Clinical implication of the new dosimetry formalism in IMRT quality assurance

Innovation/Impact: This is the first study demonstrating that the application of the new dosimetry formalism improves the dosimetry consistency of quality assurance in clinical nonstandard field deliveries.

We evaluated the feasibility of applying the new dosimetry formalism\(^1\) to clinical IMRT quality assurance process. Based on the new dosimetry formalism\(^1\), the clinical correction factor \( k_{\text{Clin}, f} \) was measured for a calibrated Exradin A12 chamber in 20 different IMRT QA fields. The clinical correction factor accounts for the difference between clinical field and reference field (a 10×10 cm\(^2\)) delivery conditions. This correction factor is defined as

\[
k_{\text{Clin}, f} = \frac{D_{\text{Clin}}}{D_{\text{ref}}} = \frac{D_{\text{Clin}}}{D_{\text{ref}}}
\]

Reference doses in an IMRT QA field, \( D_{\text{Clin}} \), and a 10×10 cm\(^2\) field, \( D_{\text{ref}} \), were measured using a PTW micro liquid ion chamber, which has a collecting volume filled with a water-equivalent material. Using the Exradin A12 chamber, the measured dose in each IMRT QA field without or with the clinical correction factor was compared with the calculated dose using (i) Analytical Anisotropic Algorithm (AAA) or (ii) Monte Carlo (MC) methods (EGSnrc).

Clinical correction factors \( k_{\text{Clin}, f} \): Figure 1 shows the measured clinical correction factors \( k_{\text{Clin}, f} \) of the 20 IMRT QA fields in the fully-rotated and collapsed deliveries as a function of homogeneity index (HI) at the Exradin A12 collecting volume. The HI is defined as

\[
\text{HI} = \frac{D_{\text{max}} - D_{\text{min}}}{D_{\text{ave}}}.
\]

When the HI is less than 4.5% in the fully-rotated delivery, the clinical correction factor is close to unity within 0.7%. For more heterogeneous IMRT QA fields, the correction factor is different from unity by up to 2.7%. In the collapsed delivery, the HI is greater than that in the fully-rotated delivery for the same QA field due to greater residual dose gradient effects. Hence, the measured correction factor deviates from unity by up to 3.7%. Figure 2 shows the comparison of the clinical correction factor obtained from the measurement and MC simulations for each IMRT QA field. Except 4 individual fields, the measured and calculated clinical correction factors agree to within 0.5% and 1% in the fully-rotated and collapsed deliveries, respectively, which confirms the accuracy of our clinical correction factor measurements.
applying the new dosimetry formalism. Collecting volume. This is because the AAA does not account for the IMRT QA process. For each QA field, the measured dose without the correction factor is different by up to 5% in both deliveries compared with the AAA-calculated dose. When applying the clinical correction factor, the discrepancy between the measured and calculated doses becomes worse for some QA fields, which is by up to 8%, especially in the collapsed delivery. This is because the AAA does not calculate the dose distribution sufficiently accurate, especially in the penumbra region of an individual small field. The fact that the measured correction factors make the IMRT QA process more consistent is demonstrated when we compare the corrected measurement results with the MC-calculated dose. In this case, the discrepancy with the measured dose without the correction factor reduces to within 3%. Furthermore, for both deliveries, it is clearly shown that the clinical correction factor improves the discrepancy between the measured and MC-calculated doses, especially for an IMRT QA field having higher dose heterogeneity. This is because the correction factor accounts for the dose gradient over the Exradin A12 collecting volume.

We demonstrated that the application of the new dosimetry formalism improves dosimetric consistency of the IMRT QA process. The suggested practical method of applying the new dosimetry formalism will help more accurately verify radiotherapy delivery.