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Knight Cancer Institute at Oregon Health & Science University

A Method of Improving the Effective Spatial Resolution for Small Field IMRT QA with 2D-array Device

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Purpose

To improve the effective spatial resolution of small field IMRT QA with a 2D detector array, thus improving the accuracy of 3D dose reconstruction.

Methods and Materials

Intensity modulated radiation therapy (IMRT) delivers a more conformal tumor dose and provides better normal tissues sparing than conventional 3D conformal treatment. The accuracy of IMRT plans must be verified for each course of radiation treatment using a quality assurance (QA) device. Current 2D QA devices have a detector spacing of 5 -10 mm, which is too sparse for small field IMRT. We propose a new method to improve the spatial resolution of 2D detector arrays. A radiation beam is delivered to the QA device from a small grazing angle θ (i.e. the angle between beam and detector plane). Compared to the standard procedure (θ=90°), our new method improves spatial resolution by a factor of 1/sinθ along the projection of the gantry rotation. Theoretically, a smaller grazing angle will result in higher spatial resolution. However, there is a lower limit to the grazing angle due to the physical dimensions and angular dependence of the detector array. First, the grazing angle must be large enough so that the projection of the beam is covered by the detector array. Second, the grazing angle must be large enough for the detectors to still have a reliable response despite the angular dependence. In this study, two QA devices (Delta4 and PTW) were used to perform QA on a spine IMRT plan. The measured 2D dose planes were compared with the calculated dose using 2% dose deviation criteria. 3D dose volumes were reconstructed based on 2D measurements and the reference dose (or PDD curve). Dose at position x is calculated by

$$Dose\ (x) = \frac{Reference\ Dose\ (x)}{Reference\ Dose\ (projection\ in\ 2D\ array)} * Measured\ dose\ (projection\ in\ 2D\ array)$$

The reference dose can be the radiation dose of an open field with equivalent field size. We should not use the treatment field as the reference because it contains specific information of the QA plan and is no longer independent.

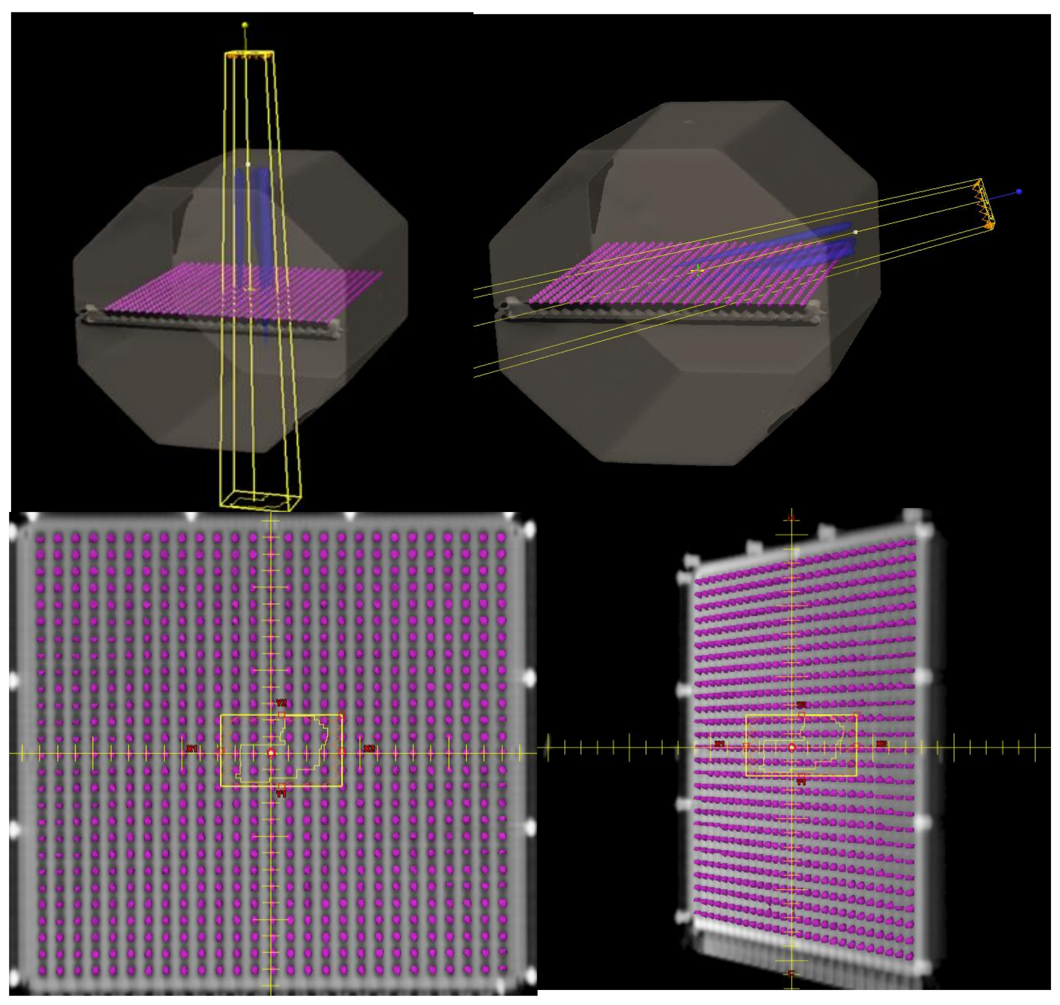

Figure 1. QA setup and BEV. The grazing angle is 90° for the left side and 30° for the right.

Results

For the Seven29/Octavius device, the effective spatial resolution was improved from 1/10 mm^{-1} to 1/5 mm^{-1} when the grazing angle decreased from 90° to 15°. For the PTW device, this number was improved to from 1/3.1 mm^{-1} to 1/1.3 mm^{-1} when the grazing angle decreased from 50° to 15°.

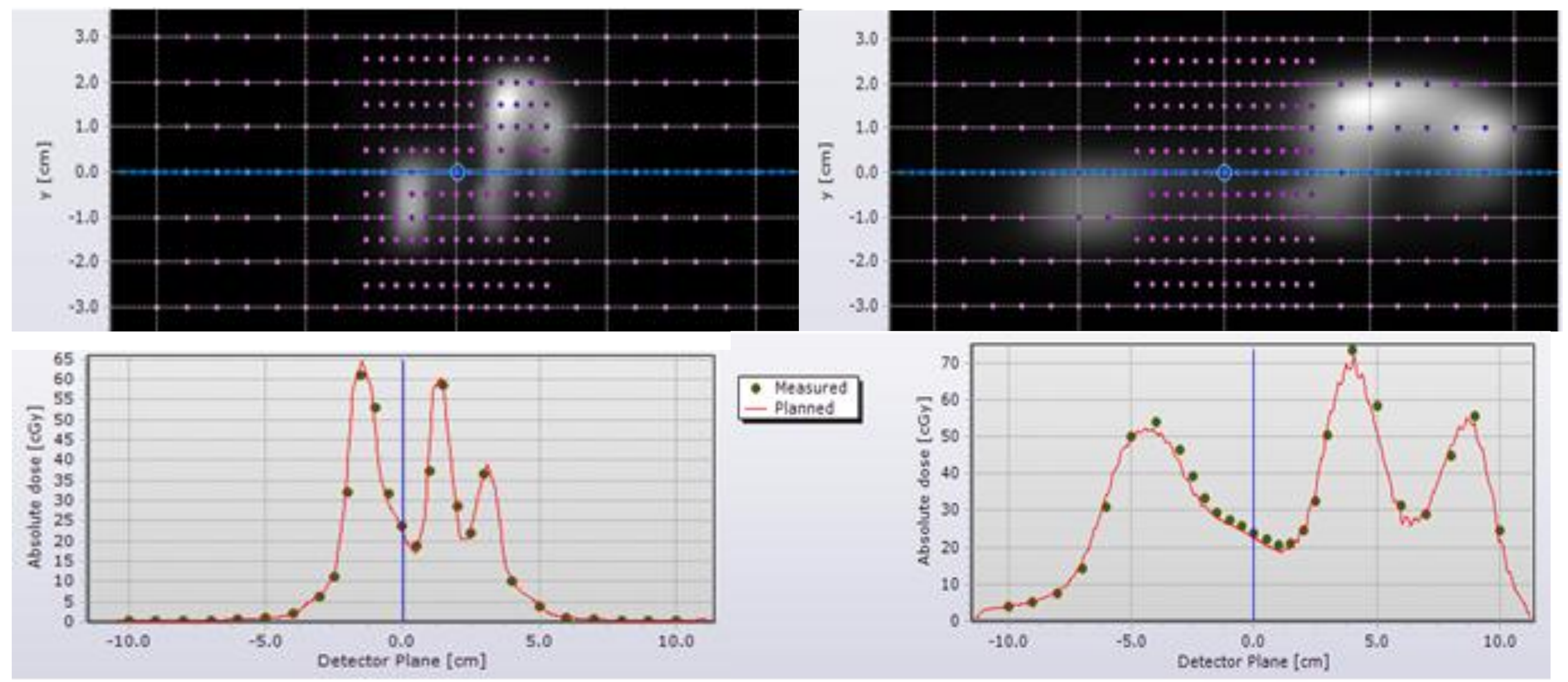

Figure 2. QA measurements showed that the average passing rate (with 2% dose deviation criteria) was 74% for 15° grazing angle, only slightly lower than the passing rate of 80% for the 50° grazing angle.

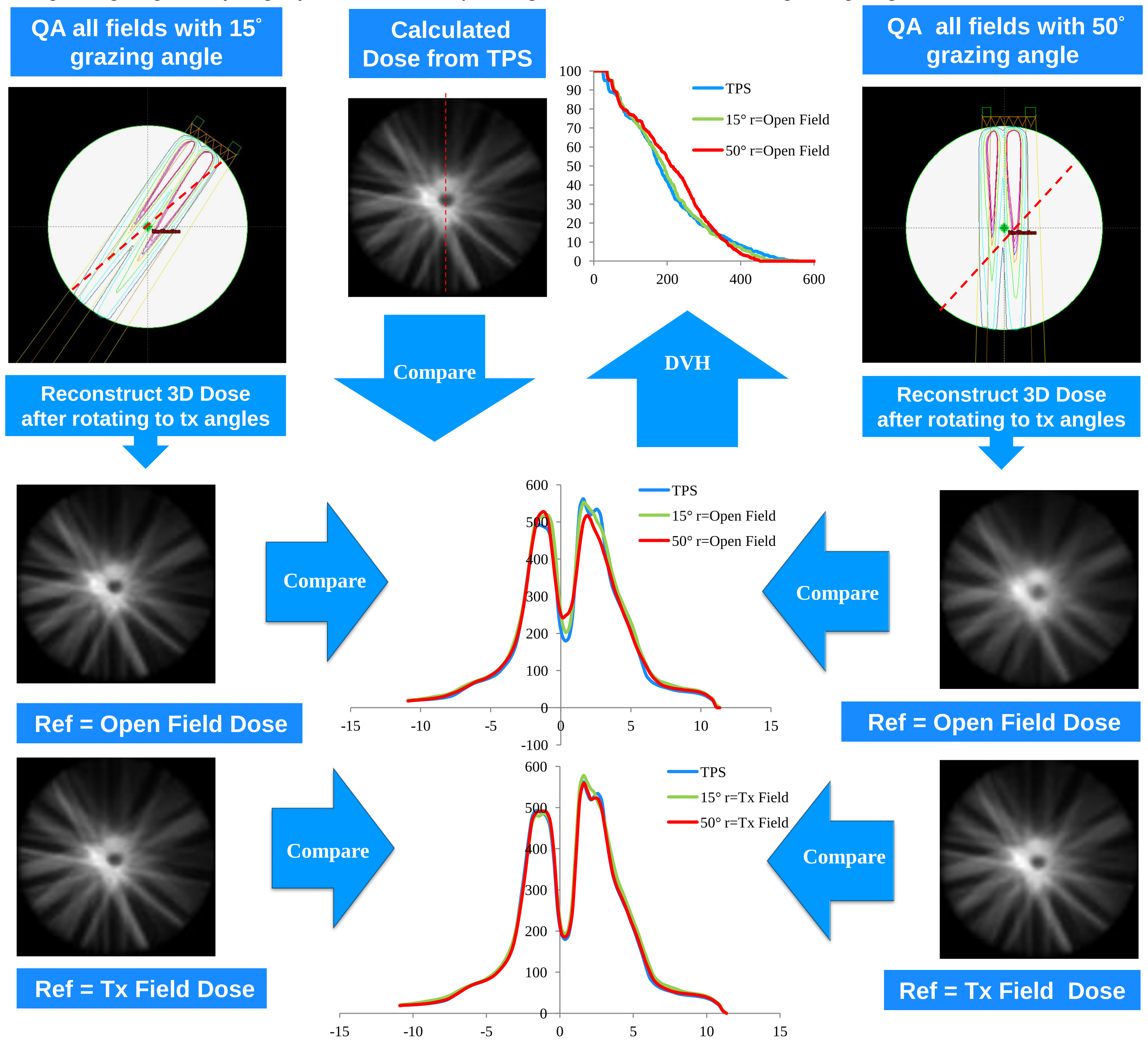

Figure 3. Comparison of axial views of the reconstructed 3D volumes (Left: Reconstructed Dose with 15° grazing angle, Right: Reconstructed Dose with 50° grazing angle, Middle: Calculated Dose from the treatment planning system). When open field dose is used as the reference dose, the dose distribution reconstructed from 15° grazing angle show similar dose cord dose sparing as the one calculated by the TPS. The one reconstructed with 50° grazing angle has higher cord dose, which may cause a false alarm. When the treatment field dose is used as the reference dose, the three dose distributions are very close because all of them are correlated to the calculated dose distribution.

Conclusion

A moderately small grazing angle can improve effective spatial resolution. Compared to the standard procedure, the measured 2D dose planes have slightly lower passing rates but the reconstructed 3D dose volumes were more accurate.