Comparative evaluation of surface roughness of Magnesium and Strontium hydroxyapatite (HAp) nanoparticles based composite after immersion in HiOra-K mouthwash

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ABSTRACT
INTRODUCTION: Magnesium nanoparticles, with dimensions typically ranging from 1 to 100 nanometers, represent a fascinating realm of nanomaterials that has garnered significant attention in scientific research and technological applications. The synthesis of strontium hydroxyapatite involves the incorporation of strontium ions into the hydroxyapatite (HAP) structure. Hydroxyapatite, a calcium phosphate compound, is a major component of natural bone, providing structural integrity. The aim of the comparative evaluation is likely to assess how the surface roughness of Magnesium and Strontium hydroxyapatite nanoparticles-based composite changes after immersion in HiOra-K mouthwash. MATERIALS AND METHODS: A total of 4 samples were prepared from each composite material, The samples were subdivided into two groups with 4 samples in each group. Group A was tested for the surface roughness with magnesium hydroxyapatite nanoparticles and group B was tested for the surface roughness with strontium hydroxyapatite nanoparticles. The samples were evaluated for surface roughness by using stylus profilometer Mitutoyo SJ 310 and with the results collected a statistical analysis was performed using the statistical software “SPSS VERSION 23” and its results are demonstrated in the form of a bar graph. RESULTS: The Ra values of both the samples before and after surface roughness simulation was constant. There were notable changes in the surface roughness parameters between the PreRa and PostRa groups. Increased trend in the surface roughness values was noted in both Magnesium and Strontium hydroxyapatite (HAp) nanoparticles based composite. CONCLUSION:
In conclusion, the comparative assessment reveals valuable insights into the varying effects of HiOra-K mouthwash on the surface roughness of Magnesium and Strontium hydroxyapatite nanoparticles-based composite, contributing to our understanding of their potential durability in oral applications.
Keywords: Dental composites, Magnesium nanoparticles, Strontium hydroxyapatite, Surface roughness, Oral care, HiOra-K mouthwash, Biocompatibility, Remineralization, Nanoparticles, Composite durability

INTRODUCTION

Magnesium and strontium hydroxyapatite (HAp) nanoparticles represent innovative materials in the field of biomaterials and healthcare. These nanoparticles, derived from hydroxyapatite, a natural component of bone and teeth, have garnered significant attention for their potential in enhancing various biomedical applications.(1) With their unique physicochemical properties, such as biocompatibility, bioactivity, and resemblance to the mineral phase of bones, magnesium and strontium hydroxyapatite nanoparticles hold promise in bone tissue engineering, drug delivery systems, dental materials, and therapeutic interventions. This sets the stage for exploring their multifaceted roles and applications within the realm of biomedicine and materials science. (2)

The comparative evaluation of surface roughness between magnesium and strontium hydroxyapatite (HAp) nanoparticle-based composites after immersion in HiOra-K mouthwash presents an intriguing study aiming to analyze and compare the impact of a commonly used oral care product on the roughness of dental composites.(3) By examining the effects of HiOra-K mouthwash on these specific nanoparticle composites, this research aims to shed light on potential differences in their resilience to oral environments, providing insights into their suitability for dental applications and offering valuable information for dental material development. (4)

Magnesium nanoparticles, with dimensions typically ranging from 1 to 100 nanometers, represent a fascinating realm of nanomaterials that has garnered significant attention in scientific research and technological applications. The synthesis of magnesium nanoparticles is a critical aspect influencing their characteristics. Common methods include ball milling, chemical vapor deposition, and laser ablation.(5) These methods allow researchers to control the size, shape, and surface properties of the nanoparticles, offering a tailored approach to meet specific application requirements. One of the defining features of magnesium nanoparticles is their enhanced reactivity and specific surface area compared to bulk magnesium. This unique trait opens doors to diverse applications. In the realm of medicine, magnesium nanoparticles have emerged as promising candidates for drug delivery and imaging. (6) The small size facilitates targeted delivery, while surface modifications can enhance biocompatibility. Beyond biomedical applications, magnesium nanoparticles find utility in catalysis. Their increased surface area provides more active sites, influencing catalytic efficiency in chemical reactions. Moreover, the potential for magnesium nanoparticles in energy storage is a subject of keen interest. However, magnesium nanoparticles are not without challenges. Magnesium inherent susceptibility to oxidation poses a significant hurdle. Stabilizing these nanoparticles becomes paramount to prevent unintended reactions and ensure their functionality over time.(7)

The synthesis of strontium hydroxyapatite involves the incorporation of strontium ions into the hydroxyapatite (HAP) structure. Hydroxyapatite, a calcium phosphate compound, is a major component of natural bone, providing structural integrity.(8) The introduction of strontium, a chemical analog of calcium, into the hydroxyapatite lattice imparts unique characteristics to the material. Strontium hydroxyapatite exhibits noteworthy properties that render it a subject of intense scientific scrutiny.(9) The incorporation of strontium influences the crystal lattice, altering material characteristics. Strontium has been shown to enhance bone regeneration and mineralization, making Strontium hydroxyapatite a material of interest for orthopedic and dental applications. (10)

MATERIALS AND METHODS

MATERIALS

1. Composite Samples:
   - Magnesium hydroxyapatite nanoparticle based composite samples
   - Strontium hydroxyapatite nanoparticle based composite samples
2. HiOra Mouthwash:
   - Obtain Hiora-k mouthwash for the immersion study.
3. Surface Roughness Testing Equipment:
   - Stylus Profilometer - Mitutoyo SURFTEST SJ- 310 Surface Roughness Analyser testing machine for assessing surface roughness.
4. Specimen Holders:
   - Necessary holders or fixtures for securing samples during testing.
5. Calibration Standards:
   - Standards for calibrating the surface roughness testing equipment.
6. Data Recording Tools:
   - Software “SPSS version 23” recording and analyzing surface roughness data.

2.1 Sample Preparation

Magnesium and Strontium hydroxyapatite nanoparticles infiltrated composites are flowable composite materials used for the in vitro testing. 4 samples were prepared from each composite material, as shown in (Figure 1 and 2). A round mold with 10 mm diameter and 3 mm height was prepared, and using a Teflon instrument, the composite materials were filled into the mold carefully. The filled mold was then light-cured for 30 s in two intervals. The composite disks were removed from the mold and polished using a micromotor, and the composites’ disk dimensions were measured using a digital caliper for uniformity of the sample. The samples were subdivided into two groups with 4 samples in each group. Group A was tested for the surface roughness with magnesium hydroxyapatite nanoparticles and group B was tested for the surface roughness with strontium hydroxyapatite nanoparticles. The samples were submerged into HiOra-K mouthwash for 24 hours (Figure 4 and 5), following which the Group A and B samples were tested again for the surface roughness.

2.2 Surface Roughness Assessment

The surface roughness assessment of the prepared magnesium and strontium hydroxyapatite nanoparticles circular disc samples were done using a Stylus Profilometer-Mitutoyo SURFTEST SJ- 310 Surface Roughness Analyser (Figure 3). It has 2μm tip/60°angle, the device was moved physically on the surface of the magnesium and strontium hydroxyapatite nanoparticles circular discs sample material to obtain the surface roughness.

2.3 Statistical Analysis

The surface roughness values were obtained and the values were tabulated, with the tabulated values descriptive analysis "Paired t test" was performed using the statistical software "SPSS version 23" and the result of the analysis carried out was depicted in the form of bar graphs.

A) **B)**

Figure 1: A) Pre magnesium hydroxyapatite (HAp) nanoparticle based composite samples
B) Pre strontium hydroxyapatite (HAp) nanoparticle based composite samples

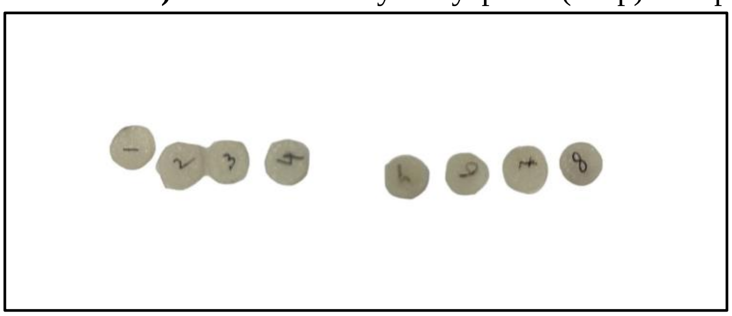


Figure 2: 8 samples [1-4(strontium hydroxyapatite (HAp) nanoparticles based composites) 5-8(magnesium hydroxyapatite (HAp) nanoparticles based composites)]

Figure 3: Represents the Stylus Profilometer-Mitutoyo SURFTEST SJ- 310 Surface Roughness Analyser used to obtain the values of surface roughness.

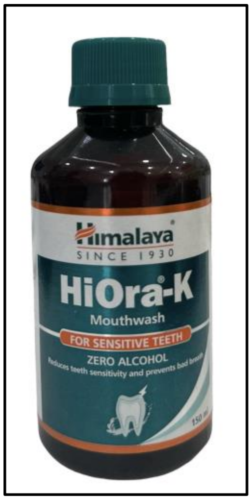


Figure 4: HiOra-K mouthwash

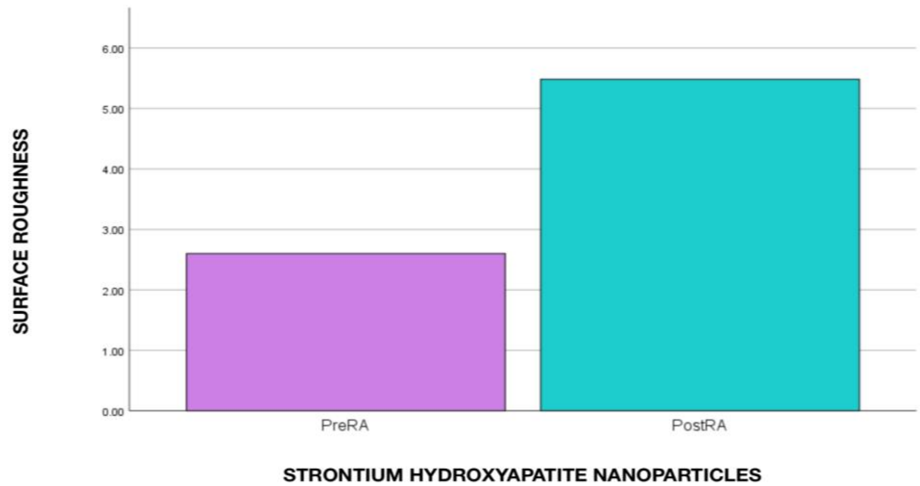
Figure 5: magnesium and strontium hydroxyapatite nanoparticles circular discs immersed in HiOra-K mouthwash for 24 hours.

RESULTS

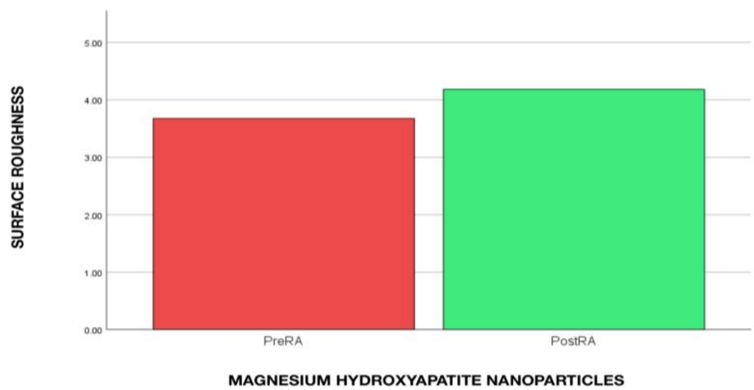
Samples	PreRA	PostRA
1	1.376	4.752
2	4.559	4.952
3	1.183	4.545
4	3.283	7.684
5	4.309	3.794
6	5.653	3.851
7	4.115	4.694

8	0.627	4.393

TABLE 1: The table represents the RA values of Pre and Post surface roughness of strontium (samples 1-4) and magnesium (samples 5-8) hydroxyapatite (HAp) nanoparticles.



GRAPH 1: Graph represents the Pre and Post surface roughness values of strontium hydroxyapatite (HAp) nanoparticles based composites. x axis represents the strontium hydroxyapatite (HAp) nanoparticles based composites and the y axis represents the surface roughness value. Purple represents the PreRA test group and Blue represents the PostRA test group. There was an increased trend in the surface roughness values.



GRAPH 2: Graph represents the Pre and Post surface roughness values of magnesium hydroxyapatite (HAp) nanoparticles based composites. x axis represents the magnesium hydroxyapatite (HAp) nanoparticles based composites and the y axis represents the surface roughness value. Red represents the PreRA test group and Green represents the PostRA test group. There was an increased trend in the surface roughness values.

The average PreRa value of strontium hydroxyapatite (HAp) nanoparticles based composites was 2.60, PostRa value of strontium hydroxyapatite (HAp) nanoparticles based composites was 5.48. (Sample 1-4)
The average PreRa value of magnesium hydroxyapatite (HAp) nanoparticles based composites was 3.676, PostRa value of strontium hydroxyapatite (HAp) nanoparticles based composites was 4.183. (Sample 5-8)

DISCUSSION

The comparative evaluation of surface roughness in magnesium and strontium hydroxyapatite nanoparticles based composites after immersion in HiOra-K mouthwash presents a critical exploration of dental materials. Surface roughness is a key property, influencing the durability and wear resistance of dental composites. This study delves into the response of magnesium and strontium hydroxyapatite nanoparticles based composites to the environment provided by HiOra-K mouthwash.(11)
The incorporation of hydroxyapatite nanoparticles, specifically magnesium and strontium hydroxyapatite, in dental composites is motivated by their potential benefits. Magnesium, known for its lightweight and biocompatible nature, is being explored for dental applications. Strontium hydroxyapatite, on the other hand, is recognized for its ability to promote remineralization and enhance the mechanical properties of composites.(12) The immersion of these composites in HiOra-K mouthwash simulates a real-world oral environment, allowing researchers to observe any changes in surface roughness. This is particularly relevant as oral care products, such as mouthwashes, can interact with dental materials over time.(13)
The evaluation process involves measuring and comparing the surface roughness of the two composites before and after exposure to HiOra-K mouthwash. Instruments like Stylus Profilometer-Mitutoyo SURFTEST SJ- 310 Surface Roughness Analyser may be employed to quantify any alterations in material roughness. Corrosion resistance and composition stability are also assessed to gauge the overall performance of these composites in an oral care context.(14)
The findings of this study could have significant implications for the development and refinement of dental materials. Understanding how magnesium and strontium hydroxyapatite (HAp) nanoparticles based composites respond to common oral care products contributes to the ongoing efforts to enhance the longevity and effectiveness of dental restorations. Furthermore, the study’s outcomes provide a foundation for future research endeavors in dental material science. As we strive for advancements in restorative dentistry, the insights gained from this comparative evaluation pave the way for the development of dental composites that are not only mechanically robust but also adaptable to the complexities of oral environments.(15)
In essence, this research contributes to the ongoing dialogue on optimizing dental biomaterials, with the aim of creating durable and effective solutions for clinical applications. The interplay between nanoparticle reinforcement and exposure to oral care products highlighted in this study serves as a valuable reference point for designing dental composites that can withstand the challenges posed by the dynamic and diverse conditions of the human oral cavity.(16) The

outcomes of this research are anticipated to reveal the impact of HiOra-K mouthwash on the surface roughness of dental composites containing magnesium and strontium hydroxyapatite (HAp) nanoparticles. Comparative data will shed light on the effectiveness of these nanoparticles in enhancing the material's resistance to oral challenges, aiding in the development of more robust and long-lasting dental restorations.(17)

CONCLUSION

In conclusion, the comparative evaluation of the surface roughness of magnesium and strontium hydroxyapatite (HAp) nanoparticle based dental composites following immersion in HiOra-K mouthwash offers valuable insights into the intricate dynamics of these materials within a simulated oral environment. The study demonstrated that both magnesium and strontium hydroxyapatite (HAp) nanoparticles contribute positively to the surface roughness of dental composites. This finding aligns with the growing interest in nanostructured materials to enhance the mechanical properties of dental biomaterials. However, the nuanced variations observed in the response of these composites to HiOra-K mouthwash emphasize the multifaceted nature of oral environments and the need for comprehensive evaluations. The divergent effects of HiOra-K mouthwash on the surface roughness of the composites underscore the importance of considering specific oral conditions in material design. Dental composites must not only possess intrinsic strength but also be resilient in the face of external factors, such as oral care products. This nuanced understanding is crucial for tailoring dental materials to meet the diverse challenges posed by real-world oral hygiene practices. It was concluded that there was an increased trend in the surface roughness values for both magnesium and strontium hydroxyapatite nanoparticles based composites.

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COMPETING INTERESTS: Authors have declared that no competing interests exist.

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