Investigation of In-Vivo Dosimetry for Deep Inspiration Breath-Hold Technique in Breast Cancer Radiotherapy

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Purpose

Breast cancer (B.C) is the most common of cancer among women worldwide. The treatment of B.C is decided, according to the stage of the tumor. External RT is one of treatment modality of B.C. Especially in patients with left B.C, reduction of irradiated heart of dose-volume quantities is crucial.

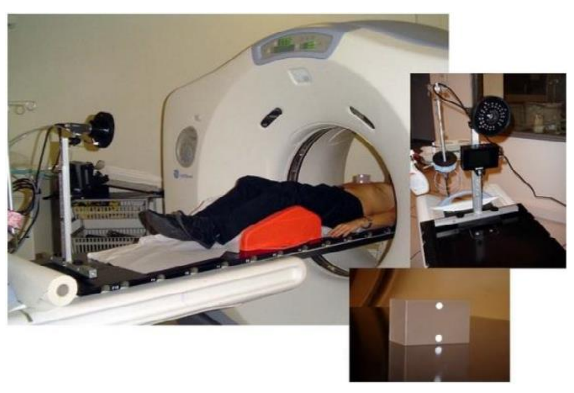
Organ movements controlled Breath-hold RT technique (BHRT) is one of the methods which is being used for the treatment of left sided B.C. Techniques to be applied to the patient should be controlled carefully. The most precise way to determine the accuracy of treatment is 'In-vivo Dosimetry (IVD)'.

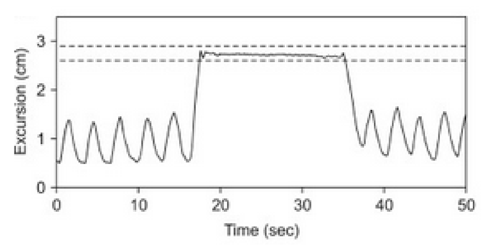
In this study, the availability of in-vivo dosimetry was investigated for high accuracy applicability of the deep inspiration breathhold (DIBH) RT technique.

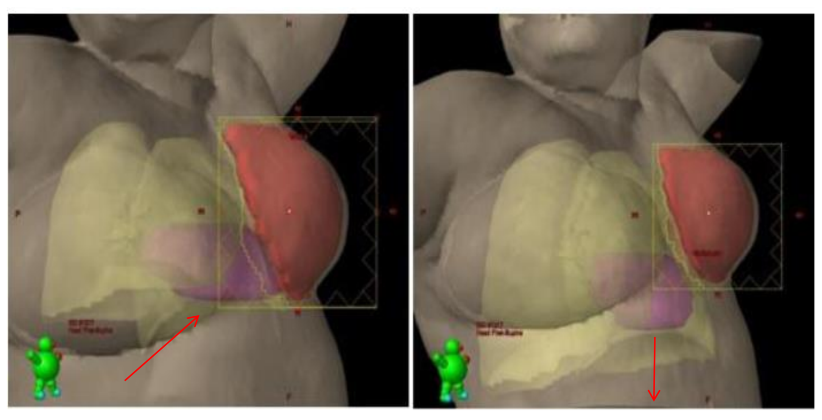
Methods

For IVD, TLD and OSL dosimetry systems were used. Before IVD measurements begin, open field surface dose responses of TLD and OSL dosimeters were investigated in different depths and field sizes. In our study, we chose markus parallel plate ion chamber as a reference dosimeter. Results were normalized to the dose at dmax (1.5 cm for 6 MV). Dosimeters are made from different materials and each of them has its own effective depth of measurement. For a decent surface dose measurement, water equivalent thicknesses (WET) of dosimeters should be taken into account. The physical effective point of measurement for Markus p.p. ion chamber was defined as 0.023 mm, at the inner surface of the proximal collecting plate. In this study, OSLs were used in closed configuration and the effective measurement depths for closed have been reported to be 0.85 mm. The use of TLD dosimetry requires great attention because the effective measurement distance changes according to the TLD material. It was taken the middle point of TLDs as the effective measurement distance, 0.4 mm. To obtain the dose at 0.07mm depth, an interpolation calculation was made by comparing the PDD data to a four-order polynomial fit of Markus chamber measurements in the buildup region. For TLD and OSL dosimeter measurements, extrapolation was made because their effective depths of measurement were just above the phantom. To compare the results, doses at the same points were obtained. For the same field sizes and depths, doses were calculated in Eclipse TPS, measured and calculated results were compared.

Figure 1







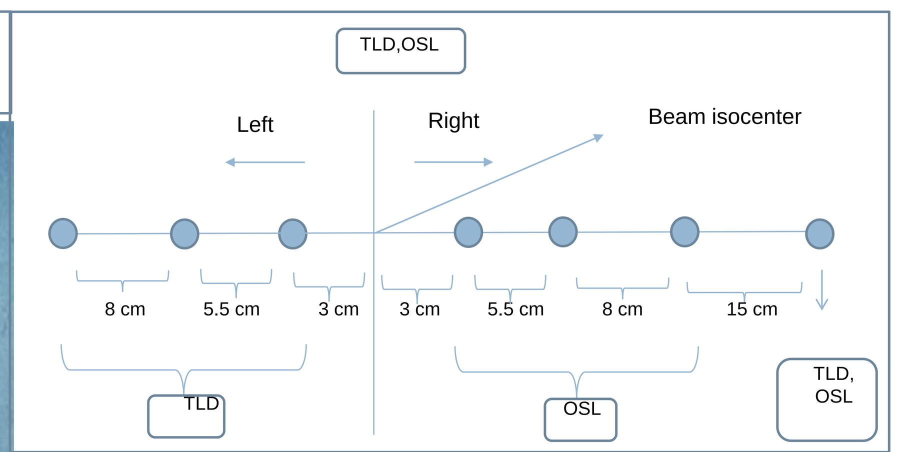
*The simulation of the patient with Breath-hold technique and the beam's eye views of different CT images (changing of the heart position by different breath modes (free breathing and breath-hold) is seen)

Early stage 10 left breast cancer patients underwent CT scans with breath control system and RT plans were created by using FinF technique. It was aimed to investigate the compliance of the doses received during the treatment with the intended doses of the patients by IVD. The skin depth was assumed to be 0.07 mm, the depth recommended in the ICRU 39 report.

Doses calculated in TPS were compared by measured doses which were obtained by placing the TLDs and OSLs at 3,5.5,8 and 15 cm (contralateral breast) distances from the center of the beam on the patient's skin and around the thyroid organ in every single fraction.

Figure 2

Placement of the TLD and OSL dosimetry systems on the patient.



Schematic representation of TLD and OSL placement.

Results

In the study, the skin dose measurements were taken with TLD and OSL at all points. The average differences between the measured and calculated doses were found to be -15.88% and -15.65% for TLD and OSL, respectively (Figure 3). The average median dose differences were obtained for TLD and OSL, respectively; 2.99% (min:-83.59; max: 46.87) and -9.65% (min:-90.25; max:57.56) for contralateral breast, 16.75% (min:-26.12; max: 91.35); -17.63% (min:-43.73; max:84.79) for thyroid (Figure 4).

Figure 3

	Eclipse TPS (surface)	TLD (surface)	% Difference	Eclipse TPS (surface)	OSL (surface)	% Difference
PATIENT 1	3589	4161	-13,74%	3431	3631	-5,52%
PATIENT 2	4028	4607	-12,56%	3550	3639	-2,45%
PATIENT 3	3846	4443	-13,43%	2695	3761	-28,35%
PATIENT 4	3773	4426	-14,76%	2697	3592	-24,92%
PATIENT 5	4041	4544	-11,08%	3111	3638	-14,48%
PATIENT 6	3085	3939	-21,66%	3134	3610	-13,19%
PATIENT 7	3659	4443	-17,65%	2875	3587	-19,84%
PATIENT 8	3441	4071	-15,47%	3102	3606	-13,98%
PATIENT 9	3367	4198	-19,79%	3016	3921	-23,07%
PATIENT 10	3473	4269	-18,65%	3360	3764	-10,73%
$\bar{x} \pm$ SD (n)	-15,88 ± 3,43 (10)			-15,65 ± 8,38 (10)		
Median (Min.-Max.)	-15,11 ((-21,68) - (-11,07)) p = 0,005			-14,23 ((-28,34) - (-2,45)) p = 0,005		

Field Doses

Figure 4

	THYROID			CONTRALATERAL BREAST (15 cm)		
	Eclipse TPS	TLD	% Diff.	Eclipse TPS	TLD	% Diff.
PATIENT 1	229	180,44	27%	330	2010,8	-84%
PATIENT 2	146	100,19	46%	251	308,0	-19%
PATIENT 3	322	271,20	19%	685	466,4	47%
PATIENT 4	172	104,65	64%	475	436,8	9%
PATIENT 5	190	217,24	-13%	524	373,2	40%
PATIENT 6	106	92,36	15%	283	457,11	-38%
PATIENT 7	185	165,87	12%	390	435,14	-10%
PATIENT 8	130	67,94	91%	372	355,50	5%
PATIENT 9	77	104,22	-26%	265	199,59	33%
PATIENT 10	129	119,37	8%	244	240,78	1%
$\bar{x} \pm$ SD (n)	24,28 ± 34,98 (10)			-1,58 ± 39,25 (10)		
Median (Min.-Max.)	16,75 ((-26,12) - 91,35)			2,99 ((-83,59) - 46,87)		

	THYROID			CONTRALATERAL BREAST (15 cm)		
	Eclipse TPS	OSL	% Diff.	Eclipse TPS	OSL	% Diff.
PATIENT 1	215	177,08	21%	301	3085,67	-90%
PATIENT 2	138	74,68	85%	210	231,88	-9%
PATIENT 3	302	480,68	-37%	663	1500,97	-56%
PATIENT 4	156	258,23	-40%	400	364,57	10%
PATIENT 5	173	304,34	-43%	455	288,77	58%
PATIENT 6	101	90,54	12%	248	478,39	-48%
PATIENT 7	169	311,39	-46%	356	554,13	-36%
PATIENT 8	123	135,65	-9%	328	317,21	3%
PATIENT 9	66	89,10	-26%	238	264,04	-10%
PATIENT 10	117	103,77	13%	222	198,90	12%
$\bar{x} \pm$ SD (n)	-7,04 ± 40,97 (10)			-16,70 ± 41,91 (10)		
Median (Min.-Max.)	-17,63 ((-43,73) - 84,79)			-9,65 ((-90,25) - (57,56)		

Out of Field Doses

Conclusions

Measured and calculated contralateral breast dose differences change from patient to patient. Similar to open field percentage depth dose measurements, surface dose measurements by using OSL and TLD have been found to be approximately 15% greater than TPS. OSL ve TLD results were found similar and both of them are suitable for skin dosimetry. Cumulative dose can be obtained by using OSL, therefore it can be prefered for IVD.