

The contribution of optically stimulated luminescence dosimetry in quality control in radiotherapy

A contribuição da dosimetria por luminescência opticamente estimulada no controle de qualidade na radioterapia

Renato S. Fernandes¹ and Yvone M. Mascarenhas²

¹Universidade de Mogi das Cruzes, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo – São Paulo (SP), Brazil.

²Universidade de Mogi das Cruzes/Sapra Landauer – São Carlos (SP), Brazil.

Abstract

In 2011, Brazil will have more than 489,000 new cases of cancer. Of these patients, a considerable contingent will be submitted to radiotherapy procedures. Thus, efficient systems that guarantee the quality of the beams used in radiotherapy procedures are extremely important because collaborate with the overall success of treatment. This paper presents the use of OSL (optically stimulated luminescence) dosimetry procedures in quality control in radiotherapy, making verification of the symmetry of treatment of radioactive fields emitted by linear accelerators. The use of OSL dosimetry was compared to procedures performed daily, using ionization chambers. Dosimeters of aluminum oxide doped with carbon (Al₂O₃: C) were distributed on a map, with the delimitation of a field 20x20 cm arranged as follows: one in the center of the field; four equidistant distributed, forming a square 10x10 cm; and 4 remaining distributed equidistant, forming a square of 20x20 cm. This arrangement is similar to equipment used for checking the symmetry of radioactive fields using ionization chambers. The analysis of data obtained in the symmetry axis X made a variation of 0.2% in OSL dosimetry while using the equipment provided with an ionization chamber, 0.1%. Noting the Y axis, the variation of data for OSL dosimetry was 0.04% and ionization chambers, 0.1%. The use of OSL dosimetry proved to be simple, with accessible instrumentation and making a possible reinterpretation of the data obtained. However, the data suggest that the broader performance of procedures using OSL dosimetry, seeking greater familiarity with the system, can reduce the variation in results.

Keywords: dosimetry, radiation therapy, quality control, cancer, ionization chambers.

Resumo

Em 2011, o Brasil terá mais de 489.000 novos casos de câncer. Desses pacientes, um notável grupo será submetido a procedimentos de radioterapia. Desse modo, sistemas eficazes que garantam a qualidade dos feixes utilizados nos procedimentos de radioterapia são extremamente importantes, pois colaboram com o sucesso total do tratamento. Este trabalho apresenta o uso dos procedimentos de dosimetria de luminescência opticamente estimulada (OSL) no controle de qualidade na radioterapia, verificando a simetria dos campos radioativos emitidos por aceleradores lineares. O uso de dosimetria OSL foi comparado aos procedimentos realizados diariamente, utilizando câmaras de ionização. Dosímetros de óxido de alumínio dopados com carbono (Al₂O₃: C) foram distribuídos em um mapa, com a delimitação de um campo de 20x20 cm organizado da seguinte maneira: um no centro do campo; quatro distribuídos equidistantes, formando um quadrado de 10x10 cm; e quatro restantes, sendo distribuídos equidistantes, formando um quadrado de 20x20 cm. Essa organização é similar ao equipamento utilizado para verificar a simetria dos campos radioativos que utilizam câmaras de ionização. A análise dos dados obtidos no eixo X da simetria fez uma variação de 0,2% na dosimetria de OSL, enquanto ao utilizar o equipamento fornecido com uma câmara de ionização fez 0,1%. Ao notar o eixo Y, a variação dos dados para a dosimetria de OSL foi de 0,04% e as câmaras de ionização, 0,1%. O uso da dosimetria de OSL provou ser simples, com instrumentação acessível e tornou possível a reinterpretação dos dados obtidos. Entretanto, os dados sugerem que a realização de procedimentos mais amplos utilizando dosimetria OSL, visando uma maior familiaridade com o sistema, podem reduzir a variação dos resultados obtidos.

Palavras-chave: dosimetria, terapia de radiação, controle de qualidade, câncer, câmaras de ionização.

Introduction

The Instituto Nacional do Cancer (INCA) showed, in 2009, an estimated new cancer cases in Brazil for the year 2010. These data reported that more than 489,000 new patients were affected by some cancer in 2010. This information will also be valid for the year 2011¹.

The use of radiotherapy, either alone or combined with other methods (chemotherapy and surgery), has emerged as an effective curative modality, especially in malignant neoplasm in the initial stages².

Radiotherapy is the use of ionizing radiation for therapeutic purposes. Radiation doses used are high and any error during the treatment procedure can cause serious patient injury, including death³.

The need to systematize actions for the quality control of radiotherapy treatments has been evident in recent years⁴.

According to World Health Organization, the quality control in radiotherapy is established based on the actions that ensure consistency between the clinical prescription and their administration to patients in relation to the target volume, the lowest level in healthy tissue, minimal exposure of personal checks on the patient and adequate patient monitoring for determining the outcome of treatment⁵.

An efficient system of quality assurance in radiotherapy minimizes errors in treatment planning and administration of the dose to the patient, allows the intercomparison of results between different treatment centers and provides the possibilities and functionalities of a processing equipment to be used with a high level of consistency and accuracy⁴.

Several types of dosimeters can be used for quality control in radiotherapy beams: ionization chambers, diodes, films, metal oxide semiconductor (MOSFET) and TLD (thermoluminescent dosimeters)⁶⁻⁸.

New dosimeters and dosimetry procedures have been developed. We can highlight the optically stimulated luminescence dosimetry (OSL)⁹.

The arrival of use of technology in radiotherapy increases its effectiveness, as well as the errors incidence¹⁰.

It is critical that the verification procedures of the beam are simple and reliable⁴.

Thus, the use of OSL dosimetry shows promise. It has advantages such as high luminescence efficiency, stability, sensitivity, precision and accuracy, control of luminescence emitted, speed reading, rereading and possibility of low power consumption, making possible the use of handheld devices¹¹.

The symmetry of the fields was the parameter chosen for this analysis.

Materials and methods

OSL dosimeters were irradiated 9 (InLight™ with detectors of aluminum oxide doped carbon in the atmosphere).

These dosimeters were arranged on a map, with the delimitation of a field 20x20 cm arranged as follows: one in the center of the field; four equidistant distributed, forming a square 10x10 cm; and the remaining four equidistant distributed, forming a square of 20x20 cm (Figure 1). The dosimeters were arranged in this way to ensure intercomparison with data obtained during the commissioning of the linear accelerator.

Dosimeters were placed on 1.5 cm of solid water (acrylic) to ensure set build up (Figure 2).

The model was irradiated with 100 cGy at a distance of 100 cm (isocenter), using a 6 MeV beam produced in a linear accelerator from Varian Medical Clinac 600c sn 515. To read these dosimeters, it was used MicroStar produced by Landauer Co. (Figure 3).

The data obtained were compared with readings taken every day from Double Check™ equipment (Figure 4), Victoreen®. This equipment consists of a reader, equipped with nine ionization chambers which, when irradiated by a radiation field of 20x20 cm, capture signals in the center of the field, 5 and 10 cm. The readings were taken between 1 and 7 October 2010.

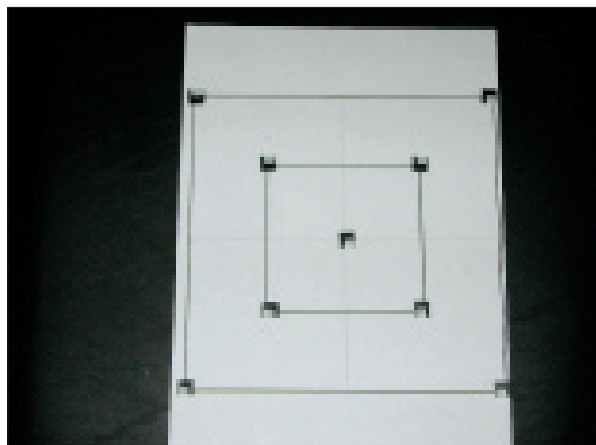


Figure 1. Placed in fields dosimeters 10x10 cm and 20x20 cm.

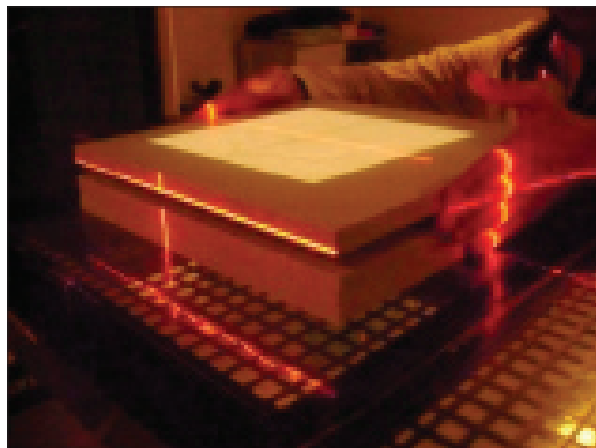


Figure 2. Dosimeters arranged on the solid water. On the whole, 1.5 cm in the same field in order to ensure build up.

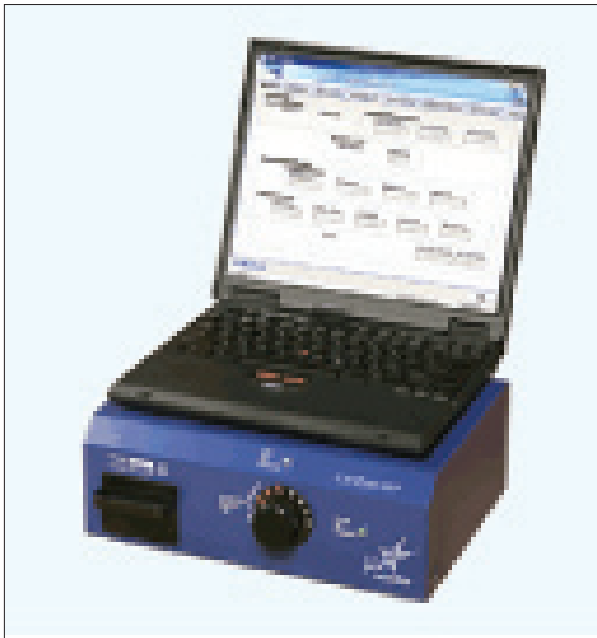


Figure 3. MicroStar Reader.

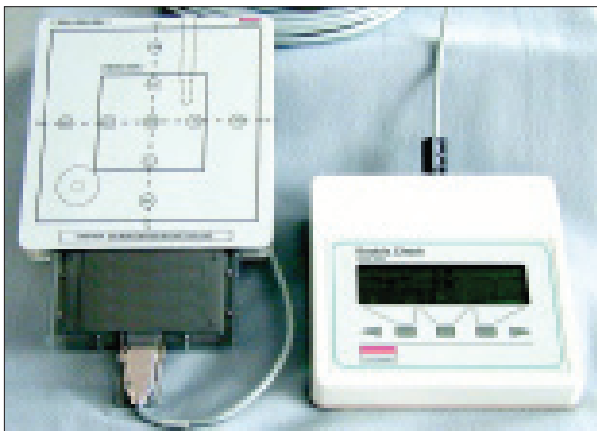


Figure 4. Double Check™ model 7200, Victoreen®.

Discussion

The data obtained with the OSL dosimetry allow us to observe a change in the symmetry of the field in the X direction of approximately 0.2% (Figure 5A). With the equipment use in the reading routine, this variation was around 0.1%. Note that the fluctuations in the readings are accompanied by two similar systems. In Y, we see a variation around 0.04% when using the OSL dosimetry (Figure 5B). With the routinely use of the equipment, we note a variation of 0.10%. Fluctuations in the readings are noted in a similar way in the two systems.

Conclusions

The OSL dosimetry was presented as an important tool in the daily check of the symmetry of the radiation fields emitted by linear accelerators.

Features, such as possibility of re-readings, stability, sensitivity and ease of handling equipment, ensure wide use OSL dosimetry in radiotherapy.

Expansion in the frequency and quantity measures can provide more familiar to all, with steps leading to a smaller range of variation.

More reading using the OSL dosimetry should be conducted to obtain more data for comparison with the system used routinely.

Acknowledgment

The authors thank the Department of Radiation Oncology and Department of Medical Physics of Instituto de Radiologia do Hospital das Clínicas da Faculdade de Medicina da USP and Sapra Landauer for their support in this work.

Results

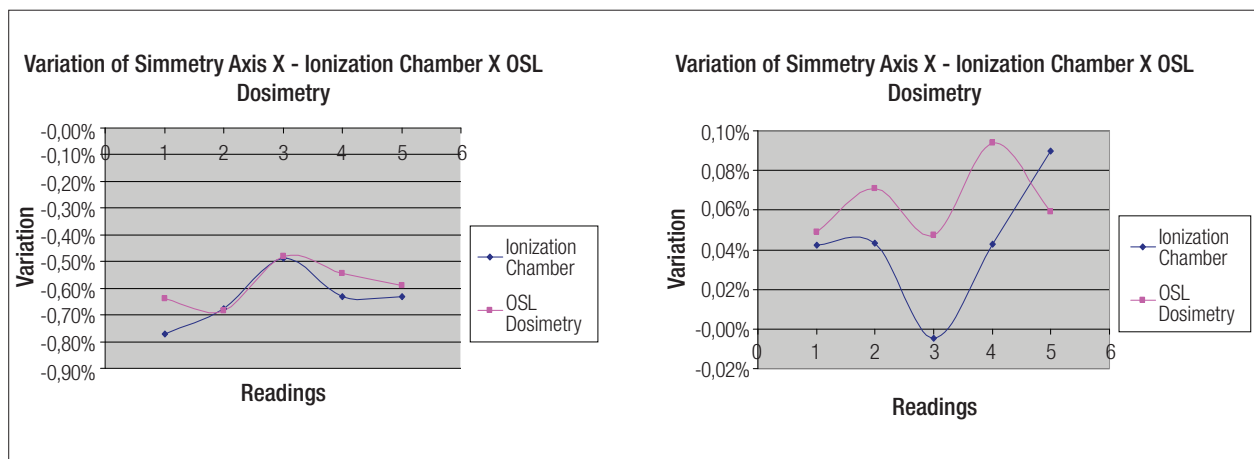


Figure 5. Comparison between data obtained with both ionization chamber and OSL dosimetry for variation of symmetry of the field in the X (a) and Y (b) directions.

References

1. Brasil. Ministério da Saúde. Instituto Nacional de Câncer. Estimativa 2010: incidência de câncer no Brasil/Instituto Nacional de Câncer. Rio de Janeiro: INCA; 2009.
2. Perez CA, Brady LW. Principles and practice of Radiation Oncology. Philadelphia: JB Lippincott; 2004.
3. Berdaky MF, Caldas LVE. Implantação de um programa de controle de qualidade de um acelerador linear de 6 MeV de fótons. Radiol Bras. 2001;34(5):281-4.
4. Brasil. Ministério da Saúde. Instituto Nacional de Câncer. TEC DOC - 1151: aspectos físicos da garantia da qualidade em radioterapia. Rio de Janeiro: INCA, 2000.
5. World Health Organization. Quality assurance in radiotherapy. Geneva: WHO; 1988.
6. Bentel GC. Radiation therapy planning. New York: McGraw-Hill; 1996.
7. Hendee WR, Ibbott GS. Radiation therapy physics. St. Louis: Mosby; 1996.
8. Scaff LAM. Física da Radioterapia. São Paulo: Sarvier; 1997.
9. Yukihiro, EG, McKeever SWS. Optically stimulated luminescence (OSL) dosimetry in medicine. Phys Med Biol. 2008;53(20):351-79.
10. Alvarez L. Tecnologia aumenta eficácia e incidência de erros da radioterapia. O Estado de São Paulo [Internet] [cited 2011 Jan 16]. Available from: http://www.estadao.com.br/estadaodehoje/20100208/not_imp507824,0.php.
11. McKeever SW, Moscovitch M. On the advantages and disadvantages of optically stimulated luminescence dosimetry and thermoluminescence dosimetry. Radiat Prot Dosimetry. 2003;104(3):263-70.