Comparison of Compressive Strength and Microleakage of Zirconia Reinforced Flowable Composite and Zirconia Reinforced GIC in Class V Cavities - An In-Vitro Study

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Abstract: ***This study investigates the comparative efficacy of zirconia - reinforced glass ionomer cement GIC and zirconia - reinforced flowable composite in restoring Class V cavities. Specifically, it evaluates their compressive strength and microleakage properties. The research comprises an in vitro analysis of 48 samples divided into subgroups for each material type. The zirconia - reinforced GIC demonstrated higher compressive strength, while the zirconia - reinforced flowable composite exhibited significantly lower microleakage. These findings suggest that while zirconia - reinforced GIC offers superior strength, the flowable composite is more effective in minimizing leakage. This study contributes to the field of restorative dentistry by providing insights into the performance of these materials in Class V cavity restorations, highlighting the need for further research, particularly on the relatively new zirconia - reinforced flowable composite.***

Keywords: Dental Caries, Zirconia - Reinforced Materials, Compressive Strength, Microleakage, Class V Cavities

1. Introduction

One of the most frequent causes of tooth structure loss is dental caries, which affects the shape and function of the impacted tooth. Various restorative materials can be used to repair teeth affected by dental caries. A restorative substance restores the biological, functional, and aesthetic qualities of the tooth structure.[1]

One of the most important techniques included in MID is ART (Atraumatic Restorative Treatment). It consists of two components: sealing of caries - prone pits and fissures with a sealant, and use of a sealant in combination with restoring cavitated dentin lesions. The main difference between the ART approach and other minimally invasive operative interventions is that ART uses hand instruments only. Thus, when ART is used either to seal pits and fissures or to restore tooth cavities, hand instruments are used in conjunction with adhesive materials or systems. However, in practice, glass - ionomer cement (GIC) has become the most predominantly used material mainly because of its delayed setting reaction that allows handling of the material before it is completely set. Composite resin has also been used to restore primary molars with hand instruments only. Polymerization of the material by the use of cord or cordless curing devices is considered as part of the ART approach.2

For the successful restoration of class V cavities in restorative dentistry, the choice of materials with high compressive strength and little microleakage is crucial. On the lingual or buccal surfaces of teeth, close to the gingival border, are Class V cavities.

Due to their position and ongoing exposure to oral fluids, these cavities are extremely difficult to restore, hence it is crucial that the restorative materials utilized in these cavities have excellent sealing and retention capabilities. Due to their improved characteristics, zirconia - reinforced flowable composite and zirconia - reinforced glass ionomer cement have been developed as alternatives for filling class V cavities.

Zirconia - reinforced flowable composites have been more well - liked recently since they outperform conventional flowable composites in terms of both mechanical and aesthetic qualities. According to studies, transparent matrix and flowable composites work better together to restore non - carious cervical lesions than other materials. These flowable composites are more flexible and better able to tolerate the loads and strains exerted on class V restorations because they have a lower modulus of elasticity.[3] Additionally, it has been discovered that zirconia - reinforced flowable composites have higher compressive strengths than traditional flowable composites, which is significant in providing the requisite strength for class V restorations to withstand occlusal stresses.[4]

Another one is glass ionomer cement reinforced with zirconia for Class V cavities This substance is renowned for its exceptional self - adhesive qualities, which make it simple to use and reduce the need for extra bonding chemicals. In addition, zirconia - reinforced glass ionomer cement has effective fluoride release and absorption properties, which can aid in preventing subsequent caries in the repaired tooth structure.5 This new flowable composite has been described as being indicated for the restoration of Class V cavities, small Class I cavities, lining material, pit and fissure sealing, restoration of non - carious cervical lesions, and ceramic repair due to its simplified application procedure.

However, it should be noted that there is a lack of studies specifically evaluating the use of zirconia - reinforced flowable composites for its compressive strength and microleakage in class V cavities.

Hence, the aim of my study is to compare and evaluate the compressive strength and microleakage of zirconia - reinforced flowable composite and zirconia - reinforced GIC in class V cavities.

Aim

To compare and evaluate the compressive strength and microleakage of zirconia - reinforced flowable composite and zirconia - reinforced GIC in Class V cavities.

Objectives

- To compare the compressive strength of zirconia - reinforced flowable composite materials and zirconia - reinforced GIC.
- To compare the microleakage of zirconia - reinforced flowable composite materials and zirconia - reinforced GIC in Class V cavities.

2. Material and Method

48 samples will be taken. It will be divided into 2 groups – compressive strength and microleakage. Further 4 subgroups will be there, zirconia - reinforced flowable composite and zirconia - reinforced GIC, each containing 12 samples.

Sample Size Estimation –

Using the formula,

$$n = \frac{2(SD)^2(Z_{1-\alpha/2} + Z_\beta)^2}{(d)^2}$$

Where,

SD = STANDARD DEVIATION

$Z_{1-\alpha/2}$ = 1.96 AT 95% CONFIDENCE INTERVAL

Z_β = 0.84 AT 80% power

d = MEAN DIFFERNCE

Substituting the values, we get

n= 11.38

By adding 10% for sample loss if any, n= 12

Therefore the total sample size is 12 per group.

Armamentarium and Materials –

- Zirconia reinforced GIC (SHOFU zirconomer improved)
- Zirconia reinforced flowable composite (WALDENT nanoflow zirconium)
- 24 extracted premolars.
- Plastic spatula
- GIC mixing pad
- Curing light
- Composite instruments
- Cement placing spatula
- Vaseline
- Distilled water
- 0.5% basic fuchsine dye
- Thermocycler
- Universal testing machine
- Stereomicroscope
- Containers.

3. Methodology

Compressive Strength Evaluation

A total of 24 specimen blocks were prepared with 12 samples of each type of restorative material, namely subgroup 1: Zirconia reinforced flowable composite (WALDENT nanoflow zirconium) and group 2: Zirconia reinforced GIC (SHOFU zirconomer improved). Samples of each restorative material were fabricated using metal split molds of dimensions 5 x 5 x 5 mm to evaluate compressive strength. These prepared samples were stored at 37 ± 1°C for 24 hours in distilled water before testing. Samples were subjected to a universal testing machine connected to a load - measuring cell with load applied at a crosshead speed of 0.50 ± 0.25 mm/min till the fracture of the sample.

Microleakage Evaluation

Orthodontically extracted 24 premolars free from crack, caries, restoration, or white spot lesions on the buccal surface were selected. Teeth were cleaned and stored in distilled water until use. Class V cavities on the buccal surface of premolars were prepared of dimensions 2 mm depth, 3 mm width, and 2 mm height in occlusal - gingival direction using high - speed flat end straight diamond bur (SF - 41 ISO 109/010 Mani Dia Burs) with water coolant. All the tooth preparations were randomly divided into 2 subgroups of 12 samples each and restored with respective materials, that is group 3: Zirconia reinforced flowable composite (WALDENT nanoflow zirconium) and group 4: Zirconia reinforced GIC (SHOFU zirconomer improved).

All the procedures were done by a single trained investigator. All restored teeth were stored in distilled water at 37°C for 24 hours. Later, they were subjected to 200 thermocycles at 5°C and 55°C lasted for 30 seconds to simulate the variation in oral thermal condition. These samples were immersed in 0.5% basic fuchsine dye at 37°C for 24 hours, followed by washing in water and drying.

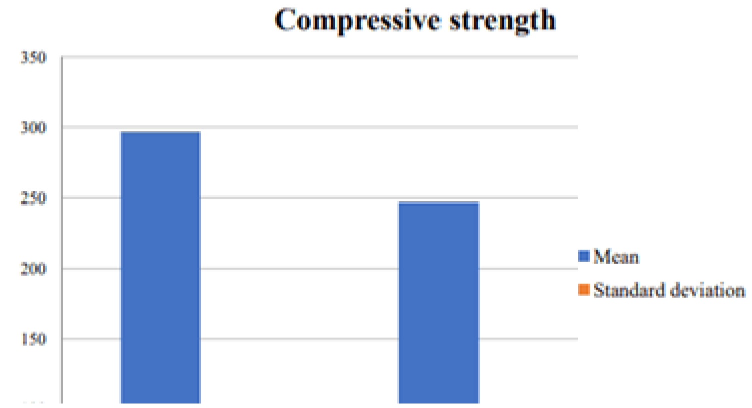
Later, each tooth was longitudinally sectioned through the center of restoration with the help of a diamond disk under water coolant. All sections were observed under a stereomicroscope at 20× magnification. After observing each longitudinal section of a particular tooth, a section with greater microleakage was selected for scoring. The leakage distance from the margins to the determined limit was recorded in micrometers. The obtained data were tabulated.

All statistical analysis will be performed by using the SPSS software. The mean and the standard deviation will be calculated for each variable. Analysis of the data between groups will be carried out by paired and unpaired t - test. $P < 0.05$ was considered as statistically significant.

4. Results

Table no 1 show that the highest mean compressive strength is of Zirconia reinforced GIC, 296.66±30.71 compared to Zirconia reinforced flowable composite, i. e, 246.74±21.52 which is statistically significant ($p < 0.001$).

Sl. No.	Materials	Mean±SD	p Value
1	ZR-GIC	296.66±30.71	<0.001
2	ZR-COMPOSITE	246.74±21.52	



Sl. No.	Materials	Mean±SD	p Value
1	ZR-GIC	5.92±3.22	<0.001
2	ZR-COMPOSITE	1.07±0.72	

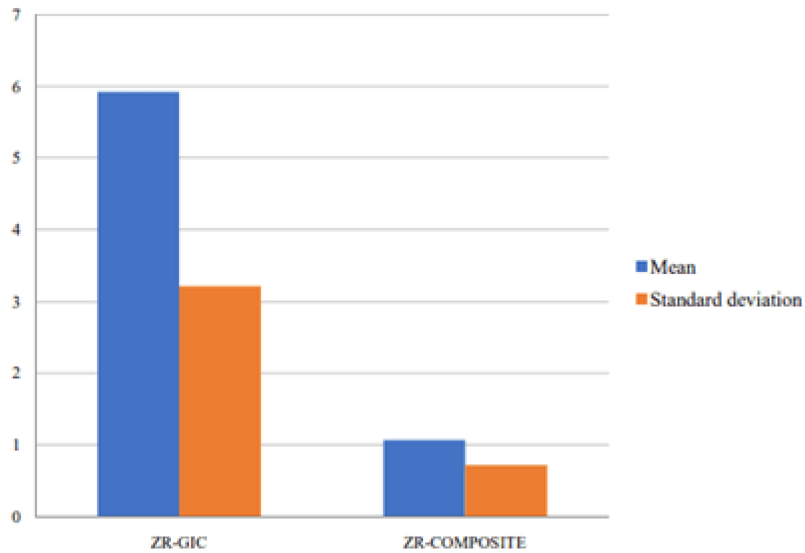
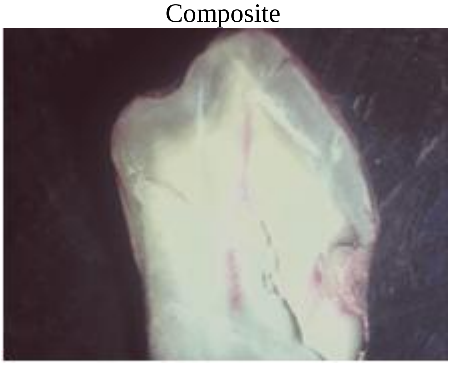
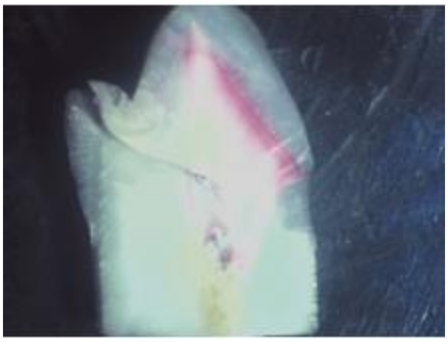


Table 1: Comparison of Compressive Strength of ZR - GIC and ZR - Composite

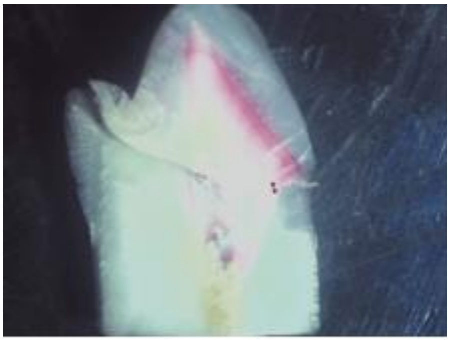
Table no 2 shows that the highest mean microleakage was seen with zirconia reinforced GIC i. e.5.92±3.22 when compared to Zirconia reinforced flowable composite, 1.07±0.72 which is statistically significant ($p < 0.001$).

Table 2: Comparision of Microlakage of ZR - GIC and ZR - Composite





ZR - REINFORCED GIC



FLOWABLE ZR - COMPOSITE

This study indicates that the zirconia reinforced GIC had comparable compressive strength with zirconia reinforced flowable composite whereas zirconia reinforced flowable composite have least amount of microleakage.

5. Discussion

Dental restorative materials' main objective is to replace the healthy tooth structure's biological, aesthetic, and functional qualities. Greater stability, more stable load distribution, and greater clinical success are all benefits of stronger restorative materials, which also resist fracture and deformation. Compressive strength is frequently used to assess how well restorative materials perform in clinical settings. Since it resists the compressive and tensile pressures generated during mastication, compressive strength is crucial for restoration.[1, 6]

The present study evaluated and compared the compressive strength and microleakage of two different zirconia reinforced material, i. e., zirconia reinforced flowable composite and zirconia reinforced GIC. We found that the zirconia - reinforced GIC had more compressive strength compared to zirconia reinforced flowable composite. Our study is in accordance with the finding of Vemina P Chalissery, who found that Both CS and DTS were found to be significantly higher for the zirconia - reinforced GIC and silver amalgam compared with GIC.7 According to Walia R, the compressive strength was found to be highly significant ($P < 0.01$) with the maximum score for Giomer followed by Ceram - x, Zirconomer, and Ketac Molar.8 According to Shetty, highest compressive strength was exhibited by Zirconomer followed by Zirconomer Improved and Ketac Molar. All the tested restorative materials exhibited sufficient compressive strengths with Zirconomer exhibiting significantly higher compressive strength.[9] In contrast, according to Dr. leneena gudugunta et al, the results obtained amalgam has the highest and composite have higher compressive strength compared to zirconomer.[10]

The zirconium oxide, glass powder, tartaric acid, and polyacrylic acid in zirconomer, which demonstrated the best compressive strength value in this investigation, are combined with deionized water as the liquid. The presence of zirconia fillers is responsible for the higher mechanical property. In Zirconomer, the glass component is subjected to meticulously regulated micronization in order to create the ideal homogeneous particle size, which further results in improved mechanical properties like increased strength. The durability of the material and its capacity to sustain occlusal stress are further strengthened by the glass particle’s homogeneity.[9, 11, 12]

According to our study, the microleakage was found to be more in zirconia reinforced GIC when compared to zirconia reinforced flowable composite material. our study’s result for microleakage is in accordance with Patel MU, who found that the zirconomer exhibited the highest micro leakage as compared to composite and amalgam but composite having higher micro leakage as compared to amalgam and lower micro leakage as compared to zirconomer.[13]

According to dhivya S, Zirconomer improved exhibited lower microleakage when compared to Cention N and Equiaforte cements.[14] In contrast, the highest mean score of leakage was recorded in KetacTM Silver followed by Zirconomer and composite. The lowest mean score of dye penetration was verified in amalgam. Statistically, there were significant differences between Zirconomer and other groups of KetacTM Silver and amalgam, whereas the Zirconomer groups had no significant differences with composites.[15] According to Mahajan S, Out of all the restorative materials used in this study Zirconomer showed minimum microleakage and GIC showed maximum microleakage. There was no statistical difference between zirconomer and composite’s microleakage in gingival area.[16]

Due to the fact that the performance and outcome of the restorative material vary between ex vivo and in vivo oral settings, the present study's main disadvantage is that it was conducted in vitro. Unlike the performance of the restorative material, oral condition simulation of temperature and moisture cannot be maintained in an in vitro investigation. A small selection of materials that had been polymerized using one kind of unit were used to examine the physical characteristic. Therefore, larger sample size clinical investigations are needed in the future. Also, more studies are needed to be done on zirconia reinforced flowable composite as it is a comparatively new material.

More advance tests are needed to be done to check for microleakage for example – SEM, microCT etc. The present study's main disadvantage is that it was conducted in vitro. Unlike the performance of the restorative material, oral condition simulation of temperature and moisture cannot be maintained in an in vitro investigation. A small selection of materials that had been polymerized using one kind of unit were used to examine the physical characteristic.

Therefore, larger sample size clinical investigations are needed in the future. Also, more studies are needed to be done on zirconia reinforced flowable composite as it is a comparatively new material.

6. Conclusion

Zirconia - reinforced flowable composite is a newer restorative material having promising properties having lesser microleakage compared with zirconia - reinforced GIC and slightly comparable mechanical properties with zirconia - reinforced GIC.

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