More Than a Safety Net: 3D EPID *In Vivo* Dosimetry Supports Clinical Decision-Making in Online Adaptive Radiotherapy

Figure. 3D EPID in vivo dosimetry detects clinically relevant treatment errors and helps to quantify their dosimetric impact.

Online adaptive radiotherapy (oART) is gaining traction in clinical practice, though still predominantly used for conventional treatments. Due to the high daily planning effort, selecting patients for oART requires careful consideration. EPID-based in vivo dosimetry offers a practical way to identify which patients could benefit most from this advanced technique.

Clinically Proven Back-Projection Algorithm for 3D Dose Reconstruction

3D EPID in vivo dosimetry adds an important safety layer to radiotherapy QA. Unlike traditional methods such as phantom measurements or dose recalculations, it can detect patient-related errors like anatomical changes or positioning inaccura-

cies. VERIQA RT EPID 3D uses a back-projection approach to reconstruct a clinically relevant 3D patient dose from 2D EPID images. The algorithm was developed by the Department of Radiation Oncology at the Netherlands Cancer Institute – Antoni van Leeuwenhoek Hospital (NKI-AVL) and builds on 20 years of clinical experience. It includes a patent-pending inhomogeneity correction based on Monte Carlo principles, enabling accurate dose reconstruction even in treatment regions with significant tissue density variations.

In Vivo Verification as a Safety Net

Monte Carlo-based dose calculations, such as those performed with VERIQA RT MonteCarlo 3D, are considered the gold standard for plan verification. However, they only detect planning errors. In contrast, 3D EPID-based in vivo dosimetry can identify clinically relevant errors across the full spectrum – including planning, transfer, machine and patient-related issues.

VERIQA RT EPID 3D requires no additional measurements, as EPID imaging runs automatically in the background during patient treatment. The 3D patient dose reconstructed via back-projection provides well-documented safety – without the need for constant monitoring. A traffic light system with customisable alarm thresholds highlights deviations, helping clinicians decide when closer inspection or a new planning CT is needed. Available since May 2025, the system has undergone extensive clinical testing across Europe.

Dr. Gaspar Sanchez Merino (Txagorritxu Hospital, Spain), who supervised a preclinical study, notes: "We see enormous potential in this tool to enhance treatment accuracy and improve patient safety."

3D EPID In Vivo Dosimetry: Supporting oART Treatment Decisions

In vivo dosimetry with VERIQA RT EPID 3D helps identify patients who may benefit from oART. This advanced treatment method requires daily planning, which is time- and resource-intensive, yet ensures adaptation to the patient's anatomy on the day of treatment. By enabling the monitoring of larger patient cohorts over time, EPID-based in vivo dosimetry supports informed decisions about which treatment regions are best suited for online-adaptive radiotherapy.

Ann van Esch, who clinically validated VERIQA RT EPID 3D together with the medical physics team at CHU UCL Namur in Belgium, emphasises: "VERIQA helps us detect dosimetrically relevant changes and focus our attention where adaptive therapy would be most beneficial." She highlights the breast as a promising region for oART due to frequent anatomical changes caused by swelling.
Modular Platform for Flexible QA

Verification strategies vary by clinic, but a clear trend toward computational methods is emerging. The modular VERIQA software platform enables flexible combinations of verification methods. For example, Monte Carlo-based dose recalculation with VERIQA RT MonteCarlo 3D can be effectively complemented by VERIQA RT EPID 3D in vivo dosimetry – covering all relevant error sources without additional beam time.

Getting Started with EPID In Vivo Dosimetry

Introducing EPID-based in vivo dosimetry into clinical practice raises important questions – particularly regarding evaluation criteria and alarm interpretation. The strict criteria used for dose verification with VERIQA RT MonteCarlo 3D or conventional phantom-based QA cannot be directly applied to EPID-based in vivo dosimetry. PTW supports clinical users throughout implementation, and a whitepaper with recommendations from NKI-AVL offers practical guidance based on two decades of experience.

Before clinical commissioning, using a phantom such as RUBY is recommended. As an end-to-

end phantom, RUBY enables the simulation of anatomical and positioning errors. Comparing these with the in vivo results obtained from VERIQA RT EPID 3D helps users understand the system's capabilities and learn to interpret findings – ensuring smooth integration into daily clinical practice.

Building Know-How for oART

Experience with in vivo dosimetry builds valuable expertise for oART, where traditional measurement-based plan verification is no longer feasible. The patient receives the plan of the day, which can be efficiently verified during each treatment using EPID-based in vivo dosimetry – one more reason to explore this method as part of routine clinical practice.

For further insights into the clinical use and benefits of 3D patient dosimetry, PTW provides webinars and a detailed whitepaper with practical guidance from the NKI-AVL.

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