Gadolinium oxide Nanoparticles Infusion in Heat-Cured Acrylic Denture Base Material: Impact on Glass Transition Temperature and Mechanical Strength Enhancement

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Received: November 18, 2023; Revised: December 04, 2023; Accepted: February 13, 2024

Abstract

Introduction: Nano dentistry has paved the way for advanced therapeutic opportunities in various dental disciplines, particularly in the improvement of oral health. One area of focus is the enhancement of mechanical properties of dental materials, such as acrylic resins commonly used in denture base materials. Various strategies, including chemical corrections and the addition of particles, have been explored to augment the mechanical qualities. This study investigates the impact of incorporating Gadolinium oxide nanoparticles into heat-cured acrylic denture materials. Materials and Methods: The denture base was processed using a standardized approach, with the addition of Gadolinium oxide nanoparticles during the monomer phase. A total of 120 specimens were fabricated. 30 specimens for each test using 10 specimens for each nanoparticle concentration (Control 0%, 1%, and 1,5% nanoparticles). The nanoparticles were dispersed using sonication to ensure uniform distribution. The study assessed properties such as glass transition temperature using a differential scanning calorimeter, impact strength and transverse strength utilizing an Instron universal testing machine, and surface roughness via profilometer measurements. Scanning electron microscope also utilized. One way ANOVA was used to determine the mean differences. Results: The study revealed significant improvements in glass transition temperature, impact strength, and transverse strength. The peak values were often seen in the 1.5% wt. group. Surface roughness, however, showed non-significant changes with nanoparticle additions, possibly due to the minimal involvement of nanoparticles on the outer surface. Conclusion: Incorporating Gadolinium oxide nanoparticles into heat-cured acrylic denture base materials demonstrated notable enhancements in key mechanical properties. The findings suggest that nanoparticle additions contribute to increased strength and rigidity, as evidenced by improvements in impact and transverse strength. However, surface roughness remained largely unaffected. This study contributes valuable insights into the potential benefits of nanotechnology in optimizing dental materials for improved clinical performance and patient outcomes.

Keywords: Glass transition temperature, Impact strength, Transverse strength, Gadolinium oxide.

1. Introduction

The primary objective of dentistry is the restoration or replacement of lost or damaged tooth structure to fulfill both functional and aesthetic requirements for patients. Among prosthetic appliances, dentures, crafted from resin-based polymeric

systems, remain the predominant choice (Muklif et al., 2015). Despite the widespread use of polymethyl methacrylate (PMMA) in denture bases, there has been limited exploration into enhancing its thermal properties. In the case of elderly patients, denture bases with improved thermal characteristics play a crucial role in enhancing patient satisfaction, preserving oral tissues, improving sensation, and minimizing the perception of dentures as objects (Kul Aladağ and Yesildal, 2016).

Traditionally, polymers are acknowledged as thermal insulators due to their inherently lower thermal properties compared to metals and ceramics (Liu et al., 2020). However, these materials are associated with certain limitations, notably in terms of mechanical properties (Powers et al., 2014).

Poly (methyl methacrylate) (PMMA) is extensively employed in dentistry due to its favorable optical properties, biocompatibility, and aesthetic appeal. However, PMMA exhibits suboptimal mechanical characteristics in terms of fatigue resistance, impact resistance, and bending strength. Addressing these challenges is imperative to enhance the overall performance of PMMA as a base for denture construction (Bettencourt et al., 2010). The measurement of transverse strength is preferred over tensile and compressive strength assessments, as it accurately reveals the loading conditions experienced by dentures within the oral cavity. Transverse strength is generated when stress is applied to the midpoint of a beam that is supported at both ends (Sakaguchi et al., 2012).

The tremendous development in nanotechnology has paved the way for a new period in oral health care called Nano dentistry by providing advanced therapeutic opportunities in various dental disciplines to improve overall oral health (Ali et al., 2017). A different strategy have been used to enhance mechanical characteristics, involves chemically correcting polymeric structure by the addition of specific components. (Bettencourt et al., 2010).

An alternative approach to enhance acrylic resin involves the incorporation of particles and fibers. Polymers often benefit from the addition of micrometer and nanoscale fillers to enhance stiffness, bolster strength, augment solvent resistance, or reduce production costs (Nejatian et al., 2006). The introduction of nanoparticles as a reinforcing agent has been observed to exert a discernible impact on the physical properties of acrylic resins (Sodagar et al., 2013).

Gadolinium oxide nanoparticles exhibit thermal characteristics that make them of interest in various applications. Their thermal properties, such as specific heat capacity and thermal conductivity, can be tailored based on the size, shape, and composition of the nanoparticles. These characteristics are relevant in fields like nanoelectronics and materials science, where the control of thermal behavior is crucial for the development of efficient electronic devices and thermal management systems. Researchers are exploring ways to optimize gadolinium oxide nanoparticles for specific thermal applications, contributing to advancements in nanotechnology and related fields. The study was aimed to evaluate the effect of Gadolinium Oxide nanoparticles addition to heat cure acrylic denture base material on the following properties: glass transition temperature, impact strength, transverse strength, and surface hardness.

2. Materials and Methods

2.1Materials

The materials used are presented in Table-1.

Table 1: Materials used in the Study.

Material	Manufacturer
heat curing acrylic resin (meliodent, regular heat curing denture base material)	Kulzer, Germany
Gadolinium Oxide nanoparticles	Sky spring nanomaterials, USA

2.2 Study Design

In this prospective study, G-power 3.1.7.9 was used to determine the sample size (program written by Franz-Faul, Universitatit Kiel, Germany) with power 95%, alpha error is 5% two-sided, effect size F equal to 0.4, sample size is 10 specimens for each group. Specimens with visible defects in the material or damaged were excluded as they could affect the study's outcomes. The specimens were divided into 3 groups with 10 specimens in each group. The study took about five months to complete.

2.3 Specimens Grouping

Groupings were established through predefined percentages of Gadolinium Oxide nanoparticles, derived from initial pilot studies. Control group comprised specimens without any addition (0.0 wt.%). Conversely, 1% group formed the experimental category, featuring the inclusion of 1 wt. % Gadolinium Oxide nanoparticles, while 1.5% group constituted another experimental cohort, integrating 1.5 wt.% Gadolinium Oxide nanoparticles. Each test involved 30 specimens, 10 for each group.

2.4 Mold preparation

Complete dentures and acrylic specimens undergo a uniform processing procedure. The application of a separating agent to the plastic patterns is followed by a drying period. The dental stone is then prepared following the manufacturer's guidelines (using a ratio of 100g powder to 20 ml water) and poured into the lower half of the flask. Vibrations are applied to eliminate any entrapped air bubbles. Subsequently, the plastic patterns are positioned to nearly half their depth, and the stone is allowed to set, as depicted in Figure 1.

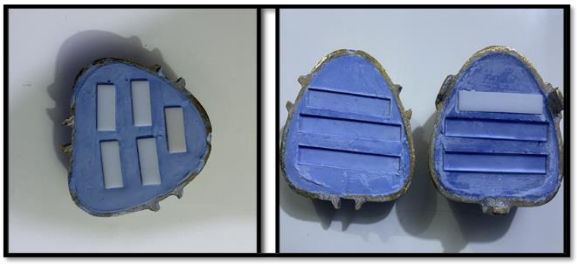

Figure 1: Flasks with Mold.

2.5 Addition of Gadolinium oxide nanofillers:

Nano Gadolinium Oxide nanoparticles were added to the liquid monomer, and the nano particles were efficiently distributed in the monomer by a probe sonication (120 W, 60 KHz) for three minutes to break it down into individual nanoparticles. as presented in (Figure 2) (Mohammed et al.,2009).

Figure 2: Procedure of sonication of both monomer and Nano fillers. Monomer and Nano Fillers are Sonicated in Probe Sonication Apparatus.

The materials are manipulated and blended in accordance with the guidelines provided by the manufacturer. In order to

mitigate the risk of particle aggregation and phase separation, the monomer containing the nanopowder is promptly combined with acrylic powder. The mixture is then covered and allowed to stand until reaching the dough stage.

2.6 Packing of acrylic resin

Once the acrylic reached the dough stage, it was removed from the mixing jar and carefully deposited into the pre-coated mold cavity. Subsequently, the two halves of the flask were securely sealed together. The sealed flask was then positioned beneath the hydraulic press, as illustrated in Figure 3, and a consistent pressure was applied until the flask achieved a tight closure, reaching 100 psi. Excess acrylic was allowed to flow out, and the flasks were secured using flask clamps, ready for the curing process.

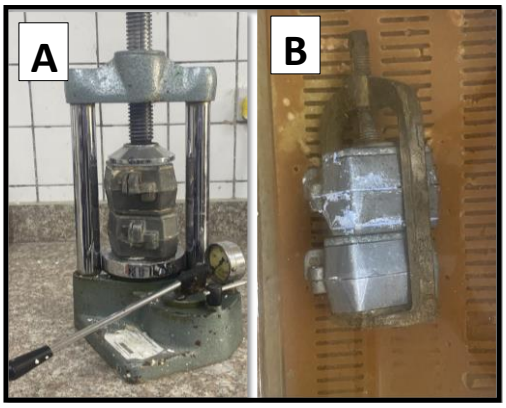

Figure 3: A, Hydraulic press with Flask. B, Flask inside Water Bath.

2.7 Curing of acrylic resin:

The clamped flasks are placed in the water bath and the temperature is 100° C and switch off the water bath for 15 minutes, then open the bath for 20 minute then switch off and left the clamp in water until cooling and finally open the flask carefully and the acrylic specimens are removed, as show in (Figure 4).

Figure 4: Water bath for Acrylic Resin Curing.

2.8 Finishing and polishing:

All acrylic resin specimens are completed using finishing burs and polished with a lathe polishing machine (excluding those for the surface roughness test).

2.9 glass transition temperature test (Tg)

The specimen must be in powder form, ten (mg) powder are prepared so the acrylic specimens were shaved with a sharp knife as show in (Figure 5).

Figure 5: Prepared Powder Form.

The differential scanning calorimeter (DSC-60, Shimadzu, Japan) (Figure 6) is a tool for determining the thermal transition. The DSC device is connected to a control and program unit that displays the data, and the computer determines the Tg value. The acrylic powder sample was placed in an aluminum pan of a DSC device, and the Tg value was measured using a DSC thermogram with an empty aluminum pan as a control. Before beginning the

measurement, the heating rate was set to (10 C/min) and the chart speed was set to (20 mm/min) for all heating procedures. Using a predetermined temperature range of 20^0 to 400^0C in a dynamic nitrogen environment (flow rate of 25 cm^3 per minute).

Figure 6: Differential Scanning Calorimeter (DSC) Device.

2.10 Impact strength test

The specimens, with dimensions of 80mm in length, 10mm in width, and 4mm in thickness, were subjected to an impact strength test according to the ISO 179 (2000) standard. Prior to testing, the specimens underwent a conditioning period in distilled water at 37°C for 48 hours, following ADA specification No. 12 (1999). The impact testing procedure was conducted in accordance with ISO No. 179 (2000), utilizing an impact testing device depicted in Figure 7.

During the test, each specimen was horizontally supported at one end and impacted by a swinging pendulum with an energy of 2 Joules. The impact energy reading in joules was obtained from the scale. The Charpy impact strength was subsequently calculated in kilojoules per square meter using the prescribed equation:

Impact strength = $\frac{E}{b.d}\ 10^3$ (ISO No. 179, 2000) where's *E*: represents impact energy in Joules, *b*: represents width of specimens in millimeters, and *d* is the depth of specimen in millimeter.

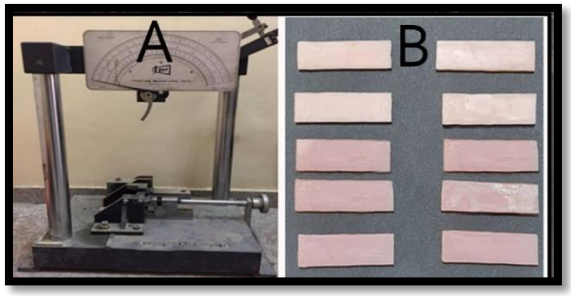

Figure 7: (A) Impact testing machine. (B) 1-Expermental samples 2-Control Samples.

2.11 Transverse strength test

The specimens, with dimensions of 65mm in length, 10mm in width, and 2.5mm in thickness, underwent testing using an Instron universal testing machine, as illustrated in Figure 8. The testing setup involved placing the specimens on bending fixtures with two parallel supports spaced 50mm apart. The load was applied across the head at a rate of 1mm/min through a central rod positioned between the supports, inducing deflection until the specimens fractured. The transverse strength was subsequently determined using the following formula:

T = $\frac{3PL}{2bd^2}$ (ADA specification No.12, 1999), where:

T: represents the transverse strength measured in N/mm².

P: denotes the maximum force applied to the specimens, measured in Newtons (N).

L: corresponds to the distance between the supports, measured in millimeters (mm).

b: represents the width of the specimens, measured in millimeters (mm).

d: signifies the depth of the specimens, measured in millimeters (mm).

Figure 8: Instron Universal Testing Machine.

2.12 Surface roughness test (Ra)

The specimens utilized in this investigation were constructed with dimensions measuring 65mm in length, 10mm in width, and 2.5mm in thickness. To analyze the microgeometry of these test specimens, a profilometer was employed, as depicted in Figure 9. This apparatus features a surface analyzer equipped with a diamond-tipped pen designed to trace the profile of surface imperfections. The stylus possesses a maximum movement range of 11mm, enabling it to capture all the peaks and recesses that define the surface characteristics of the test specimen. Three specific locations were chosen, including one at the center and two at either end. The average of three readings at each location was then computed for subsequent analysis.

Figure 9: Surface Profilometer.

2.13 Scanning Electron Microscope (SEM)

The scanning electron microscope analysis was conducted on both the control specimen of acrylic resin and specimens containing Gadolinium Oxide nanoparticles (1%, 1.5% wt.) to elucidate the distribution of nanoparticles within the polymer matrix, utilizing a magnification of up to 2000X. Specimens for the scanning electron microscope were prepared by cutting small sections of the acrylic resin specimen (sized appropriately to fit a specific SEM plate) and subsequently coating them with gold using a rotary pump coater (plasma sputter) and Tungsten gas. Following this preparation, the specimens were examined using a scanning electron microscope.

2.14 Statistical analysis

A one-way analysis of variance (ANOVA) using release 16 of SPSS Inc. (Chicago, IL) was employed, considering a significance level of $p < 0.05$. To check the assumption of equal variances, Levene's test of homogeneity was performed at $\alpha = 0.05$. With a p-value greater than 0.05, equal variances were assumed. A Tukey post hoc test was subsequently conducted to determine where the differences were between each of the three groups.

3. Results

3.1 Glass transition temperature

The highest transverse strength was observed in the 1.5% group, followed by the 1% group. A one-way analysis of variance (ANOVA) test indicated a highly significant difference among the examined groups. To delve deeper into the source of this difference, additional data analysis was performed using Tukey's Honestly Significant Difference (HSD), as presented in Table 2. The table highlights a highly significant difference between the control group and both the 1% and 1.5% groups. Additionally, a significant difference was observed between the 1% and 1.5% groups.

Table 2: Descriptive Statistics, one way ANOVA, and Tukey HSD for Tg Test.

Groups	N	Mean	One-way ANOVA		Tukey HSD	
			F	Sig.	Groups	P -value
Control	10	97.323	26.961	0.000 (HS)	Control and 1%	0.001 (HS)
1%	10	99.7			Control and 1.5%	0.000 (HS)
1.50%	10	101.523			1% and 1.5%	0.012 (HS)
Levene Statistic 2.516, Sig. :0.153						

3.2 Impact strength test

Results of descriptive statistics, ANOVA, and post-hoc test are presented in Table-3. In the table the test results showed highly significant ANOVA, and Highly significant differences among all groups. The highest value for transverse strength was recorded for 1.5% group followed by 1% group.

Table 3: Descriptive Statistics, one way ANOVA, and Tukey HSD for Impact Strength Test.

Groups	N	Mean	One-way ANOVA		Tukey HSD	
			F	Sig.	Groups	P -value
Control	10	10.7450	60.629	0.000 (HS)	Control and 1%	0.000 (HS)
1%	10	12.7310			Control and 1.5%	0.000 (HS)
1.50%	10	13.7460			1% and 1.5%	0.003 (HS)
Levene Statistic 0.190, Sig. 0.828						

3.3 Transverse Strength Test

The transverse strength attained its peak value in the 1% group, with the 1.5% group closely following. A one-way analysis of variance (ANOVA) uncovered a highly significant difference among the various groups. Notably, there was a highly significant difference between the control group and the 1% group, while the disparity between the control group and the 1.5% group was found to be non-significant. Furthermore, a significant difference was observed between the 1% and 1.5% groups, as detailed in Table-4.

Table 4: Descriptive Statistics, one way ANOVA, and Tukey HSD for Transverse Strength Test.

Groups	N	Mean	One-way ANOVA		Tukey HSD	
			F	Sig.	Groups	P -value
Control	10	82.1330	12.756	0.000 (HS)	Control and 1%	0.000 (HS)
1%	10	87.8860			Control and 1.5%	0.694 (NS)
1.50%	10	83.1310			1% and 1.5%	0.002 (HS)
Levene Statistic 2.164, Sig. 0.135						

3.4 Surface Roughness Test

Results of descriptive statistics, ANOVA, and post-hoc test are presented in Table-5. In the table the test results a decrease in roughness values, and showed non-significant ANOVA, which means that there was no statistically significant decrease in roughness value among the groups.

Table 5: Descriptive statistics, one way ANOVA, and Tukey HSD for surface roughness test.

Groups	N	Mean	One-way ANOVA	
			F	Sig.
Control	10	1.4490	0.756	0.479 (NS)
1 %	10	1.3910		
1.5 %	10	1.3260		
Levene's statistic 0.435, Sig. 0.651				

3.5 Scanning electron microscope

The SEM picture presented in Figure-10. It reveals distribution of nanoparticles along with some agglomerations.

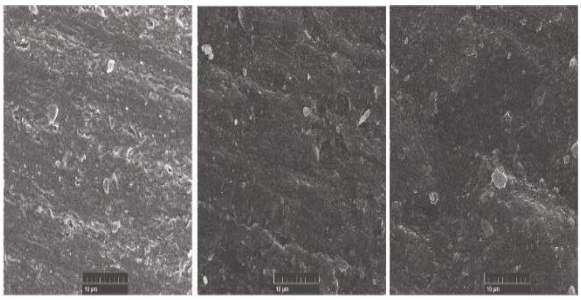

Figure 10: Scanning Electron Microscope; from left to right, Control, 1%, and 1.5%.

4. Discussion

Nano filler incorporation into a polymer has been a frequent method for improving the polymer's functioning in a variety of applications (Caseri et al., 2000). Mechanical, rheological, and thermal characteristics have been improved greatly (Moniruzzaman, et al., 2006). Several enhancements in material properties can be attributed to modifications occurring in the polymer's characteristics near the particles, arising from distinct interactions between the polymer and the filler, as opposed to interactions between polymer molecules (Desai et al., 2005). Notably, the impact is amplified as the filler size decreases, particularly when in the nanometer range, owing to the inverse relationship between the surface-area-to-volume ratio of the filler and its size.

In this study Tg was calculated from the temperature of the peak maxima of DSC curves obtained for pure PMMA and PMMA nanocomposite. The value of glass transition temperature increased for Galdolinium Oxide nanocomposite at 1.5wt%, the DSC peak shifted toward higher temperature when compared to control group, it was found that the addition of Gadolinium Oxide nanofillers to PMMA caused increased in Tg , this may be due to the melting temperature of nanofillers are higher which may reach to 2080^0C,the magnitude of the shift being dependent on the type and amount of nanofillers. The favorable interfacial reaction between reinforcing materials and the PMMA polymer in composites is manifested in the Differential Scanning Calorimetry (DSC) scans of PMMA composite specimens containing Gadolinium Oxide nanoparticles in the PMMA matrix, resulting in an elevation of the glass transition temperature (*Tg*). This increase in *TG*indicates the establishment of strong bonding between the reinforcing materials and the PMMA polymer composite. Additionally, the introduction of nanofillers is known to constrain the mobility of PMMA chains, serving as agents to enhance the cross-linking density between the nanofillers and PMMA chains. Consequently, this results in elevated molten state viscosity and an increase in the glass transition temperature across all composite specimens. These findings align with prior studies conducted by Chow et al. (2008) and Carola et al. (2011).

Impact strength, defined as the energy necessary to cause the fracture of a material under the influence of an impact force (Anusavice, 2013), was evaluated in this study. The results demonstrated the highest impact strength value in the 1.5%wt group, surpassing both the 1%wt and control groups. The incorporation of Nano fillers may contribute to limiting the mobility and deformation of the matrix by introducing a mechanical restraint, as suggested by Fulga et al. (2014).). Furthermore, nanoparticles that form Van der Waals bonds between chains and particles increase the constraint between particles/polymer chains and polymer chains themselves, causing chains to carry additional forces (Ke and Stroeve., 2005). Nevertheless, given the particle sizes

of Gadolinium Oxide Nano powder (<100 nm) employed in this study, the mechanical properties of particulate-filled polymer composites are significantly influenced by factors such as the size, concentration, and distribution of filler particles within the polymer matrix, coupled with strong adhesion at the interface. In this context, Gadolinium Oxide Nano particles are anticipated to occupy the interstitial spaces among polymer particles, resulting in a heterogeneous mixture. Importantly, this is not expected to induce the displacement of polymer chain segments. Ultrasonication of Nano particles may also help in proper distribution of nanoparticles in the polymer matrix however the low percentage of nano filler that was added in this study might have helped in well embedding in polymer matrix and this positively affected impact strength (Gupta et al.,2001).

Impact strength in this study has similar results to Alanmel and Thedan (2020) who add Titanium di oxide Nano-fillers to Heat Cured Acrylic Resin which showed increase in impact strength with large percentages. This result is in agreement with Alwan (2014) who added 3% wt. Titanium oxide nano filler to heat cure PMMA. But disagree with Kamil and Al-Judy (2018) when silicon carbide was added to acrylic resin. The dissimilarity could be because of the different filler type.

The measurement of transverse strength involves applying a load at the center of a beam that is supported at each end, commonly referred to as a three-point bending or transverse test. The maximum stress observed in this test is termed the transverse strength and provides insights not only into the material's strength but also its expected deflection (Sakaguchi et al., 2019). Transverse (flexural) strength encompasses compressive, tensile, and shear strengths, collectively indicating a material's resistance to fracture (Jagger et al., 2002). This testing methodology simulates the flexural loading experienced by an upper denture during mastication. The assessment of acrylic denture base via a transverse bending test adopts a three-point loading system, aligning with the loading conditions encountered in clinical scenarios (Dhuru, 2004). The observed increase in transverse strength associated with the addition of nanoparticles (NPs) is attributed to a reduction in intermolecular space distance, thereby decreasing free space distance between polymer chains. This reduction fills the gaps between chains, attracting resin molecules and facilitating more intricate network chains during the curing process (Ke and Stroeve, 2005).

Good distribution and dispersion of NPs in polymer matrix as resulted from SEM, lead to reduction in the mobility of the polymer chains due to formation of high immobility Nano layer around each NPs, so the network of nanoparticles reduces the overall mobility of the nanocomposites system so increase strength and rigidity. The transfer of stress from the more flexible polymer to the higher modulus, more rigid and stiffer filler particles could possibly explain the increase in transverse strength (Anusavice, 2013).

The result agrees with Alanmel and Thedan (2020) who add Titanium di oxide Nano-fillers to Heat Cured Acrylic Resin showed increase in transverse strength. The result is in agreement with Ebrahim et al. (2019) who incorporated 1.5% by wt. Zirconium oxide (ZrO2) nanofillers but disagree with Al-Judy (2018) when silicon carbide was added to acrylic resin. Also disagree with Karadi (2017) who found that when 2% by wt. Hydroxy apatite nano filler incorporated to heat cure acrylic there was a highly significant decrease in transverse strength, this could be attributed to the difference in type of nano filler used, concentration of nano filler and difference in particle size used.

Given the adverse impact of heightened surface roughness on dentures, the paramount objective in resin restoration has consistently been the attainment of a smooth and glossy surface with minimal or no surface scratches. The sleek and shiny surface of acrylic resin plays a crucial role in preventing the accumulation of stains, debris, and plaque, as emphasized by Harrison et al. in 2004. the well-being of tissues in direct contact with dentures is influenced by the surface roughness of the denture base. Many intraoral microorganisms, particularly those associated with conditions like caries, periodontal disease, and denture stomatitis, can thrive in the oral environment by adhering to non-shedding oral surfaces and forming colonies (Morgan and Wilson, 2001). In this study, no significant changes were observed with varying percentages of added Gadolinium Oxide nanoparticles. This may be attributed to the very small size of Gadolinium Oxide nanoparticles. Additionally, the surface roughness test specifically addresses the outer surface, not the inner surface of the nanocomposite. When a small percentage of nanoparticles is incorporated into the acrylic resin, only a few particles are involved on the surface of the specimens. As a result, the impact on surface roughness is minimal. Therefore, the addition of Gadolinium Oxide nanoparticles is unlikely to have a significant effect on surface roughness when compared to the control group.

The result of this study coincides with the result obtained by Kamil and Al-Judy (2018), when silicon carbide was added to acrylic resin. Also, coincide with the result obtained by Jasim, and Ismail (2014), when alumina oxide was added to acrylic resin, but disagree with the result obtained by MAH and Aljafery (2015) when add ZrO2-Al2O3 nanoparticles to heat cured acrylic resin denture base material.

Conclusions

Incorporating Gadolinium Oxide nanoparticles into PMMA improves thermal stability with an increased glass transition temperature. Improved impact and transverse strength which indicates mechanical reinforcement and reduced intermolecular spaces. The non-significant change in surface roughness suggests minimal impact on outer surface characteristics. Overall, these modifications represent promising advancements in thermal and mechanical properties for potential applications in diverse purposes.

Future Scope

Explore different nanoparticle types and concentrations for diverse PMMA nanocomposite properties. Investigate long-term stability and biocompatibility under simulated oral conditions. Assess cytotoxicity for potential dental applications. Study processing techniques' impact on nanoparticle dispersion. Investigate novel nanoparticle-polymer combinations for tailored dental materials.

Limitations

Focused on Gadolinium Oxide; other nanofillers and their combinations need exploration. Low nanoparticle percentage may limit observable effects, necessitating optimization studies. Primarily examined outer surface roughness, neglecting potential changes in the inner surface. Additional investigations needed to understand effects on flexural modulus and hardness. Cytotoxicity of Gadolinium Oxide nanocomposites on oral tissues requires further exploration before clinical applications.

Source of Funding

Entirely self-funded.

Ethical clearance

An in-vitro study.

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الجسيمات النانوية لأكسيد الجادولينيوم في المادة الأساسية لأطقم الأسنان الأكريليكية المعالجة بالحرارة: التأثير على درجة حرارة التحول الزجاجي وتعزيز القوة الميكانيكية

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خلاصة

المقدمة: لقد مهد طب أسنان النانو الطريق لفرص علاجية متقدمة في مختلف تخصصات طب الأسنان، وخاصة في تحسين صحة الفم. أحد مجالات التركيز هو تحسين الخواص الميكانيكية لمواد طب الأسنان، مثل راتنجات الأكريليك المستخدمة عادة في المواد الأساسية للأسنان. وقد تم استكشاف استراتيجيات مختلفة، بما في ذلك التصحيحات الكيميائية وإضافة الجزيئات، لزيادة الصفات الميكانيكية. تبحث هذه الدراسة في تأثير دمج جزيئات أكسيد الجادولينيوم النانوية في مواد أطقم الأسنان الأكريليكية المعالجة بالحرارة. المواد والطرق: تمت معالجة قاعدة طقم الأسنان باستخدام أسلوب موحد، مع إضافة جزيئات أكسيد الجادولينيوم النانوية خلال مرحلة المونومر. تم تصنيع ما مجموعه ١٢٠ عينة. ٣٠ عينة لكل اختبار باستخدام ١٠ عينات لكل تركيز جسيمات نانوية (التحكم ٠%، ١%، و١,٥% جسيمات نانوية). تم تفريق الجسيمات النانوية باستخدام

Ultrasonic device لضمان التوزيع الموحد. قامت الدراسة بتقييم خصائص مثل درجة حرارة التزجج باستخدام مسعر المسح التفاضلي، وقوة التأثير والقوة العرضية باستخدام آلة اختبار عالميةInstron ، وخشونة السطح من خلال قياسات الملف التعريفي. كما تم استخدام المجهر الإلكتروني الماسح. إحدى الطرق التي تم بها استخدام ANOVA لتحديد فروق المتوسطات. النتائج: كشفت الدراسة عن تحسينات كبيرة في درجة حرارة التزجج، وقوة التأثير، والقوة العرضية. غالبًا ما شوهدت قيم الذروة عند ١,٥٪ بالوزن. مجموعة. ومع ذلك، أظهرت خشونة السطح تغيرات غير مهمة مع إضافات الجسيمات النانوية، ربما بسبب الحد الأدنى من مشاركة الجسيمات النانوية على السطح الخارجي. الاستنتاج: أظهر دمج جزيئات أكسيد الجادولينيوم النانوية في المواد الأساسية لأطقم الأسنان الأكريليكية المعالجة بالحرارة تحسينات ملحوظة في الخواص الميكانيكية الرئيسية. تشير النتائج إلى أن إضافات الجسيمات النانوية تساهم في زيادة القوة والصلابة، كما يتضح من التحسينات في التأثير والقوة العرضية. ومع ذلك، ظلت خشونة السطح دون أن تتأثر إلى حد كبير. تساهم هذه الدراسة برؤى قيمة حول الفوائد المحتملة لتقنية النانو في تحسين مواد طب الأسنان لتحسين الأداء السريري ونتائج المرضى.