

QUALITY CONTROL OF BREAST IRRADIATION WITH THERMOLUMINESCENT DOSIMETER

Puntiwa Insang, MSc.^{*}, Sivalee Suriyapee, M Eng.^{**},
Taweap Sanghangthu, MSc.^{*}

^{*} Department of Radiology, King Chulalongkorn Memorial Hospital

^{**}Department of Radiology, Faculty of Medicine, Chulalongkorn University

Abstract

Objective : Radiation therapy is the one modality of treatment in breast cancer. The important process in radiotherapy is patient positioning that should remain the same for a course of treatment in 25 fractions. The aim of this work is to measure the patient dose during external beam irradiation with the thermoluminescent dosimetry (TLD) to observe the dose delivered to assure the reproducibility of patient positioning throughout the course of radiation treatment.

Materials and Methods : The TLD-100 chips (LiF, 3.2 × 3.2 × 0.89 mm³) were calibrated at 100 cGy with 6 MV photon beam of Varian Clinac 21EX. The TLD chips were loaded into the plastic tube with 3 chips per tube. Ten patients in breast cancer irradiated with 3 dimensional conformal tangential field techniques were studied. Five TLD tubes were attached on the skin surface of patient along the cross line in the center of the radiation field and three tubes were placed on the contra-lateral breast; medial, middle and lateral border. The gentian violet was marked at the patient skin to align the TLD tube, the TLD tubes must be placed at the same position in the next measurement. The frequency of one patient position verification with TLD measurement is 10 times for 25 fractions of a treatment course.

Results and Discussion : The uncertainty of TLD dose measurement was 3.78% with 95% confidence level. The maximum variation of TLD dose measurement in each point on the patient surface for 10 times irradiation was 3.8% for irradiated breast, which was comparable to the uncertainty of TLD. So the result illustrated more reproducibility of the patient positioning acquired from less variation of dose obtained. The points that showed high dose difference in irradiated breast and contra-lateral breast illustrated the misalignment of TLD due to the patient's anatomy. The less dose difference occurred in the fixed position of TLD.

Conclusion : The TLD dose measurement can be used to investigate the reproducibility of patient positioning in breast cancer.

Key words: breast irradiation, TLD dose measurement, quality assurance in radiotherapy

I. INTRODUCTION

Early stage breast cancer has a significantly higher survival rate with combined modality treatment of operation, chemotherapy and radiation (1). A good successful radiation treatment of breast cancer should provide long-term disease free survival with good cosmetic. The conventional technique for breast irradiation is two tangential fields. A uniform dose distribution within the target volume is designed by wedge or bolus. Nowadays, the 3-dimensional conformal radiotherapy technique (3DCRT) becomes using with breast cancer more than 2 dimensional (2D) technique because it is clarify in dose conformity and dose distribution uniformity in patients, which ensure that the treatment doesn't miss the tumor lesion. However, the dose reproducible cannot be assured due to the size and shape of the breast, and the set up of the patient. The important process in radiotherapy is patient positioning that should remain the same during simulation and all the course of treatment. For the breast positioning, the patient lay supine with appropriate immobilization of breast board and knee support. The set up of breast board is noted and will be used as a reference for daily set up. The patient position verification of breast irradiation is usually based on matching bony anatomy landmarks, as visible on Electronic Portal Images (EPIs) to the same anatomical landmark visible in the Digital Reconstruction Radiograph (DRRs) (2,3).

Many researchers have studied separately in patient positioning and investigated the radiation dose during the course of treatment (4,5), but nobody has studied in the reproducibility of patient position combined with the dose reproducible during the course of treatment. This study is a prospective study in breast irradiation. The research objective is to investigate the reproducibility of radiation dose in patient positioning in breast irradiation with thermoluminescent dosimetry (TLD). The TLD is used as a radiation detector due to small size, no need cable and easy to place on patient skin.

II. MATERIALS AND METHODS

The TLD used for this study is lithium fluoride crystal doped with magnesium and titanium (LiF:Mg, Ti) which is known as TLD-100. The dimension of the TLD chip is $3.2 \times 3.2 \times 0.89$ mm³. The TLD were calibrated in the virtual water phantom with 6

MV photon beam from Varian Clinac 21EX linear accelerator (Varian Medical System, Palo, Alto, CA), 5 cm depth, 12×12 cm² field size and monitor unit (MU) delivery equivalent with 100 cGy at depth of measurement. The uncertainty and linearity of dose range between 5-300 cGy of the TLD group were studied before dose measurement in patient.

The data were obtained in 10 breast cancer plans. Most of the patients were irradiated on left breast with 3D conformal tangential field technique. The dose distributions in target volume were improved by using bolus and wedge for three plans and the remaining plans were normal beams. The doses were measured with TLD in each patient for 2 times a week result in 10 times during the course of treatment. All patients were fully informed about the procedures and agreed to sign the consent form, they cooperated voluntarily well all over the course.

After calibration, TLDs were inserted into the plastic tube with 3 chips per tube. The number of each tube was labeled. Five of TLD tubes were placed on the skin surface of irradiated breast along the cross line through the center of field and 3 tubes were placed on the contra-lateral breast at medial, middle and lateral border. The gentian violet was marked on the patient skin to align the TLD tube. These must be placed at the same position in the next measurement. The TLD doses were measured 10 times for 8 positions in a course of treatment, 25 fractions of 200 cGy daily in each patient. The TLD doses were read with the reader (Harshaw model 5500, Bicon, Solon, Ohio, USA). The dose reading in each tube of TLD was averaged. For the course of treatment, the average and SD of dose reading were calculated in each position and %CV representing the reproducibility of dose in patient positioning in breast cancer was determined.

III. RESULTS AND DISCUSSION

Table I shows the source of uncertainty of TLD using in this study. The uncertainty of TLD is 3.78% at 95% confidence level. Figure 1 show the TLD dose reading related with the delivered dose between 5-300 cGy in linear curve, the linear regression is 0.9994.

Table I. The uncertainty of TLD using in this study

Source of uncertainty	SD	n	SD of mean	Probability distribution	Divisor	Uncertainty (%)
1. TLD uncertainty	0.056	1	0.056	Normal	1	0.056
2. TLD calibration						
- TLDs	0.005	1	0.005	Normal	1	0.005
- Ionization chamber	0.015	3	0.009	Normal	1	0.009
3. Calibration factor of ionization chamber (calibration certificate)	0.018	1	0.018	Normal	2	0.009
4. Measuring accuracy	3.27	3	1.888	Normal	1	1.888
Combined uncertainty						1.889
Expanded uncertainty (k=2) confidence level						3.778

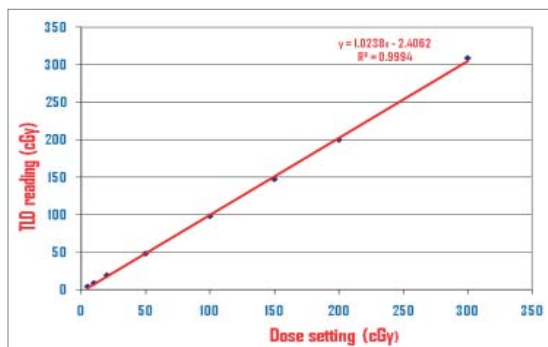


Fig. 1 TLD dose linearity at dose range between 5-300 cGy.

Figure 2 shows the distribution of TLD dose measurement of the irradiated breast. The range of TLD dose reading is 149.2 to 305.75 cGy, the maximum deviation is 3.8%. The TLD doses were varied at position 1 to 5 due to the curve of the patient's breast. However, the position no.3 was lower deviation for all plans due to the less error in TLD placing by using the nipple as the landmark. The high %CV was on position no. 1 and no. 2 because these positions located at irregular surface.

For the contra-lateral breast, The TLD dose readings were ranged from 5 to 9 cGy. Figure 3 shows the TLD dose distribution of the contra-lateral breast. The maximum %CV of contra-lateral breast was 9.1%. The high percentage of dose variation was due to the comparison was in the lower dose value.

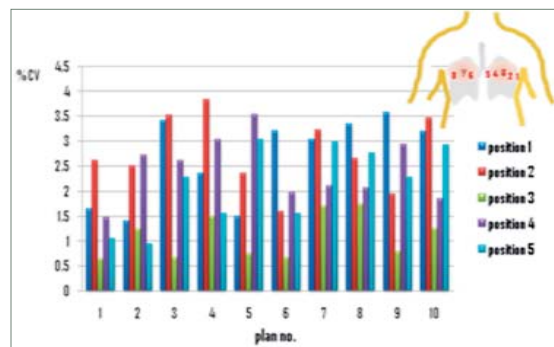


Fig. 2 The distribution of TLD dose measurement on position no.1 to no. 5 in irradiated breast.

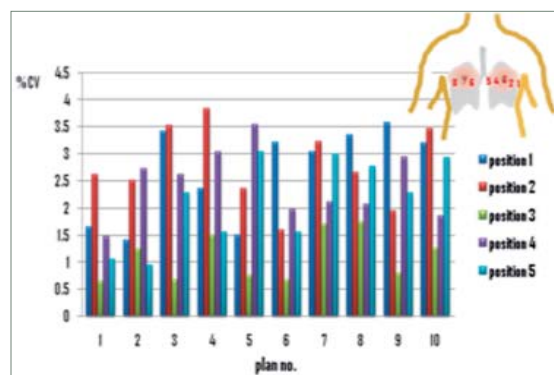


Fig. 3 The distribution of TLD dose measurement on position no.6 to no. 8 in contra lateral breast.

During the data collection, we found that the gentian violet marking at the patient skin had more effect in the uncertainty of TLD dose measurement due to TLD placing on patient skin. If the gentian violet fades when treating in the more fractions, the radiotherapist may add the skin marker. It was possible that the mark was shifted when compared with the first fraction.

From our previous study, the accuracy of patient positioning in irradiation of breast cancer was performed with EC-L film. The position error was within 2.5 mm in cranio-caudal and antero-posterior

direction. For this study, the variation of TLD dose measurement in the irradiated breast was within 3.8%, this was included the uncertainty of TLD 3.78% (95% confidence level). The TLD dose reproducibility illustrated the correct of patient reposition during the course of breast irradiation.

IV. CONCLUSION

The TLD dose measurement can be used to investigate the reproducibility of patient positioning in breast cancer.

REFERENCES

1. Dobbs J, Barrett A, Ash D. Practical radiotherapy planning. 3rd ed. New York: Arnold, 1999; 200-6.
2. Salm A, Strijbos J, Dijcks C, et al. Use of skin marker and electronic portal imaging to improve verification of tangential breast irradiation. *Radiother Oncol* 2009; 90(1): 106-9
3. Spadea MF, Baroni G, Riboldi M, et al. Patient set-up verification by infrared optical localization and body surface sensing in breast radiation therapy. *Radiother Oncol* 2006; 79(2) : 170-8
4. Grimaldi L, Onofrio G, Cilla S, et al. Breast in vivo dosimetry by a portal ionization chamber. *Med. Phys.* 2007 ; 34(3): 1121-7
5. Hamers HP, Johansson KA, Venselaar JL, et al. In vivo dosimetry with TLD in conservative treatment of breast cancer patients treated with the EORTC protocol 22881. *Acta Oncol.* 1993; 32(4): 435-43.

