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Original research article

Technical and dosimetric aspects of the total skin electron beam technique implemented at Heidelberg University Hospital

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ABSTRACT

Aim: To give a technical description and present the dosimetric proporties of the total skin electron beam technique implemented at Heidelberg University Hospital.

Background: Techniques used for total skin electron beam irradiation were developed as early as in the 1960s to 1980s and have, since then, hardly changed. However, new measurements of the established methods allow deeper insight into the dose distributions and reasons for possible deviations from uniform dose.

Materials and methods: The TSEI technique applied at Heidelberg University Hospital since 1992 consists of irradiating the patient with a superposition of two beams of low energy electrons at gantry angles of 72° and 108° while he is rotating in a standing position on a turntable at 370 cm distance from the accelerator. The energy of the electron beam is degraded to 3.9 MeV by passing through an attenuator of 6 mm of Perspex. A recent re-measurement of the dose distribution is presented using modern dosimetry tools like a linear array of ionization chambers in combination with established methods like thermoluminescent detectors and film dosimetry.

Results: The measurements show a strong dependence of dose uniformity on details of the setup like gantry angles.

Conclusions: Dose uniformity of −4/+8% to the majority of the patient's skin can be achieved, however, for the described rotational technique overdoses up to more than 20% in small regions seem unavoidable.

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1. Background

Total skin electron irradiation (TSEI) is a radiotherapy technique used in the treatment of a number of malignant diseases occurring in the skin such as mycosis fungoides, Sézary syndrome or Kaposi's sarcoma.[1–9] TSEI has shown good and even excellent results in experiences observed over many years[2,3,5,6] with long term control of early staged disease,[2,3,5,6] and also satisfactory palliative results.[2,8,9] These diseases can affect large areas or even the total surface of the skin so that the target in radiotherapy may be equally large. Doses required for the treatment of cutaneous lymphoma are in the region of 30–36 Gy[1,4,5] although experiences with lower doses of 10–20 Gy are discussed.[5,6] Generally, radiotherapy is performed with low energy electrons with a penetration of less than 1–2 cm which exclude other organs at risk than the skin itself. The tolerance dose of healthy skin is around 50 Gy,[10] so that the risk of therapeutic doses around 36 Gy is acceptable, except for the eye lens and toe- and fingernails which can be excluded by additional shielding during treatment.

Treating the entire skin of an adult human with his arms stretched overhead requires a sufficiently uniform radiation field of around 50 cm × 220 cm. Physical conditions for large area electron treatment have been described in literature.[11–13] Techniques to produce large electron fields include the superposition of two fields at two gantry angles,[11–16] matching multiple fields,[3,17] producing single large fields with a special beam flattening filter,[18] using multiple rotational arc fields[19] or by movement of the patient through a shorter field on a translation couch.[20] Treating the complete circumference of the patient is achieved by either irradiating the patient with static fields from various directions (which requires different positioning of the patient for each field)[11,12,16] or by rotating the patient in the beam.[14,15,18] The technique used at Heidelberg University Hospital was developed in 1992 and applies a combination of the methods described by AAPM Rept. 23.[12] and Müller-Sievers et al.[14,15]. Aim: This work reports a recent re-measurement of the Heidelberg set-up for total skin electron beam therapy which was necessary after a software upgrade of the accelerator which caused a reduction of the applicable field size.

2. Materials and methods

2.1. *Patient set-up for TSEI*

TSEI at Heidelberg Department of Radiation Oncology is applied with a Siemens Oncor accelerator by rotating the standing patient in a superposition of two large fields of low energy electrons at gantry angles of 72° and 108° (Fig. 1). The patient stands on a turntable with axis of rotation at 370 cm distance from the accelerator focus. The patient holds a swivel bar to keep his arms stretched and to support his stand. To help weak patients stand during the long treatment times of around 30 min, the patients can optionally lean against a bicycle seat mounted on a post behind the patient.

During rotational irradiation, parts of the inner leg of the patient are shielded by the other leg. To reduce this effect, the patient stands in two swordsman-like positions, alternating the extended leg each day (Fig. 2). Remaining areas of skin which show insufficient reaction to the radiation are boosted with single fields of low energy electrons at clinical decision.

The motion of the turntable is initiated by the "beam on" signal of the accelerator and stopped on "beam off". Turntable motion is controlled by a photoelectric sensor which sends a signal to the accelerator to interrupt the irradiation, should the rotation stop. An electronic counter displays the number of rotations with a resolution of 1/10th. To ensure a minimum of beam overlap, the position at which irradiation stops at each fraction is noted, and the next fraction is started at this position.

Treating the entire skin of an adult human with his arms stretched overhead requires a sufficiently homogeneous radiation field of around 50 cm × 220 cm. The maximum collimator setting for electrons that can be run in patient mode by the accelerator Siemens Oncor is 33 cm × 33 cm at 1 m, produced

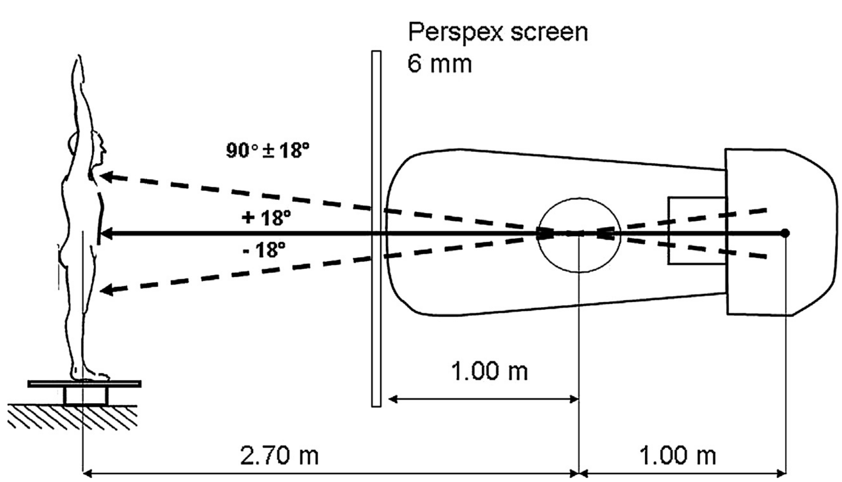

Fig. 1 – Patient setup for total skin electron beam irradiation (TSEI) at Heidelberg University Hospital. The patient stands on a rotating turntable at 3.70 m distance from the accelerator focus and is irradiated by two large superposed electron beams at gantry angles of 70° and 110°. The 6 MeV electrons from the accelerator are attenuated by a screen of 6 mm Perspex to an incident energy of 3.9 MeV at the patient.