PTCOG-AO 2025
HONG KONG
NOV 7-9
PTCOG-AO

Theme: Physics

Abstract No.: PTCOG-AO2025-ABS-0153

Abstract Title: A Comprehensive Solution for Efficient Patient-Specific Quality Assurance in Carbon-Ion Radiotherapy

Author Names: Gahee Son[1], Yongdo Yun[2], Seok-Ho Lee[3], Min Cheol Han[2*], Jin Sung Kim[2], Chan Hyeong Kim[1]

[1]Department of Nuclear Engineering, Hanyang University, Seoul, Korea
[2]Department of Radiation Oncology, Yonsei University College of Medicine, Seoul, Korea
[3]Department of Integrated Medicine, Yonsei University College of Medicine, Seoul, Korea

Aims:

- This study aims to develop a comprehensive platform for patient-specific quality assurance (PSQA) in carbon-ion radiotherapy (CIRT), by integrating measurement-based, log-based, and hybrid PSQA approaches.

Methods:

Architecture of the Comprehensive QA Framework for CIRT

- An overview of the comprehensive QA framework for CIRT is shown in Figure 1.
- Measurement-based method: Uses a 2D detector for absolute dose verification.
- Log-based method: Reconstructs 3D dose from beam parameters (i.e., spot position, monitor units, and nominal energy) in delivery logs (e.g., DICOM-RT Record) using an independent dose calculation algorithm.
- Hybrid method: Calibrates the log-reconstructed dose to absolute dose levels using a measured dose.

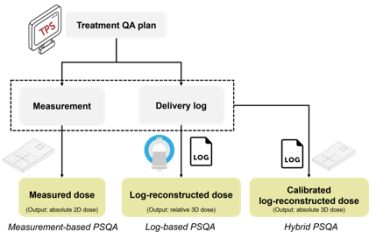


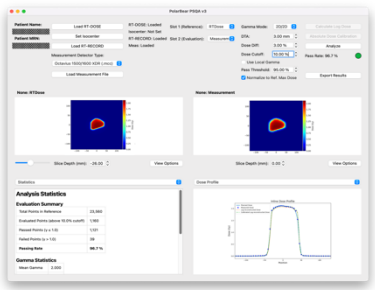
Figure 1. Workflow of the comprehensive PSQA platform.

Implementation and Evaluation of the PSQA Framework

- QA dataset: Five prostate treatment plans
- Measurement depths: Proximal / Central / Distal (within spread-out Bragg peak)
- 3D dose reconstruction: Using delivery logs
- Calibration: Using the absolute dose at the proximal depth
- Dose evaluation: 2D or 3D gamma analysis (2%/2 mm)

Result:

- Figure 2 presents the graphical user interface of the developed PSQA platform for CIRT, featuring dose map visualization, gamma analysis, and profile comparison among planned dose, measured dose, log-reconstructed dose, and hybrid dose.
- Across five cases, the measurement-based approach showed the highest agreement with the planned dose (mean 2D/3D γ passing rate: 98.6%), followed by the hybrid (97.7%) and log-based (97.1%) methods. Figure 3 shows an example of dose distributions at the proximal depth obtained using the three PSQA methods.
- Compared with the measured dose, the hybrid methods demonstrated better agreement (mean 2D γ passing rate: 99.3%) than the log-based approach (98.5%).



Demo

Figure 2. Graphical user interface of the developed PSQA platform for CIRT.

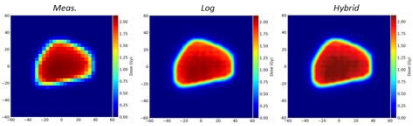


Figure 3. Example of dose distributions at the proximal depth obtained using three PSQA methods.