cr: YSGG laser on the SBS of composite to GIC and RMGIC. They concluded that both the treatments led to better bond strengths in conventional GIC. However, among the RMGIC groups, better bond strengths were observed exclusively in the laser treatment group.

Otsuka *et al*.[39] carried out a study to determine how acid etching and air abrasion of GIC and RMGIC affected the bond strengths while using a SEA. Increased bond strengths were observed for conventional GIC, but the opposite was observed for RMGICs.

It is pertinent to state that there was a fair amount of variation in the mean bond strengths in the studies reviewed in this article. This can be advocated the different methodologies employed. Moreover, there was a disparity in the crosshead speed used while evaluating bond strengths. Studies indicate that samples tested at 0.5 mm/min showed remarkably better cohesive vs. adhesive results than other crosshead speeds.[40] SBS evaluated with crosshead speeds of 0.50 and 0.75 mm/min are more desirable.[41]

Limitations

Many studies were not comparable due to the different brands of materials used and a variation in the methodology employed.

CONCLUSION

The use of SEAs resulted in superior bond strengths than total-etch bonding agents in the sandwich technique. Better results were obtained when SEA was employed on unset GIC in comparison to set GIC. Moreover, SEA applied over uncured RMGIC achieved better results as compared to cured RMGIC. Also, RMGICs due to the similarity in composition to composites fare reasonably better than conventional GICs in the sandwich technique.

Future implications

The success of the sandwich technique is primarily dependent on the bond strength of composite to GIC. SEAs are less technique sensitive and save ample chairside time. Hence, further exploration in the form of various clinical studies should be carried out.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived or financial or nonfinancial in this article.

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