Commissioning of an In-Vivo Quality Assurance Method using the Electronic Portal Imaging Device

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INTRODUCTION

EPID-based in-vivo quality assurance (QA) has been demonstrated for several years to be a great candidate for creating permanent record of the daily treatments. However, mostly academic institutions have implemented the QA approach. This research is the first to evaluate the performance and limitation of a commercial product.

The objectives of this study were to

- Explore the workload required for clinical implementation of a commercially available EPID-based in-vivo QA approach.
- To investigate its physical performance in terms of accuracy for different clinical treatment situations (IMRT and VMAT).

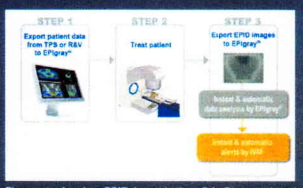

Figure 1. In-vivo EPID based plan QA. Plan review is point based and review on the web from anywhere.

METHODS AND MATERIAL

The platform EPIgray V2. (Dosisoft, Cachan, Francev), which machine model compares ratios of TMR with EPID signal to predict dose was commissioned for an Artiste (Siemens Oncology Care Systems) and a Truebeam (Varian medical systems) linear accelerator following the given vendor's instructions. The systems were then tested on three different phantoms (homogeneous stack of solid water, anthropomorphic head and pelvis) and on a library of patient cases. Simple and complex fields were delivered at different exposures and for different gantry angles. The effects of the table attenuation and the EPID sagging were evaluated. Gamma analysis of the measured dose was compared to the predicted dose for complex clinical IMRT cases.

Figure 2. Truebeam STx calibrated for EPIgray.

Verifications for 3D and IMRT plans:
- Patient anatomy is contoured in the treat ment planning system (TPS).
- Plan is defined and approved.
- Contours, POI and DICOM images are sent to the EPIgray station.
- Treatment is delivered while the EPID is placed at 150 cm from the source.
- Port during images (integrated and dosimetry mode) sent to EPIgray and dose prediction is automatically performed and compared to TPS.

Verifications for VMAT (developer mode):
- DICOM plan approved in the clinic.
- Convert plan to XML.
- Adapt to developer mode and add the imaging features to perform VMAT verification.
- VMAT verifications are performed in Cine mode (also named "Continuous").
- Images are saved in Service mode.
- Matlab code is introduced to convert the Cine images.
- Converted images transfered to EPIgray.

Figure 3. Anthropomorphic head phantom to test whole brain treatments and IMRTs.

Figure 4. Pelvis anthropomorphic phantom to test prostate IMRT.

Figure 5. Clinical cases: 15 brains, 5 lungs, 5 spines, 5 pelvis and 5 extremities.

RESULTS

Commissioning of the EPIgray system for two photon energies took 8 hours. The difference between the dose planned and the dose measured with EPIgray was better than 3% for all phantom scenarios tested. Preliminary results on patients demonstrate an accuracy of 5% is achievable in high dose regions for both 3DCRT and IMRT. Large discrepancies (>5%) were observed due to metallic structures or air cavities and in low dose areas. Flat panel sagging was visible and accounted for in the EPIgray model.

Quantitative results:

(Showing the % error between TPS and measured with EPID for 10+ fractions)

I. Simple fields (AP/PA) delivered to phantoms or patients:
Error [%]: mean: 0.2 ± std 1.5
II. Simple fields (3DCRT) delivered to phantoms or patients:
Error [%]: mean: -0.1 ± std 2.4
III. Complex fields (IMRT) delivered to phantoms:
Error [%]: mean: 0.2 ± std 2.6
IV. Complex fields (IMRT) delivered to patients:
Error [%]: mean: 0.3 ± std 2.9
V. Largest errors observed (>5%):
- Outside the field (this is not currently modeled by EPIgray V2).
- In the presence of metallic structures such as retention device or the couch.
- In lungs and air cavities.

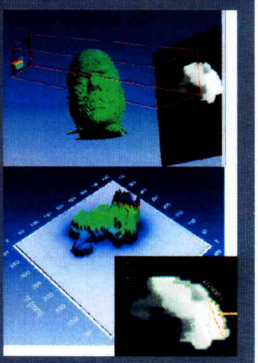

Figure 6. Example of measured fluence and the conversion to dose in EPIgray.

DISCUSSION

Dose reconstruction using the EPID signal is a promising option to document the safe delivery of highly modulated treatments. Although encouraging, our results with lung patients show the limitation of a simple approach based on RTMR data. More advanced approches to convert the flat panel signal into exit fluence would most likely be required for complete dose reconstruction and dose guided therapy of thoracic patients. However, in the context of dose verification, an accuracy inside 5% at several points inside the anatomy may be sufficient to assure the safe delivery of today's advanced techniques. Structures in the treatment table or patient support devices with high attenuation are definite limitations. More advanced models will have to be tested to better account for their effects in the dose reconstructions. The reconstruction of dose outside the fields is also difficult but in general not as critical. The RTMR approach is currently being modified to better reconstruct dose in those low areas.

CONCLUSION

The accuracy achieved by EPIgray is adequate to document the safe delivery of complex modulated treatments such as IMRT. An accuracy better than 5% was demonstrated for selected high-dose points on a large number of phantom and patient cases. Our current work is focusing on improving the reconstructed dose from VMAT and FFF deliveries. A seperate model has been created and scatter correction kernels are being investigated.

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