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Comparative Evaluation of Microlekage of Zirconia-Reinforced Glassionomer and Two Conventional Restoratives: An In Vitro Study

[1]Dr. Kola. Srikanth Reddy, [2]Dr. Rahamtulla Syed, [3]Dr. Shamini Pawar, [4]Dr. Pushpa Latha H.M, [5]Dr. A. Aravind Kumar, [6]Dr. Vijaykumar K.V

[1]Professor.Department of pedodontics & preventive dentistry, Meghna institute of Dental sciences, Nizamabad, Telangana state, India.
[2]Associate Professor, Department of Orthodontics, Care Dental College & Hospital, Guntur, A.P, India.
[3]Asst.Professor, Department of Pedodontics & Preventive Dentistry, Meghna institute of Dental sciences, Nizamabad, Telangana state, India.
[4]Professor, Department Pedodontics & Preventive Dentistry, Meghna Institute Of Dental Science, Nizamabad, Telangana state, India.
[5]Associate Professor, Department of Periodontics & Implantology, Meghna Institute Of Dental Science, Nizamabad, Telangana state, India.
[6]Professor & H.O.D, Department of Public health Dentistry, Malla Reddy Dental College for womens, Hyderabad, Telangana state, India .

Corresponding Author

Dr. Kola. Srikanth Reddy,
Professor. Department of pedodontics & preventive dentistry, Meghna institute of Dental sciences, Nizamabad, Telangana state, India.

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ABSTRACT

Background: Dental materials used for permanent restorations are intended to replace lost and defective dental tissues and be chemically stable and inert in the oral environment.
Aims and Objectives: To compare and evaluate marginal microleakage of zirconia-reinforced Glassionomer with two conventional restoratives. To analyze the microlekage of the cements being tested.
Materials and methods: For testing microlekage, class V, cavities were prepared on 60 extracted maxillary premolars. Each set of dentition permanent teeth was divided into 3 groups of 20 specimens each to be restored with selected restorative material: Group A (Zirconomer), Group B (Hidence, Group C (Posterior Extra). These teeth were subjected to thermo cycling, dye immersion, sectioning, and examination under a Stereomicroscope to assess the degree of microlekage. The scoring was done according to the scoring criteria put forward by Khera and Chan, which were further tabulated and statistically analyzed.
Results: Microlekage of 3 groups showed no significant difference. Statistically analyzed using the one-way ANOVA test and the unpaired test, and pair-wise comparison was done using the Turkish multiple postdoc procedure.
Conclusion: It can be concluded that Zirconomer-reinforced Glassionomer proved to be a better restorative material than the other cements used in the study.

Key words: Dye penetration, Microlekage, Zirconomer-reinforced Glassionomer cement.

INTRODUCTION

Since their invention in 1970, glass-ionomer cements (GICs) have been widely used in pediatric dentistry. They have undergone many modifications in composition until the recent Zirconomer cement, which claims to have superior properties compared to their primal versions. One of the important requisites of restorative material is adhesion to the tooth structure, failure of which leads to microleakage.

Conventional GICs have been used in dentistry for over 40 years [1]. The attractiveness of these materials is their intrinsic properties, which make them useful as restorative and adhesive materials.

Microleakage is the most common cause of failure for all restorative materials, since it is a major contributing factor to secondary caries and early pulpal involvement. Consequently, an interest arises in finding a restorative material that has better bonding with the dental tissues, thereby minimizing the chances of microleakage.

These include anti-cariogenic properties due to its ability to release and store fluoride; hence, it has been an excellent choice of material for the treatment of patients at high risk for caries. It also has excellent biocompatible properties because polyacrylic acid is a week acid with macromolecules of high molecular weight that are prone to joining the calcium of the tooth, making it difficult to move inside the dentinal tubules, being less irritating to the pulp tissue, and being less cytotoxic compared to resinous adhesives. [2]

The most common tests used for the determination of the mechanical behavior of materials are CS, diametric tensile strength (DTS), shear bond strength, flexural strength (FS), surface hardness (Vikers hardness number or Knoop hardness number), and wear rate.

The clinical success of the newer restorative materials depends on good adhesion with the dentinal surface to resist various dislodging forces acting on them.

Hence, the present study was undertaken to evaluate the microleakage of recently available hidence and to compare it with the previously existing posterior extra-restorative material on permanent teeth.

MATERIALS AND METHODS

This study was conducted at a dental college and hospital in the Department of Pedodontics and Preventive Dentistry.A total of 60 teeth, 30 non-carious retained premolars, and 30 premolars extracted for orthodontic reasons were selected for this study.

Inclusion criteria

1. intact crown structure were included.
2. The selected teeth were either extracted for orthodontic reasons or exfoliated due to pre-shedding mobility.

Exclusion criteria

1. Teeth were fractured, and any kind of developmental anomaly (or caries) was excluded.

To avoid related structural changes occurring due to these factors.

After mechanical debridement, the teeth were cleaned with pumice water slurry and stored in normal saline until further use.

Standard Class V cavities were prepared on the buccal surface of all 60 premolars using #245 carbide burs (SS White Burs Inc., New Jersey, USA) in a high-speed handpiece with a profuse volume of water coolant. The dimensions of the cavities prepared were limited to the following: mesiodistally 3 mm wide, occluso gingival height of 2 mm, and depth of 2 mm (Figure 1 a-e). The dimensions of the cavities were millimetrically standardized using a Williams probe. All the preparations were performed by the same operator.

Each set of permanent dentition was divided into three groups of 20 specimens each to restore with the selected restorative material: Group A (Zirconomer), Group B (Hidence), and Group C (FIJI-IX GP) [Table 1]. Specimens of Groups A and B were conditioned with 10% polyacrylic acid for 15 s, rinsed with water, air-dried, and restored with the respective cements according to the manufacturer's guidelines, whereas in Group C, the specimens were coated with primer, air-dried for 10 s, and light-cured for 10 s.

The aqueous (acidic polyalkenoic acid, reactive resins, and nanofillers) and nonaqueous pastes (fluoroaluminosilicate glass, reactive resins, and nanofillers) were mixed (according to the manufacturer's guidelines), and the mixture was placed into the cavity following two-step incremental techniques, where the first small increment was placed in the most inaccessible area of the preparation, and subsequent additions were made and light-cured for 30 s each. All the restored teeth were stored in normal saline until further use to prevent dehydration.

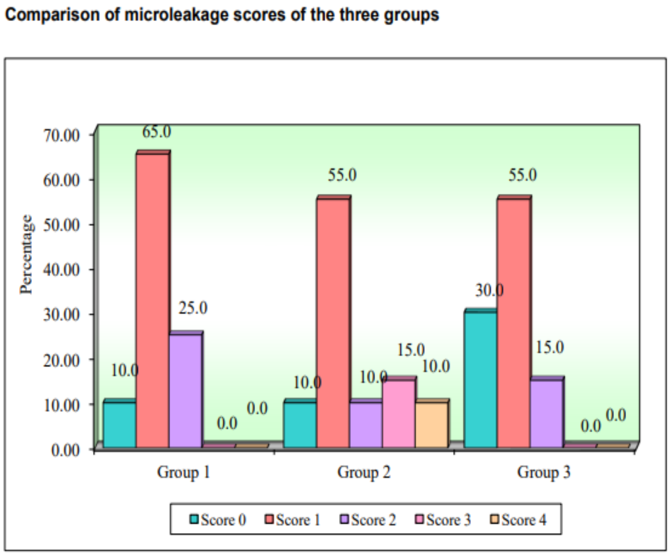
To simulate the oral environment, the test specimens were subjected to thermocycling at temperatures of 5°C ± 1°C and 55°C ± 1°C with a dwell time of 30 s. This procedure was alternatively repeated 100 times.

Following the thermocycling procedure, the test specimens were coated with two layers of dental varnish except for 1 mm around the restoration, and the root apices were sealed with sticky wax and immersed in 2% methylene blue dye for 24 h. Later, the samples were rinsed under tap water and sectioned buccolingually with the help of a safe-sided diamond

disk. The specimens thus obtained were observed under a stereomicroscope, and photomicrographs were taken at ×20 magnification.
The degree of dye penetration is not influenced by the number of thermal cycles [3]. In the present study, the sample was subjected to 100 cycles with a dwell time of 30 s.
The degree of microleakage was evaluated by the dye penetration from the occlusal margin to the base of the cavity on the photomicrographs using the evaluation criteria put forward by Khera and Chan [4] [Figure 2].
The values thus obtained were tabulated and statistically analyzed using the Mann-Whitney U-test and the Kruskal-Wallis ANOVA test.

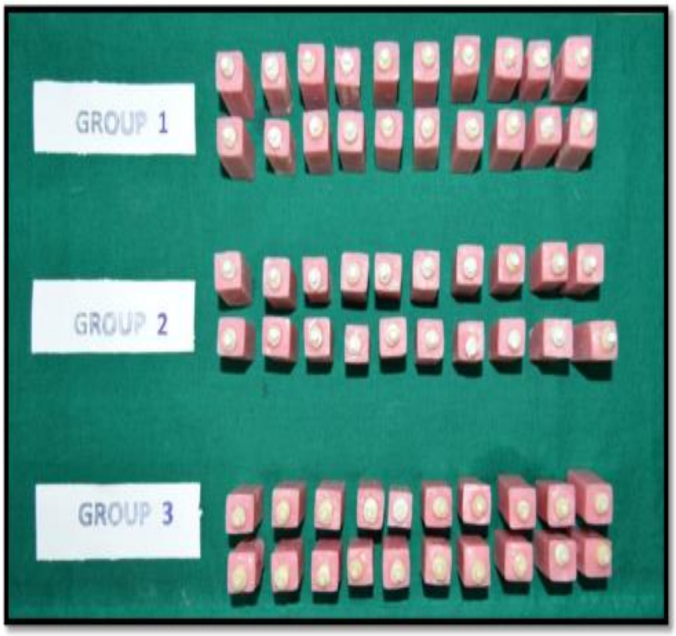
RESULTS

A total of 60 study specimens were fabricated according to ISO specifications using 8mm height and 4mm diameter split Teflon molds. Out of which, 60 specimens were evaluated for microlekage after a storage period of 1 day, and the other 60 specimens were evaluated after 7 days [Table 1].
The specimens were then observed under a stereomicroscope with a magnification of 40x11, and the degree of marginal leakage was determined by the criteria described by Khera and Chan as follows: [Table 2].
This table shows the microleakage scores of three groups. The score of 1 was the highest in all three groups. This table also shows that there is no statistically significant difference among the three groups. [Table 3, Graph 1].



GRAPH 1;Comparison of Microlekage scores of the three groups.

Figure 1 a ; Materials used in the study.

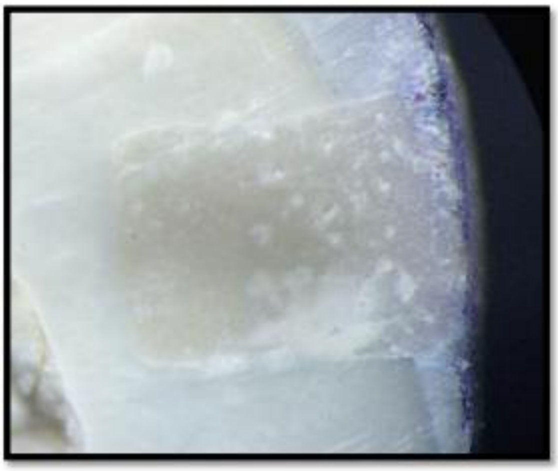


Figures 1 b; Teeth samples of the three groups.

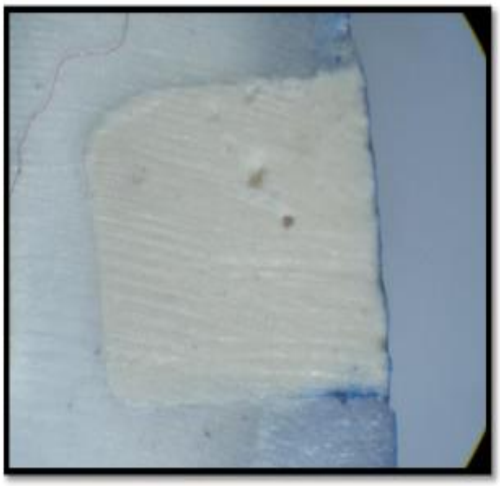
Figures 1 c ; Thermocycline machine.

Figures 1 d ; Teeth immersed in Methylene blue dye.

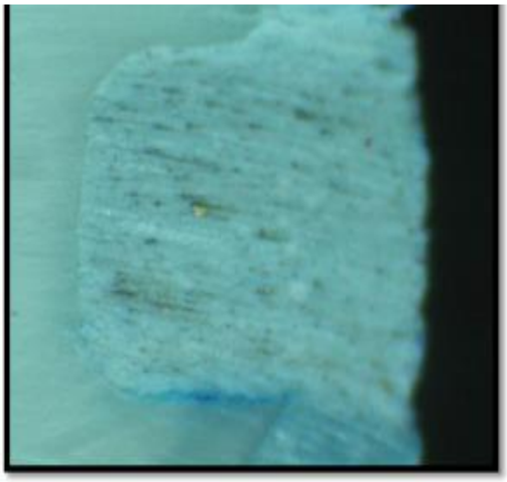
Figure 2; sectioning teeth.



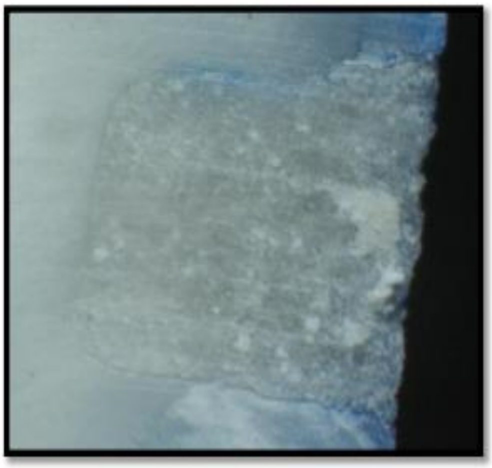
Score; 0



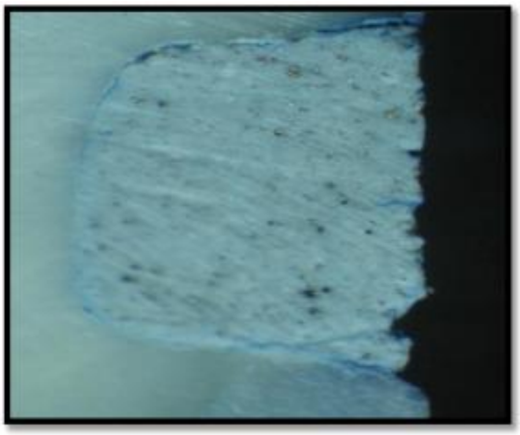
Score; 1



Score ; 2



Score; 3



Score ; 4.

DISCUSSION

There is a continuous search for restorative materials and techniques that will provide optimal adhesion to tooth structure to minimize microlekage as well as have excellent mechanical and physical properties.

Different microleakage test methods have been used for years to predict the performance of restorative material at the tooth-restorative interface. [5]

The present in vitro study utilized the dye penetration technique to study the microlekage using Zirconomer (Group 1), silver-reinforced (Group 2), and posterior extra (Group 3) with recommended dentin pretreatments in permanent teeth. Microlekage can be assessed by various methods, such as radioisotopes, dye, air pressure, neutron activation analysis, PH changes, and SEM.

However, dyes and radioisotopes are the most commonly used. In the present study, 2% methylene blue dye was selected as a measure of microleakage because of its low molecule weight, which is smaller than bacteria that could detect leakage where bacteria could not penetrate. [6,7].

Dye being the most popular. This method allows the production of sections showing leakage in contrasting colors for both teeth and restoration without the need for further chemical reactions or exposure to potentially hazardous radiation. In the present study, 2% methylene blue was selected because of its easy availability and manipulation. [8]

In the present study, no statistically significant difference in microlekage scores was noticed in permanent teeth in all three tested materials. Studies by Schmitt and Lee et al. [9] and Pair et al. [10] have also found similar results.

The mean values of the three materials are different and comparable. This can be attributed to the enamel structure of permanent teeth. The fact that it interferes with the bonding of restorative materials occupies high significance over here. Other reasons, such as enamel thickness in permanent teeth and dentin being softer in primary teeth, also seem to influence the bonding, which inadvertently increases the microlekage of primary teeth. [11]

In relation to permanent teeth, all three groups showed statistically no significant difference with respect to microlekage scores. The values were significantly higher in Group 2 compared to other groups. In a study by Wesh and Hembree et al. [12], GIC showed less microleakage than other materials.

A similar study conducted by Patel MU et al. [13] used extracted molars with class 1 restorations to evaluate and compare the microlekage of posterior teeth with Amalgam, Composite, and Zirconomer and concluded that Zirconomer exhibited the maximum microlekage as compared to Composite and Amalgam and stated that while Composite is being aggressively marketed and new materials like Zirconomer are original, Amalgam still proves to be one of the best materials.

The results obtained from that study showed that all three restorative materials that were investigated exhibited microlekage. However, other studies have shown that cavity preparation at the enamel margins results in consistently stronger bonds, which decrease the microlekage at the enamel margin.

This present study was contrary to our study [13]. It must be taken into consideration that diverse study protocols such as tooth used, type of cavity preparation, and storage time may affect the results of the study.

In this present study, Zirconomer improved exhibits a lesser microleakage value when compared to HIDENCE GROUP and FIJI-IX GP, which is statistically significant with a p value of less than 0.05%. It might be due to the incorporation of zirconia fillers, which is an uneven compound and hence deviations its phase from monoclinic to tetragonal and then to cubic, and vice versa, by increasing in volume, counteracting the volumetric shrinkage expressed during polymerization. [14,15,16].

The Zirconomer group showed the least microleakage. Zirconomer has the virtuous attributes of good chemical and dimensional stability, toughness, and mechanical strength. Moreover, it is a tooth-colored material. The wide distribution of zirconia fillers allows for a high packing density of the powder with the hydrogel salt matrix [17].

It is contradictory to the study conducted by Talat Naz et al. [18], in which they concluded the mean micro leakage of Zirconomer Improved was found to be greater than Cention N. Contradiction results may be due to variations in the selection of tooth samples, storage time, and type of cavity preparation, which will affect the microleakage.

The present study is similar to the study conducted by Albesti et al. [19], who concluded that Zirconomer Improved displayed minimum microleakage when tested by the dye penetration method. It could be due to the fact the fact that the incorporation of zirconia fillers would cause interference in the chelating reaction between the carboxylic group (COOH) of polyacrylic acid and the calcium ions ($Ca2+$) of tooth apatite.

Contrary to this study, Sahadev CK et al. [20] showed a significantly lower microleakage for cention N than Zirconomer. The authors attribute this result to the incorporation of organic/inorganic ratios and the monomer composition of the material, which validates its low volumetric shrinkage.

In this present study, microlekage values with scores 1 were highest in all 3 groups studied, but microlekage values with scores 0 were high in group 3 (HS Posterior Extra) compared to other groups. According to Brackett et al. [21], the marginal gap is said to be increased when the bond strength at that surface is less strong. The marginal gap increases the microlekage at the restoration margin. In the present study, there was statistically no significant difference between the 3 groups. The marginal gap with a score a score greater than 2 was high in group 2 (HIDENCE) because of decreased bond strength compared to the other two groups.

Group 3 specimens showed significant microlekage when compared to specimens in Group 2, which is in concord with the study conducted by Robins and Cooly et al. [22]

CONCLUSION

Zirconomer is currently projected as the "White Amalgam." None of the three materials were free from microleakage. Zirconia-modified glass ionomer cement demonstrated the least microleakage and proved to be better than the silver-reinforced group or Posterior Extra. In addition, improved Zirconia-modified glass ionomer cement may prove to be the ideal material in minimally invasive dentistry. However, further in vitro and in vivo studies should be performed to investigate other physical qualities of the material, and long-term clinical experiences may be suggested.

Limitations;

The study design is in vitro, and this forms a major limitation of the current study. The effect of Zirconomer must be assessed under in vivo conditions to better determine the utility of the restorative material.

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