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Medizinische Fakultät Mannheim der Universität Heidelberg

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Patient-Specific Online Dose Verification Based On Transmission Detector Measurements

dolphin®

J Thoelking, Y Sekar, J Fleckenstein, F Lohr, F Wenz, H Wertz

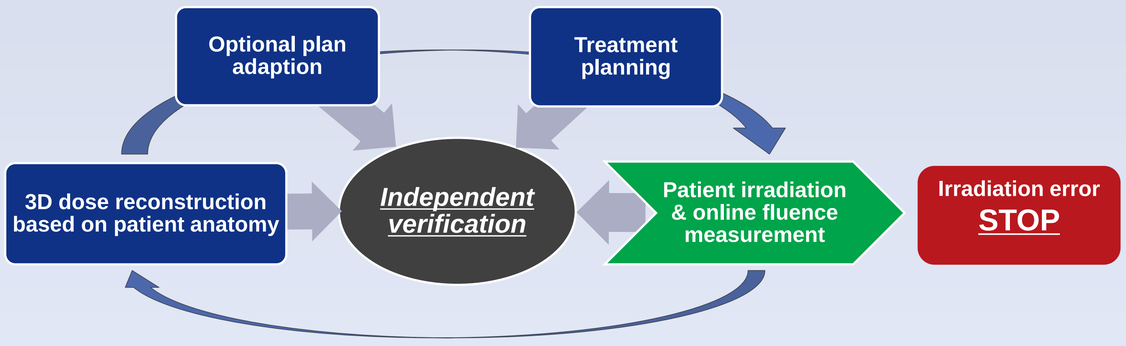
University Medical Center Mannheim, University of Heidelberg, Germany

Purpose:

From pre-treatment....

Treatment planning → QA-plan → Pre-treatment measurement → 2D- / 3D-verification → Patient treatment

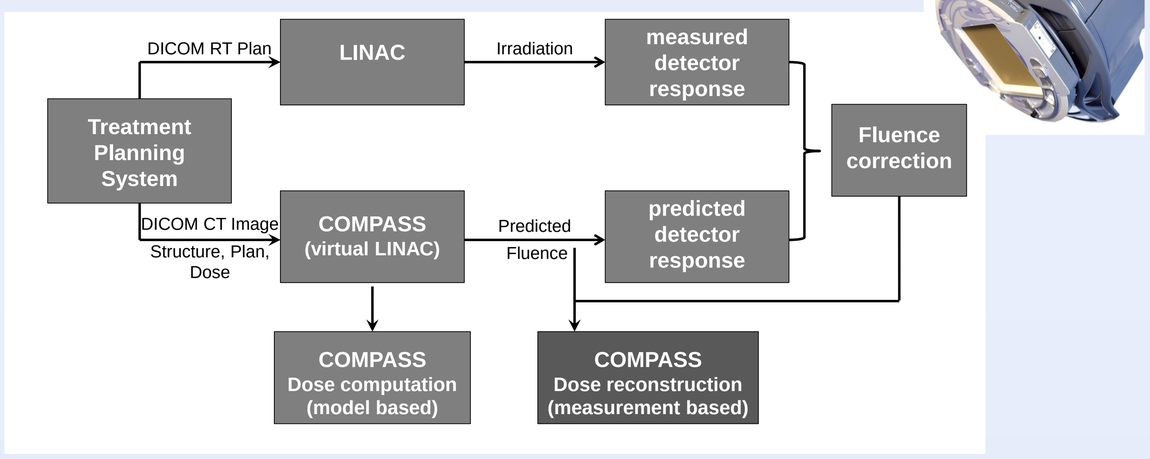
... to online IMRT-verification



The development and introduction of the new online verification should be performed in our department with the Dolphin transmission detector and corresponding verification software COMPASS (IBA Dosimetry, Germany).

This study presents the clinical performance, including dosimetric plan verification in 2D as well as in 3D and the error detection abilities of a new transmission detector (TD) for online dose verification.

How COMPASS works:

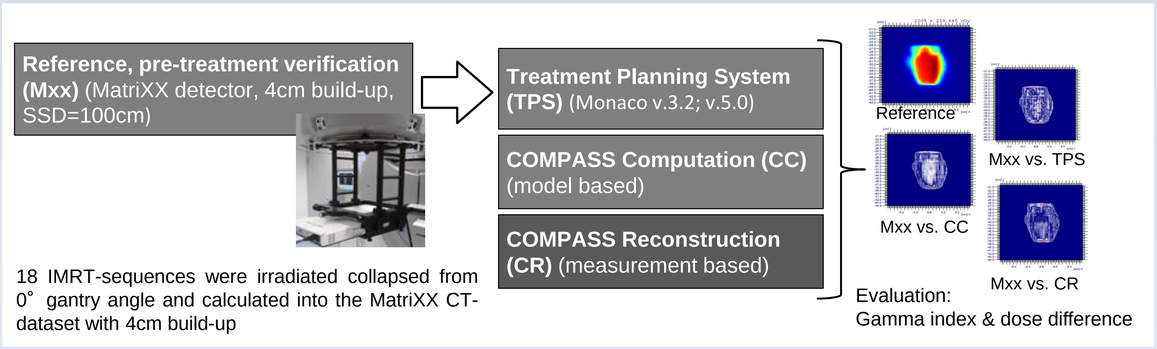


Methods:

To validate the dosimetric performance of the new device following test procedures were carried out:

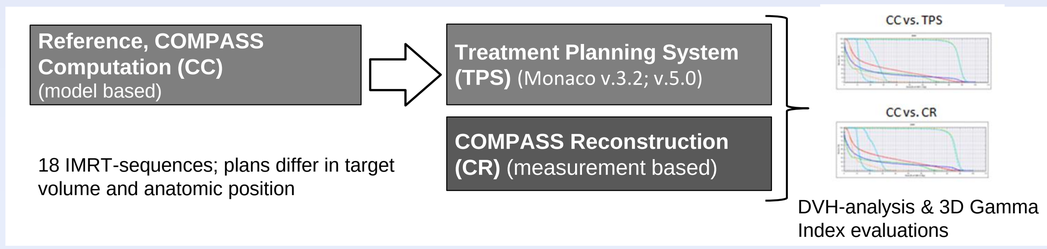
1) 2D Evaluation:

Comparison to a conventional 2D pre-treatment verification method



2) 3D Evaluation:

Comparison of the 3D dose reconstruction inside the patient anatomy by various dose volume indices and 3D Gamma evaluations against dose computation and TPS.



3) Sensitivity:

Different types of errors for leaf positions and for the LINAC output were introduced in a typical IMRT-plan.

- shift of both leaf banks towards the central beam axis from 0-5mm
- shift of both leaf banks in same direction from 0-5mm
- modifications of the number of MU from -10% to +10%

Results:

1) 2D Evaluation

Gamma Index evaluation

	Mxx vs. TPS	Mxx vs. CC	Mxx vs. CR	Mxx vs. TPS	Mxx vs. CC	Mxx vs. CR
Mean in (%) *	99.3	99.8	99.7	96.2	98.6	98.1
S. d. in (%) **	0.5	0.4	0.6	1.4	1.1	1.9
Min in (%) *	98.0	98.4	98.5	94.3	96.1	93.7
Max in (%) *	100	100	100	99.3	100	100
			γ(3%/3mm)			γ(2%/2mm)

Dose difference evalutaion

	Mxx vs. TPS	Mxx vs. CC	Mxx vs. CR	Mxx vs. TPS	Mxx vs. CC	Mxx vs. CR
Mean in (%) *	98.6	99.3	99.5	96.3	97.8	98.2
S. d. in (%) **	0.4	0.4	0.5	1.0	0.9	1.6
Min in (%) *	98.1	98.5	98.2	94.8	95.7	95.1
Max in (%) *	99.6	99.9	99.9	98.2	99.0	99.7
			Δ(±5%)			Δ(±3%)

* mean, minimal and maximal number of passing pixels for defined acceptance criterion
** S. d. = standard deviation

→ Excellent agreement for COMPASS compared to a conventional 2D pre-treatment verification method.

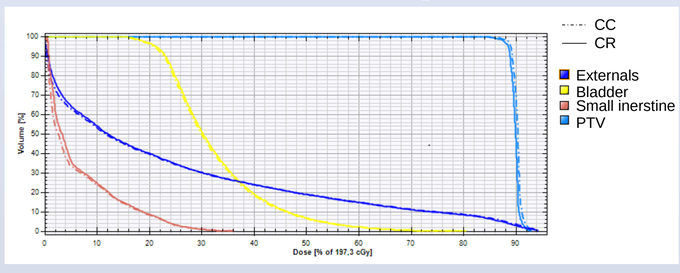
2) 3D Evaluation

3D – Gamma Index evaluation

	CC vs. CR	CC vs. TPS
Mean in (%) *	0.29	0.32
S. d. in (%) **	0.07	0.04
Min in (%) *	0.18	0.26
Max in (%) *	0.41	0.41
	γ(3%/3mm)	

The mean Gamma index was evaluated for the target volume

Dose volume histogram

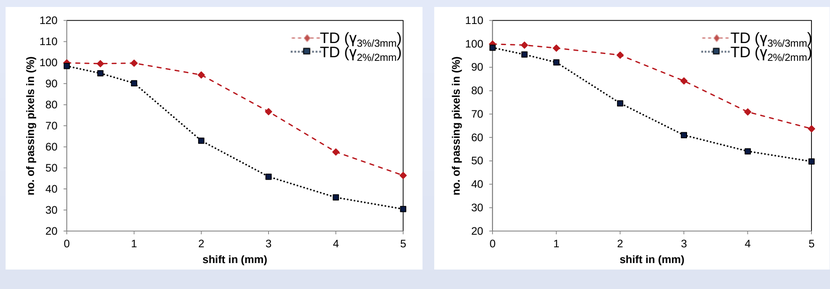


DVH of one representive prostate IMRT-plan; CC is compared to CR

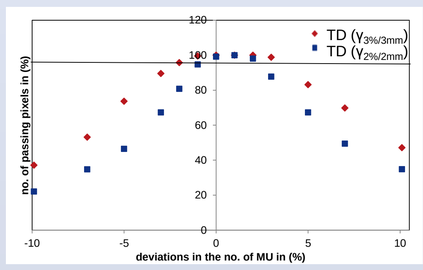
→ Good agreement for dose reconstruction based on TD read-out compared to dose computation.
Minimal dose underestimation (<2%) within the target volume when analyzin DVH indices.

3) Sensitivity

Error detection capability for leaf bank shifts



Error detection capability for deviations in LINAC output



Base line for 95% of pixels are passing the gamma criterion (pixel value >1)

→ Positional errors in leaf banks >1mm as well as errors in LINAC output larger than -2% and +3% could clearly identified with the TD.

Conclusion:

Since 2D and 3D evaluations for all IMRT and VMAT treatment plans were in excellent agreement with reference measurements and dose computation, the new TD is suitable to qualify for routine treatment plan verification.

contact: johannes.thoelking@medma.uni-heidelberg.de

This study was supported by IBA Dosimetry