

CLINICAL EXPERIENCE IN THE USE OF TRANSIT DOSIMETRY FOR BREAST CANCER TREATMENT

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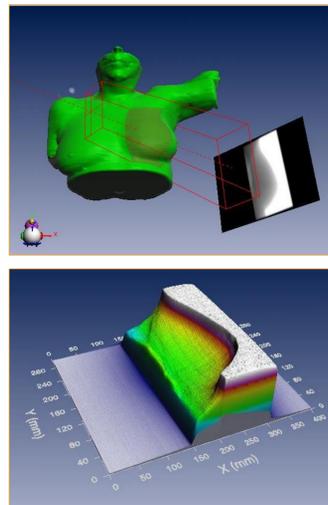
INTRODUCTION

After six years of experience in transit in vivo dosimetry (IVD), routine IVD controls for breast cancer treatments were finally introduced in 2012.

The immediate observation was that *the dose differences for breast treatments in supine position are worse than other dose differences for similar techniques, including breast treatments in lateral position* (see Figure 3).

Dosimetrical causes could be ruled out. But manually matching the measured images to the structures contoured on the CT scan resulted in better IVD results (see Figure 4).

The breast cancer treatment statistics for 176 patients (1361 controls, one control point) were analyzed. The causes and effects of the observations were investigated.



Figures 1, 2: Example of a breast patient case in EPIgray® [supine position, S4]

MATERIALS & METHODS

Treatment machines by Varian OCS:

Machine	Energies	EPID
Clinac 2	6MV, 20MV	AS500 IAS2 R-arm
Clinac 3 2100C/S	4MV, 10MV	AS500 IAS2 R-arm
Clinac 5 UNIQUE	6MV	AS500 IAS3 E-arm

Treatment Planning System:

Eclipse™ by Varian OCS

Treatment techniques:

Supine position	Lateral position
Field in Field	Opposing fields

Set up and IVD imaging:

Machine	Set up	Tolerance	IVD	Tolerance
Clinacs 2, 3	S ₀ + weekly	±3mm	S ₁ , S ₂ , S ₃	±7%
Clinac 5	S ₁ , S ₂ , S ₃ + weekly		S ₄ , S ₅ , S ₆	

*S_N: Fraction N

Analysis:

In vivo dosimetry software: EPIgray®, by DOSIsoft

Statistical software: Excel, MATLAB

Investigated parameters:

- Manual image shifts
- Treatment technique
- EPID in-treatment offset

RESULTS

Statistical analysis of the in vivo dosimetry results (July to November 2013): ②

	Number of patient plans	Average Dose Difference per control (%)
All sites	619	1.53 ±4.30
Lateral Breast treatment	148	0.76 ±3.18
Supine Breast treatment	192	2.39 ±3.36

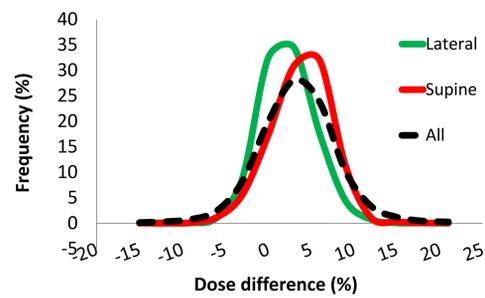


Figure 3: Distribution of the differences between planned and reconstructed dose.

Statistical analysis of the performed image shifts on supine treatment IVD images: ① ②

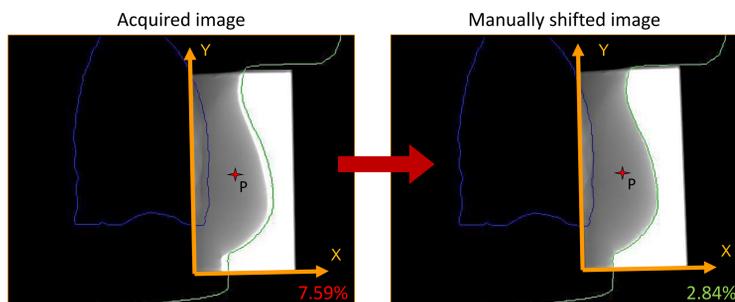


Figure 4: Example of a lateral (X) image shift in EPIgray® [CLINAC 5, supine position, S4].

Dose difference per control point P:

$$\text{Diff} = \frac{\text{Dose[plan]} - \text{Dose[EPIgray]}}{\text{Dose[plan]}}$$

Machine		Clinac 2	Clinac 3	Clinac 5
Average dose difference ± Standard Deviation (%)	Before the shift	3.1 ±3.9	2.8 ±4.9	6.6 ±5.4
	After the shift	2.8 ±3.0	1.8 ±3.5	3.6 ±2.9
% of control points out of tolerance	Before the shift	9.9	19.6	32.9
	After the shift	4.7	5.7	6.5
% of images shifted		25%	33%	56%

Lateral (X) shift example (Clinac 5): ① ③

Breast	Field	Average shift ± St. dev. (mm)
Right	Tangential, Internal	5.6 ±3.1
	Tangential, External	-5.4 ±2.4
Left	Tangential, Internal	-5.4 ±3.9
	Tangential, External	4.2 ±4.7

Shifted images (%)	55
Image shifts <3mm (%)	17
Shifts involving EPID offset (%)	0
Average EPID offset (mm)	0

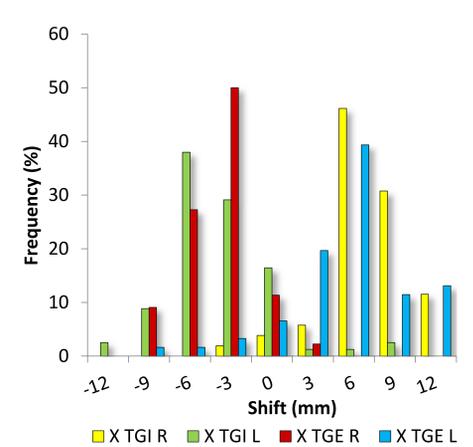


Figure 5: Distribution of the lateral image shifts for tangential external and internal fields (TGE, TGI), for the right and left breast, on the CLINAC 5.

Longitudinal (Y) shift example (Clinac 2): ① ③

Field	Average shift ± St. dev. (mm)
Tangential, Internal/External	-6.7 ±9.3

Shifted images (%)	25.4
Image shifts <3mm (%)	15
Shifts involving EPID offset (%)	51
Average EPID offset (mm)	-4.1 ±8.2

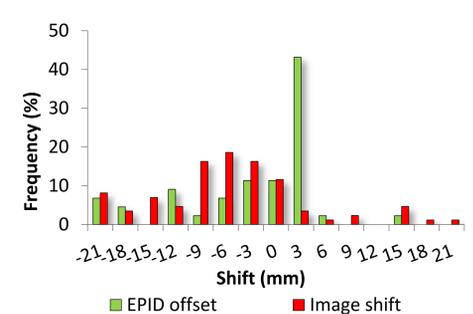


Figure 6: Distribution of the longitudinal image shifts and recorded EPID offset, on the CLINAC 2

CONCLUSION

- For this type of treatment: Matching the recorded IVD images with structures ⇔ matching the volume with the recorded equivalent depth
- Different image shift causes:
 - Lateral shifts: Set up error ↓ Tendency to protect the lung !
 - Longitudinal shifts: Set up error and EPID offset ↓ Asymmetrical fields, matching to an additional lymph node plan, mechanical EPID problems ...
- Set up errors:
 - If set up and IVD imaging planned for the same fraction: optimal to reduce false positive alerts
 - If not: good opportunity to follow set up errors and rectify/update the set up measures
- EPID offset:
 - now checked and corrected by EPIgray®
 - less false positive, and false negative, alerts resulting from voluntary and involuntary offsets.
- Next: Use the IVD system to follow the evolution of the breast and received dose over the course of the treatment => *one step closer to adaptive RT!*

References

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- Williams, M.V., McKenzie, A. Can we afford not to implement in vivo dosimetry? BJR. 2008, 681-684
- Nijsten SM, Mijnheer BJ, Dekker AL, et al. Routine individualized patient dosimetry using electronic portal imaging devices. Radiother Oncol 2007; 83:65-75.

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Together, let's beat cancer.

