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Original Article

# Experience of the Commissioning and Implementation the Total Skin Electron Therapy (TSET) at Siriraj Hospital

**Lalida Tuntipumiamorn, MD., Lukkana Apipanyasopon, MD., Piyanan Liammukda, MD., Khammook Krongyuth, MD., Chumpot Kakanaporn, MD., Porntip Iampongpaiboon, MD., Surat Vinijsorn, MD.**

*Division of Radiation Oncology, Department of Radiology, Faculty of Medicine, Siriraj Hospital, Mahidol University, Prannok Rd, Bangkok-10700, THAILAND*

## Abstract

**Objective:** TSET at our institution has been commissioned. Technique and dosimetry were investigated and reported.

**Methods & Materials:** According to the Stanford six-dual field technique, using a high dose rate (888 MU/min) mode 6 MeV electron, at 400 cm SSD, on Varian 23 EX linear accelerator, investigation for the optimal irradiation geometry and TSET dosimetric features were performed.

**Results:** Acceptable field symmetry was obtained at the gantry angle ± 17.5° from 90°. Using a 1 cm perspex scatterer, the electron mean energy was degraded from 6 MeV to 2.1 MeV. Depth of dose maximum was detected at the surface to a depth of 2 mm. with R80 and R50 were at 0.52 and 0.9 cm from the surface, respectively. Absolute dose to water at a calibration point from the dual gantry in the high dose rate mode delivery was 1.367 Gy/1000 MU. The overlap factor (B) in this study was found to be 2.93. Phantom dosimetry revealed the accuracy of delivered dose was within ± 5%. Skin dose distribution was within ± 10%, of the dose at prescription point and the x-ray background dose averaged over a phantom body was 0.58%. Dose homogeneity over the patient's flat surface varied only a few percents. But at the tangential surfaces, the 10-30% difference from the delivered dose were presented.

**Conclusion:** TSET procedure for our first mycosis fungoides patient was successfully commissioned and implemented to the patient. Acceptable dosimetric features with the high dose rate electron mode were achieved. At one year follow-up, a satisfactorily clinical result was detected from the given technique.

## Introduction

It is acknowledged that TSET have been used for both primary and secondary cutaneous malignancies involving large segments of a body such as mycosis fungoides, lymphoma cutis cutaneous lymphoma and Kaposi's sarcoma.[1-2] Various TSET techniques have been developed with an objective to obtain a large electron field to deliver a uniform specified dose over the entire skin surface to a particular depth.[3-5] However, in practice, it is difficult to deliver to the entire skin of a patient with the irregular surface without the overdose and underdose. Moreover, the photon contamination from electron beam may be a source of side effects for the patient. It is strongly recommended that, in each particular TSET technique, the x-ray background magnitude must be known accurately and that an acceptable level averaged over a body volume should be 1% or less of the total mean electron dose at dose maximum.[6] At our institution, based on availability of the standard linear accelerator, the Stanford TSET technique was selected for our first mycosis fungoides patient. With a large SSD, dual angled electron beams and the six patient positions geometry, a thorough commissioning procedure of the proposed TSET technique was carried out and discussed.

## Materials & Methods

With the 23 EX Varian linear accelerator at 400 cm SSD and the collimator size 36x36 $cm^2$, the optimal beam geometry was first investigated. To flatten and degrade the electron energy, a 1 cm thick perspex panel, was placed at 30 cm in front of a 1x1.8 $m^2$ in size wooden board. Vertical profiles in different dual gantry angles varied from $\pm$ 13.5° to 18.5° from a horizontal plane were quickly assessed at equal intervals by using 12 electron diodes. 2D spatial distribution at the angle presented the best field symmetry will be examined using the TLD-100 dosimeters. Appropriate placement for the beam degrader was also investigated at between 30 and 50 cm in front of the treatment plane.

Dosimetric characteristics including central axis depth dose and electron beam output at a calibration point will be carried out with the optimal geometry obtained from the previous step. The electron depth dose was measured to a depth of 10 cm using PTW Markus parallel plate (PP) chamber and solid water phantom. In addition, to investigate the efficiency of the beam degrader, depth dose curves and beam profiles between with and without the scatterer were compared. Possible inaccurate depth dose from a cable effect of PP chamber was reevaluated using TLD-100 chips.[7-8] Electron beam parameters ;depth of dose maximum, R80 and R50, were determined from the measured depth dose curve. Then, the electron mean energy and output determination at the calibration point were carried out according to the code of practice for high energy electron beams from TRS-398.[9]

Total prescription dose, 36 Gy, was planned to deliver in 9 weeks for this patient[10]. A whole skin irradiated with 2 Gy was achieved from 12 treatment fields in six-dual angles and six positions in two days. To calculate the monitor unit per treatment field, the overlap factor (B) was determined from the mean treatment skin dose as described by AAPM Report No.23.[11] In this study we used 72 TLD-100 caps distributed uniformly on the 26 cm in diameter x 35 cm in height polystyrene cylindrical phantom. After irradiating the phantom under a complete cycle from the TEST technique, the mean treatment skin dose along a circumference of the

cylindrical phantom was achieved. The overlap factor (B) was then calculated from the ratio of mean treatment skin dose to the absolute dose at the calibration point (0, 0, 0) received from a single-dual pair irradiation. The number of monitor units to deliver the prescribed dose per field per treatment cycle was obtained from the following equation(1). (Factor 0.5 means at the prescription point, 50% of dose delivered from the beam up and down)

Dose per field = (Prescribed dose x 0.5)/ B
Monitor Unit = Dose per field/Electron beam output .....(1)

To verify the dose distribution, beam calibration accuracy and dose penetration, humanoid phantom dosimetry was performed. Sixty-eight TLD-100 measurement points were chosen as recommended by Antolak JA, et al.[12] We also inserted 41 TLD caps at the various anatomical locations from head to pelvis inside the phantom to evaluate the x-ray background dose receiving from TSET.

Since the surface contour between the humanoid phantom and the actual patient are different, in vivo dosimetry with TLD was performed at the first fraction as a pretreatment quality assurance. Accuracy of the delivered dose, surface dose distribution, dose to critical organs (such as lens) will be assessed. The entire procedure was evaluated. Careful consideration was made by the team to ensure the quality of the treatment before applying to the patient.

## Results

### Optimal Treatment Geometry

Uniform vertical profile assessed from diodes was shown at the gantry angle of 72.5° and 107.5° (±17.5° from 90°). 2D spatial dose distributions at this dual gantry angle were remeasured using numerous of TLD-100 dosimeters. It was found that the field symmetry were observed within ± 5% on the entire length of 180 cm and 40 cm field width as seen in Fig. 1 and 2.

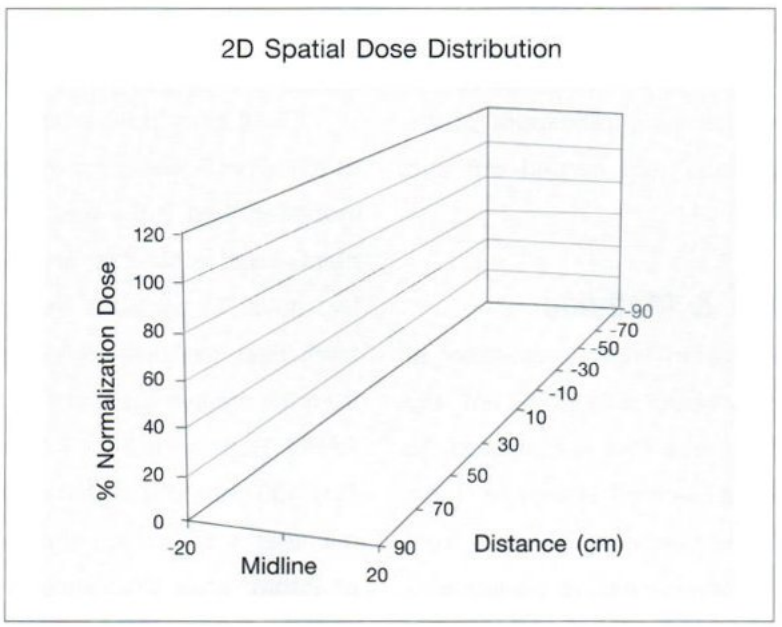
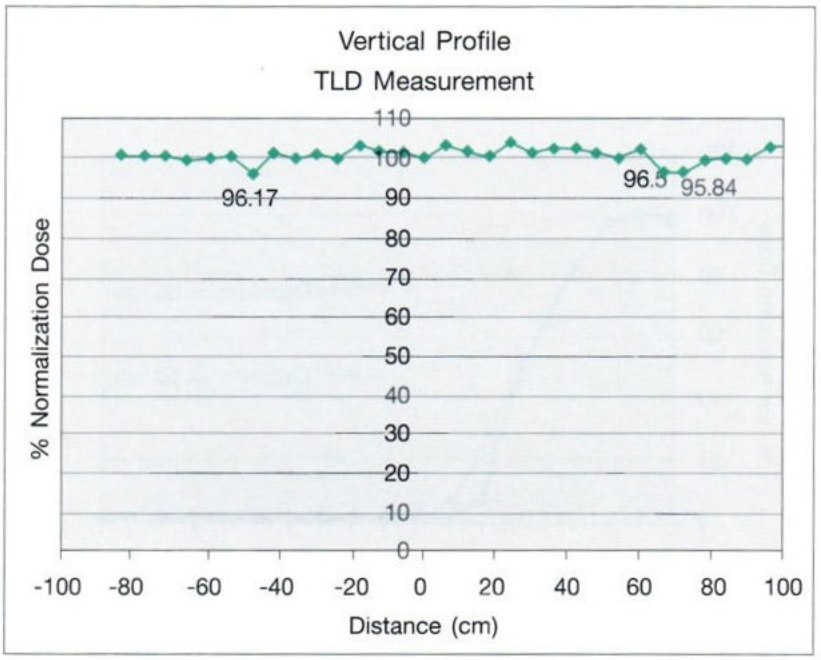



Fig. 1 2D spatial dose distribution at the gantry angles ± 17.5° from 90°



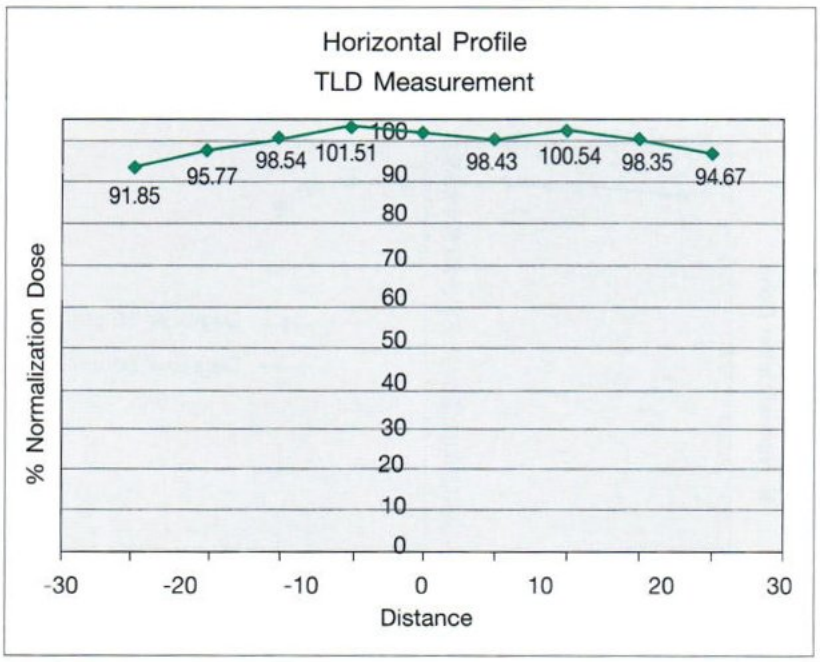
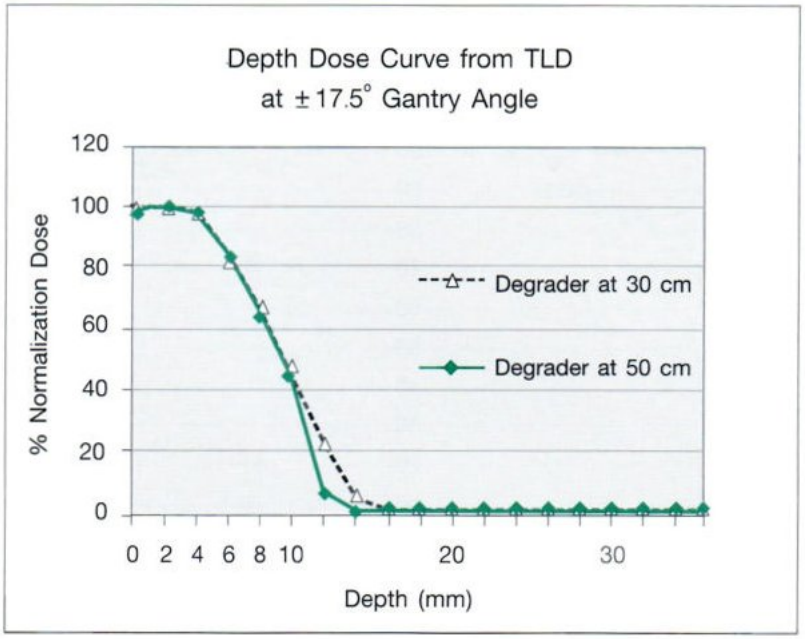




Fig. 2 Satisfactory field symmetry were found within ± 5% on the entire length of 180 cm and 40 cm field width



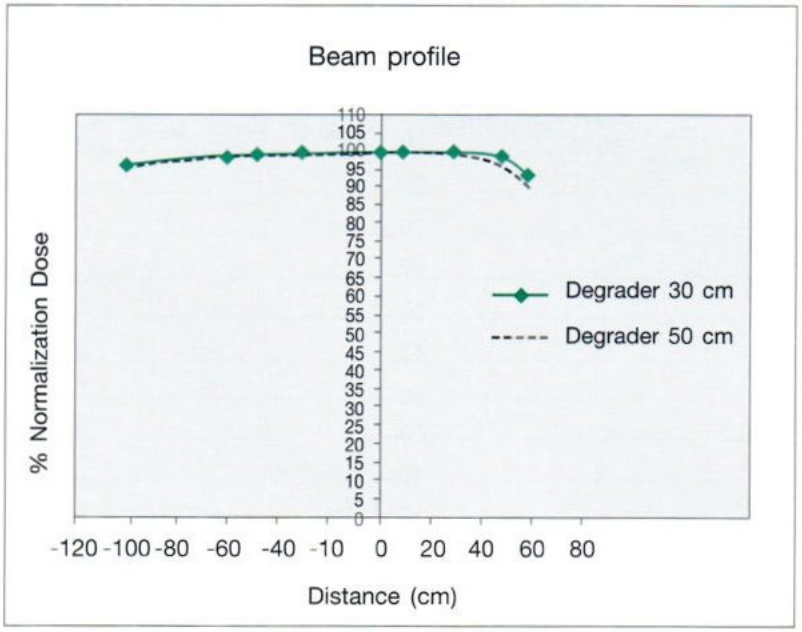




**Fig. 3** Electron profile and depth dose curve at gantry angles ± 17.5° from 90° compared between two different locations of the beam degrader.

Concerning about the location for the beam degrader, no difference of the beam characteristic between the 30 and 50 cm distance in front of the treatment plane were detected as shown in Fig. 3. However, in this study, the 30 cm distance was selected due to a slightly better surface dose.

### TSET Dosimetric Characteristics

It was clearly shown that using the beam degrader, the higher surface dose and shallower depth dose were obtained when compared with the open beam as seen in Fig 4. Depth of dose maximum was presented at the surface to a depth of 2 mm. and beam penetration, R80 and R50, were at 0.52 cm and 0.9 cm below the surface, respectively. The electron mean energy at the treatment SSD was determined to be 2.1 MeV.

Accurate photon contamination dose when assessed with TLDs in humanoid phantom was found to be less than 1%. This result was in contrast to the PP chamber which the cable effect will increase the contaminated dose to the level of 12%.

### Beam Output at a Calibration point

TSET calibrated dose was evaluated at the calibration point located at (0,0,0) as shown in Fig 5. The output was determined by Markus PP chamber in the solid water phantom and was found to be 136.7 cGy /1000 MU from the dual gantry angles.

### The overlap factor (B)

With the 72 TLD measurement points, the result of the mean treatment skin dose from the six-dual fields, 1000 MU irradiation, on the cylindri-

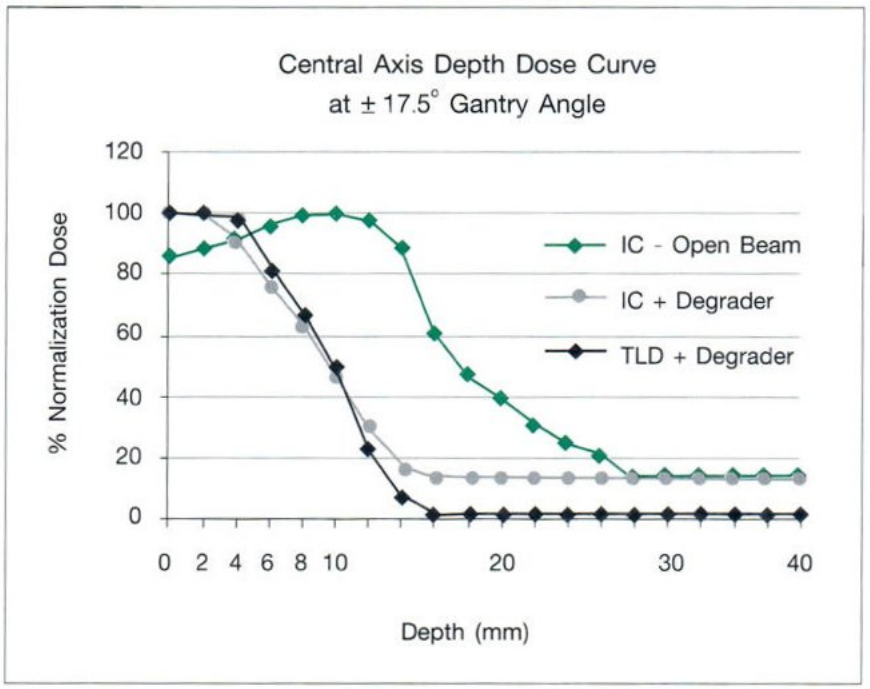



**Fig.4** Central axis depth dose curve compared between the presence and absence of the beam degrader, and between the parallel plate ionization chamber and TLDs.

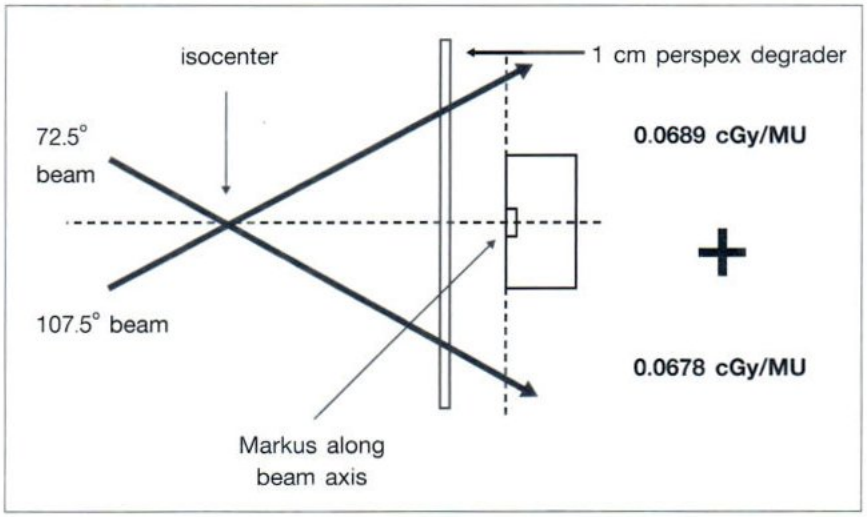



Fig.5 Absorbed dose measurement geometry and dose determination from each dual angle

cal phantom was equal to 383.33 cGy ± 5.54%. With the same geometry and number of MUs, the absolute dose at the calibration point received from a single-dual pair field was 130.83 cGy. Accuracy of the calibrated output was verified by the deviation of the measured dose from the expected dose (136.7cGy) and was about 4.29%. From previous study, typical B factor was reported in the range 2.5 to 3.1[11], and in this investigation was found to be 2.93. With the prescribed dose 2 Gy per cycle (in 2 days) with six dual beams per cycle, monitor units required for 72.50 and 107.50 treatment beam were 495 and 503 MU, respectively.

### Phantom Dosimetry

Dose verification on the rando phantom showed the measured dose at the prescription point was 94.8% of the delivered dose. Acceptable dose uniformity at the entire flat surface of the phantom was achieved as illustrated in Fig 6. Photon contaminated dose, measured from 41 TLD points, was found to be 0.58% of the total prescribed dose.

### In Vivo Patient Dosimetry

Owing to the difference between the humanoid phantom and the actual patient, dose verification on the first treatment fraction was performed. Results of the measured doses at various anatomical locations of the patient is presented in Table 1. Due to the obesity of the patient, some areas expected to be underdosed such as inframammary region, buttock skin fold were added in the experiment.

## Discussion

To provide a large, uniform and low energy electron field, the appropriate material and thickness of the scatterer-degrader was required for the TSET. Selection and placement of the degrader are strongly influenced by the need to minimize the background radiation.[13] Anacak Y, et al has reported

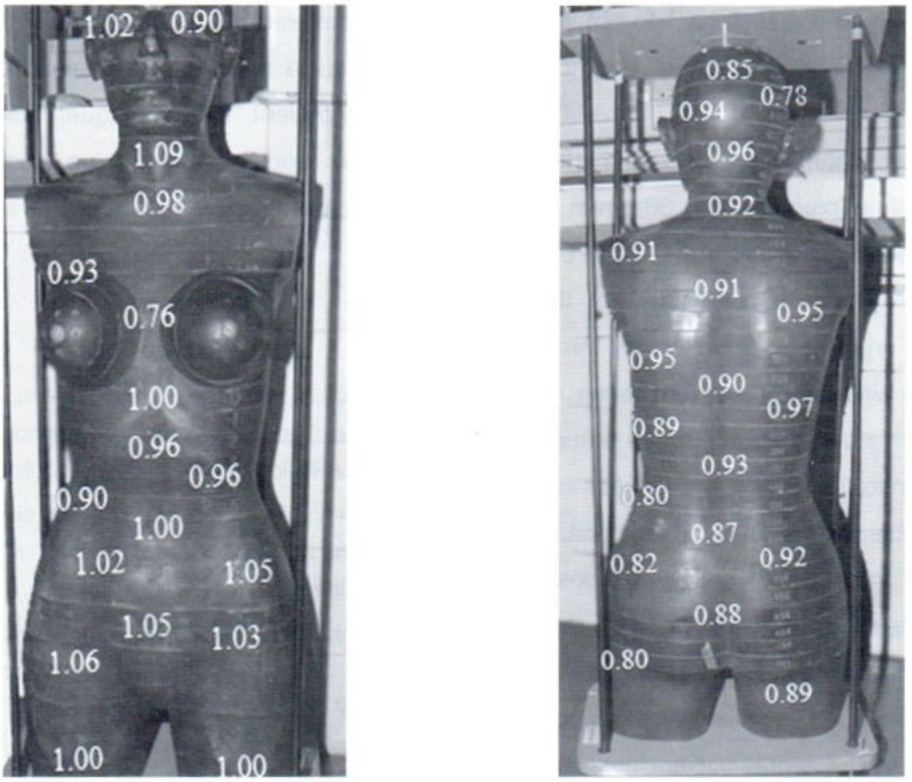



Fig.6 Surface dose distribution on humanoid phantom

Table 1 Patient's surface doses measured on the first fraction of treatment.

| Anatomical Location | % of Prescription Dose | Anatomical Location | % of Prescription Dose |
|---|---|---|---|
| Vertex | 81 | Eyelid (No shielding) | 84 |
| Neck | 89 | Axilla | 76 |
| Shoulder | 78 | Elbow | 86 |
| Breast | 98 | Under breast | 70 |
| Hand | 89 | Finger | 92 |
| Ant Abdomen (prescription point) | 96 | Post Abdomen (prescription point) | 104 |
| Lat Abdomen | 103 | Buttock | 73 |
| Ant Thigh | 89 | Medial Thigh (close to perineum) | 31 |
| Mid dorsal foot | 86 | Toe | 100 |

that, the thicker the beam degrader, the worse the dose homogeneity at the surface.[14] To obtain better dose homogeneity, a thinner beam degrader was suggested.

In this investigation, we used our old 1 cm thick perspex panel placed at the 30 cm in front of the treatment plane as a beam degrader. Both the acceptable background dose (0.58% of the prescription dose) and the dose uniformity throughout the flat surface, within ± 10%, were taken.

About the dose homogeneity on actual TSET patient, dose uniformity within ± 15% was reported to be acceptable by several publications.[15-17] In our study, the variation of measured dose from prescription dose on the flat surface of the body, was within 10%. However, due to the four oblique treatment positions, in addition to, the size of the patient, doses at the tangential and self shielding areas such as shoulder, axilla, elbow, underbreast and buttock, showed a lower dose from 70% to 78% of the prescribed dose. These results were found to be comparable to those of past studies.[14,16] No overdose was seen for thin areas such as hands, fingers and toes, of the body.

For dose to critical organs, such as lens of the eyes, using external wax shields (about 3 cm thickness), the lens dose were reduced from 84% to approximately 10% The data suggested using the internal eye shielding should be more suitable. Underdosed areas including soles of feet and the perineum were considered by the physician to be subject to local boost fields during the TSET was performed.

## Conclusion

TSET for our first mycosis fungoides patient was successfully commissioned and implemented to the patient. Acceptable dosimetry with the high dose rate electron mode was achieved. At one year follow-up, a satisfactorily clinical result was found for this patient. The technique was experienced as complex, and time consuming to develop; rigorous quality assurance was needed as well.

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