Standardization and Automation of Monitor Unit Calculation for Clinical Electron Simulation and Treatment in a Multi-Center Radiation Oncology Network

Guang-Pei Chen, Victor Chen, Christina Sarosiek, Ranae Conlin, Asma Amjad, An Tai, Douglas Prah, Eric Paulson

Department of Radiation Oncology, Medical College of Wisconsin, Milwaukee, Wisconsin, United States

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INRODUCTION

Internal review of the departmental Radiation Oncology Incident Learning System (ROILS) events identified multiple near-miss and treatment deviations related to incorrect electron monitor unit (MU) calculations, particularly in urgent treatments. Contributing factors included manual data transcription combined with on-the-fly change of settings, inconsistent reference (book value) use, and variability in workflows across machines and treatment locations.

PURPOSE

- Urgent clinical electron radiotherapy for postoperative treatments (e.g., keloid) is often performed without CT-based planning. MU calculation on-the-fly is needed.
- In a large hospital network with multiple treatment locations, variability in electron data and workflows across treatment machines, together with on-the-fly changes of treatment parameters including beam energy, applicator or cutout size, bolus thickness and source-to-surface distances (SSD) increases risk of calculation error and decreases efficiency.
- To develop and clinically implement a standardized, automated electron monitor unit calculation workflow designed to improve efficiency, consistency, and safety.

METHODS AND MATERIALS

- Electron beams with same energy were matched over all available machines.
- Beam data including percentage-depth-dose (PDD) curves, profiles, applicator and cutout factors, etc., at various source-to-surface distances were obtained with Monte-Carlo dose calculation in Monaco (Elekta Instruments, Stockholm). These data were used to generate a centralized electronic databook and corresponding electron beam configuration for a custom software tool for MU calculation.
- A library of pre-manufactured circular and rectangular cutouts was established using 3D-printed plastic inserts, and validated with measurements.
- A software tool interfaced to the record-and-verify (R&V) system was developed with machine-related parameters configured to guide users through a standardized workflow. A visualization tool integrated into the software enabled rapid, intuitive selection of electron energy, field size, and bolus thickness based on prescription and target configuration. It automatically updates cone/cutout factors and identifiers etc and calculates MU, and generates an RTP file and report for import into the R&V system. The efficiency and robustness of the workflow was validated in five patients.

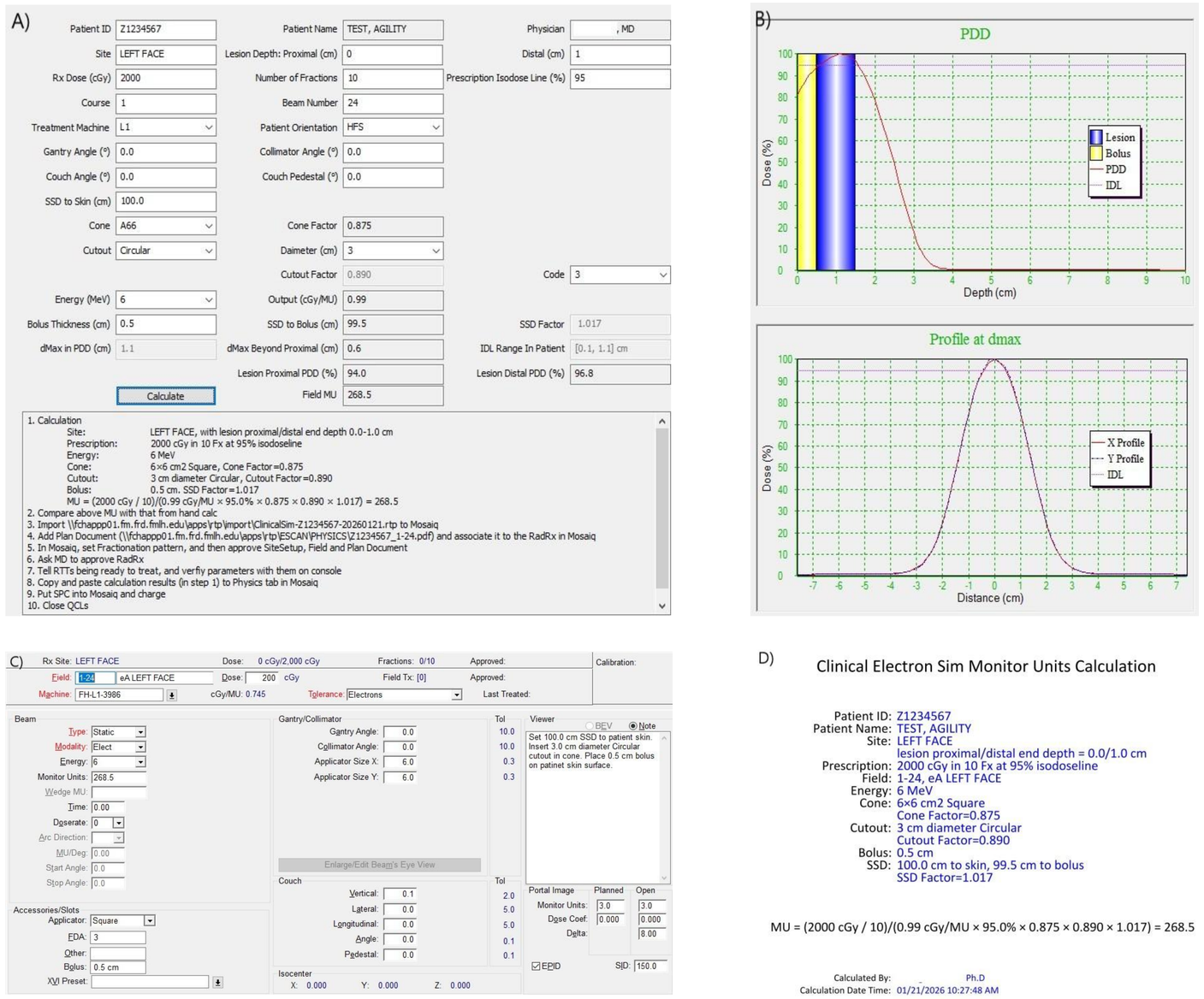

Figure 1: A) Program GUI showing inputs and instructions. B) PDD and profile with isodose line, lesion and bolus indicators. C) Electron field imported into the R&V from the automatically generated RTP file from the program. D) Program automatically generated calculation report.

RESULTS

- Beam matched within 2% for each individual energy.
- Validation of these cutouts indicated that the dimensions were within 1% and the measured cutout factors were within 1.5% of the book values.
- Workflow validation indicated that an average saving of 10 minutes was achieved in calculation and documentation, no calculation error was observed due to on-the-fly setting changes. The databook was made available on the department intranet to verify software based MUs with hand calculations.

CONCLUSIONS

Standardization and automation of electron MU calculation across a multi-center network enables safe and efficient clinical electron simulation and treatment workflows in urgent clinical settings.