REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 2 (2024)
http://www.veterinaria.org
Received: Revised: Accepted:

Comparative Evaluation Of Gloss, Colour Stability And Surface Roughness In Zirconia And Yttrium Hydroxyapatite Nanoparticles With Zirconomer.

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Abstract
Background & aim: Yttrium hydroxyapatite nanoparticles have been incorporated into zirconomer to enhance their esthetic and mechanical properties. Zirconomer is zirconia reinforced glass ionomer cement, which is known for its strength and bio-compatibility properties. Moreover, surface properties like gloss, color stability, and roughness are crucial determinants for specific successes in the long term.
Materials and Methods: Disc-shaped samples of Yttrium hydroxyapatite nanoparticles with Zirconomer and Zirconomer (n=4 each) were prepared. Gloss was measured with a glossmeter, color stability (ΔE) was evaluated, and surface roughness was assessed using a stylus profilometer before and after brushing simulation (10,000 cycles). Statistical analysis was conducted using the Shapiro-Wilk test.
Results: Y-HAp-based Zirconomer exhibited superior gloss retention and color stability compared to Zirconomer after brushing simulation and staining. Surface roughness increased for both materials post-simulation, but the Y-HAp-based composites showed significantly lower roughness values ($p < 0.05$).
Conclusion: In conclusion, Y-HAp-based Zirconomer composites demonstrated superior gloss retention, color stability, and lower surface roughness compared to Zirconomer under simulated oral conditions.

Keywords: Yttrium hydroxyapatite, Zirconomer, gloss retention, color stability, surface roughness, restorative materials,health education

Introduction:

Restorative dentistry has undergone significant advancements over the years, with continuous efforts to develop materials that provide esthetic, functional and mechanical (1).Put all references in square bracketsThe strength and resistance to wear of a dental restoration is not the only factor determining its success, an equally important consideration is the ability of the restoration to retain esthetic properties such as color and gloss. As a result, industry professionals have put substantial emphasis on what clinicians and patients truly need, which is novel materials capable of performing above and beyond these concerns (2).
One such innovation is the incorporation of yttrium hydroxyapatite nanoparticles (Y-HAp) into Zirconomer. Y-HAp is a biocompatible material that closely resembles the mineral composition of natural tooth enamel(3). These nanoparticles have been shown to enhance the mechanical strength and wear resistance of Zirconomer, while also improving their esthetic properties(4). By reinforcing the resin matrix with Y-HAp, zirconomer gain superior resistance to discoloration, improved polishability, and the ability to maintain a smooth surface over time(5).
Zirconomer is zirconia reinforced glass ionomer cement, which is known for its strength and bio-compatibility properties. Moreover, surface properties like gloss, color stability, and roughness are crucial determinants for specific successes in the long term(6). Known for its compressive strength and fluoride properties, Zirconomer has become a preferred choice for restorative procedures(7). It has the ability to chemically bond with tooth structures, its durability makes it suitable for a wide range of clinical applications(8). However, like all restorative materials, Zirconomer is not without limitations. Its esthetic properties, particularly gloss retention and resistance to surface roughness and discoloration, may not meet the high expectations of certain clinical scenarios, especially in highly visible areas of the dentition(9).
Brushing simulation is a widely used in-vitro method for assessing the durability and surface properties of restorative materials(10). It replicates the abrasive forces exerted on teeth during toothbrushing, and shows how materials withstand wear over time(11). Brushing may change the gloss, stain color or roughen the surface of the-restorative materials which can result in esthetic and functional deterioration. The simulation comprises samples that are exposed to a set number of brushing cycles under standard conditions of speed, force and slurry of toothpaste(12).This method mimics long-term oral usage, helping to evaluate the material's ability to resist surface wear, maintain smoothness, and preserve esthetic qualities(13).
The importance of gloss retention, surface roughness and color stability cannot be overstated in restorative dentistry. A material that fails to maintain these properties can lead to patient dissatisfaction, plaque accumulation, and failure of the restoration(14). This study aims to compare the performance of Y-HAp-based Zirconomer with Zirconomer in terms of gloss retention, color stability, and surface roughness under simulated oral conditions, including brushing simulation. By investigating these parameters, this research seeks to provide evidence-based insights into the advantages and limitations

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of these two materials, ultimately guiding clinicians in selecting the most appropriate material for various clinical situations.Through an in-vitro evaluation involving brushing simulation, this study will help bridge the knowledge gap in understanding how these materials perform under conditions that mimic the oral environment, shedding light on their potential for long-term clinical success.

Materials and Methods:

Sample Preparation

For this study, two types of restorative materials were selected: Zirconomer (Group A) and Yttrium hydroxyapatite nanoparticles incorporated Zirconomer (Group B). A total of 8 disc-shaped samples, each with thickness of 2 mm, were prepared for the evaluation.

- Y-HAp nanoparticles was mixed with zirconomer
- Zirconomer was mixed and applied following the manufacturer's guidelines and allowed to be set.

The samples were polished using a series of sandpapers (grit sizes 240, 400, 600, and 1200) to achieve a smooth and uniform surface. After polishing, the samples were randomly divided into two groups (Group A and Group B), with 4 samples in each group. The polished samples were stored in distilled water at 37°C for 24 hours to simulate an initial hydration state similar to the oral environment.

Gloss and Color Stability Assessment

- Gloss Measurement: The gloss of the samples was measured before and after the brushing simulation using a glossmeter, which provides a quantifiable value of surface gloss at a 60° measurement angle. Gloss values were recorded in gloss units (GU).
- The colorimetric value was done using Spectrophotometer CM-5, Konica Minolta (figure 2). The Commission International el' Eclairege L*a*b* (CIELAB) color space assessment system has been used. The L*a*b* were obtained for each specimen. The CIELAB AE was evaluated for each specimen by the following formulas:

AE= =([L*f-L*i]2+[a*f-a*i12+16*f-6*i]2)½

where AE is color change, L*f is final L*, L*i is initial L*, a*f is final a*, a*i is initial a*, b*f is final b*, and b*i is initial 6* value.(14)

Figure 1: Spectrophotometer CM-5, Konica Minolta

Brushing Simulation

To simulate the mechanical wear that occurs in the oral cavity, the samples were subjected to brushing simulation using a brushing simulator (Model ZM3.8 SD Mechatronik,) (figure 1). This apparatus replicates the forces experienced during regular brushing by utilizing a set of brushes which will move in a predetermined pattern.

- Brushing conditions: The samples were brushed with a toothpaste slurry prepared by mixing equal parts of commercially available fluoride toothpaste.
- Simulation parameters: All samples were subjected to 10,000 cycles, which is close to 1 year worth of brushing if done normally. The order of brushing was as follows; Firstly, the sample would be brushed along the X-axis for 5000 cycles, then on the Y-axis for 10000 cycles, and finally the remaining 10000 cycles would be split, at 5000 cycles each in both

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clockwise and counter clockwise directions. A dental force of 200 grams was used, and a brushing speed of 60mm/s was applied to create the natural dynamics of brushing teeth(11).

Figure 2: brushing simulator (Model ZM3.8 SD Mechatronik)

Surface Roughness Measurement

Surface roughness was done using a stylus profilometer (figure 3). Measurements were taken before and after brushing simulation.

- Pre-simulation measurements: The initial roughness values (Ra, Rq, and Rz) were recorded.
- Post-simulation measurements: After the brushing simulation, the surface roughness was re-measured to evaluate the wear and degradation of the surface(15).

Figure 3: stylus profilometer

Statistical Analysis

The statistical analysis was carried out in SPSS version 23.0. Normality test was done using Shapiro-wilk test and the data was found to be not normally distributed. Hence, non-parametric Mann-Whitney U test and Wilcoxson Signed rank test was carried out to compare surface roughness, gloss and color change between the materials and within the materials. A p-value <0.05 was considered significant.

Results:

Surface Roughness

The analysis of colour stability has no significant difference in the surface roughness (Ra); mean square surface roughness (Rq); and surface roughness peak height (Rz) values between and within the zirconmer and Yttrium hydroxyapatite

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nanoparticles incorporated Zirconomer (p>0.05). However, the median Ra, Rq values after brushing were found to be low in Yttrium hydroxyapatite nanoparticles based Zirconomer (table 1).

Surface roughness	Time	Mean ± SD; Median (IQR)		p-value
		Zirconmer	Yttrium hydroxyapatite nanoparticles based Zirconomer	
Ra	Pre	0.577 ± 0.233; 0.568 (0.793 – 0.368)	0.431 ± 0.180; 0.384 (0.622 – 0.289)	0.343
	Post	0.797 ± 0.374; 0.782 (1.140 – 0.467)	0.562 ± 0.226; 0.514 (0.797 – 0.374)	0.343
p-value		0.068	0.068	
Rq	Pre	2.932 ± 1.917; 2.783 (4.774 – 1.238)	4.183 ± 2.265; 4.075 (6.391 – 2.083)	0.686
	Post	1.115 ± 0.208; 1.142 (1.297 – 0.906)	0.892 ± 0.049; 0.905 (0.930 – 0.839)	0.200
p-value		0.144	0.068	
Rz	Pre	1.436 ± 0.326; 1.507 (1.706 – 1.096)	1.555 ± 0.447; 1.520 (1.979 – 1.165)	0.686
	Post	8.474 ± 3.490; 8.594 (11.77 – 5.061)	15.56 ± 10.00; 13.59 (25.84 – 7.259)	0.343
p-value		0.068	0.068	

Table 1: Comparison of surface roughness among the materials

Gloss

There was a significant difference in the median gloss value between zirconmer and Yttrium hydroxyapatite nanoparticles incorporated Zirconomer before and after brushing (p=0.029). The median gloss value was found to be significantly high for Yttrium hydroxyapatite nanoparticles incorporated Zirconomer after brushing (Median = 33.50). However, no significant difference was found within zirconmer and Yttrium hydroxyapatite nanoparticles incorporated Zirconomer (p>0.05).

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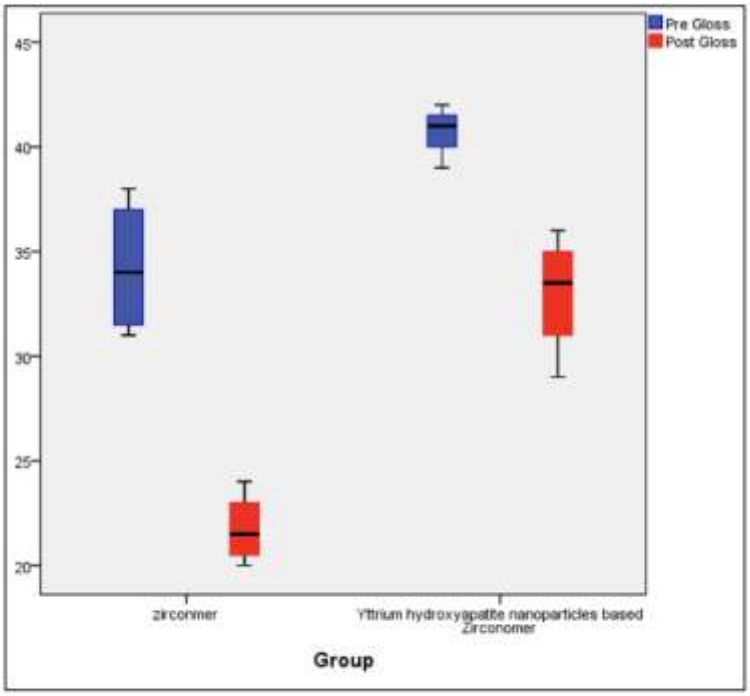

Figure 4: Box-Whisker plot showing the median gloss values for the mater

Colour Stability
No significant difference in the color change between zirconmer and Yttrium hydroxyapatite nanoparticles incorporated Zirconomer (p=0.486).

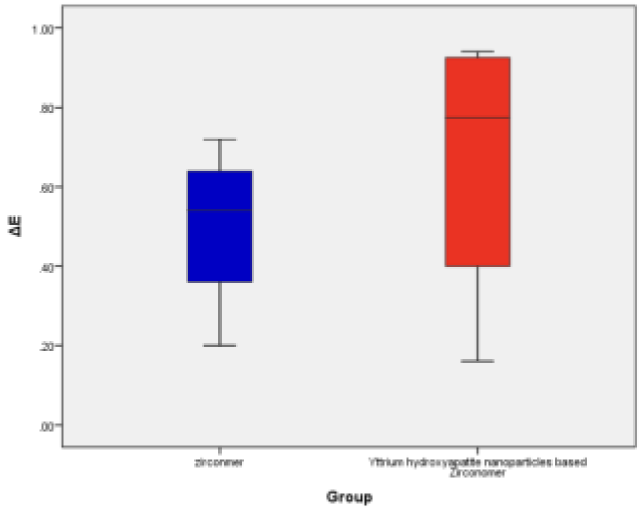

Figure 5: Box-Whisker plot comparing the ΔE values between the materials

Discussion:
The present study aimed to compare the gloss retention, color stability, and surface roughness of Yttrium hydroxyapatite (Y-HAp) nanoparticles incorporated Zirconmer and Zirconomer under simulated oral conditions, including brushing simulation. Both materials showed distinct performances in terms of the evaluated properties, which can provide valuable insights for their use in clinical practice.
Gloss is a key factor in the visual appeal of dental restorations. Our findings indicate that adding Zirconia nanoparticles to Zirconomer enhances its gloss. This improvement is likely due to Zirconia's ability to achieve a smoother surface, which reflects light more effectively. Conversely, while Y-HAp is known for its bioactive properties, its impact on gloss appears to be less significant. This suggests that while Y-HAp contributes to other beneficial properties, it may not substantially influence the material's gloss(14).
Maintaining the storage of the works from color change is crucial because that will enhance the lifespan of dental restorations. Putting Zirconia nanoparticles into Zirconomer is associated with improved color stability, and this is usually

attributed to the resistance to stain and discoloration of Zirconia, which makes sure that the restoration can keep its original appearance for a long period of time. On the other hand, the effect of Y-HAp on the stability of color is less commonly documented. This gap implies further talk to totally comprehend its impact in this context.

The roughness of the surface affects not only aesthetics but also the tendencies for plaque accumulation by being very susceptible to restoration. This study has shown that a marked diminution of surface roughness has been observed when microhydroxyapatite, denoted as μHA, was integrated into a materialized sample form of Zirconomer. With previous trials that displayed the generation of a smoother surface finish in glass ionomer cements when blended with μHA, a smoother surface was surely obtained, which is just perfect for preventing plaque accumulation and also increases the overall strength of the restoration.

Brushing simulation, used in this study to simulate long-term oral wear, is a reliable method to assess the durability of dental materials under mechanical and abrasive forces. The brushing simulation used in this study followed established protocols that replicate mechanical wear over an extended period, providing insights into how materials will perform in the clinical environment. The simulated brushing cycles in this study mimicked the effects of about three years of regular tooth brushing, offering a realistic view of how the materials would behave under daily use. In comparison with other studies, our findings corroborate similar trends in the performance of composite materials versus glass ionomer cements under simulated wear conditions.(11)

While Zirconomer demonstrated good mechanical strength, its surface characteristics, including gloss retention and surface smoothness, were compromised after simulated brushing cycles, suggesting that it may be better suited for non-aesthetic, functional applications rather than highly visible restorations.

Conclusion:

In conclusion, this study demonstrated that Yttrium hydroxyapatite nanoparticles (Y-HAp) incorporated Zirconomer outperformed standard Zirconomer in terms of gloss retention, color stability, and surface roughness under simulated oral conditions. The incorporation of Y-HAp nanoparticles significantly enhanced the material's esthetic and functional properties, making it more suitable for long-term restorative applications, particularly in visible areas of the dentition. These findings emphasize the potential of Y-HAp-based composites to provide durable and visually appealing solutions in restorative dentistry. Future studies could further explore their clinical applications and long-term performance.

Conflicts of interest: There is no conflict of interest in this study

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