Clinical implementation of MOSFET for daily in vivo measurements

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AIM

To develop a method to perform daily in vivo dose measurements using MOSFET without build-up cap to be used in treatment units not provided with a record and verify system

MATERIAL

• **Treatment unit**

•Cobalt unit theratron 780 (theratronix)

•***In vivo* dosimetry system**

•MOSFETdetectors TN-502 RD (Thomson Nielsen). Characteristics in Table I.

•Reader Autosense model TN-RD-60 (Thomson Nielsen).

•Build up caps: 0.6 cm radius hemispherical brass cap and 1cm radius *plastic water* ™ cap (fig. 1)

•**Reference dosimetry system**

0.6cc cylindrical ionisation chamber (PTW) connected to an INOVISION electrometer (Fluke Biomedical). Calibration factor trazable to a Secondary Standard Dosimetry Laboratory (CIEMAT).

•**Phantom**

plastic water ™ (CIRS) phantom. Slab thickness ranging from 0.1 to 6 cm, slab area 30x30 cm^2. Special slab for the i.c.

•**Patients**

A series of 10 patients with 2 coplanar opposite fields.

Table I MOSFET in vivo system. Detector specifications.

Detector type	MOSFET
Model	TN-502 RD standard (Thomson Nielsen)
Electrometer	Autosense TN-RD-60 (Thomson Nielsen)
Water equivalent depth of the effective measurement point (g/cm^2)	0.07
Effective detection area (mm^2)	0.04
Detector particularities	• Dual MOSFET • Biased during irradiation (high sensitivity mode)
Coating material	Epoxy
Detector picture	

(a)
(b)

Fig. 1(a) Images of the plastic water cap (left) and brass cap (right)
(b) The same picture but turned upside down showing that both have a groove for the MOSFET

METHODS and RESULTS

1.CALIBRATION METHODOLOGY

A. Calibration dose: As the precision of MOSFET readings depends on the dose and MOSFET have a limited dose-related lifetime, the minimal dose and the sample size to achieve acceptable precision was studied. Two MOSFET were irradiated till they became useless, one with 1 Gy irradiations the other with 0.5 Gy irradiations.

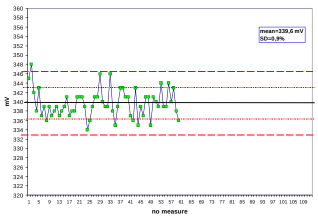


Fig 1. Mosfet response (mV) at repeated irradiadions of 1 Gy. The black line correspond to the mean value and the red dashed lines to 1% and 2% deviation from the mean.

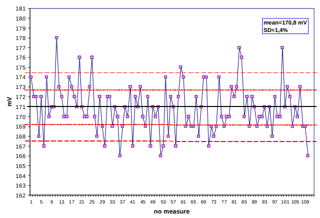


Fig 2. Mosfet response (mV) at repeated irradiadions of 0.5 Gy. The black line correspond to the mean value and the red dashed lines to 1% and 2% deviation from the mean.

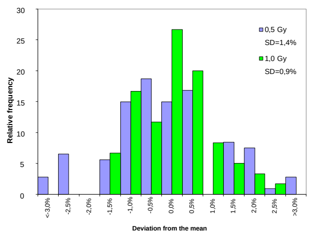


Fig. 3. Relative frequency of readings for 0.5 and 1 Gy irradiations

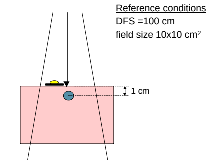
Table II. Number of measurements, i.e. sample size, to get a 2% accuracy when measuring with a MOSFET (accumulated dose in Gy between brackets)

Confidence level	0.5 Gy irradiations	1 Gy irradiations
90%	4 (2 Gy)	3 (3 Gy)
95%	5 (2.5 Gy)	4 (4 Gy)
99%	8 (4 Gy)	5 (5 Gy)

Table III. Dose attenuation at 5 cm depth produced by the MOSFET alone and with the studied build-ups caps

BUILD UP CAP	DOSE ATTENUATION 5cm DEPTH
None	0.15%
Plastic water (1cm radius)	3.23%
Brass (0.6 cm radius)	4.10%

B. Calibration factors



$$F_{cal} = \frac{absorbed\ dose\ IC}{Diode\ reading\ (with\ plastic\ water\ cap)}$$

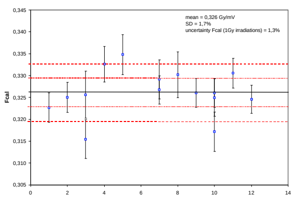


Fig 4. Intra-lot homogeneity. The points correspond to different Mosfets. The black line shows to the mean value of all studied MOSFETs and the red dashed lines a 1% and a 2% deviation from this mean.

C. Correction factors

CF	
Field size	$\frac{OF_{ic}(z_{ref}, SSD=80)^1}{OF_{MOSFET}(SSD=80)}$
SSD	$\frac{R_{ic}(z_{ref}, 10x10, SSD)/R_{ic}(z_{ref}, 10x10, SSD=80)}{R_{MOSFET}(10x10, SSD)/R_{MOSFET}(10x10, SSD=80)}$
wedge	$\frac{transmission\ ic(z_{ref}, 10x10, SSD=80, wd)}{transmission\ MOSFET(10x10, SSD=80, wd)}$
angle	$\frac{R_{MOSFET}(SSD=80, 0°)}{R_{MOSFET}(SSD=80, angle)}$

[1]OF = R(c x c) / R (10 x 10)

R applies for reading, ic for ionization chamber, c for field size, wd for wedge angle and z_{ref} for the reference depth (1 cm)

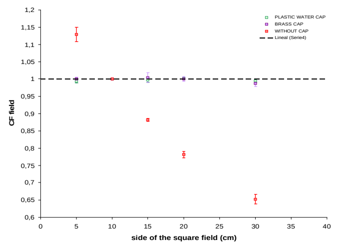


Fig 5. Field size CF for the MOSFET alone and with the studied build-up caps

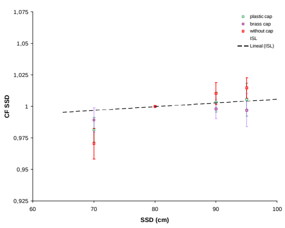


Fig 6. SSD CF for the MOSFET alone and with the studied build-up caps

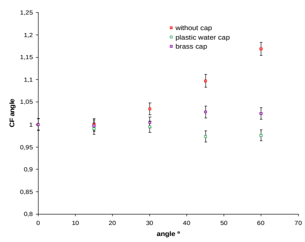


Fig 7. Angle CF for the MOSFET alone and with the studied build-up caps

D. Results in patients

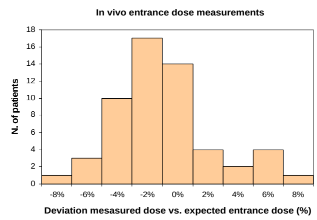


Fig 9. Histogram of the deviations between the measured entrance dose and the expected entrance dose for a cohort of patients. In cases where the result was > 5% (tolerance level) they were repeated, obtaining acceptable values in the repetition. No correction values were applied as they are close to 1when measuring with the *plastic water*™ cap.

Conclusions

•Due to the high dose reduction caused by the build-up caps (table III) they cannot be used to monitor the entrance dose during the whole treatment.

•As the correction factors are high without any cap (fig. 5-8) they cannot give us the dose with a good aacuracy, but they are very sensitive to any variation. For instance, an error of 5 cm in field would lead an error of almost 15% in their reading, so they are perfect for checking errors in treatment units without a record and verify system.

•The proposed methodology is: the first day two mosfets are placed at the entrance, one covered by the plastic water cap and the other one without any cap. The former is placed only the first day, to correctly monitor the entrance dose. The latter is left during the whole tratment. Its reading is taken the first day and it serves as a constancy check.

•As MOSFETs have a limited lifetime, when calibrating and determining the correction factors the number of measurements is crucial. As the number of measurements to get an accuracy of 2% is not the double (within a certain confidence level, see table II) when reducing the dose to one half, **it is better to perform more measurements of less dose than less measurements at a higher dose**.

•As the intra-lot homogeneity is of the order of the MOSFET intrinsic precision (fig. 4), **the calibration factor of one MOSFET can be used for the whole lot**.

•The dependence of the intrinsic precision of MOSFET on the measured dose (Fig.1-3) has to be taken into account when determining the correction factors. Therefore, irradiations have to be programmed to yield the same dose in every condition. To acomplish that, from a first measurement we calculate the irradiation time to have the same reading aproximately. Later, correction factors are calculated using dose rates instead of total doses.