ISSN : 2949 - 9100

International Journal of Health and Dentistry Care (IJHDC)

IJHDC : Health and Dental Publication

Available Online at: www.ijhdc.com

Volume – 4, Issue – 1, January – February – 2025, Page No. : 10 – 15

Comparative Study in Microhardness of Resin Modified Glass Ionomer Cement With And Without Nanoparticle Additives Against Zirconomer

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Citation This Article: Mrochazka K S, Kartin P Z, "Comparative Study in Microhardness of Resin Modified Glass Ionomer Cement With And Without Nanoparticle Additives Against Zirconomer", IJHDC – January – February – 2025, Volume. – 4, Issue – 1, P. No. 10 – 15.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Introduction: Dental caries has been considered as a historically important component of the global oral disease burden. Thus, the quest for an ideal restorative material with optimum physical properties and durability exists. There was a lack of availability and development in the field of restorative materials.

Aim: The aim of the study was to evaluate the difference in microhardness of RMGIC with nanochitosan, nanozincoxide, nano titanium dioxide against Zirconomer.

Materials and Methods: Sixty intact, non-carious, non-restored mandibular premolar teeth, extracted for therapeutic reasons were taken. Class V cavities of dimension 2mm depth and 2mm width and 5mm length were prepared. In group 1, the cavities were restored with RMGIC (GC GOLD LABEL II, JAPAN) in the ratio 3.2:1. In Group 2, the cavities were restored using RMGIC modified with 10% weight of nanochitosan . In Group 3, RMGIC was modified by adding 2% weight of nano zincoxide was added. In Group 4, RMGIC modified by adding 5% weight of nano titanium dioxide. In Group 5, Zirconomer (SHOFU, KYOTO, JAPAN) was mixed in the ratio 2:1 on a mixing pad with plastic spatula for 1 min 30 sec till a thick mix is obtained and was condensed into the prepared cavity. Finishing was done using fine abrasive after 24 hours of setting. Microhardness tests done 24 hours after initial set of the cements. The samples were then mounted on a resin block and subjected to a load of 100gf for 14 secs, five indentations made on each sample with the Vickers microhardness indenter and the diagonals of indentation were measured.

Conclusion: According to the findings of the study, RMGIC modified with Nano Titanium Dioxide showed the highest increase in microhardness values followed by

RMGIC with nano zinc oxide, RMGIC with nanochitosan, Zirconomer and the RMGIC group with least values of microhardness among the tested samples.

Keywords: Nanochitosan, Nanozincoxide, Zirconomer, Polyacrylic Acid.

Introduction

Resin modified glass ionomers were developed to enhance mechanical properties, reduce setting time and moisture sensitivity that comprises of fluoro-aluminosilicate glasses, photo-initiators, polyacrylic acid, water, and a water-soluble methacrylate monomer like hydroxyethyl methacrylate with fluoride release and chemically adherence to tooth structure which undergoes setting through acid-base reaction and addition polymerization. The nanotechnology offers notable antimicrobial characteristics and exhibit physical properties comparable to conventional materials due to their reduced size and increased surface area. Chitosan, derived from alkaline N-deacetylation of chitin found in crustacean shells like crabs, shrimps, and lobsters, with non-toxic, biocompatible, and biodegradable properties. Chitosan nanoparticles have advantages such as increased surface area and charge density leading to enhanced interactions with the surrounding medium. Zinc oxide (ZnO) nanoparticles exhibit diverse properties as inorganic nanoparticles, effectively combating a wide spectrum of Gram-negative and Gram-positive bacteria, and hindering biofilm formation even at minimal concentrations. ZnO nanoparticles possess a broad antibacterial spectrum capable of eradicating organisms implicated in caries development, while exhibiting precise toxicity towards bacteria and minimal impact on human cells. There were no significant differences observed in the flexural and antibacterial properties of RMGI containing 2 wt.% of ZnO nanoparticles compared to higher concentrations. Nanoparticles of TiO_2 have emerged as reinforcing fillers in dental resin composites and epoxy materials. Introduction ofTiO_2 NPs into glass ionomer cement at concentrations of 3% and 5% (w/w) enhanced fracture toughness, compressive strength, flexural strength, and hardness. Zirconomer is the glass ionomer cement with zirconia fillers also known as the “white amalgam” along with longevity of traditional amalgam and the protective advantages of glass ionomer, with no potential mercury hazards. When uniformly integrated into the glass component, zirconia further fortifies the material, ensuring enduring durability and superior tolerance to occlusal load. Its high flexural modulus and compressive strength guarantee longevity in stress-bearing regions. The Vickers and Knoop hardness tests are standardized as micro-hardness tests. The Vickers microhardness test, have a square-based pyramid for indentation, with the diagonals of the indentation measured and averaged and is more sensitive to measurement errors than the Knoop test and is particularly suitable for small rounded areas.

Aim

The aim of the study was to evaluate the difference in microhardness of RMGIC and its modification with nanochitosan, nanozincoxide and nano titanium dioxide followed by comparison with the microhardness values of Zirconomer.

Materials and Methods

A total of 50 intact, non-carious, non-restored mandibular premolar teeth, extracted for therapeutic reasons and free of any developmental anomalies were selected based on the inclusion and exclusion criteria The samples were uniformly distributed as 12 each among the five groups using random sampling technique.

Group I - RMGIC (GC GOLD LABEL II LC, JAPAN)

Group II – RMGIC with nano chitosan (ULTRANANOTECH)

Group III - RMGIC with Nano Zinc oxide (ULTRANANOTECH)

Group IV - RMGIC with Nano Titanium dioxide (ULTRANANOTECH)

Group V - Zirconomer (SHOFU, KYOTO, JAPAN)

All the specimens were stored in deionized water at 37°C for 24 hours. To remove surface debris, the specimens were washed with distilled water for one minute in an ultrasonic bath. Class V cavities of dimension 2mm depth and 2mm width and 5mm length were prepared The prepared cavities were conditioned with 10% polyacrylic acid. The RMGIC manipulated according to the manufacturers instruction with 3.2:1(1 scoop powder: 2 drop liquid) ratio in a mixing pad with the help of agate spatula. Mixing was done till a thick mix is obtained. The mix is then finally packed in a class V cavity and kept for 24 hours for complete setting. For group 2, 10%wt of nano chitosan added to RMGIC powder, mixed well manually till a uniform mix is obtained. For group 3, 2% weight of Nano Zinc Oxide measured with analytical balance added to RMGIC powder, mixed well manually till a uniform mix is obtained. For group 4, 5% wt of nano titanium dioxide measured with analytical balance was added to RMGIC powder ,mixed well manually till a uniform mix is obtained. For group 5, Zirconomer powder and liquid were taken the ratio of 2:1 mixed using plastic spatula on a mixing pad for 1 min 30 sec until a thick mix was obtained and it was condensed into the prepared cavity. The cement was allowed to set for 24 hrs. The set cement is taken out and polishing done with fine grit abrasive.

The samples were then mounted on a resin block and subjected to microhardness testing. The load of 100gf was applied for 14 secs, five indentations were made on each sample with the Vickers microhardness indenter and the values were calculated by measuring the diagonals of indentations.

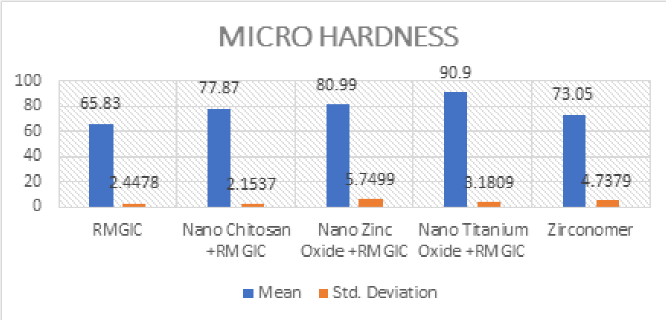
Results

Highest microhardness was obtained in group D – RMGIC with Nano Titanium dioxide followed by group C- RMGIC with Nano Zinc Oxide, Group B – RMGIC with Nano Chitosan, Group E – Zirconomer and the least microhardness was obtained in RMGIC group.

Figure 1: Microhardness test image obtained

Statistical Analysis

Data was analyzed using the statistical package SPSS 26.0 (SPSS Inc., Chicago, IL) and level of significance was set at $p<0.05$. Descriptive statistics was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using Shapiro Wilkinson test. Inferential statistics to find out the difference between the group was done using ONE WAY ANOVA test followed by BONFERRONI TEST.



Graph 1: Microhardness values

Discussion

An ideal restorative material should withstand masticatory forces and exhibit durability in the oral cavity over an extended period. The physical properties of resin-modified glass ionomers are generally favorable and comparable to those of conventional glass ionomers. Due to resin cross-linking and rapid setting, resin-modified glass ionomers appear to exhibit greater resistance to dissolution in water. The incorporation of zirconia has notably enhanced the mechanical properties when compared to traditional amalgam. Zirconia-reinforced GIC is a viable option for posterior restorations in areas subject to significant load. While abrasion resulting from tooth brushing induces less surface wear in nano-RMGICs compared to conventional RMGICs. Different nanoparticles have attained huge enthusiasm throughout the years because of their notable antimicrobial properties. The incredible antibacterial impact of these nanostructured specialists is fundamentally ascribed to the increased surface area to volume ratio empowering more noteworthy latency of atoms on the surface, which provides maximum contact with the environment. According to the study by Petri et al. on chitosan-modified glass ionomer cement (GIC), it was found that incorporating 10 wt.% chitosan with GIC led to improvements in flexural strength and fluoride release by reducing interfacial surface tension, thereby facilitating better interaction. Nano chitosan can enhance the adhesion and mechanical properties due to its smaller size, it can effectively fill small voids between larger RMGIC component particles and form more physical and chemical bonds with polyacrylic acid polymers. It exhibits unique characteristics not found in regular chitosan, such as enhanced permeability, improved biocompatibility, increased charge density. The physical and chemical attributes of ZnO nanoparticles (NPs) are greatly influenced by their shape and sizeIts widespread application in dentistry is attributed to its unique optical, magnetic, morphological, electrical, mechanical, and photochemical properties. Titanium dioxide (TiO_2) nanoparticles exist in three polymorphic variants found in nature: tetragonal rutile, anatase, and orthorhombic brookite The presence of TiO_2 notably influences the hydration process of cement and contributes to the development of its internal structure. The particle size typically ranges from 30-50nm, with the anatase form being utilized in the study.

Surface hardness tests appear to be appropriate for evaluating the degradation and durability of dental materials. In the present study, for the evaluation of surface microhardness, Vickers hardness test was chosen. The Vickers microhardness tester offers several benefits, including its non-destructive nature during sample preparation and its ability to cover the entire hardness range with a single scale. This testing method is particularly well-suited for examining small, thin parts regardless of their surface treatment. The load of 100 g was chosen for this study for hardness indentation because they created longer Vickers diagonals, which were recommended to prevent errors in optical measurement. It was observed that the addition of nanoparticles enhanced the surface microhardness of

RMGIC than that of Zirconomer as the smaller particle size increases the surface area and reactivity of nanoparticles as it gets incorporated into the powder particles and increases the bonding. Among the nanoparticles added, RMGIC modified with Nano Titanium Dioxide showed highest microhardness values compared with Nano Zinc Oxide and Nano Chitosan The increased microhardness is due to the nanoparticle size that reduces the interfacial tension between the different components of the GIC and increased the surface and charge density, leading to better interactions which makes RMGIC with Nano Titanium Dioxide a more clinically suitable choice for clinical treatments.

Conclusion

Within the limitations of the present in vitro study, addition of nanoparticles to RMGIC increased the surface hardness more than that of the Zirconomer group. RMGIC modified with Nano Titanium Dioxide showed the highest increase in microhardness among the modification with nanoparticles, followed by the Nano Zinc Oxide group and then by the Nano Chitosan group.

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