

Evaluation of Adhesive and Compressive Strength of Glass Ionomer Cements

Ramashanker · Raghuwar D. Singh ·
Pooran Chand · Sunit Km. Jurel · Shuchi Tripathi

Received: 25 July 2010 / Accepted: 17 June 2011 / Published online: 26 June 2011
© Indian Prosthodontic Society 2011

Abstract The aim of the study was to assess, compare and evaluate the adhesive strength and compressive strength of different brands of glass ionomer cements to a ceramometal alloy. (A) Glass ionomer cements: GC Fuji II (GC Corporation, Tokyo), Chem Flex (Dentsply DeTrey, Germany), Glass ionomer FX (Shofu-11, Japan), MR dental (MR dental suppliers Pvt Ltd, England). (B) Ceramometal alloy (Ni–Cr: Wiron 99; Bego, Bremen, Germany). (C) Cold cure acrylic resin. (E) Temperature cum humidity control chamber. (F) Instron Universal Testing Machine. Four different types of Glass ionomer cements were used in the study. From each type of the Glass ionomer cements, 15 specimens for each were made to evaluate the compressive strength and adhesive strength, respectively. The 15 specimens were further divided into three subgroups of five specimens. For compressive strength, specimens were tested at 2, 4 and 12 h by using Instron Universal Testing Machine. To evaluate the adhesive strength, specimens were surface treated with diamond bur, silicone carbide bur and sandblasting and tested under Instron Universal Testing Machine. It was concluded from the study that the compressive strength as well as the adhesive bond strength of MR dental glass ionomer cement with a ceramometal alloy was found to be maximum compare to other glass ionomer cements. Sandblasting

surface treatment of ceramometal alloy was found to be comparatively more effective for adhesive bond strength between alloy and glass ionomer cement.

Keywords Adhesive strength · Ceramometal alloy · Compressive strength · Glass ionomer cement

Introduction

Dental luting cements form the link between a fixed restoration and the supportive tooth structure. Recently, glass ionomer cement has had a significant impact on restorative dentistry, as it bonds chemically to the tooth and release fluoride, which prevents the secondary caries. Apart from small restorations, glass ionomer cement can be used for repair of defective composite resin restoration, ceramometal alloy restoration margins and for luting of crown and bridge prostheses.

There are several reports on adhesion between glass ionomers and composite resins, but little information is available on adhesive properties between ceramometal alloy and glass ionomer cement. Therefore, this comparative study has been undertaken to evaluate the adhesion of different brands of glass ionomer cement to a ceramometal alloy.

Materials and Methods

Fabrication of Specimens

Two different types of specimens were made for obtaining compressive strength and adhesive strength, which were divided into division A and division B as follows:

Ramashanker · R. D. Singh · P. Chand ·
S. Km. Jurel · S. Tripathi
Department of Prosthodontics, Faculty of Dental Sciences,
C.S.M. Medical University, Lucknow, Uttar Pradesh, India

R. D. Singh (✉)
Type IV, Flat No. 9, Butler Palace Colony, Lucknow 226001,
Uttar Pradesh, India
e-mail: raghuwards@rediffmail.com

Division A Specimens

These specimens were used to assess the compressive strength of different brands (denoted as groups in the study) of glass ionomer cements. Specimens were made by mixing recommended powder–liquid ratio of different glass ionomer cements, mechanically spatulated for 20–30 s. Each specimen was made in the dimension of 2 mm thick and 5 mm in width and length (Fig. 1). The prepared and set specimens were stored in a temperature cum humidity control chamber at 37–40°C, until they were tested [1]. For each brand of the cement 15 specimens were made, which were further divided into three subgroups having five specimens each, as shown in Table 1,

- Subgroup (a) Specimen tested at 2 h.
- Subgroup (b) Specimen tested at 4 h.
- Subgroup (c) Specimen tested at 12 h.

Division B Specimens

The specimen of a Ni–Cr based ceramometal alloy (Wiron 99; Bego, Bremen, Germany) was made in the form of an alloy ingot—2 mm thick and 5 mm in diameter. These specimens were fixed to the chemically cured polymethyl methacrylate resin bars. Conventional glass ionomer cement (Fuji II-group I) was mixed according to the

manufacturer’s recommendations. The mixed cement was injected into a syringe tube (cross sectional diameter 5 mm), that was partly filled with chemically cured poly methyl methacrylate (PMMA) [2]. The syringe tube was placed in contact with the surface of treated ceramometal alloy specimens and cement was allowed to set for 4 min. The specimen assembly was stored in a temperature cum humidity control chamber until they were tested.

For each type of cement (denoted as group), five specimen assemblies were made, which were further divided into three subgroups, having five specimen each as shown in Table 1,

- Subgroup (a) ceramometal alloy surface treated by diamond bur.
- Subgroup (b) ceramometal alloy surface treated by silicone carbide bur.
- Subgroup (c) ceramometal alloy surface treated by sand blasting.

Master Assembly

This assembly includes an 11 inch long flat rod, on which six metal plates having a dimension of 3 cm vertical and 2.5 cm horizontal are attached with the help of nuts and bolts [3]. These metal plates hold the syringe (Fig. 2). Four metal plates were round. Notches were placed in the

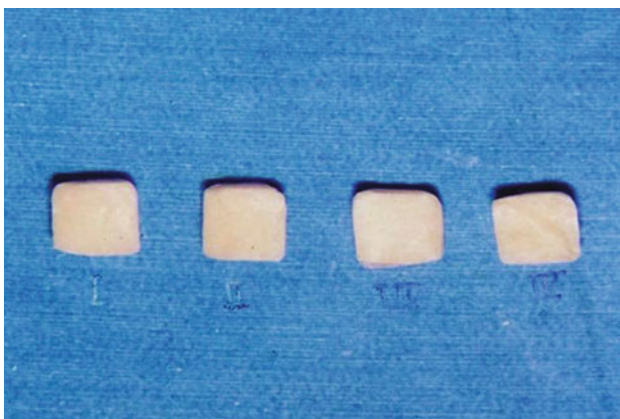


Fig. 1 Specimens for compressive strength testing

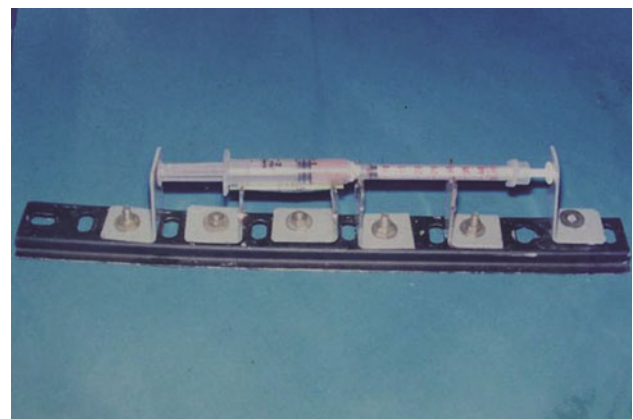


Fig. 2 Master assembly with specimen for adhesive strength testing

Table 1 Distribution of specimens made up of different brands of Glass ionomer cements

Group I GC Fuji II
 Group II Chem flex
 Group III Glass ionomer FX
 Group IV MR dental

| Groups | Division—A specimens | | | Division—B specimens | | |
|-----------|----------------------|------------|------------|----------------------|------------|------------|
| | Subgroup a | Subgroup b | Subgroup c | Subgroup a | Subgroup b | Subgroup c |
| Group I | 5 | 5 | 5 | 5 | 5 | 5 |
| Group II | 5 | 5 | 5 | 5 | 5 | 5 |
| Group III | 5 | 5 | 5 | 5 | 5 | 5 |
| Group IV | 5 | 5 | 5 | 5 | 5 | 5 |
| Total | 20 | 20 | 20 | 20 | 20 | 20 |

vertical sections of four metal plates to aid in placement of two syringes (Fig. 2). One end vertical section of the plate on each side acts as stops to prevent displacement of the syringes.

Testing of Compressive Strength

The specimens were mounted vertically one after the other between two platens of the jig attached to the Instron Universal Testing Machine. Now the Instron machine was set in the following manner,

Cross heads speed of 0.5 mm/min

Immediate return after fracture

A 5,000 kg load was applied

The maximum load at which the specimen fractured was recorded. The following formula was used to calculate the compressive strength (MPa) of the specimens,

$$\text{Compressive strength} = P \times 9.804 / \pi r^2$$

where P was a compressive fracture load (in kg) and r was radius of the specimen (1 mm).

Testing of Adhesive Strength

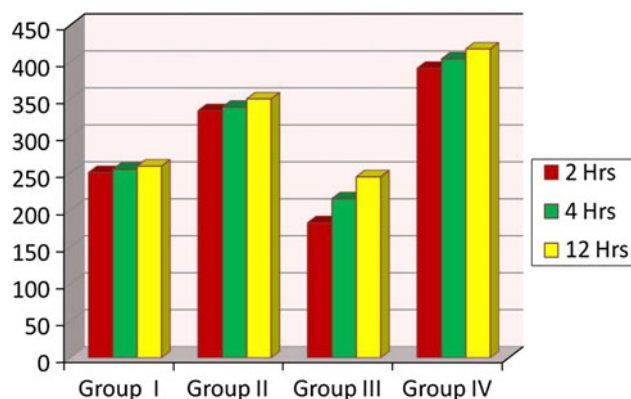
The specimen was tested with the help of Instron Universal Testing Machine. The specimens were mounted horizontally on the Instron Universal Testing Machine and the load was applied vertically at a crosshead test speed of 20 mm/min. The peak load at which bonded specimen assembly separated was recorded and adhesive bond strength was calculated accordingly.

Results

The result was analyzed statistically by using student t test. The compressive strength was maximum for group IV and minimum for group III, as shown in the Table 2 and Graph 1. These observations indicate that mean compressive strength increased with time in each group of the cement. As shown in the Table 3 and Graph 2, the result

Table 2 Analysis of compressive strength in different groups at different time intervals

| Groups | 2 H | 4 H | 12 H |
|--------|--------------------------|--------------------------|--------------------------|
| | Mean \pm SD $n = 5$ | Mean \pm SD $n = 5$ | Mean \pm SD $n = 5$ |
| I | 250.30 \pm 0.251 | 254.85 \pm 3.72 | 259.14 \pm 2.47 |
| II | 334.04 \pm 2.79 | 338.84 \pm 2.19 | 349.97 \pm 19.38 |
| III | 182.50 \pm 2.51 | 215.08 \pm 10.61 | 244.65 \pm 4.56 |
| IV | 391.40 \pm 2.19 | 403.98 \pm 11.90 | 417.51 \pm 20.38 |



Graph 1 Compressive strength in different groups at different time intervals

shows the increasing order of mean adhesive strength, that is maximum with the ceramometal alloy surface treated by sandblasting (subgroup c), than in ceramometal alloy surface treated by silicone carbide stone (subgroup b), and minimum with ceramometal alloy treated by diamond bur (subgroup a). Adhesive strength was found maximum in group IV, followed by group II, then in group I and minimum in group III cements irrespective of each subgroup.

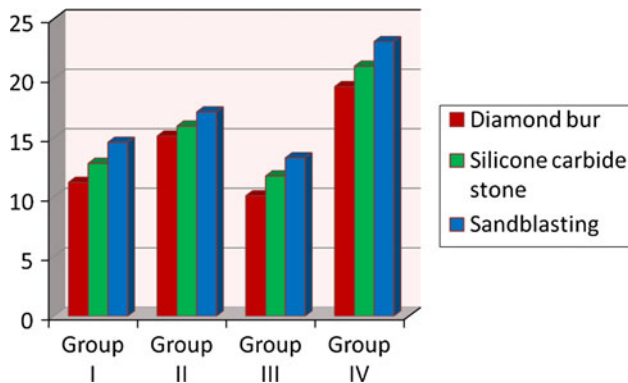
Discussion

The present in vitro study was conducted to assess, compare and evaluate the compressive strength and adhesive bond strength of four different brands of glass ionomer cements with a ceramometal alloy. Glass ionomer cements are being used for restoration of minor secondary carious lesion, sealing of endodontic access and in repairing of defective margins such as amalgam restoration, composite and ceramometal alloy restorations and building of fractured crown margins [4]. Little information is available on the bonding between various types of glass ionomer cements to ceramometal and metal alloys.

In the present study, the evaluation was done for adhesive strength and compressive strength of different brands of commercially and locally available glass ionomer restorative cements, which can also be used for marginal defect corrections. The result of the present study delineates that the compressive strength of each group of the glass ionomer increased as the time elapsed, as shown in Table 2 and Graph 1. The results were in accordance with previous studies [5, 6]. This can be explained on the basis of the mechanism of setting of the glass ionomer cements, that the formation of calcium polysalts is responsible for the initial set strength. Later on, the aluminum polysalts form over the next several hours, which improve physical properties such as the compressive strength of the set material [4, 6].

Table 3 Analysis of adhesive strength in different groups after different types of surface treatments

| Groups | Diamond bur Mean \pm SD | Silicon carbide stone Mean \pm SD | Sand blasting Mean \pm SD |
|-----------------|------------------------------|--|--------------------------------|
| I ($n = 5$) | 11.24 \pm 0.1693 | 12.848 \pm 0.778 | 14.612 \pm 0.2941 |
| II ($n = 5$) | 15.146 \pm 0.1064 | 15.974 \pm 0.1725 | 17.168 \pm 0.5998 |
| III ($n = 5$) | 10.12 \pm 0.1255 | 11.782 \pm 0.3839 | 13.314 \pm 0.2982 |
| IV ($n = 5$) | 12.296 \pm 0.4059 | 21.00 \pm 0.33538 | 23.08 \pm 0.2550 |

**Graph 2** Adhesive strength in different groups with different surface treatments

Williams and Billington (1989) [7] analyzed the compressive strength of glass ionomer cements after 30 min, 1 and 24 h using different specimen dimensions and he found that specimens with larger dimensions (12 \times 6 mm) presented higher compressive strength values and also greater variability in the results. Glass ionomer cements are very technique- and methodology-sensitive, and are even subject to failures during manipulation, a very important aspect when materials that require manual mixing are tested. For these reasons, in the present study smaller specimen dimension (5 \times 2 mm) was used to investigate mechanical property of glass ionomer cements, according to ISO 7489:1986 specifications [8]. The objective was to reduce the variability that may result when large amounts of material are manipulated.

When defects adjacent to the existing ceramometal restorations are repaired, adhesion between ceramometal alloy and restorative material is important to prevent micro leakage. Several investigators studied the relationship of micro leakage to the type of cements used and found that the use of glass ionomer cements in crown cementation did not predispose micro leakage [9]. Hence, the different groups of commercially available glass ionomer cements were used to evaluate the adhesive bond strength in the present study, and it was found that adhesive bond strength of MR dental (group IV) glass ionomer cement was maximum, followed by GC Fuji (group I), then Chemflex (group II) and was minimum with GI FX (group III)

cement at a definite time interval and the similar environment condition as shown in Table 3 and Graph 2.

The present study also revealed that the comparative compressive strength of MR dental glass ionomer cement was maximum, followed by Chemflex, then GC Fuji and minimum with GI FX as shown in Table 2 and Graph 1. In this study, the means of improving the bond strength of the ionomer cement to the surface of ceramometal alloys were evaluated because the previous studies have shown that the good retention of glass ionomer cement results in less micro leakage. It was found that adhesive strength of all group of cements with ceramometal alloy treated by sandblasting was higher than with ceramometal alloy treated either by grinding with diamond bur or by silicone carbide stone, as shown in Graph 2. The previous studies done by Vallittu and Forss also support such findings [1]. Several other studies also revealed that sandblasted ceramometal alloy offer good micromechanical retention to dental material. The improved adhesive strength with sandblasted ceramometal alloy can be explained on the basis of micromechanical retention. The previous studies through scanning electron microscopy had explored that alloy surface ground with diamond bur or silicone carbide stone had less micro irregularities, than the alloy surface which had been sandblasted. Therefore, ceramometal alloy surface ground with diamond bur or with silicone carbide stone resulted much coarse and less micro irregularities surface topography, hence it did not offer good retention.

Conclusion

Within the limitations of this in vitro study, the following conclusions were drawn:

1. The adhesive bond strength between ceramometal alloy specimens and glass ionomer cements of different groups was found to be statistically significant, being maximum in group IV, followed by group II and group I and minimum being with group III cements.
2. The adhesive bond strength of ceramometal alloy specimens treated with sandblasting was found to be maximum, followed by silicone carbide and diamond bur, which was statistically significant.

3. The compressive strength of group IV glass ionomer cement was found to be maximum, followed by group II and group I, while minimum in group III being statistically significant within all the groups.
4. The compressive strength of different groups of glass ionomer cements was maximum after 12 h, followed by at 4 h and minimum at 2 h which was statistically significant.

References

1. Forss H (1993) Release of fluoride, other elements from light-cured glass ionomers in neutral, acidic conditions. *J Dent Res* 72(8):1257–1262
2. Cattani-Lorente MA, Godin C, Meyer JM (1993) Early strength of glass ionomer cements. *Dent Mater* 9(1):57–62
3. Naegeli DG, Duke ES, Schwartz R, Norling BK (1988) Adhesive bonding of composites to a casting alloy. *J Prosthet Dent* 60(3):279–283
4. Craig RG (1989) Restorative dental material, 8th edn. The CV Mosby Company, St. Louis, pp 197–199
5. Seppa L, Forss H, Ogaard B (1993) The effect of fluoride application on fluoride release and the antibacterial action of glass ionomers. *J Dent Res* 72(9):1310–1314
6. Swartz ML, Phillips RW, Clark HE (1984) Long-term F release from glass ionomer cements. *J Dent Res* 63(2):158–160
7. Williams JA, Billington RW (1989) Increase in compressive strength of glass ionomer restorative materials with respect to time: a guide to their suitability for use in posterior primary dentition. *J Oral Rehabil* 16(5):475–479
8. International Organization for Standardization. ISO 7489 (1986). Dental glass polyalkenoate cements. Geneva
9. White SN, Ingles S (1994) Influence of marginal opening of microleakage of cemented artificial crowns. *J Prosthet Dent* 71:257