

## **EFFECT OF DIFFERENT GAMMA RADIATION DOSES ON THE MECHANICAL PROPERTIES OF ESTHETIC RESTORATIONS**

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### **ABSTRACT**

This in-vitro study investigated effect of different gamma radiation doses on the mechanical properties of esthetic restorations. A total of 84 standardized specimens were prepared for this study. Each 21 of them were prepared using the following four resin composites: Ceram X (Dentsply), Z350 xt (3M ESPE), Xtra fill (Voco) and Grandio (Voco). Then, the 21 specimens were divided as follows: 3 specimens representing the control group (C) were cured using wood pecker LED light cure unit, 9 specimens were subjected to gamma radiation after curing (IaC) from which three were subjected with a dose of 10 Gy (IaC-10), the other three with 30Gy (IaC-30) and the last three with 60 Gy (IaC-60); the last 9 specimens were subjected to gamma radiation before curing (IbC) from which three were subjected with a dose of 10 Gy (IbC-10), the other three with 30Gy (IbC-30) and the last three with 60 Gy (IbC-60). All specimens were subjected to measurement of surface microhardness in Vickers hardness tester. The depth of cure was calculated by obtaining the microhardness ratio through dividing VHN of the bottom surface by VHN of the top surface. Data was then recorded, tabulated and statistically analyzed.

Most results of the specimens' top showed statistically significant increase in mean microhardness of IaC and IbC sub-groups in relevance to the control groups. Most results of the specimens' top showed statistically significant increase in mean microhardness of IbC sub-group in relevance to IaC sub-group. Results of (B/T) showed increase in mean depth of cure of IbC sub-groups in relevance to the control group and to IaC sub-groups, where most of them are statistically significant. Pearson correlation coefficient between top and bottom was found to be statistically significant ( $r = 0.9$ ).

In conclusion, surface microhardness of different composite resin have improved following being subjected to gamma radiation by various doses, on the other hand most of the results of the depth of cure was low for the group IaC and has improved for the group IbC.

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## INTRODUCTION

In the 21<sup>st</sup> century, the incidents of cancer, which is a life threatening disease, is on the rise, so most medical researchers are focusing on ways to prevent and treat such a disease. Cancer has represent a public health problem; it develops with multiple stages over the years and if it is detected before the cells become malignant at an early stage, the treatment can be very effective and with high chances of cure, surgical treatments commonly used in cancer treatment, other therapies including radiotherapy and chemotherapy (**Carini et al, in 2012**). Radiotherapy is the main choice for treatment of cancer patients. However, ionizing irradiation presents a main side effect. This damage is more evident at the head and neck region (**Cardoso et al, in 2005**). Also, it has deleterious effects on dental tissues occurring mainly at the dentin-enamel junction and direct damage as a result of structural changes of the crystalline portion and in the organic portion of dental mineralized tissues (**Hu et al, in 2002**).

All the tissues situated in the field of radiation are subjected to a damage effect from the ionizing irradiation. According to this ionizing radiation, every tissue subjected to radiation has different reactions to radiotherapy varying from acute, transient to late effects (**Anscher et al, in 2005**). High energy ionizing radiations were directly applied on dental materials, as gamma or electron radiation affects the mechanical properties of these dental materials and changed proportionally with high radiation dose (**Behr et al, in 2005**).

Composite resins are highly esthetic restorative materials and widely used for restoring anterior and posterior teeth. Using of nanofill and nano hybrid composite resin materials with finer inorganic filler particles are produced by means of advanced technology to produce a more durable restoration that can be less abraded with harder surfaces (**Lim et al, in 2002**). A new type of composite resins

is a bulk fill and can be applied in bulks of 4mm, without need for a prolonged curing time (**Czasch & Ilie, in 2013**).

Oral cancer patients have dental restorations fabricated of a variety of dental materials. These composites consist of a polymerizable resin matrix, reinforcing glass particles fillers, and silane coupling agents. However, all resin composite materials are subjected to volumetric shrinkage which is ranging from 1.5% to 5% during its polymerization depending on the molecular structure of the monomer, the percentage of filler, and the rate of cure (**Craige & Rowers, in 2006**). The mechanical properties of dental materials changed proportionally with increasing gamma radiation dose (**Haque S, in 2001**). Polymeric materials are affected by ionizing radiations such as gamma rays, accelerated electrons,  $\alpha$  – particles, protons and neutrons, under various conditions (**Lednický et al, in 2007**).

The Vicker's microhardness testing is a very efficient method and in the same time it is considered to be a non-destructive tool for studying the mechanical properties of polymers (**Lednický et al, in 2007**). While, measuring the hardness values of the bottom surface can be used to calculate the depth of curing for resin composites (**Czasch & Ilie, in 2013**).

This study was done to investigate the influence of different levels of therapeutic dose of gamma radiation on the mechanical properties of four commercially available dental composite resins.

## MATERIALS AND METHODS

Four different commercially available esthetic composite restorative materials: Ceram X (Dentsply), Z350 xt (3M ESPE), Xtra fill (Voco) and Grandio (Voco), were used at this study. Their descriptions are shown in table 1.

Two sectional Teflon mold, one 2x3 (2 mm in diameter and 3 mm in thickness) and the other 2x2

(2mm in diameter and 2mm in thickness) were used to prepare the resin composite specimens. The 2x2mm was used for the incremental fill composite, which are Ceram X, Z350xt and Grandio. Whereas the 2x3mm was used for the bulk fill composite, which is Xtra fill. From each material, twenty one standardized disc-shaped specimens were prepared for this study, totaling for eighty four samples. This was done by applying the resin inside the mold cavity over glass slides separated by transparent celluloid Mylar strip to achieve uniformly smooth surfaces and to prevent inhibition of surface polymerization. The molds were placed under pressure of 1 kg from the top to remove excess material.

After that, the specimens of the four composite resins were distributed as follows and as shown in table 2:-

- Control group (C): consisting of three specimens which were cured then pushed out of the mold.
- Irradiated after Curing group (IaC): consisting of nine specimens which were cured then pushed out of the mold. After that, they were subjected to gamma radiation using cobalt radiotherapy machine: three of the specimens were subjected with a dose of 10 Gy (IaC-10), the other three with 30Gy (IaC -30) and the last three with 60 Gy (IaC -60).
- Irradiated before Curing group (IbC): consisting of nine specimens which were kept in the mold and subjected to gamma radiation using cobalt radiotherapy machine: three of the specimens were subjected with a dose of 10 Gy (IbC-10), the other three with 30Gy (IbC-30) and the last three with 60 Gy (IbC-60). After which, they were all cured then pushed out of the mold.

All specimens were kept in light proof containers, before laboratory investigation, at 37°C for 24 hours to prevent any further post light-curing polymerization if exposed to ambient light.

The curing of the specimens were performed with photo activation using wood pecker light emitting diode light cure unit (Guangxi china) with light intensity 1000mw/cm<sup>2</sup> applied for 20 seconds on a 0 mm surface contact. The bottom surface was marked using a pen marker to be easily distinguished from the top surface to be examined.

The radiotherapy machine is basically a lead box which contains the radioactive Cobalt that can be adjusted to different doses of gamma radiation.

All specimens were subjected to measurement of surface microhardness in Vickers hardness tester using a digital microhardness tester (Wilson hardness vicker's testing machine, made by Buhler, USA). Three indentations were made at each specimen surface using a 100gf (HV 0.1) load for 10 seconds at the top surface and also the same indentations at the bottom surface. The indentation depth numbers of the three indentations were taken from the dial gauge, averaged, and then converted to a single Vickers Hardness Number (VHN) value. The depth of cure was calculated by obtaining the microhardness ratio, which was computed by dividing VHN of the bottom surface by VHN of the top surface. The values were considered to be accepted when the ratio was equal to or greater than 80%.

Data was analyzed using Statistical Package for Social Science software computer program version 22 (SPSS, Inc., Chicago, IL, USA). Data were presented in mean and standard deviation. One way Analysis of variance (ANOVA) and tukey were used for comparing data. Pearson's correlation was used to correlate between top & bottom surface. Three way ANOVA followed by post-hoc Bonferroni was used to detect the effect of groups, resins and dose on top, bottom and top-bottom. P value less than 0.05 was considered statistically significant.

TABLE (1) Material specifications, manufacturers and compositions

Material	Manufacturer	Type	Resin matrix	Filler size	Filler degree
Ceram X	Dentsply USA	Nano-Ceramic	Bis-GMA, TGDMA, UDMA, Methacrylate	Glass filler (1.2 – 1.6 $\mu\text{m}$ )	Up to 77%
Z350 xt	3M Dental Products St. MN USA	Nanofill	Triethyleneglycol Dimethacrylate Urethane Dimethacrylate, Bis-EMA, Bis-GMA	Zirconia-Silica (0.6- 1.4 $\mu\text{m}$ )	78.5
Xtra fill	Voco GmbH, Cuxhaven, Germany	Bulk fill	Bis- GMA, UDMA, TEGDMA	Barium–boron–alumino–silicate glass (2–3 $\mu\text{m}$ )	86%
Grandio	Voco GmbH, Cuxhaven, Germany.	Nano hybrid	Bis-GMA, TEGDMA	Barium–boron–alumino–silicate glass (0.1–2.5 $\mu\text{m}$ ), Silica: 20–60 nm	87%

TABLE (2) Variables used in this Study

Groups	Description
C	Negative control group
IaC	Irradiated after Curing group
IaC-10	Irradiated with a 10Gy dose after Curing sub-group
IaC-30	Irradiated with a 30Gy dose after Curing sub-group
IaC-60	Irradiated with a 60Gy dose after Curing sub-group
IbC	Irradiated before Curing group
IbC-10	Irradiated with a 10Gy dose before Curing sub-group
IbC-30	Irradiated with a 30Gy dose before Curing sub-group
IbC-60	Irradiated with a 60Gy dose before Curing sub-group
T	Top surface of the specimen
B	Bottom of the specimen
B/T	Curing Depth

## RESULTS

Table 3 & Figure 1 show descriptive statistics of mean microhardness and standard deviation of each control group and subgroup.

### Surface Microhardness (T) Results

The mean microhardness recorded for the specimen's top of the control group of Grandio ( $94.9 \pm 7.8$ ) and Xtra fill ( $87.7 \pm 3.7$ ) was, statistically significant, the highest, while the mean microhardness recorded for the top of the control group of Ceram X was, statistically significant, the lowest.

Regardless of the results of the control group, the highest mean microhardness of the specimen's top was recorded for Grandio with irradiation dose of 60Gy before curing ( $171.3 \pm 18.8$ ). While both sub-groups of Ceram X with irradiation dose of 10Gy after and before curing showed the lowest mean microhardness ( $69.1 \pm 5.3$ ;  $68.4 \pm 2.5$ ).

Most results of the specimens' top showed statistically significant increase in mean microhardness of the irradiated after curing sub-groups (IaC) and

the irradiated before curing sub-groups (IbC) in relevance to the control groups except for the results recorder for: (i) Ceram X with irradiation dose of 60Gy which showed no statistically significant decrease in mean microhardness value of the irradiated after curing sub-group ( $70.0 \pm 4.5$ ) in relevance to its control group ( $60.4 \pm 3.5$ ). (ii) Grandio with irradiation dose of 30Gy which showed statistically significant decrease in mean microhardness of the irradiated after curing sub-group ( $84.4 \pm 5.6$ ) in relevance to its control group ( $94.9 \pm 7.8$ ).

Most results of the specimens' top showed statistically significant increase in mean microhardness of the irradiated before curing sub-groups (IbC) in relevance to the irradiated after curing sub-groups (IaC) except for the results recorded for: (i) Ceram X with irradiation dose of 10Gy which showed no statistically significant decrease in mean microhardness value of the irradiated before curing sub-group ( $68.4 \pm 2.5$ ) in relevance to the irradiated after curing sub-group ( $69.1 \pm 5.4$ ). (ii) Grandio with irradiation dose of 10Gy which showed no statistically significant increase in mean microhardness of the irradiated before curing sub-group ( $117.3 \pm 9.5$ ) in relevance to the irradiated after curing sub-group ( $112.4 \pm 4.1$ ).

In the irradiated before curing sub-group, the results of mean microhardness recorded for doses 30Gy and 60Gy was statistically significant higher than those recorded for dose 10 Gy. Whereas, the results of mean microhardness recorded for the dose 60Gy of the Ceram X ( $105.7 \pm 8.4$ ) was the only statistically significantly higher than that recorded for the dose 30Gy ( $84.9 \pm 2.5$ ).

There was a statistically significant difference between both sub-groups at an F-value of 659.5 and P-value < 0.001; between the four resins at an F-value of 596.6 and P-value < 0.001; between the three doses at an F-value of 73.8 and P-value < 0.001. In addition, there was a statistically significant difference at the interaction between

the sub-groups and resins at an F-value of 33.7 and P-value < 0.001; between the sub-groups and doses at an F-value of 61.7 and P-value < 0.001; between resins and doses at an F-value of 6.6 and P-value < 0.001. When the three variables interacted together, the difference was significant at F-value of 12.4 and P-value < 0.001 (Table 4).

### Curing Depth (B/T) Results

The results of mean depth of cure recorded for the specimen's (B/T) of the control group of Xtra fill ( $79.7\% \pm 1.8\%$ ) and of Z350 xt ( $78.8\% \pm 4.7\%$ ) were, statistically significant, the highest.

Regardless of the results of the control group, the highest mean depth of cure of (B/T) was recorded for Z350 xt with irradiation dose of 30Gy before curing ( $99.1\% \pm 0.5\%$ ). While the lowest mean microhardness of (B/T) was recorded for Ceram X with irradiation dose of 30Gy after curing ( $52.0\% \pm 5.1\%$ ).

Results of (B/T) showed increase in mean depth of cure of the irradiated before curing sub-groups (IbC) in relevance to the control group and to the irradiated after curing sub-groups (IaC), most of which were statistically significant.

There was a statistically significant difference between both sub-groups at an F-value of 69.2 and P-value < 0.001; between the four resins at an F-value of 28.1 and P-value < 0.001; between the three doses at an F-value of 3.9 and P-value = 0.022. In addition, there was a statistically significant difference at the interaction between the sub-groups and resins at an F-value of 7.1 and P-value < 0.001; between the sub-groups and doses at an F-value of 2.5 and P-value = 0.043; between resins and doses at an F-value of 6.3 and P-value < 0.001. When the three variables interacted together, the difference was significant at F-value of 12.7 and P-value < 0.001 (Table 4).

**Correlation between top and bottom**

Pearson correlation coefficient between top and bottom was found to be statistically significant ( $r = 0.9$ ) (Table 5)

Table 3 representing Mean of microhardness and Standard Deviation (SD) of the top (T), Bottom (B) and (B/T)% for control group and both sub-groups according to resin type & irradiation dose before and after curing

	C			10Gy Radiation Dose						30Gy Radiation Dose						60Gy Radiation Dose					
	Mean	SD	P	IaC-10		IbC-10		P	IaC-30		IbC-30		P	IaC-60		IbC-60		P			
				Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD	Mean	SD				
Ceram X	T	60.4	3.5	69.1 <sup>a</sup>	5.4	68.4 <sup>a</sup>	2.5	0.003*	78.8 <sup>a</sup>	4.2	84.9 <sup>ab</sup>	2.5	<0.001*	71.8 <sup>a</sup>	3.2	105.7 <sup>ab</sup>	8.4	<0.001*			
	B	39.5	2.5	46.1	3.3 <sup>a</sup>	55.8	2.9 <sup>ab</sup>	<0.001*	40.8	2.0	79.6	7.5 <sup>ab</sup>	<0.001*	43.5	0.9 <sup>a</sup>	88.0	1.8 <sup>ab</sup>	<0.001*			
	(B/T)%	65.5	4.7	67.2	8.2	81.7 <sup>ab</sup>	5.6	0.001*	52.0 <sup>a</sup>	5.1	93.7 <sup>ab</sup>	6.2	<0.001*	60.7	1.5	83.6 <sup>ab</sup>	4.9	<0.001*			
Z350 xt	T	71.1	1.8	75.4 <sup>a</sup>	2.1	78.7 <sup>ab</sup>	1.7	<0.001*	74.9 <sup>a</sup>	2.7	95.7 <sup>ab</sup>	2.9	<0.001*	70	4.5	102.9 <sup>ab</sup>	11.3	<0.001*			
	B	56.0	1.3	60.3	1.1	66.1	11.0 <sup>a</sup>	0.046*	47.4	1.9 <sup>a</sup>	94.8	2.9 <sup>ab</sup>	<0.001*	63.9	2.5 <sup>a</sup>	89.2	6.9 <sup>ab</sup>	<0.001*			
	(B/T)%	78.8	3.1	80.1	3.5	84.2	14.8	0.560	63.2 <sup>a</sup>	1.4	99.1 <sup>ab</sup>	0.5	<0.001*	91.5 <sup>a</sup>	2.3	87.4	9.1	0.005*			
Xtra fill	T	87.7	3.7	96.2 <sup>a</sup>	3.6	120.2 <sup>ab</sup>	2.8	<0.001*	86.8	5.7	132.4 <sup>ab</sup>	2.8	<0.001*	110.8 <sup>a</sup>	4.8	136.7 <sup>ab</sup>	8.5	<0.001*			
	B	69.8	2.9	70.4	4.5	114.3	3.6 <sup>ab</sup>	<0.001*	76.2	3.4	105.4	13.5 <sup>ab</sup>	<0.001*	88.8	4.4 <sup>a</sup>	126.5	4.7 <sup>ab</sup>	<0.001*			
	(B/T)%	79.7	1.8	73.4 <sup>a</sup>	6.7	95.1 <sup>ab</sup>	2.0	<0.001*	88.2	8.1	79.7	10.7	0.120	80.2	3.9	92.9 <sup>ab</sup>	8.1	0.001*			
Grandio	T	94.9	7.8	112.4 <sup>a</sup>	4.1	117.3 <sup>a</sup>	9.5	<0.001*	84.4 <sup>a</sup>	5.6	155.7 <sup>ab</sup>	6.3	<0.001*	116.3 <sup>a</sup>	9.5	171.3 <sup>ab</sup>	18.8	<0.001*			
	B	66.3	2.2	90.6	5.1 <sup>a</sup>	101.8	1.5 <sup>ab</sup>	<0.001*	58.3	1.5 <sup>a</sup>	152.3	5.9 <sup>ab</sup>	<0.001*	64.7	3.3	153.6	19.0 <sup>ab</sup>	<0.001*			
	(B/T)%	70.2	5.2	80.8 <sup>a</sup>	6.7	87.4 <sup>a</sup>	8.3	0.002*	69.4	6	97.8 <sup>ab</sup>	0.2	<0.001*	55.8 <sup>a</sup>	3.5	89.7 <sup>ab</sup>	6.8	<0.001*			

\*: significant at  $P < 0.05$

a: significance relative to Control group (with IaC & IbC) in the same row

b: significance between IaC & IbC sub-group in the same row

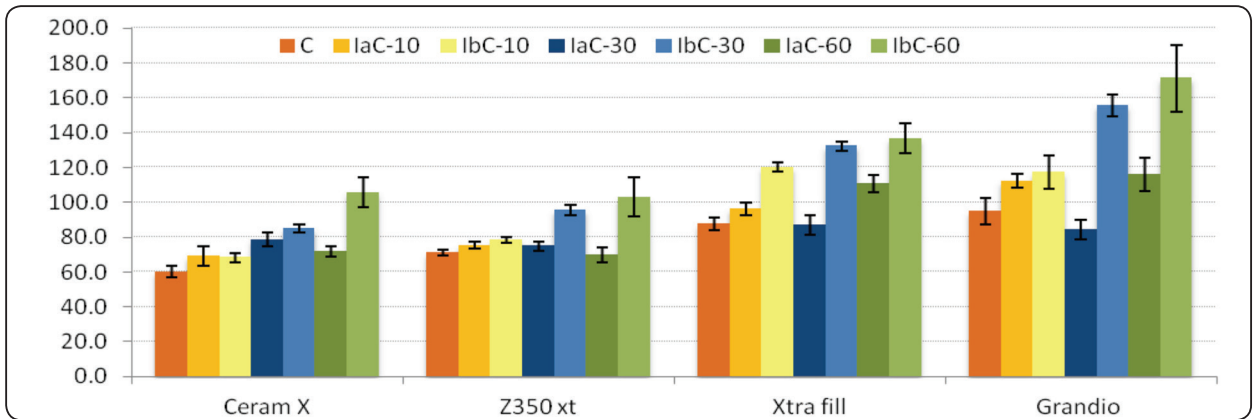


Fig. (1) Representing mean of microhardness and standard deviation of the top (T) for control group and both sub-groups according to resin type & irradiation dose before and after curing

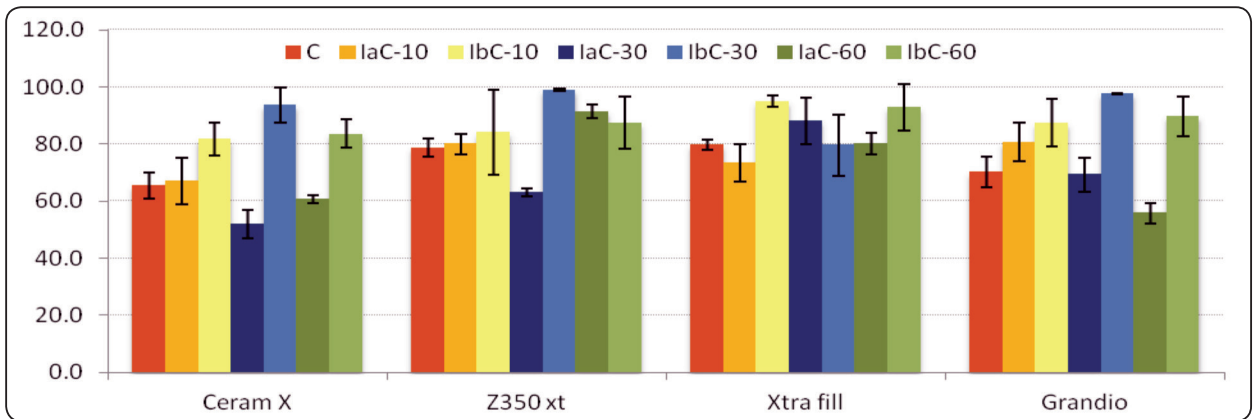


Fig. (2) Representing the curing depth (B/T) % and standard deviation for control group and both sub-groups according to resin type & irradiation dose before and after curing

TABLE (4) Representing three way ANOVA results for the effect of different variables on mean of microhardness

Source of variation	T		(B/T)	
	F-value	P-value	F-value	P-value
Sub-group	659.5	<0.001*	198.4	<0.001*
Resin	596.6	<0.001*	54.6	<0.001*
Dose	73.8	<0.001*	0.3	0.761
Sub-group * Resin	33.7	<0.001*	10.6	<0.001*
Sub-group * Dose	61.7	<0.001*	7.3	0.043*
Resin * Dose	6.6	<0.001*	5.0	<0.001*
Sub-group * Resin * Dose	12.4	<0.001*	15.0	<0.001*

\*: significant at P <0.05

TABLE (5) Representing Pearson correlation coefficient between top and bottom

		Bottom
Top	r	0.917
	P	<0.001*

r: Pearson Correlation coefficient

\*: significant at P <0.05

## DISCUSSION

Radiotherapy is one of the methods used for the malignant tumor treatment; however the ionizing radiation has numerous adverse effects on the healthy tissues as well as the dental restorations which is the field of radiation (**Novais et al, in 2015**).

In the present study, the top and bottom microhardness analysis was done before and after subjecting the in vitro samples of different resin composites to three doses of gamma radiation 10Gy, 30Gy and 60Gy. This was done to simulate the patients whose tooth is restored with resin composite materials and undergoing radiotherapy for the treatment of head and neck cancer. And these gamma radiation doses selected for the study, could be of high importance if they have affected the mechanical properties of esthetical dental materials (**El-Bediwi et al, in 2010**).

This study measured top and bottom microhardness, since it gives an indication about the effective polymerization of the resin composite and provides an indication on the mechanical property of the material to predict their wear resistance and if it will worn away or be abraded by the opposing teeth (**Poggio et al, in 2012**).

Measurement of microhardness of the bottom surface and calculating (B/T) ratio is an effective method for evaluating the depth of cure of resin composite (**Nagi et al, in 2015**).

In the present study, four different resin composite have been selected as they represent the most common new dental composite in the market representing bulk filled and incremental filled composites.

In this study, two groups were selected and correlated: one of which was photo-activated before irradiation, and this was done to simulate patients having a restoration and exposed to radiation for treatment of oral cancer. While the other group was photo-activated after irradiation, this was done to

study the effect of gamma radiation of uncured resin composite and hence its effect on the mechanical properties on the final composite restoration.

The results of the current study showed that the highest mean microhardness of the specimen's top was recorded for Grandio with irradiation dose of 60Gy before curing ( $171.3 \pm 18.8$ ). **Poggio et al, in 2012**, explained that this may be due to Grandio's large particles and its high filler content.

The results of the present study showed a significant increase in the mean surface microhardness at radiation doses 10Gy, 30Gy and 60Gy. These results are in agreement with **Al Saif, in 2017**, who stated this increase of microhardness could be resulted from the continued polymerization reaction which is caused by the incident therapeutic radiation beam, and further explained this as the short wave length of the gamma radiation used in this study has which is about (0.001-0.1) has a greater intensity and higher penetration power of composite resins materials when compared to visible curing ones. Also, these results are also in agreement with **Novais et al, in 2015**, who found that irradiation with Cobalt 60Gy increased the VHN of Ketac Molar. On the other hand, the results of this study contradicted with **El-Bediwi et al, in 2010**, who found that filtek Z250 vickers hardness results was decreased when exposed with gamma radiation and explained this by the fact that when Filtek Z250 was subjected to radiotherapy ionization emitted due to radiation resulted in breaking of resin composite bonds and resulted in the decrease of microhardness.

In the present study, most results of the specimens' top showed statistically significant increase in mean microhardness of the irradiated before curing groups (IbC) in relevance to the irradiated after curing groups (IaC) this is in agreement with **Cruz et al, in 2008**, who explained that as when light curing occurred after irradiation, the irradiation dose has a direct effect on the organic matrix of the composite and it unexpectedly modify its structure by creating



excitation points with high mobility and this lead to move strong bond links happens within the composite and hence increases microhardness. But when light curing occurred before irradiation, there was also some degree of excitations but since the chains are linked already, the high radiation energy together with the rigid structure have resulted in the breaking of bonds within the cured resin composite.

In the present study, the ratio between the microhardness of the bottom of the resin composite over the one of the top was measured as a method used to assess the depth of cure which is considered another significant parameter indicating the resin composite's resistance to tension and to insure adequate polymerization. **Poggio et al, in 2012**), also used the same method.

The depth of cure of resin composite has always been calculated by dividing the microhardness value of the bottom of the resin composite by the microhardness of its top and the results are in the form of percentage values. Generally, to consider adequate curing of the bottom surface, the depth of cure values should not be below the range from 80% to 85%. It was also stated that the degree of polymerized composite is proportional to the amount of light curing used. Moreover, the degree of polymerization should be almost the same through its depth and therefore depth of cure or hardness ratio between bottom and top values should be approaching 100%, but due to the phenomena of light scattering which occurs when the light of polymerization unit passes through the composite and resulted in the decrease of the intensity of light thus the effectiveness of curing at button surface decreased. In the contrary, for the top surface, any low intensity lights can cause effective curing and resulting in adequate polymerization (**Poggio et al, in 2012**).

As for this study, the highest mean depth of cure of (B/T) was recorded for Z350 xt with irradiation dose of 30Gy before curing ( $99.1\% \pm 0.5\%$ ). While the lowest mean microhardness of (B/T) was

recorded for Ceram X with irradiation dose of 30Gy after curing ( $52.0\% \pm 5.1\%$ ). For the Xtrafil bulk fill composite, it is a trend during manufacturing to increase the percentage of the inorganic filler content and hence this increased to a great extent the depth of cure of such material. The higher HN values for the Z350xt may be due to the presence of silica and zirconia nanofillers in its composition which was directly reflected in the enhancement of the physical and mechanical properties of such material (**Nagi et al, in 2015**).

## CONCLUSIONS

Under the limitation of this study, it is concluded that individuals whose teeth are restored with resin composite and who are then exposed to gamma radiation, their resin composite filling is:

- Highly likely to benefit of an improved surface microhardness.
- Highly compromised and negatively affecting the microhardness of the deepest part of the cured composite (depth of cure) especially for the group IaC stimulating patients of head and neck cancer who are exposed to cobalt 60 radiation dose.

Further clinical investigations (invivo studies) are required in order to study the effect of gamma radiations on the dental materials in oral environment when exposed to different doses and times of radiation. Also, further investigations are required as to subject uncured resin composite samples to small amount of gamma radiation for a short time during its manufacturing without affecting curing of the composite. This may possibly enhance the mechanical properties of the resin composite overall in healthy individuals and in patients receiving radiotherapy. And if it works it can help to solve the problem that faces resin composites after being exposed to gamma radiation. If the later recommended investigation doesn't improve the physical and mechanical properties of the resin

composite, the resin composite manufactures would need to look into developing new resin composite materials whose composition would not allow them to be negatively affected by gamma radiation.

### **CLINICAL RECOMMENDATIONS**

In the event of radiotherapy treatment, the application of final resin composite restoration may require to be postponed after the end of radiotherapy treatment and instead intermediate restoration should be applied. As for the existing restoration, it may need to be assessed and replaced when necessary.

Increasing polymerization time and intensity of the curing machine within limit may be of added value to achieve better depth of cure of resin composite restorations.

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