International Journal of Applied Sciences: Current and Future Research Trends
(IJASCFRT)
ISSN (Print) , ISSN (Online)

https://ijascfrtjournal.isrra.org/index.php/Applied_Sciences_Journal

In-vivo Dosimetry and Radiation Cataract in Brachytherapy Patients

Ana Pitskhelauri[a*], Irine Gotsiridze[b]

[a,b]*Georgian Technical University, Tbilisi, Georgia*
[a]*Email: mirzokhid.askarov90@gmail.com*

Abstract

Radiation cataract causes partial opacity or cloudiness in the crystalline lens and results from damaged cells covering the posterior surface of the lens. Symptoms can appear as early as one or two years following high-dose exposure and many years after exposure to lower doses. Cataract is a frequent complication of brachytherapy when treated melanoma with localization on the face, nearby with eyes. Radiation Protection and International Commission on Radiological Protection assumptions that a radiation dose of at least 2 Gy is associated with increased cataract risk. For the protection of eyes is used shielding with lead plates in many clinics in the world in pair with in-vivo dosimetry for monitoring. There are several technologies for in-vivo dosimetry. One of them is OSL (optically stimulated luminescence) technology, which is practiced at at Fridon Todua Named Research Institute of Clinical Medicine, Tbilisi, Georgia. For in-vivo dosimetry is used special nanoDot dosimeters. They are designed for use in single point radiation assessment applications. Due to theirs small size, they do not affect the quality of the treatment. The nanoDot dosimeters are wireless and radiolucent. Brachytherapy in Fridon Todua Named Research Institute of Clinical Medicine has been introduced since 2018. During the period 2018-2020, in-vivo dosimetry was carried out in patients with melanoma located on the face in 689 fractions of radiation therapy, including 236 in 2018, 201 in 2019 and 252 in 2020. According to the results of dosimetry monitoring, the risk of cataract occurrence was revealed in only 5 patients (22.7%) in 2018, 2 patients (12.5%) in 2019 and 4 patients (14.8%) in 2020. This risk has been minimized by a dose correction within the limits to allow successful treatment.

Keywords: brachytherapy; in-vivo dosimetry; radiation; cataract; patients.

1. Introduction

Radiation cataract causes partial opacity or cloudiness in the crystalline lens and results from damaged cells covering the posterior surface of the lens.

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* Corresponding author.

Symptoms can appear as early as one or two years following high-dose exposure and many years after exposure to lower doses. The excess cataracts seen are of the types generally associated with radiation: posterior subcapsular and cortical cataracts. Figure 1 shows the relation between radiation dose and cortical opacity of lens.

Figure 2 describes how lens opacity is caused by radiation. There is a transparent layer of epithelial cells on the interior frontal side of the capsule that covers the lens. This layer maintains the function of the lens by slowly growing toward the center, achieved through cell division at the periphery (called the equator) of the lens. Because radiation is especially harmful to dividing cells, exposed cells at the equator are most prone to damage. For unknown reasons, damaged cells move toward the rear of the lens before converging on the center. Such cells prevent light from traveling straight forward, resulting in opacity [1].

Cataract is a frequent complication of brachytherapy when treated melanoma with localization on the face, nearby with eyes. Radiation Protection and International Commission on Radiological Protection assumptions that a radiation dose of at least 2 Gy is associated with increased cataract risk.

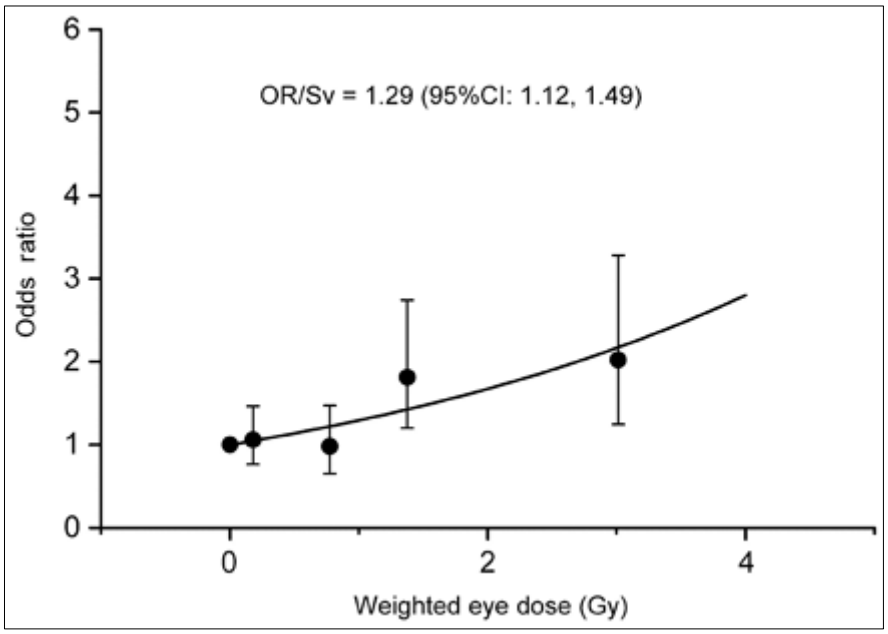

Figure 1: Cortical opacity of lens and radiation dose.

For the protection of eyes is used shielding with lead plates in many clinics in the world in pair with in-vivo dosimetry for monitoring. This is considered to be the best method control of radiation cataract when the location of melanoma is on face, nearby the eyes [2].

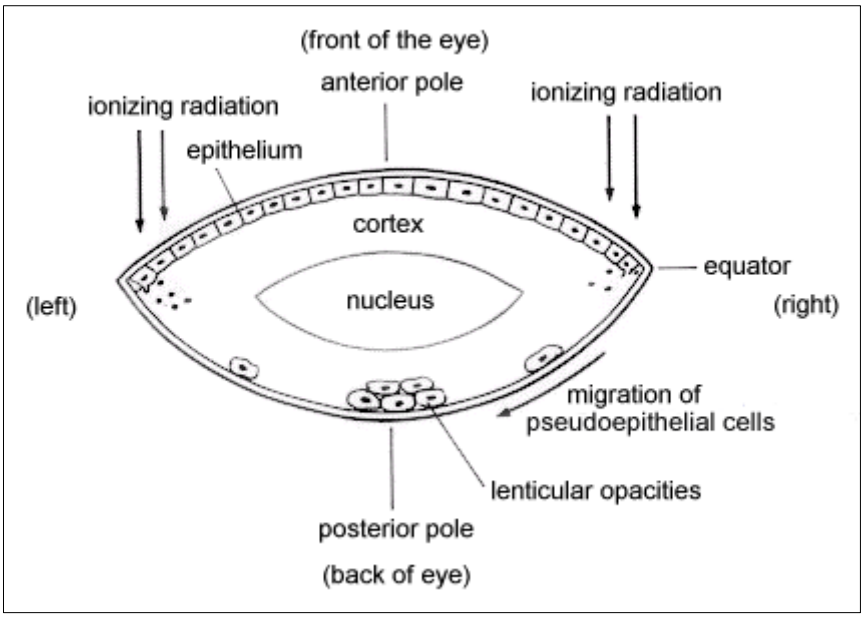

Figure 2: Lens opacity at the posterior subcapsular region caused by radiation (from Effects of A-bomb Radiation on the Human Body, ed by HICARE in 1991, courtesy of Bunkodo Co., Ltd., Tokyo)

There are several technologies for in-vivo dosimetry. One of them is OSL (optically stimulated luminescence) dosimetry practiced at Acad. Fridon Todua Medical Center, Tbilisi, Georgia, where we do our research. For OSL dosimetry we use special nanoDot dosimeters.

2. Materials and Methods

In physics, optically stimulated luminescence (OSL) is a method for measuring doses from ionizing radiation. Optically stimulated luminescence (OSL) technology is a dramatic breakthrough in radiation detection. The key to the success of OSL technology is the detector material, aluminum oxide crystals (AI2O3:C).

Aluminum oxide crystals were first developed as a supersensitive thermoluminescense detector (TLD), but its real advantages were recognized only after advances in optical technology. With OSL, the amount of radiation exposure is measured by stimulating the AI2O3:C material with green light from either a laser or light emitting diode source. Aluminum oxide crystals are manufactured using a proprietary crystal growth process. High purity aluminum oxide is melted at high temperatures and recrystallized in order to introduce dopants and oxygen vacancies. The dopants and vacancies dictate the OSL properties of the radiation sensitive AI2O3:C. Custom designed furnaces are used to precisely control the process necessary to produce aluminum oxide crystals for radiation measurement.

The amount of light released during optional stimulation is directly proportional to the radiation dose and the intensity of stimulation light. The first OSL dosimeter based on aluminum oxcide was first introduced in 1996 to

a limited market with the official LUXEL® technology launched in 1998. Today, OSL technology dosimetry is very popular.

As for OSL nanoDot dosimeters, they are designed for use in single point radiation assessment applications, and are engineered to be read them out. The nanoDot dosimeter can be used in medical applications, in vivo dosimetry, and researches. Due to their small size (square ABC plastic, 10.0X10.0 mm, 2.0 mm thick) , they do not affect the quality of the treatment. The nanoDot dosimeters are wireless and radiolucent.

The nanoDot dosimeters can be used without buildup to make surface dose measurement. In radiation oncology, they can be used with buildup to make measurements at various depths, which is what we use in in-vivo dosimetry for brachytherapy patients when treated melanoma with localization on the face, nearby with eyes. [3]

The OSL nanoDot dosimeter has got the following technical specifications: dose operating range is 10 µGy to >100Gy for general applications; lower Limit of Detection is 0.1 mGy; useful Energy Range is from 5 keV to 20 MeV; energy Dependence is follow - Accurate within ±10% over diagnostic energy range 70-140 kvP, but within ±5% for photons and electrons from 5 MeV-20MeV; accuracy (total uncertainly - single measurement) is ±10% with standard nanoDot and ±5.5% with screened nanoDot; precision is ±5%, k=2 for both standard and screened nanoDot.

Key features and advantages of nanoDot dosimeters are the following: nondestructive readout; allows for reanalysis and reuse; accurate measurement across a wide dose range; no need to anneal every time the dosimeter will be exposed to ionizing radiation; element correction factors are not required; minimal fading; dosimeter archiving is possible; dosimeters are durable (shock resistant; moisture resistant; high temperature tolerance); no required heating parameters and gas to maintain; effective replacement for older radiation measurement technology (e.g., TLD). [4]

Brachytherapy in Acad. Fridon Todua Medical Center has been introduced since 2018. During the period 2018-2020, OSL dosimetry was carried out in patients with melanoma located on the face in 689 fractions of radiation therapy, including 236 fractions in 2018, 201 fractions in 2019 and 252 fractions in 2020. These results are shown at the table 1.

For this period (2018-2020) the risk of cataract occurrence was revealed in only 11 patients, including 5 patients (22.7%) in 2018, 2 patients (12.5%) in 2019 and 4 patients (14.8%) in 2020. At the table 2 it is done the data for 10 patients for each year with highest doses. For every patients it was used shielding with lead plates.

Table 1: Number of brachytherapy fractions and patients with risk of cataract occurrence (2018-2020)

Number of brachytherapy fractions and patients with risk of cataract occurrence	**2018**	**2019**	**2020**
Number of brachytherapy fractions	236	201	252
Number of brachytherapy patients with risk of cataract occurrence	5	2	4

From the table 2 it is clear that in 2018 the highest dose was 3,53 Gy, in 2019 2.12 Gy, but in 2020 2.81 Gy. In all these cases the risk has been minimized due to dose correction within the treatment interest.

Table 2: Summary doses of brachytherapy patients (2018-2020)

Summary doses (Gy)	**2018**	**2019**	**2020**
Summary doses of Brachytherapy patients (Gy)	3.53	2.07	1.48
	3.07	1.54	2.81
	1.78	2.12	1.44
	1.78	0.35	1.52
	1.47	1.22	2.07
	1.78	0.73	0.91
	2.39	1.04	2.03
	2.62	1.45	0.95
	1.86	0.33	2.05
	2.16	0.22	0.95

3. Results

During the period 2018-2020, at Acad. Fridon Todua Medical Center, Tbilisi, Georgia, in-vivo dosimetry was carried out in patients with melanoma located on the face in 689 fractions of radiation therapy, including 236 in 2018, 201 in 2019 and 252 in 2020.

According to the results of dosimetry monitoring, the risk of cataract occurrence was revealed in only 5 patients (22.7%) in 2018, 2 patients (12.5%) in 2019 and 4 patients (14.8%) in 2020. This risk has been minimized by a dose correction within the limits to allow successful treatment.

4. Discussion

Using OSL technology in-vivo dosimetry is very important for monitoring in brachytherapy patients. This is effective way in pair with shielding with lead plates for radiation cataract prevention when the location of melanoma is on face, nearby the eyes.

For future I plan to continue studying doses of brachytherapy patients with melanoma localized on the face, nearby with eyes, on the base of Fridon Todua Named Research Institute of Clinical Medicine, Tbilisi, Georgia.

Acknowledgments

Society of Rheology, 405133029; Popularization of Rheology Science Program (PRSP); Project “Georgian

reality: The sustainability of scientific research during the Covid-19 pandemic"

References

[1]. Neriishi K, Nakashima E, Minamoto A, Fujiwara S, Akahoshi M, Mishima HK, Kitaoka T, Shore R: Postoperative cataract cases among atomic bomb survivors: Radiation dose response and threshold. Radiation Research 2007.

[2]. Madan M Rehani. Radiation and cataract. Et al. Ratiat Prot Dosimetry. 2011.

[3]. Renu Sharma, Paul A. Jursinic. In-vivo measurements for high dose rate brachytherapy with optically stimulated luminescent dosimeters. The International Journal of Medical Physics Research and Practice "Medical Physics". University of California at Davis. https://doi.org/10.1118/1.4811143 2013.

[4]. Paul A. Jursinic. Changes in optically stimulated luminescent dosimeter (OSLD) dosimetric characteristics with accumulated dose. The International Journal of Medical Physics Research and Practice "Medical Physics". University of California at Davis. https://doi.org/10.1118/1.3267489 2009.