Cherenkov Imaging with a Predicted Surface Dose Overlay for Treatment Verification

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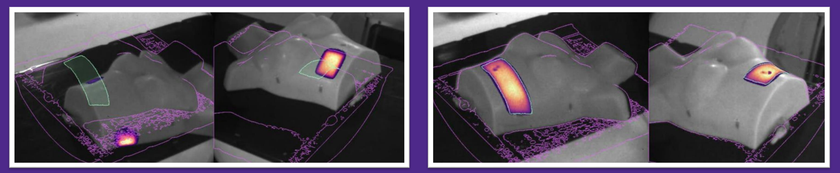
PURPOSE / OBJECTIVES

Cherenkov imaging utilizes light emitted during radiation therapy, allowing for visualization of radiation treatments on patients. Cherenkov emissions indicate the treated region and therefore can be used for positional verification; however, there is no method to confirm that the Cherenkov image matches the prediction from the treatment planning system (TPS). In this study, the potential of incorporating a predicted surface dose overlay (PSDO) with Cherenkov image review is examined.

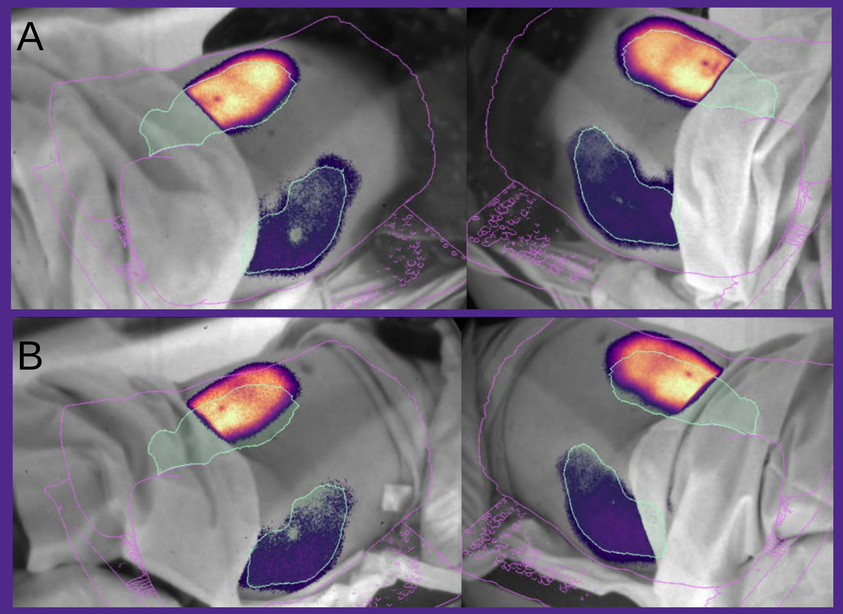
MATERIAL & METHODS

PSDOs were generated using the TPS RTPlan and RTDose files for each beam, and CT scan. A surface rendering of the patient was created using a non-zero Hounsfield unit threshold. At each point on the surface rendering, the planned dose at the surface is generated by sampling normal to, and at a 5mm depth (where most of Cherenkov light is generated) into the dose volume. The PSDO is generated using a 14% isodose of the 5mm planned maximum surface dose and displayed on top of the Cherenkov images. Evaluation of the PSDO was performed on treatments delivered to phantoms at the planned position and after couch shifts to simulate inaccurate patient setups. All patient imaging review was performed on an IRB approved protocol. The patient imaging was scored as congruent if the PSDO shape, size and position visually matched the Cherenkov emissions and non-congruent if not matching. If part of the treatment area was blocked (clothes, sheets or gantry), only the visualized treatment was evaluated.

In phantom studies using tangential breast plans, the predicted surface dose overlay was visually congruent at the planned position and non-congruent when the phantom was shifted from the initial position. The predicted plan overlay was less sensitive for treatment plans delivered on the abdomen of the phantom, an area that lacks distinctive anatomical features. In these areas lacking anatomy, accuracy of the technique was restored if biologic fiducials, i.e. blood vessels, were used in conjunction with the PSDO.



Patient imaging on first day of treatment with congruence between PDSO and Cherenkov emissions (A). Eight days later for final treatment, non-congruence can be visualized as a result of change in patient anatomy (B).



RESULTS

Site	Number of Patients	Total Fractions Reviewed	Cherenkov Overlay Matches	Cherenkov Overlay Mismatches
Abdomen	4	22	16	6
Bone	4	22	22	0
Brain	4	53	53	0
Breast	16	241	210	27
Head and Neck	3	91	91	0
Lung	4	57	57	0
Total	39	604	567	33

Treatment Modalities	*Total*
3D-CRT	*20*
VMAT	*19*

RESULTS

604 treatment fractions for 39 consecutive patients receiving standard of care treatment and pre-treatment imaging were evaluated. Non-congruence of the PSDO with the Cherenkov emission image was detected in 2 treatment courses, totaling 33 of the 604 (5.4%) reviewed treatment fractions. One case was due to anatomy change that occurred during the treatment course. The second case was due to inaccuracy in patient setup and resulted in excess contralateral chest wall dose. This second case was not previously recognized by the treatment team and was not detected by pre-treatment weekly port films or daily SGRT.

SUMMARY / CONCLUSION

PSDO incorporated into Cherenkov imaging systems is a useful tool for evaluating accuracy of treatment delivery and has potential for improving treatment quality. Further work is warranted to optimize and determine the added benefit of this technique in large patient studies.