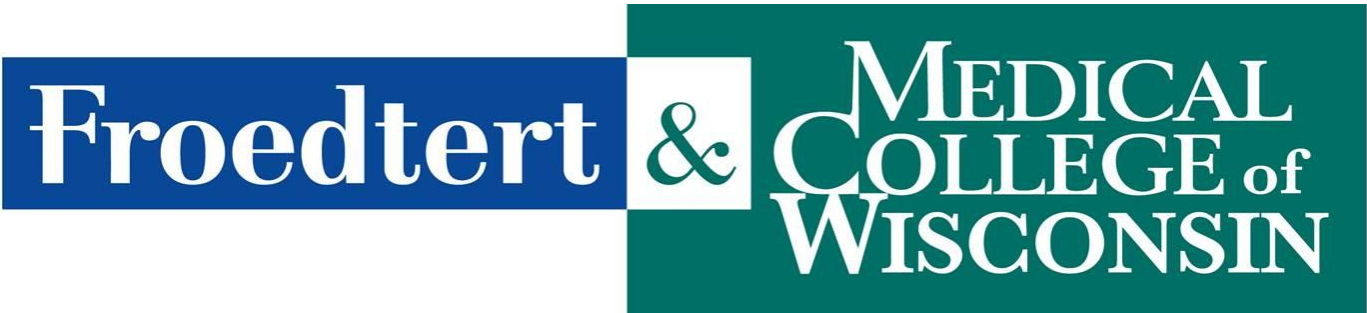




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Standardization and Automation of Monitor Unit Calculation for Clinical Electron Simulation and Treatment in a Multi-Center Radiation Oncology Network

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INTRODUCTION

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

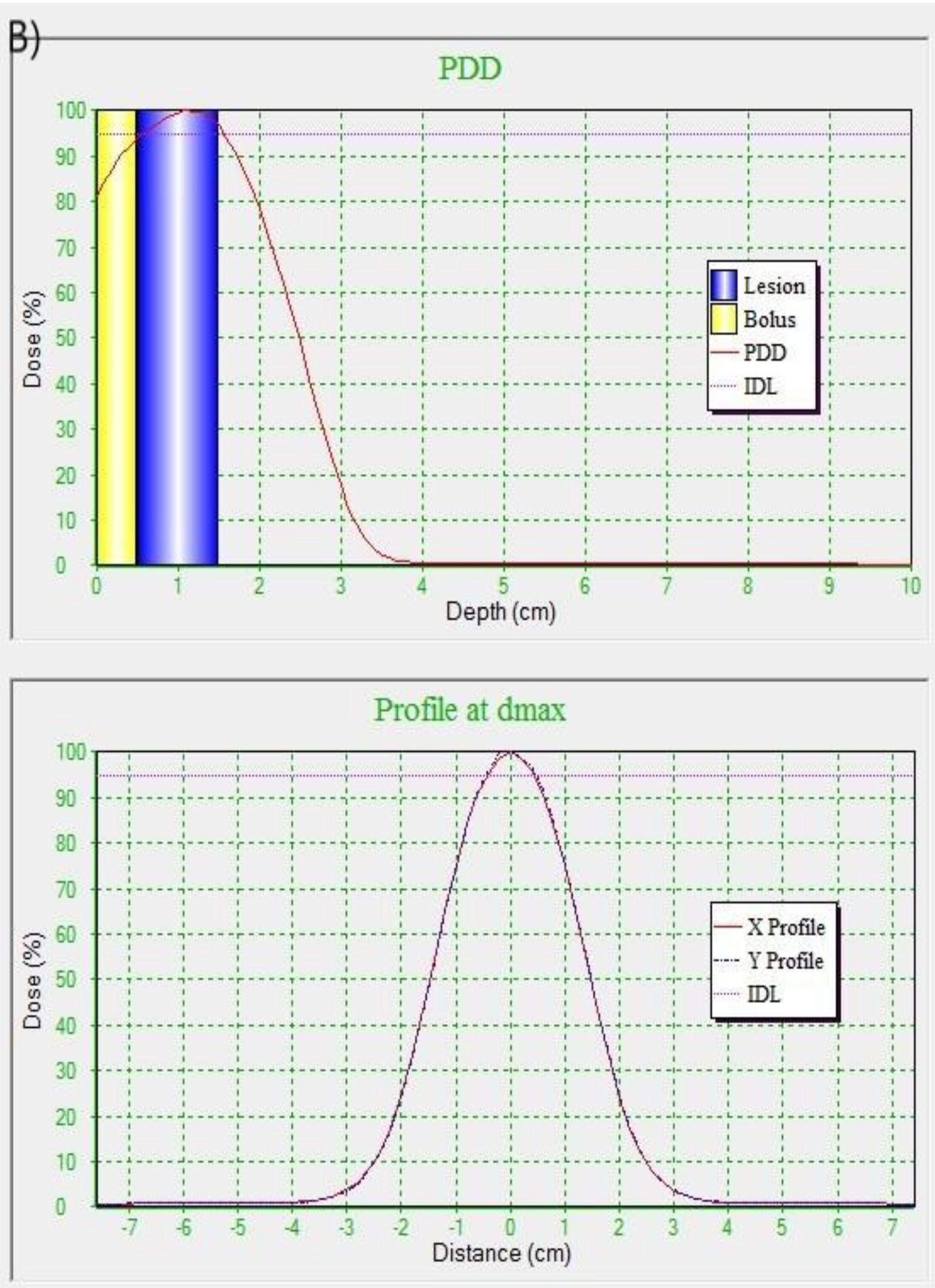
- Electron beams with same energy were matched over all available machines.
- Beam data including percentage-depth-dose (PDD) curves, profiles, applicator and cutout factors, etc., at various source-to-surface distances were obtained with Monte-Carlo dose calculation in Monaco (Elekta Instruments, Stockholm). 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.

A) Patient ID: Z1234567, Patient Name: TEST, AGILITY, Physician: , MD, Site: LEFT FACE, Lesion Depth: Proximal (cm): 0, Distal (cm): 1, Rx Dose (cGy): 2000, Number of Fractions: 10, Prescription Isodose Line (%): 95, Course: 1, Beam Number: 24, Treatment Machine: L1, Patient Orientation: HFS, Gantry Angle (°): 0.0, Collimator Angle (°): 0.0, Couch Angle (°): 0.0, Couch Pedestal (°): 0.0, SSD to Skin (cm): 100.0, Cone: A66, Cone Factor: 0.875, Cutout: Circular, Daimeter (cm): 3, Cutout Factor: 0.890, Code: 3, Energy (MeV): 6, Output (cGy/MU): 0.99, Bolus Thickness (cm): 0.5, SSD to Bolus (cm): 99.5, SSD Factor: 1.017, dMax in PDD (cm): 1.1, dMax Beyond Proximal (cm): 0.6, IDL Range In Patient: [0.1, 1.1] cm, Lesion Proximal PDD (%): 94.0, Lesion Distal PDD (%): 96.8, Field MU: 268.5

Calculate

1. Calculation
Site: LEFT FACE, with lesion proximal/distal end depth 0.0-1.0 cm
Prescription: 2000 cGy in 10 Fx at 95% isodoseline
Energy: 6 MeV
Cone: 6x6 cm2 Square, Cone Factor=0.875
Cutout: 3 cm diameter Circular, Cutout Factor=0.890
Bolus: 0.5 cm, SSD Factor=1.017
MU = (2000 cGy / 10) / (0.99 cGy/MU × 95.0% × 0.875 × 0.890 × 1.017) = 268.5
2. Compare above MU with that from hand calc
3. Import \\fchapp01.f.m.frd.fmlh.edu\apps\tp\import\ClinicalSim-Z1234567-20260121.rtp to Mosaik
4. Add Plan Document (\\fchapp01.f.m.frd.fmlh.edu\apps\tp\ESCAN\PHYSICS\Z1234567_1-24.pdf) and associate it to the RadRx in Mosaik
5. In Mosaik, set Fractionation pattern, and then approve SiteSetup, Field and Plan Document
6. Ask MD to approve RadRx
7. Tell RTTs being ready to treat, and verify parameters with them on console
8. Copy and paste calculation results (in step 1) to Physics tab in Mosaik
9. Put SPC into Mosaik and charge
10. Close QCLs

C) Rx Site: LEFT FACE, Dose: 0 cGy/2.000 cGy, Fractions: 0/10, Approved: , Calibration: , Field: 1x2, eA LEFT FACE, Dose: 200 cGy, Field Tx: [0], Approved: , Machine: FH4-1-3986, cGy/MU: 0.745, Tolerance: [Electrons], Last Treated: , Beam: Type: Static, Modality: Elect, Energy: 6, Monitor Units: 268.5, Wedge MU: , Time: 0:00, Degrate: 0, Arc Direction: , MU/Deg: 0.00, Start Angle: 0.0, Stop Angle: 0.0, Accessories/Slots: Square, EDA: 3, Other: , Bolus: 0.5 cm, XXL Preset: , Gantry/Collimator: Gantry Angle: 0.0, Collimator Angle: 0.0, Applicator Size X: 6.0, Applicator Size Y: 6.0, Tol: 10.0, 10.0, 0.3, 0.3, Enlarge/Edit Beam's Eye View, Couch: Vertical: 0.1, Lateral: 0.0, Longitudinal: 0.0, Angle: 0.0, Pedestal: 0.0, Tol: 2.0, 5.0, 5.0, 0.1, 0.1, Isocenter: X: 0.000, Y: 0.000, Z: 0.000, Portal Image: Planned, Open, Monitor Units: 3.0, 3.0, Dose Coef: 0.000, 0.000, Delta: 6.00, EBD, SID: 150.0



D) Clinical Electron Sim Monitor Units Calculation

Patient ID: Z1234567
Patient Name: TEST, AGILITY
Site: LEFT FACE
lesion proximal/distal end depth = 0.0/1.0 cm
Prescription: 2000 cGy in 10 Fx at 95% isodoseline
Field: 1-24, eA LEFT FACE
Energy: 6 MeV
Cone: 6x6 cm2 Square
Cone Factor=0.875
Cutout: 3 cm diameter Circular
Cutout Factor=0.890
Bolus: 0.5 cm
SSD: 100.0 cm to skin, 99.5 cm to bolus
SSD Factor=1.017

MU = (2000 cGy / 10) / (0.99 cGy/MU × 95.0% × 0.875 × 0.890 × 1.017) = 268.5

Calculated By: Ph.D
Calculation Date Time: 01/21/2026 10:27:48 AM

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.