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Dosimeter selection for small field percentage depth dose and tissue-maximum ratio measurements

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INTRODUCTION

The measurement of small field tissue-maximum ratio (TMR) and/or percentage depth dose (PDD) data is necessary for the calculation of dose for stereotactic radiotherapy treatments within treatment planning systems of independent dose verification software.

The measurement of beam configuration data, including TMRs and PDDs, is complicated by volume averaging effects and a loss of lateral charged particle equilibrium in small fields. For this reason, various small-field-suitable dosimeters (e.g. diodes, scintillators) are recommended in the literature in place of the large ionisation chambers typically used for beam configuration data measurements in larger fields.

The objective of this study was to evaluate whether relatively large volume ionisation chambers, that are unsuitable for other small field applications, might be used for accurate TMR or PDD measurements.

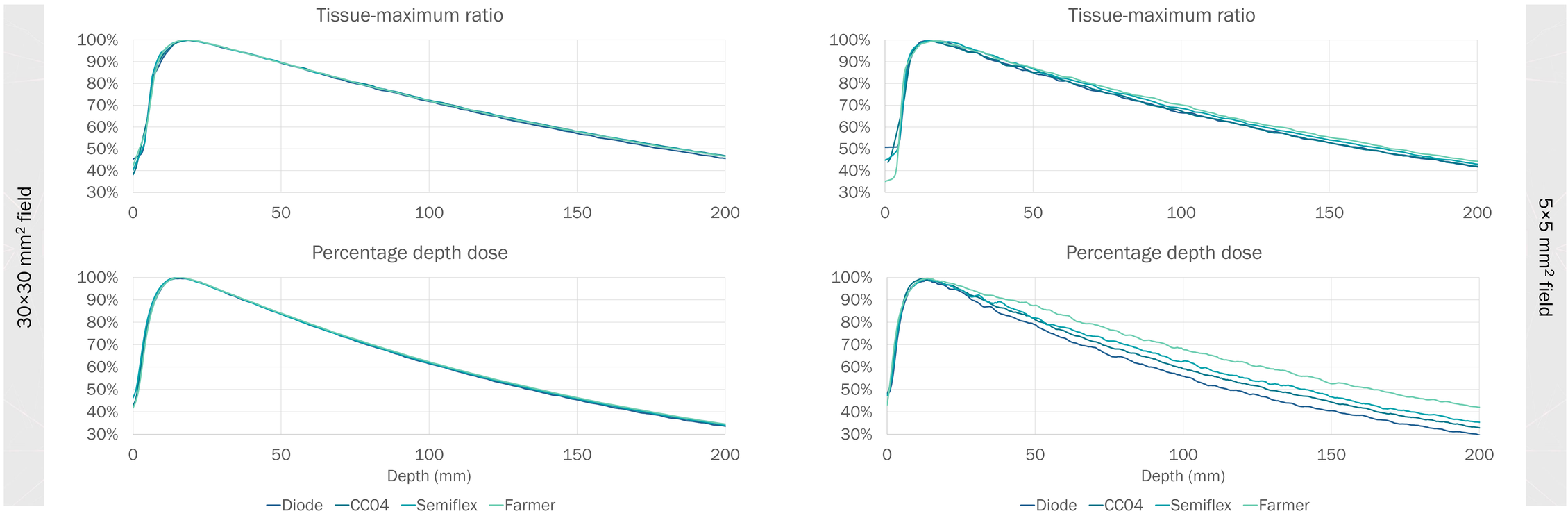
MATERIALS & METHODS

PDD and TMR measurements were performed in an IBA BluePhantom 3D water tank with 100 cm SSD and 100 cm SDD, respectively. Four dosimeters were used:

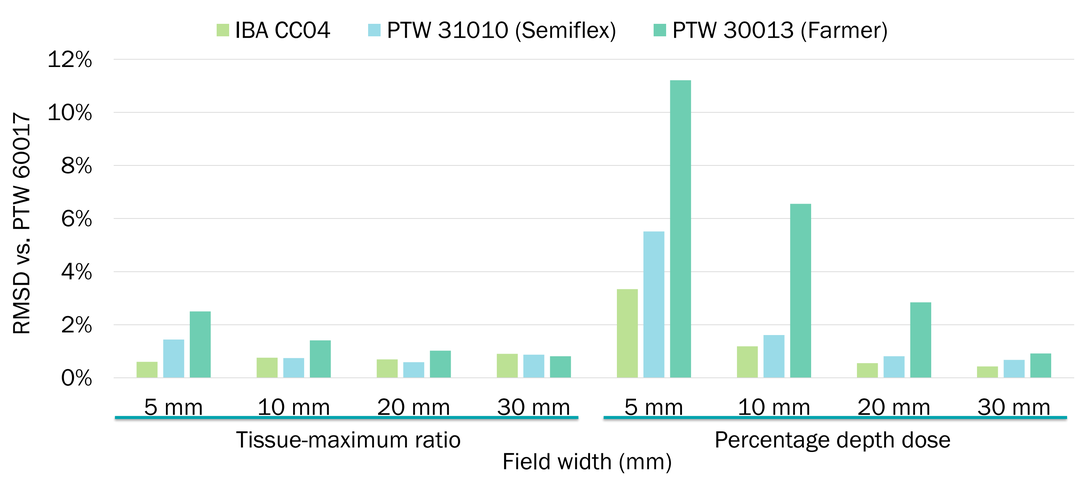
DETECTOR	VOLUME (cm^3)
PTW 60017 Diode E	0.00003
IBA CC04 Chamber	0.04
PTW 31010 Semiflex	0.125
PTW 30013 Farmer	0.6

Data was acquired for four field sizes (0.5×0.5, 1×1, 2×2 and 3×3 cm^2) produced using an Elekta linac. Scans were done consistent with published recommendations[1,2]. Lateral scans were repeated for each field size to verify the positioning of the detector in the field centre. Dose was measured to depths of 250 mm. Measurement data was resampled to 0.5 mm, where necessary, and smoothed with a 2 mm window mean filter.

MEASUREMENTS



ANALYSIS & DISCUSSION



Root-mean-square deviations were calculated between diode measurements (the *gold standard* data) and measurements acquired using the other dosimeters.

The largest disagreement in PDD profiles existed between the PTW 60017 diode and PTW 30013 chamber measurements at the smallest field size, with an RMSD of 11.2%. The corresponding RMSD for TMR data was 2.5%.

The impact of a larger active volume is reduced when measuring TMRs, where the field size varies minimally with depth (i.e. where conditions relating to volume averaging and lack of lateral charged particle equilibrium vary minimally).

The results indicate that accurate TMR measurements may be obtained using dosimeters otherwise considered unsuitable for small field applications.

CONCLUSION

While the PTW 30013 is not suitable for small field dosimetry, it provides a useful example of how TMR measurements are less sensitive to the active volume of the dosimeter than PDD measurements.

If small-field-suitable dosimeters are unavailable, TMR measurements may provide more accurate beam characterisation data than PDD measurements, particularly as there is no well-established method for PDD to TMR conversion for small fields.

REFERENCES

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2. International Atomic Energy Agency (2017) *Technical Reports Series No. 483. Dosimetry of Small Static Fields Used in External Beam Radiotherapy.*