Commissioning of OSLDs as an *In-vivo* Dosimeter in INTRABEAM Radiotherapy for Early Stage Breast Cancer.

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Abstract

A NOVEL treatment modality for early stage breast cancer is Intra Operative Radiation Therapy (IORT) using INTRABEAM radiation therapy system. It uses very low energy KV X-rays (~20keV) to treat lumpectomy site while limiting dose exposure to the normal structures . Dose to skin near the insertion site can be higher if there is not enough separation between the applicator and the skin. A purse- string stitch is used to keep the skin away from the applicator surface. *In-vivo* dosimeters (dose measuring device) can be used to measure and document skin dose while patient undergoing treatment. This study was designed to commission Optically Stimulated Thermoluminescence Dosimteres (OSLDs) for Low energy KV Xrays used for INTRABEAM therapy. The calibration was performed in tissue equivalent medium (water) and OSLDs were placed carefully in water to study its response with different radiation dose and Energy fluence. Plotted calibration curves were employed to estimate dose received by exposed OSLDs during treatment to measure skin dose.

Introduction

INTRABEAM radiotherapy system *(Figure 1)is* an intraoperative radiotherapy (IORT) system operates at 50kVp, 40 µA and produces x-rays with effective energy 20keV, 0.64mm Al HVL. It is used for treating early breast cancer by delivering 20Gy to the lumpectomy cavity(*Figure 2*). X-ray source or XRS probe (*Figure 3*) is connected to a spherical applicator (*Figure 4*) with diameter ranging from 2.5cm to 5cm depending on the size of the lumpectomy cavity. Dose of 20Gy is prescribed to the surface of the applicator (*Figure 5*) which delivers about ~10Gy to a depth of 5mm and ~5Gy to a depth of 10mm in water. Treatment time can vary from 30 minutes to 60minutes to deliver 20Gy to the applicator surface depends on the size of the applicator used.

Figure1:INTRABEAM Radiotherapy System

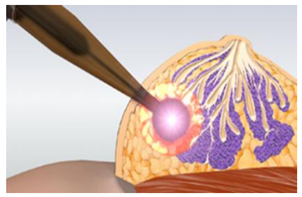

Figure 2: Applicator with X-ray probe positioned in the lumpectomy site. Treatment duration is ~20 to 50minutes to deliver 20Gy in single fraction to the lumpectomy site.

Figure 3: XRS probe

Figure 4: Applicator set, diameter ranging from 2.5cm to 5cm .

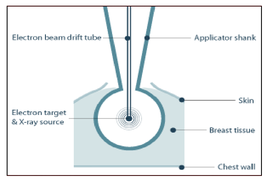

Figure 5: Cross sectional view. Separation between the skin and probe surface is critical for reducing the skin toxicity.

Figure 6: In-vivo dosimeter - OSLD

Methods and Materials

INTRABEAM system, using low energy X-rays of ~20keV effective energy, 0.64mm of Al HVL, deliver 20Gy to the spherical applicator surface. Optically Stimulated Luminescence Dosimeters (OSLDs – Landuer's +/-2% screened nanoDOTs - *Figure 6*) were used for this study. OSLDs were water proofed using 3M Tegaderm film and held by a custom made solid water holder. OSLDs were irradiated in water at distances from the applicator surface ranging from 5mm up to 40mm. Measurements were repeated three times for each depth. Depth dose data in water as provided by the manufacturer is applied for estimating the delivered dose to OSLDs. Irradiated OSLDs were analyzed using microStar reader after giving a minimum 10 minutes delay to allow suppression of ambient phosphorescence. Calibration curves (Dose vs Counts) were generated for each applicator/probe combination and validated by performing comparisons in plastic water using PTW MARKUS plane-parallel Ionization chamber and virgin OSLDs.

Results

Calibration curves were generated for spherical applicators with diameters ranging from 2.5cm to 5cm(*Figure 7 - 10*). OSLD calibration curves were validated by performing a set of measurements in water using OSLDs (*Table 1*). Measured dose were compared with expected dose, which were derived from the depth dose data (*Figure 11*) provided by the manufacturer. The results were within +/-6% as expected based on the OSLD sensitivity uncertainty and OSLD positioning uncertainty. The reproducibility of OSLD measurements were +/- 2% (1σ).

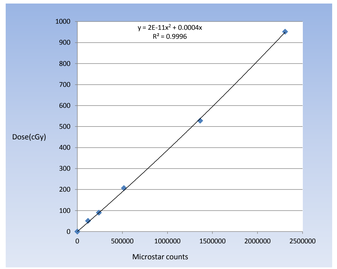

Figure 7:OSLD calibration curve generated for XRS probe with 2.5cm spherical applicator

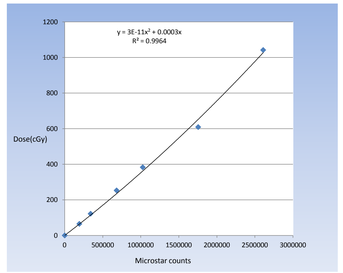

Figure 8:OSLD calibration curve generated for XRS probe with 3.0cm spherical applicator

Applicator Size/Depth	Measured dose(cGy)	Expected dose(cGy)	% diff
25mm / d=3cm	92.2	90	2.44
30mm/d=2cm	266	250	6.4
40mm /d=2cm	257.9	244	5.7
45mm/d=2cm	280	283	-1.06
50mm/d=3cm	179.3	171	4.85

Table 1: Validation of the OSLD calibration curves used for In vivo dosimetry in INTRABEAM radiotherapy

Discussion

Skin toxicity can be an issue for patients undergoing INTRABEAM radiotherapy if the skin to applicator distance is not adequate. It warrants the importance of measuring and documenting skin dose. *In-vivo* dosimeter selected for this study was Optically stimulated Luminescence Dosimeters(OSLDs) made from Al_2O_3:C. OSLDS were widely been used as a *in vivo* dosimeter in external beam therapy. For Intraoperative radiotherapy using low energy kV X_rays currently used *in-vivo* dosimeters are radiochromic films and TLDs. OSLD materials over-responds to superficial and orthovoltage X-rays by a factor of 3-4 as compared to megavoltage X-rays or gamma rays. Measurements were performed in water at different depths to incorporate change in energy spectrum with depths and the change in OSLD sensitivity with energy and dose. Calibration curves were generated for each XRS probe/applicator combination.

Conclusions

OSLDs can be used for *in-vivo* dosimetry for intrabeam therapy and can accurately measure skin dose for patients receiving INTRABEAM therapy. Immediate reading and the ease of use provide added advantages to use OSLDs as an *in-vivo* dosimeter. This calibration method incorporates the change in energy spectrum with depth and hence the change in OSLD sensitivity with energy.

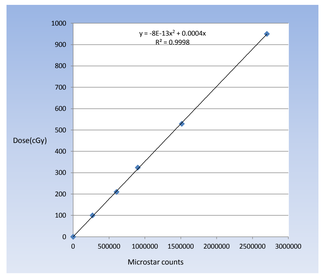

Figure 9:OSLD calibration curve generated for XRS probe with 3.5cm spherical applicator

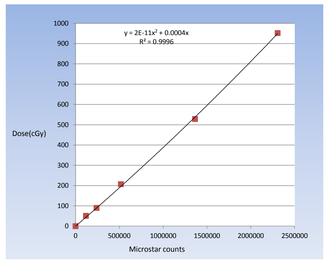

Figure 10:OSLD calibration curve generated for XRS probe with 4.0cm spherical applicator

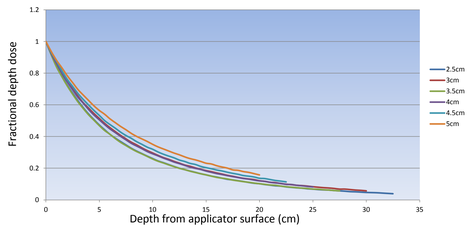

Figure 11: Fractional Depth Dose (FDD) data provided by the manufacturer

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