Revista Brasileira de Física Médica.2011;5(1):31-4.

Implementation of intraoperative radiotherapy in a linear accelerator VARIAN 21EX

Implementação da radioterapia intraoperatória em um acelerador linear VARIAN 21EX

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Abstract
The aim of this paper is to present the experience on intraoperative radiotherapy, which has as the reference center the network of radiotherapy in Chile. It is detailed the construction of a system of applicators with an easy coupling on a linear accelerator collimator. It is also detailed the cost and the measurements set up with their corresponding percentage depth dose and isodose curves. This technique was implemented in a Varian Clinac 21EX for beams with 6, 9 and 12 MeV electron energy. The coupling system provides a good dose distribution both laterally and in depth for different energies. This provides a good coverage of treatment planning volume.

Keywords: intraoperative radiotherapy, dosimetry, electron beam.

Resumo
O objetivo deste estudo é apresentar a experiência com a radioterapia intraoperatória, que tem como centro de referência a rede de radioterapia no Chile. Detalha-se a construção do sistema de aplicadores de fácil ajuste em um acelerador linear. Também detalhou-se os custos e as medidas em relação ao PDD correspondente e às curvas de isodose. Esta técnica foi implementada em um Varian Clinac 21EX para feixes com 6, 9 and 12 MeV. O sistema de acoplamento fornece uma boa distribuição da dose lateralmente e em profundidade para diferentes energias. Com isso, é possível planejar o volume do tratamento.

Palavras-chave: radioterapia intraoperatória, dosimetria, feixe de elétrons.

Introduction

The current radiotherapy requires high-tech equipment and multidisciplinary professionals in order to comply with the requirements in implementation of special techniques[1]. Intraoperative radiotherapy (IORT) is an area of interest for the treatment of certain cancers; a single electron dose is given intraoperatively on the tumor bed[2-3]. IORT avoids conventional radiotherapy after surgery and improved tumor control[4-5]. It also allows direct visualization of the tumor precisely defined. This allows full or partial protection of normal tissues through the organs mobilization and/or energy selection[6].

This paper shows the implementation of IORT in a linear accelerator Varian 21EX for beams with 6, 9 and 12 MeV electron energy. It was based on calibration protocols: TRS 398[7], ICRU 71[8] and TG72 (report 92)[9].

Materials and methods

Equipment description

We worked in a dual accelerator VARIAN 21EX, which has 6 and 18 MV nominal photon energies and 6, 9, 12, 15 and 18 MeV electrons energies. Measuring was made with a relative dosimetry phantom PTW MP3, a Markus TN34045

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parallel plane camera, a Pinpoint TN31014 and a semi-flexible TN 31002 with a PTW Freiburg electrometer (Unidos E).

In order to complete the system, five acrylic cylindrical applicators were designed and built with 4.4 cm internal diameter, 0.5 cm thick, and 22 cm in length. They have bevelled in 0°, 15º, 30º, 45º and 50º in the extreme (Figure 1).

For the location of these applicators in the cone of 10 x 10 cm, it was necessary to build a cerrobend block of equal area, as depicted in Figure 2. For the construction of these acrylic applicators over the coupling system, it was not necessary a large investment as it is required when the institutions buy the standard equipment generally used for this technique. In our case, the cost was under US$ 100.00.

Figure 3 shows the system developed at the *Instituto Nacional Del Cancer*. Measurements were made in it with the source-skin distance (SSD) equals to 112 cm and non gap is left between the water surface and the applicator.

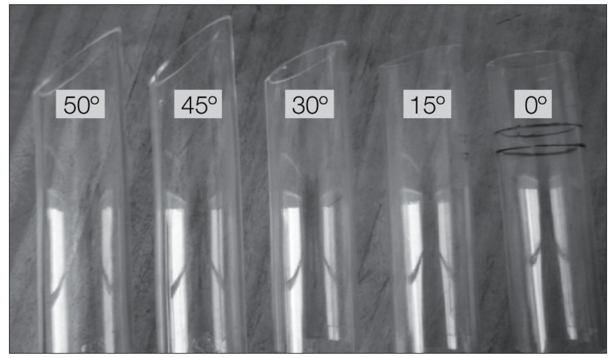

Figure 1. Different acrylic cylindrical applicators.

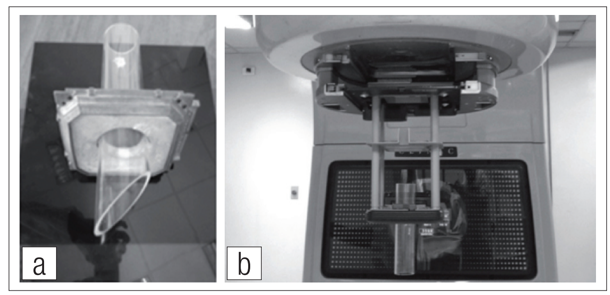

Figure 2. a) cylindrical applicator inserted into the cerrobend block; b) set-up for measurements.

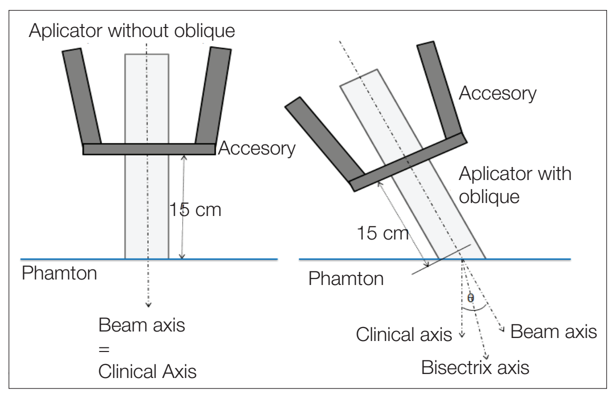

Figure 3. Definition of “bisectrix axis” for intraoperative radiotherapy electron applicator with oblique incidence of the beam axis (angle θ).

Results

Figures 4, 5 and 6 show the curves of isodose distributions for the energies of 6, 9 and 12 MeV obtained for electron beams, to beveled applicators for 0, 15, 30 and 45 degrees. These curves were taken with the semi-flexible ionization chamber TN 31002 (0.125 cm^3).

Figure 7 shows the coverage of the isodose curves using the applicator without bevel to 6 MeV.

Figures 8, 9, 10 and 11 show some of the measured curves of percentage depth dose using different applicators on axes: these curves were taken with the semi-flexible ionization chamber TN 31002 (0.125 cm^3).

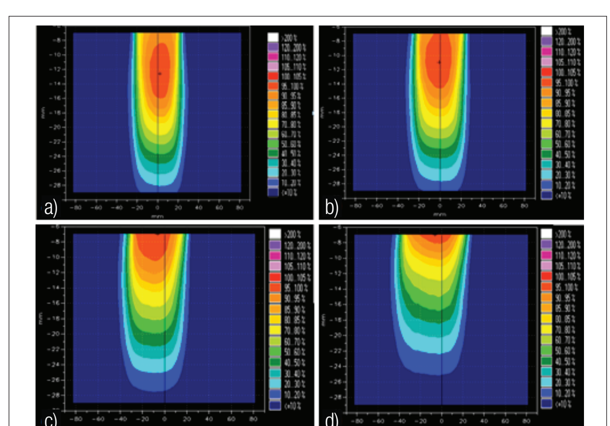

Figure 4. Typical isodose distributions measured from the accelerator VARIAN for 6 MeV beams using the applicator: a) 0 degree bevel; b) 15 degrees bevel; c) 30 degrees bevel; and d) 45 degrees bevel.

Conclusions

One of the most important aspects in this paper for the implementation of the technique is significantly lower costs for the construction of the applicators and the coupling system.

The data obtained are similar to the values published in the TG 72 report.

As shown in Figures 4, 5 and 6, for small cones, a good homogeneity of the isodose distribution was obtained and confirmed with the coverage curve in Figure 7.

Fifty per cent of the isodose curves have a diameter close to the applicator.

The measured of R50 in the different axes (bisector, beam and clinical) for each applicator was specific for each of the used energies (6, 9 and 12 MeV), but it is dependent on both the angle and radius of the acrylic cone.

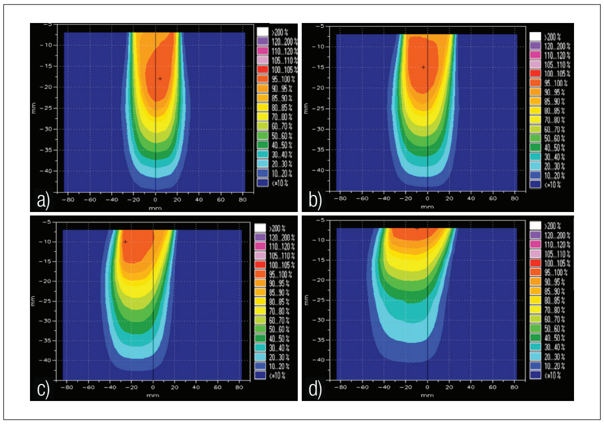

Figure 5. Typical isodose distributions measured from the accelerator VARIAN for 9 MeV beams using the applicator: a) 0 degree bevel; b) 15 degrees bevel; c) 30 degrees bevel; and d) 45 degrees bevel.

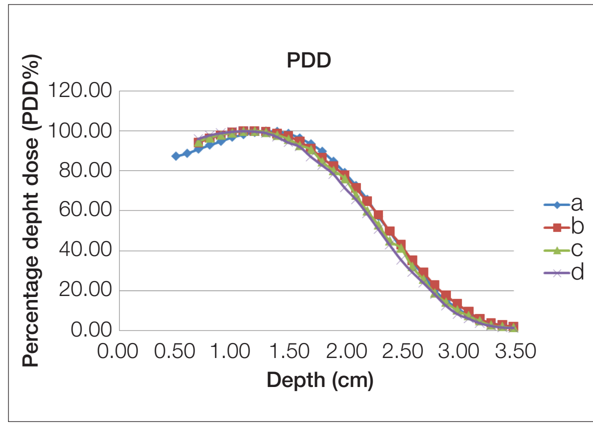

Figure 8. a) The depth doses percentage of the beam axis using the 0 degree bevel applicator. Percentage depth dose using the 15 degree bevel applicator: b) In the beam axis, c) In the bisectrix axis, d) In the clinical axis. For a 6 MeV electron beam.

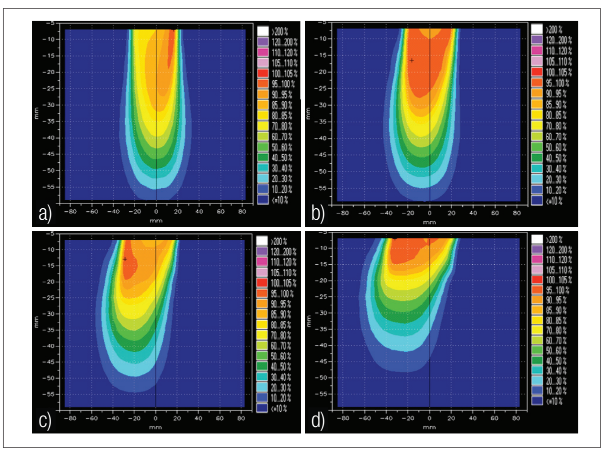

Figure 6. Typical isodose distributions measured from the accelerator VARIAN for the 12 MeV beams using the applicator a) 0 degree bevel; b) 15 degree bevel; c) 30 degree bevel; and d) 45 degrees bevel.

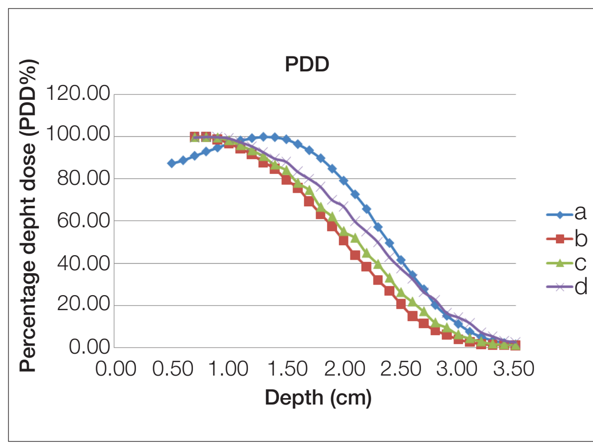

Figure 9. a) The beam axis percentage depth doses using the 0 degree bevel applicator. Percentage depth dose using the 30 degree bevel applicator: b) In the beam axis, c) In the bisectrix axis, d) In the clinical axis for a 6 MeV electron beam.

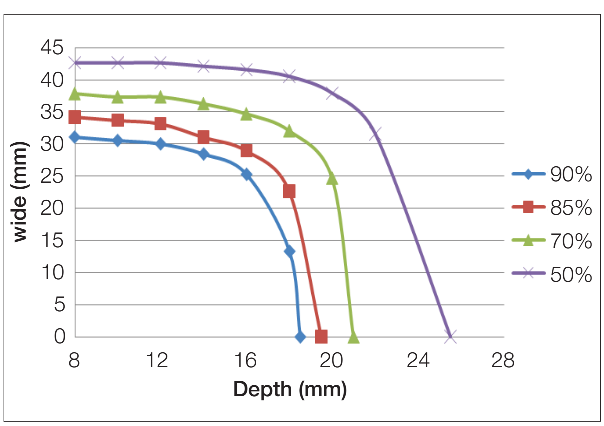

Figure 7. Coverage of the isodose curves of 90, 85, 70 and 50%. Width *versus* depth, using applicator from 0 degree with 6 MeV.

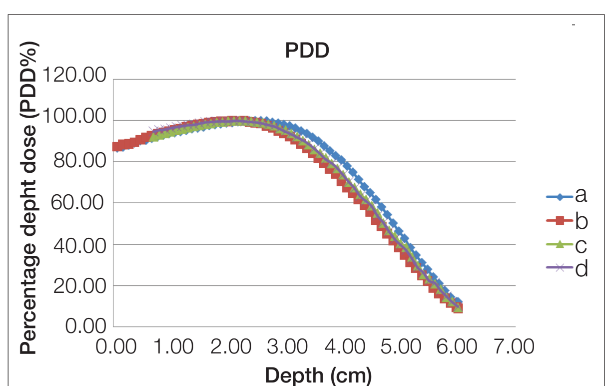

Figure 10. a) The beam axis percentage depth doses using the 0 degree bevel applicator. Percentage depth dose using the 30 degree bevel applicator: b) In the beam axis, c) In the bisectrix axis, d) In the clinical axis for a 12 MeV electron beam.

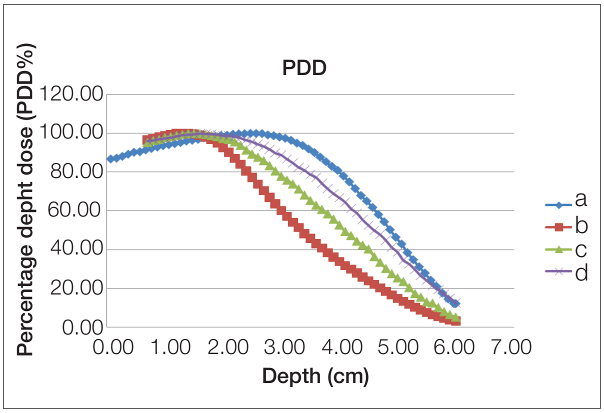

Figure 11. a) The beam axis percentage depth doses using the 0 degree bevel applicator. Percentage depth dose using the 30 degree bevel applicator: b) In the beam axis, c) In the bisectrix axis, d) In the clinical axis for a 12 MeV electron beam.

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