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Generation of predetermined isodose inclination with the use of a motor driven wedge filter

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Summary

Aim The aim of this work was to determine an algorithm to obtain a predetermined inclination angle of isodoses for the Saturn 43F linear accelerator with the use of a motor driven wedge filter.

Materials/Methods It was assumed that a predetermined inclination angle of a reference isodose could be obtained after combining absorbed doses during irradiation with an open field and with a field with a constant 60° wedge. In order to find relations between isodose angles and the irradiation time doses were measured first in a plexiglas phantom and then in a water phantom at the reference depth for the combination of an open field and a field with a 60° wedge. The doses measured under the wedge were normalized with use of the 60° wedge coefficients and converted using tabulated values of the percent depth doses into depth values. Then the angles of isodose slope were calculated.

Results The results are presented in tables and in figures. The polynomials used to calculate times t_0 and t_{60} for predetermined isodose angles were obtained.

Conclusions The polynomials obtained differ from energy to energy. The differences in isodose inclination angles increase with irradiation time using a 60° wedge. The higher is the energy of the beam, the greater is the inclination of the isodoses using the same physical wedge. The differences between the results of measurements in a solid phantom and in a water phantom are due to the differences in depth dose distributions between both materials.

Key words **dose measurements • time calculations • motor driven wedge filter • Saturn**

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BACKGROUND

The use of wedge filters in radiotherapy has two aims: first to obtain reduction in the doses in places where their accumulation is not recommended, and the other to make it possible to obtain a predetermined shape of the isodoses in the tumour volume [1,2]. Therapeutic machines used to be equipped with a set of variable solid wedge filters. Their day-to-day use had several disadvantages such as a limited number of filters available, their size and weight which made routine application difficult for the staff.

One way to avoid this inconvenience was the implementation of motor driven wedge filters. In the Saturn 43F accelerator a solid 60° wedge filter was installed inside the collimator. The predetermined inclination of isodoses inside the irradiated object was obtained by appropriate splitting the irradiation with the wedge and then without the wedge (open field) [3].

AIM

The aim of this work was to determine the algorithm of calculating the proportions of the irradiation time with the open field (t_0) and with a 60° wedge filter (t_{60}) to obtain the predetermined inclination angle of the isodose.

MATERIALS AND METHODS

First we measured coefficients of a 60° wedge on the central axis for energies of 6, 15 and 25 MV: the dose rate in the open field was divided by the dose rate under the wedge [4].

By definition a wedge filter angle [3] is equal to an angle of the isodose slope at a reference depth (Figure 1). An isodose must be drawn crossing the perpendicular to the beam axis at the reference depth. The line between two points from this isodose (in ¼ and ¾ of the field width) and the perpendicular to the beam axis form a wedge angle.

Measurements were carried out in two stages. In the beginning stage the measurements of the doses were made with the use of an IONEX 2500/3A dosimeter with a graphite ionization chamber 2571 in a solid plexiglas phantom at the depth of 10 cm for 15 MV and 25 MV photons and at the 5 cm for 6 MV photons. The measurements were carried out for the field size of 10 cm × 10 cm at the distance from the source to the phantom surface (SSD) of 100 cm alternatively for the open field and then for the 60° wedged field.

The doses were measured on a central axis (CAX) and at the off-axis points at the distance of 2.5 cm from CAX in both directions (along the wedge). The doses measured under the wedge were normalized to those measured in the open field at CAX. Finally, for any photon energy a set of three normalized doses was obtained. Each dose corresponds to a position in CAX or in ±2.5 cm off CAX at the same depth in a phantom, under the wedge. In radiotherapy the curve derived from these points is called a dose profile. The profile inclination corresponds to the wedge angle but obviously is not equal to the inclination of the isodose at the reference depth. Therefore, a recalculation was made using tabularized values of percent depth doses (PDD). For each

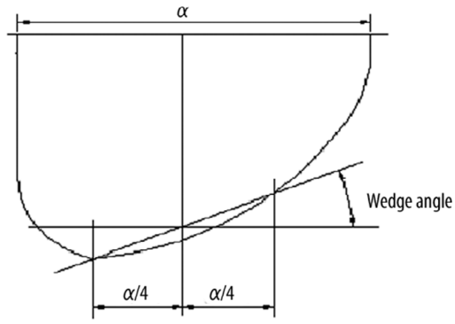

Figure 1. Definition of a wedge filter angle (α is a field width).

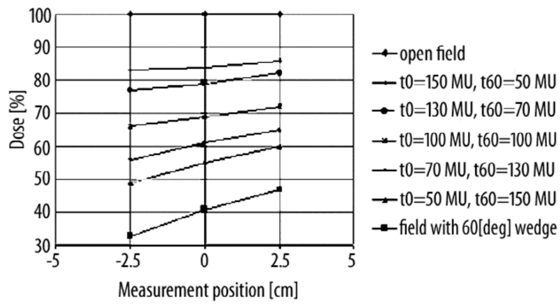

Figure 2. Doses for 6 MV photons at the depth of 5 cm at the points along the wedge: in CAX (0) and at the distance of ±2.5 cm off the CAX for some selected combinations of irradiation time with (t_{60}) and without the wedge (t_0).

of the three points, the measured and normalized dose was fit to the percent depth dose (PDD) and the appropriate depth was read off. Finally, an isodose could be drawn for the three points above. Its inclination to the open field isodose was adopted as the predetermined wedge angle. The tangent of the wedge angle could be obtained by dividing the difference between depths for off-axis points by the distance between these points.

During the measurements the irradiation time was set to 200 monitor units [MU]. Doses were measured for various portions of the irradiation time with (t_{60}) and without wedge (t_0). The combinations of t_0/t_{60} were: 200/0; 150/50, 130/70, 100/100, 70/130, 50/150, 0/200. The least squares method was used to match the obtained angles to polynomials, thus making it possible to calculate times t_0 and t_{60} for the predetermined isodose angle.

In the stage of our experiment the measurements were made in a water phantom, with the use of an Ion Chamber Array LA-48 PTW and a Multidos dosimeter. The Array LA-48 allows obtaining a complete profile of the beam with 47 small ion chambers. Its measuring length is 37 cm, and the spatial resolution is 8 mm. The profile was measured along the wedge, and it passed through CAX. The irradiated field size was 20×20 cm (the maximum field with wedge filters). The measurements were carried out at the