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DEPTH DOSE DATA FOR 4 MeV LINEAR ACCELERATORS WITH LEAD OR URANIUM FIELD FLATTENERS

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Precise dosimetry data is a prerequisite for an effective treatment planning system in radiation therapy. Per cent depth dose data obtained from two 4 MeV linear accelerators—one equipped with lead and another with depleted uranium as field flatteners—are compared with published values. This comparison clearly establishes that variations exist between depth doses which become very significant at depths greater than 10 cm of water.

Material and Method

Measurements were made on two Varian Clinac-4 linear accelerators; one an isocentrically mounted unit equipped with a lead field flattener and the other a stationary unit equipped with depleted uranium as the field flattener. A water phantom of size 66 cm×60 cm×66 cm and a Baldwin-Farmer chamber of 0.6 cm³ volume connected to a Keithly 616 digital electrometer in conjunction with a model 6169 ion chamber interface were used for measurements. The calibration of the system was in accordance with the National Bureau of Standards, i.e., the Baldwin-Farmer chamber was calibrated against ⁶⁰Co and a C_λ of 0.94 was used. Each value reported is the average of 4 measurements.

Results

The measured central axis per cent depth dose values for 4 MV roentgen rays equipped with a lead

field flattener for a few selected depths are compared with values in the literature as indicated for a 10 cm×10 cm field size at 80 cm SSD in Table 1. The per cent difference when the values are compared with those in Brit. J. Radiol. Suppl. No. 11 appear in Table 3. The per cent depth dose values flattened by a uranium field flattener are given in Table 2. The per cent difference in the values when compared with those of Brit. J. Radiol. Suppl. No. 11 is listed in Table 4.

Conclusion

The 4 MV roentgen rays flattened by a uranium field flattener have slightly higher penetrability and in addition give improved field features and dose homogeneity within the beam (NAIR & KARTHA 1978, NAIR et coll. 1978) when compared to 4 MV roentgen rays using a lead field flattener. Values given in Brit. J. Radiol. Suppl. No. 11 cannot be taken for granted for 4 MV roentgen rays with different field flatteners since these values show that the error can be as much as 6 per cent compared with the present results and as much as 12 per cent compared with other published data when uranium field flatteners are used assuming depths greater than 10 cm. Thus direct measurement of individual beam parameters even in accelerators with supposedly similar characteristics must be emphasized.

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Table 1*Comparison of central axis percentage depth doses for 4 MV roentgen rays with lead field flattener*

Depth (cm)	Per cent depth doses for 10 cm×10 cm field at 80 cm SSD					
	Present values	Manufacturer's data	MCCULLOUGH	PETERSON & GOLDEN	CASTRO & KOPENHAVER	Brit. J. Radiol.
1	100.0	100.0	100.0	100.0	100.0	100.0
2	96.2	95.4	96.6	96.8	98.0	97.2
3	91.7	91.5	92.0	92.2	92.5	92.5
4	87.7	86.4	87.4	87.4	87.1	87.4
5	82.4	82.0	82.9	82.4	81.5	82.4
6	78.2	77.7	78.2	77.9	77.0	77.8
7	74.0	73.4	73.9	73.8	72.0	73.1
8	69.5	69.5	69.5	68.8	68.0	68.8
9	64.3	65.5	65.4	64.6	63.5	64.4
10	61.3	61.5	61.6	60.8	59.9	60.5
15	43.9	44.0	44.7	43.9	42.1	43.8
20	31.5	31.7	32.1	31.4	29.5	31.5
25	22.7	23.5	—	22.6	22.0	22.8
30	16.4	17.5	—	16.2	—	16.5

Table 2*Comparison of central axis percentage depth doses for 4 MV roentgen rays with uranium field flattener*

Depth in water (cm)	10 cm×10 cm at 80 cm SSD					20 cm×20 cm at 80 cm SSD				
	Present values	MCCULLOUGH	Review Committee		Brit. J. Radiol.	Present values	MCCULLOUGH	Review Committee		Brit. J. Radiol.
			Filter No. 4	Filter No. 6				Filter No. 4	Filter No. 6	
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	97.5	96.5	—	—	97.2	97.6	96.8	—	—	97.7
3	92.8	91.7	—	—	92.5	93.2	92.9	—	—	93.5
4	88.0	87.1	—	—	87.4	88.9	88.7	—	—	89.2
5	83.4	82.7	82.3	83.0	82.4	84.8	84.8	84.5	84.8	84.1
6	78.8	78.3	—	—	77.8	80.5	81.1	—	—	79.6
7	74.3	73.9	—	—	73.1	76.7	77.0	—	—	75.2
8	70.3	69.7	—	—	68.8	73.0	73.3	—	—	71.2
9	66.1	65.5	—	—	64.4	69.5	69.9	—	—	67.5
10	62.2	61.7	61.4	62.0	60.5	65.9	66.2	65.7	65.5	63.8
15	45.2	45.3	45.0	45.4	43.8	50.0	50.5	50.3	50.1	47.5
20	32.9	33.1	33.1	32.8	31.5	37.6	38.4	38.0	37.7	35.4
25	23.6	—	24.3	24.0	22.8	27.5	—	28.7	28.3	26.4
30	17.0	—	17.9	17.9	16.5	20.6	—	21.5	22.0	19.7

Table 3

Percentage differences relative to Brit. J. Radiol. depth dose values for 4 MV roentgen rays (lead field flattener) 10 cm×10 cm at 80 cm SSD

Depth (cm)	Present values	Manufacturer's data	McCULLOUGH	PETERSON & GOLDEN	CASTRO & KOPENHAVER
2	-1.0	-1.9	-0.6	-0.4	+0.8
5	0.0	-0.5	+0.6	0.0	-1.1
10	+1.3	+1.7	+1.8	+0.5	-1.0
15	+0.2	+0.5	+2.1	+0.2	-3.9
20	+0.3	+0.6	+1.9	-0.3	-6.3
25	-0.4	+3.1	-	-0.9	-3.5
30	-0.6	+6.1	-	-1.8	-

Table 4

Percentage differences relative to Brit. J. Radiol. depth dose values. 4 MV roentgen rays (uranium field flattener)

Depth (cm)	10 cm×10 cm at 80 cm SSD				20 cm×20 cm at 80 cm SSD			
	Present values	McCULLOUGH	Review Committee		Present values	McCULLOUGH	Review Committee	
			Filter No. 4	Filter No. 6			Filter No. 4	Filter No. 6
2	+0.3	-0.7	-	-	-0.1	-0.9	-	-
5	+1.2	+0.4	-0.1	+0.7	+0.8	+0.8	+0.5	+0.8
10	+2.8	+2.0	+1.5	+2.5	+3.3	+3.8	+3.0	+2.7
15	+3.2	+3.4	+2.7	+3.7	+5.3	+6.3	+5.9	+5.5
20	+4.4	+5.1	+5.1	+4.1	+6.2	+8.5	+7.3	+6.5
25	+3.5	-	+6.6	+5.3	+4.2	-	+8.7	+7.2
30	+3.0	-	+8.5	+8.5	+4.6	-	+9.1	+11.7

SUMMARY

Per cent depth dose data for a few selected depths for 4 MV roentgen rays from Varian Clinac-4 linear accelerators equipped with lead or uranium field flatteners are presented and compared with published data. A difference by as much as 12 per cent was found.

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