EVALUATION OF BACKSCATTER FACTORS (B_w) AND PERCENTAGE DEPTH DOSE (PDD) DATA IN TG-61 PROTOCOL AND BJR SUPPLEMENT 25 FOR SUPERFICIAL X-RAY RADIOTHERAPY

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Introduction

Our recently commissioned Xstrahl 150 superficial X-ray therapy unit (Figure 1) could be programmed to beam on at several combinations of tube peak potential difference (kV) and external filtration (Al and Cu) materials (Figure 2). Although the typical characteristics of kilo-voltage beam, such as the percentage depth dose (Pdd) and backscatter factor (B_w), are available in some publication [1,2] to facilitate the machine commissioning by medical physicist, they were reported under certain condition (HVL-kV combination) that may hinder the use of such data accurately in clinical application. The purpose of this work was to i) measure the percentage depth dose (Pdd) of a machine with combination of tube potentials and HVL different from those in TG-61 protocol and BJR Supplement 25, and ii) evaluate the appropriateness of using published B_w for open-ended cones to derive cutout factor for regular field defined with lead cutout.

Figure 1 Xstrahl 150 Superficial X-ray therapy unit

Figure 2 External filter (Al and Cu)

Method

First half value layer (HVL) of those clinically used filters was measured based on recommendation of Section II.C of the AAPM's TG-61 protocol using NE2571 thimble chamber. Tube potentials (kV) were verified using RaySafe Xi. We measured the Pdd of Filter 7 (120 kV, HVL: 5.15 mmAl), Filter 8 (140 kV, HVL: 8.03 mmAl) and Filter 9 (150 kV, HVL: 1.01 mmCu) of open-ended cones (diameters from 2 cm to 5 cm at SSD 15 cm, 10 cm to 15 cm at SSD 25 cm) and cutout factor for regular field defined with lead cutout (Figure 3) (diameters from 2 cm to 14 cm in 15 cm cone) using Markus chamber in Solid water slabs (Gammex RMI-457). In order to remove electron contamination, a piece of 80 gsm plain paper was placed on top of the Markus chamber (Figure 4) during the measurement [3]. Pdd was also measured using NACP chamber in water phantom (iba blue phantom) to evaluate the characteristics of RMI-457 for kV beam measurement (Figure 5). The result was compared to the cutout factors calculated with published B_w (after interpolated to that of measured HVL of our superficial X-ray therapy unit) for open-ended cones in the TG-61 protocol.

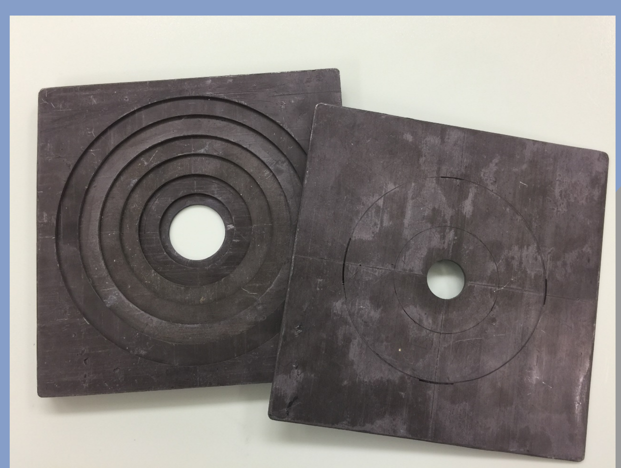

Figure 3 in-house made lead cutout

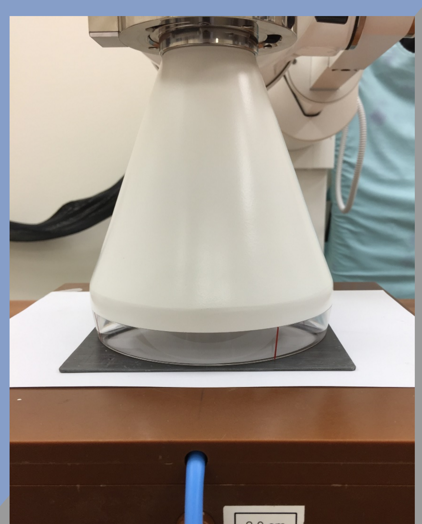

Figure 4 Markus under the paper

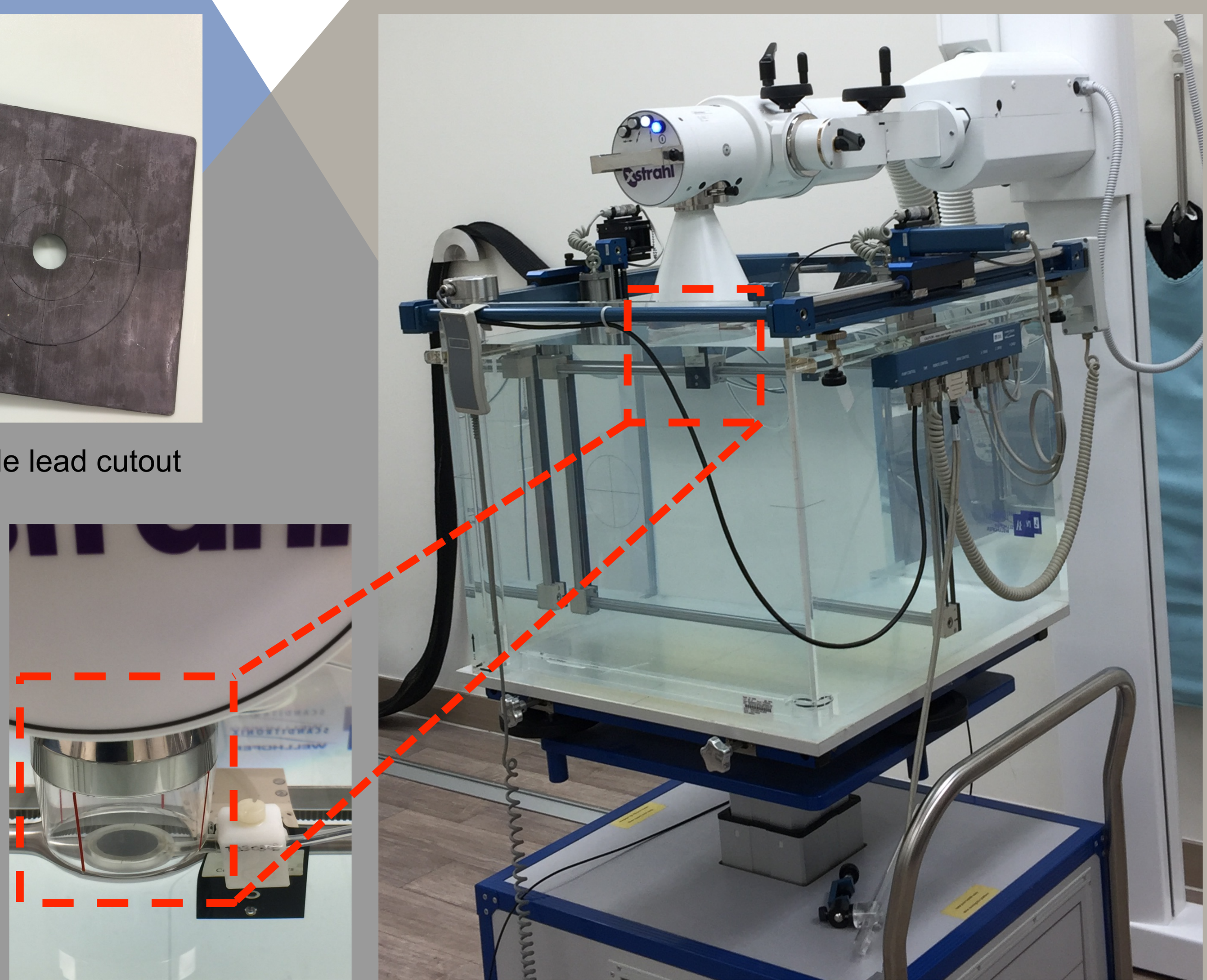

Figure 5 Pdd measurement using NACP chamber in water phantom

Results

The external filtration material, measured kV and first HVL was shown in table 1.

HVL (BJR Supp.25)	HVL (Xstrahl 150)	kV (BJR Supp.25)	kV (Xstrahl 150)	Ex. Filt. (BJR S.25)	Ex. Filt. (Xstrahl 150)
5.0 mmAl	5.15 mmAl	100	123.0	1.8mmAl + 0.1mmCu	0.5mmAl + 0.1mmCu
8.1 mmAl	8.03 mmAl	120	143.6	1.1mmAl + 0.3mmCu	1.2mmAl + 0.2mmCu
1.0 mmCu	1.01 mmCu	200	153.6	N.A.	0.2mmAl + 1.0mmCu

Difference in Pdd at various depths between measurement in Solid water slabs (with Markus) and water phantom (with NACP) was shown in Figure 6, where Filter 9 was used as an example. Pdd in water phantom could only be extended to 5 mm below water surface, and it was normalized at 2 cm depth for comparison. The Pdd data obtained by Solid water slabs and water phantom were very similar, up to 2.2% for a few data points at 15 cm diameter cone. There was considerable difference between the Pdd data by measurement and those in BJR Supp. 25. The difference was less than 3% in general. However, the difference of some data points at shallow depth were up to 10.8% (Figure 7).

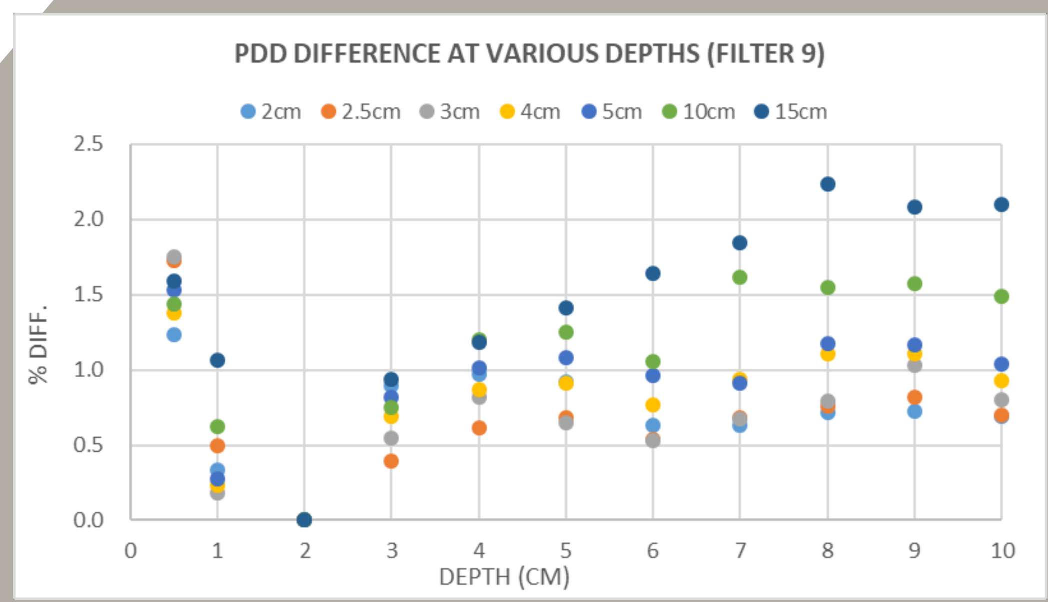

Figure 6 Pdd difference between measurement using Solid water and water phantom at various cone sizes (Filter 9)

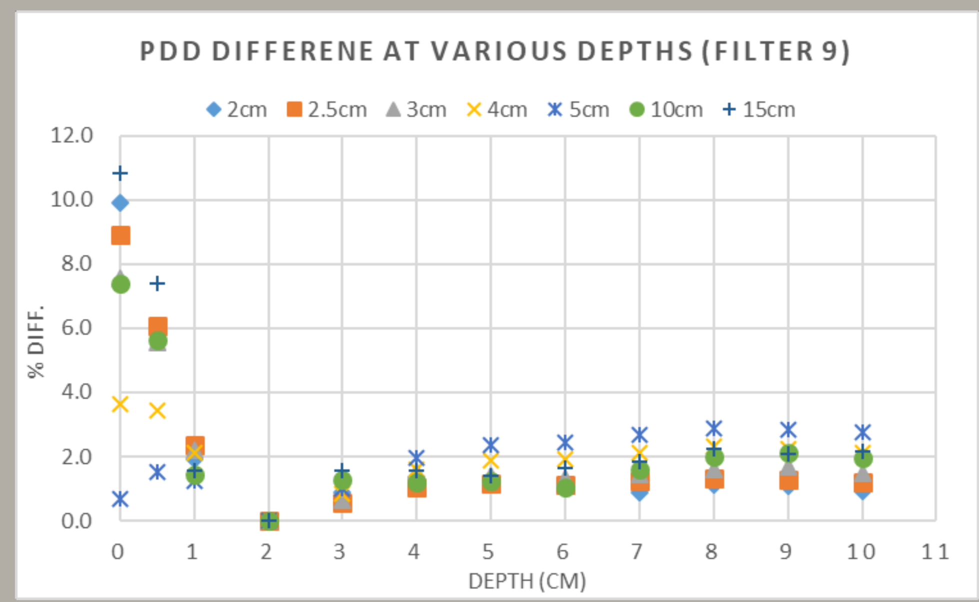

Figure 7 Max. Pdd difference by measurement (water phantom / Solid water) and those in BJR Supp. 25 at various cone sizes (F9)

Cutout factor for regular field defined with lead cutout (CF_m) was determined as follows,

$CF_m = I_c / I_o$ *where I_c, I_o are the corresponding ionizations measured with lead cutout of various sizes and 15 cm open cone*

CF_m determined was compared to the "published cutout factor (CF_p)", which is the ratio of B_w of open-ended cones of various sizes in TG-61 protocol. The difference between the measured cutout factor for regular field defined with lead cutout (CF_m) and the published CF_p of open-ended cone could be up to 3.5% (Table 2).

Dia. (cm)	15	14	12	10	8	6	4	3	2
CF_m	1.000	0.992	0.975	0.955	0.931	0.900	0.861	0.838	0.812
CF_p	1.000	0.990	0.971	0.951	0.917	0.883	0.841	0.816	0.785
% diff.	0.0	0.2	0.4	0.4	1.5	1.9	2.4	2.7	3.5

Table 2 A comparison between CF_m and CF_p

Conclusion

Since TG-61 protocol and BJR Supp. 25 are still the important references for kilo-voltage beam data commissioning, the B_w and Pdd data in these documents should be used with awareness of the size of lead cutout, and combination of tube potential (kV) and HVL when calculating treatment time for superficial x-ray radiotherapy. We recommend to measure the Pdd and cutout factor for regular field defined with lead cutout of kilovoltage x-ray therapy unit if the combination of tube potential (kV) and HVL is different from those in publication significantly. The use of Solid water slabs to facilitate measurement of kV beam data was feasible according to our study.

Reference

[1] BJR Supplement 25, Central Axis Depth Dose Data for use in Radiotherapy: 1996

[2] Ma et al., Medical Physics 28, 868-893 (2001)

[3] C H M Lee and K K D Chan, Physics in Medicine and Biology 45, 1-8 (2000)