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Surface Roughness and Color Change of Gamma Irradiated Nanohybrid Resin Composite and Giomer Restorative Materials

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The impact of gamma radiation on color stability and surface roughness of Nanohybrid composites and Giomer is essential to investigate for clinical success of these materials. The goal of this in vitro study is to examine the surface roughness and color change of nano-hybrid resin composites and Giomer restorative materials subjected to gamma radiation. A total number of 40 disc-shaped specimens were made, twenty of which were made from Filtek Z-350/ 3M ESPE, Nanohybrid composite and the other twenty were made from Beautiful II/ Shofou, Giomer restorative materials. Ten subgroups of each material were created: the non-irradiated group (control) and the gamma-irradiated group. After being stored in artificial saliva for 24 hours and 6 months, the surface roughness and color change of the materials were evaluated using a digital microscope for roughness and a Spectrophotometer (ΔE) for color. After six months, the Giomer control group had the highest surface roughness, while the Giomer irradiated group had the lowest after twenty-four hours. The Giomer group, stored for 6 months, experienced the highest color change, followed by the Nanocomposite group at the same storage period then Giomer group at twenty-four hours storage, respectively. The Nanocomposite group experienced the least color change after twenty-four hours. The surface roughness and color stability of both materials in this study were adversely impacted by time. Gamma radiation, on the other hand, improved the color stability of both tested materials and had a beneficial effect on Giomer's surface roughness.

Keywords: Gamma radiation, Nano-composite, Giomer, surface roughness, color change.

Introduction

Unfortunately, head and neck tumors have been increasing in recent years (Bray et al., 2018). For malignant neoplasms in the head and neck, radiotherapy is the most common treatment option, with doses ranging from 40 to 70 Gy (Al-Nawas et al., 2006).

Nano-filled resin composites, which combine the strength and durability of micro-hybrid composites with the aesthetics of micro-filled composites, are the most employed dental restorative materials. However, it has been asserted that in high caries risk patients, such as those receiving radiation therapy, the release of fluoride ions from glass ionomer cements (GICs) enhances protection against the formation of recurrent caries (De Moor et al., 2011; Gupta et al., 2015). One of the countless trials being carried out to boost the properties of the restorative materials already in use, is the invention of a hybrid product known as Giomer, which combines the advantages of both materials. Pre-reacted glass fillers are added to the resin composite matrix to enhance its functional and aesthetic properties and prevent caries. (Rusnac et al., 2019).

Esthetic devaluation is unavoidable once restorative material is placed in the oral cavity

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after a while, since its surface characteristics change. Plaque, staining, recurring decay, gingival irritation, and discoloration were the outcomes of these alterations. According to certain in vitro research, the surface roughness of restoration has a substantial effect on the buildup of plaque and bacterial adherence (Aykent et al., 2010; Lins et al., 2016). In addition, while the debris is retained, the aesthetic restoration often absorbs the staining agent's color, perhaps resulting in permanent discoloration. This compromises the visual appeal of the tooth-colored aesthetic restoration and undermines its primary objective (Ibrahim et al., 2020).

This article's goal was to investigate the surface roughness and color change of nano-hybrid resin composites and Giomer restorative materials exposed to gamma radiation in a clinically simulated environment. According to the tested null hypothesis, gamma radiation would have an identical impact on the surface roughness and color change of nano-hybrid resin composites and Giomer restorative materials.

Materials and Methods

This study did not dictate ethical approval as it was conducted totally on restorative materials disc specimens without including any human subjects.

Sample size calculation

The G*Power version 3.1.9.72 was used to determine the study size. A power analysis with adequate power was developed in order to perform a statistical test of the null hypothesis, which states that there will be no difference between the tested groups. Based on the findings of a prior study, the anticipated sample size (n) was 24 specimens in total (i.e., 6 specimens each subgroup) with 0.05 alpha level , 0.2 beta , i.e., power equals 80%, and 0.744 effect size (f). To boost the study's power, the number was increased to 40 specimens (10 specimens per grouping).

Specimen grouping

Forty prepared specimens in total, were split into two major groups (20 each) based on the restorative material used: Filtek Z350 nanocomposite or Beautiful II Giomer. Based on their exposure to gamma radiation, each group was split into two subgroups (10 each): the radiation-free control group and the gamma-irradiated group. All specimens were stored in artificial saliva and then evaluated for color change and surface roughness 24 hours later, and again after six months.

Specimen preparation

Split Teflon molds with consistent dimensions of 6 mm in diameter and 2 mm in thickness were used to produce specimens of both materials, Nanocomposite and Giomer (Elolimy, 2020). Table 1 lists the materials' precise compositions and trade names. One operator handled the restorative materials following the manufacturer's instructions. The mold was set on a flat slab of glass covered with a mylar strip, and the aesthetic restorative materials were put into it. Using a plastic tool, both components of the same shade (A2) were applied in a single step. To fully fit the material to the inner part of the mold, another Mylar strip was put over it, and a microscope slide was forced against the mold with a 250-g pressure. After the extra material was removed, a calibrated LED curing unit (3MTM EliparTM S10 LED, 1200 mW/cm2) was used to photo-activate the specimen for 20 seconds at its top surface. The curing tip was positioned at zero distance from the specimen and perpendicular to it. The cover slide was taken out of the mold as soon as the light-curing process was complete, and an irreversible mark was made on the bottom surface (Abd El Halim, 2012). The specimen was taken out of the mold, supported by mosquito forceps, and polished in a wet environment using aluminum oxide discs (Soflex, 3M) in descending order from medium to superfine (Cruvinel et al., 2007). This allowed the removal of a weak layer that is rich in resin, providing a testing surface that is level, smooth, and hard (Marghalani, 2010). An ultrasonic cleaner (Shenzhen Codyson, CD-4830, China) was used for five minutes to fully clean the specimens.

Irradiation procedure

A fractionated gamma-radiation of 60 Gy was administered to half of the specimens from each material using an Indian Co60 gamma cell (dose rate of 0.757 KGy/h) as 20 Gy daily, three times a week (Abaza et al., 2018; Seif et al., 2013). Irradiation was carried out at the National Centre for Radiation Research and Technology (NCRRT) in Cairo, Egypt.

Storage process

In order to replicate one of the oral environmental conditions, the specimens were retained in artificial saliva within the incubator at 37ºC. After discarding the artificial saliva used for the irradiation procedure, a new volume was used to store the specimens in the incubator. It was periodically replaced every week to avoid its saturation by ions leaching out from the restorative materials due to their disintegration (Nahsan et al., 2015).

TABLE 1. Materials trade name, specification, composition and manufacturer.

Material trade name	Specification	Composition	Manufacturer
Filtek™ Z350	**Nanohybrid resin composite**	Bis-GMA[1], UDMA[2], TEGDMA[3] and Bis-EMA[4] resins, non-agglomerated fillers 4-11 nm zirconia, 20 nm silica and an aggregated zirconia/silica cluster fillers (0.6-10µ) **(Micron)**. The filler loading is 78.5% by weight. Shade A2.	3M ESPE, Dental Products, St. Paul, MN, USA (www.3MESPE.com).
Beautiful II	**Flouride releasing restorative material (Giomer)**	Bis-GMA[1], TEGDMA[3], S-PRG[5] filler (0.8 µ) based on fluoroboroaluminosilicate glass, Camphoroquinone, Pigments and others.	SHOFU INC, Kyoto, Japan (www.shofu.com)
Artificial saliva	**Storage media**	Na_3PO_4 - 3.90 mM $NaCl_2$ - 4.29 mM KCl - 17.98 mM $CaCl_2$ - 1.10 mM $MgCl_2$ - 0.08 mM H_2SO_4 - 0.50 mM $NaHCO_3$ - 3.27 mM and distilled water. The pH was set at a level of 7. 2 (Lata et al., 2010).	Faculty of Pharmacy, Cairo University.

Surface roughness assessment

The necessity for quantitative surface topography characterization without contact is met by optical (non-contact) approaches (Abouelatta, 2010). A USB digital microscope with an inbuilt camera (U500X Capture Digital Microscope, Guangdong, China) connected to a compatible PC was used to take images of the specimens (Ali et al., 2020).

The following image acquisition system was utilized to capture the images used in this investigation; First, a digital camera with a resolution of three mega pixels (U500X Digital Microscope, Guangdong, China) located in a vertical position 2.5 cm from the specimens. The axis of the lens and the illumination source were at a roughly 90-degree angle. Then eight LED lights (controlled by a control wheel) were used to achieve illumination, and the color index (Ra) was nearly 95%.

The images were shot at their highest resolution and connected to a suitable PC by a 90X fixed magnification. Each image has a resolution of 1280 × 1024 pixels when it was recorded. To define and standardize the measuring region, Microsoft Office Picture Manager was used to chop off digital microscope images to 350 x 400 pixels. WSxM software was utilized to create and evaluate a 3D image of the cropped photographs' surface profile for the specimens. (Horcas et al., 2007) (Ver 5 develop 4.1, Nanotec, Electronica, SL). All limitations, frames, sizes, and measured parameters were represented in pixels within the WSxM software. In order to transform the pixels into absolute real-world units, system calibration was carried out. In order to calibrate, a scale produced by the software was compared to an object of recognized size, a ruler in this case. Three sites in the central area, each measuring 10 µm by 10 µm, were then used to take 3D photographs of each specimen both before and after the storage time. The size of the typical bacteria that would attach to the repair surface in vivo was taken into consideration while choosing this area (Giacomelli et al., 2010). The average heights (Ra), expressed in µm, were calculated by WSxM software and can be considered a well-grounded indicator of surface roughness (El Saiedy et al., 2023).

Color measurement

The specimens' colors were measured using a reflecting spectrophotometer (X-Rite, model RM200QC, Neu-Isenburg, Germany). The aperture size was set to 4 mm, and the specimens were positioned exactly in respect to the apparatus. On a white background, measurements were made using the CIE L*a*b* color space in respect to the CIE standard illuminant D65. The following formula was used to assess the specimens' color changes (ΔE):

$\Delta E_{CIELAB} = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})$ ½

where a* = (changing the color of the axis red/green), b* = (color variation axis yellow/blue), and L* = brightness (0-100) (Ferreira et al.,2022; Johnston, 2009).

Statistical analysis

Numerical data were represented using the mean and standard deviation (SD) values. The assumptions of variance homogeneity and normality were confirmed using Levene's and Shapiro-Wilk's tests, respectively. Multi-level mixed model ANOVAs were used to evaluate the data. The Bonferroni correction post hoc test was performed to compare simple effects in the case of a significant interaction using the pooled error term of the main model with p-value modification. A significance criterion of p<0.05 was established for every test. Statistical analysis was conducted employing R statistical analysis software, version 4.3.2 for Windows.

Results

I- Surface roughness results

Results of the three-way ANOVA presented in **Table 2 and Fig. 1** revealed that there was a significant effect of time (0.001) and irradiation (0.048) separately and under the interaction between material, time, and irradiation variables (p=0.039) on surface roughness of the nanohybrid resin composite and Giomer restorative materials.

TABLE 2.Three- way ANOVA for surface roughness:

Parameter	Sum of squares (II)	df	f-value	p-value
Material	5.23E-06	1	1.18	**0.284**
Time	0.00035	1	79.22	**<0.001***
Irradiation	1.78E-05	1	4.02	**0.048***
Material*time	6.45E-06	1	1.46	**0.230**
Material* irradiation	1.61E-05	1	3.64	**0.059**
Time*irradiation	3.89E-06	1	0.88	**0.350**
Material*time*irradiation	1.93E-05	1	4.36	**0.039***

Df= Degree of freedom, *Significant (p<0.05)

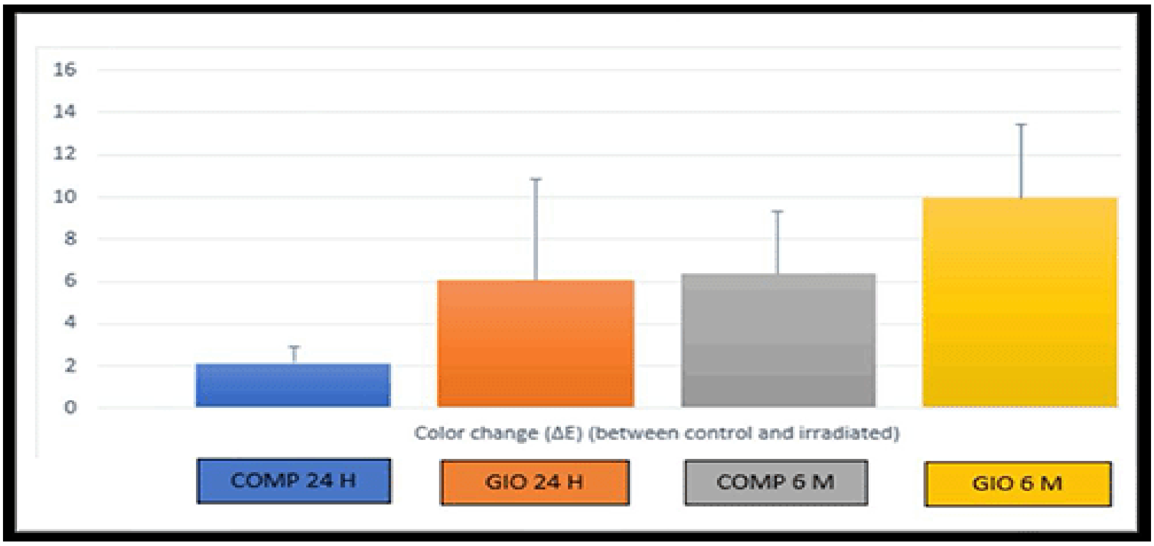

Fig. 1. Bar chart showing mean and standard deviation values (error bars) of surface roughness for different groups.

Results of the Bonferroni correction post hoc test presented in **Table 3** showed that, after 24 hours, there was a non-significant difference between Nanocomposite and Giomer restorative materials as well as a non-significant difference between non-irradiated and irradiated groups. On the other hand, after 6 months storage period, there was a non-significant difference between control and irradiated Nanocomposite groups and a significant decrease in surface roughness of irradiated Giomer group than the control of the same material. Among the control groups of the same time interval, there was a significant increase in Giomer material than Nanocomposite, however, there was a non-significant difference between both materials. Summing up, the eminent surface roughness was observed in the Giomer control group after 6 months and the least was observed in the Giomer irradiated group after 24 hours.

Data in **Table 4** also showed that regardless of material or irradiation status, specimens measured after six months had significantly higher roughness than those measured after 24 hours ($p<0.05$). Finally, they showed that control Giomer specimens measured after six months had significantly higher roughness than irradiated specimens ($p=0.001$).

II- Color change results (ΔE)

II.1- Color change between non-irradiated and gamma irradiated groups

Results of two-way ANOVA presented in **Table 5** showed that material type and time of testing had a significant effect on the color change between the control and irradiated groups($p<0.001$). However, their interaction had a non-significant effect on the color change ($P=0.774$). For intergroup comparisons, data are presented in **Table 6 and Fig. 2**, which showed that the color change in the Giomer group after six months was the highest (9.94±3.52) followed by composite after six months (6.37±2.91) and Giomer after 24 hours (6.08±4.73) and the least was the composite after 24 hours (2.13±0.79). The interaction between the different groups was statistically significant at $p<0.001$.

II.2 - Color change between 24 hours and six months groups

Results of the two-way ANOVA presented in **Table 7** showed that irradiation had a significant effect on the color change between 24 hours and six months ($p<0.001$). However, the material type ($P=0.766$) and the interaction between the material type and the irradiation had a non-significant effect on the color change ($P=0.567$). For intergroup comparisons, data are presented in **Table 8** and **Fig. 3,** which showed that the color change in the Giomer (11.74±5.05) and composite (10.96±3.98) control groups had higher color change than in composite (7.98±3.39) and Giomer (7.73±2.08) irradiated groups. The interaction between the different groups was statistically significant at $p=0.002$.

TABLE 3. Simple effects comparisons, mean and standard deviation (SD) values of surface roughness for different materials and irradiation status:

Time	Samples	Surface roughness (Mean±SD)		p-value
		Composite	Giomer	
24 hours	*Control*	0.2910±0.0019	0.2908±0.0026	**0.890**
	Irradiated	0.2899±0.0024	0.2899±4e-04	**0.971**
	p-value	**0.212**	**0.121**	
6 months	*Control*	0.2926±0.0022	0.2948±0.0025	**0.008***
	Irradiated	0.2936±0.0024	0.2930±0.0015	**0.380**
	p-value	**0.171**	**0.010***	

*; Significant (p<0.05)

TABLE 4. Simple effects comparisons, mean and standard deviation (SD) values of surface roughness for different times.

Material	Samples	Surface roughness (Mean±SD)		p-value
		24 hours	6 months	
Composite	Control	0.2910±0.0019	0.2926±0.0022	0.023*
	Irradiated	0.2899±0.0024	0.2936±0.0024	<0.001*
Giomer	Control	0.2908±0.0026	0.2948±0.0025	<0.001*
	Irradiated	0.2899±4e-04	0.2930±0.0015	<0.001*

*; Significant (p<0.05)

TABLE 5. Two-way ANOVA for color change (ΔE) (between control and irradiated):

Parameter	Sum of squares (II)	df	f-value	p-value
Material	145.20	1	18.22	<0.001*
Time	295.20	1	37.05	<0.001*
Material*time	0.67	1	0.08	0.774

Df= Degree of freedom, *Significant (p<0.05).

TABLE 6. Intergroup comparisons, mean and standard deviation (SD) values of color change (ΔE) (between control and irradiated) for different groups.

Color change (ΔE) (between control and irradiated) (mean±SD)				p-value
Composite 24hrs	Giomer 24hrs	Composite 6m	Giomer 6m	
2.13±0.79^{C}	6.08±4.73^{B}	6.37±2.91^{B}	9.94±3.52^{A}	**<0.001***

Means with different superscript letters within the same horizontal row are significantly different*; significant (p ≤ 0.05) ns; non-significant (p>0.05)

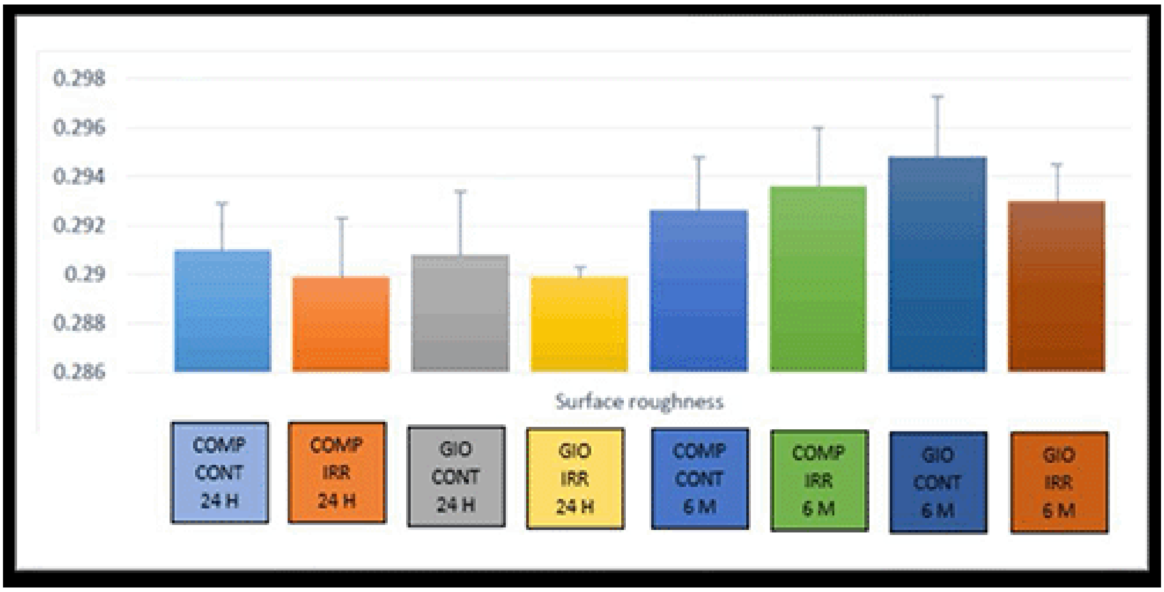

Fig. 2. Bar chart showing mean and standard deviation values (error bars) of color change (ΔE) (between control and irradiated) for different groups.

TABLE 7.Two-way ANOVA for color change (ΔE) (between 24 hours and 6 months):

Parameter	Sum of squares (II)	df	f-value	p-value
Material	145.20	1	0.09	**0.766**
Irradiation	295.20	1	15.40	**<0.001***
Material*irradiation	0.67	1	0.33	**0.567**

Df= Degree of freedom, *Significant (p<0.05).

TABLE 8. Intergroup comparisons, mean and standard deviation (SD) values of color change (ΔE between 24 hours and 6 months) for different groups.

Color change (ΔE) (between 24 hours and 6 months) (mean±SD)				**p-value**
Composite control	**Giomer control**	**Composite irradiated**	**Giomer irradiated**	
10.96 ± 3.9^{8}A	11.74 ± 5.05^{A}	7.98 ± 3.3^{9}B	7.73 ± 2.0^{8}B	**0.002***

Means with different superscript letters within the same horizontal row are significantly different*; significant (p ≤ 0.05) ns; non-significant (p>0.05).

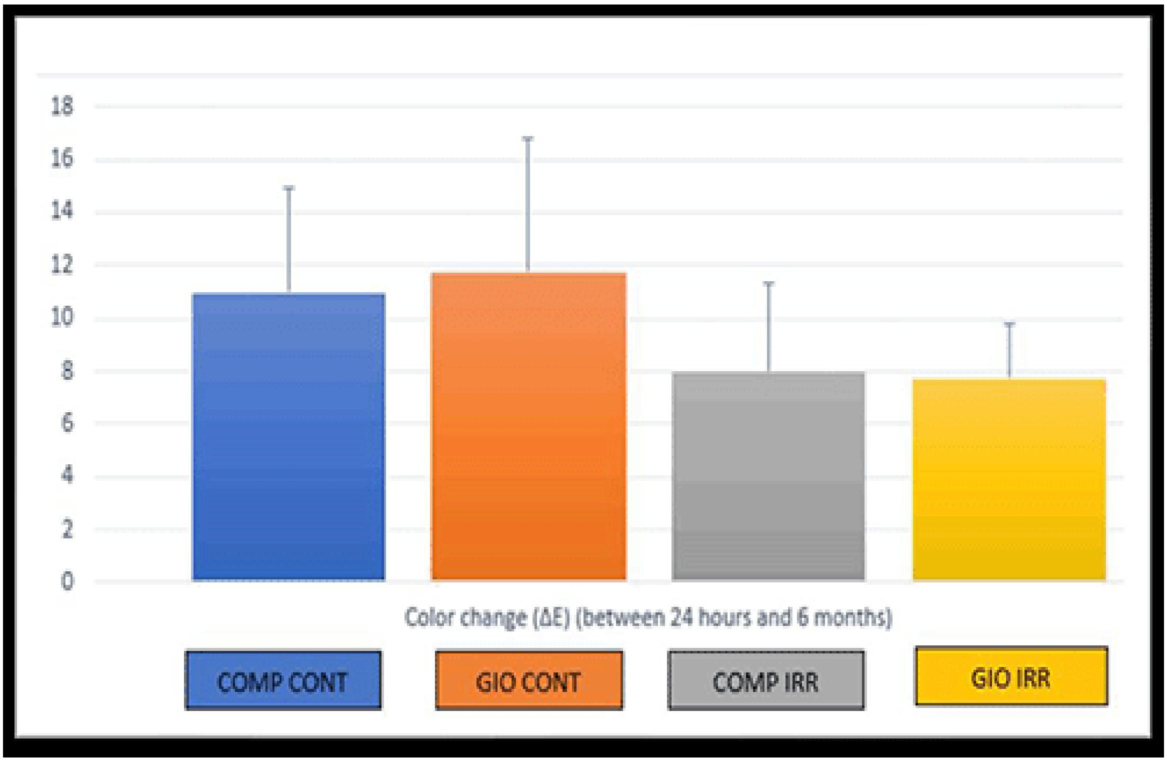

Fig. 3. Bar chart showing mean and standard deviation values (error bars) of color change (ΔE) (between 24 hours and 6 months) for different groups.

Discussion

One of the biggest issues facing medicine in the twenty-first century is the prevalence of head and neck cancer (Basker et al., 2012). With a current high cure rate of about 80% , radiation therapy is an effective treatment for head and neck malignancies (Helen & Macus, 2017). Since they are the most widely used dental materials for direct dental restorations and can be exposed to ionizing radiation in patients going through head and neck radiotherapy, nanohybrid resin composite and giomer materials were investigated in this study (Francois et al., 2020).

The impact of 60 Gy dose of therapeutic radiation on the surface roughness and color stability of nanocomposite and giomer restorative materials, was examined in the current study per a previous study (Lima et al., 2019). To make sure the materials had fully set, both experiments were performed after 24 hours, then assessments were repeated after a 6-month storage period (Malek et al., 2022). The surface roughness of dental materials encourages bacterial adherence and chromogenic substance aggregation, increasing the risk of subsequent caries and discoloring the restoration, respectively (de Amorim et al., 2021).

One of the non-contact optical profilometers used in this investigation to measure surface roughness, was a digital microscope. Instead of measuring a single line from the surface, it can measure an area, generating 3D measurements and determining the volumes of bumps or vacancies. Furthermore, acquiring a wide field of view provides additional surface data (Ali et al., 2020; Srinivas et al., 2015). Since color stability is another essential characteristic for patients who have high standards for appearance, it was also chosen to be examined for both research materials using a Spectrophotometer, which is a suggested technique for dental applications (Brook et al., 2007). Artificial saliva, pH=7.2, was used as a storage medium for clinical simulation in all tested groups (Malek et al., 2022).

The null hypothesis was renounced by the current study's findings, which showed that ionizing radiation would not change the investigated materials' surface characteristics, such as surface roughness and color stability. For both the non-irradiated and gamma irradiated groups, as well as the irradiated 6 m group, there was no significant difference in surface roughness after a 24-hour storage period. This was in line with Ibrahim et al.'s 2020 study, which discovered a non-statistically significant variation in surface roughness between restorative materials made of nanocomposite and Giomer. In contrast to the nanocomposite in our investigation, the control Giomer group's results were noticeably higher after six months of storage. The TEGDMA chains, found in both materials under investigation, are more likely to expand and blend in with higher amounts of water, which accounts for both materials' capacity to absorb water. However, the Filtek Z-350 nanocomposite was more resistant to water sorption due to the presence of UDMA oligomer, which is more hydrophobic than the other oligomers listed (Abdel Hamid & Abou Nawarey, 2012).

Nevertheless, the resin matrix's composition may not be the only factor influencing the amount of water absorbed. Giomer includes pre-reacted glass polyacid zones on the surface, which might provide osmotic pressure and likely enhance water sorption (Boaro et al., 2013). Giomer may, therefore, be more impacted by water sorption than nanocomposite. Additionally, the variation in solubility between the two resin-based materials may be due to the cross-links' density and degree of conversion inside each material (Saba et al., 2017). In contrast to Filtek Z-350 nanocomposite, Giomer's surface roughness was discovered to be impacted by storage, which may be attributed once more to water sorption and resin matrix breakdown.

Additionally, the results showed that the difference in roughness between the non-irradited and gamma-irradiated groups was not statistically significant, except for the Giomer 6 m groups, which displayed a decrease in surface roughness. Turjanski et al., in 2023, who claimed that there was statistically non-significant difference between the irradiation and control groups, concurred with this. The impact of gamma radiation on the surface roughness of restorative materials is still vague due to conflicting findings in the literature. A study employing scanning electron microscopy by de Amorim et al. in 2021, showed that depending on the exposed particles'size, radiation could reveal filler particles in subsurface layers of composites and even separate the glass ionomers' coating resin layer, generating surface roughening. A previous study that documented an unaltered roughness of a micro-filled and packable composite supports the surface roughness' stability of irradiated resin composites (Viero et al., 2011).

Adversary results were declared by Lima et al. in 2019**,** who documented a significant increase in surface roughness in composites and resin-modified glass ionomers after radiotherapy. Ugurlu et al.**,** in 2020, investigated roughness by atomic force microscopy and revealed that radiation did not affect Giomer and conventional glass ionomer. Inversely, Atalay & Yazici, 2024, who looked into how radiotherapy affected the surface roughness and microhardness of modern bioactive restorative materials, claimed that extended storage in artificial saliva may have outweighed the negative effects on these materials' surface properties, which could be one reason why the surface roughness in the Giomer group decreased after a 6-month storage period.

In the current study, surface roughness significantly rised after six months of storage in artificial saliva for all groups under investigation. This was consistent with Ibrahim et al., 2020, who detailed that the surface roughness of Beautifil-Bulk Restorative and Filtek Z350XT differed significantly before and after thermocycling. It is generally known that water can enter polymer chains and produce hydrolysis, which deteriorates the physical properties of resin composites through intermolecular space and porosity. The polymer chains' seperation by molecules that do not form primary chemical bond chains, is the cause of the composites' decreased physical properties (Pribadi & Soetojo, 2011).

In color change assessments, previous studies showed that CIEDE2000 represents better the color differences perceived by the human eye than the classical CIELAB formula (Ren et al,2015). However, CIELAB has also been widely used to color stability evaluation of dental restorative materials due to its simplicity. (Rodrigues et al, 2022) For color change results, there were statistically significant differences ($\Delta E > 3.33$) between non-irradiated and gamma irradiated groups for both investigated materials in both storage durations. After a 6-month storage period, both resin composite and Giomer groups showed higher color change than the 24-hour groups. This was in line with the findings of Turjanski et al. in 2023, who reported that all of the materials examined exhibited some degree of aging-related discoloration. This is because the post-reaction of resin composites causes the polymer's refractive index to progressively alter, and glass ionomers undergo a similar color change during long maturation (Gurgan et al., 2020). In Giomer, the glass component's acid-base reaction occurs before the surface pre-reacted glass ionomer (S-PRG) is incorporated within the resin matrix (McCabe & Rusby, 2004). In actuality, discoloration due to resin breakdown may be arised from water sorption. The resin matrix can absorb water by a direct route; however, the glass particles can only adsorb water onto the surface without absorbing water into the restoration core. Consequently, the resin content and the bond quality between the filler and resin matrix are the two primary parameters influencing the quantity of water sorption. In the resin composite group, leaching out of residual monomers leaves back porosity, which leads to discoloration aggravated by aging. In addition, time-related discoloration might be due to the process of hydrolysis, which affects the resin matrix and the filler-matrix interface (Lepri et al., 2014).

Specimens in the non-irradiated groups showed significantly more discoloration for both materials than did the gamma-irradiated specimens ($p<0.05$). This finding was not supported by earlier studies, as Gamma radiation was assumed to cause discoloration resulting from free radicals' formation and entrapment or phenolic stabilizers' decomposition products. Discoloration can be predicted because polymeric materials are acknowleged to alter color when exposed to radiation, even if there aren't enough thorough investigations on how radiation affects the color of methacrylate polymers placed in dental composites. (Nauh & Bahareth, 2013)**.** Nevertheless, Gamma radiation has higher power of penetration and intensity than those with the visible light curing units, which could affect the polymeric resin's degree of conversion. Therefore, the extended polymerization originating from the incident therapeutic radiation beam could produce an increased degree of polymerization (Kazem & Abouauf, 2017).

Consequently, through molecular stimulation and ongoing polymerization of the non-polymerized surface layer, this can enhance connecting between polymerized chains. (Seif et al., 2013; Cazzaniga et al., 2015)**.** Through hydrogen interactions between NH or OH groups and ether or carbonyl groups, as well as amongst themselves, polymerized chains can create crosslinks, particularly for hydroxyl-hydroxyl groups of monomers (Lemon et al., 2007)**.** This was demonstrated in our investigation by a noticeably better color change of the nanocomposite that contained a larger proportion of dimethacrylate monomers, such as Bis-GMA and Giomer restorative material.

The ideal clinical strategy, restorative materials, and tactics for patients after radiation therapy are still a way off, according to this and other studies. Therefore, more research into the direct influences of radiation on different aesthetic restorative materials need in vivo trials. The absence of temperature and mastication settings, the brief storage period, and the inability to accurately reproduce clinical bonding difficulties are some of the study's limitations. Due to variations in composition, the results might not apply to other materials. The impacts of radiation and other mechanical properties in clinical situations require further investigation.

Conclusions

Given the constraints of this investigation, it is feasible to draw the conclusion that, in terms of surface roughness and color stability, nanocomposite is a more effective restorative material than Giomer. Surface roughness was not negatively impacted by the therapeutic dose of gamma radiation, however the color change was positively impacted. However, the surface roughness of both tested materials was negatively impacted by storage.

Data availability

The datasets promoted and/or analyzed during the present study are obtainable from the corresponding author upon sensible request.

Conflict of interest

No conflict of interest.

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Authors' contributions

1. EFA: Methodology, Validation, Software, Data Curation, Resources, Formal analysis, Investigation, Resources, Conceptualization, Writing - Original Draft, Writing - Review & Editing, Project administration.
2. AAY: Conceptualization, Methodology, Investigation, Validation, Resources, Project administration, Data Curation, Writing - Original Draft, Writing - Review & Editing.

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