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Short Communication

Statistical Analysis and Verification of the Percentage Depth Dose Calculation Based on the Tissue Maximum Ratio in External Beam Radiotherapy

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Abstract. The aim of this study was to perform a statistical analysis to verify the calculated percentage depth dose (PDD) based on the tissue maximum ratio (TMR) with the PDD measurements taken in water. Photon beams (6 and 15 MV) produced by a Varian linear 2100 C/D accelerator were used. PDDs and TMRs were measured at various depths and field sizes (5 × 5, 10 × 10, 15 × 15, 20 × 20 and 30 × 30 cm^2) using a PTW 31006 ionisation chamber and a scanning water tank. By comparing the calculated and measured PDD results, it was noted that for larger field sizes the deviation between the calculated and measured PDD was smaller. Deviations between the calculated and measured results were found to be higher in the build-up regions of the 6 and 15 MV photon beams. For the statistical analyses, t-tests were performed using the measured and calculated PDDs for each field size but showed insignificant deviations for the 6 and 15 MV photon beams. The mean t-test values are 0.95 and 0.97 for the 6 and 15 MV photon beams, respectively.

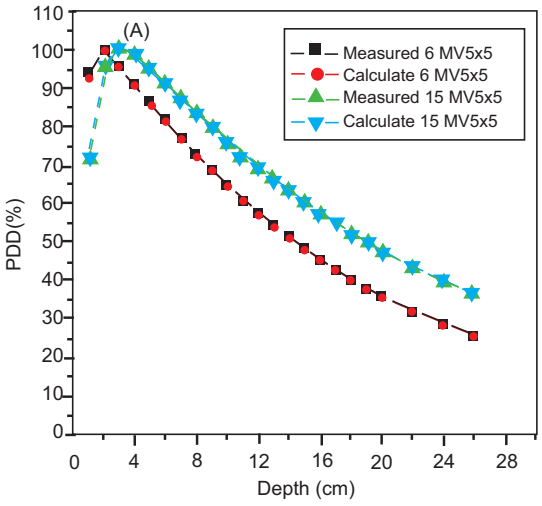
Keywords: external beam radiotherapy, tissue maximum ratio, dosimetry

Different methods for dose measurement and calculation have been studied by many researchers (Birgani and Mahdi, 2005; Tsalafoutas *et al.,* 2000; Kanellitsas *et al.,* 1975; Sterling *et al.,* 1967; 1964). For many treatment planning systems, tissue maximum ratios (TMR) are required as input. Hence, there are well-known conversion methods expressing TMR values in terms of percentage depth dose (PDD), phantom scatter factor (Sp), and inverse square law (van Battun *et al.,* 2002). PDD is defined by Birgani *et al.* (2009).

For comparing the dosimetry and calculated data, some statistical parameters were used such as standard deviation and t-test. (Birgani *et al.,* 2009). The standard deviation and t-test shows that the difference between measured and calculated values is within acceptable range according to the ICRU Report No. 24 (ICRU, 1976).

Figures 1-3 show that the calculated PDDs and measured values have very little deviation, which was obtained by statistical parameter standard deviation as given in Table 1 for the 6 MV and 15MV photon beams. It has been observed that for larger field sizes the deviation between the measured and calculated values has approached towards zero as shown in Fig. 2 and 3.

The maximum dose of the 15 MV photon beam is at 3 cm which is actually D_{max} of the 15 MV in both measures and calculated values as shown in Fig. 4 (Khan, 2010).



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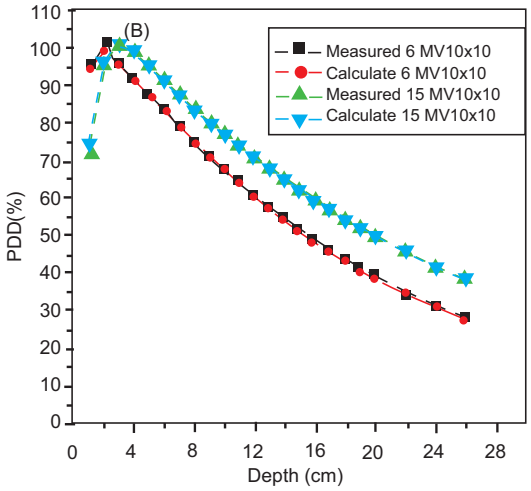
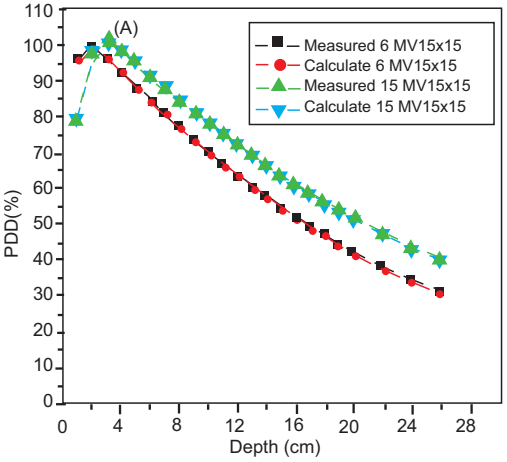


Fig. 1. (A) Shows comparison of PDDs for 5×5 cm^2 treatment fields and (B) illustrates for 10×10 cm^2 treatment field in photon beams of the 6 and 15 MV.



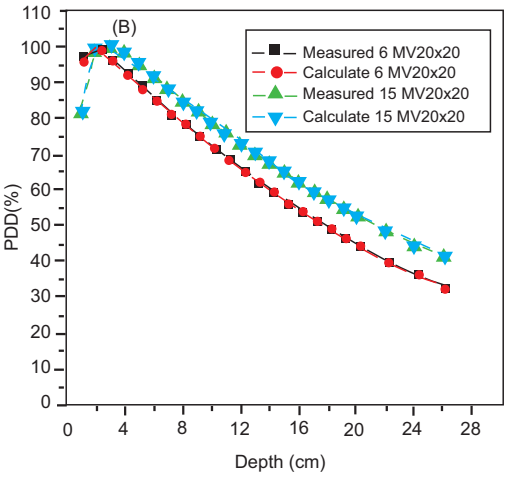


Fig. 2. (A) Shows comparison of PDDs for 15×15 cm^2 treatment fields and (B) 20×20 cm^2 treatment field in photon beams of the 6 and 15 MV.

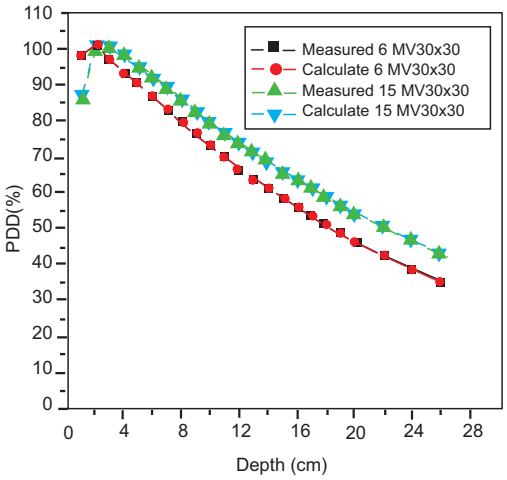
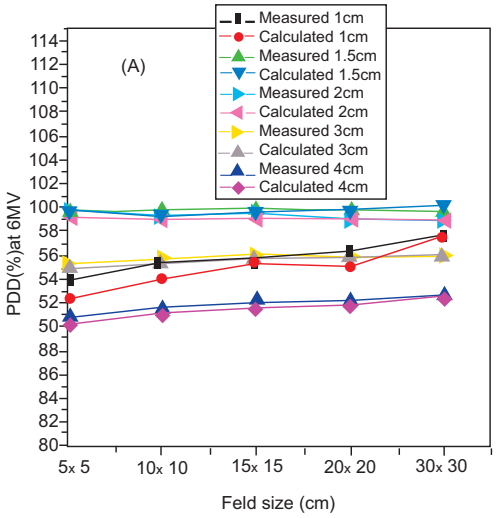


Fig. 3. Comparison of PDDs for 30×30 cm^2 treatment fields in photon beams of the 6 and 15 MV.



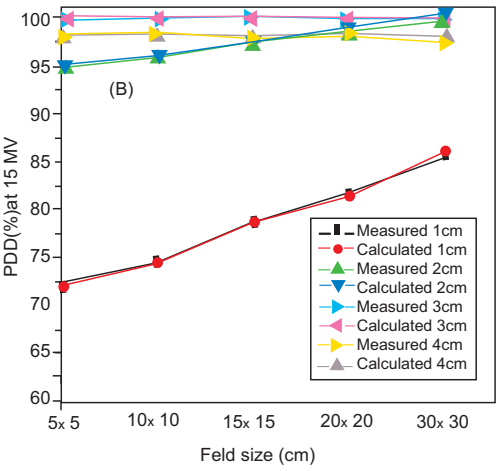


Fig. 4. (A) Measured and calculated PDDs for the 6 MV photon beams and (B) for the 15 MV photon beams at different depths and field sizs.

Table 1. Statistical summary of different tests

	SD of measured values for 6 MV	SD of calculated values for 6 MV	t-test for measured and calculated values for 6 MV	SD of measured values for 15 MV	SD of calculated values for 15 MV	t-test for measured and calculated values for 15 MV
Maximum	24.52	24.44	0.99	21.35	21.37	0.98
Minimum	21.75	22.11	0.92	19.54	19.64	0.93
Mean	23.07	23.31	0.95	20.32	20.42	0.96

Accurate data acquisition is very important to establish a reliable dose calculation model of the treatment planning system. (Klein *et al.,* 2003; Ravikumar and Ravichandran, 2000; Horton, 1983, Gagnon and Grant, 1975).

This study illustrates that as the photon beam energy increases, the surface dose decreases and increases as the field size increases, due to contribution of retro diffused electron in measured values. Furthermore, it is recommended that the formula used to calculate the PDD has approximately same results with the measured data.

Acknowledgement

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