The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
20(1): 223-229, 2025 www.thebioscan.com

Comparative Evaluation of Physical Properties of Conventional Glass Ionomer Cement with Different Additives: An In- vitro Study

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Conflict of interest: No! Conflict of interest is found elsewhere considering this work.

Source of Funding: There was no financial support concerning this work

DOI: https://doi.org/10.63001/tbs.2025.v20.i01.pp223-229

KEYWORDS
microleakage,
compressive strength,
cetrimide,
chlorhexidine,
glass ionomer cement

Received on:
12-11-2024

Accepted on:
10-12-2024

Published on:
27-01-2025

ABSTRACT

Aim: This study aimed to evaluate and compare the Physical properties of Type IX Glass ionomer cement (GIC) incorporated with 2% chlorhexidine (CHX) and 2% cetrimide.

Settings and Design: An *in-vitro* comparative study

Material and Methods: The study comprised six test groups - Group 1 (Conventional GIC), Group 2 (GIC + 2% CHX), and Group 3 (GIC + 2% cetrimide). Each group contained 15 samples, which were evaluated for microleakage using dye penetration test. Class I cavity was prepared in all the samples and were restored with experimental GICs. CHX and cetrimide in powder form were added to conventional Type IX GIC at 2% W/W ratio. Thermocycling was done and dye penetration test was performed. Samples were sectioned and were evaluated for microleakage under stereomicroscope. Group 4 (Conventional GIC), Group 5 (GIC + 2% CHX), and Group 6 (GIC + 2% cetrimide) were evaluated for Compressive strength using universal testing machine. Kruskal–Wallis test complemented by Tukey's post-hoc test and intragroup comparison was made by Student's paired t-test for the comparative analysis of both microleakage and evaluation of compressive strength between the three experimental type IX GICs.

Result: Group I showed least microleakage, Group 4 showed highest mean compressive strength.

Conclusion: The present study demonstrated that experimental GICs containing CHX and cetrimide, increased the microleakage and decreased the compressive strength of the parent material.

INTRODUCTION

Disease of dental caries dates back to ancient times and is the most common disease besetting human race.[1] Bacteria plays a key role in its development. Dental caries is the most common reason for loss of tooth structure. The therapeutic procedures used in treatment of caries do not always eliminate all the microorganisms in the residual tissues. [2] Sometimes recurrent caries can lead to failure of restoration which can be attributed to mainly two reasons either residual microorganisms or microleakage post restoration. The persisting cariogenic bacteria, with the lack of hermetic seal, can cause recurrent caries, leading to failure of restoration.[6] One possible solution to overcome this problem is to use dental material with a bactericidal or atleast with bacteriostatic property.

Basic properties of dental materials for restorative treatment have been greatly improved by newer innovation and addition of recent products available in market. Such improvement of restorative materials has contributed to, restoring the ideal anatomical form and function with less removal of tooth structure, leading the way to aesthetic restorative treatments and minimal intervention dentistry. Accordingly, it is proposed that innovation of restorative materials in the new era could be directed toward a new dimension: Development of materials with "bio-active functions" to provide therapeutic effects.[3]

As one bio-active function proposed for restorative materials is an antibacterial activity, it can be highlighted for the restorative treatment of caries. The ability to control bacteria would be advantageous to eliminate the risk of further demineralization and cavitation, since dental caries is an infectious disease, and eradication of cariogenic bacteria is an important principle.[3]

Conventional glass ionomer cements, introduced in 1972, by Wilson and Kent, is a tooth colored and chemically adhesive material, with a therapeutic action of anticariogenicity making tooth structure more resistant to caries, and so is being widely used in dentistry. 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.[4] However there is one drawback that GIC lacks antibacterial activity. The therapeutic benefits may be gained by combining GIC with antibacterial agents.[5,6]

Chlorhexidine (CHX) and cetrimide (CT) are antiseptics with a wide spectrum of action and their use has been generalized over the past two decades.[7,8] Cationic chlorhexidine absorbs on to the surface enamel of the tooth by binding to anionic components such as salivary glycoproteins, this action reduces adhesion of protein on to the tooth surface and delays formation of dental pellicle, which is the first step in initiation of dental caries. CHX also affects the colonization rate of oral bacteria on enamel surface and results in prolonged antimicrobial action.

Cetrimide is a cationic surfactant with bactericidal activity and the capacity to decrease the biofilm's mechanical stability. Cetrimide has demonstrated its effectiveness against gram positive and gram negative bacteria and exerts residual antimicrobial activity over time. Thus addition of chlorhexidine and cetrimide to conventional glass ionomer cement can impart antibacterial property to glass ionomer cement. Studies have shown that incorporation of antibacterial agents, frequently results in alterations in the physical properties like compressive strength, diametral tensile strength, microhardness, surface roughness, microleakage of restorative materials. Therefore, antibacterial GICs used in the ART approach require an optimum amount of antibacterial agents that do not jeopardize the basic properties of the parent material. Both chlorhexidine and cetrimide are safe to use in mouth.

Material and Methods

The present study was an *in vitro* design, and ethical approval for the study had been obtained from the institute where the study was conducted.

Freshly extracted human premolar teeth, extracted for orthodontic or periodontic purpose, were collected from department of oral and maxillofacial surgery in Ahmedabad Dental College and Hospital.

Forty-five intact caries free, cracks free and restorations free, premolar teeth extracted for orthodontic or periodontic reasons were collected. All the samples were used within 3 months of extraction. All the teeth were subjected to surface debridement with hand scaling and then the teeth were cleaned with pumice and stored in normal saline. Then class I occlusal cavity was prepared in all the teeth 2mm occluso gingival depth, 2mm buccolingual width and 3mm mesiodistal width. Then all the teeth were divided into 3 groups and restoration was done.

- For Group I – (n = 15) teeth were restored with type IX GIC by mixing powder and liquid on a mixing pad according to manufacturers instructions.
- For Group II – (n = 15) The mixture was prepared for 2% CHX diacetate group, for which 1g of GIC type IX powder was proportioned on a mixing pad and weighed to which 20mg (2%) of CHX powder was added. The desired concentration of GIC powder and CHX was obtained using digital analytical scale. This powder mixture was mixed with GIC liquid as per manufacturers instructions on a mixing pad. Then the fifteen teeth with a prepared cavity were restored with prepared mixture of type IX GIC incorporated with 2% chlorhexidine.
- For Group III – (n = 15) The mixture was prepared for 2% Cetrimide group, for which 1g of GIC type IX powder was proportioned on a mixing pad & weighed to which 20mg(2%) of cetrimide powder was added. The desired concentration of GIC powder and cetrimide was obtained using digital analytical scale. This powder mixture was mixed with GIC liquid as per manufacturers instructions on a mixing pad. Then the fifteen teeth with a prepared cavity were restored with prepared mixture of type IX GIC incorporated with 2% cetrimide.

After restoring the teeth, the teeth were stored in deionized water at 37°celcius for 24 hrs for final set of the restorative material. Then all the restored teeth were subjected to finishing and polishing using GIC polishing bur and then again were stored in deionized water at 37 °celcius for 24 h. Then each tooth of the 3 groups was subjected to thermocycling at 5° and 55° celcius temperature for 250 cycles each with a dwell time of 30 seconds and with an interval of 30s and then stored in distill water again for 24h. Teeth were prepared for dye penetration test by sealing the root apices with sticky wax. Then all the teeth were coated with nail varnish except around restoration leaving 1-2mm around the margins, then the teeth were left to dry out completely. Then the teeth were immersed in 2% methylene blue dye for 24 h. After 24h, all the samples were washed thoroughly under running water for 30 mins and then the coronal portion of the specimens were sectioned at the level of cervical line and mounted on acrylic blocks. All the mounted blocks were sectioned buccolingually from the middle and split into mesial and distal parts which were then observed under stereo microscope to evaluate the microleakage. Out of 4 sides of each restoration i.e. buccal and palatal/lingual margin of mesial and distal side, the interface showing maximum dye penetration were considered.

The images were captured using Olympus camera and the scores were given to the tooth obtained samples using criteria mentioned as follows

Table 1: Scoring criteria for dye penetration

Scores	Criteria
0	No microleakage. No dye penetration
1	Microleakage observed only at the cavity wall of the enamel. Dye penetration through the cavity margin reaching the enamel
2	Microleakage observed at the cavity wall of the dentin, but not on the cavity floor. Dye penetration through the cavity margin reaching the dentin
3	Microleakage observed on the cavity floor. Dye penetration through the cavity margin reaching the cavity floor

METHOD FOR EVALUATION OF COMPRESSIVE STRENGTH

45 cylindrical shaped plastic molds with an inner diameter of 4mm and 6mm height were used to prepare the specimens. Powder and liquid were mixed according to manufacturers instructions. The experimental groups were hand mixed and loaded into the mold with the help of a sterile dental instrument and stored at

room temperature for 24 hours. Molds were filled with respective restorative materials and divided into 3 groups:

- Group IV - Fifteen molds were restored with GIC type IX.
- Group V - Fifteen molds were restored with GIC type IX incorporated with 2% CHX.
- Group VI - Fifteen molds were restored with GIC type IX incorporated with 2% Cetrimide.

After 24 hours, the ends of each sample were ground flat using GIC polishing bur The samples were then removed from molds. Then the samples were positioned in a universal testing machine (Instron 1500HDX) and compressive force was applied with a cross head speed 1.0mm/min and the values were obtained for the sample in N/mm². Each specimen was placed with the flat ends between the plates of the testing machine and the compressive load was applied along the long axis of the specimen.

Statistical analysis

The scores were obtained and were subjected to statistical analysis to consider whether "P" is <0.05 by the Kruskal-Wallis test complemented by Tukey's post-hoc test and intragroup comparison was made by Student's paired t-test for the comparative analysis of both microleakage and evaluation of compressive strength between the three experimental type IX GICs. On statistical analysis, the obtained P value is typically < 0.001 thus in this study, we reject the null hypothesis and there exists statistical significant differences between the restorative materials used. Statistical evaluation in all tests was performed with SPSS version 20.0 software (IBM USA).

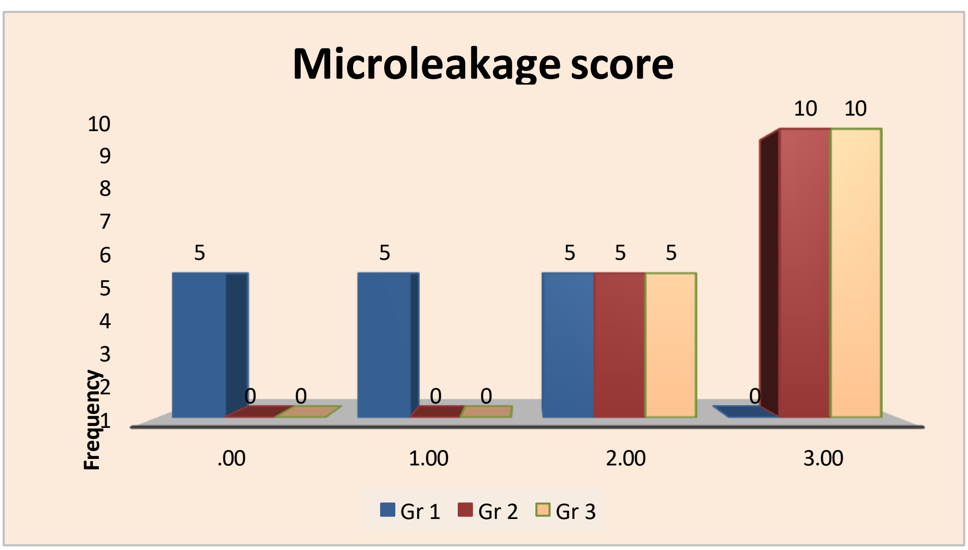
Results:

The results of this study showed that microleakage was observed in all the groups. On intergroup comparison of the three experimental GICs with respect to microleakage, there is statistically significant difference between three groups. As per data illustrated in table 2, the microleakage level was similar in group II (Type IX GIC + 2% chlorhexidine) and group III (Type IX GIC +2 % cetrimide) with the mean value (2.67). Where as group I (Type IX GIC) showed the least microleakage among all the groups with mean value (1).

Table 2: Comparison of mean microleakage scores between three different experimental GICs

Group	Mean	a n	Standar d Error	IQR	uskal-allis Test	P Value
Group I	1	1	0.21	0 - 2	26.566	<0.001
Group II	2.67	3	0.12	2 - 3		
Group III	2.67	3	0.12	2 - 3		

Graph 1: Intergroup comparison of dye penetration among three experimental type IX GICs

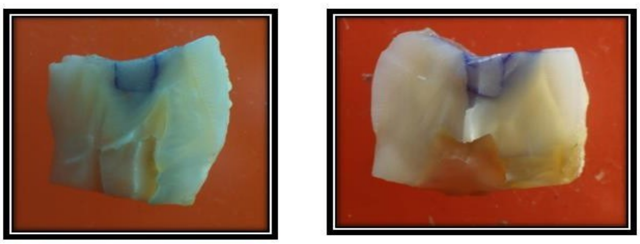


Using post - hoc comparison, it is seen that there is significant difference between Group I and Group II and between Group I and Group III (in both cases P<.001) Figure 1 shows results of microleakage

sectioned specimen with score 0

sectioned specimen with score 1

sectioned specimen with score 2



sectioned specimen with score 3

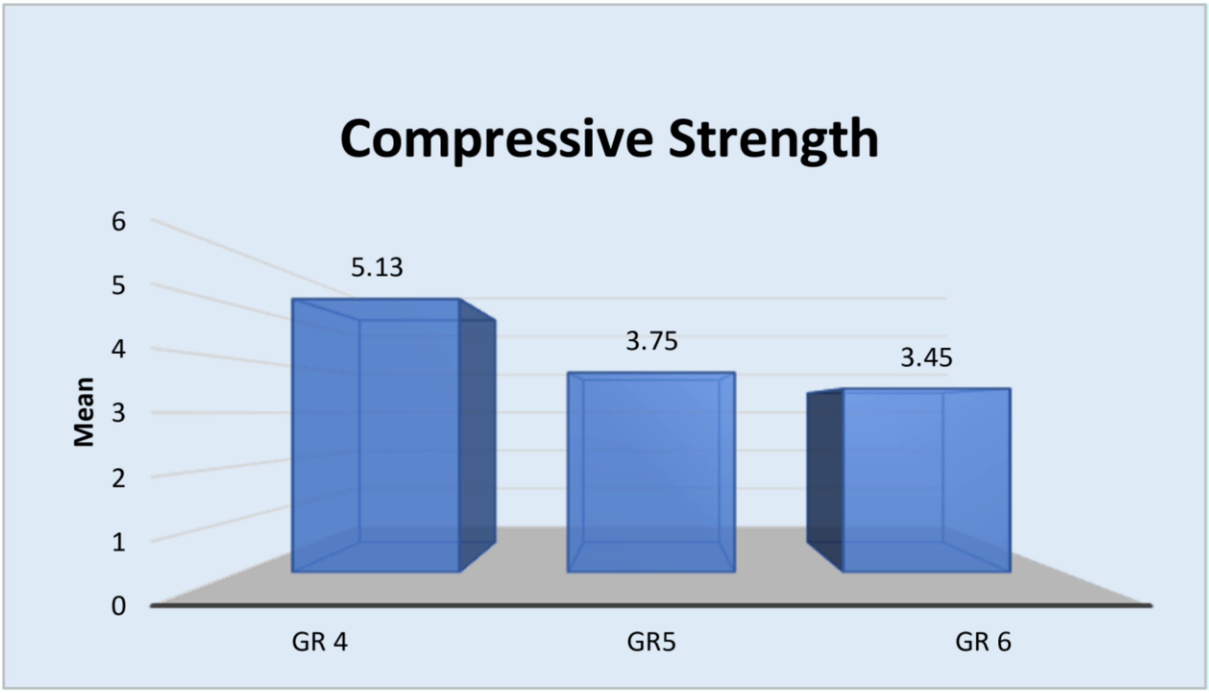
As per data illustrated in table 3, group IV (Type IX GIC) showed the highest mean compressive strength (5.13). Where as mean compressive strength of group V (Type IX GIC + 2% Chlorhexidine) – (3.75) and group VI (Type IX GIC + 2% Cetrimide) - (3.45) was comparable.

Table 3: Comparison of mean compressive strength between three different experimental GICs

Group	Mean	a n	ndard Error	IQR	uskal- Wallis Test	P Value
Group IV	5.13	4.87	0.33	4.19 - 5.75		
Group V	3.75	3.67	0.23	3.06 - 4.13	14.133	<0.001
Group VI	3.45	3.25	0.26	2.73 - 3.60		

Using post hoc comparison it is seen that there is significant difference between mean compressive strength between Group IV and Group V, Group IV and Group VI (in both cases P<0.001) Graph 2 shows that the highest compressive strength was exhibited by the conventional type IX GIC, followed by the type IX GIC containing 2% chlorhexidine, and the least value was exhibited by the type IX GIC containing 2% cetrimide.

Graph 2: Intergroup comparison of Compressive strength among three experimental type IX GICs



DISCUSSION

Globally, dental caries ranks among the most prevalent diseases of the human race. Bacteria plays a key role in their development. The persisting cariogenic bacteria, with the lack of hermetic seal, can cause recurrent caries, leading to failure of restoration. Realization that dental caries is reversible in the initial stages and a dynamic biochemical event at a micron level, has changed the way the profession recognizes the caries process. [9] Alternative methods of treating caries are frequently used in areas with few dental facilities and care providers. One such alternative therapy is atraumatic restorative treatment, which involves minimal cavity preparation using only hand instruments followed by restoration of the cavity with an adhesive filling material, such as GIC.[10]

The quest to search an ideal restorative material has been a challenge for the researchers and academicians in the fraternity of restorative dentistry. The glass ionomer family of materials is one of the most versatile of the acid-base cements, and has many applications in dentistry (Wilson and McLean 1988) as a restorative material, a lining material or a base (dentin substitute), a luting cement for crowns and bridges (Knibbs 1988) etc.

Glass-ionomer cements (G1C) possess certain unique properties like release of fluoride which contributes to some reduction in the number of residual bacteria in cavities as well as remineralization of the softened dentin and imparts anticariogenic potential, GIC bonds chemically to enamel and dentine, and has low coefficient of thermal expansion, relatively it is biocompatible. Whereas there are certain disadvantages of GICs that it has low fracture toughness and wear resistance, it is very sensitive to moisture especially during initial setting reaction, it lacks antibacterial property.

Fuji IX is a high strength posterior restorative material and has been reported to release approximately 10ppm of fluoride during 48hrs. Fuji IX GIC was used in the present study, since this is the most frequently reported material in in vivo and in vitro studies in the past. Deepalakshmi M et al (2010) [6], Yesilyurt C et al (2009)[11], Tuzuner T et al (2011) [12] used type IX GIC in their respective studies for evaluating antibacterial and physical properties of modified type IX GICs. Considering the material as a gold standard in high-strength posterior restoratives, it could be efficiently used for the assessment of compressive strength and microleakage of the modified cement.

In this study chlorhexidine and cetrimide were selected as antibacterial agents. They were incorporated in type IX GIC by 2% w/w and microleakage and compressive strength were evaluated.

Chlorhexidine (CHX) and cetrimide (CT) are antiseptics with a wide spectrum of action and their use has been generalized over the past two decades. Cationic chlorhexidine absorbs on to the surface enamel of the tooth by binding to anionic components such as salivary glycoproteins, this action reduces adhesion of protein on to the tooth surface and delays formation of dental pellicle. CHX also affects the colonization rate of oral bacteria on enamel surface and results in prolonged antimicrobial action. Streptococcus mutans which is considered one of the most cariogenic bacteria has been shown to be particularly sensitive to chlorhexidine. Investigators Ribeiro J and Ericson D (1991), Sanders BJ et al (2002),Takahashi Y et al (2006) [13], Türkün LS et al (2008)[5], highly recommend the usage of the CHX diacetate, particularly between 1% and 5% final concentrations to obtain optimum antibacterial effects without jeopardizing the basic physical properties of the GICs. A concentration of 2% CHX diacetate was selected in the present study, as chlorhexidine diacetate is a more stable antibacterial material, not prone to decomposition and can be easily blended with GIC. At the concentrations used clinically the biocompatibility of CHX is acceptable having a low degree of toxicity. In this study chlorhexidine diacetate was as a proven gold standard, functioning as a potent metalloproteinase inhibitor while capable of reducing bacterial load substantially, to which we could compare the efficacy of cetrimide.

Cetrimide is a cationic surfactant, a quaternary ammonium derivative, with bactericidal activity and the capacity to decrease the biofilm's mechanical stability. Cetrimide has demonstrated its effectiveness against both gram positive and gram negative bacteria and exerts residual antimicrobial activity over a period of time. It is entirely non toxic at a concentration of up to 2%. Cetrimide reduces the surface tension of liquids. This characteristic could facilitate its penetration in areas with difficult access such as inner lumen of dentinal tubules.

The principal aim of determining microleakage is to predict the longevity and performance of the restorative material used. Thus, the restorative material which maintains the marginal seal for a long time span and also resists the bacterial fluid infusion in and around the restored cavity decreases clinical problems such as formation of secondary caries and discolorations of the restored material due to caries formation. An overall view thus indicates that material properties such as thermal expansion and elasticity play a vital role in modifying the marginal sealing ability and also the nonmaterial- related factors such as cavity preparation, material application technique, also to be taken into account as well, for the better resistance and retention of the material to the tooth interface. The marginal adaptation of any restorative material with good sealing ability prevents maximum microleakage. The restorative material and the tooth interface should have identical thermal expansion to limit microleakage. So, we have evaluated and compared microleakage of modified GIC to unmodified GIC.

As GIC has low fracture toughness and poor wear resistance, it won't be able to withstand masticatory forces in class II tooth preparation, and so chances of marginal fracture of GIC restoration would be high, so mainly it is used for restoring class I cavity clinically, so we have evaluated the property of type IX GIC in class I cavity and hence class I occlusal cavity was selected as method of choice in this study. Thermocycling is a laboratory method. To simulate the original oral environment, thermal stresses are usually employed by thermocycling on the tooth restoration at different degrees and different rates. In this study, to produce a dynamic oral environment, the restored teeth were subjected to thermal changes through thermocycling. Thermal cycles ranging between 200 and 1000 were used in some studies [Bertrand et al., 2006; Sungurtekin and Oztas, 2010] [14]. In the present study, 250 thermal cycles were done to prevent dehydration of samples, before testing for microleakage.

Several researchers have measured the temperature fluctuations in the oral cavity while consuming hot and cold food. When reviewing the literature, it shows that thermocycling specimens between 5° and 55°C is appropriate to cover oral temperature fluctuations in mouth.

In this study, the root apices of all the samples were sealed with sticky wax to prevent any dye penetration through the apices during the procedure and also to avoid false-positive results. Later, all the prepared teeth were coated with nail varnish around the restoration except 1–2 mm left around the margins to limit the dye penetration into the margins of the prepared and sealed cavity only. For microleakage tests, the guidelines emphasize the need to standardize tooth quality, type of cavity preparation, and method used to evaluate microleakage at the margin. In this study dye penetration test was performed because the staining of microleakage and nanoleakage using colored agents is the most commonly used technique. Dye penetration method involves the use of contrasting dyes as an immersion solution to stain the areas of microleakage, and then the tooth–restoration interface is examined for evidence of staining. Notably, the most commonly used solutions are 0.5% basic fuchsin, 2% methylene blue, and 50% silver nitrate. The dye penetration assay has many advantages over other techniques. First, no reactive chemicals are used along with no radiation.[15] Second, different dye solutions are available; therefore, the technique is highly feasible and easily reproducible[16]. The current studies Fusayama T, Terachima S (1972) have failed to clearly establish which dyes are suitable for use with microleakage test as some of the dyes can react with dentin such as basic fuchsin. Another important issue with dye penetration methods is the particle size of the used dye which could affect the reliability of the test. [17]

In present study 2% methylene blue dye was used. Methylene blue dye which has a low molecular weight was selected as the leakage indicator because of its frequent use in studies for evaluating microleakage of restorative materials. Moreover, it can be detected easily under visible light, it is soluble in water, diffuses easily into the specimen. In this study, intergroup comparison of three experimental GICs with respect to microleakage showed a statistically significant difference ($p < 0.001$) by the Kruskal–Wallis test. The microleakage level was high in Group II (type IX GIC + 2% chlorhexidine) and Group III (type IX GIC + 2% cetrimide) with a mean value of 2.67 whereas Group I (Type IX GIC) with a mean value of 1.00 showed the least microleakage. Using post - hoc comparison, it is seen that there is significant difference between Group I and Group II and between Group I and Group III (in both cases $P<.001$). Hence it is clear from the results that microleakage was more in experimental type IX GICs with additives compared to parent material.

The resultant decrease in the marginal sealing ability of type IX GIC after addition of 2% W/W CHX and cetrimide could be due to various reasons like cationic salts that may interfere with the bond formation of glass ionomer with the tooth structure, that can lead to failure of adhesion between GC Fuji IX and tooth. Also failure of adhesion of restoration with tooth can occur because of incorporation of void/air bubble during the bulk placement of material into the cavity. Improper manipulation of test cements with inacurate powder liquid ratio can result in poor mix so the consistency of the test material can be porous incorporating voids that can increase the possibility of microleakage.

The results of this study with respect to microleakage are in accordance with the study done by Jaidka S et al (2016)[18] who evaluated & compared the microleakage of type IX GIC, 0.5 % chlorhexidine incorporated GIC and 0.5% triclosan incorporated GIC, and showed that type IX GIC showed the least microleakage and there was statistically significant difference between mean microleakage of type IX GIC (1.53) and GIC incorporated with chlorhexidine (3.13). Ahluwalia P. et al (2012)[1] who evaluated marginal sealing ability of chlorhexidine modified glass ionomer cement and concluded that 1 % chlorhexidine incorporated GIC showed higher microleakage than type IX GIC.

One of the study done by SM Mathew et al (2013)[19] who evaluated microleakage of CHX modified glass ionomer cement. The study showed that addition of 1% CHX diacetate to type IX GIC showed comparable results regard to microleakage. The result of this study was in contrast to the result of the present study. This could be due to 1% of chlorhexidine was used in this study and in the present study 2% CHX was used so this could have ensued because the lower concentration i.e. 1% of chlorhexidine did not hinder the formation of bond of the glass ionomer with the tooth structure. Also it was an in vivo study and ours was an in vitro study

Since there have been very few studies evaluating the microleakage of CHX modified GIC, further investigation for evaluation of microleakage of type IX GIC incorporated with different concentration of chlorhexidine and cetrimide are required. Another exploratory domain of the present study was to evaluate and compare the compressive strength of the type IX GIC, type IX GIC incorporated with 2% CHX & 2% cetrimide.

The ability of the restorative dental material to withstand the functional forces is an important requirement for their long-term clinical performance. The fracture resistance of the restorative material has specific resistance called fracture stress, exceeding of which can result in fracture of the restored material and in turn results in increased microleakage. Thus, the compressive strength of the restorative material placed into the cavity walls plays a vital role mainly during the application of masticatory forces.

According to British specification, 125 MPa is considered as a minimal value to resist the normal masticatory force commonly used by humans, whereas some authors believe that this value should be 100 MPa in primary dentition. [20] In this study compressive strength of the experimental GICs were evaluated and compared after 24hrs of final set of the material using universal testing machine. It is important to compare the physical properties of GIC after 24 h or more because their final setting is achieved after 24 h, and they usually present lower strength values during the first few hours.

The results of present study with respect to compressive strength demonstrated that, The highest compressive strength was exhibited by the conventional type IX GIC, followed by the type IX GIC containing 2% chlorhexidine, and the least value was exhibited by the type IX GIC containing 2% cetrimide. The possible reason for decrease in the compressive strength can be attributed to cationic salts, which hamper the setting reaction of the polyacrylic acid glasses, thereby extending the setting time, due to an interfered proton attack and leaching of ions from the glasses. In addition, the slight modification in powder/liquid ratios by adding CHX diacetate and cetrimide may have also influenced the compressive strength.

The results of present study with respect to compressive strength are in accordance with the studies done by various authors. Takahashi Y et al (2006)[13] evaluated antibacterial, physical, and bonding properties of glass-ionomer cements (GIC) containing chlorhexidine (CHX) and concluded that incorporation of CHX diacetate at 2% or greater, significantly decreased compressive strength.

Deepalakshmi M et al (2010)[6] evaluated the antibacterial and physical properties of GIC with chlorhexidine and cetrimide, and concluded that incorporation of chlorhexidine diacetate and cetrimide, at 2%, significantly decreased the compressive strength of GIC. Prabhakar et al (2014)[3] studied the effect of 1% xylitol (XYL) (artificial sweetener) and 1% chlorhexidine (CHX) diacetate on antibacterial property against *Streptococcus mutans* and physical properties of conventional glass-ionomer cement (GIC), who concluded that conventional GIC showed the highest compressive strength after 24 h. Although both CHX and XYL affected the physical properties of conventional GIC to an equal extent.

Mittal S et al (2015)[21] evaluated the antimicrobial efficacy and compressive strength of conventional glass ionomer cement (GIC) containing chlorhexidine and antibiotics at varying concentrations, and concluded that compressive strength at the end of 24 h decreased in the experimental groups as compared to the conventional GIC, but no difference was found between the experimental groups. Mishra A. et al (2017)[22] studied antibacterial effect and physical properties of chitosan and chlorhexidine-cetrimide-modified glass ionomer cements and concluded that chlorhexidine-cetrimide-modified glass ionomer cements exhibited least compressive strength values and conventional GIC exhibited the highest compressive strength value.

So in the present study it can be concluded that addition of 2% W/W CHX and cetrimide to conventional type IX GIC altered the marginal sealing ability and compressive strength of type IX GIC.

CONCLUSION

Conventional type IX GIC is high strength posterior GIC used in pediatric and geriatric restorations. GIC is also useful in atraumatic restorative treatment. Though the fluoride releasing property of GIC imparts anticariogenic potential to GIC, but there is a drawback that it lacks antibacterial activity. Hence chlorhexidine and cetrimide were incorporated in type IX GIC to enhance its antibacterial property.

Within the limitations of the present study, it can be concluded that incorporation of antibacterial agents like chlorhexidine and cetrimide to type IX GIC, increased the microleakage and decreased the compressive strength of the parent material. Although a single concentration of 2% was tested in the present study, incorporation of lower concentration of chlorhexidine and cetrimide should also be explored.

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