Intraoperative electron beam intercomparison of 6 sites using mailed thermoluminescence dosimetry: Absolute dose and energy

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1. Purpose/Objective

In 2018, the Netherlands Commission on Radiation Dosimetry launched a subcommittee on the subject of intraoperative radiotherapy. We performed a dosimetry audit specific to intraoperative irradiation and the diversity of equipment and accelerators among committee members in Belgium and The Netherlands.

2. Material/Methods

Preceding the intercomparison, a questionnaire was sent to all 6 participating sites about accelerator equipment, dosimetry equipment and practice.

In this study, three types of IOERT dedicated mobile accelerators were represented: Mobetron 2000 (IntraOp), LIAC HWL and LIAC (SIT). Mobetron produces electron beams with energies of 6, 9 and 12 MeV, while LIAC HWL and LIAC can deliver 6, 8, 10 and 12 MeV. TLDs were ordered from the Radiation Dosimetry Services (RDS) (Houston, USA) [1]. A set of three 30×85×85 mm^3 PMMA slab phantoms was used (mailed). Each slab has a central hole designed to accommodate a PMMA insert (90×30×30 mm^3) in which two sets of three TLDs were located, at users' specific depths, one set at depth as close as possible to D_{max} and one set around R50. TLDs were to be irradiated to 300 cGy at D_{max}. According to the RDS, a test is considered satisfactory if the difference between the expected and the measured dose is less than 5% or when the difference between the expected and the measured R50 is less than 5 mm.

3. Results

The audit focused on the accuracy of D_{max} for the reference collimator (diameter 100 mm, 0° bevel) and for a collimator representative of clinical activity (50 mm collimator for breast irradiations and 50 mm 45° beveled collimator for pelvic irradiations), as well as checks on beam energies.

Audit measurements with the reference applicator were performed for 20 beams, 12 from Mobetron and 8 from SIT machines. All measurements came back as satisfactory, with a ratio between the RDS dose and the stated dose ranging from 0.95 to 1.03. The average value was 0.984.

A total of 17 beams (9 for Mobetron and 8 for SIT machine) were checked and considered satisfactory with the 50 mm 0° bevel applicator. The RDS dose to stated dose ratios ranged from 0.96 to 1.01. The mean value was 0.992.

The last verification concerned a typical beam used in pelvic irradiation (50 mm 45° beveled, 6 MeV) and revealed a difference of +14% compared to the expected dose at D_{max}. This difference was confirmed by additional measurements.

The statistical analysis did not reveal any factors that would have significantly influenced the results (type of machine, dosimetric protocol used, beam energy, calibration laboratory) apart from a small difference for the results obtained with the ROOS chamber and the NACP chamber.

For the R50 determinations, 37 beams were checked and considered satisfactory. The differences ranged from -5 to 2 mm. The average difference was -0.62 mm.

4. Conclusion

All except one absolute dose values of non-reference beams and all energy values are well within measurement accuracy of RDS TLDs. Still, one outlier could be found and this demonstrates the relevance of redundant output factor determinations and independent verification.

5. References

[1] Kirby TH, Hanson WF, Johnston DA. Uncertainty analysis of absorbed dose calculations from thermoluminescence dosimeters. Med Phys 1992;19:1427–33. https://doi.org/10.1118/1.596797.