Original Article

Shear Bond Strength between Conventional Composite Resin and Alkasite-Based Restoration Used in Sandwich Technique: An *In Vitro* Study

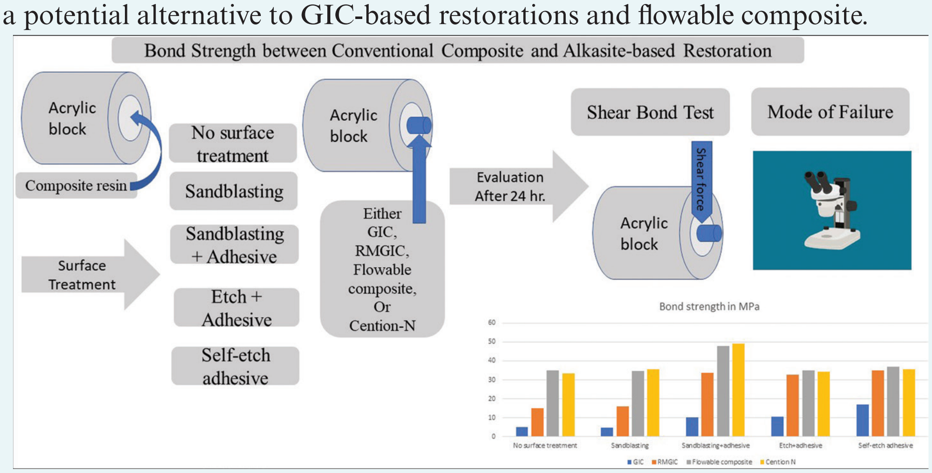
Alaa E. Dawood, Emad F. Alkhalidi, Mohammad A. Saeed

Department of Conservative Dentistry, College of Dentistry, University of Mosul, Mosul, Iraq

Abstract

Aim: The success of layered restorations necessitates the utilization of an improved restorative material compatible with composite restorations. Therefore, in this line of research, the strength of adhesion of conventional resin-based dental composite to different filling materials was tested. **Materials and Methods:** Conventional composite resin was bonded to four restorative materials (Group I: conventional glass ionomer cement (GIC), Group II: resin-modified glass ionomer cement, Group III: flowable composite, and Group IV: Cention-N) received no surface treatment (Subgroup A: control), sandblasting using 50-µm aluminum oxide particles (Subgroup B), sandblasting and resin adhesive (Subgroup C), acid etch and resin adhesive (Subgroup D), or self-etch resin adhesive (Subgroup E). After 24 h, the strength of adhesion between the conventional composite resin and the other tested filling materials was estimated by using a universal testing machine and compared using one-factor analysis of variance and Tukey's method. **Results:** The conventional GIC had the minimum values of adhesion strength while the flowable composite and Cention-N had the maximum values of adhesion strength ($P < 0.05$). The treatment of the used restorative materials with sandblasting and resin adhesive boosted the adhesion strength ($P < 0.05$). The surface treatment of GIC-based materials with either acid etch and resin bonding agent or self-etch resin bonding agent boosted the adhesion strength ($P < 0.05$). **Conclusion:** Cention-N sandblasted and coated with resin adhesive before the application of conventional composite resin in layered restorations is a potential alternative to GIC-based restorations and flowable composite.

Graphical Abstract



Address for correspondence: Dr. Alaa E. Dawood, Department of Conservative Dentistry, College of Dentistry, University of Mosul, Mosul 41001, Iraq.
E-mail: alaaedress@uomosul.edu.iq

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jpcd

DOI: 10.4103/jispcd.jispcd_4_24

How to cite this article: Alaa ED, Emad FA, Mohammad AS. Shear bond strength between conventional composite resin and alkasite-based restoration used in sandwich technique: An *in vitro* study. J Int Soc Prevent Communit Dent 2024;14:161-6.

Received : 10-Jan-2024
Revised : 14-Mar-2024
Accepted : 18-Mar-2024
Published: 29-Apr-2024

Keywords: *Cention-N, GIC, RMGIC, sandwich restoration, shear bond strength*

Introduction

The aim of combining different restorative materials by using a layering technique, which is known as the sandwich technique, was to enhance the success of the final restorations.[1] The type of the inner layer used in sandwich restorations is chosen based on its favorable properties, such as minimal pulp tissue irritation, reduced microleakage, improved dentinal adhesion, ease of handling, low elastic modulus, and possible low polymerization shrinkage stress.[2] The bond strength between the different layers of sandwich restoration is crucial to the overall restoration's success. Conventional glass ionomer cement (GIC), resin-modified glass ionomer cement (RMGIC), and flowable composite are frequently used materials underneath conventional resin composite in sandwich restorations.[3] Deep proximal cavities with subgingival margins are restored with sandwich restorations using GIC or flowable composite to elevate the gingival seat before the placement of composite resin.[4] It is recommended to surface-treat GIC before applying the composite restoration on top of it to increase adhesion at the GIC-composite interface. The relatively weak adhesion of the GIC to resin-based dental composite could be attributed to the inferior mechanical features of GIC and the difference of the chemistry of these two materials.[5] The flowable composite is also known for its low strength, which may risk the survival of sandwich restorations.[6] The low filler amount in the flowable composite produces substantial volumetric contraction during polymerization, which might contribute to debonding at the tooth-filling interface.[7] Therefore, the success of sandwich restorations necessitates the use of an alternative improved restorative material compatible with composite restorations.

Cention-N is a self-cured (and light-cured) self-adhesive bulk-fill resin-based alkasite filling material with an improved flexural strength and a special filler component, which aims to relieve the stress of polymerization shrinkage.[8] Cention-N can be used to fill teeth cavities with or without adhesive bonding agent after mixing its components (the ion-leachable glass-silicate powder and resin-based liquid). Cention-N has superior dentinal shear bond strength in comparison with composite resin and GIC restorations.[9] The potential release of ions and the improved marginal adaptation of Cention-N may contribute to possible antimicrobial and anticaries effects.[10] Therefore, Cention-N could be a promising alternative for replacing GIC and flowable composite in sandwich restorations.

The objective of this study was to measure the strength of the adhesion between conventional resin-based dental composite and four different restorative materials (GIC, RMGIC, flowable composite, and Cention-N) treated using different surface treatment methods. This study also attempted to identify the type of the bond failure.

Materials and Methods

Samples preparation

Conventional restorative GIC (Securafil, Willmann & Pein GmbH, Barmstedt, Germany), RMGIC (Glass Liner, Willmann & Pein GmbH), Cention-N (Ivoclar Vivadent AG, Schaan, Liechtenstein), and flowable composite (Beautifil-Bulk Flowable, Shofu Dental Corporation, CA, USA) were used in the experiment of this study, and their bond strength to conventional resin-based dental composite (PALFIQUE LX5, Tokuyama Dental Corporation, Tokyo, Japan) was measured. Cylindrical specimens of the conventional GIC (Group I), RMGIC (Group II), flowable composite (Group III), and Cention-N (Group IV) were prepared (50 samples for each material) by handling the materials (according to the instructions provided by the manufacturer) and packing them into pre-prepared molds (cylindrical chambers of 10 mm diameter and 2 mm depth prepared in acrylic resin blocks). A translucent celluloid ribbon was placed on the unset materials and pushed against the mold using a 4-mm thickness glass slab. The conventional GIC was left to harden for 10 min before surface treatment. The samples of RMGIC, flowable composite, and Cention-N were light-treated for 40 s using a VRN-VAFU Light Emitting Diode (LED) curing device (Guilin Veirun Medical Technology Co., Ltd., Guilin, China) at the curing intensity of 1000 mW/cm^2. The specimens of each cement were subdivided into five subgroups (N = 10): Subgroup A—Control: no surface treatment. Subgroup B—the surface of the specimens was sandblasted for 30 s with an air abrasion unit (Air Prophy Unit, Being Foshan, Guangdong, China) using 50-µm aluminum oxide particles and then water-washed and air-dried for 15 s. Subgroup C—the surface of the specimens was sandblasted for 30 s, water-washed, air-dried for 15 s, and covered with resin bonding agent (Scotchbond 1XT, 3M Dental Products, Saint Paul, MN, USA) and light-cured for 15 s. Subgroup D—the surface of the specimens was acid-etched for 30 s using a 37% H_3PO_4 (phosphoric acid) gel (3M Dental Products), water-washed, air-dried, and covered with Scotchbond 1XT resin bonding agent and light-cured for 15 s. Subgroup E—the surface of the specimens was covered with self-etch resin bonding agent (Scotchbond Universal, 3M Dental Products) and light-cured for 15 s.

Conventional composite resin blocks were built on the abovementioned specimens using a standardized plastic cylindrical mold (4 mm diameter and 2 mm height). The composite resin was inserted in the mold and pressed using a translucent celluloid ribbon and 4-mm thickness glass slab. The composite resin was then light-treated for 40 s using the LED curing device. The plastic mold was removed, and the specimens were soaked in clean filtered water in black containers at 37°C for 24 h.

Shear bond strength test

A custom-built blade attached to a universal testing machine (GESTER International Co., Ltd, Quanzhou, China) with a speed of 0.5 mm/min was employed to detach the conventional composite resin from the tested cements. The strength of adhesion in megapascal (MPa) was computed by dividing the failure force measured in Newton on the bonding surface area measured in square millimeter.

Determination of failure mode

The failure type was also determined by inspecting the specimens under 10× microscopic magnification (Stereomicroscope, OPTIKA, BG, Ponteranica, Italy). The specimens were classified according to the failure mode into cohesive type of failure (within the conventional resin-based composite or within the other tested filling materials), adhesive type of failure (at the junction between the conventional resin-based composite and the other tested filling materials), or mixed failure (adhesive and cohesive).

Statistical analysis

The findings of the adhesion strength experiment were statistically analyzed using IBM statistical package for social sciences (SPSS), version 25 (IBM® SPSS® Statistics, New York, NY, USA). One-factor analysis of variance and Tukey's method were performed.

Significance level

Statistical significance was set at a level of $P < 0.05$.

Results

Shear bond strength

The values (means and standard deviations) of the shear bond strength between the conventional resin-based composite and the other tested filling materials are presented in Table 1. The minimum bond strength was reported with the conventional GIC (in all the subgroups of the surface treatment) in comparison with the other tested materials ($P < 0.05$). The adhesion strength values of the RMGIC were significantly lower than the adhesion strength values of the flowable composite and Cention-N in all the subgroups of the surface treatment ($P < 0.05$), except when the three materials were treated with either acid etch and resin bonding agent or self-etch resin bonding agent. The difference was statistically insignificant among the bond strength values of the RMGIC, flowable composite, and Cention-N when the three materials were treated with either acid etch and resin bonding agent or self-etch resin bonding agent. The variation between the adhesion strength values of the flowable composite and Cention-N was

Table 1: Means and standard deviations of the shear bond strength between conventional composite resin and four different restorative materials in MPa

		Mean (SD)			
		Type of the cement			
Surface Treatment	N	GIC	RMGIC	Flowable composite	Cention N
No surface treatment (Control)	10	4.92 (0.9) $^{A, a}$	15.1 (1.1) $^{B, a}$	35.08 (2.7) $^{C, a}$	33.28 (3.2) $^{C, a}$
Sandblasting	10	4.74 (0.4) $^{A, a}$	16.1 (2.1) $^{B, a}$	34.58 (3.8) $^{C, a}$	35.54 (2.8) $^{C, a}$
Sandblasting + Resin adhesive	10	10.32 (0.6) $^{A, b}$	33.58 (3.1) $^{B, b}$	47.72 (5.3) $^{C, b}$	49.3 (4.1) $^{C, b}$
Etch + Resin adhesive	10	10.36 (1.1) $^{A, b}$	32.64 (2.9) $^{B, b}$	35.08 (2.3) $^{B, a}$	34.22 (2.8) $^{B, a}$
Self-etch adhesive	10	16.98 (0.7) $^{A, c}$	35.14 (4.2) $^{B, b}$	36.86 (2.3) $^{B, a}$	35.68 (3.6) $^{B, a}$

N=Number of specimens, SD=Standard deviation. Values marked with different capital letters (A-C) indicate a significant difference between the different test materials received the same surface treatment ($p < 0.05$). Values marked with small letters (a-c) indicate a significant difference between the subgroups of the same material statistically insignificant in all the subgroups of the surface treatment ($P > 0.05$). The sandblasting alone has no significant effect on the adhesion strength values of the tested filling materials ($P > 0.05$). The surface treatment using sandblasting and resin bonding agent significantly boosted the adhesion strength values of the four tested filling materials compared with the control groups and sandblasting groups ($P < 0.05$). The surface treatment using either acid etch and resin bonding agent or self-etch bonding agent significantly boosted the adhesion strength values of the conventional GIC and RMGIC compared with the control groups ($P < 0.05$). The surface treatment using either acid etch and resin bonding agent or self-etch bonding agent had no significant effect, either on the flowable composite or on Cention-N. The surface treatment of the conventional GIC with self-etch bonding agent produced the maximum adhesion strength values in comparison with the other methods of surface treatment of the conventional GIC ($P < 0.05$).

Failure mode

The modes of failure of the adhesion strength test are listed in Table 2. The adhesive type of failure was the predominant type of failure of the control groups (no surface treatment). Ninety percent of the specimens of the sandblasted conventional GIC and Cention-N showed adhesive failure. Eighty percent of the specimens of the sandblasted and resin-coated RMGIC and Cention-N showed cohesive failure. Ninety percent of the specimens of the etched and resin-coated RMGIC showed cohesive failure, while 90% of the specimens of the etched and resin-coated Cention-N showed adhesive failure. Eighty percent of the specimens of the self-etched conventional GIC, and all the specimens of the self-etched RMGIC showed cohesive failure. The number of the specimens with cohesive failure increased after the sandblasting of the RMGIC and flowable composite. More cohesive failures were seen with sandblasting and resin adhesive surface treatment, especially for the RMGIC, flowable composite, and Cention-N. The treatment of the GIC and RMGIC using self-etch bonding agent was associated with more cohesive failures.

Discussion

This study measured the strength of adhesion between the conventional composite resin and four different restorative materials that could be used under the conventional composite resin in sandwich restorations. The shear bond strength is obtained by measuring the minimum shear force that separates two materials bonded together by pushing them in different directions. To calculate the adhesion strength in MPa, the shear force is divided by the area of the bonded surface.[11] In fact, the shear bond strength test did not precisely measure the interfacial bond between the tested materials but rather reflected the cohesive strength of the substance, especially when it is less than the adhesive bond.[12] Therefore, cohesive failures associated with shear bond strength test are strong indication of high strength of adhesion.[13] This comes in harmony with the outcomes of the current research where the high adhesion strength values were associated with more cohesive mode of failures.

The modification of the outer surface of the tested dental filling materials with sandblasting and resin adhesive increased the bond strength in comparison with the control groups. This is probably explained by the surface roughness produced by the sandblasting and the subsequent micromechanical adhesion induced by the application of resin adhesive.[14] The sandblasting alone did not enhance the adhesion strength of the tested filling materials because the conventional composite resin has high surface tension and did not properly wet the surface without the use of the resin adhesive.[15]

The increased shear bond strength after surface treatment of GIC with etch and rinse adhesive (in

Table 2: Failure modes

Surface Treatment	N	Failure modes (A/C/M) — Type of the cement: GIC	RMGIC	Flowable composite	Cention N
No surface treatment (Control)	10	10 /0 /0	9 /1 /0	6 /3 /1	8 /1 /1
Sandblasting	10	9 /0 /1	3 /5 /2	3 /5 /2	9 /0 /1
Sandblasting + Resin adhesive	10	6 /3 /1	0 /8 /2	2 /6 /2	0 /8 /2
Etch + Resin adhesive	10	5 /3 /2	0 /9 /1	6 /2 /2	9 /1 /0
Self-etch adhesive	10	2 /8 /0	0 /10 /0	7 /2 /1	8 /1 /1

N=Number of specimens, A=adhesive failure, C=cohesive failure, M=mixed failure comparison with control groups) could be attributed to the possible micromechanical adhesion and hybrid-like layer formation. On the other hand, the phosphoric acid may possibly weaken the cement surface as it is more aggressive than the acidic monomer of the self-etch resin bonding agent. This may explain the superiority of bonding GIC-based materials with self-etch resin bonding agent over bonding with etch and rinse resin bonding agent.[16] The interactions between the dihydrogenphosphate functional group of 10-MDP (10-methacryloyloxydecyl dihydrogenphosphate added to self-etch resin bonding agent) and the calcium ions content in the matrix of GIC might have also led to a chemical bond of the self-etch resin bonding agent to GIC-based materials.[17] The surface treatment using either acid etch and resin bonding agent or self-etch resin bonding agent had no significant effect, either on the flowable composite or on Cention-N, because the use of 37% phosphoric acid or weak-acid monomer does not increase the surface irregularity and roughness of resin-based restorations.[18]

The weak adhesion between the conventional GIC and resin-based dental composite reported in the present research could be due to the difference in the chemistry and setting reaction of these two materials.[19] The adhesion strength of RMGIC to the resin-based dental composite was more than the adhesion strength of the conventional GIC to the resin-based dental composite due to the possible chemical interaction, which may occur between the resin components of RMGIC and the resin-based dental composite.[20] The chemical reaction between the resin-based filling materials (especially the flowable composite and Cention-N) and the conventional composite resin produced greater adhesion strength in comparison with the adhesion strength of the GIC-based materials to the conventional composite resin. For successful outcome of the sandwich filling, a strong chemical union between the layers of the filling is more desirable, more stable, and less likely to fail under stress in comparison with micromechanical retention.[21] Besides its ability to chemically bond to conventional composite resin, Cention-N is a dual-cure ion-releasing self-adhesive (can be used with or without dentine adhesive) restorative material with special isofillers which work as a reliever of shrinkage stress.[8] Therefore, Cention-N might be a suitable candidate to replace the GIC-based cements and flowable composite resin in layered restorations. The use of Cention-N involves mixing two elements (powder and liquid) that might lead to incorporation of air bubbles producing more porous material with possible surface roughness in comparison with conventional composite resin.[22] Therefore, it might be better to use Cention-N underneath conventional composite restoration to maximize the surface smoothness, degree of polishability, and esthetic outcome of the final restoration.

One of the drawbacks of this study is the absence of simulation of the dental cavities because the influence of the configuration factor (C-factor) on the polymerization shrinkage was ignored. To assess the effectiveness of Cention-N in sandwich restorations, additional research utilizing simulated cavities is required.

Conclusions

Within the environments and limitations of the experiment of this research, the following can be concluded:

1. It is possible to recommend Cention-N as a suitable alternative to GIC-based restorations and flowable composite in layered restorations.
2. Cention-N can be used without surface treatment or it can be sandblasted and coated with resin adhesive before the application of conventional composite resin in layered restorations.
3. It is recommended to treat the surface of GIC-based cements with self-etch adhesive before placing the conventional resin-based dental composite in layered restorations.

Acknowledgement

This study was supported by the College of Dentistry at the University of Mosul, Iraq.

Financial support and sponsorship

Self-funded.

Conflict of interest

There are no conflicts of interest.

Authors contributions

The first author contributed to the study concept and design, and contributed to material preparation, data collection, data analysis, and writing up the manuscript. The second author contributed to the study concept and design, and contributed to material preparation and data collection. The third author contributed to the study concept and design, and contributed to material preparation and data collection.

Ethical policy and institutional review board statement

Not applicable.

Patient declaration of consent

Not applicable.

Data availability statement

The data used and analyzed in this study are available in this article.

List of Abbreviations

GIC: glass ionomer cement
RMGIC: resin-modified glass ionomer cement
LED: light emitting diode
ANOVA: analysis of variance
10 MDP: 10-methacryloyloxydecyl dihydrogenphosphate
C-factor: configuration factor

References

1. Manihani A, Mulay S, Beri L, Shetty R, Gulati S, Dalsania R. 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. Dent Res J (Isfahan) 2021;18:72.
2. Pawar M, Saleem Agwan MA, Ghani B, Khatri M, Bopache P, Aziz MS. Evaluation of class II restoration microleakage with various restorative materials: A comparative in vitro study. J Pharm Bioallied Sci 2021;13:S1210-4.
3. Moazzami SM, Sarabi N, Hajizadeh H, Majidinia S, Li Y, Meharry MR, *et al*. Efficacy of four lining materials in sandwich technique to reduce microleakage in class II composite resin restorations. Oper Dent 2014;39:256-63.
4. Dietschi D, Spreafico R. Current clinical concepts for adhesive cementation of tooth-colored posterior restorations. Pract Periodontics Aesthet Dent 1998;10:47-54; quiz 56.
5. Ramos AB, Moro AFV, Rocha GM, Reis Perez CD. Micro-shear bond strength of composite resin to glass ionomer cement using an alternative method to build up test specimens. Indian J Den Ress 2018;29:651-6.
6. Balos S, Pilić B, Petronijević B, Marković D, Mirković S, Sarcev I. Improving mechanical properties of flowable dental composite resin by adding silica nanoparticles. Vojnosanit Pregl 2013;70:477-83.
7. Baroudi K, Rodrigues JC. Flowable resin composites: A systematic review and clinical considerations. J Clin Diagn Res 2015;9:ZE18-24.
8. Yao C, Ahmed MH, Zhang F, Mercelis B, Van Landuyt KL, Huang C, *et al*. Structural/chemical characterization and bond strength of a new self-adhesive bulk-fill restorative. J Adhes Dent 2020;22:85-97.
9. Alla RK, Medicharla U, Mohammed S, Abusua F, Bhupathi A, Kanumuri MV. An update on Cention N: An aesthetic direct bulk-fill restorative material. Int J Dent Mater 2023;5:17-21.
10. Donly KJ, Liu JAD. enamel demineralization inhibition at restoration margins of Vitremer, Z 100 and Cention N. Am J Dent 2018;31:166-8.
11. Mazumdar P, Singh S, Das D. Method for assessing the bond strength of dental restorative materials; An overview. J Dent Med Sci 2021;20:28-32.
12. El Mourad AM. Assessment of bonding effectiveness of adhesive materials to tooth structure using bond strength test methods: A review of literature. Open Dent J 2018;12:664-78.
13. Gopikrishna V, Abarajithan M, Krithikadatta J, Kandaswamy D. Shear bond strength evaluation of resin composite bonded to GIC using three different adhesives. Oper Dent 2009;34:467-71.
14. Otsuka E, Tsujimoto A, Takamizawa T, Furuichi T, Yokokawa M, Tsubota K, *et al*. Influence of surface treatment of glass-ionomers on surface free energy and bond strength of resin composite. Dent Mater J 2013;32:702-8.
15. Arslan S, Demirbuga S, Ustun Y, Dincer AN, Canakci BC, Zorba YO. The effect of a new-generation flowable composite resin on microleakage in Class V composite restorations as an intermediate layer. J Conserv Dent 2013;16:189-93.
16. Wexler G, Beech DR. Bonding of a composite restorative material to etched glass ionomer cement. Aust Dent J 1988;33:313-8.
17. Yoshida Y, Nagakane K, Fukuda R, Nakayama Y, Okazaki M, Shintani H, *et al*. Comparative study on adhesive performance of functional monomers. J Dent Res 2004;83:454-8.
18. Loomans BA, Cardoso MV, Opdam NJ, Roeters FJ, De Munck J, Huysmans MC, *et al*. Surface roughness of etched composite resin in light of composite repair. J Dent 2011;39:499-505.
19. Mangum FI, Berry EA, 3rd, Parikh UK, Ladd D. Optimal etching time of glass ionomer cement for maximum bond of composite resin. J Am Dent Assoc 1990;120:535-8.
20. Panahandeh N, Torabzadeh H, Ghassemi A, Mahdian M, Akbarzadeh Bagheban A, Moayyedi S. Effect of bonding application time on bond strength of composite resin to glass ionomer cement. J Dent 2015;12:859-67.
21. Knight GM, McIntyre JM, Mulyani. Bond strengths between composite resin and auto cure glass ionomer cement using the co-cure technique. Aust Dent J 2006;51:175-9.
22. Kaptan A, Oznurhan F, Candan M. In vitro comparison of surface roughness, flexural, and microtensile strength of various glass-ionomer-based materials and a new alkasite restorative material. Polymers 2023;15:650.