ASTRO 2023 PAY IT FORWARD
PARTNERING WITH OUR PATIENTS

Feasibility of EPID Based In-Vivo Dosimetry for On-Couch Adaptive Radiotherapy

G. Razinskas[1], R. Schindhelm[1], J. Tamihardja[1], L. Bohorquez[2] and S. Wegener[1]
1 University Hospital Wurzburg, Department of Radiation Oncology, Wurzburg, Germany
2 LAP, Boynton Beach, FL

Uniklinikum Würzburg

INTRODUCTION

CBCT-based online adaptive radiotherapy allows treatment plans to be tailored to the anatomy of the day. For this purpose, dose optimization and computation are performed on a synthetic CT (sCT), i.e. a density map of the planning CT deformably registered onto the acquired CBCT. Plan-specific quality assurance of adaptive treatment sessions is currently limited to the vendor's own secondary dose calculation on the sCT.

AIM

The use of EPID recordings promises to detect deviations in beam delivery or patient position, incorrect sCT data, and anatomical changes. The purpose of this research was to evaluate the feasibility of using a new commercial technology available for in-vivo dose reconstruction based on EPID exit beam measurements.

METHOD

EPID images were recorded from on-couch adapted, hypofractionated treatment plans created for a prostate patient on an ETHOS linear accelerator (Varian Medical Systems, Palo Alto, CA). Secondary dose calculation of the adapted plan and 3D reconstructions from EPID images of the absolute dose delivered to the patient were performed with the in-vivo dosimetry system RadCalc (LAP Laser GmbH, Lüneburg, Germany, version 7.2). Comparison of reconstructed and planned delivery was conducted by means of gamma analysis and DVH metrics (Figure 1).

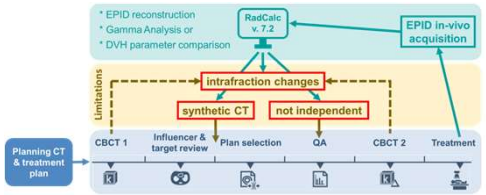


Figure 1: ETHOS on-couch adaptive workflow and the use of EPID-based in-vivo dosimetry with RadCalc to address potential limitations.

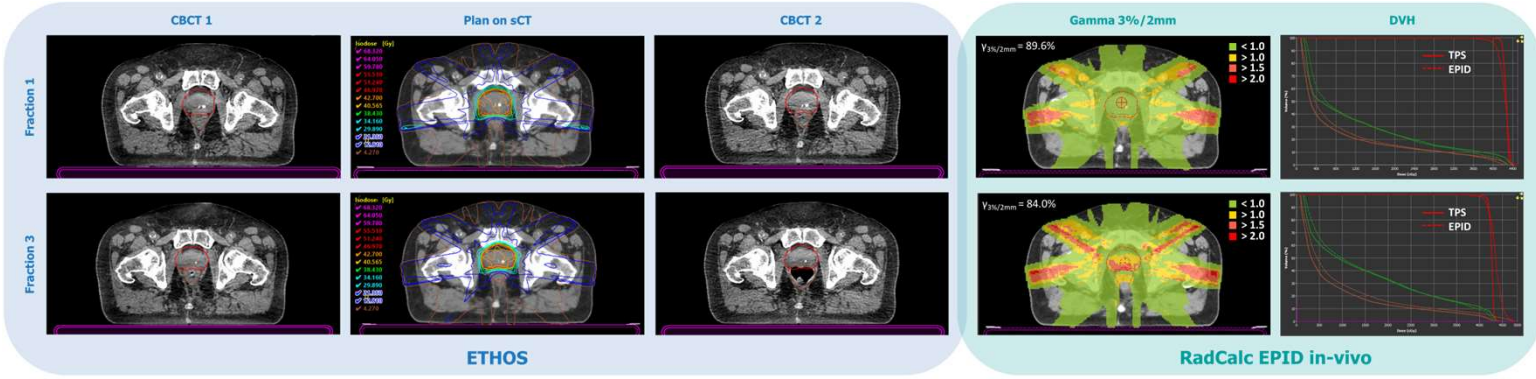
RESULTS

Comparisons of the intended plan to a second volumetric check (collapsed cone – CC algorithm), and to the EPID in-vivo calculation, produced gamma passing rates averaged over the 7 fractions of 98.3% and 88.8% at TG-218/219 [1,2] recommended criteria (Table 1). DVH metrics showed average deviations of -2.9% / -3.3% for PTV D95% and -1.2% / -0.2% for PTV D50% between intended dose and secondary / EPID in-vivo dose. The pronounced discrepancies for fraction 3, in terms of both reduced gamma passing rates and increased deviations for the EPID reconstructed dose, coincide with a large air cavity in the rectum showing up in the patient's CBCT prior to treatment (Figure 2). Secondary dose calculation based on the density information of the CBCT as an additional option for QA confirmed origin and magnitude of this effect.

Table 1: Comparison of secondary and EPID reconstructed dose distributions for a prostate patient with the planned dose using Gamma evaluation. Change in PTV DVH metrics between EPID reconstructed and secondary dose. All values are given in percent.

Fraction	Gamma 3%/2mm		Gamma 5%/3mm			
	CC	EPID	CC	EPID	ΔPTV $D_{95\%}$	ΔPTV $D_{50\%}$
1	98.9	89.6	99.9	98.2	-1.5	-1.3
2	98.3	89.1	99.8	98.2	-1.5	-1.3
3	98.2	84.0	99.8	96.9	-2.4	-3.7
4	99.0	90.7	99.9	98.7	-1.5	-1.7
5	98.4	89.8	99.9	98.6	-1.5	-1.6
6	97.2	88.2	99.5	97.4	-1.3	-1.2
7	98.1	90,3	99.7	98.1	-1.5	-1.3
Average	98.3	88.8	99.8	98.0	-1.6	-1.7

Figure 2: Evaluation of adaptive fractions 1 and 3 in terms of Gamma analysis and DVH comparison. Intrafractional anatomical changes are apparent between the initial CBCT and the CBCT acquired directly before treatment.



CONCLUSIONS

In-vivo EPID dosimetry of adaptive clinical plans is feasible. It was exemplary demonstrated that it reveals fractions with noticeable anatomical changes between the sCT and the patient anatomy during treatment. As new recommendations were published on in-vivo dosimetry through TG 307 [3], the development of new clinical tools and evaluation of existing commercial solutions is essential, also in the context of the growing use of on-couch adaptive technology.

REFERENCES

[1] **Miften M et al**. Tolerance limits and methodologies for IMRT measurement-based verification QA: Recommendations of AAPM Task Group No. 218. *Med Phys. 2018; 45(4); e53–e83*
[2] **Zhu T et al**. Report of AAPM Task Group 219 on independent calculation-based dose/MU verification for IMRT. *Med Phys. 2021; 48(10); e808–e829*
[3] **Dogan N et al**. AAPM Task Group Report 307: Use of EPIDs for Patient-Specific IMRT and VMAT QA. *Med Phys. 2023; 50(8); e865–e903*

ACKNOWLEDGEMENTS

The authors thank LAP for the opportunity to evaluate the software RadCalc.

CONTACT INFORMATION

Mail: Razinskas_G@ukw.de