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Evaluation of OAR Sparing and Influence on a Next-Generation BgRT Platform

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PURPOSE / OBJECTIVES

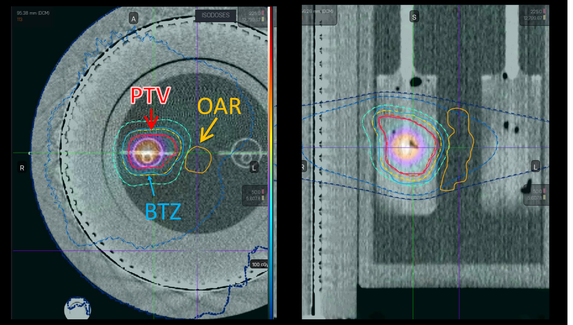
For biology-guided radiotherapy (BgRT) treatment on the RefleXion X1 PET-linac, patients must meet stringent criteria regarding the proximity and ^{18}F-FDG activity of OARs near the target. The next-generation X2 platform has an increased PET field of view, as well as new planning, PET detection, and target tracking algorithms under development. **We sought to investigate the X2 system's ability to spare OARs close to the BgRT target while preserving dose conformality, as well as its delivery robustness against interference from FDG-avid OARs.**

reflexion X2 PET-linac

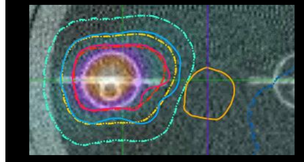
METHODS AND MATERIALS

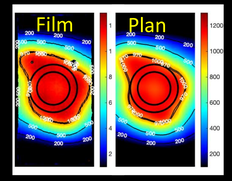
We performed six OAR-related phantom tests on developmental X2 systems. Two tests explored the X2's ability to carve dose away from a virtual, non-FDG-avid ("cold") OAR located ~ 1 cm from a static or moving BgRT target while preserving dose conformality. The other four tests utilized a custom phantom and involved FDG-avid ("hot") volumes of various activity and relative separation to the static or moving BgRT target, to simulate the impact of "hot" OARs on target tracking and dose delivery.

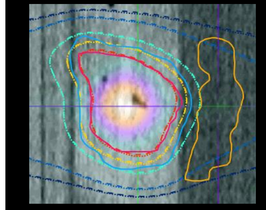
STUDIES 1-2: SPARING OF "COLD" OAR

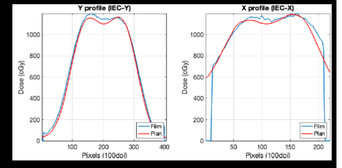


ArcCheck phantom containing BgRT target instrumented with ion chamber + film



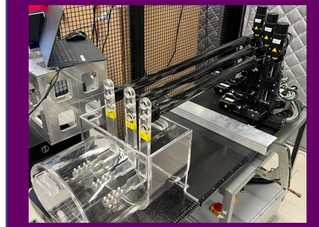




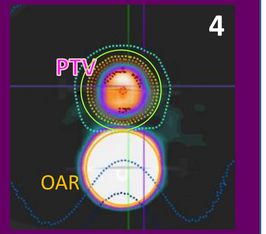


Target	1. Static	2. Moving
IC reading (target)	+1.3%	+1.9%
ArcCheck gamma	97.5%	96.3%

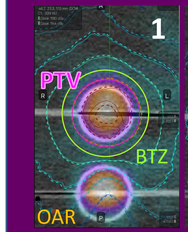
STUDIES 1-4: SPARING OF "HOT" OARs



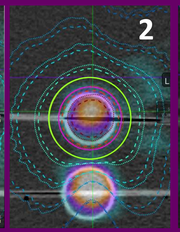
Custom water-filled phantom with independently moving arms



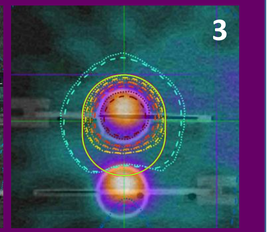
Moving target, extremely "hot" OAR



Static target



Moving target



Moving target, OAR inside BTZ

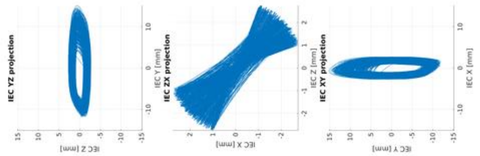
* In tests 1-3, PTV and OAR (fill:background) activities were (8:1)
* In test 4, PTV and OAR activities were (8:1) and (20:1), resp.
* PTV and OAR center-to-center separation always 6 cm @ start

Study	1	2	3	4
IC reading (target)	+2.8%	-1.7%	+1.2%	-1.8%
Film margin loss (mm)	1.0	1.4	1.1	1.8

RESULTS

In the "cold" OAR tests, the X2 treatment planning system generated conformal plans which also satisfied dosimetric constraints for the virtual OAR structure near the BgRT target. At delivery, ion-chamber point-dose measurements agreed within 2% and phantom array gamma passing rates were above 96% (3%/2mm), confirming that delivery spared the virtual OAR.

In the "hot" OAR tests, the X2 system was able to generate and deliver conformal plans even with the OAR encroaching on or slightly into the target tracking region. Ion-chamber point-dose and film measurements confirmed clinically satisfactory delivery, with point doses within 3% of planned doses.



3D trajectory of moving BgRT target in "hot" OAR study #4

SUMMARY

We performed a suite of phantom tests to investigate the capabilities of the next-generation RefleXion X2 system regarding OAR sparing and OAR influence on BgRT treatment plan preparation and delivery. **The X2 system was able to generate clinically satisfactory plans which exhibited very good conformality and robust target tracking at delivery despite OAR constraints; this could substantially increase patient eligibility for BgRT.**