Study of Onedose Mosfet for Quality Assurance of Advance Radiotherapy Techniques

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Abstract*:* In advanced treatment the patient dose verification having most important role. In routine clinical practice clinical dosimetry QA is essential. For this practice Phantom and various detectors are used. Now a days instead of the ionchamber detector we used semiconductor detector. Onedose MOSFET ™ (Sicel Technology) used which compare with reference detector like ion chamber (cc01,cc13,FC65 & Dosimetry Film) for 6 MV and 15MV Energy beam. It has good response in linearity, dose rate and angular measurement for both energys. The MOSFET has good linearity in the range with linearity coefficient of 0.992. In this study it has independent dose rate but in range. It has good response in multi institutional QA process with better response.

Kumar *et al* 2009[8] measured for isocenter found that absolute dose was compared with the treatment planning system (TPS) plan. The maximum variation observed in cco1 ionization chamber because of their small volume. The micro ionization chamber shows more deviations when compared with semi flex and 0.6 cm^3 with a maximum variation of 4.76%, 1.49%, and 2.23% for micro-ionization, and farmer chambers. We also observed maximum variation with MOSFET within 3 % .

Keywords: *MU,QA,VMAT*.

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I. INTRODUCTION:

The MOSFET dosimeter is a miniature non-intrusive semiconductor radiation detector. The MOSFET is a sandwich type device with a positively doped (P-type) silicon semiconductor substrate in addition to an insulating oxide layer separating it from the negatively doped (N-type) silicon. Prior to radiation a sufficiently large negative voltage is applied to the poly-silicon gate, with the result that a significant number of minority carriers (holes) will be attracted to the oxide-silicon surface from both the bulk silicon substrate between the source and drain regions. Once a sufficient concentration of holes has accumulated there, a conduction channel is formed, allowing current to flow between the source and drain. The voltage necessary to initiate current flow is known as the device threshold voltage.

When a MOSFET device is irradiated, three things happen within the silicon dioxide layer (sensitive region): a build-up of trapped charge in the oxide; the increase in the number of interface traps; and the increase in the number of bulk oxide traps Electron-hole pairs are generated within the silicon dioxide by the incident radiation. Electrons move out of the gate electrode while holes move in a stochastic fashion towards the Si/SiO2 interface where they become trapped in long term sites, causing a negative threshold voltage shift, which can persist for years. The difference in voltage shift before and after exposure can be measured, and is proportional to dose The MOSFET dosimeter offers several advantages over the conventional dosimeters, including its small detector size, immediate retrieval of information about the measured dose, immediate reuse, and its ability to conduct multiple point dose measurements. In addition, the MOSFET dosimeters can provide immediate readouts for *in vivo* dose measurements as well .In this study we studied characteristic One dose MOSFET and it's use for the quality assurance for rapid arc.

II. Material and Method:

The oneDose MOSFET system (OneDose™, Sicel Technologies, Morrisville,NC—distributed by Med-Tec, Orange City, IA) is a single *p*-type MOSFET detector and an EEPROM device

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Fig 1.One Dose MOSFET detector with Reader system..

The OneDose system is small, with a measured area of 3 mm in diameter and 25 mm in length. The detectors are factory calibrated with a Co-60 beam with full build-up conditions. The detectors are wireless, which make them easier to use. The accuracy of the detectors as specified by the manufacturer is ± 1 cGy for a dose that is less than 20 cGy and ± 5% for a dose of 20 cGy to 500 cGy (Sicel Technologies Inc).. Each detector is valid for one use only. OneDose MOSFET detectors are considered a safe, non-invasive dose verification system that could be used with all types of radiation therapy treatments.

A. Dose reproducibility and Linearity:

We investigated the dose reproducibility of the MOSFETs to examine the linearity of MOSFET response with dose and, in particular, the minimum dose that can be measured in relation to the sensitivity of the MOSFETs. Known doses were delivered to five MOSFETs ranging from 50 cGy to 600 cGy. The results of five dosimeter readings were averaged, and then the percent standard deviation was computed for each known dose.

B. Dose Rate Dependences :

We investigated whether the responses of MOSFET detectors are dose rate independent by taking readings at three different SSDs (120 cm, 100 cm, and 80 cm) at two different dose rates (80 MU/min and 400 MU/min). Fifty cGy was delivered each time with a field size of 10 × 10 cm^2.

C:.Angular response :

We investigate the angular response of MOSFET with gantry angle from 270^0 to 0^0 by 20^0 interval and then from 0^0 to 90^0 by 20^0 interval escape last and first of reference 0^0 interval by 10^0 gantry angle. We measure the respective voltage with each gantry angle.

D.MOSFET calibration :

MOSFET needs to be calibrated before clinical use. To avoid the setup uncertainly and phantom correction related issue, a arc plan of field size 10 x 10 cm^2 was generated by treatment planning system to determine the response of MOSFET as per planned Treatment Planning(TPS) System dose in indigenous phantom. This was done in order to reduce the effects of daily linac output variations , differences between the phantom and liquid water and to take into account the attenuation of beam by various part of treatment couch. A dose of 200cGy was planned at Isocenter. The phantom was irradiated with MOSFET and response of MOSFET was recorded calibration coefficient was determined. So determined calibration coefficient was used to determine dose for VMAT QA. The treatment planning system was consider as reference for determining the calibration coefficient.

Seven OneDose^{TM} MOSFET detectors were irradiated (one for each patient). These detectors were pre calibrated by the manufacturer for Co-60 energy and above. The MOSFET was placed at the position in the phantom corresponding to a region of high dose and low dose gradient. The lasers were aligned with the center of the phantom. All the MOSFET detectors were zeroed before the measurements and read between 3 to 10 minutes of post irradiation. This was done to avoid the fading effect. The measured dose at central axis with MOSFET was compared with calculated dose from TPS.

III. RESULT:

A. Linearity for Energy 6 MV :

MOSFET response at 10 cm depth by applying dose from 50 MU to 600 MU is shown in figure.2

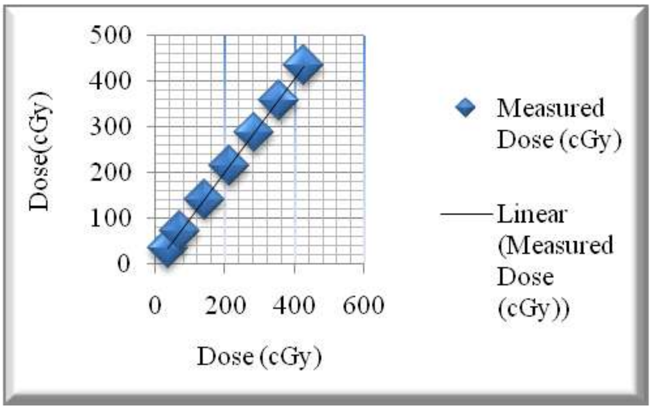

Fig2 Dose Linearity response of MOSFET for Energy 6 MV.

B.Dose Rate Dependence for Energy 6MV:

MOSFET response at different dose rate is shown figure 3. We got maximum variation of 2.96 % at dose rate 500 with respect to 300 dose rate which is clinically use .

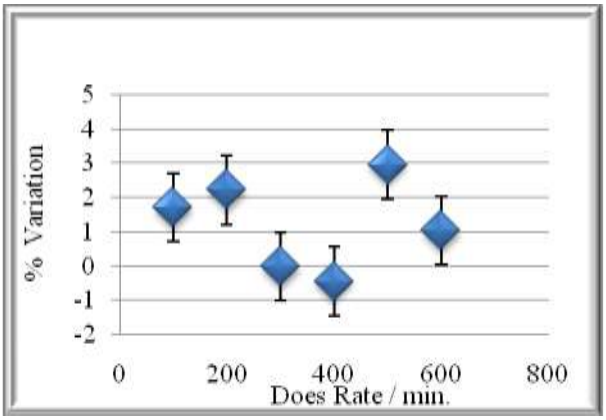

Fig 3 Dose rate response of MOSFET for 6 MV Energy.

We observed from fig MOSFET response is relatively independent of dose rate.

C. Angular response for MOSFET:

Normalized response of MOSFET is shown in to Fig. 4 , clarify that the detector have good response in rotational IMRT.

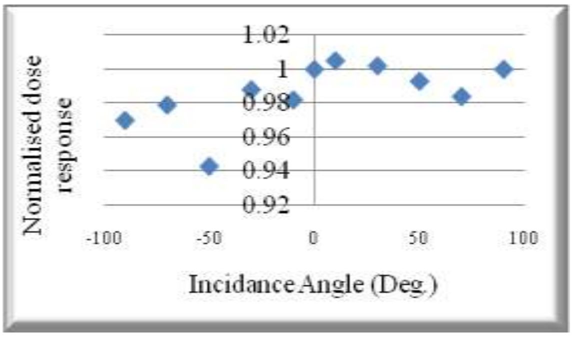

Fig.4. Angular response of MOSFET for 15 MV Energy.

Patient quality assurance for Conformal Arc measurements using MOSFET.

We observed that maximum variation between TPS calculated dose and ion chamber is 1.81 and maximum variation between TPS calculated and MOSFET measured dose is 2.29 %. Percentage variation between TPS calculated and Ion chamber and diode is shown in fig..

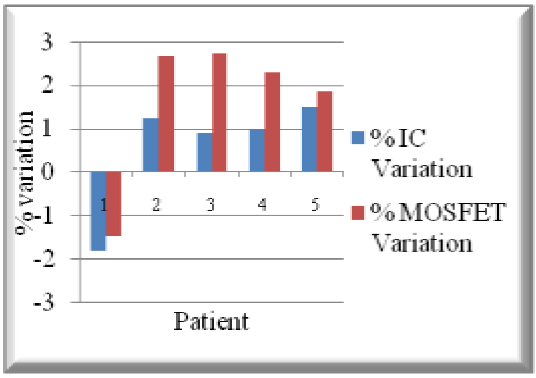

Fig.5. Variation of IC and MOSFET with TPS.

D. Patient Quality Assurance using MOSFET on Tomotherapy:

We observed maximum variation between calculate dose and measured dose with ion chamber is 1.35% and maximu variation between calculated dose and measured dose with MOSFET is 3.23% .

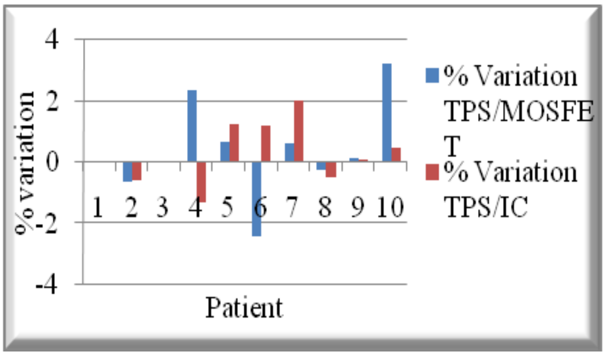

Fig 6.Variation in TPS with Ion chamber and MOSFET.

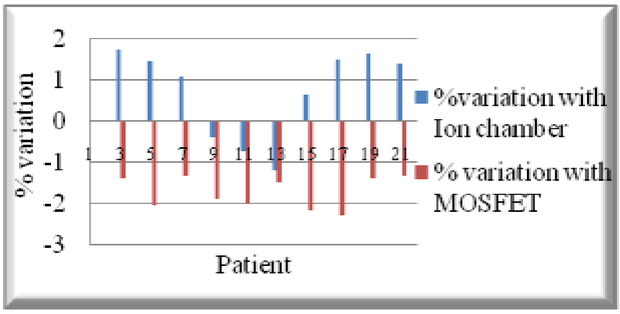

Fig.7. Comparison of dose variation with I.C. and MOSFET in RapidArc.

IV. Discussion:

We observed the MOSFET exhibits good linearity in the studied range with linearity coefficient of 0.992. It was observed that response of the MOSFET was independent of dose rate in the studied dose rate range .. The linearity of the MOSFET as reported in literature [3] for the dose range 0.05 Gy to 4.2 Gy in terms of linearity coefficient is 0.998. This is in good agreement with our measurements. The reproducibility of our measurement was found to be 1.4% above 70 cGy is in line with reported literature [3]. The angular dependence of the MOSFET was found to be within 2.5% which is in excellent agreement with the reported values reported[1]. Similar measurements results reported [4] are also in good agreement with our measurements.

We measured central axis dose using MOSFET for conformal arc treatment and compared with calculated dose from treatment planning system . Since conformal arc treatments does not involved any beam modulation result of these measurement had given us confidence to use Diode and MOSFET with indigenous phantom for complex treatment like Rapid arc and Tomotherapy. Kumar *et al* 2009[8] measured isocenter absolute dose was compared with the treatment planning system (TPS) plan. The micro ionization chamber shows more deviations when compared with semi flex and 0.6 cm^3 with a maximum variation of 4.76%, 1.49%, and 2.23% for micro-ionization, semi flex, and farmer chambers. We also observed maximum variation with MOSFET within 3 % . MOSFET is used for IMRT patient dosimentry [3,4] but very few literature is available about use of VMAT. The average variation between calculated and measured dose reported in literature[5-7] for IMRT plan was within 3%. Appling same criteria for acceptance for VMAT QA result in this study we found variation between calculated and measured dose less than 3 %.

V. CONCLUSION:

We carried out patient specific QA with different volume ion chambers and compared it with MOSFET. For conformal arc we did measurements with .65 cc chamber and diode. We did not observe any significance variation between two chambers. The MOSFET detectors were able to measure the RapidArc QA plans accurately and was found to produce reproducible data. Testing the main three elements of variation for RapidArc delivery is a necessary component of VMAT evaluation and this device allows for a time-efficient method of doing so. MOSFET results had also shown good agreement for tomotherapy patient QA.

REFERENCES:

[1] A.B. Rosenfeld, G. I. Kaplan, T. Kron, B. J. Allen, A. Dilmanian, I.Orion, B. Ren, M. Lerch, and A. Holmes-Siedle, ‘‘MOSFET dosimetry of x-ray microbeams,’’ IEEE Trans. Nucl. Sci. NS-**46**, N6, 1774–1780, (1999).

[2] Jing Cai , Jinbo Yue ,Robert McLawhorn , Wensha Yang , Krishni Wijesooriya , Neal E. Dunlap , Ke Sheng , Fang – Fang Yin , Stanley H. Benedict , “Dosimetric comparison of 6MV and 15MV single arc rapidarc to helical tomotherapy for the treatment of pancreatic cancer”, Medical Dosimetry ,**36**- 3: 317 -320 (2011).

[3] Scalchi P and Francescon P 1998 Calibration of a MOSFET detection system for 6 MV in vivo dosimetry Int. J.Radiat. Oncol. Biol. Phys. **40** 987–93.

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16 – 19

[4] Soubra M, Cygler J and Mackay G 1994 Evaluation of a dual bias dual metal oxide-silicon semiconductor field effect transistor detector as radiation dosimeter Med. Phys. **21** 567–72

[5] A.B. Rosenfeld, M. G. Carolan, B. J. Allen, and V. I. Khivrich, ‘‘MOSFET Dosimeters: role of encapsulation in mixed gamma-neutron and megavoltage x-ray fields,’’ IEEE Trans. Nucl. Sci. NS-**42**, 1870–1877, (1995).

[6] Halvorsen “Dosimetric evaluation of a new design MOSFET in vivo dosimeter”, Med. Phys. **32** 110–7, (2005).

[7] Dirk Verellen, Sven Van Vaerenbergh, Koen Tournel, Karina Heuninckx, Laurent Joris, Michael Duchateau, Nadine Linthout, Thierry Gevaert, Truus Reynders, Iwein Van de Vondel, Luc Coppens, Tom Depuydt, Mark De Ridder and Guy Storme “An in-house developed resettable MOSFET dosimeter for radiotherapy”, Phys. Med. Biol. 55 (2010).

[8] Kumar R, Sharma SD, Deshpande S, Ghadi Y, Shaiju VS, Amols HI, Mayya YS. Acrylonitrile Butadiene Styrene (ABS) plastic based low cost tissue equivalent phantom for verification dosimetry in IMRT. J Appl Clin Med Phys. Dec 17;11(1):3030,2009.