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"FLEXURAL STRENGTH AND COMPRESSIVE STRENGTH OF CONVENTIONAL GLASS IONOMER LUTING CEMENT AND RESIN MODIFIED GLASS IONOMER LUTING CEMENT AFTER INCORPORATION OF CHLORHEXIDINE."

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Abstract:

Introduction: *Glass ionomer luting cements (GIC) and Resin modified glass ionomer luting cements (RMGIC) are used to attach and seal fixed dental prostheses to teeth. Despite of their anticariogenic properties, there is still existence of caries. Studies have shown incorporation of chlorhexidine (CHX) can increase its antimicrobial action without affecting their physical properties.*

Objectives of the study: *The objective was to evaluate the effect of incorporation of CHX on flexural and compressive strength of conventional GIC and RMGIC. To compare the strength of both the cements on incorporation of CHX.*

Methodology: *Forty bar shaped specimens and cylindrical specimens of both the cements were prepared for flexural strength and compressive strength testing using stainless steel mold. CHX powder was incorporated into experimental groups of both luting cements in a concentration of 1%. Specimens were stored in artificial saliva for 24 hours. Flexural strength and compressive strength of the specimens was determined using universal testing machine. Morphological evaluations for fractured surfaces were done using scanning electron microscopy. The data was statistically analyzed using independent sample t-test.*

Result: *The results of the study showed that, addition of 1% CHX decreased compressive and flexural strength of both conventional GIC and RMGIC. On addition of CHX RMGIC showed better compressive and flexural strength compared to conventional GIC.*

Conclusions: *The Chlorhexidine (CHX) amount should be kept below 1% for both the cements to sustain their strength.*

Key words: ***Glass Ionomer Luting Cement; Resin Modified Glass Ionomer Luting Cement; Chlorhexidine; Compressive Strength; Flexural Strength.***

Introduction

Dental luting cements link fixed dental restorations and tooth structure. This attachment may be mechanical, chemical, or a combination of both methods. In addition to providing a gap-free interface, the luting cements should ideally also help to prevent micro leakage and secondary caries and decrease the failure rate of partial fixed dental prostheses.[1] The ability of glass ionomer cement to release fluoride continuously over an extended period of time, results in an anticariogenic potential showing a reduction in caries adjacent to the restoration.[3]

Recently, there has been considerable interest in luting materials with adhesive capabilities and therapeutic potential. Glass ionomer cements (GIC) are acid–base cements which are used widely in dentistry which have been used more recently as bone cements.[6] Conventional GICs are complex materials, constituted by a calcium and aluminium polyacrylate matrix with glass particles embedded in it.[7] Conventional glass ionomer luting agents have fluoride ion release, physio-chemical bonding to tooth structure, and a low coefficient of thermal expansion.[8,9] Resin-modified glass ionomer cements also release fluoride and contain resin components for improved physical and mechanical properties.[10] Resin luting agents are required for cementation of porcelain veneers, all-ceramic crowns, and indirect composite or ceramic restorations and are now available in autopolymerization, light-polymerization, and dual-polymerization formulations. Several attempts in developing GIC with enhanced antibacterial effects by addition of bactericides, such as, chlorhexidine hydrochloride, cetyl pyridinium chloride, cetrimide, and benzalkonium chloride have been reported in the literature.[11] Two groups of bacteria are responsible for initiating caries: Streptococcus mutans (SM) and Lactobacillius casei (LB).[12,13] Among the different antimicrobial agents used to control dental microorganisms the use of chlorhexidine (CHX) mouth rinses to control dental plaque and gingivitis has been well established.[14] Chlorhexidine has been considered as one of the most effective and safe substances.[15] Therefore, to provide specific and continuous antibacterial protection against complex microorganisms residing between the teeth and fixed restorations, incorporating CHX may improve clinical success. The addition of small concentrations (1%) of chlorhexidine increased the antibacterial activity without compromising the mechanical properties.[18]

The luting cements are subjected to compressive and tensile stresses by masticatory forces.[19] Luting cements must withstand masticatory and parafunctional stresses for many years in a warm and wet oral environment.[20]

Procedure

Two glass ionomer cements were employed in this study, a conventional glass ionomer luting cement (Fig. 1) which was grouped as A and a resin-modified glass ionomer luting cement (Fig 2) which was grouped as B. For each cement type twenty bar shaped specimens of dimension 25×2×2mm (according to ISO Standard-4049)[6] were made to test the flexural strength (grouped as Fs) and twenty cylindrical specimens of dimension 12×6mm (according to ANSI/ADA Specification no 66)[19] were made for compressive strength testing (grouped as Cs) using a brass mold of appropriate dimension as shown in Fig 3 and Fig 4 respectively. The molds were coated with petroleum jelly. Control group contained twenty specimens for each type of cement, which were prepared according to recommended powder liquid ratio for testing both flexural and compressive strength. Three measuring spoons of powder and 3 drops of liquid were necessary to fill the 12mm x 6mm matrix, three measuring spoons of powder and 3 drops of liquid were necessary to fill the 25×2×2mm matrix. They were manipulated over a mixing sheet using plastic spatula which were supplied by the manufacturer. A plastic plate was placed below the trough; the mix was over packed into the trough and tightly covered with plastic plate.

The experimental groups containing total of forty specimens were prepared by adding 0.342 g of CHX diacetate monohydrate (Fig 5), which is commercially available as a solid powder, to 30g glass ionomer powder and for 11 gram of RM GIC 0.11g of CHX was incorporated. Within 60 seconds after the end of mixing, the cements were packed into the split molds and covered with the plastic plates. One hour later, the specimens were removed

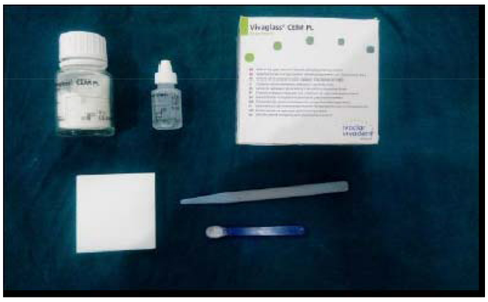


Fig1- Conventional GIC

Fig2- Resin modified GIC

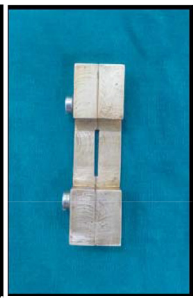


Fig3- brass mold - flexural strength

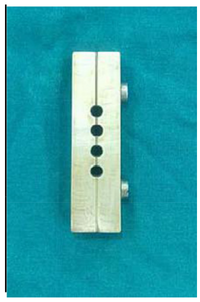


Fig4- Brass mold- compressive strength

Fig 5 – chlorhexidine diacetate powder

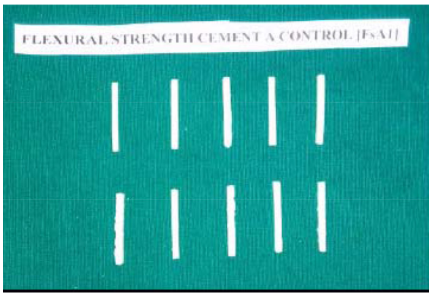


Fig6-GIC control group specimens-flexural strength

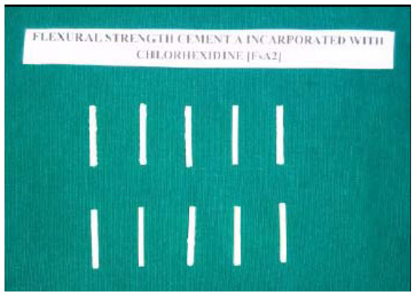


Fig 7- GIC specimens incorporated with 1% Chlorhexidine- flexural strength

Figure 8- RMGIC control group specimens- flexural strength

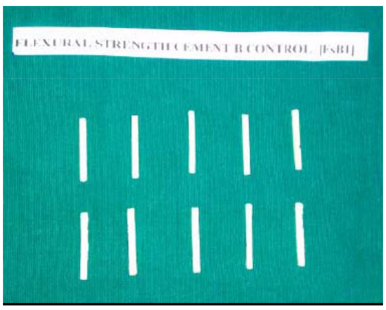


Fig 9- RMGIC specimens incorporated with 1% flexural strength

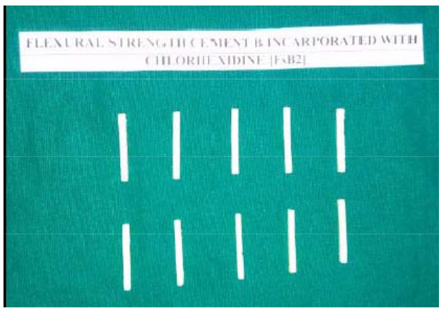


Fig 10- GIC control group specimens -chlorhexidine- compressive strength from the mold and stored at room temperature in artificial saliva (wet mouth – synthetic saliva with pH of 6.43± 0.26 consisting of 0.8g NaCl, 2.4g KCl, 1.5g NaH2 PO4, 0.1g Na2S and 2 g CO[NH2]2) for 24 hours.

Analysis of Mechanical Properties

Flexural strength of the specimens was determined using three point bending test in a universal testing machine. A load was applied in the center of the specimens at the crosshead speed of 0.5 mm/min. The mounting apparatus was mounted parallel with the supporting beams 20 mm apart (Fig 14).

Fig 11- GIC specimens incorporated with 1% Chlorhexidine- compressive strength.

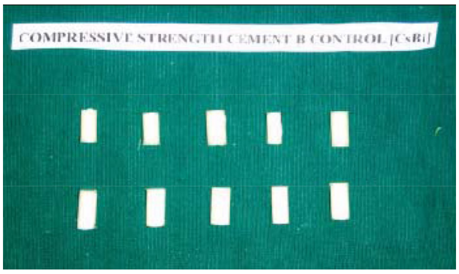


Fig 12- RMGIC control group specimens compressive strength

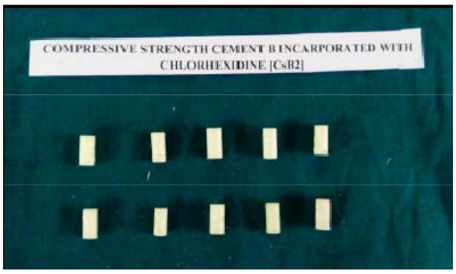


Fig 13- RMGIC specimens incorporated with 1% chlorhexidine -

Fig 14- Three point bending test to check compressive strength flexural strength using universal testing machine.

Fig 15- Compressive strength testing - universal testing machine

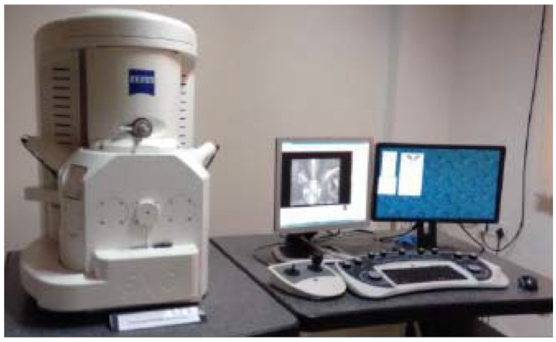


Fig 16 – Scanning electron microscope

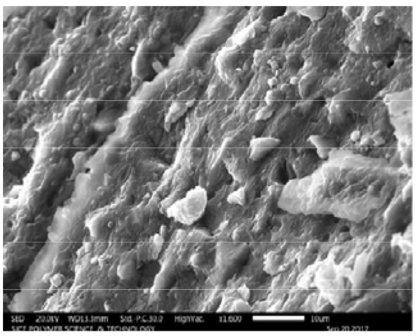


Fig 17 – SEM image of the fractured surface of GIC incorporated with CHX

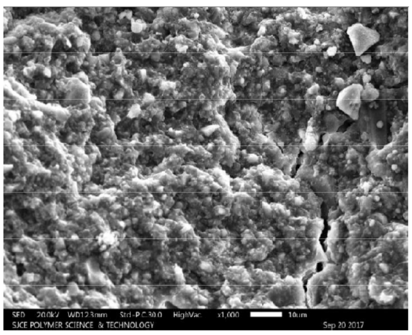


Fig 18 – SEM image of the fractured surface of RMGIC incorporated with GIC

The specimens were loaded until the first sound of a crack was detected. The flexural strength values of each specimen were calculated with the following formula:

F=3PfL/2WH2

Where Pf - measured maximum load at the time of specimen fracture,

L - distance between the supports on the tension surface (20mm),

W - mean specimen width,

H - mean height of specimen between the tension and compression surfaces.

Compressive strength of the samples was determined using universal testing machine under a crosshead speed of 0.5 mm/min until the specimen fractures (Fig 15).

Table 1- Comparison of mean compressive strength of GIC and GIC incorporated with CHX using independent t test.

Groups	N	Mean	Standard Deviation	P Value
GIC	10	36.3360	0.945845	O.O22(S)
GIC with CHX	10	28.592	2.3302.1	0.022 (S)

(S – Significant, p value < 0.05)

Table 3- Comparison of mean compressive strength of GIC with incorporated CHX and RMGIC incorporated with CHX using independent t test.

Groups	N	Mean	Standard deviation	P Value
GIC With CHX	10	28.592	2.33O21	0.000 (H.s)
Rm Gic With CHX	10	41.993	2.41166	

(H.S – Highly significant, p value < 0.05)

Results will be recorded in Megapascals.

C = F/πr2

Where F - measured maximum load at the time of specimen fracture,

r - radius.

Morphological evaluation for fractured experimental group surfaces was done using scanning electron microscopy (Fig 16).

Results

Compressive strength of GIC and GIC incorporated with 1% CHX was compared, the result obtained are shown in Table 1. On adding 1% CHX to GIC resulted in significant decrease in compressive strength ($p<0.05$). Compressive strength of RMGIC and RMGIC incorporated with 1% CHX was compared. Highest compressive strength was shown by RMGIC but the strength values decreased significantly by adding 1% CHX as seen in Table 2. Compressive strength of RMGIC mixed with 1% CHX was higher than GIC experimental group according to independent t-test. Least strength was shown by GIC mixed with 1% CHX as shown in Table 3 and is represented in Graph 1.

The effect of incorporation of 1% CHX to conventional GIC and RMGIC on flexural strength was compared. In comparison with the control adding 1% CHX for both GIC and RMGIC resulted

Table 2- Comparison of mean compressive strength of RMGIC and RMGIC with incorporated CHX using independent t test.

Groups	N	Mean	Standard Deviation	P Value
RM-GIC	10	48.2780	1.91669	0.000 (H.s)
RM-GIC with CHX	10	41.9930	2.41166	0.000 (H.s)

(H.S – Highly significant, p value < 0.05) in significantly decreased values when analyzed with independent t test ($p < 0.05$).Flexural strength of RMGIC with 1% CHX was higher than that of GIC with 1% CHX. Highest flexural strength was shown by RMGIC > RMGIC mixed with 1% CHX > GIC > GIC mixed with 1% CHX when analyzed with independent t test ($p<0.05$).

Morphological evaluation of fracture surfaces of both the experimental groups were evaluated by SEM study (Fig 17) shows the SEM image of fracture surface of GIC with 1% CHX at X1600 magnification. Different sizes of glass particles which were loosely bonded to the matrix were seen. Fig 18 shows the SEM image of fracture surface of RMGIC with 1% CHX at X1000 magnification. The fracture surface of the RMGIC contained many small glass particles dispersed in the polymer matrix. Unlike GIC, the fracture surface of RMGIC exhibited a more tightly integrated glass particle–polymer matrix surface and less exposed glass particles. In addition, large fractured fragments of the resin constituent were observed in the RM GICs, compared with the GICs.

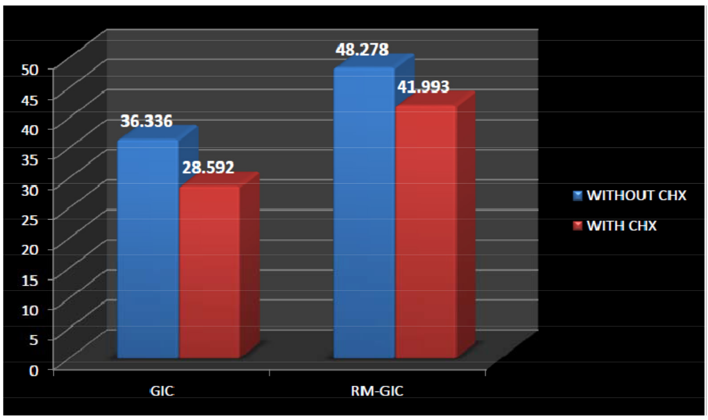
Discussion

Glass ionomer cements (GICs) were introduced in dental practice in 1972 by Wilson, Kent. The powder component contains aluminum-fluorosilicate glass that dissolves upon interaction with polyacrylic acid in the liquid component. The reaction releases calcium and aluminum ions that interact with the carboxylic acid groups. Calcium ions present in the hydroxyapatite of dental hard tissues, enamel and dentin, react with the carboxylic acid of GICs, creating a chemical bond between the cement and the tooth structure.

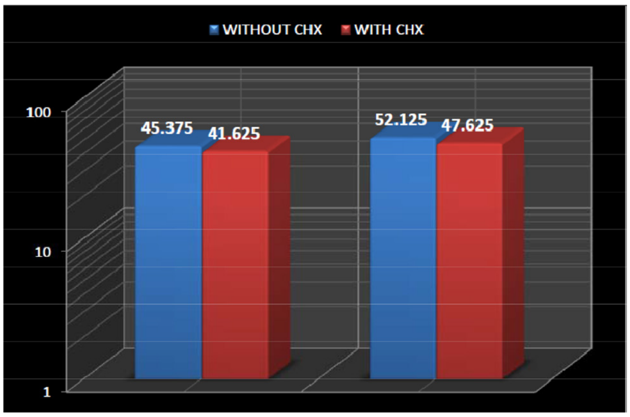
GICs are widely used in dentistry for its advantages of potential to inhibit caries because of fluoride release, adhesion to tooth tissue, reduced marginal leakage due to thermal changes in the oral environment since coefficient of thermal expansion of glass ionomer cement is similar to that of enamel and dentin. Resin modified glass ionomer cements (RMGICs) were introduced to provide a material with improved mechanical properties and the light cure facility.[16]

The most commonly used strength value to characterize dental cements is compressive strength. It is the ultimate strength to withstand compression stress mainly for hard brittle materials.[12] However, such materials typically fail in flexure rather than in compression, and in recognition of this, there has been some work in recent years to characterize them in terms of biaxial flexure strength.[22]

Graph 1: Mean compressive strength of GIC and RMGIC, control and experimental groups



Graph 2 : Mean compressive strength of GIC and RMGIC, control and experimental groups.



In order to improve the antibacterial characteristics of GIC, chlorhexidine (CHX) in the form of chlorhexidine diacetate powder has been added to it.[22] CHX has also been seen to have long-term antibacterial properties because of its unique ability to bind to hydroxy apatite, whereby, a gradual release creates a bacteriostatic milleu over a prolonged period of time.[4] Addition of CHX in liquid form results in decreased properties due to more rapid leaching of CHX in liquid form than in powder form and CHX diacetate is preferable to use, as it is a more stable material, not prone to decomposition, can be easily blended with glass ionomer powder.[22] Therefore in the present study CHX was added to CGIC in powder form.

In the present study specimens were stored for a day because a minimum of 24 hr storage is required for the maturation of GIC, where calcium ions linked to carboxyl groups of polyacrylic acid chains are replaced by aluminum ions, and also according to a study done by Cattani-Lorente MA et al[10].

In the present study incorporation of 1% CHX for both CGIC and RMGIC resulted in significant decrease in compressive and flexural strength properties. The microstructure of GICs is formed as a result of the acid–base reaction between the proton donating acidic liquid and proton accepting basic powder resulting in filler glass particles distributed within a salt-like hydrogel.[25] The compressive strength of the cement arises from the reinforcing glass filler particles, which resists compressive forces on loading rather than the weak matrix.[25] In experimental groups RMGIC had significantly higher values than CGIC, this is consistent with the study done by Xie D et al[9] and Mallmann A et al.[19] This is due to the inclusion of resinous polymers that present higher mechanical strength.

Limitations of the study include not considering the change in temperature and pH which may occur in oral cavity during consumption of various beverages. The artificial saliva used did not consist of enzymes and plaque biofilm that is present in a real life scenario. The result may not be same to other commercially available GICs due to difference in the filler size and can be evaluated for change in strength by adding CHX for other commercially available materials. Clinically it's tedious to keep weighing CHX and cement powder for proper water powder ratio for each patient. This can be solved by adding predetermined amount of CHX to the whole bottle of cement, but the storage stability of such cements is unknown

Conclusion

Within the limitations of the study it could be concluded that-

- Addition of 1% CHX to both GIC and RMGIC resulted in decrease in comprehensive and flexural strength.
- RMGIC showed higher strength values with or without addition of CHX compared to GIC.
- Irregularly distributed CHX particles and voids with different size and depths linking the crack propagation were seen in SEM. The CHX amount should be kept below 1% for both of the cements so that the physical –mechanical properties are not altered.

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