Validation of MOSFET Dosimetry for In-Vivo Dose Verification in Patients with Implanted Electronic Devices

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Introduction

- Recent discontinuation of OSLDs prompted the adoption of MOSFETs as an alternative for in-vivo dose verification for patients with cardiac implantable electronic devices (**CIEDs**).
- Dose to CIEDs must be characterized as **radiation interactions in these devices can compromise their functionality**.[1]
- MOSFET signal is known to be dependent on photon energy, dose rate, source-to-surface distance (SSD), and oblique beam angles.[2,3]

Purpose: Characterize the response of MOSFETs under a range of clinically relevant beam delivery parameters and determine workflow compatibility of MOSFETs in CIED dose verification.

Methods

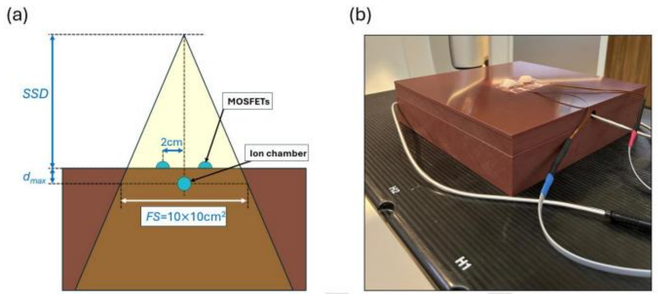

Figure 1. *(a) Solid water and MOSFET setup schematic. (b) 6 MV setup for MOSFETs.*

A solid water-based setup (***Figure 1***) was used to compare ion-chamber response to standard sensitivity MOSFET (TN-502RD-H, Best Medical Canada) readings. Seventeen test plans were compared and delivered on a Varian TrueBeam, covering varied beam parameters:

- 6 MV vs. 15 MV Photons, 6-18 MeV Electrons
- 6 MV vs. 6 FFF Photons
- 100 MU/min – 1400 MU/min Dose Rate
- 83-113 cm SSD
- Oblique Gantry 30 ° and 60°

End-to-end validation was performed with an anthropomorphic phantom. A head-and-neck VMAT plan was generated and a setup CBCT was acquired prior to plan delivery. MOSFETs were localized on CBCT, and readings were compared to the treatment planning system point dose.

Results

- Across all measurements, MOSFET readings were within ±5.4% of ion-chamber reference.
- The most significant differences occurred with high-SSD electron setups and beam energy variations (15-20%).
  - Depth corrections were applied to account for variations attributable to detector positioning.
- No significant trends were identified with dose rate or FF versus FFF delivery.
- For end-to-end measurements, the MOSFET and treatment planning system agreed within 7%, with MOSFETs visible on CBCT despite high-density artifacts from the pacemaker.

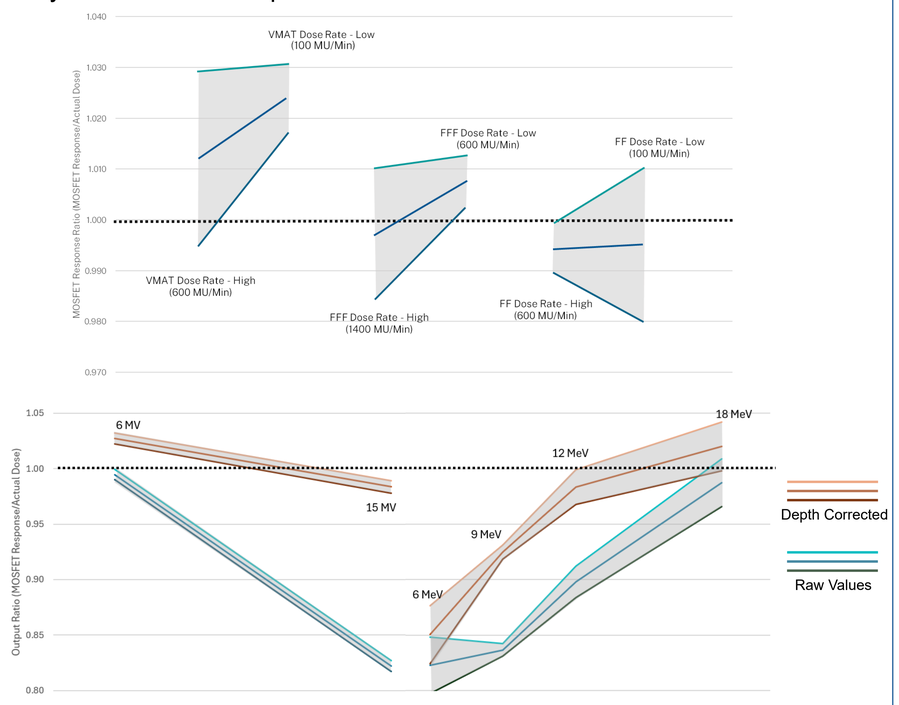

Figure 2. *Ratio of MOSFET/Ion Chamber response for varying dose rate and FFF vs FF (top) and varying energy (bottom) delivery. Upper line and lower line indicate response of individual MOSFETs with centre line illustrating averaged response.*

Figure 3. *Acquired CBCT image demonstrating the visibility of MOSFETs near high-density pacemaker artefact.*

Discussion

- Significant differences occurred with high-SSD electron setups and beam energy variation.
  - These correspond to geometries where the MOSFETs and ion-chamber sample different effective depths within the steep-gradient build up region, highlighting the **need to account for detector depth and MOSFET placement** when interpreting results.
- Visibility on CBCT demonstrates workflow compatibility for MOSFETs in CIED dose verification, even in presence of high-Z artefacts.
  - Dosimetric accuracy was acceptable at 7%, and comparable to other available in-vivo methods (i.e. diodes)

Conclusion

- Through individual tests assessing MOSFET response to different beam parameters, significant dosimetric disagreements were not found when varying dose rate or FFF versus FF delivery
- Differences in measurements for beam energies could be accounted for when assessing the difference in positions of the ion-chamber and MOSFETs
- End-to-end validation demonstrates workflow compatibility.

We demonstrated that MOSFETs have acceptable accuracy, CBCT visibility, and negligible dose rate dependence for practical clinical adoption for CIED dose management.

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More Info

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References

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