RESEARCH ARTICLE

Comparison of Retentive Strength of Glass Ionomer Cement, Resin-modified Glass Ionomer Cement, and Adhesive Resin Cement with Nickel–Chromium Cast Crown: An *In Vitro* Study

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Abstract

Aim: This study was undertaken to compare and evaluate retentive strength of glass ionomer cement (GIC), resin-modified glass ionomer cement (RMGIC), and adhesive resin cement with nickel–chromium (Ni-Cr) cast crowns.

Materials and methods: Thirty orthodontically extracted caries-free premolars were prepared using a surveyor and jig assembly to achieve standardized tooth preparation. All the 30 teeth after tooth preparation and fabrication of metal copings were divided into the following three groups: group I is the control group in which conventional GIC was used as the cementing agent. Twenty teeth were prepared, of which 10 were for group II (RMGIC) and 10 specimens for group III 3M ESPE (adhesive resin luting cement). Metal crowns were cemented using conventional GIC, RMGIC, and adhesive resin cement, and all specimens were stored at 37°C for 1 week. Before testing for retention, crown pull test was done using universal testing machine and a tensile load at crosshead speed of 0.5 mm/minute was applied. The maximal force to remove the crown was recorded in kgF and was converted to MPa.

Results: Group I had a mean retentive strength of 2.276 MPa. Group II had a mean retentive strength of 5.516 MPa. Group III had a mean retentive strength of 6.446 MPa. The results were subjected to statistical analysis, and the mean retentive strength and standard deviation of each group were calculated. Tukey's multiple comparison test and analysis of variance yielded significant results.

Interpretation and conclusion: Within the limitations of the study, the following conclusions can be drawn: The retentive strength of self-adhesive resin cements was better than RMGIC and conventional GIC.

Keywords: Glass ionomer cement, Resin-modified glass ionomer cement, Retentive strength, Self-adhesive resin cement.

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Introduction

The retention of extracoronal restorations has been extensively discussed in the dental literature. Loss of retention has been reported as one of the leading causes for failure in crown and fixed partial denture prosthesis. For successful restoration, crown to tooth structure retention is very critical. Prolonged retention of crown to the prepared tooth structure is required for good clinical performance. This retention factor depends on variables such as tooth preparation geometry, restoration fit, bond between cement and metal, bond between tooth structure and cement, and the type of cementing agent used.

The interfacial space between a fixed restoration and prepared tooth is filled by a luting agent that flows into the surface irregularities of crown and tooth, thereby securing the prosthesis in place. In spite of its known disadvantage, the zinc phosphate cement was traditionally considered the most popular, especially for its the feature of lack of adhesion and solubility. The retention of prosthesis to the prepared tooth is increased by using a luting cement. The cement not only provides mechanical resistance to restoration displacement but also resists fracture when a load is applied to the prosthesis. When the luting cement adheres to restoration and surface of the tooth, further improvisation on the retention is observed.[1]

Conventional glass ionomer cements (GIC) are very popular because they can release fluoride.[1] The development of resin modified glass ionomer cement (RMGIC) offers benefit of both conventional GIC and resin, i.e., fluoride release and good adhesion. Adhesive resin cements provide a stronger bond and adherence to precious alloys and base metals.[2]

Dental luting agents are the adhesive medium between the prepared tooth surface's indirectly fabricated restorations. An ideal luting agent possesses favorable compressive and tensile strength, should be able to provide a durable bond between dissimilar materials, should be able to prevent dislodgment as a result of cohesive and interfacial failures, and should have sufficient fracture

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toughness. The two primary mechanisms for adhesion of dental cements are physiochemical bonding and mechanical interlocking. Hence, this study was undertaken for evaluation and comparison of the retention of conventional GIC, RMGIC, and self-adhesive resin cement with nickel–chromium (Ni-Cr) cast crowns.

Materials and Methods

Method of Collection of Data

An informed consent and prior ethical clearance were obtained from educational institution prior to collection of data, and the nature of investigation was informed.

The materials used in the investigation were prepared and handled according to the manufacturer's instructions.

Sample Collection and Storage

A total of 30 human maxillary premolar teeth (14–18 years) advised for orthodontic extractions were selected for the study. The teeth were stored at room temperature in distilled water. Each tooth was hand scaled, cleaned to remove soft debris by placing them in 1% hydrogen peroxide solution for 24 hours, and rinsed with distilled water.

Preparation of Mold for Specimen Embedding

Polyvinyl siloxane putty impression material was used to make a cylindrical mold of standardized dimensions of 20 mm length and 20 mm diameter using a standardized cylinder. Commercially available autoploymerizing acrylic resin powder and monomer (DPI-RR Cold Cure) were mixed in a ratio prescribed by the manufacturer. It was poured into the putty mold when the mix was in fluid stage, i.e., about 5 minutes from the commencement of mixing, teeth samples were embedded vertically in the center of the mold 2 mm below the cementoenamel junction, exposing the entire crown. In the radicular part of the teeth using diamond bur (SHOFU) grooves of about 1 to 2 mm depth were made horizontally to aid in the retention of acrylic in which the tooth has to be embedded. After polymerization was complete, the specimen was easily removed from the mold (Fig. 1) and the specimen was then stored in distilled water.

Distribution of Specimen

A total of 30 teeth were selected for the study, each group had 10 teeth.

Group I: Conventional GIC (GC Fuji; GC Corporation).
Group II: RMGIC (Rely X^{TM} Luting 23M ESPE).
Group III: Adhesive resin luting cement (Rely XM Ultimate Clicker 3M ESPE).

Preparation of Teeth

All standardized teeth preparation was performed using a surveyor and jig assembly milling machine for complete metal crowns.

Fabrication of Crowns

To divide the prepared teeth into three groups of 10 specimens each, the random table number method was followed.

The impressions were made in a custom impression tray with polyvinyl siloxane material and then the dies were poured with improved stone. A noncarbon red pencil was used to mark on the dies an external outline of 0.5 mm chamfer finish line. Dies were painted with two layers of die spacer silver color (13 microns; RENFORT) on the axial surfaces.

Wax patterns (Fig. 2) of crowns were sprued immediately and invested in inlay investment. Powder–liquid ratio of 100 g/40 mL was mixed for 1 minute using a vibrator for inlay investment. At 350°C for 30 minutes, wax patterns were vaporized and the investments were heated for 30 minutes at 850°C. With an induction casting machine, crowns were cast in Ni-Cr alloy. Sprues were removed using stones, and rubber points were used to finish the castings externally. Using a small round diamond stone, the internal perfections were removed.

Cementation of Crowns

Teeth were randomly distributed into three groups to receive three different types of luting cements. According to the manufacturer's instructions, cements were manipulated. Sufficient amount of cement was filled in the prosthesis and firmly seated with hand pressure (Fig. 3). After 10 minutes, excessive cements were removed from the crown margins. All the procedures were performed by a single investigator, all the teeth were stored and incubated at 37°C for 7 days in prepared artificial saliva.

Testing of Retentive Strength

Using universal testing machine, the retentive strength was tested, which is fitted with an instron recorder. Acrylic base part of samples was gripped by lower grip holder of the machine. A stainless steel

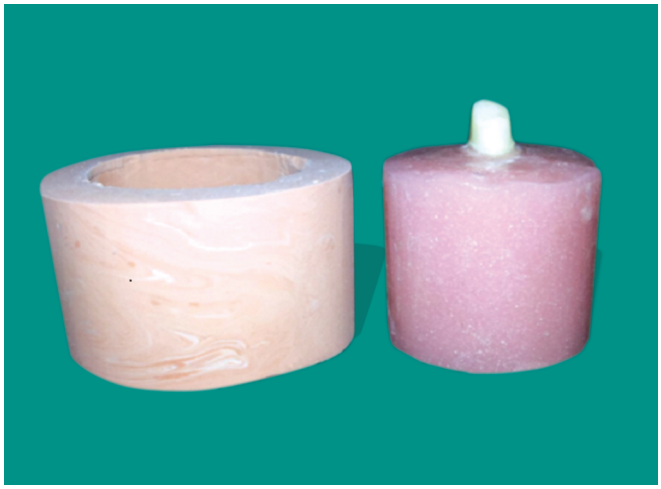

Fig. 1: Polyvinyl siloxane putty mould and specimen tooth

Fig. 2: Wax pattern

Fig. 3: Cementation of crown

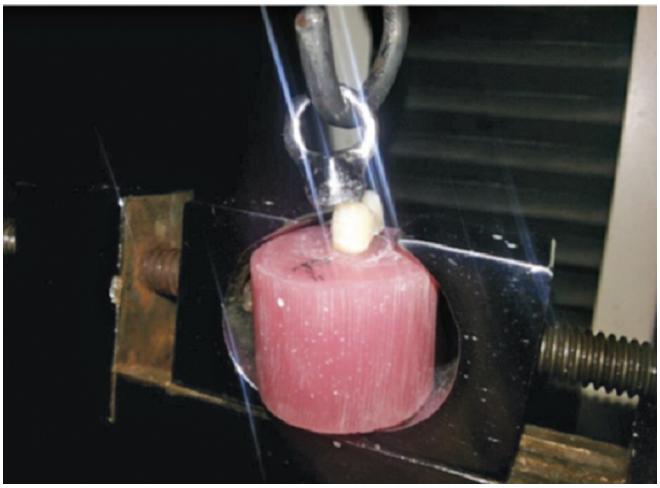

Fig. 4: Dislodged crown using universal testing machine

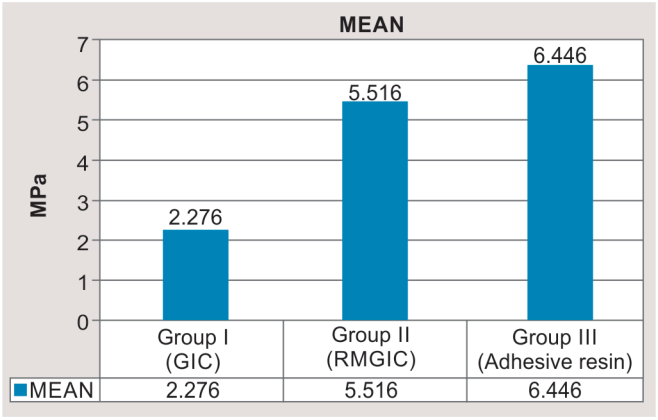

Fig. 5: Intergroup comparison of retentive strength between cements

hook was passed through the loop on crown, which was held by upper gap jaw.

The application of the load was from zero recording, which was gradually increased till the Ni-Cr crowns showed the first signs of dislodgment, during crown removal and then the values were recorded. All specimens underwent the same procedure. During crown removal, the force was applied directly parallel to the long axis of tooth. According to the American Dental Association (ADA) specification for cements, crosshead speed of instron was 0.5 mm/minute (Fig. 4).

Results

Group I: conventional GIC: The mean retentive strength was 2.276, whereas the highest value was 3.65 and the lowest value was 1.03.
Group II: RMGIC : The mean retentive strength was 5.516, whereas the highest value was 6.23 and the lowest value was 3.31.
Group III: Adhesive resin luting cement: The mean retentive strength was 6.446, whereas the highest value was 7.14 and the lowest value was 5.6.

One-way analysis of variance revealed significant association between the cement type and retention of Ni-Cr crowns. Significant differences were noted among the groups. Therefore, the multiple comparison *post hoc* test was conducted to find the difference between various pairs of cements. The *post hoc* test revealed a

Table 1: Shows mean retentive strength of cements

	GIC	*RMGIC*	*Adhesive resin cement*
Sample	*I (GC FUJI)*	*II (Rely XTM luting 2)*	*III (Rely X clicker)*
1	2.57	5.95	7.14
2	3.65	5.75	6.83
3	3.06	6.23	7.03
4	1.84	5.83	6.3
5	2.19	4.93	6.65
6	1.03	5.62	6.87
7	2.75	3.31	5.5
8	1.95	5.52	6.03
9	2.07	6.12	5.66
10	1.65	5.9	6.45
Mean	2.276	5.516	6.446

significant difference in mean retentive strength between group I and groups II and III and between groups II and III. Groupwise comparison shows statistical significance among these groups (p value < 0.001).

Comparison and evaluation of luting agents showed the retentive strength of Rely XM Ultimate Clicker 3M ESPE cement was significantly higher than the other two cements. The statistical difference was very highly significant ($p < 0.001$), with F value 63.511. Intergroup comparison of mean retentive strength between groups I, II, and III is also depicted in table (Table 1) and graphically (Fig. 5).

Discussion

Every dental restoration has a goal to develop a prolonged bonding between the tooth structure and prosthesis, and this union depends on many other factors such as tooth preparation geometry, restoration fit, and the type of cementing agent used.[3]

According to Kaufman EG, the factors affecting retention in a prepared tooth are (1) the tooth surface area, (2) the prepared tooth height, (3) convergence degree of the opposing preparation walls, and (4) the prepared area surface texture.[4] Cementation failure is the main reason for failure in clinical scenario.[5]

The retentive properties of adhesive luting cements are of great importance in the success of fixed prosthodontics. The stresses

developed during mastication are complex. The properties of luting agents such as shear strength, compressive strength, and the fracture toughness are all critical in determining the durability of fixed restoration. The retentive ability of cementing agent and its adhesive properties is determined by the tensile bond strength.[6]

Due to the high cutting efficiency, versatility in shapes, dimensions, and grit sizes, dental diamond rotary instruments are widely being used. The cutting speed is rapid and greater tooth surface roughness noticed with large grit diamonds. Mechanical retention lies on the area interlocked between the cement and tooth and greater retention of a casting can result from greater area of cross section from dentinal projection. Thus, the final outcome of the cast restorations is significantly affected by the dental rotary instruments used for tooth preparation.[7]

The utmost effort is taken to standardize the factors that significantly influences the test results like stump height, convergence, and surface area.[4]

Among all the luting agents, GICs have proved to be one of the best adhesive cements due to their chemical bonding to tooth structure, and they make popular choices for vital teeth because of their physicochemical bonding to the dentin, ability to resist caries, long-term fluoride release[1], minimal effect on the pulp, and low coefficient of thermal expansion. Luting agent which results in potential chemical bonding between prosthetic surface and tooth is used to enhance retention.[8]

The RMGIC basically sets by an acid–base reaction between pendant methacrylate groups modified aqueous solution of polyalkenoic acids and fluoroaluminosilicate glass powder. These cements have tensile and compressive strengths greater than many cements such as zinc phosphate, polycarboxylate, and some other modified glass ionomers but has less strength as compared to resin composites. With regard to the adhesion of this cement to dentin and enamel surface, fluoride release property is similar to that of glass ionomers, but they usually exhibit more resistance to moisture and are less soluble than the GICs. A recent report had demonstrated that during early phases of setting in, visible light polymerization and RMGIC acid–base reactions inhibit each other, which explains the low retentive strength of this cement.[9,10]

Adhesive resin cements are composed of filled bisphenol A-glycidyl methacrylate (BIS-GMA) resin and various other methacrylates. Polymerization reaction is through chemically initiated mechanisms, photopolymerization, or a combination of both. Several dental materials and tooth structure have adhesion to this cement. Due to its property of getting activated in light, a higher degree of conversion was seen under light polymerization conditions, and these resin cements typically exhibit higher retentive strengths.[9,11] In the primers, because of the presence of phosphate esters, dentin or enamel decalcification would occur, thus resulting in micromechanical bonding between resin cement and the tooth's hard tissues, thereby showing significant improvement. Ionic bonding on tooth may occur between positively charged calcium ions and the negatively charged phosphate ester monomers.[9,12] Hence, adhesive resin cements show better retentive strength compared to other cements.

Conclusion

The following conclusions can be drawn, within the limitations of the study:

- The retentive strength of dual-polymerized self-adhesive resin cements was better than RMGIC and conventional GIC.
- Rely XM Ultimate Clicker 3M ESPE significantly improved crown retention when compared with RMGIC and conventional GIC.
- The RMGIC showed better retentive strength than conventional GIC.
- Due to the differences in the *in vitro* and *in vivo* conditions, utmost care was taken to conduct the study but still immense research is required to come up with a cementing agent with the best properties.

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