



COMPARISON OF THE COMPRESSIVE STRENGTH OF CONVENTIONAL AND RESIN-MODIFIED GLASS IONOMER CEMENTS

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ABSTRACT

Introduction: Glass ionomer cements have many advantages as restorative materials: adhesion to the tooth structure, fluoride releasing capacity, biocompatibility. However, their mechanical properties are not as desirable as they should be for the conventional glass ionomers, questioning their use as a restorative material.

Aim: The aim of this study was to compare the compressive strength of two encapsulated commercial glass ionomer cements – a conventional glass ionomer (Riva Self Cure) and a resin-modified glass ionomer cement (Riva Light Cure).

Materials and methods: Six conventional and six resin-modified glass ionomer cement specimens were prepared and kept in 10ml of deionised water at 37°C for 24 hours and 28 days. The specimens (after 24 hours and 28 days) were loaded in an Instron mechanical testing machine in compression until failure. A crosshead speed of 1mm/min and load cell of 30kN was used to conduct the compressive strength test.

Results: Resin-modified glass ionomer cement showed greater compressive strength values after 24 hours and 28 days than conventional glass ionomers. The compressive strength of both cements increased from 24 hours to 28 days, with conventional glass ionomers showing a greater change over the time period.

Conclusion: Resin-modified glass ionomer cements have greater compressive strength properties than conventional glass ionomers. This suggests that the cross-linked polymer matrices have higher strengths than gel network formed by acid-base reactions in conventional glass ionomers.

Keywords: conventional glass ionomer cement, resin-modified glass ionomer cement, compressive strength,

INTRODUCTION

Glass ionomer cements (CIG), also referred to as glass polyalkenoate cements are used as restorative and adhesive dental materials mainly because of the ability to bond to enamel and dentine and to release fluoride [1, 2]. The positive features of glass ionomer cements as obturation materials are chemical adhesion to dental structures, biological sealing of dentin, biocompatibility, coefficient of thermal expansion similar to the dental structure, and anticariogenic properties due to their fluoride release [3, 4]. Despite the advantages, undesirable characteristics have also been reported, such as inferior mechanical properties, limited esthetics, difficulty in handling, short working time, long setting time, low strength, toughness and poor resistance to acid attack. [4]. Since the introduction of GICs, several modifications in the material's composition were performed to minimize undesirable features that could limit their clinical use. The incorporation of hydrophilic resin monomers into an aqueous solution of polyacrylic acid led to the development of a more resistant, resin-modified glass ionomer material (RMGI). The RMGI emerged as an attempt to overcome the limitations portrayed by conventional glass-ionomer cements (CGIC). RMGIs exhibit improved mechanical properties, while keeping the desirable characteristics of the conventional GICs [3]. The addition of resin chemistry to glass ionomers has improved properties such as a prolonged working time with a rapid set when light cured, strength resistance to acid attack and wear resistance [1, 5, 6, 7]. Additionally, easy-handling materials, supplied in capsules, are available, allowing for an ideal powder/liquid ratio and automatic mixing, facilitating the manipulation, and optimizing the materials' properties [8]. The superior mechanical properties, easy handling, and improved esthetic results presented by RMGIs have enabled their use in the permanent dentition.

AIM:

The aim of this study was to compare the compressive strength of two encapsulated commercial glass ionomer cements – a conventional glass ionomer (Riva Self Cure) and a resin-modified glass ionomer cement (Riva Light Cure).

MATERIALS AND METHODS:

A conventional glass ionomer cement and a resin-modified glass ionomer cement were evaluated for this study. The conventional glass ionomer was Riva Self Cure shade A2 and A3 (SDI, Bayswater, Australia). The self-cure batches (shade A2 and A3) consisted of 0.45g powder 0.14g liquid (0.13mL) per capsule. The resin-modified glass ionomer used was Riva Light cure high viscosity shade A3 (SDI, Bayswater, Australia). The light-cure high viscosity A3 batch consisted of 0.43g of powder 0.14g of liquid (0.13mL) per capsule.

Six samples of conventional and six samples of resin-modified glass ionomer cements were prepared using commercial encapsulated Riva self-cure and Riva light-cure capsules.

For the Riva self-cure, the capsules were activated using a clicker before being placed in an ESPE Rotomix machine (RotoMix, 3M ESPE, Ontario, Canada, Figure 1) for 12 s. The capsule was then immediately placed into a capsule applicator, and the trigger was clicked until the paste was seen through the clear nozzle.

Fig. 1. ESPE Rotomix machine

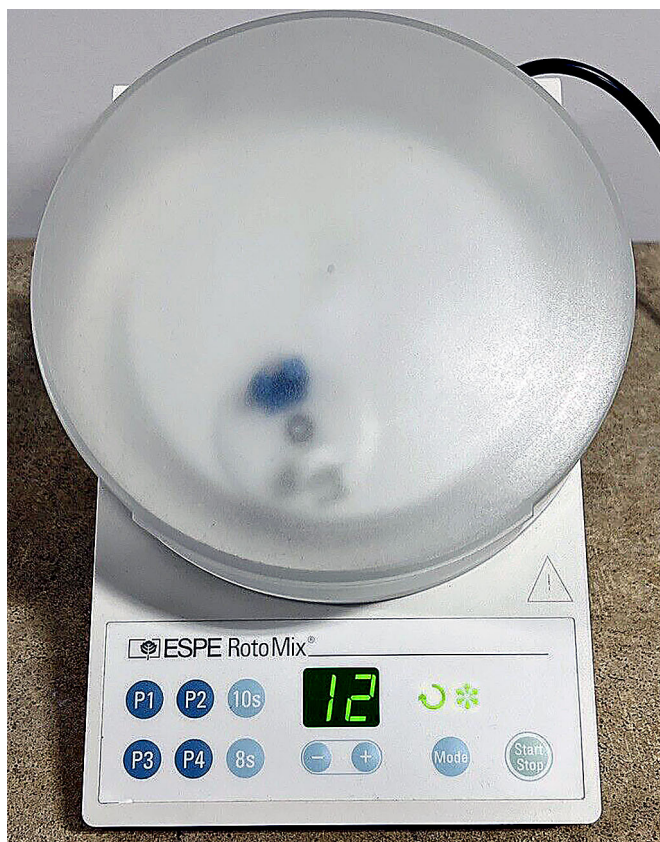
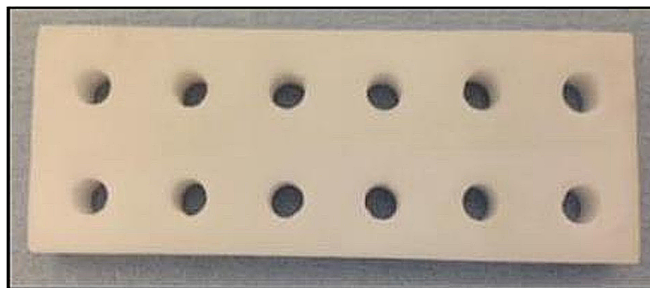


Fig. 2. Mould plate



The paste was filled into a mould (ISO standard 4 x 6 cm) (Figure 2). The Riva Self-cure was extruded into the mould and compressed using an acetate sheet on either side. 7-8 capsules were extruded into the mould and compressed using an acetate sheet as self-cured specimens would consist of possible defects, therefore, making more than the desired amount was necessary. The mould consisting of prepared samples was placed at 37°C in a drying and heating chamber (Series FD, BINDER GmbH, Tuttlingen, Germany) for 15 min before being removed using a syringe. The finished samples were placed in 10ml of deionised water test tubes and kept in an incubator for the desired amount of time. The procedure for Riva light-cure samples was the same as Riva self-cure until the paste was filled into the mould. The next step consisted of blue light being applied on either of the sample (covering the sample completely) for 20 s. A syringe was then used to remove the samples from the mould and placed in 10ml of deionised water.

A vernier calliper was used to measure the dimensions of the specimens. An Instron mechanical testing machine (Instron Universal Testing Machine, Instron Corp., Canton, USA) was used to load the specimens (after 1 day and 28 days) in compression until failure. A crosshead speed of 1mm/min and load cell of 30kN was used to conduct the compressive strength test. The bearing surface of the testing machine was cleaned after performing the test on a sample. Specimens were aligned centrally on the base plate of the machine in order to allow the load to be applied to opposite sides of samples. The following equation was used to determine the compressive strength:

$$C = \frac{4p}{\pi d^2}$$

Where: p is the maximum force applied in newtons (N);

d is the measured diameter of the specimen, in millimetres (mm).

The above equation was taken from the British Standard (BS) European Standard (ES) International Organisation for Standardisation (ISO) 2003 – BS EN ISO 9917-1:2003.

RESULTS:

The tables below show the dimensions and compressive strength values for the RMGIC and CGIC after 24 hours and 28 days. From Table 1, the compressive strength for the 6 RMGIC samples after 24 hours range between 370.93 MPa and 521.52 MPa – a value of 150.59. Table 2, representing data for 6 CGIC samples after 24 hours, indicates a range value of 341.91 – ranging between 145.66 MPa for sample 1 to 487.57 MPa for sample 2. When comparing the two tables, RMGIC have greater compressive strength values after 24 hours than CGIC.

Table 1. Dimensions of the RMGIC samples used for 24-hour compressive strength test.

Samples no.	Height (mm)	Diameter (mm)	Compressive strength (MPa)
1	6.58	4.36	449.22
2	6.50	4.38	521.52
3	6.56	4.67	473.12
4	6.60	4.47	370.93
5	6.63	4.37	418.33
6	6.83	4.43	467.57

Table 2. Dimensions of the CGIC samples used for 24-hour compressive strength test.

Samples no.	Height (mm)	Diameter (mm)	Compressive strength (MPa)
1	6.58	4.31	145.66
2	6.62	4.28	487.57
3	6.57	4.28	194.73
4	6.54	4.20	197.25
5	6.70	4.25	311.18
6	6.50	4.29	400.17

Table 3 shows that the compressive strength for 6 RMGIC samples after 28 days ranges between 446.29 MPa and 593.74 MPa, with a range value of 147.45. Moreover, when excluding the compressive strength value of sample 2 and comparing the other samples, values are very similar. This shows that RMGIC shows consistency for 24 hour and 28-day compressive strength data; with a range value of 150.59 and 147.45, respectively. When looking at Table 4, the CGIC data ranges between 370.62 MPa and 533.66 MPa after 28 days – a value of 163.04. When comparing the data obtained after 24 hours and 28 days, it can be observed that the results obtained for CGIC are not as consistent as the RMGIC. To add, after 28 days, the range values are similar for both samples to those after 24 hours.

Table 3. Dimensions of the RMGIC samples used for 28 day compressive strength test.

Samples no.	Height (mm)	Diameter (mm)	Compressive strength (MPa)
1	6.62	4.55	543.65
2	6.58	4.65	446.29
3	6.55	4.43	559.88
4	6.55	4.46	585.27
5	6.51	4.36	532.53
6	6.87	4.21	593.74

Table 4. Dimensions of the CGIC samples used for 28-day compressive strength test.

Samples no.	Height (mm)	Diameter (mm)	Compressive strength (MPa)
1	6.60	4.32	533.66
2	6.60	4.26	483.13
3	6.36	4.45	436.29
4	6.52	4.10	370.62
5	6.63	4.47	468.27
6	6.70	4.17	516.96

Fig. 3. A graph comparing compressive strength for RMGICs and CGICs at 24 hours and 28 days.

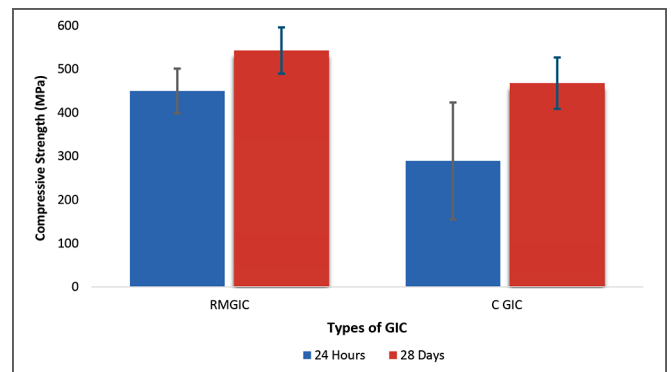


Figure 3 indicates that the compressive strength (average) of CGIC samples also increased when comparing from 24 hours to 28 days. After 24 hours, the average compressive strength for CGIC was 289.43 MPa. After 28 days, the average compressive strength value for the samples was 468.15 MPa. From this, it can be stated that the increase in strength from 24 hours to 28 days was 178.72 MPa

From Table 5, the compressive strength (average) of RMGIC samples increased from 24 hours to 28 days. The average compressive strength of samples after 24 hours was 450.12 MPa. In contrast, after 28 days, the compressive strength was 543.56 MPa, with an increase of 94.33 MPa. Additionally, the range of results obtained for 24 hours was

150.59 and 147.45 for 28 days. This suggests that the range for RMGIC was very similar throughout the given time period. This indicates that the CGIC showed a more significant change over the time period than the RMGIC. The mean and standard deviation values for RMGIC and CGIC for 24 hours and 28 days are given in Table 5.

Table 5. The mean and standard deviation values for RMGIC and CGIC for 24 hours and 28 days.

Types of GIC	Time	Mean (MPa)	Standard Deviation
RMGIC	24 Hours	450.12	51.41
	28 Days	543.12	53.12
C GIC	24 Hours	289.43	134.26
	28 Days	468.15	59.04

DISCUSSION:

From the results obtained by compressive strength tests conducted, it was evident that RMGICs consist of better mechanical properties than CGICs. Similar results have been reported in previous literature [9, 10, 11]. Moreover, after 24 hours and 28 days, the RMGIC specimens consisted of higher compressive strength values. The results of CGICs after 24 hours were relatively low, and this low early strength was acknowledged as a general limitation. Furthermore, the results showed that CGICs exhibited an improvement in mechanical properties over time, which was due to the maturation process of the cement. In contrast, the resin phase within RMGIC samples provides early strength; this is further improved by the slower conventional acid-base reaction. The results obtained for RMGIC specimens further emphasise this. Another possible explanation for RMGICs comprising better compressive strength than CGICs is that the content of RMGICs consists of cross-linked polymer matrices. This means that the cross-linked polymers are generally tougher and have higher strengths than the gel network formed by acid-base reactions within conventional glass ionomers. It can also be stated that filler load and composition influence the mechanical properties of restorative materials such as GICs.

Opposite results in comparison to the present study have also been reported in literature [8, 12]. For example, high viscosity CGIC in the experimentation by Khan et al. displayed maximum average compression values (221 ± 7 MPa) in comparison to low light viscosity GIC and light and auto-cure RMGIC at 1 and 28 days. This, according to the authors, could be contributed to the fact that Chemiû l-rock®, used in the study, had high viscosity and faster setting reaction. Furthermore, the higher strength could be contributed to compositional zinc-reinforcement as mentioned by the manufacturer (Dentsply Detrey GmbH Germany).

The determination of the compressive strength depends very much on the size of the samples [13]. Mallmann et al. [14] have analysed the compressive strength of samples with different dimensions in accordance with world adopted standards, using samples with sizes of 6 mm × 12 mm and 4 mm × 6 mm. Both conventional and resin-modified GICs were analysed. The technique of manipulation with glass ionomer cements is quite sensitive and presents an important factor, considering that most often the samples are being mixed manually, the preparation of larger samples is a complicated process, which could bring about higher errors. Hence, when testing the mechanical properties of GICs the use of smaller samples is suggested [13]. In the present study samples are used with dimensions in accordance with the ISO standard for dental materials of 1999.

A study by Al-Tae et al. suggests that the mixing mode and the inclusion of reactive glass additives in cements had a statistically significant effect on physical properties of the GICs [8]. Also, compressive strength increased with the addition of ZrO₂ and especially TiO₂ nanoparticles, whereas the addition of Al₂O₃ nanoparticles generally weakened the cements [15].

CONCLUSION:

Resin-modified glass ionomer cements have greater compressive strength properties than conventional glass ionomers. This suggests that the cross-linked polymer matrices have higher strengths than gel network formed by acid-base reactions in conventional glass ionomers.

REFERENCES:

- Nicholson, J. Chemistry of glass-ionomer cements: a review. *Biomaterials*. 1998 Mar;19(6):485-94. [PubMed]
- Sidhu SK, Nicholson JW. A review of glass-ionomer cements for clinical dentistry. *J Funct Biomater*. 2016 Jan 28;7(3):16. [PubMed]
- Nicholson J, Sidhu S, Czarnecka B. Enhancing the mechanical properties of glass-ionomer dental cements: a review. *Materials (Basel)*. 2020 May 31;13(11):2510. [PubMed]
- Rêgo HMC, Butler S, Santos MJC. Evaluation of the Mechanical Properties of Three Resin-Modified Glass-Ionomer Materials. *Biomed Res Int*. 2022 Aug 2;2022:4690656. [PubMed]
- Moberg M, Brewster J, Nicholson JW, Roberts H. Physical property investigation of contemporary glass ionomer and resin-modified glass ionomer restorative materials. *Clin Oral Invest*, 2019; 23(3): 1295–1308. [PubMed]
- Tyas M. Clinical evaluation of glass-ionomer cement restorations. *J Appl Oral Sci*. 2006; 14 Suppl:10-3. [PubMed]
- Oliveira GL, Carvalho CN, Carvalho EM, Bauer J, Leal AMA. The Influence of Mixing Methods on the Compressive Strength and Fluoride Release of Conventional and Resin-Modified Glass Ionomer Cements. *Int*

J Dent. 2019 Sep 15;2019:6834931. [PubMed]

8. Al-Tae L, Deb S, Banerjee A. An in vitro assessment of the physical properties of manually- mixed and encapsulated glass-ionomer cements. *BDJ Open.* 2020 Aug 11;6:12. [PubMed]

9. Menne-Happ U, Ilie N. Effect of gloss and heat on the mechanical behaviour of a glass carbomer cement. *J Dent.* 2013 Mar; 41(3):223-30. [PubMed]

10. Poornima P, Koley P. Comparative evaluation of compressive strength and surface microhardness of EQUIA Forte, resin-modified glass-ionomer cement with conventional glass-ionomer cement. *J Indian Soc Pedod*

Prev Dent. 2019 Jul-Sep;37(3):265-270. [PubMed]

11. Malhotra S, Bhullar KK, Kaur S, Malhotra M, Kaur R, Handa A. Comparative Evaluation of Compressive Strength and Flexural Strength of GC Gold Hybrid, GIC Conventional and Resin-modified Glass-ionomer Cement. *J Pharm Bioallied Sci.* 2022 Jul;14 (Suppl 1):S214-S216. [PubMed]

12. Khan MA, Babar BZ, Shereen A, Afridi WK, Liaqat S, Muhammad N, et al. Evaluation of compressive strength of conventional glass ionomer cement and resin modified glass ionomer cement. *J Khyber Coll Dentistry.* 2022 Jun;12(2):13-17. [Crossref]

13. Dimkov A, Nicholson WJ, Gjorgievska E, Booth S. Compressive

strength and setting time determination of glass-ionomer cements incorporated with cetylpyridinium chloride and benzalkonium chloride. *Prilozi.* 2012; 33(1):243-63. [PubMed]

14. Mallmann A, Ataide JCO, Amoedo R, Rocha PV, Jacques LB. Compressive strength of glass ionomer cements using different specimen dimensions. *Braz Oral Res.* 2007 Jul-Sep;21(3):204-8. [PubMed]

15. Gjorgievska E, Nicholson JW, Grabiaè D, Guclu ZA, Melitiè I, Coleman NJ. Assessment of the impact of the addition of nanoparticles on the properties of glass-ionomer cements. *Materials (Basel).* 2020 Jan 8;13(2):276. [PubMed]

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