ACCURACY OF THE DOSE CORRECTION IN IRREGULAR FIELDS FOR MEGA-VOLTAGE PHOTON BEAM RADIATION

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Abstract: The degree of dose perturbation produced by a 30cm × 30cm square polystyrene solid phantom was determined for a X-ray radiation beam, using tissue compensator (gelatin) by direct measurement and theoretical correction method. Data obtained in a square polystyrene solid phantom was used to test two accepted methods e.g., isodose shift and effective source to surface distance (SSD) method. In isodose shift method, we found a factor 0.80 for 6 MV photon beam.

1. INTRODUCTION

The basic dose distribution data are obtained in homogeneous unit density phantom for perpendicular beam incidence on flat surface. During treatment, the beam may be obliquely incident with respect to the surface and in addition, the surface may be curved or irregular in shape. Under such conditions, the standard dose distribution data cannot be applied without proper modifications or corrections [1]. Isodose curves for use in treatment planning are usually measured in a cubical water phantom with the central axis of the beam directed perpendicular to the surface of the phantom. The size of the phantom normally employed is larger enough to produce full scattering conditions. It is therefore necessary in TPS for radiotherapy to make corrections of the isodose curves to account for the curvature of the body surface [2]. Three techniques have been developed to compensate for the patient contour or beam obliquity. The three correction methods are Tissue Air Ratio (TAR), effective source to surface distance (SSD) and the isodose shift techniques [3].

It is desired to calculate the percent depth dose at point A in Fig. 1, in which S-S is an irregularly shaped patient contour. When the effective SSD method is employed, we find the isodose curves for the phantom to shift down a distance h and the new isodose level passes through the point B. The preceding methods are useful for making individual point dose calculations. However, for manual treatment planning, it is convenient to correct the entire isodose chart for contour irregularities. This can be done by an empirical method, known as the isodose shift method. Suppose S-S is the patient contour drawn on a transparent paper and as S'-S' is a flat surface line passing through the point of intersection of the central axis with the contour [1].

2. METHODS & MATERIALS

The phantom geometry was used in this study. The dimension of the phantom was 30cm x 30cm x 30cm. The polystyrene solid phantom was used for the dosimetry and polystyrene to water dose conversion factor is 1.035. A farmer ion chamber with bias voltage 400 V and the volume of 0.3cc was used to measure the photon dose. An irregular geometry of the contour was shaped by tissue equivalent material like gelatin. The polystyrene solid phantom was calibrated for making water equivalent in SSDL from Germany, 1999 [4].

For measurements, irradiations were carried out using 6MV photon (X-ray) beam with the phantom position at 100 cm SSD. Measurements of depth dose were obtained for a 10cm x 10 cm and 15cm x 15cm field size using compensator. All radiations were normalized to the D_{max} using the photon dose monitor unit. An irregular shaped body contour S-S and the D_{max} at point m are desired to calculate the percentage depth dose. The diagram shows that the tissue deficit above point A is h cm and the depth of D_{max} is d_m The percentage depth dose at point A will not change rapidly with SSD, the relative depth dose distribution along the line joining the source with point A is unchanged when the isodose chart is moved down by the distance h and positioned with its surface line at S'-S'. Suppose D_A is the dose at point A. Assuming beam to be incident on a flat surface located at S'-S',

$$D_A = D'_{max} P' \quad (1)$$

where P' is the percentage depth dose at point m'. Suppose P_{corr} is the corrected percentage depth dose at A relative to D_{max} at point m. Then

$$D_A \doteq D'_{max} P_{corr} \quad (2)$$

From these two equations we get

$$P_{corr} = P' \times \left[\frac{D'_{max}}{D_{max}} \right] \quad (3)$$

The distribution is moved, the SSD is increased by a distance h. Therefore we have

$$P_{corr} = P' \times \frac{[SSD + d_m]^2}{[SSD + h + d_m]^2} \quad (4)$$

This is the SSD method and could be used to correct the real PDD. Measurements were performed along ray lines spaced 1 cm distance apart at a distance of 100 cm SSD [5].

3. RESULTS AND DISCUSSION

The central axis depth dose values for different depths at 10 cm x 10 cm field size are shown in Table 1. The results for the homogeneous and inhomogeneous curvatures show similar variation pattern as indicated by the correlation coefficient 0.9966 existing among the values. This value of the correlation coefficient shows a good agreement of variation between them. The central axis depth dose for homogeneous curvature at D_{max} is 179.96 cGy/min [Table 1]. For horizontal beam scanning, the observed penumbra and flatness are +3.5% and 5.0mm respectively. After correction

Table 1. Central axis depth dose in homogenous and inhomogenous ceuveture at 10 cm x 10 cm field size

Body curvature/depth	Depth in cm vs dose in cGy/min												
	1.0	1.5	4.0	5.0	6.5	8.0	9.5	10.5	12.0	14.7	16.0	17.5	20.0
Homogenous	171.19	179.96	164.56	157.21	146.20	135.18	124.16	118.24	108.65	93.71	87.34	77.77	69.35
Inhomohenous	170.03	177.98	165.01	156.80	145.10	134.97	123.0	118.0	109.0	93.65	87.30	77.0	68.0

Table 2. Lateral scanning data in cGy/min of the curvature at 15 cm x 15 cm field size

Body curvature	Dose in cGy/min scanning in 1 cm lateral distance											
Dose/distance	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Homogeneous curvature	35	45	90	155	168	168.5	169	169.2	169.5	170	170	171
Inhomogeneous curvature	25	44	88	150	158	161	162	163	163	164	165	164
After adopting tissue compensator	33.98	44.23	89.30	154.2	167.21	168.02	168.51	169	170.02	170.32	170.61	172.02

Body curvature	Dose in cGy/min scanning in 1 cm lateral distance										
Dose/distance	1	2	3	4	5	6	7	8	9	10	11
Homogeneous curvature	171	170	169.5	169	169	168	167.5	155	90	45	35
Inhomogeneous curvature	165	164	163	161	160	158	158	151	88	44	30
After adopting tissue compensator	171.65	170.98	170.23	169.32	169.65	168.95	168	156.23	91.03	46.02	36.2

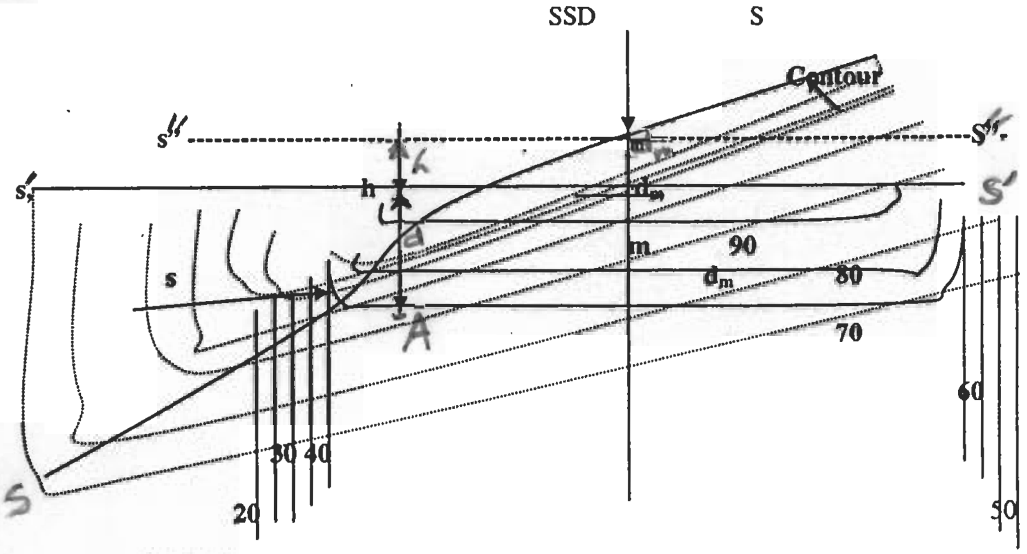

Fig. 1 Irregular shape curvature of field and dose distribution curve

for inhomogeneity by tissue compensator (gelatin) the penumbra and flatness values changed and were found to be +3.4% and 5.5mm respectively. The central axis depth dose and correlation coefficient, r^2 when measured with gelatin and subsequently corrected through equation (4) were respectively 181.03 cGy/min and 0.991. Another point is worth mentioning i.e., by using tissue compensator we used gelatin slave of 3mm thickness; and in doing so little bit of air gap might be remained in the junction of body and tissue compensation. However, the deviation is within the limit of the original measurement. The isodose curve for irregular curvature having irregular field was shifted from that of the normal flat field. It is adjusted by using the tissue compensator and the isodose correction is within the limit which was checked by theoretical isodose shift method. All percentage depth dose values were normalized to 100% based on the maximum dose measured in the phantom on the central axis for 10cm x 10cm beam. In then isodose shift method the percentage depth dose curve is same for all depths greater than 5 cm and has magnitude of 1 cm. The value of h for this ray line is 1.2 cm additional water. Therefore, an isodose shift factor 0.80 [Table 2] is associated with this ray line for deep isodose levels. From this study, it can be concluded that the isodose shift factor 0.80 is a good agreement for the compensation of patient curvature and will yield results within 3% in both the dose build up region and at deeper depth for beam obliquity. In absence of isodose correction for any irregular shape curvature, the dose distribution will be inhomogeneous. The dose optimization and equal dose distribution are the basic principles for the radiotherapy treatment procedure.

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