TECHNICAL NOTE

MOSFET dosimetry in-vivo at superficial and orthovoltage x-ray energies

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Abstract

This note investigates in-vivo dosimetry using a Metal Oxide Semiconductor Field Effect Transistor (MOSFET) for radiotherapy treatment at superficial and orthovoltage x-ray energies. This was performed within one fraction of the patients treatment. Standard measurements along with energy response of the detector are given. Results showed that the MOSFET measurements in-vivo agreed with calculated results on average within ± 5.6% over all superficial and orthovoltage energies. These variations were slightly larger than TLD results with variations between measured and calculated results being ± 5.0% for the same patient measurements. The MOSFET device provides adequate in-vivo dosimetry for superficial and orthovoltage energy treatments with the accuracy of the measurements seeming to be relatively on par with TLD in our case. The MOSFET does have the advantage of returning a relatively immediate dosimetric result after irradiation.

Key words orthovoltage, superficial x-rays, MOSFET, radiotherapy, TLD's

Introduction

In-vivo measurements of applied dose during orthovoltage and superficial x-ray treatment are important to ensure the accurate dose delivery to patients. Traditionally Thermo luminescent dosimeters (TLD) are used for dose assessment [1] in these regions due to their small size, which allows the closed end orthovoltage cones to be placed directly on the patients skin for the treatment. A metal oxide semiconductor field effect transistor (MOSFET) device also provides the required characteristics for in-vivo dosimeters similar to the TLD's [2-4]. This note presents results to assess the reproducibility of a MOSFET detector in standard conditions and for use in-vivo at superficial and orthovoltage energies.

Materials and methods

A Pantak DXT300 orthovolatge machine, capable of producing x-rays up to a nominal energy of 300kVp [5] is used for irradiation of patients and dosimeters. Two x-ray beam energies are reported in this note. These being 100kVp, HVL = 3.5mm Al and 250kVp, HVL = 2.3mm Cu. The orthovoltage machine is controlled using dose mode, ie has an in-built ionization chamber for accurate dose delivery conditions and is measured in standard conditions to deliver doses from 50cGy to 500cGy with an accuracy of within 1%.

The MOSFET detectors and system used were constructed at the University of Wollongong in 1998. The operation of the MOSFET detector is based on the build up of charge created by ionizing radiation in the gate silicon oxide. The detectors physical dimensions are approximately 3mm diameter and 3mm thick and are encapsulated in solid water [6] material to produce a tissue equivalent protective layer around the detector [7]. The detectors have a 5V bias voltage applied during irradiation to control the sensitivity of the measuring device. The n-MOSFET detectors were obtained from the Ukraine and have a 1 micrometer thick oxide layer with a aluminum gate electrode of 0.5micro meter thickness [8]. Measurements of standard doses using a MOSFET detector were performed in 100cGy allotments. 50 consecutive measurements were performed to assess the reproducibility of the detector in standard conditions. Measurements were also performed on 25 patients in-vivo at both 100kVp and 250kVp. Sites of treatment included, head and neck, torso and limbs. Field sizes ranged from 4cm diameter up to 15cm x 8cm. Treatments were performed with closed end orthovoltage cones for 250kVp beams and with open-end superficial cones at 100kVp. The

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cones were placed directly onto the patients skin surface for all treatments. The MOSFET detectors were taped firmly to the skin during exposure along with TLD detectors. TLD measurements were performed on patients to compare the accuracy of measured results**.**

Results and discussion

Table one shows the energy dependence of the MOSFET detector in the energy range 50kVp to 250kVp and compared to LiF TLD's. Results are normalized to 1 at 250kVp. The MOSFET produces a relatively large change in response over these energies. This is due to the relatively high atomic number materials used in the manufacture of this MOSFET device. The MOSFET dosimeter is placed on a TO-5 gold plate kovar substrate. Variations in the microscopic structure of each MOSFET device could vary the energy response of each individual detector [9]. Thus, a standard calibration is necessary at all clinical energies used for dosimetry and for every new MOSFET detector utilized. Figure 1 shows the reproducibility of the MOSFET detector by measuring 100cGy for 50 consecutive irradiations. Variations in the beam output were measured to be less than 1%. Results show that the MOSFET detector produces a relatively accurate result with a reproducibility of 3.6% (2SD of mean) and a largest error of 3.5%. These values are relatively consistent with the reproducibility of TLD chips with similar measurements made and a reproducibility of 3.2% (2SD of mean) calculated.

Figure 2 shows the calculated, and measured dose per fraction in-vivo for the 25 patients treated. Measurements are for MOSFET's and applied doses ranged from 200cGy to 800cGy per fraction. Results show that the MOSFET detector provides an adequate measure of absorbed dose at superficial and orthovoltage. Due to the fact that the MOSFET device has relatively large energy dependence, it is important to perform a calibration standard at each clinical energy used for treatment. Results showed that the MOSFET was adequate for dosimetry at both orthovoltage and superficial energies. The MOSFET system does have the advantage of producing immediate dose output results for analysis whereas devices like TLD's require an annealing and readout process before calculations can be made. Table two provides a breakdown of the patient results for the MOSFET detector for percentage deviations between the measured and calculated doses. For example, 28% of measurements produced a deviation of greater than 6% between calculated and measured results. The placement of the MOSFET device on the patient for measurement did not pose any problems in regards to the patient's clinical treatment set up. In all cases the detectors were placed or taped flat to the skin surface with the cones touching the device and the skin. There may be some slight problems if the treatment site was an open wound or extremely sore, although, if this was the case, the closed end cones would also not be able to be placed directly on the skin. In this case a small TLD that can be placed more easily (and lightly) on the skin may be more appropriate for dosimetry.

Energy (kVp)	Relative response (normalised to 1 at 250kVp)	TLD (LiF)
50	4.40	1.34
75	4.30	1.29
100	3.30	1.21
150	1.90	1.16
200	1.40	1.05
250	1.00	1.00

Table 1. *Energy dependence of MOSFET dosimeter to superficial an or thovoltage energies.*

Deviation (greater than)	% of results (per fraction)
0	100
2	80
4	52
6	28
8	12
10	8
12	0

Table 2. *Percentage histogram data for variations in measured and calculated doses for superficial and orthovoltage treatments.*

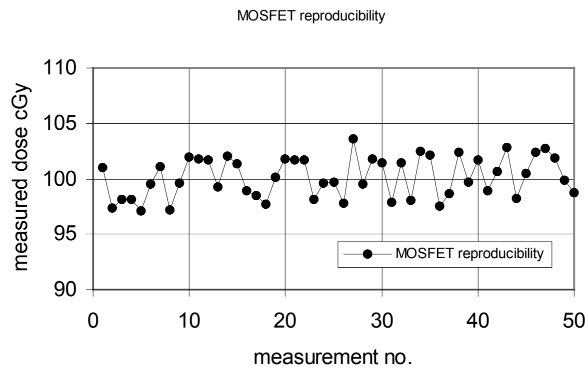

Figure 1. *Reproducibility of MOSFET detector system to 250kVp radiation with applied doses of 100cGy.*

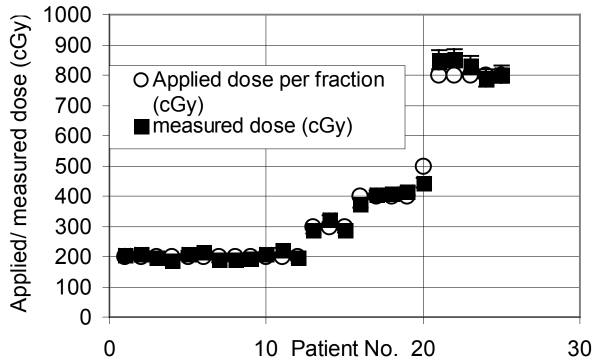

Figure 2. *Calculated and measured doses in-vivo for superficial and orthovoltage treatments.*

Conclusion

The MOSFET device has adequately measured dose in-vivo at superficial and orthovoltage energies. It is small enough to not be intrusive and provides an immediate in-vivo dose result for dose assessment. The energy response of the detector is relatively high compared to TLD's but this can be accounted for with the appropriate calibrations factors for each energy.

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