Effect of oblique beam incidence on 3D dose reconstruction for small field IMRT QA

Junan Zhang, Ph.D. and Wolfram Laub, Ph.D.

Department of Radiation Medicine, Oregon Health and Science University, Portland, Oregon

Purpose

To compare dose reconstruction accuracy with different oblique beam angles when 2d detector arrays are used for small field IMRT QA.

Methods and Materials

The purpose of IMRT patient QA is to verify radiation delivery accuracy of IMRT/VMAT treatment. In earlier days, these QAs were performed with ion chamber and radiographic film. With the advance of technologies, 2D detector arrays have gained popularity because of the simplicity and reproducibility. However, many 2D arrays (i.e. Mapcheck, PTW seven27) have a detector matrix of 1 centimeter grid size, which is significantly larger than 1-3mm grid size used for dose calculation. This causes insufficient sampling during dose fluence measurement. The problem becomes more severe for SBRT QA because the radiation fields are so small that the primary beam only covers a small amount of detectors.

The hypothesis of this study is that an appropriate grazing angle can improve spatial resolution of IMRT QA (Figure 1), especially for small fields. We performed two experiments to test the hypothesis. First, we used 2d arrays to measure a simple X-shape dose fluence with both normal and oblique incidence and compare them with dose fluences measured with EDR2 films (Figure 2).

Next, we measured dose fluences of IMRTQA with 90, 60, 30 and 15 grazing degree and use the fluences to reconstruct 3D dose volume. A spine SBRT plan was chosen as the testing case. Axial views of the reconstructed 3D dose were shown in Figure 3.

The 3D dose was reconstructed in two steps. First, we extrapolated 2D dose into 3D by applying PDD factors obtained from an open reference field. Mathematically, 3D dose $D(\vec{r})$ was calculated as

$$D(\vec{r}) = M(\text{proj}(\vec{r})) \times \text{PDD} = M(\text{proj}(\vec{r})) \cdot \frac{D_{\text{ref}}(\vec{r})}{D_{\text{ref}}(\text{proj}(\vec{r}))}$$

Where $\text{proj}(\vec{r})$ is the projection of vector $\vec{r}$ on the detector array and $M(\text{proj}(\vec{r}))$ is the measured dose at that point. $D_{\text{ref}}$ is the 3D dose of an open reference field. Secondly, we rotated the dose volume of individual beam from QA angle into treatment angle and sum them together to calculate total delivered dose. The total delivered dose was compared to the treatment planning dose calculated by Eclipse and their similarity were evaluated using gamma index, Pearson correlation, and mean dose to PTV and OAR (Figure 4). The process was performed for both phantoms (PTW/Octavius and Delta4) and repeated for all four grazing angles: 90, 60, 30, and 15 degree.

Results

![Figure 1. QA setup and BEV. The grazing angle is 90° for the left side and 30° for the right.](image)

![Figure 2. Comparisons of dose fluences and profiles measured by EDR2 film, Delta4 and PTW device.](image)

![Figure 3. Comparison of axial view of 3D dose reconstructed at different grazing angles from PTW/Octavius, Delta4 after downsampling and Delta4 without downsampling. Vertical profiles are plotted on the right column for comparison.](image)

![Figure 4. Comparison of reconstruction accuracy in terms of gamma passing rate, Pearson correlation and percent difference of cord and PTV mean dose.](image)

Conclusion

Using small grazing angle results in higher sampling rate of 2D dose fluence measurement, which helps to improve the accuracy of 3D dose reconstruction.