Medical Dosimetry, Vol. 31, No. 3, pp. 201-208, 2006

0958-3947/06/$–see front matter

doi:10.1016/j.meddos.2006.04.002

RELATIVE ELECTRON DOSIMETRY USING THE SCANDITRONIX-WELLHÖFER BEAM IMAGING SYSTEM-2G

KIRSTEN NYGAARD, M.SC., ODD HARALD ODLAND, PH.D., and LUDVIG PAUL MUREN, PH.D.

Department of Oncology and Medical Physics, Haukeland University Hospital, Bergen, Norway; and Section of Oncology, Institute of Medicine, Medical Faculty, University of Bergen, Bergen, Norway

Abstract—The Beam Imaging System 2G (BIS-2G) from Scanditronix-Wellhöfer is a two-dimensional (2D) charge-coupled device (CCD)-camera that measures the scintillation light produced by incident radiation. We examined the performance of the BIS-2G as a tool in quality control of patient boluses. In an attempt to simplify the production of the patient boluses, bolus edges were built as staircases and the dose distributions were measured and compared to the dose profiles below corresponding sloped bolus edges. Perspex plates covering half the irradiated field were used as generalized bolus edges. All BIS-2G measurements were performed using buildup of solid water while a diode measured corresponding dose profiles in a water phantom. Below the patient boluses, regions with doses < 95% and > 107% of the prescribed dose were defined. Below the edge, the relative doses measured by the BIS-2G were generally within 3% in dose and 3 mm in position compared to the diode measurements. Close to the field edge below the bolus, the BIS-2G measurements were in some cases as much as 7% lower in dose than the diode measurements. The BIS-2G measurements revealed hotspots below the patient boluses covering 1–16% of the total irradiated area. The highest point dose measured below the patient boluses ranged from 105% to 125% of the prescribed dose. For all bolus thicknesses, each edge in the staircase bolus caused a fluctuation in dose and increased the maximum dose compared to the sloped edge. For several cases, the maximum dose increased with 13% in relative dose, *e.g.*, from 103% to 116%. The BIS-2G was found to be a useful tool in quality control of patient boluses, revealing large hot spots in the treatment volume for several patients. Bolus edges built as staircases cause considerable dose fluctuations and increase the maximum dose, and can therefore not be recommended.

Key Words: **Electron dosimetry, Bolus compensator, Beam Imaging System-2G.**

INTRODUCTION

Electron dosimetry is normally performed in a water phantom to achieve full scatter conditions. A diode or an ionization chamber is used to measure the dose distribution in a raster pattern in depth or in a plane normal to the beam. Although these methods are considered the most accurate way to obtain information about the dose distribution in a radiation field, they are time-consuming both with regard to setting up the water phantom and performing the measurements.

At our institution, post-mastectomy chest wall irradiation is performed with an anterior electron beam. An individually customized tissue equivalent compensator (bolus) is designed for each patient based on measurements of the chest wall thickness from computed tomography (CT) images of the patient in treatment position. The appropriate beam energy is selected to make the deepest 90% isodose curve cover the target area and the total dose of 50 Gy is prescribed to the 95% isodose curve in 25 fractions of 2 Gy. The dose distribution in depth is modulated by the thickness of the bolus. The edge between the different bolus layers in the irradiated field cause a variation in the dose distribution and may cause hot and cold regions in the target volume below the edge.[1] The edges between the different layers are sloped to reduce these dose variations. Recently, we showed that for boluses between 10- and 30-mm thickness, a 30° angle on the edge gave the dose distribution with the smallest dose variations compared to edges of 45°, 60°, and 90°. However, for a 5-mm-thick bolus, the 90° edge

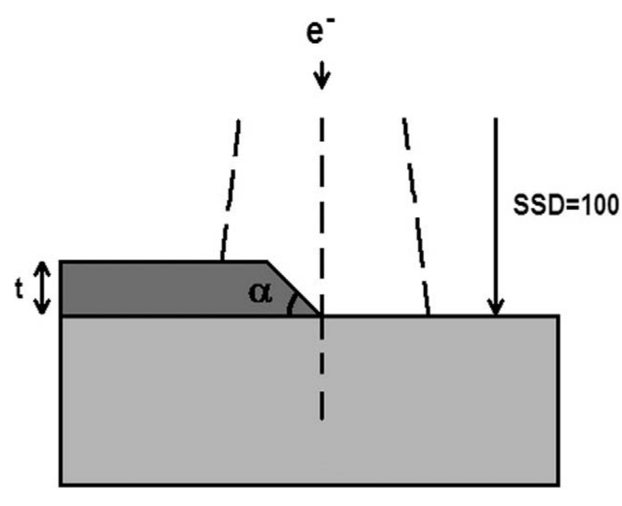

Fig. 1. Schematic illustration of the measurement geometry illustrating the positioning of the bolus in the irradiated field, with the thickness of the bolus (t), the angle of the bolus edge (α), and the source-to-surface distance (SSD).

Reprint requests to: Kirsten Nygaard, Medical Physics Section, Department of Oncology and Medical Physics, Haukeland University Hospital, N-5021 Bergen, Norway. E-mail: kirsten.nygaard@helse-bergen.no

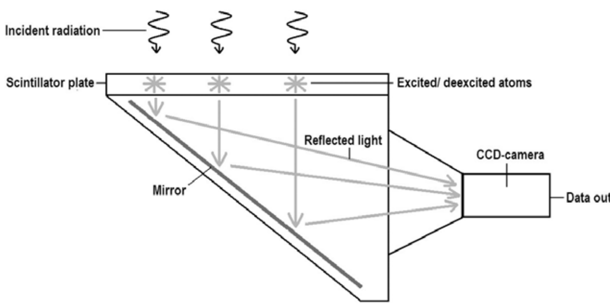

Fig. 2. Schematic illustration of the performance of the BIS-2G detector system.

did not cause significantly larger dose variations below the edge than a 30° edge when irradiated with a 9- or 15-MeV electron beam.[2]

The BIS-2G is a 2-dimensional (2D) charge-coupled device (CCD)-camera and measures the scintillation caused by the incident radiation in a scintillation plate exposed to the beam. The BIS-2G is easy to set up and apply, and it measures an entire beam profile with a spatial resolution of 1 × 1 mm^2, and provides more data than typical radiation detectors such as a diode or an ion-chamber array.[3] However, the BIS-2G measures the dose distribution with no backscatter contribution, and the first aim of this study was to examine the performance of the BIS-2G in relative electron dosimetry. This was done by comparison with measurements below the same generalized bolus edges using a diode in a water phantom. Based on the results of this study, we used the BIS-2G to measure the dose distributions below patient boluses used in the clinic, looking for hot and cold spots in a plane within the treatment volume. As the 90° edges of a 5-mm-thick bolus gave acceptable dose variations, we wanted to simplify the production of the patient boluses by making bolus edges consisting of steps of 5 mm, and compared dose profiles below these staircase edges to profiles below corresponding sloped edges. All profiles were measured using the BIS-2G.

METHODS AND MATERIALS

Generalized bolus edges

The generalized bolus edges used in this study were made of Perspex plates with the same mass- and electron-densities as the bolus material applied in clinical routine at our institution (Elasto-gel, Southwest Technologies Inc., MO[4]). The plates were 20 × 20 cm^2 and had thicknesses of 5, 10, 15, 20, 25, and 30 mm. The 4 sides were sloped with angles of 30°, 45°, 60°, and 90°. The plates were irradiated with a 10 × 10 cm^2 field using both 9- and 15-MeV electron beams. A Varian 2100 C/D Clinac® (Varian Associates Inc., Oncology Systems, CA) was used. The toe edge of the lowermost plate was aligned with the x-axis at isocenter, *i.e.*, the plates covered half the field (Fig. 1). The source-to-surface distance (SSD) to the part of the field not covered by bolus was set to 100 cm.

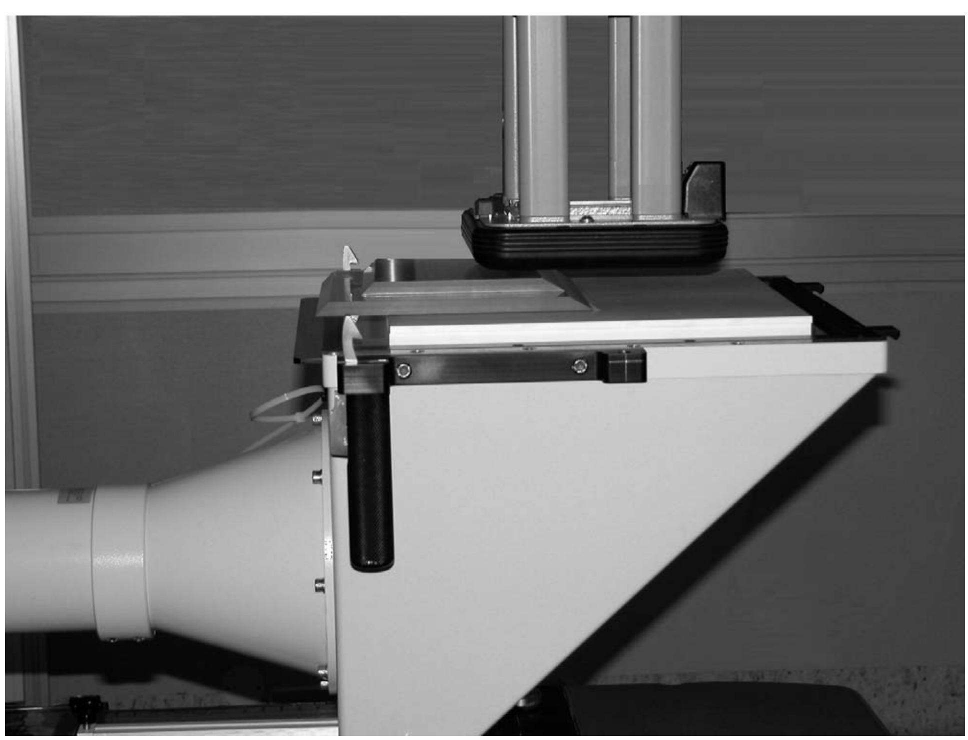

Fig. 3. A photo of the measurement setup showing a 20-mm-thick bolus edge with a 30° angle placed on 2-cm buildup on the BIS-2G.