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EVALUATION OF EFFECTS OF IONIZING RADIATION ON THE TITANIUM USED IN DENTAL RESTORATIONS

Miréia Florêncio Maio [1], Adimir dos Santos[2] and Marco A. R. Fernandes[3].

[1] Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
mfmaio@ipen.br

[2] Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
asantos@ipen.br

[3] Faculdade de Medicina de Botucatu (UNESP – Campos Botucatu)
Distrito de Rubião Júnior
18618-970 Botucatu, SP
marcosrf@salesiano-ata.br

ABSTRACT

The purpose of this work consisted of quantitative studies of the effects caused by ionizing radiation on titanium, a material used in dental restorations. Titanium is used to mitigate the deleterious effects of radiotherapy when patients with tumors in head and neck, seen when the teeth are restored within in the field of radiation. Samples were submitted to X-radiation beams from 6 and 10 Mega – Volt (MV) from a linear accelerator, VARIAN 2100C model. The samples were analyzed by X-ray fluorescence techniques to compare the chemical composition before and after the irradiation. Sample dose measurements were performed employing Geiger-Müller detectors and the ionization chamber in order to verify any residual radiation in the samples. The samples were also analyzed by gamma spectrometry by a HPGe detector. These tests were performed to determine small changes in the composition in the samples due to the radiation interaction. The results of this study may encourage the development of new research for alternative materials in dental restorations that can contribute to improve the quality of life of those patients with tumors of the mouth.

1. INTRODUCTION

Techniques to improve the dental implants are being currently developed and the most used material in these dental implants and plates is the Titanium. Several studies about this material are in development. There are still many doubts about the quality and confiability of the Titanium and, as it is a metallic material, some specialists believe that the Titanium would become radioactive after being implanted in patients with oral cancer submitted to head and neck radiotherapies.

2. MATERIALS AND METHODS

Titanium test bodies commonly used in dental implants were confectioned and divided in three groups: a pilot group with 10 samples that was not submitted to irradiation, and two groups, one with 10 and other with 7 samples, that were irradiated [1, 2].

The pilot group was analyzed using a x-ray fluorescence technique to discriminate the exact chemical composition of the materials to be irradiated, once each chemical element has its own response to radiation. After that, the samples of the other two groups were submitted to x-ray beans of 10 and 6 MV that were produced by a linear accelerator VARIAN model 2100C available at the Radiotherapy Service from the Clinicas Hospital of the Medicine Faculty of UNESP Botucatu.

The radiation dose received by each group represents the dose received (i.e. the average dose from treatment protocols) by patients with head and neck tumors submitted to cervical or facial radiotherapy, which covers a great part of the dental arcade [3, 4]. The dose was released in only one application since this corresponds to the situation of greater intensity of the acute and chronic radiobiological effects [5, 6].

After the irradiation, the measurements of the residual radiation (or the energy emission of the radiated samples) were done using dosimetry equipments like Geiger-Muller detectors and ionization chambers [7]. These samples were also submitted to gamma-ray spectrometry analysis by using a hiper-pure Germanium (HPGe) detector available at the Laboratory of Nuclear Measurements of IPEN/MB-01 Reactor located at the Nuclear Engineering Centre (CEN) of IPEN. The goal of this analysis is to obtain the photon counts of the energy peaks of the irradiated samples and to verify if there is any difference in their emission compared to the pilot sample (i.e., not irradiated sample). The chemical composition of the irradiated samples was obtained by the x-ray fluorescence technique and the results were compared to those of the pilot sample.

In brief, analysis of the chemical composition, measurements of the residual radiation, gamma-ray spectrometry, and density of the irradiated samples were carried out and these results were compared to those obtained for the non-irradiated samples.

3. RESULTS

Observing the tables 1, 2, and 3 one may note that the radionuclides responsible for the gamma-ray emission appear repeated. In other words, the photon peaks correspond to the local background radiation. Some spectrums revealed more peaks than others because of differences in their counting time according to the availability of the detector for the measurements.

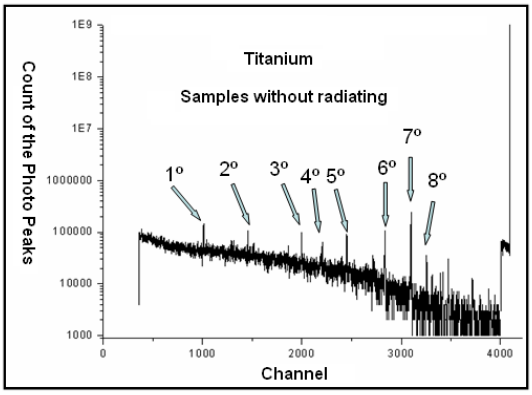

Figure 1. Spectrum of the Titanium sample non-irradiated.

Table 1. Energy and chemical element of each peak of the non-irradiated Titanium sample.

Peak	Energy (KeV)	Chemical Element
1º	511,60	Ag - 106
2º	744,42	Tc - 98
3º	1026,27	Sb - 120
4º	1133,91	Sb - 122
5º	1262,85	Eu - 154
6º	1463,72	K – 40
7º	1599,41	La - 140
8º	1681,43	Sb - 124

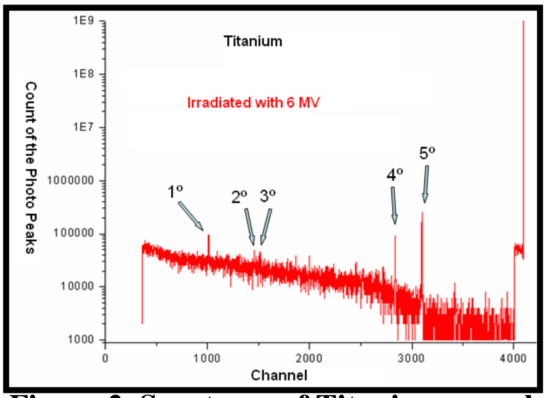

Figure 2. Spectrum of Titanium sample irradiated with 6 MV.

Table 2. Energy and chemical elements of each peak of the 6 MV irradiated Titanium sample.

Peak	Energy (KeV)	Chemical Element
1º	511,60	Ag - 106
2º	744,72	Tc – 98
3º	774,1	Te - 131
4º	1453,69	K - 40
5º	1599,32	La - 140

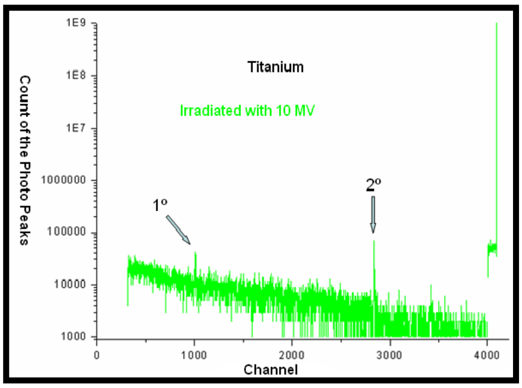

Figure 3. Spectrum of Titanium sample irradiated with 10 MV.

Table 3. Energy and chemical elements of each peak of the 10 MV irradiated Titanium sample.

Peak	Energy (KeV)	Chemical Element
1º	511,60	Ag - 106
2º	1465,69	K - 40

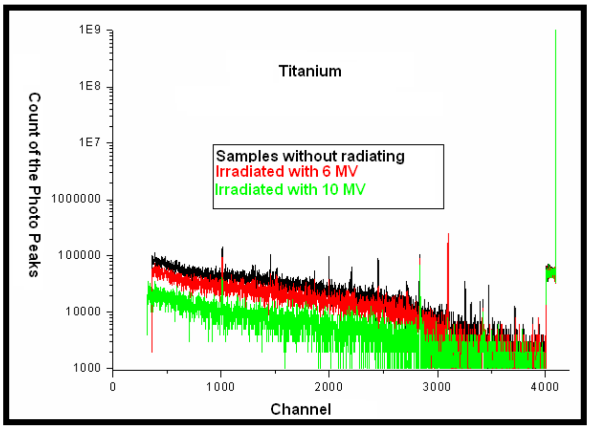

Figure 4. Spectra of samples of titanium irradiated and non-irradiated.

The tables 4, 5, and 6 show the averaged density of the Titanium irradiated samples. Comparing these values with the non-irradiated sample results and considering their standard deviation, one observes a change of 3.5%. This may happen because of the metallic feature of Titanium which makes the test bodies homogenized.

Table 4. Titanium samples before the irradiation.

	Height	Diameter	Volume	Mass	Density
	(mm)	(mm)	(cm^3)	(g)	(g/cm^3)
Mean	3,017	6,11	0,08844	0,366	4,138
Std deviation	0,009	0,011547	0,00046	0,007	0,080

Table 5. Titanium samples after the 10 MV irradiation.

	Height	Diameter	Volume	Mass	Density
	(mm)	(mm)	(cm^3)	(g)	(g/cm^3)
Mean	2,950	6,064	0,0852	0,367	4,311
Std deviation	0,065	0,038	0,0011	0,008	0,081

Table 6. Titanium samples after the 6 MV irradiation.

	Height	Diameter	Volume	Mass	Density
	(mm)	(mm)	(cm^3)	(g)	(g/cm^3)
Mean	2,985	6,080	0,0867	0,364	4,201
Std deviation	0,053	0,035	0,0019	0,010	0,109

The chemical composition of the Titanium samples was analyzed using the x-ray fluorescence technique by the Laboratory of Chemistry from the Brazilian Association of Portland Cement (ABCP). A sample of each group was used for this analysis. The results of the irradiated and the non-irradiated samples were compared to each other.

Table 7. Chemical composition of the Titanium samples.

Chemical Composition	Pilot Sample	10 MV Irradiated Sample	6 MV Irradiated Sample
Abundance %	%	%	%
Na_2O	0,15 ± 0,01	0,14 ± 0,01	0,20 ± 0,01
MgO	0,11 ± 0,01	0,14 ± 0,01	0,09 ± 0,01
Al_2O_3	8,30 ± 0,01	8,26 ± 0,01	8,38 ± 0,01
SiO_2	0,15 ± 0,01	0,17 ± 0,01	0,16 ± 0,01
P_2O_5	0,09 ± 0,01	0,06 ± 0,01	0,09 ± 0,01
SO_3	0,05 ± 0,01	0,05 ± 0,01	0,05 ± 0,01
Cl	-	0,02 ± 0,01	-
CaO	0,03 ± 0,01	0,05 ± 0,01	0,04 ± 0,01
TiO_2	86,20 ± 0,01	86,36 ± 0,01	86,14 ± 0,01
V_2O_5	4,55 ± 0,01	4,53 ± 0,01	4,56 ± 0,01
Fe_2O_3	0,20 ± 0,01	0,18 ± 0,01	0,21 ± 0,01
NiO	0,06 ± 0,01	0,05 ± 0,01	0,08 ± 0,01

4. CONCLUSIONS

The material used for dental implants analyzed here, at least for the radiation beans, energy and dose used, did not reveal properties of radio induction, i. e. did not show residual radiation after being irradiated.

Against the thoughts of some Deontology specialists, the Titanium sample studied in this work did not show relevant changes in their chemical composition after being submitted to radiation doses like those that radiotherapy patients with neck and head tumors receive.

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